Final Report

to the
U.S. Fish and Wildlife Service

Recreational Fisheries Habitat Assessment Project

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1.0 Introduction and Background

The role of GIS in fisheries and coastal management has increased dramatically in recent years. Fishery managers must consider such spatial questions as recruitment patterns across marine ecosystems, the influence of ocean currents or habitat availability on fish populations (Rahel 2004). Advances in the technology used to identify and quantify benthic habitat are providing information necessary for the spatial management of marine resources (Bax et al. 1999). Critical to developing models for the spatial management of fisheries and habitat suitability indices is an accurate description of the abundance and distribution of essential habitats (Battista & Monaco 2004) with knowledge of the association of fishes with those habitats (Bax et al. 1999).

The US Virgin Islands supports a large recreational fishery. Increasing pressures on the reef resources has led to the need to identify and quantify critical habitats. Data are lacking on the benthic habitats that support the recreational fisheries of the U.S. Virgin Islands. This is particularly true of the deeper water shelf habitats of the Virgin Islands. Until recently, benthic marine habitat maps in the US Virgin Islands have consisted primarily of nearshore, shallow water environments. NOAA produced maps of nearshore habitats based on aerial photography (Kendall, et al. 2001). However, use of aerial photography to map and define benthic habitats is depth limited.

Two methods for collecting information on benthic habitats in deeper or turbid waters are side scan sonar and multibeam. Recent side scan sonar surveys include McRea et al. 1999, Gingras et al. 2000, Kendall et al. 2001, Cochrane & Lafferty 2002. Under a contract through the Caribbean Fishery Management Council Geophysics GPR International (2003) conducted multibeam and side scan sonar surveys offshore of St. Thomas and St. Croix. Geophysics GPR International (2003) and Prada Triana (2003) created benthic habitat maps of the Hind Bank Marine Conservation District, along the shelf edge south of St. Thomas.

In an effort to describe the benthic habitats of the US Virgin Islands the Division of Fish and Wildlife initiated studies to map and identify benthic marine habitats for incorporation into a GIS database. Early efforts include the characterization of habitat in the Cas Cay/ Mangrove Lagoon and St. James Marine Reserves (Chapman 1996, Adams et al. 1998, and Volson 2001). Mapping efforts include the use of an ROV to record video of subtidal habitats (Chapman et al. 1996). This project met with substantial difficulties and was subsequently altered to include the use of side scan sonar.

Since 2001 side scan sonar has been used to map subtidal habitats of the insular shelf south of St. John as part of a US Fish and Wildlife Service funded grant. The objective of this grant was to characterize the various shelf habitats that support recreationally important fisheries in the Virgin Islands and to quantify the extent of each habitat type on the insular shelf platform south of St. John. It is anticipated that the information gleaned from this study can be combined with the nearshore habitat maps produced by NOAA/NMFS (Kendall et al. 2001) and the offshore habitat maps produced by Geophysics GPR International (2003) and Prada Triana (2003). Through the development of a series of habitat maps that span the entire shelf south of St. Thomas and St. John fisheries resources can better be assessed and managed.

2.0 Site Description

The island of St. John, US Virgin Islands is part of a volcanic chain of islands. The island is dominated by steep mountainous terrain. Much of the island is part of the Virgin Islands National Park, including some nearshore waters (Figure 1). In 2001 the Virgin Islands Coral Reef National Monument (Figure 1) was created by presidential proclamation. South of St. John the national monument covers approximately 4,369.27 ha of submerged land. The insular shelf south of St. John is managed by several agencies, the National Park Service, the US Virgin Islands territorial government, and the National Marine Fisheries Service. Therefore, there are several agencies that potentially benefit from this project.

The shelf platform extends approximately 9 nm to the shelf edge (south drop) where depths plummet from as little as 30 m to more than 1,000 m. Midway along the shelf platform is the midshelf ridge, also commonly referred to as the midshelf reef. Depth along the bank shelf shoreward of the midshelf ridge vary between 1 to 30 m and offshore of the midshelf ridge 30 to 50 m.

The survey areas was designed to overlap with a fishery independent reef fish assessment project, the Southeast Area Monitoring and Assessment Program – Caribbean (SEAMAP-C) trap study. The intent was, in addition to the objectives of this project, to allow for an analysis of reef fish abundance and habitat associations. Therefore, an area of approximately 64 square nautical miles was initially divided into sixteen 4 nm^2 survey grids, numbered 1 to 16. These were further broken into 1 nm^2 grids, numbered 1a to 1d, 2a to 2d etc.., extending from the south shore of St. John to the shelf edge (Figure 2). Several of the 1 nm^2 grids lie in waters off the shelf edge and were therefore too deep to be surveyed and included in this project.

3.0 Side Scan Sonar and Multibeam

Side scan sonar and multibeam were collected during this project. Approximately 52.62 km^2 (19.17 nm^2) of side scan sonar data were collected. Of that, roughly 10 nm^2 were collected directly by the Division of Fish and Wildlife. The remaining area was collected through a collaborative effort with the US Environmental Protection Agency. In February 2002 onboard the *OSV PW Anderson,* the US EPA with DFW staff collected side scan sonar data of survey areas stj9a to stj12b (see Figure 2). This data was collected using a dual frequency Klein 595 towfish. Horizontal and vertical positioning was accounted for during the survey, however, that information is not reported here. The data from this survey effort was provided to DFW and is included in this report.

In addition to collecting side scan sonar data, DFW collaborated with NOAA's National Ocean Service, National Centers for Coastal Ocean Science, Biogeography Team to collect multibeam data south of St. John and St. Thomas. Although the multibeam data were not directly used to delineate habitats, it was useful in discriminating feature boundaries and correcting the positions of features.

In February and March 2004 approximately 91.06 km^2 of multibeam data were collected (NOAA NCCOS, 2004). This data was made available to the Division of Fish and Wildlife. Information

regarding this mission is available at the following website:
http://biogeo.nos.noaa.gov/foster_mission_2004.

In 2005 another mission to collect multibeam data was conducted. During this mission approximately 39.9 km^2 of data was collected on the Grammanik Bank, St. Thomas, roughly 38.52 km^2 in the Virgin Islands Coral Reef National Monument, St. John, and more than 18 km^2 off of St. Thomas continuing from the 2004 data set (NOAA NCCOS, 2005). Information regarding the 2005 survey mission is available at:
http://biogeo.nos.noaa.gov/foster_mission_2005.

3.1 Geodetic Parameters and Positioning

The projection used during all survey operations was the Universal Transverse Mercator (UTM) zone 20N. The datum used in all surveys was WGS-1984. Vertical positioning was not accounted for during surveys since tidal variation is slight and manually correcting the data for tidal influence was out of the scope of this project. It is not believed that vertical variation was great enough to affect the positioning of features for the level of detail included in the final habitat maps.

Vessel positioning was sent from the GPS unit to a laptop computer running the navigation software HYPACK MAX by HYPACK, Inc. (formerly Coastal Oceanographics, Inc.). The survey vessel followed preplanned survey lines from the positioning provided in the navigation software. Survey lanes were created using the HYPACK MAX software. Twenty-five survey lanes were created for each ~1 nm^2 survey grid. Each survey lane spanned 100 m in width, 50 m on either side of the towfish. Approximately 25 m of overlap was created for each survey lane to ensure 100% coverage while allowing for minimal vessel wander. Position information was also routed to the sonar acquisition computer to provide real time positioning in the sonar record.

3.2 Survey Equipment

3.2.1 Survey Vessel

The survey platform for the majority of this study was DFW's 27 ft. diesel trawler *R/V Lindsey*. A DC electric winch was used to control the length of cable and subsequently the towfish height off the seafloor. The height of the tow point was 1.63 m from the surface of the water when the boat was resting at dock. Positioning during surveys was accomplished using a WAAS enabled Raytheon RC425 chart plotter GPS. The GPS receiver was positioned approximately midship above the wheelhouse. The offset from the receiver to the tow point was 6.27 m. The survey vessel was also fitted with a Furuno FCV-582L depth sounder.

The survey equipment operated off of a 24 volt battery bank charged via two solar panels mounted to the top of the vessel. A 'true' sinewave 1000 watt power inverter provided 120 VAC for the computers.

3.2.2 Sonar System

The side scan sonar system consisted of a single frequency 300 kHz towfish by Marine Sonic Technology, Ltd. The towfish was fitted with a stainless steel ballast, weighing approximately 45 lbs, mounted to the underside of the towfish. A wing depressor was also fitted on top of the transducers to assist in the towfish descent. The sonar acquisition software that was used was Sea Scan PC by Marine Sonic Technology, Ltd. The range of the sonar transducers was set at 50 m on either channel allowing for a 100 m swath width. Numerous towcables of varying length were used throughout the project.

3.3 Survey Operations

The survey crew generally consisted of three people, the captain, the survey operator, and a deck hand to assist in deploying and retrieving the towfish. During survey operations the vessel speed was maintained between 2.5 to 3.5 knots. As mentioned above, the captain followed preplanned survey lines. The sonar operator monitored the sonar image and adjusted the gain balance for optimal image clarity. The survey operator also controlled the winch. Adjustments of the cable altered the height of the towfish off the seafloor. The towfish was towed at an altitude of 3 to 7 m off the seafloor.

The SeaScan PC software by Marine Sonic Technology, Ltd was used during data acquisition. During data acquisition the sonar operator recorded into an excel spreadsheet the ID number for the survey line and the survey grid, the filename, date, time, direction of the ship, water depth, the length of the cable out, and calculated the layback. The towfish did not have a depth transducer so layback had to be calculated manually using the equation:

$$Layback = \left[\sqrt{c^2 - (d + h - a)^2} \right] + o$$

Where (c) is the length of cable out, (d) is the water depth, (h) is the height of the towpoint, (a) is the altitude of the towfish (or height off the seafloor), and (o) is the offset. As mentioned above in section 3.2.1 the height of the towpoint is h = 1.63 m and the offset o = 6.27 m. This layback value was entered into the excel spreadsheet to facilitate manually adding layback into the raw sonar image file later. Basic survey procedures and equipment setup are provided in Appendix I.

3.3.1 Post Processing the Data and Creating Mosaics

The side scan sonar image files were post processed to filter out ambient and vessel noise. Basic post processing procedures are presented in Appendix II. The SeaScan PC software by Marine Sonic Technology, Ltd. was used to post process the images. Once all the files for a survey day were filtered they were recorded on a CD as a back-up.

Mosaics of the data were created with a 0.1 m resolution using the software Isis Sonar and DelphMap by Triton Elics, Intl. The sonar image files were converted from *.mst* files to *.xtf* files. Each 1 nm^2 survey grid was composed of 25 survey lines. Each survey line contained 10 to 12 survey files. All of the files for a single line were ‘snipped’ together. Layback was added manually and the files were processed for the final mosaic. Mosaic procedures are presented in Appendix III. After all 25 lines that compose a single survey area were mosaicked, they were exported as a single *GeoTIFF* file. Mosaics of each completed survey area are presented in Attachment 1 and as on the included CD.

4.0 Ground Truthing the Sonar Images

Several methods were used to validate the side scan sonar images. Representative areas in the sonar record were selected for examination. Additionally select features were examined. Select features, such as reefs, were examined to validate the reef composition (i.e. living coral or gorgonians) and assist in delineating the features edges in the final habitat maps. In all cases underwater visual confirmation was conducted either by divers or digital drop video camera.

4.0.1 Diver Observations

Divers were used to provide feedback on the habitat and structure for selected areas or features of interest. The coordinates for features were derived from the geo-referenced side scan sonar mosaic. To ground truth areas, divers descended at pre-selected coordinates that were representative of a certain habitat type. The divers swam transects following pre-selected compass bearings. The direction of the dive was chosen such that different habitat types could be crossed. Additionally, dive profiles were planned in an effort to locate one feature after leaving another feature and cross a different habitat enroute. On each dive, one diver towed a surface float. Once on the bottom the diver tugged on the surface float. The boat operator navigated the boat directly above the divers and recorded the GPS coordinates. The second diver took digital video or digital photographs of the habitat and recorded the habitat type. The dive team then continued along the transect and when the habitat changed the dive team repeated the above steps recording the new habitat. At the end of the dive the dive team tugged on the surface float and recorded the habitat as above.

4.0.2 Drop Video Camera

In areas that were too deep to dive safely a drop video camera, by SeaViewer Cameras Inc., with GPS overlay was used to determine the benthic habitat. As described above in section 4.0.1 GPS coordinates were determined for selected areas or features. The drop camera was deployed and drifted just above the bottom. A record of the position, date, time, depth, length of cable deployed, and habitat was kept. GPS coordinates were overlayed on the video record so points in the video could be extracted and the track of the drop camera drift could be positioned on the side scan sonar images. The video was then analyzed and the habitat was described. The video is provided on the included DVD as *.wmv* files.

4.1 Interpreting the sonar images

The coordinates recorded during the ground truthing were entered into ArcGIS 9.0 and overlayed on the side scan sonar mosaic. This allowed the dive transect to be accurately positioned over the corresponding habitats. Figure 3 illustrates the locations of ground truthing points conducted by both diver surveys and drop video camera surveys. Each station was given a habitat classification based on the divers' notes and video or photo documentation. Table 1 is a list of ground truthing coordinates and the habitat information that was collected for each site.

Habitat validation proved very useful in interpreting the side scan sonar images. With the 0.1 m resolution in the side scan sonar mosaics numerous features could be described. At a small scale, these communities can be delineated. However at the scale the habitat maps were drawn (see section 6.0), the sonar mosaic becomes ‘messy’, due to noise in the images or layback not lining up between survey lines. Thus in the final habitat maps these small scale communities were not delineated. It should be noted however that if the need to define these communities at a small scale, the side scan sonar images could allow for this on a line by line basis rather than for an entire survey grid. In these figures, the photos correlate directly to the side scan sonar image. Thus interpretation of the sonar image can be made. Figures 4-12 provide examples of habitat validation and an interpretation of the sonar record.

Submerged vegetation can be distinguished in the side scan sonar mosaics. Seagrass habitats were found in shallow waters and provided two types of sonar return (Figure 4). Seagrass appeared as round patches or with a soft grainy appearance. In many instances, particularly in the rhodoliths/ macroalgae habitat categories, the resolution of the side scan sonar image was finer than applicable as discussed above. For example, in Figures 5 and 6 various rhodolith and macroalgae communities are apparent. In shallower waters on the bank shelf (see section 5.1 for zone description), rhodolith and macroalgae communities provide highly variable sonar returns. One of the more interesting results is the presence of what ordinarily would look like sand ripples caused by wave action. However, in most cases south of St. John these ripples are actually formed by rhodoliths moved by wave action (Figure 5d-f). Additionally, the presence of infauna can be seen in sand or rhodolith/ macroalgae communities (Figure 5m-o). Offshore of the midshelf ridge rhodolith communities have very little fleshy macroalgae growth and appear with a smoother texture in the side scan sonar record (Figure 6a-c). Generally rhodolith communities ‘turn over’ from environmental forces at regular to semi regular intervals. However, along the shelf platform of St. John they appear to be more stable since small hard coral colonies can be found recruited to them (Figure 6d-f).

Reef and hardbottom habitats can also be distinguished in the sonar record. Spur and groove habitats provide a strong sonar reflectance and have a striated appearance (Figure 7). Similarly patch reefs rise steeply from the substrate and provide a strong sonar return (Figure 8). Bank reefs and linear reefs provide a strong reflectance with numerous oblong structures (Figure 9). Along the deeper reefs the interface between a reef and the surrounding habitat is often obscured by the fact that along the edges of the main feature there is usually a mix of living coral and gorgonians (colonized pavement) or scattered coral and rock (Figure 9a-c). Colonized bedrock was found only near shore and resulted in a high relief and high reflectance in the sonar return (Figure 10). Colonized pavement on the other hand was found throughout the survey area and yielded differing sonar returns (Figure 11). The reflectance of the colonized pavement habitats was dependant on the relief of the structures. The side scan sonar images from this habitat can appear as spur and groove returns (Figure 11a-c and 11j-l) except that in general they appear as lower relief than a spur and groove coral reef habitat. Other side scan sonar images for the habitat appear flat with a few scattered rocks or barrel sponges (Figure 11d-f) and in some places become difficult to discern from other surrounding habitats (Figure 11m-o). Finally along the shelf platform offshore of the midshelf ridge an additional habitat type was found. The sonar record appeared similar to a linear reef or bank reef except these areas consisted of rock, presumably old dead coral heads, which had limited hard coral growth and small sparsely distributed gorgonians (Figure 12). These areas were classified as scattered coral/rock.

Several collaborations were established to augment ground truthing. Ground truthing was conducted in collaboration with the University of the Virgin Islands during their efforts to locate potential grouper and snapper spawning aggregations. These dives followed the protocol discussed above and are included as sites in Table 1. Additional surveys conducted with personnel from the University of East Anglia, England resulted in quantitative habitat analysis. During these surveys five 30 m transect tapes were lain along a reef and which high resolution digital photographs were taken every 1m at a fixed height off the substrate. The photos were analyzed by placing a set number of random points on each image and identifying the substrate to species level. This allowed for the community composition to be described. Tables 2 and 3 provide the results of the two surveys conducted on reefs in survey areas stj10a and stj2a, respectively. Additionally the results of these two surveys are provided as hyperlinks in the final ArcGIS project in the ground truthing layer.

5.0 Habitat Classification Scheme

Habitat classification schemes often vary regionally as well as locally. Unfortunately, inconsistency in coastal habitat classification can hinder the use of habitat maps in coral reef management and coastal resource management (Mumby & Harborne 1999). Therefore, efforts were made in this project to maintain some level of consistency with existing local habitat classification schemes (see Kendall et al. (2001), Geophysics GPR International (2003), and Prada Triana (2003).

Due to the wide acceptance of the habitat classification scheme developed by Kendall et al. (2001), where possible, the habitat categories developed by Kendall et al. (2001) were used in this project. The habitat classification scheme developed by Kendall et al. (2001) was a hierarchical scheme which was based largely on geomorphological characteristics. At the broad scale geographic zones were delineated followed by discrete habitat units. Subcategories within a particular habitat unit were also categorized with widely used structural definitions followed by a fourth level that described the amount of cover (see Table 4). However, in many circumstances the geomorphological approach used in Kendall et al. (2001) did not match the geomorphology and habitat found on the shelf platform south of St. John.

Another habitat classification scheme as presented in Geophysics GPR International (2003) and Prada Triana (2003) utilizes a more *in situ* descriptive classification in which the biologic component drives the habitat classification (Table 5). As in Kendall et al. (2001) this was also a hierarchical scheme in which the broadest level described the meta-community in a biological context rather than geomorphologically. The next sublevels also use biological and ecological descriptions. The fourth level describes the amount of cover of a particular habitat and is more geomorphological than the first three levels, for example ‘gorgonian limestone’ uses both a biological and geomorphological description. In many instances the descriptions used by Prada Triana (2003) match the habitats found along the insular shelf south of St. John more closely than Kendall et al. (2001). However, this classification scheme is new and is not as widely used as Kendall et al. (2001).

Therefore, this project attempts to utilize the classification scheme developed in Kendall et al. (2001) with some modifications similar to Prada Triana (2003) and other modifications used only to describe this project. The habitat classification scheme developed for this project is also a hierarchical classification scheme (Table 6). The habitat maps developed by Kendall et al. (2001) and Prada Triana (2003) utilized an automated habitat digitizer extension created by NOAA's NOS Biogeography Team for ArcView 3.x. The habitat maps created in this project were created using ArcGIS 9.0 and at the time the habitat maps were created for this project no such extension was available. Therefore, the hierarchical scheme in the maps was developed by entering the values for each polygon in the attribute table manually.

The classification scheme basically contains four levels with two descriptive columns (Table 6). At the broadest level the zones are defined. The zones are geographic areas on the insular shelf from the shoreline to the shelf edge. The next level is broad scale habitat. Broad habitats are general substrate categories. The habitat level provides basic habitat information with general definitions. The category level provides a more descriptive definition of the habitat. The two additional columns in the attribute table 'Desc_1' and 'Form' provide descriptions about a specific habitat category. The 'Desc_1' column identifies patch reefs as either individual patches or aggregate patch reefs and identified the type of artificial structure. The 'Form' column provides a description of the growth form of corals to be expected. The two growth forms are shallow coral, which is the typical columnar and boulder type shallow water form, and plating coral, which is typical of the deeper habitats. These areas generally have the plating growth forms of *Agaricia* spp. and *Montastraea* spp.

5.1 Habitat Classification Descriptions

Zone

Bank shelf - This zone is similar in description to bank shelf as used in Kendall et al. (2001) in that this zone is the shelf platform offshore of the shoreline except that this zone does not extend out to the shelf edge. Instead bank shelf is used to describe the shelf platform between the shoreline and the mid-shelf ridge, a historic (on geologic time scales) reef structure that follows the contours of the shelf platform.

Midshelf ridge - This zone describes the ridge like feature that run relatively horizontal to the shelf edge and shoreline. This zone is offshore of the bank shelf. The midshelf ridge appears to be a relict reef crest that has been flooded with sea level change. Thus it no longer displays the classic back reef, reef crest, and fore reef zones. For this reason, all three zones are encompassed in the midshelf ridge. The midshelf ridge is also commonly referred to as the midshelf reef, however along the areas surveyed in this study the reef appears eroded, has limited live hard coral and more represents a ridge.

Shelf platform - The shelf platform is the zone between the offshore side of the midshelf ridge and the shelf edge also referred to as the outer shelf platform in this report. This zone is similar to the bank/ shelf described in Kendall et al. (2001) between the fore reef and the bank/shelf escarpment. The shelf platform around St. John is generally deeper than the bank shelf.

Shelf edge - The shelf edge is similar to the bank/shelf escarpment in Kendall et al. (2001) and in many places it forms a ridge like structure. The shelf edge is the zone that drops off precipitously. Unlike the surveyed portions of the midshelf ridge, along the shelf edge lie several deep coral reefs.

Habitat descriptions

Unconsolidated Sediment - Unconsolidated sediment have little or no vegetation, see (Kendall et al. 2001) for description.

- **Sand -** Coarse sand has little submerged vegetation and few to no sessile invertebrates. This is similar in definition to Kendall et al. (2001) and Prada Triana (2003).

Submerged Vegetation - Submerged aquatic vegetation that can include seagrass and other fleshy macroalgae (see Kendall et al., 2001 and Prada Triana, 2003 for descriptions). Additionally, since rhodoliths are such a large component of the insular shelf in the US Virgin Islands they were included in this category (see discussion below).

- **Seagrass -** Predominately *Thalassia testudinum and Syringodium filiforme* in this survey area. This habitat was only found nearshore. See Kendall et al. (2001) for a description.

- **Rhodoliths/ macroalgae -** Any combination of rhodoliths (cf. *Lithothamnion ruptile*) and other fleshy macroalgae. Rhodoliths form small calcareous nodules that act much like rubble. In general rhodoliths move with wave action therefore there is usually little epiphytic growth and rhodoliths could be categorized as rubble or unconsolidated sediment. However in the deeper waters along the insular shelf of St. John wave energy is reduced and rhodoliths exhibit varying degrees of epiphytic macroalgae growth even including small Scleratinian corals. Rhodoliths are often associated with the fleshy macroalgae *Lobophora variegatta* thus are combined into the single habitat category.

Reef and Hardbottom - Any rocky or calcium carbonate substrate.

- **Coral Reef -** Substrates composed of Scleratinian coral with varying degrees of live cover.

    - **Spur and groove** - A coral reef with deep to moderately deep channels of alternating sand and coral cut into the reef structure. Channels generally run perpendicular to the shoreline or prevailing currents.

    - **Patch Reef -** Coral reefs that are separated from other reef structures. Patch Reefs may vary in size and may be found isolated (individual) or in close proximity to either other patches (aggregate) or coral reefs. Patch reefs generally rise sharply off the surrounding substrate.

    - **Linear Reef -** A coral reef that follows the contours of the shoreline, midshelf ridge, or shelf edge, see description in Kendall et al. (2001).

  - **Bank Reef -** A coral reef that does not follow the contours of the shoreline, midshelf ridge, or shelf edge as above. Bank reefs may have no particular orientation and may lie either along the bank shelf or outer shelf platform.

- **Colonized Hardbottom -** Substrate composed of limestone or bedrock that is not primarily composed of living coral. This category may have limited Scleratinian coral growth (usually small isolated colonies) and may have varying degrees of gorgonian growth.

  - **Colonized Bedrock** - A rocky substrate usually along the shoreline that has gorgonian growth and limited stony coral growth, see description in Kendall et al. (2001).

  - **Colonized Pavement** - Calcium carbonate substrate that has eroded leaving a substrate of relatively low relief. The predominate coverage is from gorgonians and sponges and a limited amount of stony coral growth, see description in Kendall et al. (2001).

- **Scattered Coral/ Rock** - Small coral colonies or rocks that are generally sparse in unconsolidated sediment and are too small to delineate as patches, see sand and invertebrate category in Prada Triana (2003) for description. Additionally, this category includes a unique habitat that was found along the shelf edge and shelf platform which is similar to colonized pavement and scattered coral/rock. These areas contain a high density of limestone rocks that appear to be dead coral with some gorgonian growth and limited stony coral growth (see Figure 12).

Artificial - Any structure that is anthropogenetic in nature. These may be small boats or debris that was either lost at sea or scuttled.

6.0 Benthic Habitat Maps

Habitat delineation was facilitated by side scan sonar imagery. A total of 17 *GeoTIFF* mosaics were used to create the final habitat maps. ArcGIS 9.0 developed by ESRI was used to generate the habitat maps in this project. Habitat features were visually discriminated in each side scan sonar mosaic. The final habitat maps are presented as Attachment 2. Since the survey area was such a large area, habitat maps that display the entire survey area may not be very useful. Therefore, *PDF* files and a CD containing smaller sections of the habitat maps are also provided (Attachment 3). These will be posted on the Division of Fish and Wildlife's web page: http://www.vifishandwildlife.com.

Due to the highly variable quality of the side scan sonar imagery, the habitat maps were drawn at differing scales. Two habitat maps were created (Attachment 2). The first was a broad scale habitat map in which features were drawn at a larger scale of 1:2000. This layer of the map is labeled the broad habitat category. At the scale this layer was drawn, it was often difficult to discriminate the edges of certain features. Therefore there is likely to be some variation between the drawn edge in the habitat map and the true feature in the field. NOAA created a habitat digitizer extension for ArcView 3.2 which allowed for the setting of a minimum mapping unit (MMU) whereby an attempt to draw polygons that did not meet the MMU were not allowed. Therefore maintenance of the MMU was automated. In this project, ArcGIS 9.0 does not have such a feature therefore adhering to a strict MMU was difficult. Nevertheless, the minimum mapping unit used in the broad habitat category layer was 50 m^2, although some allowances were made for the artificial category and a few other features that were isolated structures and could be easily delineated.

Individual features that were larger than the MMU but were obviously a component of a larger habitat and contained features smaller than the MMU were included in a single polygon for the larger habitat unit. For example, in several scattered coral/rock habitat polygons some individual features were larger than the MMU but a polygon was drawn around all of the features in that habitat unit (see Figure 13). Additionally, at the broad scale, habitat polygons were drawn around entire patch reef structures rather than individual patches.

The availability of the high resolution multibeam provided by NOAA's NOS Biogeography Team (section 3.0) allowed for a high precision in positioning of certain features. Since multibeam provides high resolution bathymetry it was useful in delineating the edges of features with high relief such as reef and hardbottom habitats. For this reason a second layer was created in which reef and hardbottom structures were delineated at a smaller scale and a higher level of positional accuracy. In this layer, side scan sonar was still the primary tool for delineating habitat. Multibeam was overlain with side scan sonar images where both were available. The transparency in the properties for the side scan sonar layer were set at 40% transparent to allow the viewer to see through the side scan sonar yet retain the ability to see the habitat features (Figure 14). Further, because of the often poor positional accuracy of the side scan sonar, due to manually inserting layback after data acquisition, some polygons were shifted to line-up with the multibeam positioning (Figure 14). For the purposes of habitat delineation, polygons were initially drawn around features in the side scan sonar images those polygons were then manually shifted to correspond with the same feature in the multibeam. In a few instances, the side scan sonar coverage ended on a reef and hardbottom feature. In these cases the multibeam was used to finish constructing the polygon. Table 4 lists the polygons that were either shifted or drawn using the multibeam data.

Combining the side scan sonar and multibeam technologies allowed for a highly detailed map of reef and hardbottom features to be drawn. Also because of the strong sonar reflectance of these structures, features were delineated at a scale of 1:600. Rather than attempting to adhere to a set MMU in this layer, polygons were created around side scan sonar returns that were visually distinct from one another. Therefore, the detail in patch reefs is far greater than in the broad habitat layer. Only two features in this layer were not delineated at the individual structure level. The scattered coral/rock features described above and in Figure 13 were too complex to delineate individual features and maintain usefulness to the map user. Likewise due to the poor image quality and the complex nature of the bank reef in survey areas stj11a and stj11b (Figure 15), a lower precision can be expected in the boundaries for polygons of that bank reef. Further, within any polygon in that area (Figure 15), it may be possible to have multiple habitats that were not distinct. In the deeper regions of the shelf platform, habitat boundaries were not as distinct as along the bank shelf or midshelf ridge. These areas contained rhodolith plains, with little to no fleshy macroalgae and some small scattered coral that recruited on the rhodoliths. These rhodoliths plains merged into colonized pavement or scattered coral/rock habitats then onto bank reefs with plating coral. The boundaries between these habitats were often difficult to discern visually.

6.1 Quantitative Description of Habitats Along the Insular Shelf

Habitat coverage is presented in Attachment 2 as habitat maps. Since two layers were created for habitats, there will be some differences in the total area of any given habitat between the layers. Therefore the total area covered by a habitat was determined for each layer. Figure 16 provides the total area (km^2) each habitat covered in the broad habitat layer. At the highest level in the broad habitat layer, submerged vegetation covered the 77.1% of the total surveyed area while reef and hardbottom habitats covered 22.3% (Table 8). Interestingly, unconsolidated sediment only accounted for 0.6% of the total surveyed area. However, if one were to consider rhodoliths as unconsolidated sediment, this contribution would increase significantly. When habitats are broken down in this layer, bank reef contributes 13.6% to the total area covered. Table 8 lists the area and percent of the total area each habitat covered at each of three of the hierarchical levels. The average polygon area for a particular habitat in this layer is presented in Figure 17.

The total areas and percent contribution of each habitat in the reef and hardbottom layer are presented in Table 9. As in the broad habitat layer, bank reefs contribute the most (55.95%) to the total area covered by reef and hardbottom habitats. The total areas covered by reef and hardbottom habitats are illustrated in Figure 18. The average polygon areas for each reef and hardbottom habitat are presented in Figure 19. The average area for bank reefs was just over 0.12 km^2. Knowing the average area for a habitat type may reveal some information as to how large an average feature is in the survey area.

7.0 Discussion

Side scan sonar and multibeam technologies provided a platform to create benthic habitat maps of the insular shelf south of St. John. Although the areas surveyed in this project are discontiguous, they do provide critical habitat information for previously undescribed portions of the insular shelf. One of the major assets gained in this project was the development of collaborations with other agencies. These collaborations allowed for the collection of data that otherwise would have been out of the scope of this projects ability. Collaborations with the US EPA allowed for the collection of side scan sonar data over a large area along the outer shelf platform (survey areas stj9a to stj12b). Further, through collaborations with NOAA/NOS, high resolution bathymetric data was collected along large portions of the shelf platform and shelf edge south of St. Thomas and St. John. This information, when available, can be combined with the side scan sonar data to provide additional coverage. Maintenance of these collaborations may provide opportunity to map additional areas in the future.

Through the efforts to maintain conformity to existing habitat classifications, all existing habitat maps (Kendall et al. 2001, Geophysics GPR International 2003, Prada Triana 2003) and those produced in this study may be used in conjunction with each other to provide a broader description of the habitats in the US Virgin Islands. Some interpretation may be necessary to accommodate definition differences.

Through the combination of side scan sonar and multibeam technology, high resolution digital habitat maps were created. However, the images from both the multibeam and side scan sonar will allow for further dividing the classification of the rhodolith/macroalgae habitat category. As outlined in Table 6 and Figures 5 to 6, differences in community structure with in the rhodoliths and macroalgae habitat classification may be derived at small scales. Although these divisions were not practical at the scales that the maps were drawn, the habitats as described in Table 6 may be delineated for study specific purposes. Figures 5 to 6 provide strong examples of sonar imagery and habitat for delineation purposes.

Although a considerable amount of ground truthing was conducted to produce these habitat maps, not every feature was validated. Additionally, some features, particularly in survey areas stj11a and stj11b, as explained above in section 6.0, contain complex habitats with indiscriminate boundaries. These areas are still in need of ground validation and should be investigated. The complex scattered coral and rock habitat illustrated in Figure 13 and Map 9 of Attachment 3 also require ground validation and describing. Finally, an accuracy assessment was not conducted for these habitat maps. Accuracy assessment assures the user some level of confidence in the habitat classifications (i.e. what percent of the time was habitat 'A' correctly identified). Accuracy assessments can be conducted using a drop video camera. Random points within specific habitat units should be identified and the coordinates for those points determined. The drop video camera should be deployed at those coordinates (provided on CD in accuracy assessment points folder) and the habitat, using the classification scheme presented in this report, be recorded. The results of such surveys can be analyzed using non-parametric statistics and compared against random classification. Such analysis would allow for the establishment of a level of confidence in the habitat classification of polygons.

7.1 Future work

The areas surveyed during this project are discontiguous resulting in a significant gap in data. Additionally, only a small portion of the areas that were surveyed lie along the shelf edge. This zone is increasingly becoming recognized as possibly containing critical spawning aggregation habitat. Many shelf edge coral reefs are multispecific spawning aggregation sites. Since such a small area along the shelf edge has been described, continuation of identifying habitats along the shelf edge is paramount. The collaborations established in recent years should be maintained and opportunities to collect remote sensing data through other agencies or entities should be considered.

The next logical step in integrating the habitat maps produce here is to use this information to assess the current condition of the various habitats. This project initiated steps towards that end with the quantitative community composition assessments provided in Tables 2 and 3. Surveys such as these may provide a first step towards assessing the condition of certain habitats. In addition to the basic species composition assessments, species health should be monitored, particularly in light of increasing coastal development and ocean climate change.

In addition to the above, fish and invertebrate assessment should be conducted across a wide range of the habitats contained in these maps. Coupling the spatial and quantitative habitat information presented in these habitat maps with an assessment of the fish communities will allow managers to develop better carrying capacity, stock abundance, and resource distribution models.

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Table 1. Ground truthing coordinates and habitat at each point. The columns labeled type and descriptor describe the structure and make-up of each site.

DATE_	X	Y	HABITAT	CATEGORY	TYPE	DESCRIPTOR
4/30/2003	-64.65691	18.25017	coral reef	linear reef	deep water	
4/30/2003	-64.66065	18.24725	coral reef	linear reef	deep water	
4/30/2003	-64.64530	18.26585	colonized hardbottom	colonized pavement		
4/30/2003	-64.66256	18.22458	colonized hardbottom	colonized pavement	shelf edge	
5/15/2003	-64.78197	18.30958	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	<30% sponges
5/15/2003	-64.77953	18.31063	colonized hardbottom	colonized bedrock		<30% coverage
5/15/2003	-64.77545	18.31497	seagrass	patchy	syringodium	
5/15/2003	-64.77599	18.31481	seagrass	patchy	syringodium	
6/18/2003	-64.78035	18.30951	small boat	boat		
1/9/2004	-64.78243	18.30483	colonized hardbottom	colonized pavement		
1/9/2004	-64.76740	18.23506	coral reef	linear reef	<30% live	
1/9/2004	-64.76768	18.23498	coral reef	linear reef	<30% live	
1/9/2004	-64.76903	18.23493	scattered coral/ rock	scattered coral/ rock		
1/9/2004	-64.76912	18.23493	scattered coral/ rock	scattered coral/ rock		
1/9/2004	-64.74023	18.23080	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	
1/9/2004	-64.74083	18.23068	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	
1/9/2004	-64.73985	18.23078	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	
1/9/2004	-64.75315	18.24345	coral reef	linear reef	deep water	
1/9/2004	-64.75370	18.24347	coral reef	linear reef	deep water	
1/9/2004	-64.75377	18.24347	coral reef	linear reef	deep water	
1/9/2004	-64.75348	18.24347	coral reef	linear reef	deep water	
3/25/2004	-64.78043	18.30470	rhodoliths/ macroalgae	rhodoliths+macroalgae	w/ sponges	<30% sponges
3/25/2004	-64.78421	18.30465	colonized hardbottom	colonized pavement		>70% coverage
3/25/2004	-64.78518	18.30433	colonized hardbottom	colonized pavement		<30% coverage
3/25/2004	-64.78590	18.30325	rhodoliths/ macroalgae	rhodoliths+macroalgae		
3/25/2004	-64.78660	18.30321	colonized hardbottom	colonized pavement	w/ sand veneer	
3/25/2004	-64.78661	18.30361	colonized hardbottom	colonized pavement	w/ sand veneer	<30% coverage

Table 1 cont'd. Ground truthing coordinates and habitat at each point. The columns labeled type and descriptor describe the structure and make-up of each site.

DATE_	X	Y	HABITAT	CATEGORY	TYPE	DESCRIPTOR
3/25/2004	-64.78670	18.30376	colonized hardbottom	colonized pavement	w/ sand veneer	<10%
3/25/2004	-64.78713	18.30433	colonized hardbottom	colonized pavement	w/ sand veneer	10-30% sc
4/2/2004	-64.78413	18.30728	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	
4/2/2004	-64.78560	18.30736	rhodoliths/ macroalgae	rhodoliths+macroalgae	moderate	<10%
4/2/2004	-64.78573	18.30665	colonized hardbottom	colonized pavement	w/ sand veneer	
4/2/2004	-64.78580	18.30601	colonized hardbottom	colonized pavement		<30%
4/2/2004	-64.77466	18.30663	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	50-70%
4/2/2004	-64.77583	18.30628	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	30-50%
4/2/2004	-64.77496	18.30550	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	70%
7/19/2004	-64.79280	18.26760	colonized hardbottom	colonized pavement		70%
7/19/2004	-64.67720	18.33800	coral reef	patch reef		70% live
7/19/2004	-64.76790	18.27500	colonized hardbottom	colonized pavement		70% live
7/20/2004	-64.74860	18.27500	colonized hardbottom	colonized pavement		w/ sand c
7/20/2004	-64.72550	18.26980	coral reef	linear reef		70% live
7/21/2004	-64.79780	18.26480	colonized hardbottom	colonized pavement		50% live
7/21/2004	-64.82357	18.24958	coral reef	spur and groove		50% live
7/21/2004	-64.82240	18.24870	coral reef	spur and groove		w/ sand c
8/18/2004	-64.77564	18.30117	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	w/ sand c
8/18/2004	-64.77602	18.30093	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	50%
8/18/2004	-64.77650	18.30106	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	<30% sponges
8/18/2004	-64.77616	18.30402	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	<30% sponges
8/18/2004	-64.77648	18.30413	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	<30% sponges
8/18/2004	-64.77712	18.30466	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	<30% sponges
8/18/2004	-64.75716	18.24423	coral reef	linear reef	deep water	
2/24/2005	-64.75228	18.29810	rhodoliths/ macroalgae	macroalgae	sparse	30-50% ma
2/24/2005	-64.75170	18.29743	sand	sand		<10%
2/24/2005	-64.75093	18.29728	scattered coral/ rock	scattered coral/ rock		10-30% sc

Table 1 cont'd. Ground truthing coordinates and habitat at each point. The columns labeled type and descriptor describe the structure and make-up of each site.

DATE_	X	Y	HABITAT	CATEGORY	TYPE	DESCRIPTOR
2/24/2005	-64.73491	18.30348	coral reef	patch reef	aggregate	
2/24/2005	-64.73527	18.30375	sand	sparse ma		<10%
2/24/2005	-64.73575	18.30422	coral reef	patch reef	aggregate	
2/24/2005	-64.73598	18.30428	rhodoliths/ macroalgae	sparse ma		<30%
2/24/2005	-64.73797	18.30857	coral reef	spur groove		50-70%
2/24/2005	-64.75220	18.29938	rhodoliths/ macroalgae	macroalgae		30-50%
2/24/2005	-64.75197	18.29963	coral reef	patch reef	aggregate	70%
2/24/2005	-64.75172	18.29960	coral reef	patch reef	aggregate	70%
3/3/2005	-64.74599	18.30361	coral reef	patch reef	individual	70% live
3/3/2005	-64.74636	18.30421	coral reef	patch reef	individual	70% live
3/3/2005	-64.74672	18.30652	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	w/ sand c
3/3/2005	-64.74809	18.29961	coral reef	patch reef	individual	70% live
3/3/2005	-64.74735	18.30027	coral reef	patch reef	individual	50% live
3/3/2005	-64.74716	18.30106	coral reef	patch reef	individual	50% live
3/3/2005	-64.74687	18.30188	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	w/ sand c
3/3/2005	-64.74686	18.30224	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	w/ sand c
3/3/2005	-64.73753	18.31112	coral reef	spur groove		50%
4/12/2005	-64.75946	18.29308	rhodoliths/ macroalgae	macroalgae	patchy	<30%
4/12/2005	-64.75915	18.29295	boat	decomposed boat		
4/12/2005	-64.75896	18.29285	boat	decomposed boat		
4/12/2005	-64.75886	18.29282	colonized hardbotto	colonized pavement		
4/12/2005	-64.76041	18.29299	rhodoliths/ macroalgae	macroalgae	patchy	30-50%
4/12/2005	-64.76061	18.29354	rhodoliths/ macroalgae	macroalgae	patchy	50-70%
4/12/2005	-64.76885	18.29832	rhodoliths/ macroalgae	macroalgae	patchy	>70%
4/12/2005	-64.76746	18.29840	rhodoliths/ macroalgae	macroalgae	patchy	<10%
4/12/2005	-64.75694	18.30062	rhodoliths/ macroalgae	macroalgae	patchy	<30%
4/12/2005	-64.75709	18.30072	rhodoliths/ macroalgae	macroalgae	continuous	
4/12/2005	-64.75775	18.30104	rhodoliths/ macroalgae	macroalgae	continuous	

Table 2. Results of the community composition, 30m photo transects conducted on the side scan sonar reef (stj9b-stj10a).

Side-scan sonar reef	**18°14.6538**		**64°45.4296**		18.24423	-64.75716
8/18/2004	NUMBERS REPRESENT **PERCENT** OF TRANSECT					
Transect Length	*30m*					
CATEGORY	*1*	*2*	*3*	mean	(SD)	CATEGORY
CORAL	53.5	52.9	54.8	53.8	1.0	CORAL
GORGONIANS	0.0	0.3	0.0	0.1	0.2	GORGONIANS
SPONGES	1.9	1.3	2.3	1.8	0.5	SPONGES
ZOANTHIDS	0.0	0.0	0.0	0.0	0.0	ZOANTHIDS
MACROALGAE	34.5	37.1	35.8	35.8	1.3	MACROALGAE
COALLINE ALGAE	0.0	0.0	0.0	0.0	0.0	COALLINE ALGAE
DEAD CORAL w/ **TURF** ALGAE	8.4	7.7	5.5	7.2	1.5	DEAD CORAL w/ **TURF** ALGAE
DISEASED CORALS	0.0	0.0	0.0	0.0	0.0	DISEASED CORALS
SAND, RUBBLE, PAVEMENT	1.3	0.3	1.3	1.0	0.6	SAND, RUBBLE, PAVEMENT
OTHER, LIVE	0.3	0.3	0.3	0.3	0.0	OTHER, LIVE
UNKNOWNS	0.0	0.0	0.0	0.0	0.0	UNKNOWNS
TAPE + WAND + SHADOW	0.0	0.0	0.0	0.00	0.00	TAPE + WAND + SHADOW
SHANNON WEAVER DIV. INDEX	1.80	1.97	1.81	2.19	H', using sums of all transects (see right)	
				-9.26	H', including MACX as species in sum of trans.	

	NUMBERS OF **POINTS** PER TRANSECT				
CATEGORY	1	2	3	sums	CATEGORY
CORAL	166	164	170	500	CORAL
GORGONIANS	0	1	0	1	GORGONIANS
SPONGES	6	4	7	17	SPONGES
ZOANTHIDS	0	0	0	0	ZOANTHIDS
MACROALGAE	107	115	111	333	MACROALGAE
COALLINE ALGAE	0	0	0	0	COALLINE ALGAE
DEAD CORAL w/ **TURF** ALGAE	26	24	17	67	DEAD CORAL w/ **TURF** ALGAE
DISEASED CORALS	0	0	0	0	DISEASED CORALS
SAND, RUBBLE, PAVEMENT	4	1	4	9	SAND, RUBBLE, PAVEMENT
OTHER, LIVE	1	1	1	3	OTHER, LIVE
UNKNOWNS	0	0	0	0	UNKNOWNS
TAPE + WAND + SHADOW	0	0	0	**0**	TAPE + WAND + SHADOW
t+w+s, not incl. in sums					
Sum of Points per transect	310	310	310	930	

Corals:	53.5483871	52.903226	54.83871	53.76	0.99
Branching	0	0	0	0.00	0.00
Lettuce	0	0	0	0.00	0.00
Finger	0	0.6451613	0.6451613	0.43	0.37
Plate/Sheet	0.96774194	0.9677419	1.2903226	1.08	0.19
Boulder/Mound	52.2580645	50.967742	52.903226	52.04	0.99
Cup/Flower	0.32258065	0	0	0.11	0.19
Bush	0	0	0	0.00	0.00
Fire corals	0	0.3225806	0	0.11	0.19
Ball sponge	0.00	0.00	0.00	0.00	0.00
Barrel/Vase sponge	1.29	0.00	0.65	0.65	0.65
Boring sponge	0.00	0.00	0.00	0.00	0.00
Encrusting sponge	0.65	0.65	0.97	0.75	0.19
Rope spone	0.00	0.32	0.65	0.32	0.32
Tube sponge	0.00	0.32	0.00	0.11	0.19
Boulder	0.00	0.00	0.00	0.00	0.00
Sand/Sediment	1.29	0.32	1.29	0.97	0.56
Rubble	0.00	0.00	0.00	0.00	0.00
Pavement	0.00	0.00	0.00	0.00	0.00

Diversity index summary table
*This sums all the points per species of all transects to calculate the H'.

Categories	category sum for each transect total pts.	(ni /N)(ln ni /N)
Acropora cervicornis (AC) - coral	0	0.00
Acropora palmata (AP) - coral	0	0.00
Acropora prolifera (APR) - coral	0	0.00
Agaricia agaricites (AA) - coral	10	0.28
Agaricia fragilis (AF) - coral	0	0.00
Agaricia grahamae (AG) - coral	0	0.00
Agaricia humilis (AH) - coral	0	0.00
Agaricia lamarcki (AL) - coral	0	0.00
Agaricia tenuifolia (AT) - coral	0	0.00
Agaricia undata (AU) - coral	0	0.00
Colpophyllia natans (CN) - coral	5	0.19
Dendrogyra cylindrus (DCY) - coral	0	0.00
Diploria clivosa (DC) - coral	0	0.00
Diploria labyrinthiformis (DL) - coral	0	0.00
Diploria strigosa (DS) - coral	5	0.19
Dichocoenia stokesii (DSO) - coral	0	0.00
Eusmilia fastigiata (EF) - coral	1	0.06
Favia fragum (FF) - coral	0	0.00
Isophyllia sinuosa (IS) - coral	0	0.00
Isopyhyllastrea rigida (IR) - coral	0	0.00
Leptoseris cucullata (LC) - coral	0	0.00
Manicina areolata (MAR) - coral	0	0.00
Madracis decactis (MD) - coral	0	0.00
Madracis formosa (MAFO) - coral	1	0.06
Madracis mirabilis (MM) - coral	0	0.00
Meandrina meandrites (MME) - coral	1	0.06
Montastraea annularis (MA) - coral	0	0.00
Montastraea cavernosa (MC) - coral	9	0.27
Montastraea faveolata (MFAV) - coral	0	0.00
Montastraea franksi (MFRA) - coral	0	0.00
Mussa angulosa (MAN) - coral	0	0.00
Mycetophyllia aliciae (MAL) - coral	0	0.00
Mycetophyllia danaana (MDA) - coral	1	0.06
Mycetophyllia lamarckiana (ML) - coral	1	0.06
Mycetophyllia ferox (MF) - coral	3	0.14
Oculina diffusa (OD) - coral	0	0.00
Montastraea annularis complex (MACX)	431	-11.44
Including MACX as MA	431	-11.44

Categories	category sum for each transect total pts.	(ni /N)(ln ni /N)
Porites astreoides (PA) - coral	22	0.36
Porites branneri (PB) - coral	0	0.00
Porites divaricata (PD) - coral	1	0.06
Porites furcata (PF) - coral	4	0.17
Porites porites (PP) - coral	0	0.00
Scolymia cubensis (SC) - coral	0	0.00
Scolymia lacera (SL) - coral	0	0.00
Siderastrea radians (SR) - coral	0	0.00
Siderastrea siderea (SS) - coral	4	0.17
Solenastrea bournoni (SB) - coral	0	0.00
Solenastrea hyades (SH) - coral	0	0.00
Stephanocoenia michelinii (SM) - coral	0	0.00
Tubastraea aurea (TA) - coral	0	0.00
Millepora alcicornis (MILA) - coral	1	0.06
Millepora complanata (MILC) - coral	0	0.00
Millepora squarrosa (MILS) - coral	0	0.00
		H'=
# corals of **known** species	69	2.19
check of # corals of **known** species	69	
total number of coral points	500	
(includes un-identifiable species)		
percent of coral species un-identifiable	86.20	
Including MACX in MA Category		**H'=**
# corals of known species	500	-9.26
total number of coral points	500	
percent of coral points identified to spp.	100.00	

Data and summary provided by Liz Whiteman, U.E.A.

ect

Data and summary provided by Liz Whiteman, U.E.A.

Table 3. Results of the community composition, 30m transect surveys for a spur and groove reef in survey area stj2a.

NUMBERS REPRESENT PERCENT OF TRANSECT

1/0/1900 NUMBERS REPRESENT **PERCENT** OF TRANSECT

Transect Length	*30*							
CATEGORY	*1*	*5*	*7*	*5*	*3*	mean	(SD)	CATEGORY
CORAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CORAL
GORGONIANS	35.2	31.0	33.5	30.0	41.0	34.1	4.3	GORGONIANS
SPONGES	1.3	3.5	1.0	0.0	0.0	1.2	1.5	SPONGES
ZOANTHIDS	16.1	19.4	20.6	18.1	21.3	19.1	2.1	ZOANTHIDS
MACROALGAE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MACROALGAE
COALLINE ALGAE	9.7	2.6	2.9	1.0	4.3	4.1	3.3	COALLINE ALGAE
DEAD CORAL w/ **TURF** ALGAE	0.3	1.6	0.0	0.0	0.0	0.4	0.7	DEAD CORAL w/ **TURF** ALGAE
DISEASED CORALS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DISEASED CORALS
SAND, RUBBLE, PAVEMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SAND, RUBBLE, PAVEMENT
OTHER, LIVE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	OTHER, LIVE
UNKNOWNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	UNKNOWNS
TAPE + WAND + SHADOW	0.0	0.0	0.0	0.0	0.0	0.00	0.00	TAPE + WAND + SHADOW
SHANNON WEAVER DIV. INDEX	ESENT POINT:	0.00	0.00	0.00	0.00	-15.37	H', using sums of all transects (see right)	
						-15.37	H', including MACX as species in sum of trans.	

NUMBERS OF **POINTS** PER TRANSECT

CATEGORY	0.96774194	4.83870968	7.41935484	4.83870968	3	sums	CATEGORY
CORAL	0	0	0	0	0	0	CORAL
GORGONIANS	109	96	104	93	123	525	GORGONIANS
SPONGES	4	11	3	0	0	18	SPONGES
ZOANTHIDS	50	60	64	56	64	294	ZOANTHIDS
MACROALGAE	0	0	0	0	0	0	MACROALGAE
COALLINE ALGAE	30	8	9	3	13	63	COALLINE ALGAE
DEAD CORAL w/ **TURF** ALGAE	1	5	0	0	0	6	DEAD CORAL w/ **TURF** ALGAE
DISEASED CORALS	0	0	0	0	0	0	DISEASED CORALS
SAND, RUBBLE, PAVEMENT	0	0	0	0	0	0	SAND, RUBBLE, PAVEMENT
OTHER, LIVE	0	0	0	0	0	0	OTHER, LIVE
UNKNOWNS	0	0	0	0	0	0	UNKNOWNS
TAPE + WAND + SHADOW	0	0	0	0	0	**0**	TAPE + WAND + SHADOW
t+w+s, not incl. in sums							
Sum of Points per transect	194	180	180	152	200	906	

Data provided by E. A. Whiteman, UEA

Diversity index summary table

*This sums all the points per species of all transects to calculate the H'.

Categories	total pts. (category sum for each transect)	(ni /N)(ln ni /N)
Acropora cerv	7	0.31
Acropora paln	0	0.00
Acropora proli	0	0.00
Agaricia agari	0	0.00
Agaricia fragil	8	0.33
Agaricia graha	0	0.00
Agaricia humi	0	0.00
Agaricia lama	0	0.00
Agaricia tenui	41	-0.08
Agaricia unda	3	0.20
Colpophyllia n	8	0.33
Dendrogyra cy	1	0.10
Diploria clivos	1	0.10
Diploria labyri	0	0.00
Diploria strigo	0	0.00
Dichocoenia s	0	0.00
Eusmilia fastig	0	0.00
Favia fragum	0	0.00
Isophyllia sinu	0	0.00
Isopyhyllastre	0	0.00
Leptoseris cuc	0	0.00
Manicina arec	0	0.00
Madracis deca	1	0.10
Madracis form	313	-17.37
Madracis mira	0	0.00
Meandrina me	32	0.14
Montastraea a	0	0.00
Montastraea c	0	0.00
Montastraea f	0	0.00
Montastraea f	0	0.00
Mussa angulo	0	0.00
Mycetophyllia	0	0.00
Mycetophyllia	0	0.00
Mycetophyllia	0	0.00
Mycetophyllia	14	0.37
Oculina diffus	0	0.00
Montastraea a	0	0.00
Including MAC	0	0.00

Categories	total pts. (category sum for each transect)	(ni /N)(ln ni /N)
Porites astreoides (PA) - coral	54	-0.50
Porites branneri (PB) - coral	0	0.00
Porites divaricata (PD) - coral	0	0.00
Porites furcata (PF) - coral	0	0.00
Porites porites (PP) - coral	0	0.00
Scolymia cubensis (SC) - coral	0	0.00
Scolymia lacera (SL) - coral	9	0.34
Siderastrea radians (SR) - coral	0	0.00
Siderastrea siderea (SS) - coral	0	0.00
Solenastrea bournoni (SB) - coral	0	0.00
Solenastrea hyades (SH) - coral	5	0.27
Stephanocoenia michelinii (SM) - coral	0	0.00
Tubastraea aurea (TA) - coral	0	0.00
Millepora alcicornis (MILA) - coral	0	0.00
Millepora complanata (MILC) - coral	0	0.00
Millepora squarrosa (MILS) - coral	38	0.00

		H'=
# corals of **known** species	0	-15.37
check of # corals of **known** species	535	
total number of coral points	-15	
(includes un-identifiable species)		
percent of coral species un-identifiable	3579.95	

Including MACX in MA Category		H'=
# corals of known species	535	-15.37
total number of coral points	-15	
percent of coral points identified to spp.	-3479.95	

Table 4. Structure of NOAA's classification scheme

- Zone
- Habitat
  - Third level (structural description)
    - Fourth level (level of cover)

***Zones:**

Land, Shoreline Intertidal, Lagoon, Back Reef, Reef Crest, Fore Reef, Bank/ Shelf, Bank/ Shelf Escarpment, Unknown

Habitats:

- Unconsolidate Sediments
  - Sand
  - Mud
- Submerged Vegetation
  - Seagrass
    - Continuous
    - Patchy (4 subcategories)
  - Macroalgae
    - Continuous
    - Patchy (2 subcategories)
- Coral Reef and Hardbottom
  - Coral Reef and Colonized Hardbottom
    - Linear Reef
    - Spur and Groove
    - Individual Patch Reef
    - Aggregated Patch Reefs
    - Scattered coral/Rock in Unconsolidated Sediment
    - Colonized Pavement
    - Colonized Bedrock
    - Colonized Pavement with Sand Channels
  - Uncolonized Hardbottom
    - Reef Rubble
    - Uncolonized Pavement
    - Uncolonized Bedrock
    - Uncolonized Pavement with Sand Channels
- Other
  - Land
  - Mangroves
  - Artificial
  - Unknown

* Redrawn from Kendall (2001).

Table 5. Habitat classification scheme as presented in Prada Triana (2003).

Meta-community	Community	Sub-community	Habitat types	Habitat Codes
Coral and gorgonians on consolidated sediments	corals	coral high relief	Continuous Corals	COCO
		coral patch	Coral Patch	COPA
		coral low relief	Coral Limestone	COLI
		gorgonian patch	Gorgonian Patch	GOPA
	gorgonians	plains	Gorgonian Plains	GOPL
		elevated plains	Elevated Gorgonians	ELGO
Submerged Aquatic Vegetation (SAV) on unconsolidated sediments	seagrass	Seagrass	Dense Grass	DEGR
			Sparse Grass	SPGR
			Grass-Invertebrates	GRIN
			Grass Halo & Coral Patch	HALO
	macro-algae	algae on sand	Dense Algae	DEAL
			Sparse Algae	SPAL
			Algae & Invertebrates	ALIN
		algae on silt	Shallow Algae	SHAL
			Deep Algae	DEEP
Bare or mixed invertebrates on unconsolidated sediments	sand	coarse sand	Sand Invertebrates	SAIN
			Sand no Ripple	SANR
			Sand Ripple	SARI
		fine sand	Fine Sand	FIMU
	silt	mud	Mud-Invertebrates	MUIN
			Mud Bare	MUBA
			Mud Reef	MURE

Table 6. Habitat classification scheme used in this project. Italics indicate categories that are discernable at small scales but were not classified in this project. The bold text descriptions that are included in the reef and hardbottom layer only.

Zone	Broad Habitat	Habitat	Category	Desc_1	Form
Bank Shelf	Unconlsolidated Sediment	Sand			
Midshelf Ridge		Coral Rubble			
Shelf Platform	Submerged Vegetation	Seagrass	*Dense*		
Shelf Edge			*Sparse*		
		Rhodoliths/ Macroalgae	*Rhodoliths with Macroalgae*		
			Rhodoliths no Macroalgae		
			Rhodoliths with Sand Channels		
			Macroalgae no Rhodoliths		
	Reef and Hardbottom	Coral Reef	Spur and Groove		**Shallow coral** **Plating coral**
			Patch Reef	Aggregate	**Shallow coral** **Plating coral**
				Individual	**Shallow coral** **Plating coral**
			Linear Reef		**Shallow coral** **Plating coral**
			Bank Reef		**Shallow coral** **Plating coral**
		Colonized Hardbottom	Colonized Bedrock Colonized Pavement		
		Scattered coral/ rock		**Gorgonian Patch** **With Rhodoliths** **With Coral Heads**	
	Artificial	Boat Debris			

Table 7. List of polygons that were either adjusted or drawn using the multibeam data (NCCOS 2004, 2005). The columns refer to columns in the attribute table. The column Id refers to the polygon Idand the adj_mbeam identifies what adjustmetn was made.

Id	habitat	category	desc_1	adj_mbeam
8	coral reef	patch reef	individual	drawn
9	coral reef	patch reef	individual	drawn
16	coral reef	patch reef	aggregate	shifted
17	coral reef	patch reef	aggregate	adjusted edge
18	coral reef	patch reef	aggregate	adjusted edge
19	coral reef	patch reef	aggregate	adjusted edge
20	coral reef	patch reef	aggregate	adjusted edge
21	coral reef	patch reef	aggregate	shifted
24	coral reef	patch reef	aggregate	drawn
25	coral reef	patch reef	aggregate	shifted
26	coral reef	patch reef	aggregate	shifted
27	coral reef	patch reef	aggregate	shifted
28	coral reef	patch reef	aggregate	shifted
29	coral reef	patch reef	aggregate	drawn
30	coral reef	patch reef	aggregate	adjusted edge
31	coral reef	patch reef	aggregate	adjusted edge
32	coral reef	patch reef	aggregate	adjusted edge
33	coral reef	patch reef	aggregate	drawn
34	coral reef	patch reef	aggregate	drawn
35	coral reef	patch reef	aggregate	drawn
36	coral reef	patch reef	aggregate	drawn
37	coral reef	patch reef	aggregate	drawn
38	coral reef	patch reef	aggregate	drawn
39	coral reef	patch reef	aggregate	drawn
40	coral reef	patch reef	aggregate	drawn
42	coral reef	patch reef	individual	drawn
43	coral reef	patch reef	aggregate	shifted
44	coral reef	patch reef	aggregate	shifted
45	coral reef	patch reef	aggregate	shifted
46	coral reef	patch reef	aggregate	shifted
47	colonized hardbottom	colonized pavement		shifted
48	colonized hardbottom	colonized pavement		drawn
49	coral reef	patch reef	aggregate	shifted
50	coral reef	patch reef	aggregate	shifted
51	colonized hardbottom	colonized pavement		shifted
57	colonized hardbottom	colonized pavement		shifted
58	colonized hardbottom	colonized pavement		shifted
59	colonized hardbottom	colonized pavement		shifted
60	coral reef	patch reef	aggregate	shifted
61	coral reef	patch reef	aggregate	adjusted edge
64	coral reef	patch reef	aggregate	shifted
65	coral reef	patch reef	aggregate	drawn
66	coral reef	patch reef	aggregate	shifted
67	coral reef	patch reef	aggregate	shifted
68	coral reef	patch reef	aggregate	shifted
71	coral reef	patch reef	aggregate	shifted

Table 7 cont'd. List of polygons that were either adjusted or drawn using the multibeam data (NCCOS 2004, 2005). The columns refer to columns in the attribute table. The column Id refers to the polygon Idand the adj_mbeam identifies what adjustmetn was made.

Id	habitat	category	desc_1	adj_mbeam
72	coral reef	patch reef	aggregate	shifted
76	coral reef	patch reef	aggregate	shifted
89	colonized hardbottom	colonized pavement		shifted
101	coral reef	patch reef	aggregate	shifted
104	colonized hardbottom	colonized pavement		shifted
111	coral reef	patch reef	aggregate	shifted
112	coral reef	patch reef	aggregate	shifted
113	coral reef	patch reef	aggregate	shifted
114	coral reef	patch reef	aggregate	shifted
116	coral reef	patch reef	aggregate	shifted
117	coral reef	patch reef	aggregate	shifted
118	coral reef	patch reef	aggregate	shifted
166	coral reef	patch reef	aggregate	shifted
167	coral reef	patch reef	aggregate	shifted
170	coral reef	patch reef	aggregate	shifted
175	coral reef	patch reef	aggregate	shifted
176	coral reef	patch reef	aggregate	shifted
177	coral reef	patch reef	aggregate	shifted
178	coral reef	patch reef	aggregate	shifted
181	coral reef	patch reef	aggregate	shifted
182	coral reef	patch reef	aggregate	shifted
183	colonized hardbottom	colonized pavement		shifted
185	coral reef	patch reef	aggregate	shifted
186	coral reef	patch reef	aggregate	shifted
187	colonized hardbottom	colonized pavement		shifted
188	coral reef	patch reef	aggregate	shifted
199	colonized hardbottom	colonized pavement		shifted

Table 8. Total area for each habitat at the different hierarchical levels of the broad habitat layer.

Broad Habitat	Area km^2	Percent of area	Habitat	Area km^2	Percent of area	Category	Area km^2	Percent of area
unconsolidated sediment	0.32	0.6%	sand	0.32	0.6%	sand	0.32	0.6%
submerged vegetation	40.55	77.1%	seagrass	0.28	0.5%	seagrass	0.28	0.5%
reef and hardbottom	11.75	22.3%	rhodoliths/ macroalgae	40.27	76.5%	rhodoliths/ macroalgae	40.27	76.5%
			colonized hardbottom	1.58	3.0%	spur and groove	0.15	0.3%
			coral reef	8.31	15.8%	patch reef	1.00	1.9%
			scattered coral/ rock	1.86	3.5%	linear reef	0.03	0.1%
						bank reef	7.14	13.6%
						colonized bedrock	0.01	0.0%
						colonized pavement	1.57	3.0%
						scattered coral/ rock	1.86	3.5%

The category for artificial structures was removed because they constitute such a small area.

Table 9. Total area and percent contribution of each habitat in the reef and hardbottom layer.

Habitat	Area km^2	Percent of area
spur and groove	0.15	1.49%
patch reef	0.27	2.75%
linear reef	0.02	0.25%
bank reef	5.49	55.95%
colonized bedrock	0.01	0.13%
colonized pavement	1.41	14.37%
scattered coral/ rock	2.47	25.10%

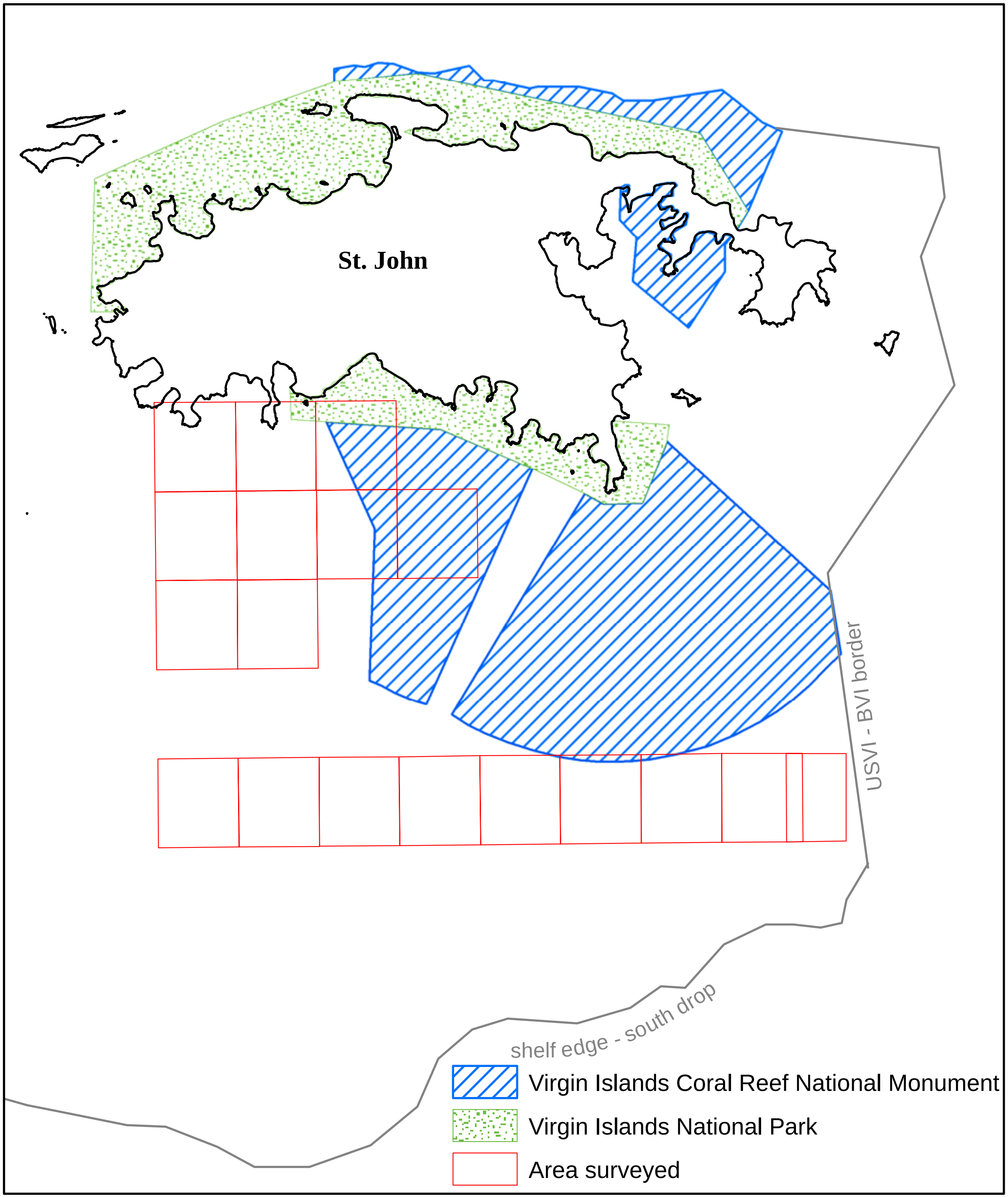


Figure 1. Map of St. John depicting approximate boundaries of the Virgin Islands National Park, Virgin Islands Coral Reef National Monument, and area surveyed with side scan sonar

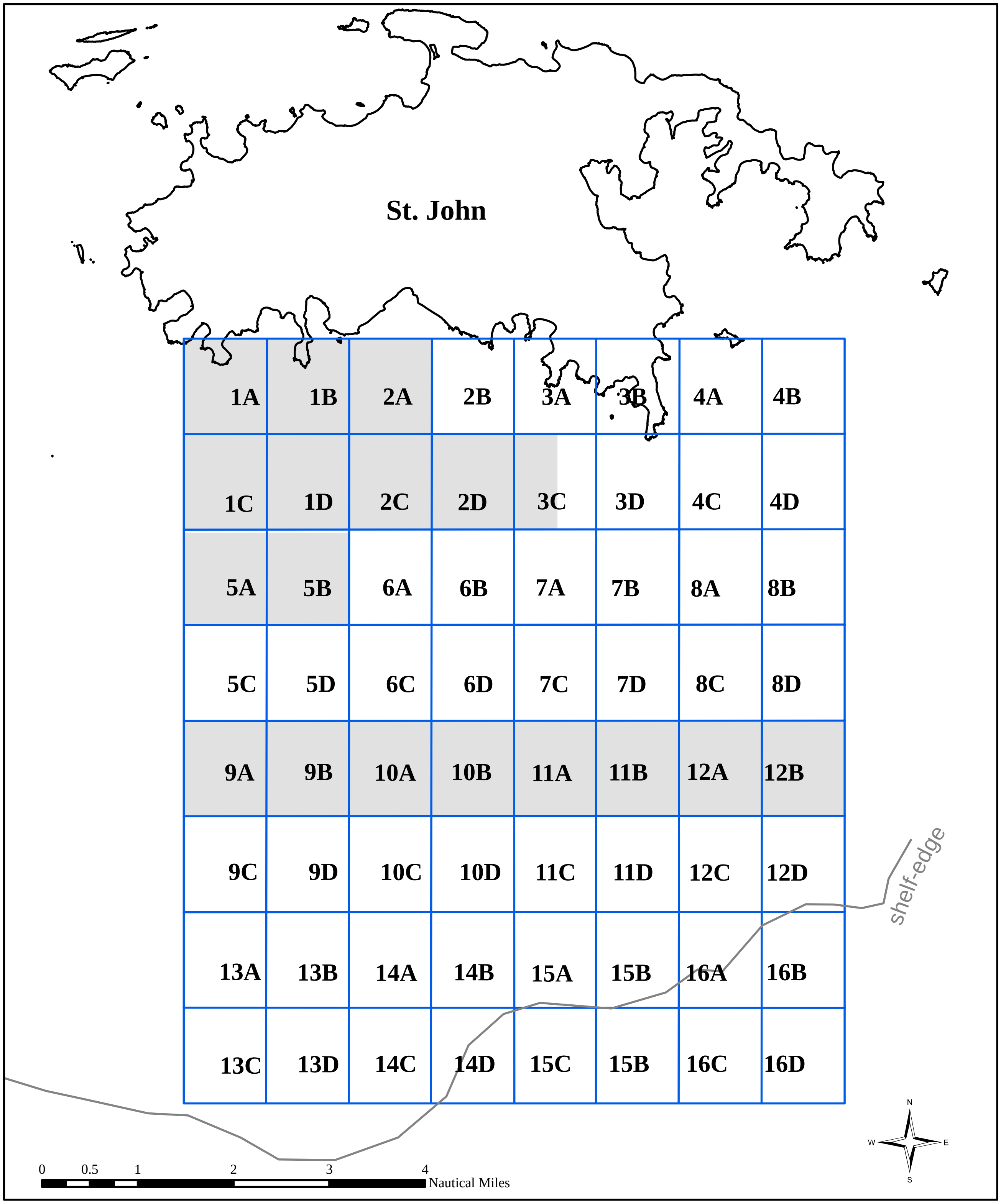


Figure 2. Side scan sonar survey area with survey grids. Shaded grids indicate survey areas that were completed in this project.

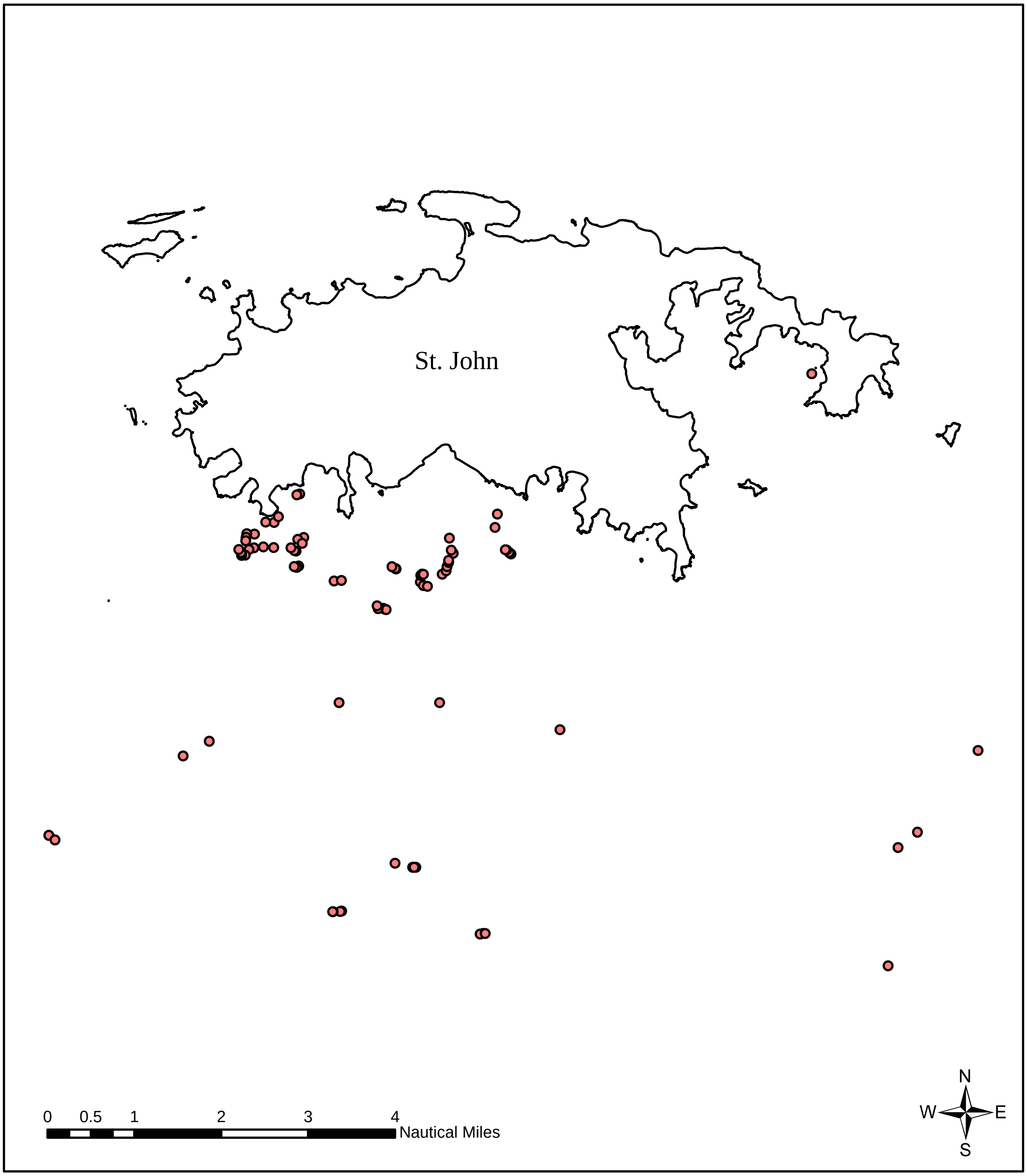


Figure 3. Ground truthing locations

Scale 1:1000

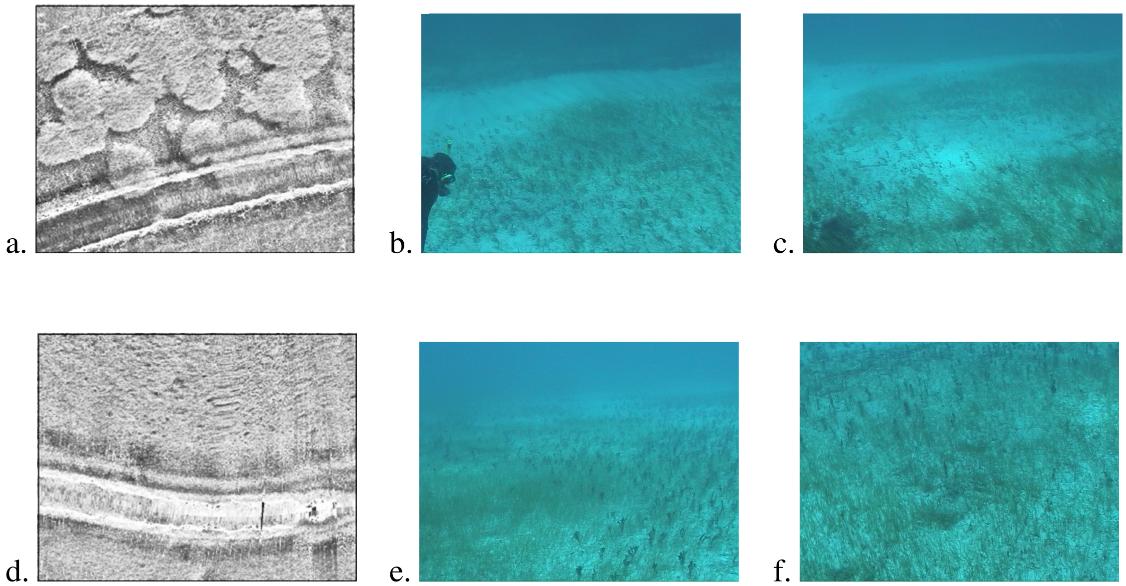


Figure 4. Ground truthing of seagrass habitats (a) side scan sonar image of dense seagrass patches, (b-c) notice the dense patches in the background, sparse patches in the foreground, and sand channels, (d) side scan sonar image of continuous seagrass *Syringodium* sp., and (e-f) sparse seagrass.

Scale 1:1000

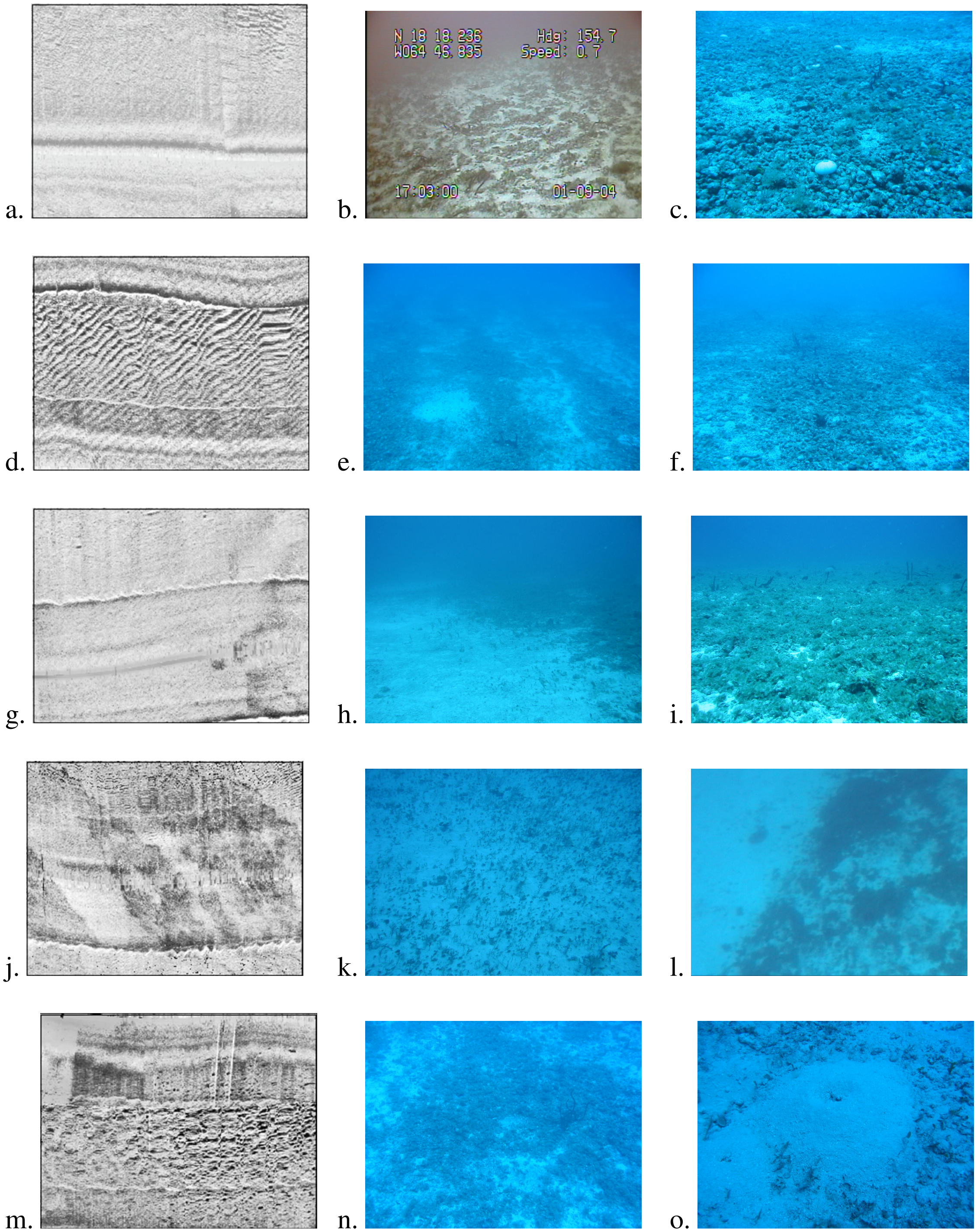
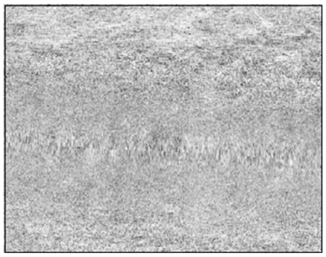
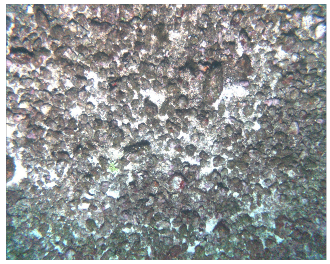
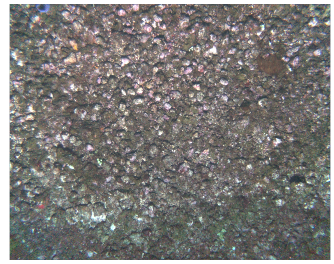
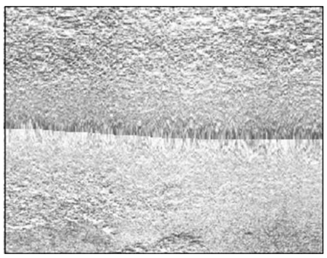


Figure 5. Ground truthing of rhodoliths/ macroalgae habitats on the insular shelf platform, (a-c) rhodoliths with little to no fleshy macroalgae, (d-f) swells and wave action forms ripples in the rhodoliths even at depths greater than 33m, (g-l) rhodoliths with fleshy macroalgae, usually *Lobophora* sp., produce bands of light and dark in the side scan sonar return, with the dark bands usually being rhodoliths with *Lobophora* sp. and the lighter areas usually contain sparse macroalgae, (m-o) the appearance of 'holes' in the side scan sonar record are indicative of areas with a dense population of infauna.

Scale 1:1000

a. 
b. 
c. 

d. 
e. 

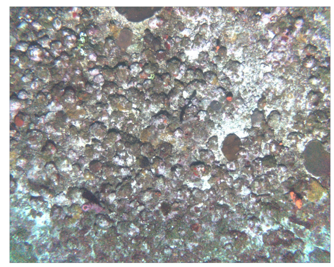
f. 

Figure 6. Rhodoliths communities along the outer shelf platform in deeper water 30-50m, (a) produce a smoother texture in the side scan sonar return and (b-c) have limited to no fleshy macroalgae. A rougher texture in the sonar return (d-f) is indicative of areas of dense rhodoliths with some small scattered stony corals. It appears that these communities rarely 'turn over' as most rhodoliths communities therefore allowing encrusting and low canopy corals to recruit to them.

Scale 1:1000

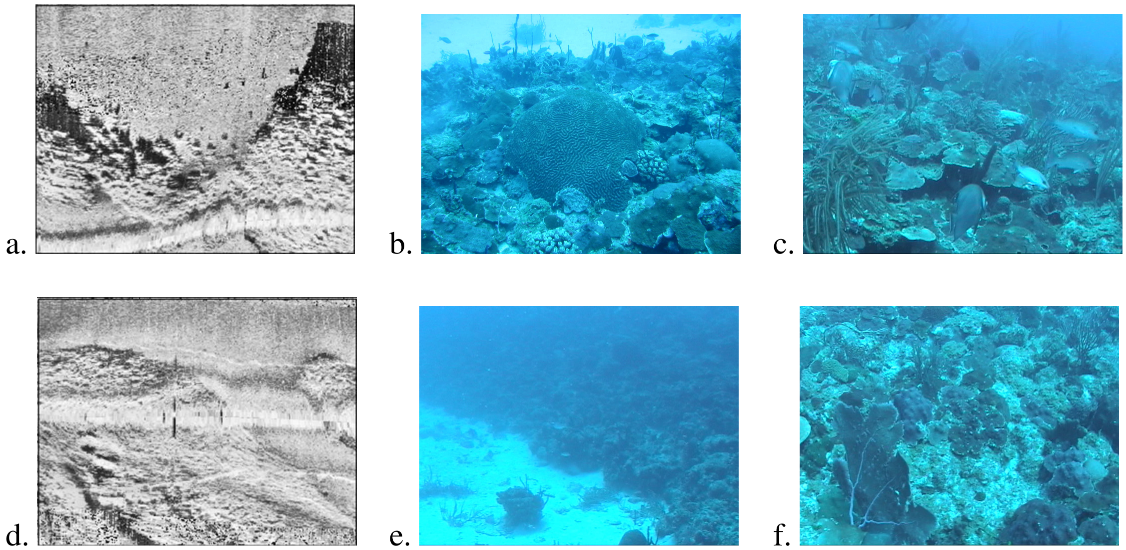


Figure 7. Patch reefs generally have distinct boundaries and rise steeply from the surrounding habitat (a, b, d, e), and often have scattered coral/ rock visible in the sonar return (a). Patch reefs also have varying degrees of stony corals and gorgonians (b, c, e, f). The above images contain examples of shallow water growth forms.

Scale 1:1000

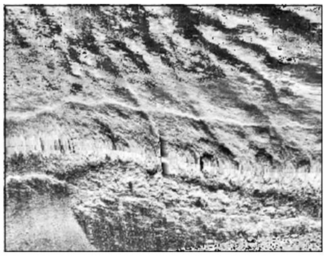
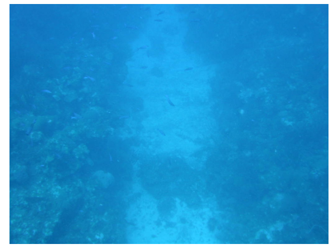
a.  b.  c. 

Figure 8. Spur and groove habitats yield distinct banding in the sonar return (a), and have deep groove features (b, c) that orient perpendicular to the shoreline of prevailing currents.

Scale 1:1000

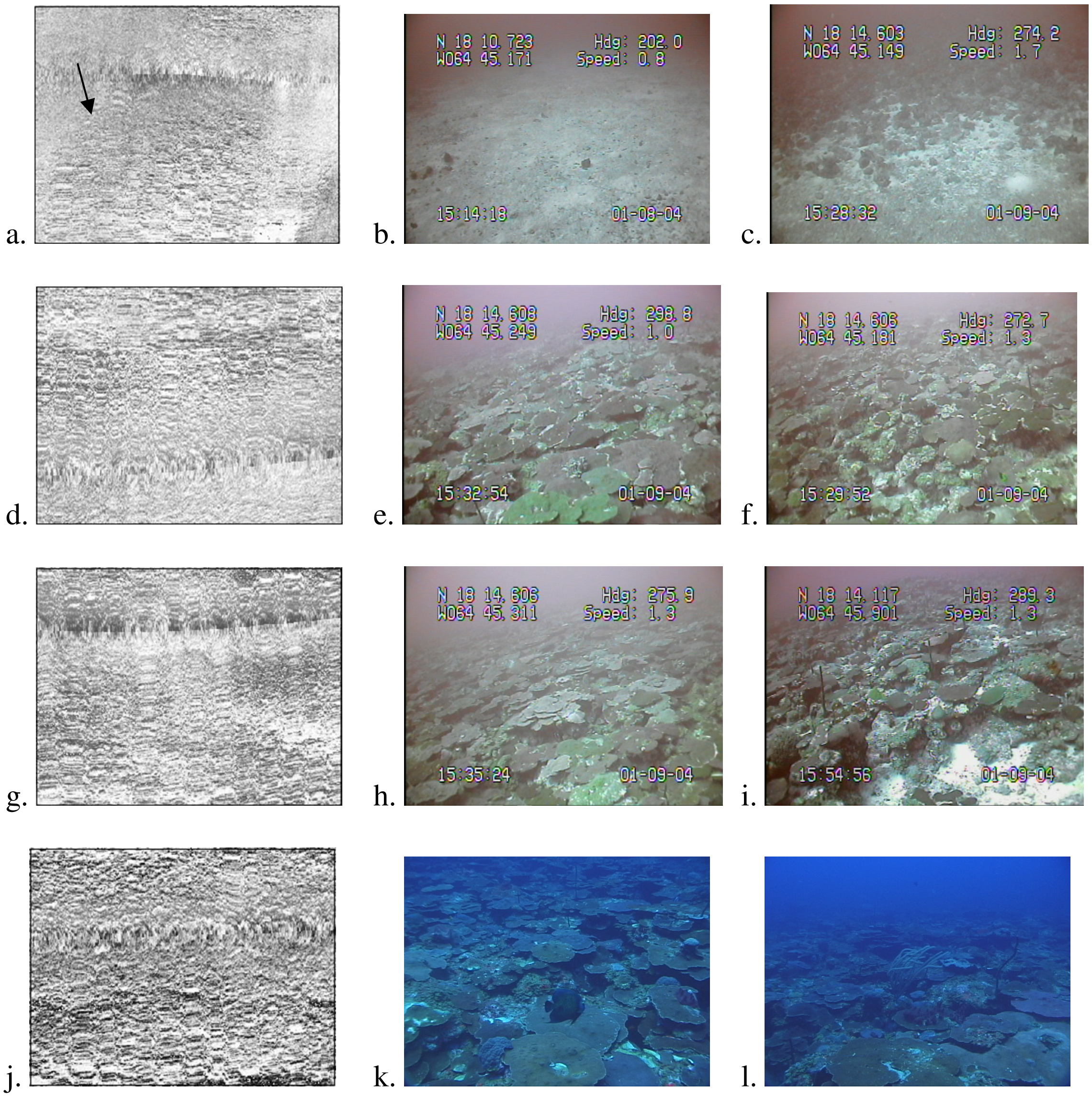


Figure 9. Coral reefs on the outer shelf platform, south of the mid-shelf reef system, (a-i) and along the shelf edge (j-l) are predominately comprised of plating forms of *Agaricia* spp. and *Montastraea* spp. On these deeper reefs the transition from sand or rhodoliths to coral reef (a-c) is often difficult to discern as no discrete boundary exists. However, the arrow in (a) probably indicates the sand to coral interface.

Scale 1:1000

a. b. c.

Figure 10. Colonized bedrock appears as large features (a), and is comprised of boulders or shoreline features and can be covered with corals, gorgonians, macroalgae, and/ or sponges (b, c).

Scale 1:1000

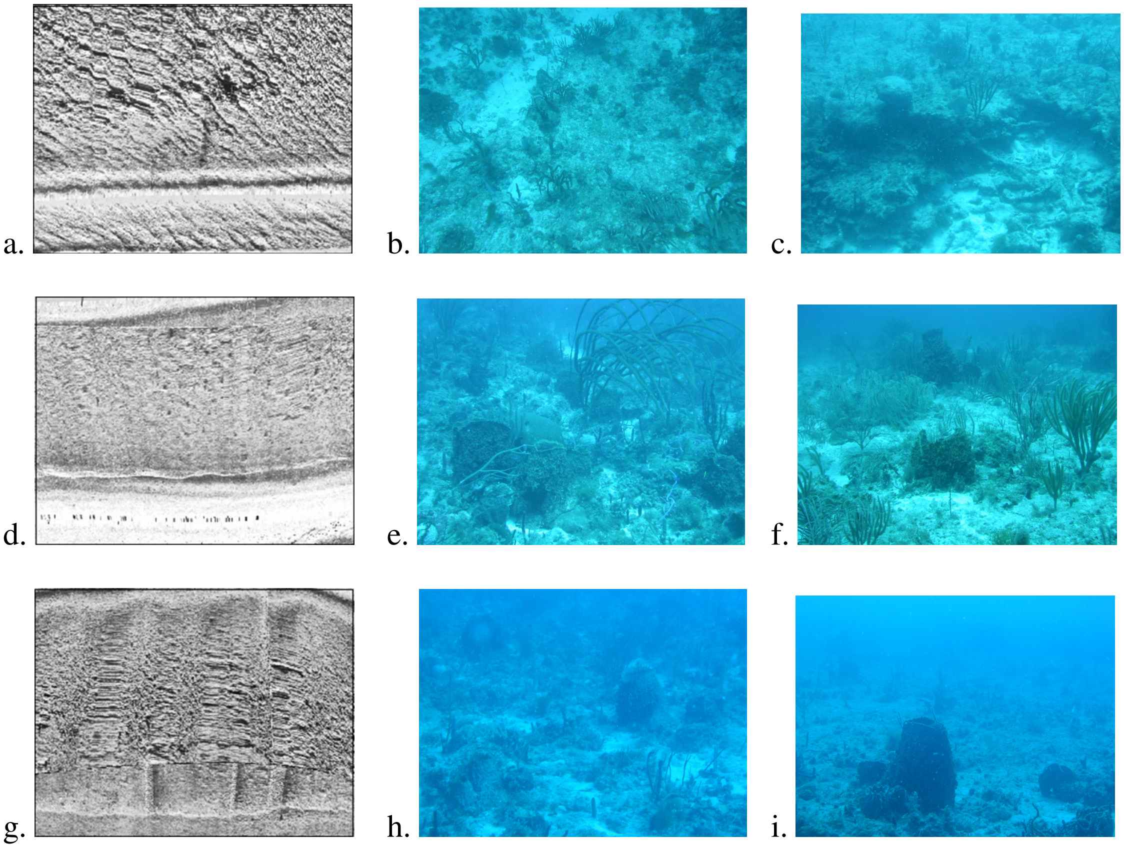


Figure 11. Colonized pavement has numerous side scan sonar returns that appear to correspond to position on the shelf platform, substrate topology, and the overlying invertebrates. Along the bank shelf spur and groove features are apparent (a-c) but have a smoother appearance than coral reef spur and groove. Across the plateau, also often referred to as gorgonian plains or hardgrounds, the sonar image appears flatter and has a grainy texture (d, g). Along this region a sand veneer covers portions of the limestone substrate which is colonized by large sponges, gorgonians and sparse corals (e, f, h, i).

Scale 1:1000

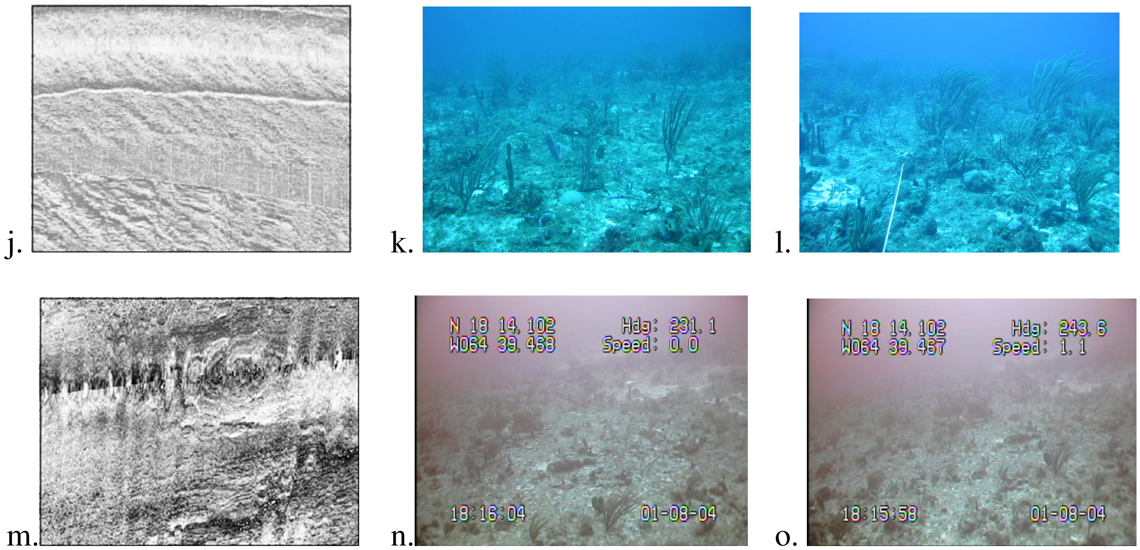


Figure 11 cont'd. Colonized pavement along the mid-shelf ridge appears as linear reef or again as spur and groove (j-l). Further out along the shelf edge the sonar return appears flatter with eroded edges. Here it is difficult to discriminate between colonized pavement habitats and rhodoliths habitats (m). On the colonized pavement gorgonians are often sparse (n, o).

Scale 1:1000

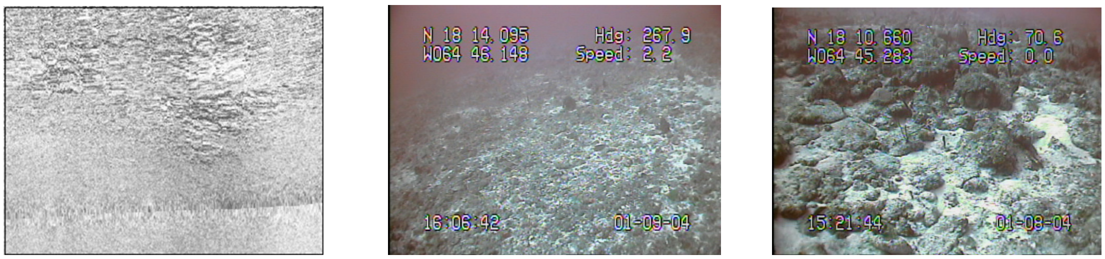
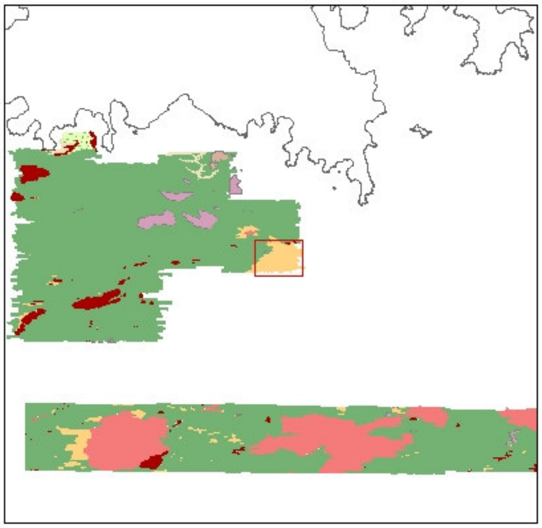


Figure 12. An additional habitat along the outer shelf platform is similar to both colonized pavement and scattered rock (a-c). This habitat consists of limestone substrate that appears to be dead coral and has some gorgonian growth with little stony coral growth. This habitat has been classified in this project as scattered coral/ rock.

a. 

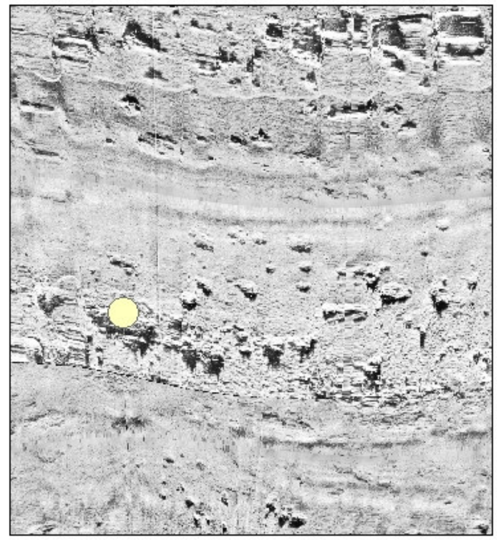
b. 

Figure 13. Example of (a) scattered coral/ rock (red square) in which the final polygon was drawn around the entire habitat but (b) individual features within that habitat could be larger than the MMU of $50m^2$ (yellow circle).

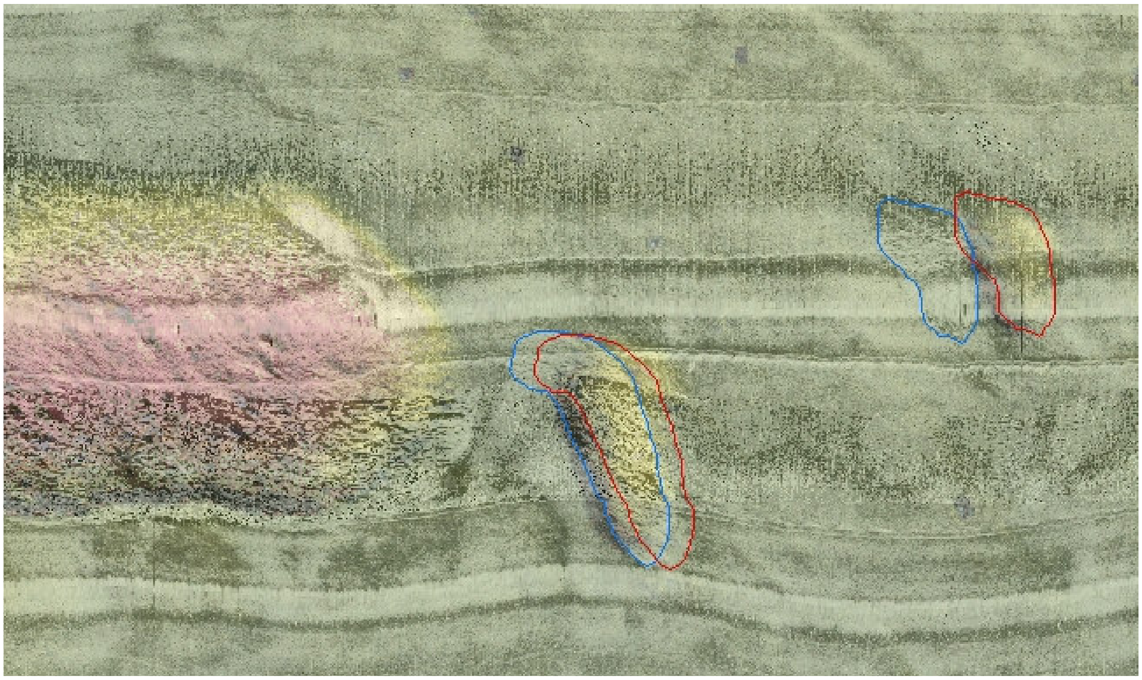


Figure 14. Polygons were created using the side scan sonar images (blue line) and then shifted to match the positioning of the multibeam (red line). The multibeam is clearly visible, as the colored features, through the side scan sonar imagery, grey shading.

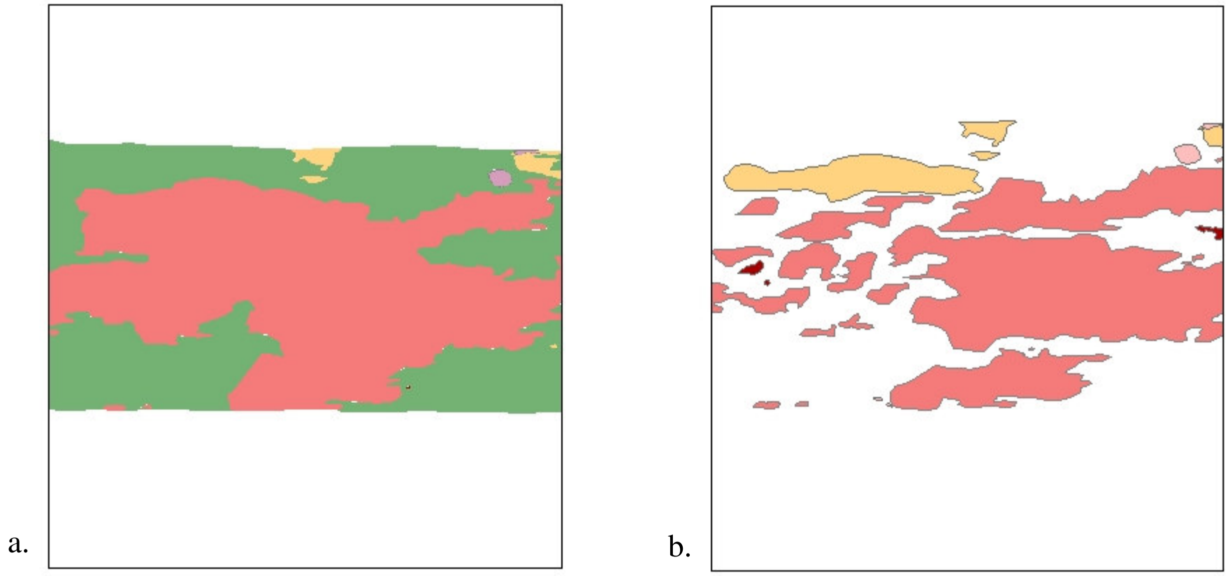


Figure 15. Differences between the bank reef in stj11a and stj11b at (a) the broad habitat scale and (b) the smaller scale of the reef and hardbottom layer. Notice that in some cases the habitat of certain polygons in the smaller scale layer changed from that of the broader scale layer. The large yellow polygon in (b) is classified as scattered coral/ rock in the smaller scale layer and (a) is included in the bank reef in the larger scale layer.

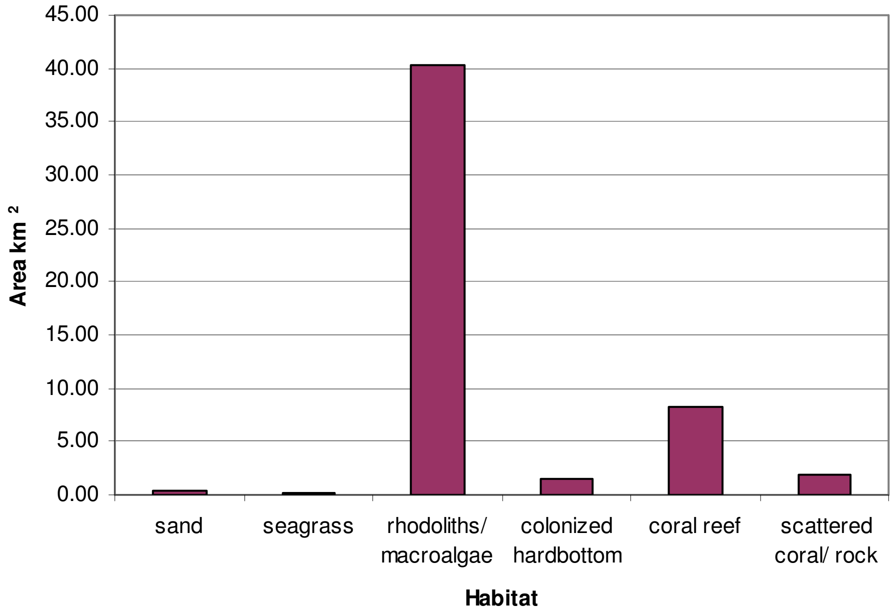


Figure 16. Total area (km^2) of each habitat in the broad habitat layer. The artificial reef category has been omitted as it contributed less than 0.01km^2.

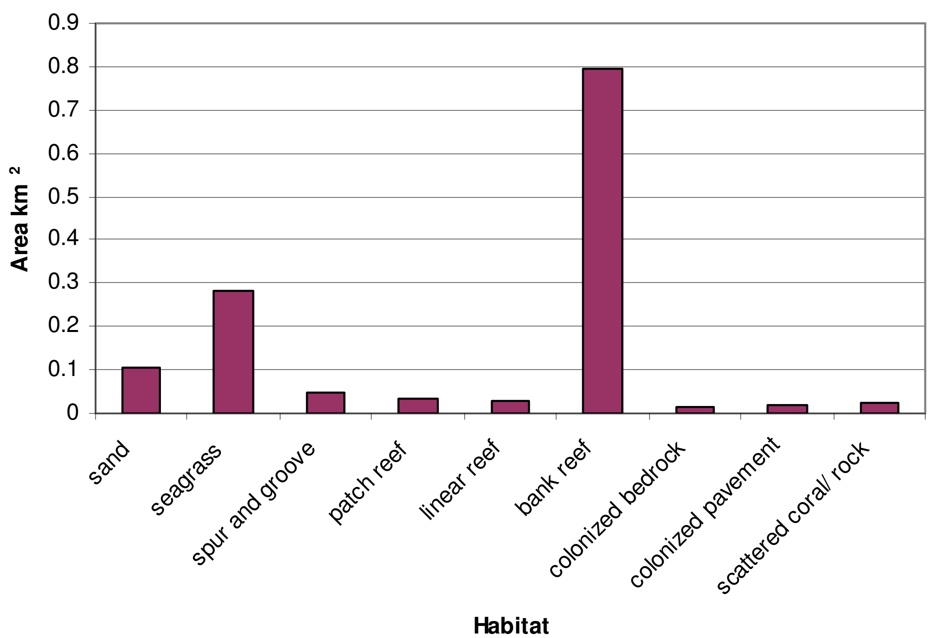


Figure 17. The average area (km^2) of polygons drawn for each habitat type in the broad habitat layer. Again artificial reefs have been removed.

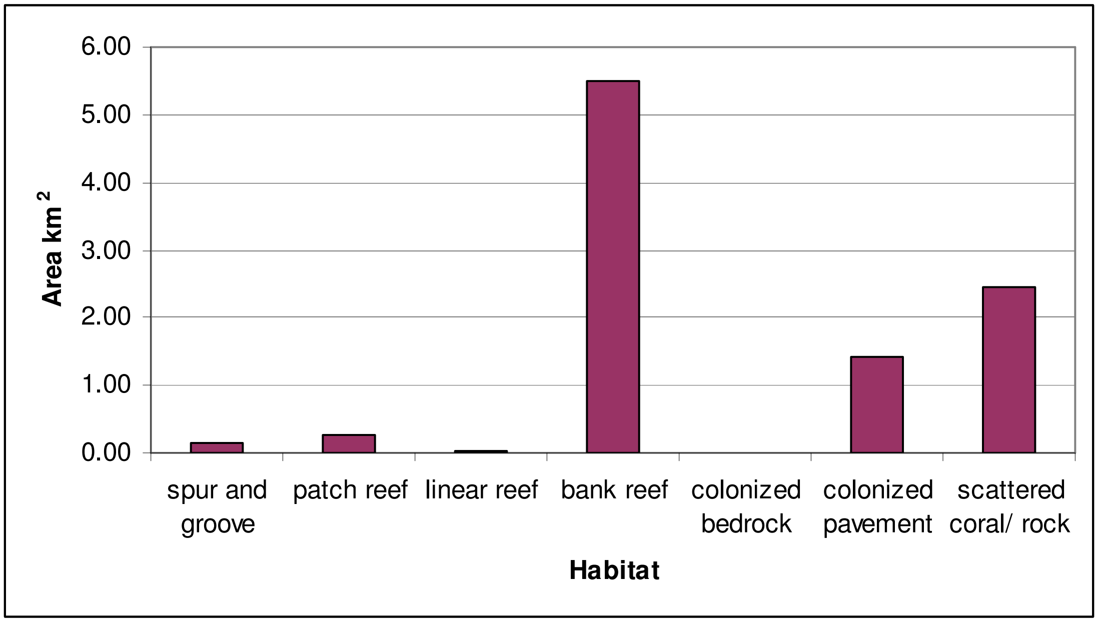


Figure 18. The total area (km^2) of each habitat in the reef and hardbottom layer.

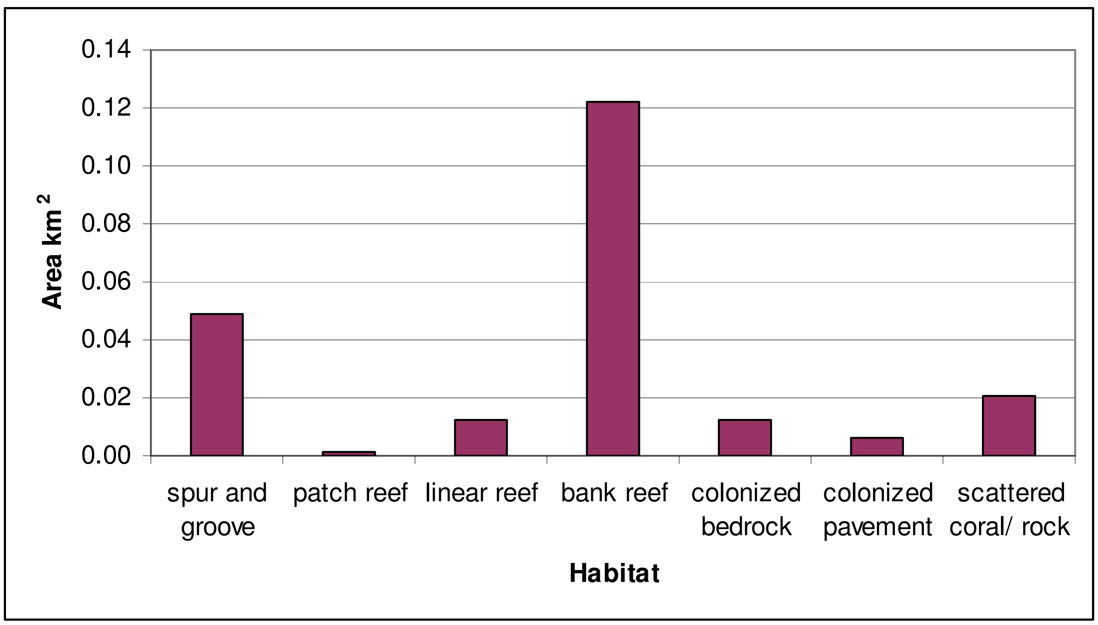


Figure 19. The average area (km^2) of polygons drawn for each habitat in the reef and hardbottom layer.

Procedures for side scan sonar acquisition

Equipment Setup

1. install WAAS GPS and primary depth sounder

2. Place the computer tower "acquisition computer" in the mounts under the Lindsay's cabin

3. place a battery back-ups in the cabin as well and plug it into the power inverter

4. plug the acquisition computer tower into the UPS

5. set the navigation laptop in the platform above the steering for the Lindsay

  a. Install the hardlock key into the printer port on the back of the laptop (**Note: the navigation software will not run without this adapter**)
  b. connect the power cord to the UPS
  c. connect one end of the split NMEA connection (serial cord labeled "NMEA connection") to the laptop and one end to the wires hanging down from the GPS unit
  d. the other end of the NMEA connection goes into *serial port 1* on the data acquisition computer, this end is labeled "to tower"

6. mount the flat screen monitor in the ball and joint mount by the passenger seat on the port side of the cockpit. The flat screen is powered by 12volts and connects to the 2pin connector in front of the ledge. The monitor cable runs down to the data acquisition computer.

7. *Data acquisition computer* – connect the monitor, connect the mouse, connect the keyboard (Note: there is a new wireless keyboard and mouse in the SSS office for the new tower) make sure the NMEA connector is connected as described above, connect the small black wire that runs alongside the power inverter to the grounding bolt in the back of the tower.

8. Connect the deck cable into the pigtail that runs out of the base of the tower

9. connect the wet end of the towcable to the towfish (it is advised to spray a little WD40 on and into the towfish connector) also be sure to connect the braided harness on the cable to the stainless steel safety wire. Run the cable throught the sheave block assembly.

10. Power on the inverter and UPS and all computers

Navigation Laptop

1. start HypackMax

2. click on survey and select *survey* a new screen starts with several windows open

3. to test the NMEA connection restore the *nmea* window at the bottom, it should scroll lat and long data

4. go to *line* and select *select file* now navigate to select the file that you want to survey

5. This will display the lines to be surveyed and the boat on the *map* window (if you are not near the survey area the distance may be to great to show both the position of the boat and the survey area – hitting 'ctrl+' or 'ctrl-' will zoom or unzoom

Table 1 cont'd. Ground truthing coordinates and habitat at each point. The columns labeled type and descriptor describe the structure and make-up of each site.

DATE_	X	Y	HABITAT	CATEGORY	TYPE	DESCRIPTOR
3/25/2004	-64.78670	18.30376	colonized hardbottom	colonized pavement	w/ sand veneer	<10%
3/25/2004	-64.78713	18.30433	colonized hardbottom	colonized pavement	w/ sand veneer	10-30% sc
4/2/2004	-64.78413	18.30728	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	
4/2/2004	-64.78560	18.30736	rhodoliths/ macroalgae	rhodoliths+macroalgae	moderate	<10%
4/2/2004	-64.78573	18.30665	colonized hardbottom	colonized pavement	w/ sand veneer	
4/2/2004	-64.78580	18.30601	colonized hardbottom	colonized pavement		<30%
4/2/2004	-64.77466	18.30663	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	50-70%
4/2/2004	-64.77583	18.30628	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	30-50%
4/2/2004	-64.77496	18.30550	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	70%
7/19/2004	-64.79280	18.26760	colonized hardbottom	colonized pavement		70%
7/19/2004	-64.67720	18.33800	coral reef	patch reef		70% live
7/19/2004	-64.76790	18.27500	colonized hardbottom	colonized pavement		70% live
7/20/2004	-64.74860	18.27500	colonized hardbottom	colonized pavement		w/ sand c
7/20/2004	-64.72550	18.26980	coral reef	linear reef		70% live
7/21/2004	-64.79780	18.26480	colonized hardbottom	colonized pavement		50% live
7/21/2004	-64.82357	18.24958	coral reef	spur and groove		50% live
7/21/2004	-64.82240	18.24870	coral reef	spur and groove		w/ sand c
8/18/2004	-64.77564	18.30117	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	w/ sand c
8/18/2004	-64.77602	18.30093	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	50%
8/18/2004	-64.77650	18.30106	rhodoliths/ macroalgae	rhodoliths+macroalgae	dense	<30% sponges
8/18/2004	-64.77616	18.30402	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	<30% sponges
8/18/2004	-64.77648	18.30413	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	<30% sponges
8/18/2004	-64.77712	18.30466	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	<30% sponges
8/18/2004	-64.75716	18.24423	coral reef	linear reef	deep water	
2/24/2005	-64.75228	18.29810	rhodoliths/ macroalgae	macroalgae	sparse	30-50% ma
2/24/2005	-64.75170	18.29743	sand	sand		<10%
2/24/2005	-64.75093	18.29728	scattered coral/ rock	scattered coral/ rock		10-30% sc

Table 1 cont'd. Ground truthing coordinates and habitat at each point. The columns labeled type and descriptor describe the structure and make-up of each site.

DATE_	X	Y	HABITAT	CATEGORY	TYPE	DESCRIPTOR
2/24/2005	-64.73491	18.30348	coral reef	patch reef	aggregate	
2/24/2005	-64.73527	18.30375	sand	sparse ma		<10%
2/24/2005	-64.73575	18.30422	coral reef	patch reef	aggregate	
2/24/2005	-64.73598	18.30428	rhodoliths/ macroalgae	sparse ma		<30%
2/24/2005	-64.73797	18.30857	coral reef	spur groove		50-70%
2/24/2005	-64.75220	18.29938	rhodoliths/ macroalgae	macroalgae		30-50%
2/24/2005	-64.75197	18.29963	coral reef	patch reef	aggregate	70%
2/24/2005	-64.75172	18.29960	coral reef	patch reef	aggregate	70%
3/3/2005	-64.74599	18.30361	coral reef	patch reef	individual	70% live
3/3/2005	-64.74636	18.30421	coral reef	patch reef	individual	70% live
3/3/2005	-64.74672	18.30652	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	w/ sand c
3/3/2005	-64.74809	18.29961	coral reef	patch reef	individual	70% live
3/3/2005	-64.74735	18.30027	coral reef	patch reef	individual	50% live
3/3/2005	-64.74716	18.30106	coral reef	patch reef	individual	50% live
3/3/2005	-64.74687	18.30188	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	w/ sand c
3/3/2005	-64.74686	18.30224	rhodoliths/ macroalgae	rhodoliths+macroalgae	sparse	w/ sand c
3/3/2005	-64.73753	18.31112	coral reef	spur groove		50%
4/12/2005	-64.75946	18.29308	rhodoliths/ macroalgae	macroalgae	patchy	<30%
4/12/2005	-64.75915	18.29295	boat	decomposed boat		
4/12/2005	-64.75896	18.29285	boat	decomposed boat		
4/12/2005	-64.75886	18.29282	colonized hardbotto	colonized pavement		
4/12/2005	-64.76041	18.29299	rhodoliths/ macroalgae	macroalgae	patchy	30-50%
4/12/2005	-64.76061	18.29354	rhodoliths/ macroalgae	macroalgae	patchy	50-70%
4/12/2005	-64.76885	18.29832	rhodoliths/ macroalgae	macroalgae	patchy	>70%
4/12/2005	-64.76746	18.29840	rhodoliths/ macroalgae	macroalgae	patchy	<10%
4/12/2005	-64.75694	18.30062	rhodoliths/ macroalgae	macroalgae	patchy	<30%
4/12/2005	-64.75709	18.30072	rhodoliths/ macroalgae	macroalgae	continuous	
4/12/2005	-64.75775	18.30104	rhodoliths/ macroalgae	macroalgae	continuous	

6. Once at the site and the towfish is launched line-up for the first survey line use the Left Right indicator window to aid steering

7. The data display window will show the line to be surveyed, logging status, and other relevant information.

8. Once you get on the line hit 'ctrl s' to start logging the GPS data – at the end of a line hit 'ctrl e' to end logging, the next line will automatically be the active line.

9. To start a new area go to *line* unload file and the go to select file

Data acquisition computer

1. start up Sea Scan PC

2. 'rub test' the towfish before leaving the dock
   a. click the Power button and then select the 300 kHz towfish
   b. click on Manual SOG (it should turn red) then click the up or down arrows to increase the speed to about 3 knots
   c. go back to the towfish and wet your hands and rub the side of the transducer – an image should appear on both channels. If not check your connections again

3. turn off the power until ready to collect data

4. Once at the site turn on the power and turn off the Manual SOG (should not be red)

5. the boats position should be across the top of the screen

6. lower the towfish to approximately 3-5 meters off the bottom [this is measure using the Len button and dragging the cursor from Nadir (the middle line in the screen) across to the first bottom return]

7. Go to *Options* and open the *Status Boxes* and open *Data storage status* so you can see the filename – leave this open on the side

8. Click the *Gain* button to open the gain adjustment window – use this like a synthesizer on a stereo to adjust the image for each channel. Adjust it to the clearest picture possible and try not to adjust it during data collection if possible **But** make sure you can clearly see objects in the image.

9. As soon as you start a line and the boat driver hits 'ctrl s' on Hypack Max you click on *Auto Save* to start a new file (you will write this filename down in a spreadsheet).

10. At the end of a line hit *Auto Save* again and write down the filename and time in the spreadsheet. Also either winch up the towfish to the same as the water depth or speed up the boat a little to raise the towfish. Do not stop logging during turns unless you cannot see the bottom clearly.

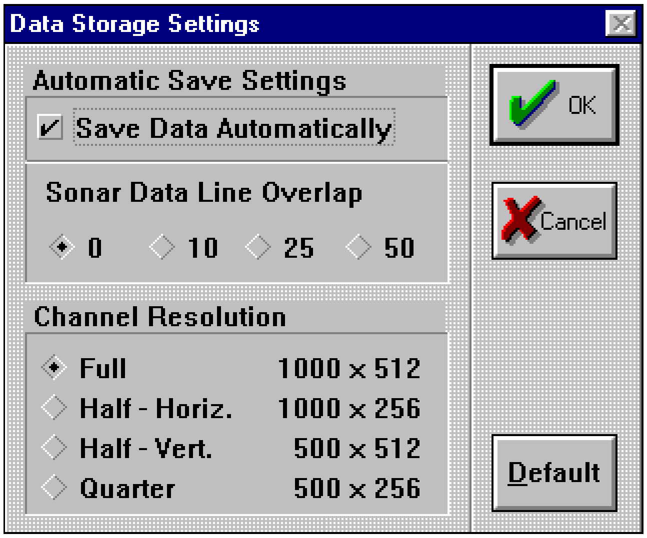
11. at the end of the Day hit the *Power* to turn it off (Red indicates power is on)

12. You must simultaneously enter information into an excel spreadsheet. Have that spreadsheet 'new sss worksheet' open so you can hit 'alt tab' to switch back and forth. (be aware if when you return to sea scan PC it does not show an image just click in the waterfall display it should come back and it does not mess up the data)

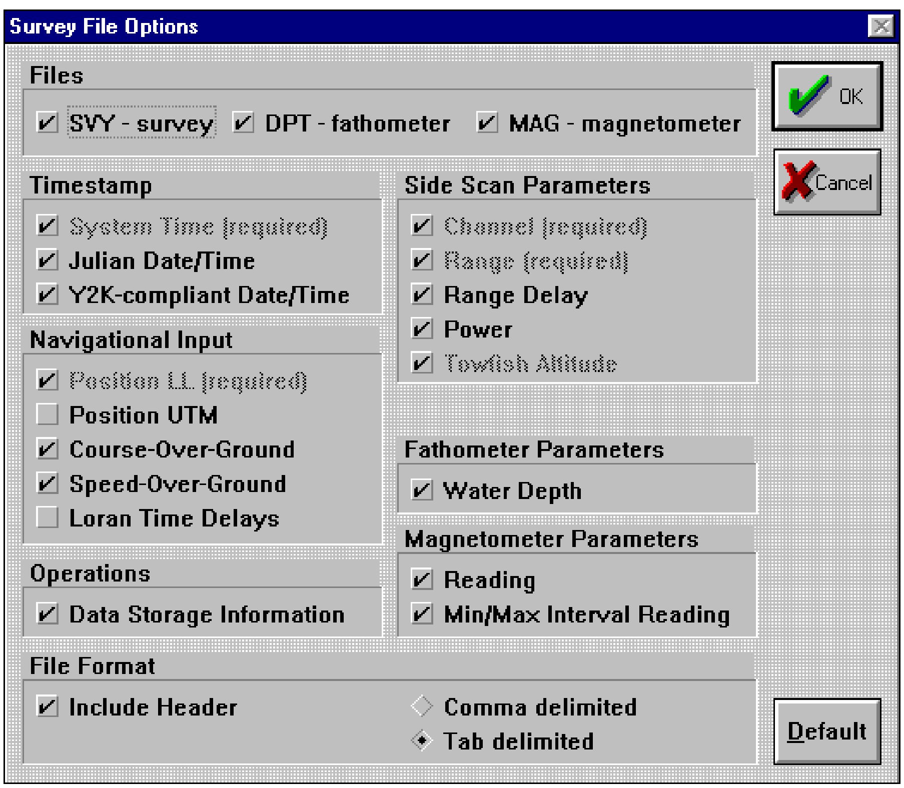
a. Enter the information under the headings, headings in Blue will update automatically **but you have to enter a new direction change and date etc…,**
b. Enter the filename given in the *Data storage status* window at the start of a line, end of line and whenever you winch in or out the cable. Enter the depth, cable out (in meters). In the comments box enter 'sol' for start of a line or 'eol' for the end of line.

Settings for Sea Scan PC data acquisition

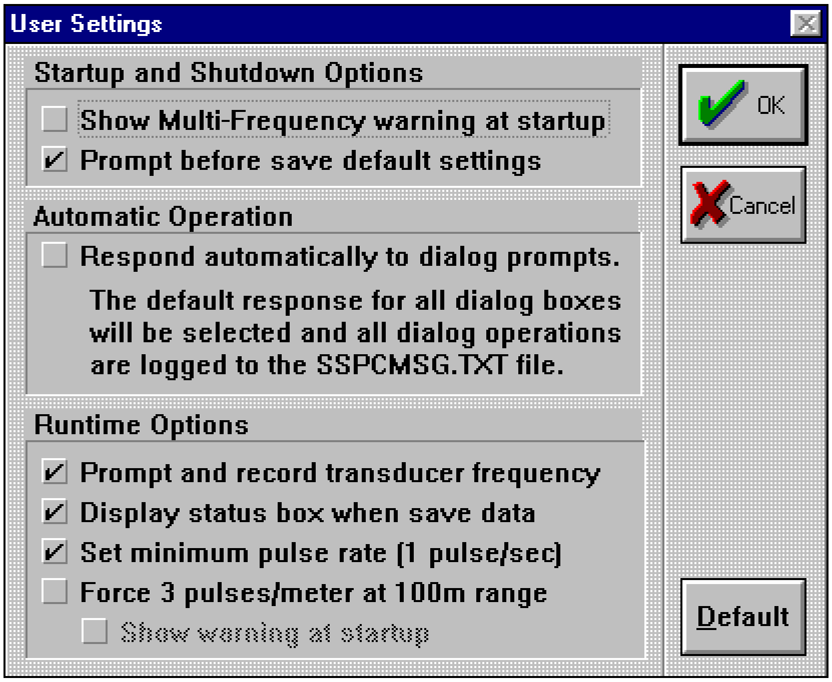
Use these windows to reset the settings for Sea Scan PC after reinstalling the software. These settings are the settings used during data acquisition.



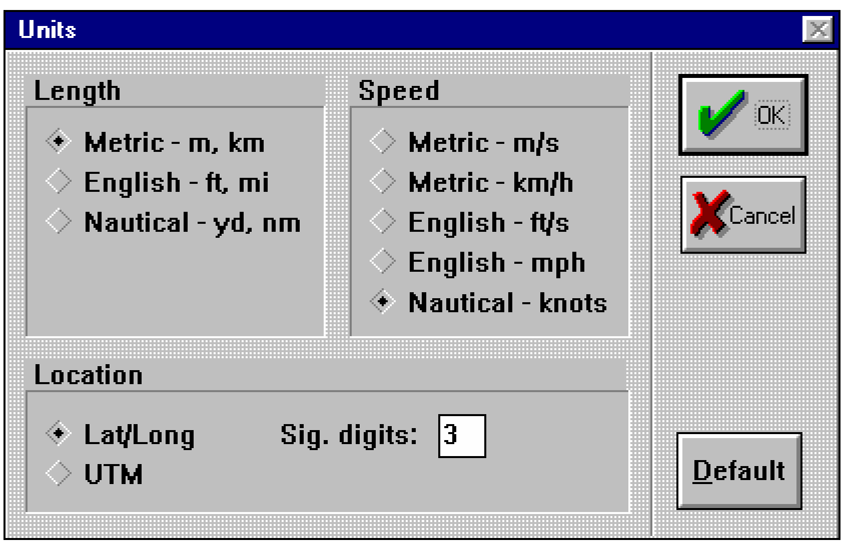
Found under ***Options →Settings→Data Storage Settings***



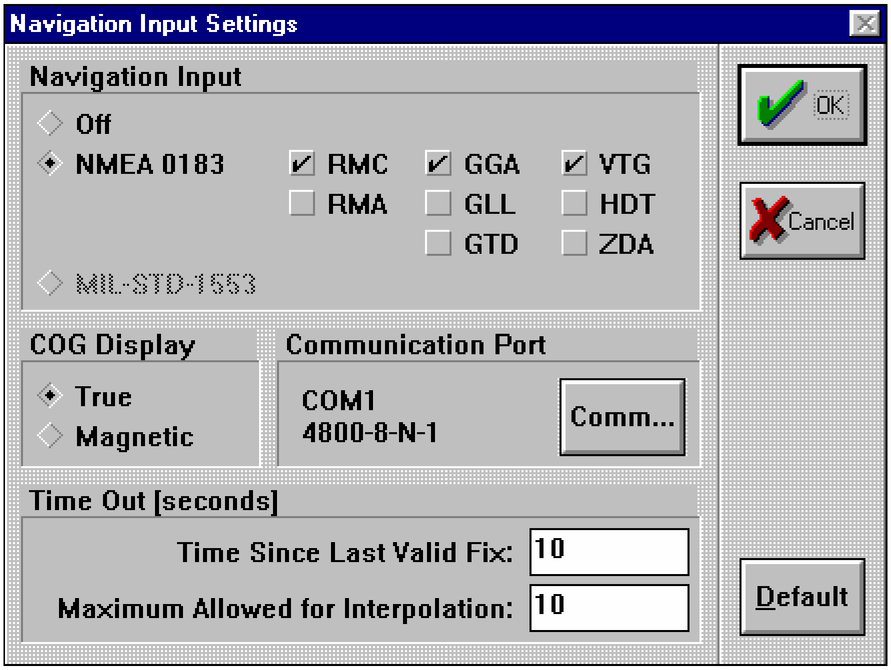
Found under ***Options →Settings→Survey File***



Found under ***Options →Settings→User***



Found under ***Options →Settings→Units***



Under ***external* → *navigation*→ *Settings***

Post Processing Side Scan Sonar Images

Computer = Data acquisition computer (LINDSEY computer)

1. Start up **SeaScan PC Review**
   1.1. Open the file *.mst* for the day the data was collected. **Note**: the files are saved according to the date and month (not year). If more than one session was conducted on the same day (but different years) the computer automatically assigns the next highest filename available (while in collection mode) and both years for that date will be in the same file folder.
      1.1.1. Open the excel spreadsheet for that day and find the files that correspond to those you want to process. Use the spreadsheet to find the files that start a line and end a line or have features/targets of interest.
   1.2. In **SeaScan PC Review** – open the first file for the line you want to process.
      1.2.1. Review the file and if the spreadsheet indicates there are annotations check the **show** button under **Options – Annotations**.
      1.2.2. If the image has residual noise - click the **Filter** button on the left of the display (Figure 1)– then click somewhere in the "waterfall" display (near a feature of interest if needed). This opens the Filter dialog window (Figure 2).
      1.2.3. click the **Record** button and scroll the available filters down to **Spike 1** and select **Spike 1 –** you can only undo the last filter run, if need be cancel the whole filter process and don't save the new image and redo.
      1.2.4. click the **entire image filter** button – **OK**
      1.2.5. close the Image Filter window
      1.2.6. save the new image under **File – Save as**. Save the filtered image into the zip drive or a temp folder for burning to a CD once you start using the newer data acquisition computer with the CDRW
      1.2.7. Play the next file in time and repeat the filter process

Important – try to play all the files and save them in the order they were collected. If you filter them out of sequence Isis Sonar will have trouble processing the navigation and may cause problems in the mosaic process. Filtering images and conducting a "save as" alters the files' date and timestamp.

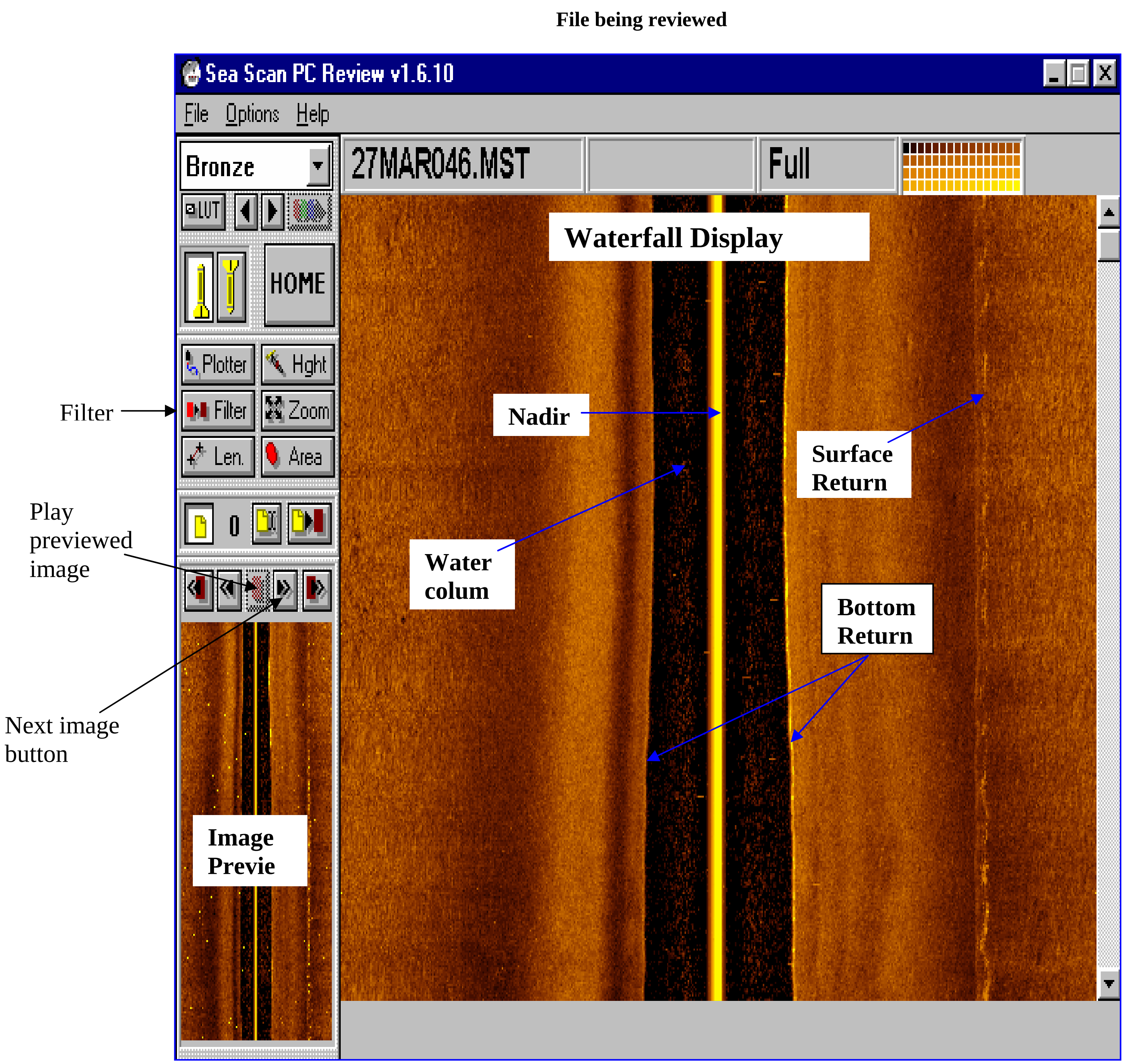
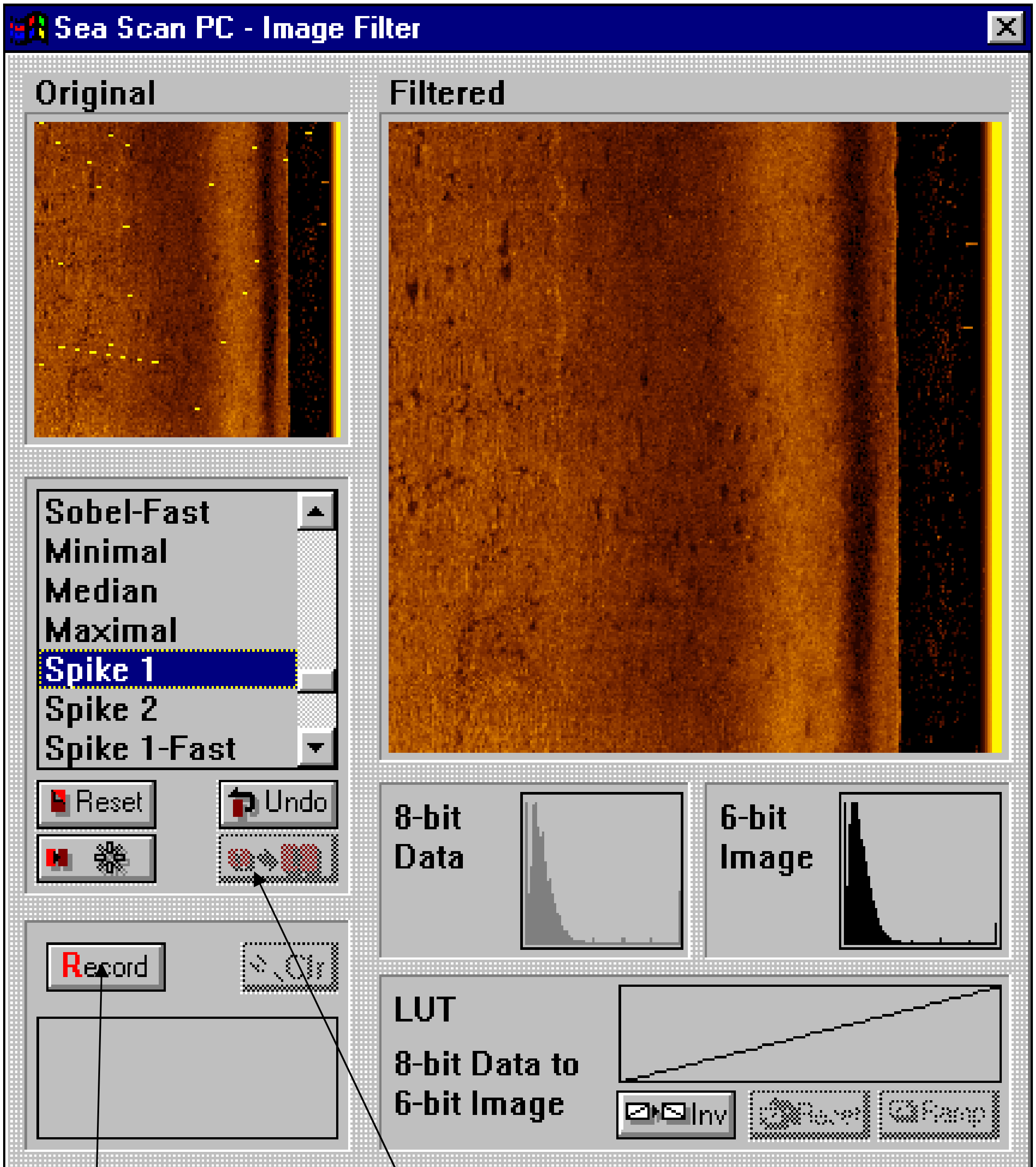


Figure 1: Main Waterfall window.



Click record button before running filter

Entire Image Filter Button

Figure 2: Filter Dialogue Window

Mosaic Procedure Basics

Computer = MOSAIC computer

In Isis Sonar

1. Playback all of the *xtf* files for a line to check them for targets [to make note of] and determine if they are usable images.

2. **Bottom Track** all the files for that survey line before continuing. The files must be accurately bottom tracked in order to get the towfish altitude. The towfish altitude is used to determine layback. **[**Bottom tracking may be done after *snipping* several files together but **must** be done before *fixing time* or generating an *ASCII report*.**]**

   2.1. **To Bottom Track** Playback a file in Isis. In the **Isis Bottom Track** dialogue box be sure **Method** is set to *Amplitude*. A thin red line should run vertically in the *Main Waterfall Window* this is the bottom track line (Figure 1). If this line wanders off or cuts into the bottom adjust the *Level* (a higher % moves the line deeper towards the bottom or cuts into the image, a lower % moves the line towards nadir, away from the bottom). *Holdoff* is the distance the towfish is off the bottom (altitude) make a guess at what this should be (generally we run at an altitude of 3-5m so set the *holdoff* at 2.5m) the track line will not search for the bottom return until beyond the *holdoff* level. [Under **Options** you can put a check in the *Save newly tracked altitude back into the original XTF file* box. This will save the new bottom track (**Note:** if you have problems uncheck the box and then just start over and recheck the box when you get the right adjustments, it will continuously save the new bottom track over previous data). You can save portions of the new bottom track by checking and unchecking the box multiple times in one file.]

   2.1.1. Replay the line and check the bottom track (to do this be sure to uncheck the *Save newly tracked altidude* box and turn *off* the bottom track in the *Bottom track* dialogue box). While you replay the line you can hit the space bar to pause the playback where the bottom track wanders. See Figure 1 for the *slowdown and speedup playback* buttons. If the bottom track wanders click in the main waterfall window where the track leaves the bottom. Then go to **File- Goto-Ping-OK** (this will take the file back to the last point you clicked in the waterfall window when you replay the line). Adjust the *Level* and *Holdoff* again and replay the segment (by hitting the space bar again), pause it again and keep going back to the *Ping* until you get it at the right level. Then let the line play through being sure to save the new bottom track segment by placing a check in the *Save newly tracked altitude* box.

3. **Snipping files:** If depth or the amount of cable out changes during a survey line you must process only those files that have the same depth and cable out as one. If two files have differing amounts of cable out process those separately, they will have

different layback. *Snip* files with the same depth and cable out together to make one longer file.

3.1. ***Snip files*** **–** to snip files together in Isis Sonar go to **Tools** →**Snip File** create a filename for the new file you are creating (example: *101_103.xtf*, for snipping files 20nov101.xtf, 20nov102.xtf, and 20nov103.xtf together) playback the files you want to snip in the proper order. When you are done playing back the files turn off the *snip file* function by going back to **Tools** → **Snip File** and clicking it, this will automatically turn it off. You can also hit the shortcut key on the tool bar that looks like scissors (Figure 1).

4. **FixTime –** You must fix time in the *xtf* files so the navigation and time stamps will run smoothly. If you do not do this you may have smearing of pixels or gaps in the final mosaic.

4.1. First copy and paste the ***fixxtime.exe*** file to the folder you are working in. The original can be found in C:\TEI\fixxtime.exe

4.2. To *Fixtime* replay the *snipped* file you just created or a single file not *snipped*. Write down the time (see Figure 1) at the start of the file and at the end of the file. Add up the total number of pings in the *snipped* file (there are 1000 pings per one file so if you *snipped* 3 files together you have 3000 pings).

4.3. Open a **DOS prompt** – change the directory to the folder that contains the file you want to fix time in. Do this by typing in **EXACTLY cd\Documents and Settings\DFW\My Documents\Side Scan Sonar\SSS Images\stj5a\20 nov 02** <hit ENTER> (note: stj5a is the folder for the area you are mosaicking and 20 nov 02 is the folder that contains the file you want to fix time, these will change to current files you are working in that you copied the *Fixxtime.exe* to). See Figure 2 for an example of the *Fixxtime* dialogue window.

4.3.1. Next type **fixxtime** <hit ENTER> (**Yes,** you must type in two xx's in fixxtime.)

4.3.2. You will be asked to type in the name of the file. Enter the entire filename (example: *101_103.xtf*) <ENTER>

4.3.3. Then you will be asked to enter the start date and time. This can be found in the *Parameters Window* of Isis (see Figure 1). <ENTER>

4.3.4. Then enter the end date and time as above <ENTER>

4.3.5. Then enter the number of *pings* in the file <ENTER>

4.3.6. When it is finished fixing the time replay the file in Isis Sonar. The time and number of pings should scroll sequentially in the *Parameters Window*.

Note: Sometimes **SSPC review** (on the Lindsay computer) alters the time stamp and date (if one file was post processed and saved one day and a second file was post processed at a later date they will be assigned different dates and times) You **MUST** change the date and time for the start date and end date to match. [**Example**: if one file was dated 25nov02 and the second file was dated 16nov02 you must enter the same date for the start and end in *fixxtime.exe*. Similarly the time may be off. If one file time was 17:05:02 and the end file time on the second was 10:23:26 you must adjust the time to run sequentially. You can do this by looking at the original files' time stamps for start and finish and changing the time in one file, if file *20nov101.xtf* has a start time of 17:05:02 and end time of 17:07:30, and file *20nov102.xtf* has a start time of 10:23:26 and an end time of 10:26:26 you can change file *102*'s time to start 1 second after file *101*, so it would start 17:07:31 and end 3 minutes later (because it's total run time was exactly 3 minutes (10:26:26 minus 10:23:26 = 3 minutes) so the end time for the file in *fixxtime.exe* will be 17:10:31].

5. **Layback**-Next generate an *ASCII Report*. To do this go to **Tools→ASCII Report**, put a check in the box for *Form 1* and click *Setup Form 1*. You should get a form that looks like Figure 3. Put checks in the corresponding boxes. Change the time in the *When to output* box to every 1 second. Click the *Browse* button to create a text file in a folder you specify. Click OK and then Click OK in the *ASCII Report window*. Replay the file (Note: you can just hit the home key on your keyboard to replay the line from the beginning). After the file plays back turn off the *ASCII Report* by going back to **Tools →ASCII Report** and removing the check in the *Form 1* Box.
   5.1. Go to the folder you put the *ASCII report* into and open the text (*.txt*) file. Insert a line at the beginning of the file with identical information as the line below except make the time 1.000 second before the start of the files' time. Example: if a file had a start time of 13:54:53.000 make the time for the new line 13:54:52.000. Do the same at the end of the file but make the time 1 second later. Make the altitude the same as the previous line. Save the file and close the window.
   5.2. Open Microsoft Excel. Open the file you just made as a *delimited text* file. When the Import text dialogue box opens click *Delimited* and *Next*. Uncheck the *Tabs* box and put a check in the *comma* box and *other* box then type *m* in the *other* box, then click *Next*. Highlight the first column and click *Date* in the *Column data format* box. Click *Finish*. You should get an Excel Spreadsheet with the first column as dates, the second as time in HH:MM:SS, and the third column should contain the towfish altitude without the *m* for meters.
      5.2.1. In the 4th column enter the total water depth in **meters** from the field sheets (spreadsheet) and in the 5th column enter the cable out in **meters**.
      5.2.2. The 6th column is for the layback calculation. This is a formula based on the equation $Layback = [\sqrt{cableout^2} - (depth + 1.63 - altitude)^2] + 6.27$ Where 1.63 is the height of the tow point and 6.27 is the offset, **all measurements should be in meters**. In excel the formula should read: =(SQRT(E1^2-(D1+1.63-C1)^2)+6.27)

         where column E is the cable out, column D is the depth, and column C is the altitude. Copy this formula and the data for the 4th and 5th columns down the spreadsheet. Then highlight the three columns and copy and *Paste special* it as *values*. Save the spreadsheet as a *comma delimited* (*.csv*) file and close the file.
      5.2.3. Go back to Isis and either close Isis or playback a completely different file than the one you are working on.

5.2.4. Go to *Windows explorer* and rename the *csv* file you just made as a *txt* file. You will have to give it a different name followed by *.txt.* I generally name it the same as the original file but with 2 in front (example: 2line23.*txt*).

5.3. Open ***NavInXtf.exe*** this is found in C:\TEI\Nav in Xtf

5.3.1. See Figure 4. In the box/ section labeled 1 click *Browse* and select the *txt* file that contains the layback information you just created (the file you just renamed eg. 2line23.*txt*).

5.3.2. In the box/ section labeled 2 click *Browse* and open the *xtf* file you want to put the layback into (eg line23.*xtf*). Then you will be asked to save a backup of the file **ALWAYS SAVE A BACKUP** to a folder labeled Backup.

5.3.3. In section 3 make sure the top box labeled *Ship* is checked (it shades lighter color than the others) and the bottom box *Sensor&Ship* is checked. Then click *Process* and *Exit* when it is done.

5.3.4. Go back to Isis and open *View→Layback.* Then replay the file you just added layback to. Layback should scroll in the *Layback* window. This file is now ready to be added to others to create a single line file or be mosaicked if you already *snipped* all of the files for that one line. Repeat the above layback and NavinXtf process for all files in that line if they were not *snipped* together. When all files have layback and have been time corrected go to Step 6.

6. ***Snip*** all of the files that make a single line (a single line should contain 10-11 files) using the same process as described in 3 above.

6.1. Be sure to note the dates and times for each file.

6.2. ***Fixtime*** for the newly created *snipped* file as was done before but name the file after the line that it represents (eg. *line12.xtf*). Save the line file into the folder for the corresponding area rather than the corresponding date folder (example: C:\Documents and Settings\DFW\My Documents\Side Scan Sonar\SSS Images\stj5a). To *fixxtime* you will have to copy the *Fixxtime.exe* to the mosaic folder you are working out of and when in DOS change the directory to the folder that contains both the file you want to fix and the *fixxtime.exe*. (Example: cd:\Documents and Settings\DFW\My Documents\Side Scan Sonar\SSS Images\stj5a). Once you have *Snipped* the files together for a single survey line and *fixed time* for that new file go to step 7.

7. **Coverage map –** Now the line file is ready to be mosaicked. Go to **Tools – Coverage Map and Mosaic** and check the *Full DelphMap mosaic* box. Two windows should come up.

7.1. One is the *Delph Mosaic and DTM* window (Figure 5). In the *Delph Mosaic and DTM* window select *set projection and bounding box*. Change the resolution to 0.1 (Figure 6) then **OK.** In the *Delph Mosaic and DTM* window select *More Options* and put checks in the boxes as in Figure 5. Select *Setup* under *Apply Layback to nav in mosaic* and put checks in the *apply layback* and *Use logged layback value* boxes (Figure 7).

7.2. The second window that comes up after you check the *Full DelphMap mosaic* box is the *Coverage Window* (Figure 8). Playback the line and this window will show the towfish's track. When the line is done playing back go to *Nav* and select *smooth navigation*. This will bring up a window like Figure 9. Leave the default values and click *Smooth now* several times, 10-15 times, then close the window. When the *Lock Coverage map* dialogue appears select *YES* to lock the coverage map. Save the navigation to a *txt* file into a folder under the area you are mosaicking called *navigation*.

7.3. Now put a check in the box next to *Build Sidescan Mosaic* in the *Delph Mosaic and DTM* window. Click *Start Mosaic* and name the line you are mosaicking after the line it corresponds to (eg. line23). Save this line in a folder for the area you are working on (eg. stj5a) under the folder **MOSAICS** (C:\Documents and Settings\DFW\My Documents\Side Scan Sonar\MOSAICS). The *add scrolled data to mosaic* message should highlight and a message *successfully started mosaic* should appear. Playback the file you are mosaicking again; when it is done playing back, click the *Done* button and close the *Delph Mosaic and DTM* window and the *Coverage Window*.

7.4. If **DelphMap** was already open the data will automatically scroll into the mosaic. If it was not open go to step 8.

In DelphMap

8. Open the project you want to work on or start a new project.
   8.1. To insert the line/ layer you just created in Isis right click on *Image Layers* (Figure 10) and select the line you created. This will insert the line. You may insert all the lines at the end when you have finished creating them in Isis or as you go.
   8.2. You can move a layer in DelphMap by clicking and dragging a line name up or down. The line that appears on top in the window on the left will also be on top in the mosaic. Lines on top will cover-up the line below.
   8.3. Once you have finished a mosaic **Merge** all of the lines into one file to be printed [if you do not merge the files printing may take several hours].
      8.3.1. Under **Tools-** go to **Merge image layers** and select the layers you want to merge (Figure 11). You can merge as few as two layers or the whole mosaic. You should merge the whole mosaic to print. Unselect the *Insert output layer into project*. Select an output file location (use the same folder as the original mosaic). Click *Merge.*
      8.3.2. Once it is done open a new DelphMap project and insert the layer as described in 8.1 above. **[It is a good idea to also create a GeoTiff of the mosaic – do this by right clicking on the layer name in the left column and selecting export]**

Printing

9. To print a Mosaic using the large plotter first connect the plotter and turn it on – before opening DelphMap. Then open DelphMap.
   9.1. Select **Project – Print Setup** and the plotter. Under the *Properties page* (Figure 12) check that the paper size is correct.
   9.2. **IMPORTANT** There are hidden settings in the Plotter that must be checked each time you want to print. If you do not uncheck the *Enable SpoolSmart* setting you will not be able to print the mosaic properly. In order to access these

settings you must Click on *About* (Figure 12) and then place the cursor arrow over the *hp invent* symbol and hold down F8 while hitting <ENTER> (Figure 13). This will bring up the *Special Options* window (Figure 14). Uncheck the box next to *16 enable SpoolSmart* and click **OK** (Figure 14).

9.3. Next select the *Scale to Fit* box in the properties page (Figure 12). This will open the *ZoomSmart Settings* window (Figure 15). Be sure that the paper size is correct and check the *Fit the Document to this paper* box and verify the paper size. Click **OK**.

9.4. Finally go to *Print preview* and *Map Layout* under *Project* and enter a title and change the scale if necessary. You should see a preview similar to Figure 16. (I have found for a mosaic of approximately 1 square mile a scale of 1:2300 works well). Click **OK**

9.5. Now go back to the print window and print the file. It may take several minutes (10-15) to spool and start printing. The print process is slow and may take an hour or more if you did not merge the files.

If you have any other troubles consult the manuals for Isis and DelphMap or call Tech support for Triton Elics International at (831) 722-7373.

Isis Main Window

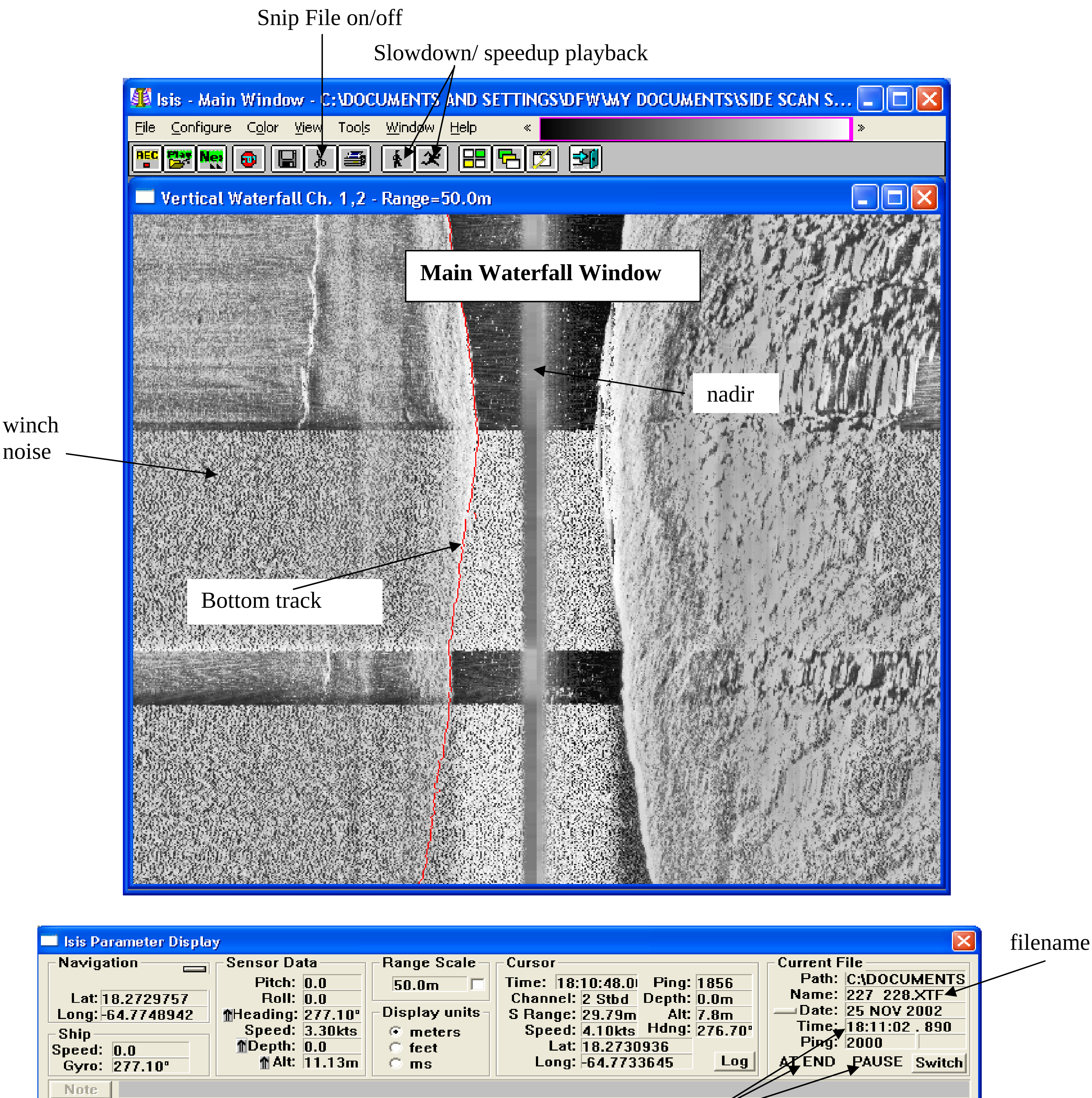


Figure 1. Isis Main Window.

Time at end of file, hit home or end to switch between start and end. Use space bar to pause playback

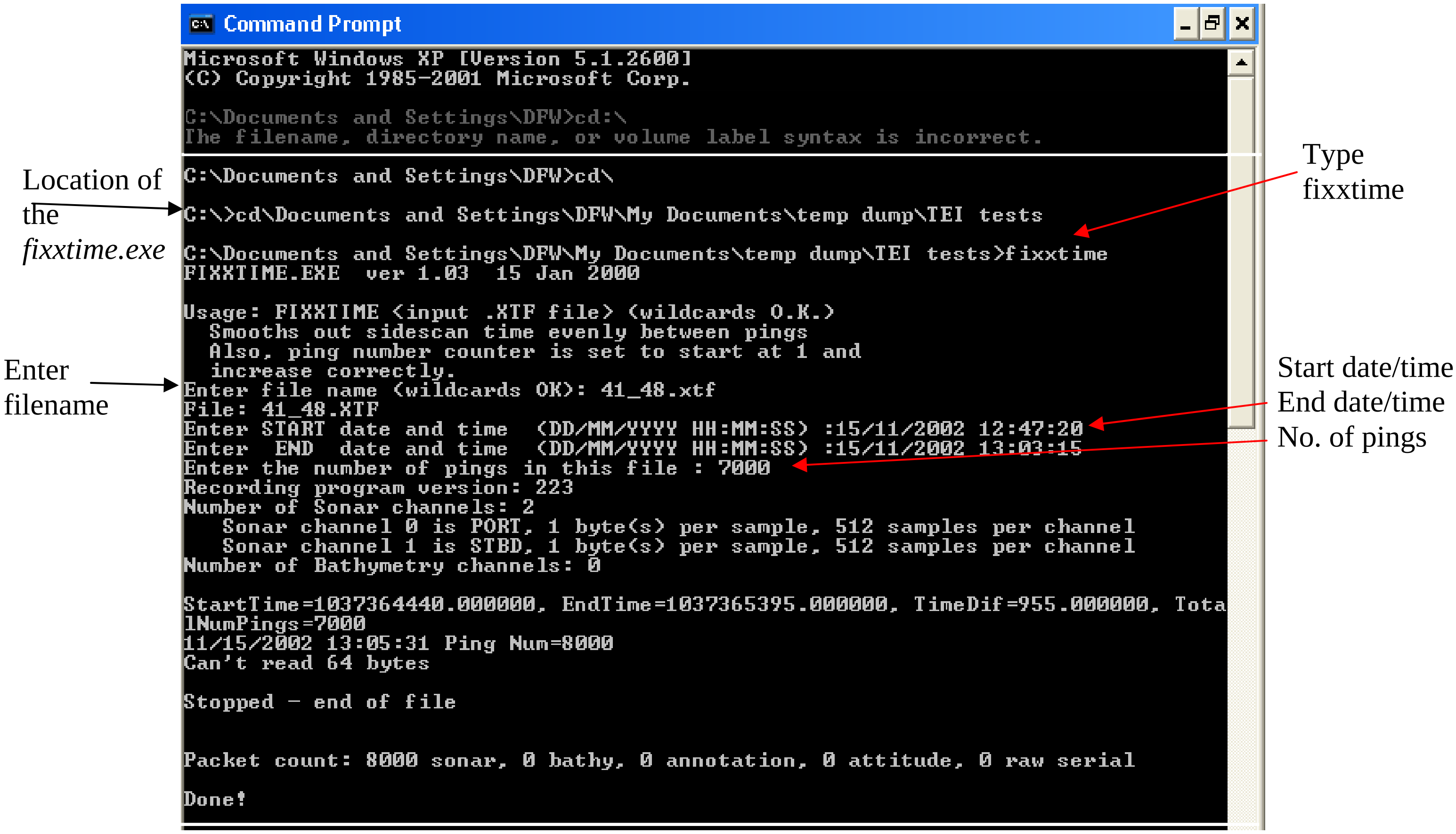


Figure 2. DOS steps to fix time for Isis Sonar for DelphMap mosaicking

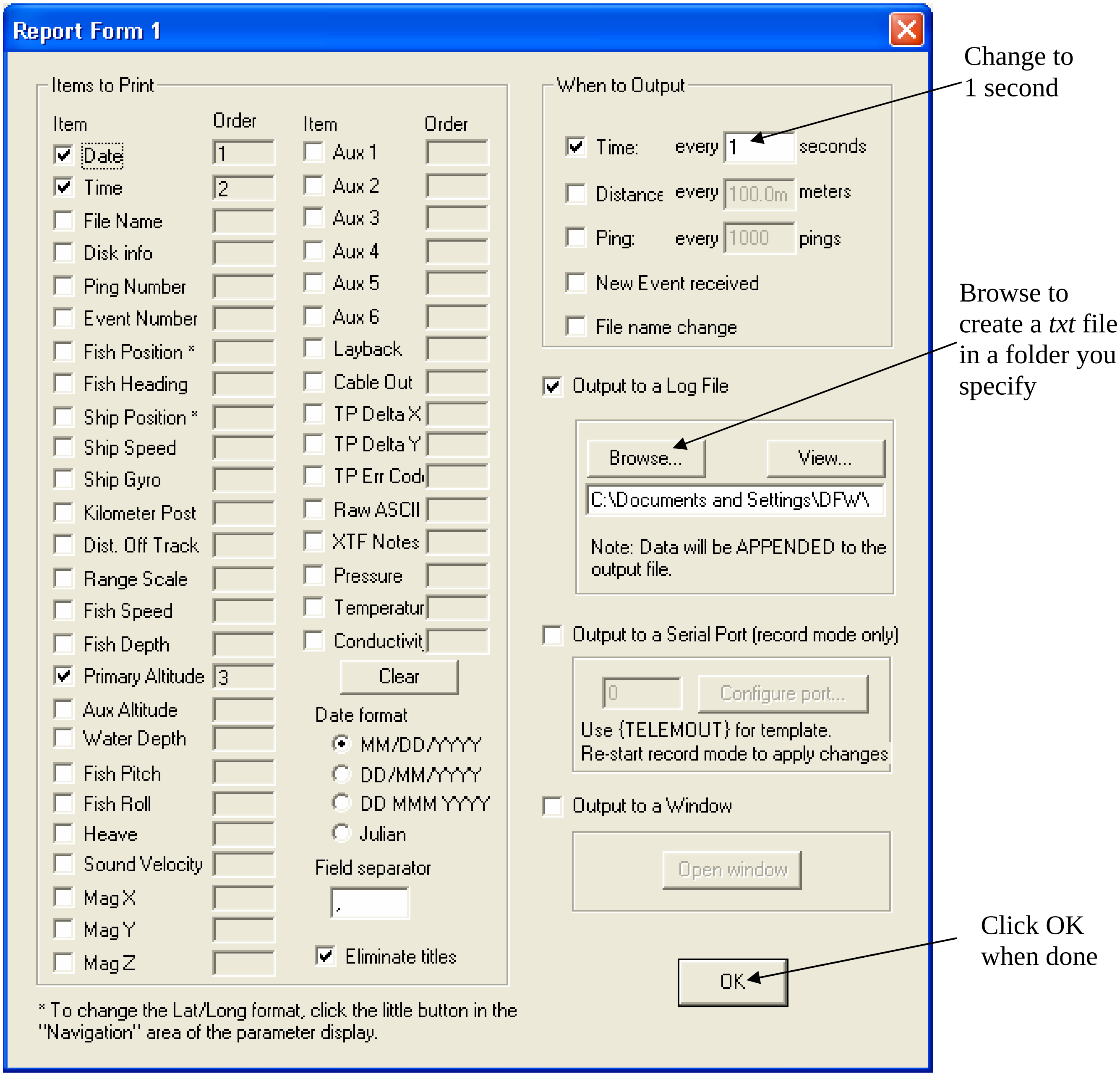


Figure 3. *ASCII Report* form. Put checks in the corresponding boxes as shown here.

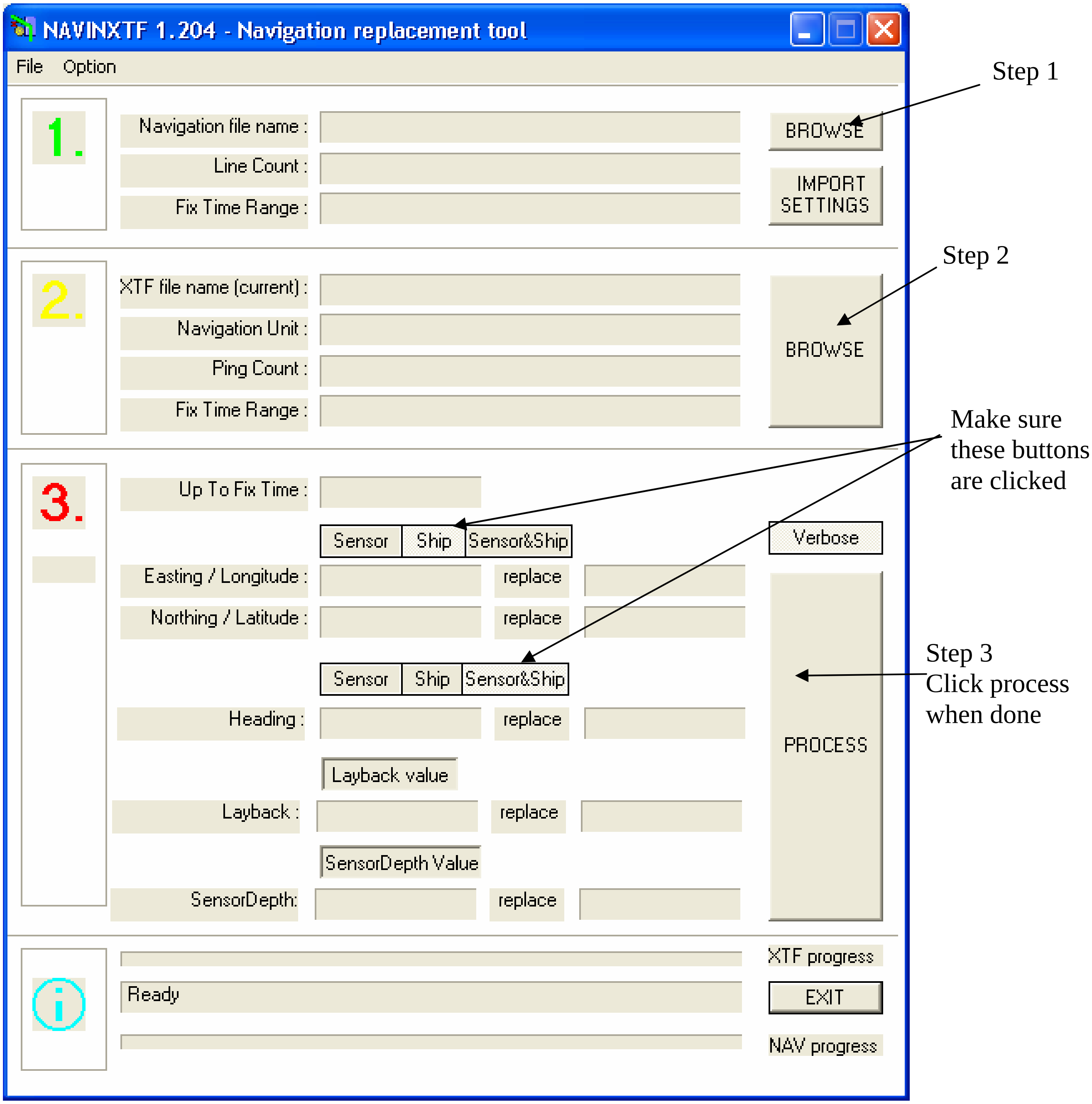


Figure 4. Navinxtf Window.

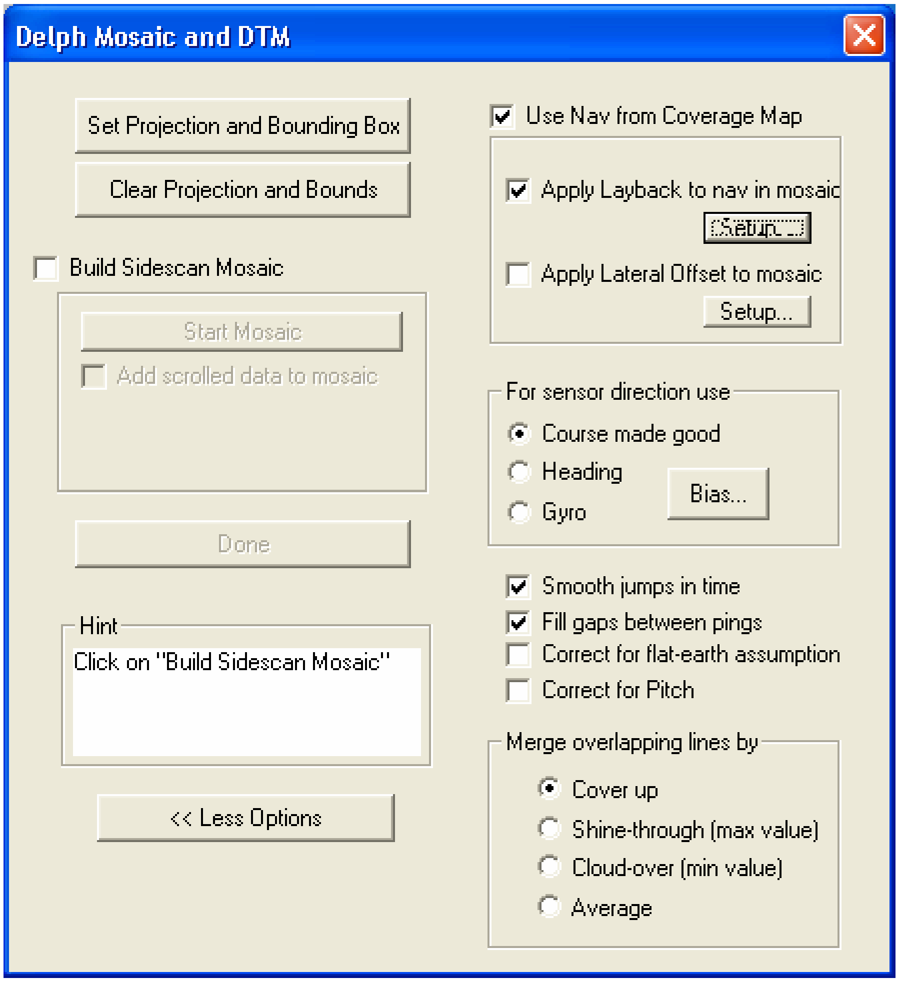


Figure 5. Window to build the mosaic.

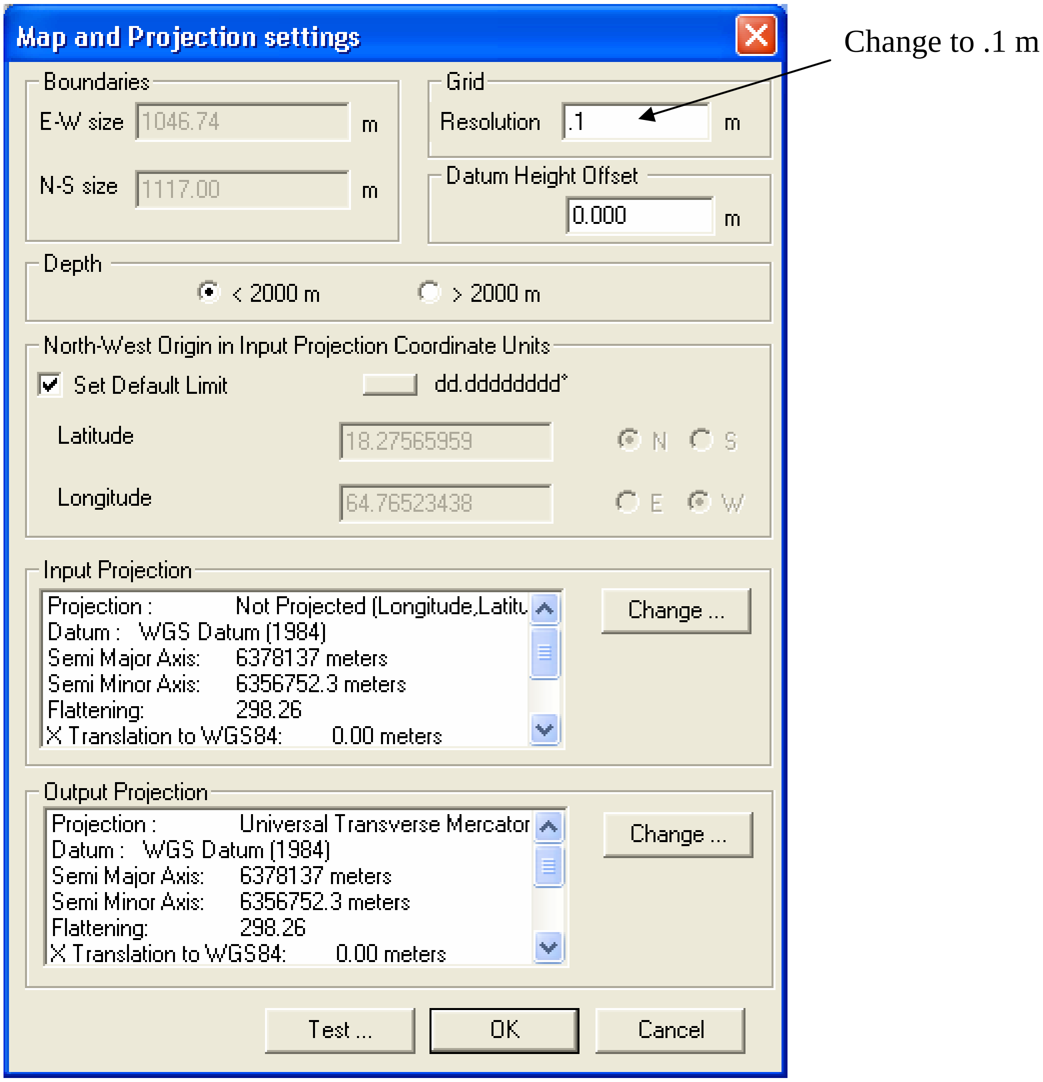


Figure 6. Projection window. Input and output should default correctly. Change the Grid resolution to 0.1 m.

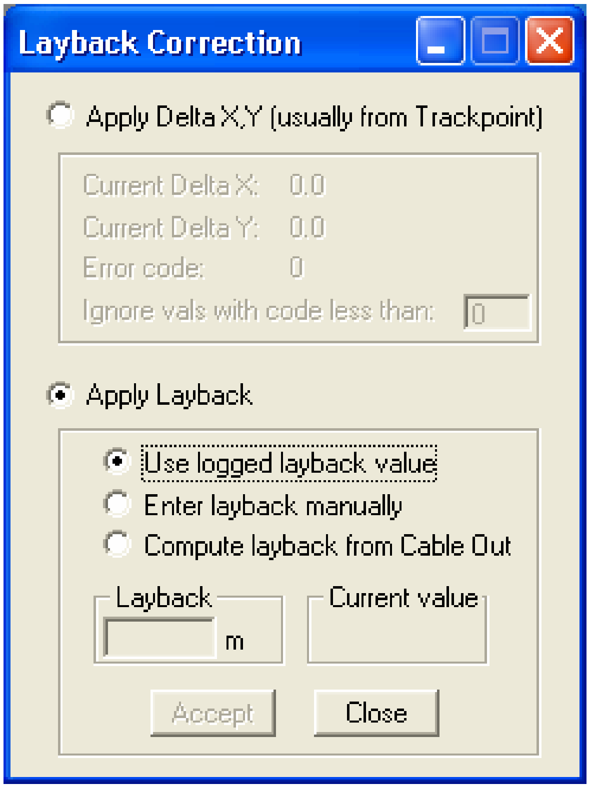


Figure 7. Check the Apply Layback to nav in mosaic. Under setup check the use logged layback value.

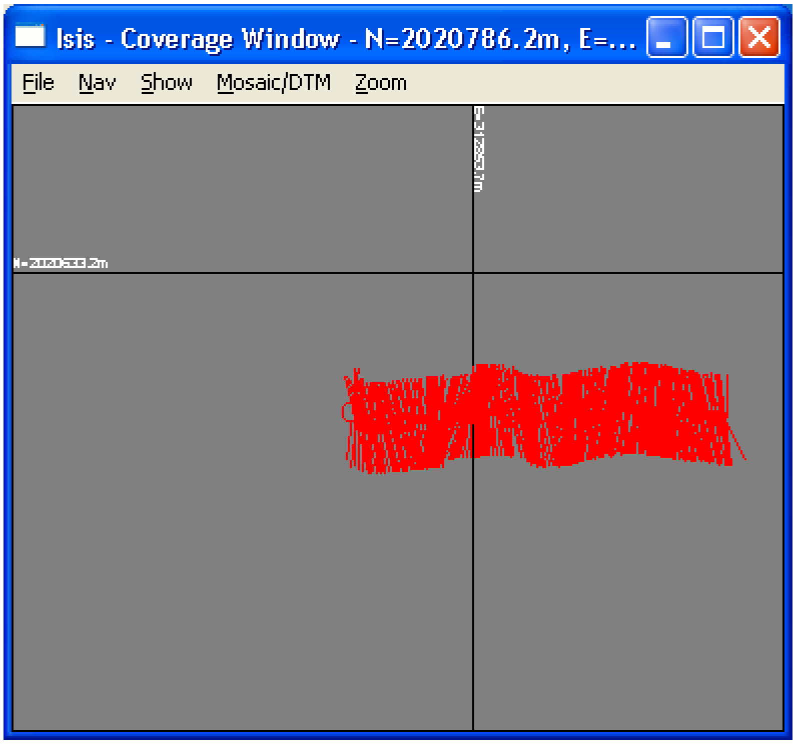


Figure 8. Coverage Window. Sonar path is in red. Go to Nav – Smooth Navigation 10-15 times and save the coverage points as a *txt* file.

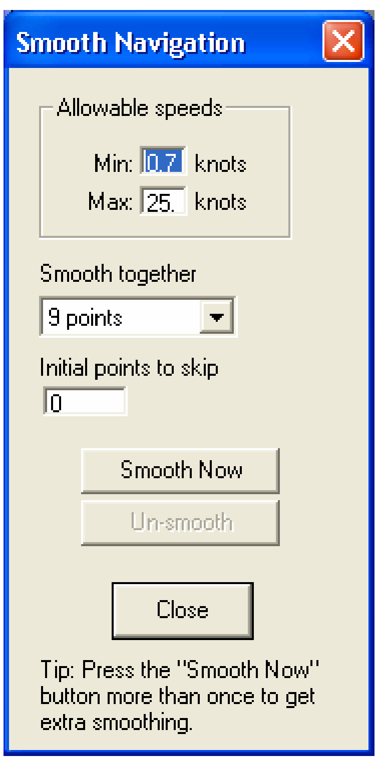


Figure 9. Smooth navigation window.

Leave defaults. Click *Smooth now* 10-15 times.

Right click to insert layers or lines

drag layers to move up or down in the mosaic window

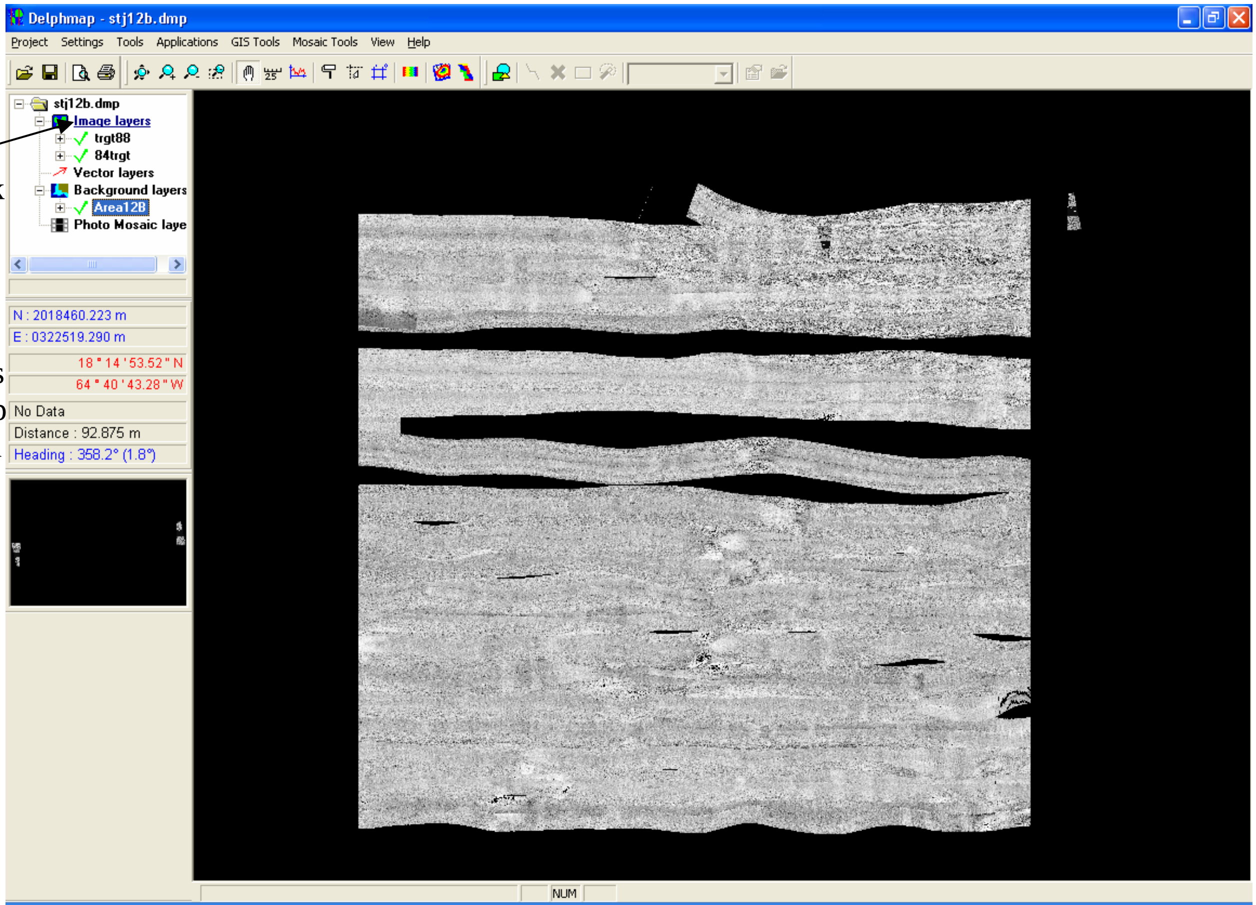


Figure 10. Delphmap Window with a mosaic.

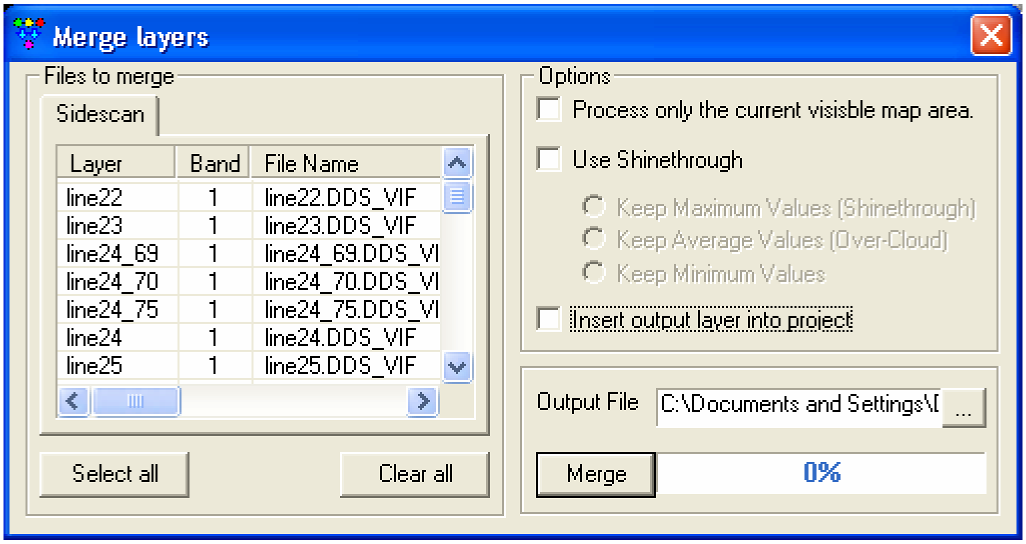


Figure 11. Merge Layer Window. Select layers to merge.

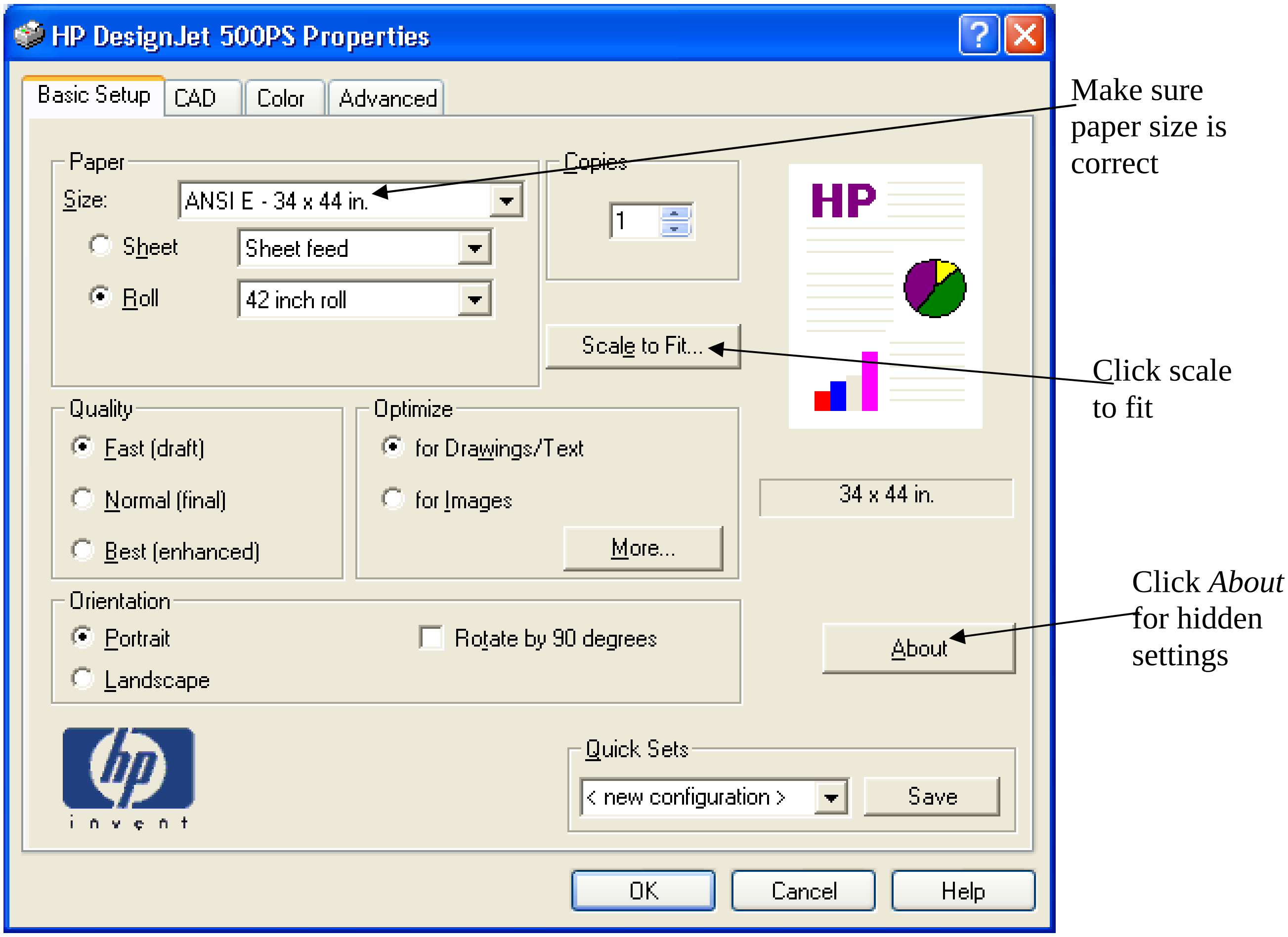


Figure 12. Printer/ plotter setup. Select *About* and go to figure 13.

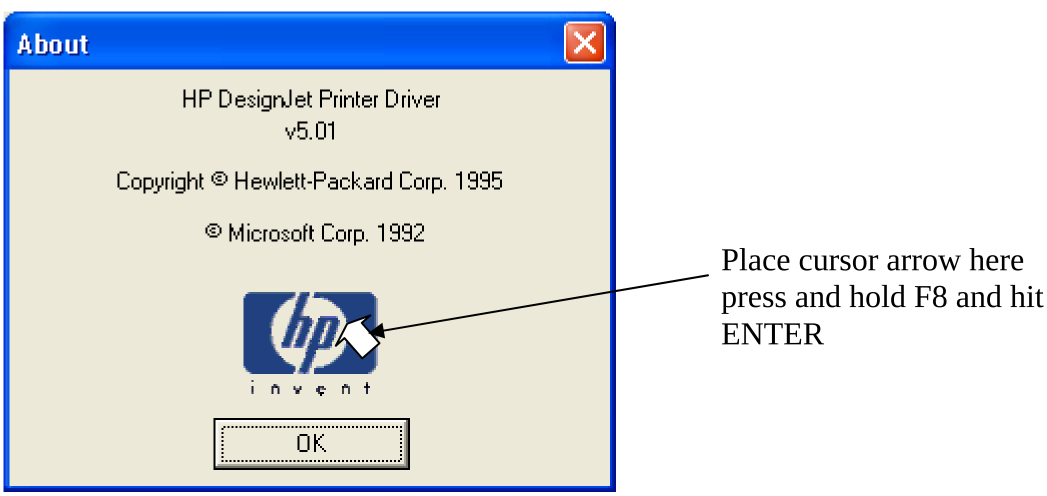
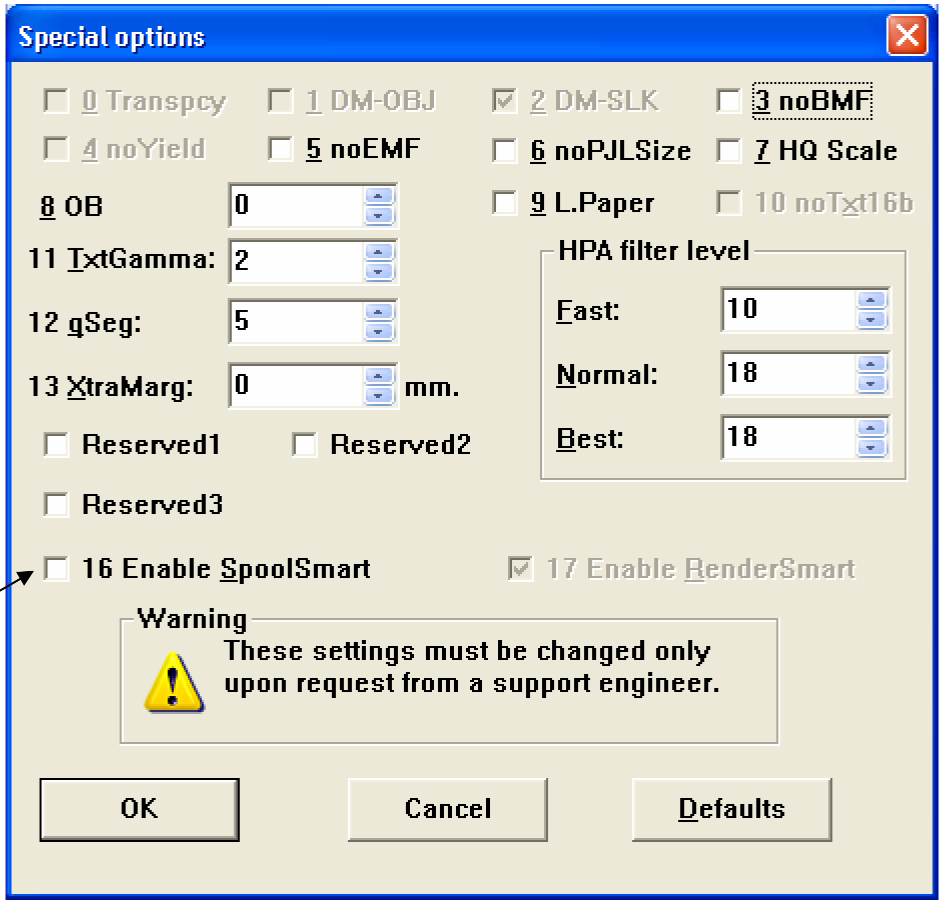


Figure 13. You must change hidden settings to print properly. Place the cursor arrow over the hp invent symbol and press and hold the F8 key while hitting <ENTER> this gives you Figure 14.



uncheck

Figure 14. After you get to these hidden settings from Figure 13 uncheck the box next to 16 Enable SpoolSmart. Leave all others as the defaults. Click **OK.**

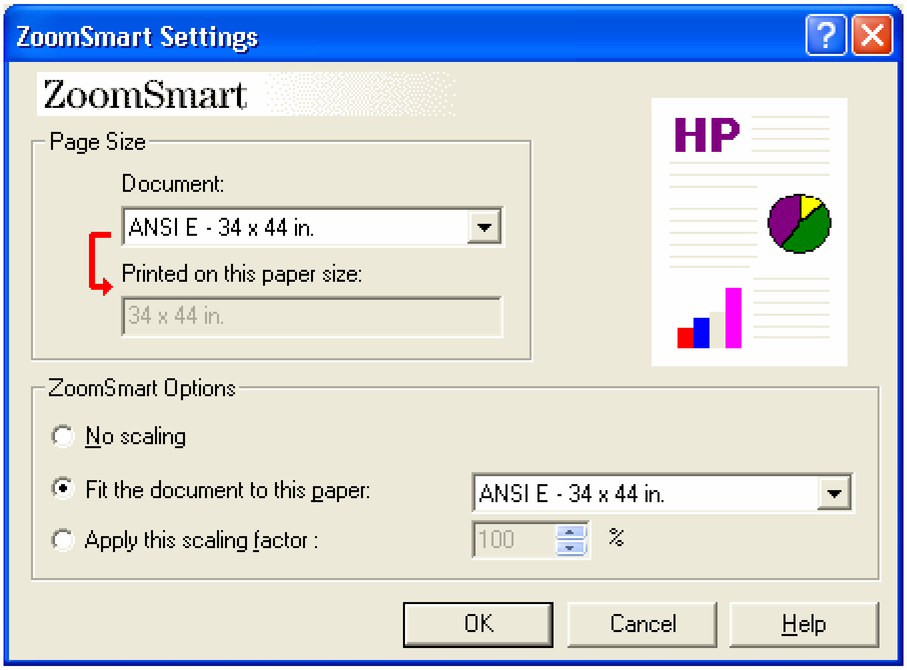


Figure 15. Click on the Scale to Fit button in the Properties page (see Figure 12). Make sure the Page size matches the size of paper you have loaded in the plotter. Click on the Fit the Document to this paper and select the right paper size. Click **OK**

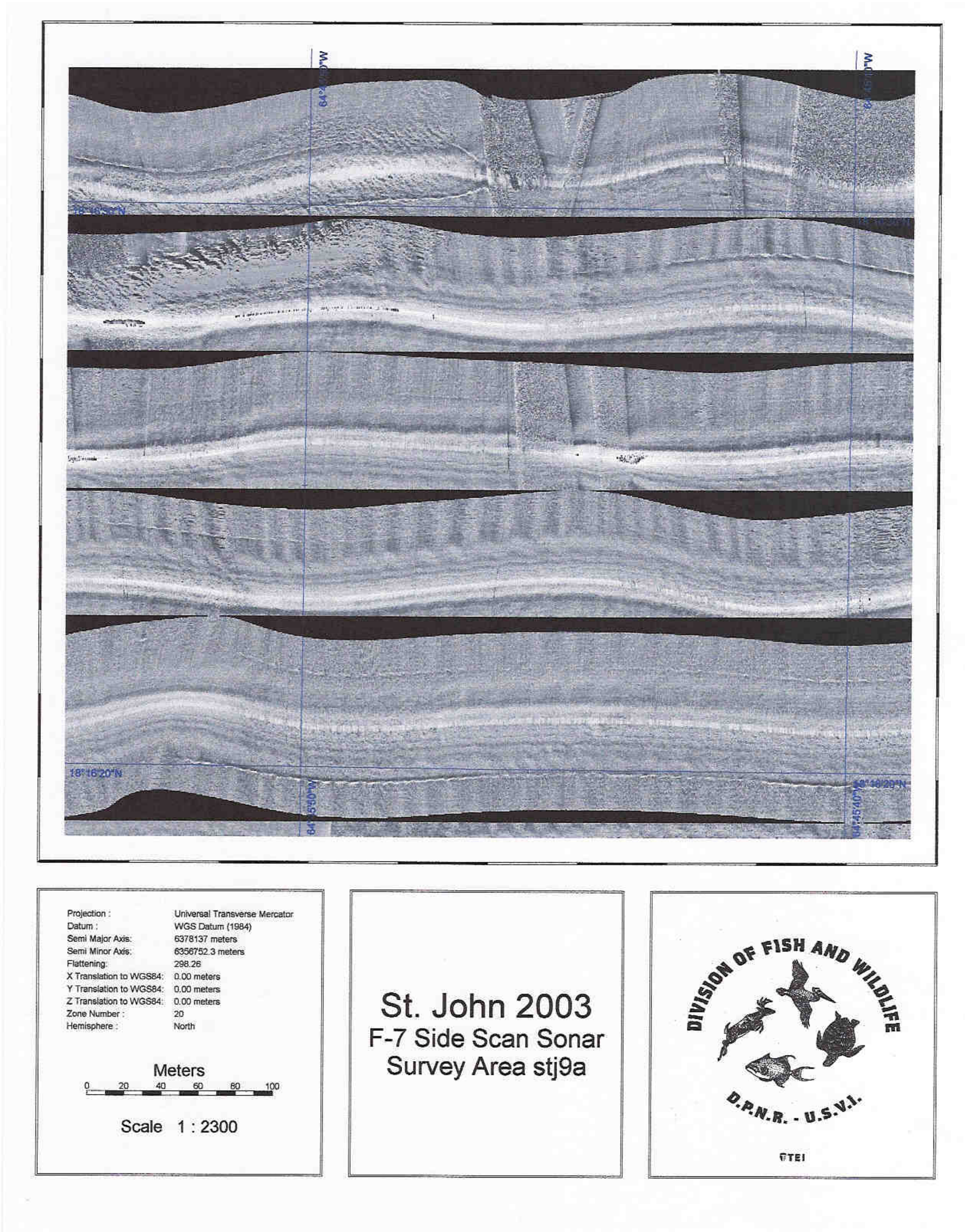


Figure 16. Print preview of the final mosaic