8-24-2001

Biological Survey Report for the Calypso Natural Gas Pipeline: Shore Approach Route North of Port Everglades Entrance Channel with Landing South of Port Everglades Entrance Channel

Richard E. Dodge
Nova Southeastern University Oceanographic Center, dodge@nova.edu

Susan L. Thornton
National Coral Reef Institute, Nova Southeastern University Oceanographic Center

David S. Gilliam
Nova Southeastern University Oceanographic Center, gilliam@nova.edu

Richard Shaul
Sea Byte Inc.

BIOLOGICAL SURVEY REPORT FOR THE CALYPSO NATURAL GAS PIPELINE

SHORE APPROACH ROUTE NORTH OF PORT EVERGLADES ENTRANCE CHANNEL WITH LANDING SOUTH OF PORT EVERGLADES ENTRANCE CHANNEL

August 24, 2001

Submitted to:

Calypso Pipeline, LLC

Submitted by:

Richard Dodge, Ph.D., Susan Thornton, M.S. and David Gilliam, Ph.D.
National Coral Reef Institute, Nova Southeastern University Oceanographic Center
8000 North Ocean Drive, Dania Beach, Florida 33004

And

Richard Shaul, M.S.
Sea Byte Inc.
19940 Mona Road, Suite 4
Tequesta, FL 33469

TABLE OF CONTENTS

List Of Tables

Executive Summary:

The Calypso Natural Gas Pipeline Project (Project) will include a 24-inch pipeline which will extend from the Exclusive Economic Zone (EEZ) off the southeast Florida coastline to a shore approach at Port Everglades in Fort Lauderdale, Florida.

This report, which was commissioned in May 2001 and completed in July, 2001, documents the results of a detailed biological survey of underwater marine habitats from 5 to 200 feet water depth for the pipeline route. The route, which was established based on the subsea survey that was completed in May 2001 by Williamson & Associates, Inc., includes a shore approach from the north of the Port Everglades entrance channel to a pipeline landing site south of the Port Everglades entrance channel. The purpose of this biological survey report was to identify benthic characteristics within the nearshore pipeline corridor and to identify and evaluate potential temporary impacts to the marine ecosystems. The pipeline corridor investigated was 300 feet wide and extended from the shoreline to the 200 foot water depth, a distance of approximately 14,000 feet. In addition, some video surveying was conducted to approximately the 250-foot depth contour (an additional distance of approximately 500 feet).

Underwater survey methods included use of SCUBA diving to conduct underwater quantitative biological transects and integrated video mapping using a vessel towed system which provided a permanent record together with a DGPS location. Remote sensing information included use of aerial photographs and LIDAR bathymetry to guide habitat delineation.

A total of eight (8) benthic habitats were defined within the pipeline corridor. These habitats included:

1. First Reef
2. Submerged Breakwater/Spoil
3. Second Reef
4. Second Reef-Sand Complex
5. Sand
6. Third Reef
7. Third Reef-Sand Complex, and
8. Third Reef Transitional.

Density (number per m^2) of hard corals, soft corals, and sponges was determined at several representative transects within certain habitats. Results of the study indicated that overall coverage by hard corals, soft corals, and sponges is very low in the proposed project area. Along the proposed pipeline route, percent hard coral coverage ranged from 0.16% in the Submerged Breakwater / Spoil Area to 1.34% in the Third Reef habitat. Soft coral density was lowest in Second Reef-Sand Complex (0.02 soft corals per m^2) and highest at the Third Reef (11.85 soft corals per m^2). Sponge density varied from 0.23 sponges per m^2 in the Submerged Breakwater / Spoil Area to 19.48 sponges per m^2 in the Second Reef zone. Previous surveys in the general project vicinity indicate that no

zooxanthellate reef-building hard corals occur in water depths greater than about 120 feet of seawater (FSW).

Direct impacts of approximately 1.60 acres of hardbottom habitat characterized by very low coverage by hard corals, sponges and soft corals are expected. These impacts will occur at proposed horizontal directional drilling exit or entrance holes, laydown areas of pipeline, trenching, and blanketing to bury pipeline from the Port Everglades entrance channel from the shoreline to the 200-foot depth contour, as shown in Tables 5, 6, and 7. A further approximately 4.34 acres of area would be affected adversely by temporary indirect effects (i.e., sedimentation and turbidity) effects as shown in Tables 8, 9, and 10. Table 11 provides a summary total that 5.94 acres of hardbottom habitat would be directly or indirectly affected. In addition, approximately 0.008 acres of very sparse seagrass (*Halophila decipiens*) will be directly impacted. Finally, no threatened or endangered species (including the federally threatened seagrass *Halophila johnsonii*) were observed in the project area.

Observations were conducted to the approximate 250-foot depth contour. Video surveys to that depth indicated benthic conditions consistent with those of the Third Reef Transitional complex and open sand. Project activities beyond 200 FSW will consist only of pipe placement directly on the sea bottom

1.0 INTRODUCTION

1.1 Statement of Purpose

Calypso Pipeline, LLC (Calypso) proposes to construct a natural gas pipeline which will include a pipeline from the Exclusive Economic Zone (EEZ) off the southeast Florida coastline to a shore approach at Port Everglades in Fort Lauderdale, Florida. The proposed pipeline will have a shore approach north of the Port Everglades entrance channel with a pipeline landfall south of the Port Everglades entrance channel in Broward County, Florida. A field biological survey was undertaken to identify benthic characteristics within the nearshore pipeline route and to identify and evaluate potential impacts to the marine ecosystems.

1.2 Florida Coral Reef Communities

Figure 1 shows the general range of coral reef and hardground communities in Florida. Reef communities exist along the southeastern and southern coast of Florida between Indian River County at the north, through Palm Beach, Broward, and Miami-Dade Counties, and ending in Monroe County in the South. The proposed pipeline landfall lies within mid-Broward County.

1.2.1 Southeast Florida General Reef Characteristics

Coral reefs along the southeast coast of Florida and in the vicinity of Port Everglades are generally linear terrace-like features, paralleling the coastline and separated by or interspersed with sand channels. The First Reef is nearest shore and crests in approximately 10-15 feet (3-4.5 meters) water depth. The Second Reef is a complex of hardground and sand channels cresting in about 25-30 feet (7-9 meters) water depth. Typically separating the Second Reef complex from the Third Reef is a sand channel of several hundred meters in east-west dimension. The Third Reef crests in approximately 50-60 feet (16-18 meters) water depth. The current Port Everglades entrance channel is dredged to a depth of approximately 45 feet (15 meters) and does not traverse the Third Reef.

Figure 2 shows a typical cross section through the coral reefs off Broward County. The frameworks of the Third and Second Reefs are primarily geologic constructs from periods of lower sea level conditions. Approximate geologic ages of the frameworks are shown.

Figure 3 provides an aerial photograph perspective of the Port Everglades entrance channel area. The reefs occur in three bands paralleling the shore in progressively deeper water.

Figure 4 provides additional detail of the study area. The marine ecosystems in this area are affected by many natural and human influences. Disturbances near the Port

Everglades channel include natural conditions such as the plumes (often consisting of fresh and sometimes turbid water) discharging from Port Everglades. Human influences include any pollution which may be in the discharge plume, the cutting through the First and Second reefs by the entrance channel dredging, the burial of some reef structures by the north and south jetties, the spoil disposal area to the north of the north jetty, and the accretion of sand on the north side of the north jetty. A recent ship grounding (Sealand Atlantic) has also affected some of the reef area to the south of the jetty. The Naval Surface Weapons Center also maintains a facility to the south of the south jetty. At least 162 cables extend directly over the bottom extending east and south of the jetty. Navy cables also occur on the north side of the jetty in less abundance.

1.2.2 Bathymetric Data

In 1998, the US Army Corps of Engineers conducted a high data density water depth survey of the entrance channel area using their laser based LIDAR system.

Figure 5 shows the sun shaded bathymetric plot. The entrance channel, reef systems, the jetties, and the disposal area to the north of the north jetty are clearly discernable.

Figure 6 provides an oblique three-dimensional LIDAR data depiction with aerial photo overlay to further illustrate the character of the study area.

2.0 SURVEY METHODS & MATERIALS

In conducting the biological survey, we have employed an integrated video mapping system (IVMS), which provides a permanent video record of the bottom with precise DGPS position data on each video frame. The video has been ground-truthed by divers as necessary. We have also taken quantitative detailed data along specific transects by SCUBA diver survey. From these data, a map with habitat classifications has been produced giving characteristics of the bottom type and biology within the area of interest. The map has been related to aerial photography and LIDAR bathymetry utilizing GIS computer systems.

Consideration has been given to potential physical impacts associated with proposed construction measures, including direction drill exit and entrance holes, pipe pull areas, trenching areas and areas to be blanketed with concrete mats.

The survey work was performed by the National Coral Reef Institute (NCRI) of Nova Southeastern University (Richard E. Dodge, Ph.D., David Gilliam, Ph.D., Bernhard Riegl Ph.D., Susan Thornton, M.S.) and by Sea Byte, Incorporated (Richard Shaul, M.S.).

The survey was completed under an addition to a contract dated December 27, 2000, for a preliminary coral investigation of the Port Everglades area, between NSU and URS Corporation, Calypso's environmental permit support consultant on this project. NSU subcontracted with authorization to SeaByte.

2.1 Scope and Project Description

Project scope of services included providing a map and biological survey of the benthic habitats within approximately 150 feet on each side of the centerline of the Nearshore portion of the proposed Calypso pipeline route out to the 200-foot water depth contour. For the purposes of this report, Nearshore is defined as that portion of the proposed pipeline that will be constructed in Florida state tidal waters that occur between the mean high water line on the coastal barrier island and the eastern limit of Florida state waters three nautical miles from the shoreline. The survey involved identifying reef and non-reef areas, generally characterizing any transitional areas, and quantifying the existence of hard corals, sponges, and soft corals along the biological transects.

The pipeline coordinates based on the subsea survey completed in May 2001 by Williamson & Associates and supplied by R.J. Brown have been used. These coordinates are:

	UTM17 in WGS84		**State Plane NAD83**	
	Meters	Meters	Feet	Feet
	Northing	East	Easting	Northing
#2 Exit	2,887,610.63	592,208.43	958790.4	644833.7
#2 Entrance	2,886,918.82	590,805.72	954186.8	642563.2
#1 Exit	2,886,632.11	590,221.70	952270.1	641622.3
#1 Entrance	2,886,026.12	588,951.64	948101.8	639633.4

2.2 Integrated Video Mapping Methods

The survey was conducted to provide continuous underwater video documentation of the benthic habitat along the pipeline route from the inshore portion of the route along the Port Everglades entrance channel eastwards to a water depth of approximately 200 feet. Some survey lines covered to as deep as 250 feet.

The survey was conducted using Integrated Video Mapping System™ (IVMS) to document the benthic habitats that occur along the proposed pipeline route. The IVMS allows precision mapping and characterization of the bottom by towing a high-resolution color video camera mounted on a towfish over the bottom. Video data are cabled up to the vessel and integrated into the IVMS software within an on-board computer. The video data are coupled with precision Differential GPS data within the on-board computer and the location of the video observations are displayed in real-time within a Geographical Information System (GIS) software program. The video record is continuously annotated with an overlay of the geographical coordinates. Audio observations made by the onboard scientists are also recorded on the audio portion of the videotape. All video data are stored on Hi-8 mm tape format. Positioning data and survey observations are recorded within the IVMS database and can be correlated to time-coded video records for precision mapping during post processing.

™ Integrated Video Mapping system is a registered trademark of Sea Byte Inc.

Video data were collected along all transects surveyed within the survey area. All records including geographical position, and audio observations were recorded automatically throughout the survey. Navigational fixes (geographical coordinates) are recorded within the IVMS database every two seconds throughout the survey.

The video/towfish was constantly towed at a speed of approximately 1.0 to 2.0 knots, and the camera was maintained at a distance of three to five feet from the sea bottom. Precision mapping of identified features was accurately conducted during post processing. The post-processing mapping effort was conducted following the field survey.

The survey was conducted along the approximate centerline of the proposed pipeline route from the 200-foot contour westward to the Submerged Breakwater / Spoil area located along the northern edge of the Port Everglades ship channel. Three parallel transects were conducted along the proposed route, one along the centerline and one at a distance of approximately 150 feet offset on either side of the centerline to document the bottom substrate and habitat that is present. The centerline was moved slightly during the survey and accordingly the IVMS transects do not always perfectly straddle the current centerline. Near exit and entrance holes for the directional drilling operation, several perpendicular IVMS transects across the pipeline centerline were conducted to document bottom conditions and the presence and extent of any sensitive communities that may occur within the area.

Video records collected provided a general characterization of the bottom as the video camera passes over the habitat. This was useful for mapping large areas and provided a general characterization of the bottom type (i.e., hardbottom, sand, etc.).

General observations of the large dominant species were made. Subsequent dives to conduct additional video and still photography and to collect quantitative biological data at representative areas were conducted to provide more detailed characterization. Photographs were collected using a Nikonos underwater camera and strobe and video records were collected using a digital video camera in an underwater housing.

Within the area called the Second Reef-Sand Complex additional transects perpendicular to the proposed pipeline route were investigated using the IVMS. A total of twelve transects oriented in an approximate north-south direction were surveyed for the presence of seagrasses and reef structures. Upon completion of the video collection, the data were reviewed and all areas of seagrasses and reef structure along the transects were mapped. The total distance of each of these habitat types was calculated and divided by the total distance mapped along the twelve transects. This provided the percentage of hardbottom habitat within the Second Reef-Sand Complex.

2.3 Biological Benthic Surveys

The scope of services also included the quantification of hard corals, sponges, and soft corals. Although the term "soft corals" encompasses a wide range of polyped sessile cnidarians, in this report it refers only to the branching gorgonians and also includes alconarians in the deeper water habitats.

To quantify percent cover of corals and density of hard corals, sponges, and soft corals on the proposed pipeline corridor, we surveyed ten representative random transects, each encompassing 30 m^2 of benthic habitat. Divers used 1 meter x 0.75 meter (0.75 m^2) quadrats along each side of a 20 meter transect line (40 total quadrats), for a total of 30 m^2 of surveyed habitat. The number of hard corals, sponges, and soft corals within each 0.75 m^2 quadrat were counted and the length and width of each hard coral was measured to the nearest centimeter. Hard corals less than one-centimeter diameter and non-fleshy (encrusting) sponges and encrusting soft corals were not counted. Hard corals were identified to species. At one site (26 meters, 80 feet depth on the Third Reef-Sand Complex) the depth was too great to survey the entire 30 m^2, and 15 m^2 was surveyed in order to remain within safe diving limits.

To calculate percent cover of corals, the length and width of each colony was applied to the equation for the area of a rectangle, unless the length and width were equal, in which case they were applied to the equation of the area of a circle. The area obtained represented the two-dimensional footprint of each of the colonies, which were summed for each transect and divided by 300,000 cm^2. The resulting value represented the percent of this habitat that is occupied by hard coral. Density (m^2) was calculated by dividing the number of corals, sponges, and soft corals on each transect by 30 m^2. In habitats designated as a "complex", the proportion of sand was appropriately included into the percent cover and density of organisms.

Along the anticipated pipeline corridor, two transects per habitat were surveyed at the Third Reef, the Second Reef, and the designated Submerged Breakwater / Spoil area near where the HDD #1 Exit hole (see Section 2.4 below) is proposed (two transects were also completed to the west of this location). One transect was surveyed at the Third Reef-Sand Complex and the Second Reef-Sand Complex area. Information from nearby transects taken in an earlier studies of the Third Reef and the First Reef was also used.

A swimming survey for seagrasses at the HDD #2 entrance hole (see Section 2.4 below), encompassing the proposed dimensions, was conducted.

Table 1 presents locations and depths of each biological transect.

Figure 8 shows the locations of the biological transects surveyed along the pipeline corridor.

2.4 Proposed Construction Activities

Following the characterization of marine resources within 150 feet of the proposed pipeline centerline, anticipated direct and indirect impacts to these resources were

determined based on the location, type, and dimensions of proposed construction features in the Nearshore project area. A detailed description of these construction measures, as provided by Calypso, is given below.

2.4.1 General Nearshore Construction

The proposed Nearshore portion of the Calypso Natural Gas Pipeline will be constructed using a combination of horizontal directional drilling (HDD) techniques and dredging. For the purposes of this report, Nearshore is defined as that portion of the proposed pipeline that will be constructed in Florida state tidal waters that occur between the mean high water line on the coastal barrier island and the eastern limit of Florida state waters, three nautical miles from the shoreline.

To minimize impacts to natural hardbottom features in the Nearshore project area, the pipeline approach to Port Everglades will be installed using two sequential directional drills totaling approximately 9,746 feet. Between the two HDD segments, an approximately 2,132-foot long by 25-foot wide by six-foot deep trench will be excavated through an existing submerged spoil area; this trench will be backfilled with washed crushed rock following pipeline installation. Where water depths are 120 to 200 feet, the pipeline will be laid directly on the sea bottom and covered with articulated concrete mats. Where water depths exceed 200 feet, the pipeline will lay uncovered on the sea bottom.

2.4.2 Proposed Construction Methods

The Nearshore portion of the Calypso Natural Gas Pipeline will be buried or covered where depths are less than 200 FSW. Pipeline cover will be achieved by horizontal directional drill (HDD), open cut trenching and backfill, or placement of articulated concrete mats. Where water depths are greater than 200 feet, the pipeline will lay directly on the sea bottom. The Nearshore pipeline will be constructed of 0.813-inch thick steel that has been concrete-coated for on-bottom stability and mechanical protection. External corrosion protection measures for the Nearshore pipeline will be accomplished with 14-16 mils of external fusion bond epoxy coating and sacrificial anodes.

Dredging

Prior to commencement of HDD activities, traditional open-cut excavation techniques will be employed to create the following components of the Nearshore pipeline construction:

- HDD entrance/exit holes. Three HDD entrance/exit holes – HDD #1 exit, HDD #2 entrance and HDD #2 exit – will be excavated first. Each of these holes will be approximately 60 feet by 75 feet and will be utilized to guide pipe strings for HDDs and also to entrain any drilling mud that might be released during HDD activities.

HDD entrance and exit holes are located in the Submerged Breakwater Spoil area or areas dominated by open sand.

- Open cut trench. To allow pipeline installation beneath the Second and Third Reef crests, an approximately 2,132-foot by 25-foot open cut trench will be excavated between the exit hole for HDD#1 and HDD #2. The open cut trench is located entirely within the Submerged Breakwater Spoil area and will not impact any naturally occurring hardbottom habitat.

HDD entrance/exit hole and open cut trench excavation will be conducted using a barge-mounted clamshell mounted on a spud barge. The barge will be spudded for station keeping, rather than anchored to avoid incidental bottom damage due to anchor wire rope sweeping. Excavated material will be loaded onto a cargo barge and hauled to a previously approved upland site for disposal.

Upon completion of both HDD and pipeline shore approach installation activities, all excavated areas will be backfilled with at least three feet of clean gravel and rock material, the uppermost 18 inches of the backfill consisting of approximately 12-inch diameter cobbles.

Horizontal Directional Drilling (HDD) Techniques

HDD techniques have been proposed for the shore approach because directional drilling is essentially trenchless construction that, with the exception of the drill entrance/exit holes and pipe lay down areas, permits installation of a pipeline without surface disruption. By employing two directional drills separated by a short trench, the project can be constructed such that the First Reef system is entirely avoided, and the majority of the Second and Third Reef zones are not impacted.

Construction of the Nearshore portion of the Calypso Natural Gas Pipeline project will involve two sequential horizontal directional drills (HDD) totaling 9,746 feet. The first and second HDDs are separated by an open cut trench which is approximately 2,132 feet long.

Completion of the first HDD will require a seabed area approximately 60 feet by 75 feet to be excavated to allow for the exit of the HDD drill string. A Nearshore jack-up or spud barge will be utilized to handle the termination of the HDD drill string and to allow for the addition of reaming tools, retrieval of drilling mud, and finally connection of the pull string to complete the HDD operation. Upon completion of the first HDD, the drilling rig will be relocated onto a jack-up barge to install the second HDD. Upon completion of both HDD operations, the two pipeline sections will be connected mid span between HDD #1 exit and HDD #2 entrance holes. The connection will be welded above water by picking up both ends of the pipeline sections above water. This operation is performed with a spud barge positioned over the open cut trench. After welding the pipeline together, it will be lowered into the open cut trench, following which the trench will be backfilled with washed gravel and finally covered with 12-inch diameter rock.

Proposed Nearshore construction steps can be summarized as follows:

- Step 1: HDD entrance and exit holes and the approximately 2,132-foot long open cut trench are excavated.

  In preparation for the first HDD, the required subsea excavation for the exit/entrance holes and the open trench between HDD #1 and HDD #2 will be completed (see above), the pipe pull string will be pulled into position prior to commencement of drilling operations, and the required drilling rig and supporting equipment will be installed and commissioned.

- Step 2: HDD #1 is drilled beneath the Port Everglades Entrance Channel from the onshore HDD #1 entrance hole, to a jackup or spud barge positioned at the HDD #1 exit hole.

  This drill, HDD #1, which will be approximately 4,616 feet in length, will be initiated from the Onshore Nova Southeastern University site and will terminate in approximately 17 feet of sea water (FSW) in a previously disturbed area, north of the Port Everglades entrance channel (see Figure 7-4).

- Step 3: The pipe string for HDD #1 is pulled into the HDD #1 exit hole along a 10-foot wide pull corridor; this pipe segment is shown installed in Figure 7-9.

  The pull string for HDD #1 will be pulled into position on the seabed from a second-generation lay barge anchored east of the HDD #2 exit hole. A Lucker linear winch positioned on a jackup or spud barge located at the HDD #1 exit hole will pull the pipeline from the anchored lay barge along a pipe pull corridor from the laybarge to the exit hole of HDD #1. The pipe pull corridor for pulling the pipeline will be an area approximately 10 feet wide located along the centerline of the right-of-way. This pipe pull corridor will extend from the HDD #2 exit hole (120 FSW depth) to the HDD #2 entrance hole (17 FSW). The balance of the pull will be through the open cut trench. After the pipe string is in position and the drill operations are completed, the pullback operation will be executed where the pipe is pulled through the drilled hole.

- Step 4: HDD #2 is drilled beneath the Second and Third Reef zones from a jackup or spud barge positioned at the HDD #2 entrance hole to the HDD #2 exit hole.

  This second HDD, which will be approximately 5,130 feet, will originate in 37 FSW and will terminate in approximately 120 FSW. The pull string will be positioned on the seabed starting at the HDD #2 exit hole (120 FSW) and will extend to the east for a distance equal to the HDD #2 pull string length. The second HDD will be sequenced similar to the first drill, with the pipe being pulled from deepwater towards shore in the pull back operation.

- Step 5: The pipe string for HDD #2 is pulled into the HDD #2 exit hole from its preinstalled position extending from the HDD #2 exit hole in an easterly direction.

- Step 6: Pipeline segments in HDD #1 and HDD #2 are connected in the open-cut trench area.

  Upon completion of both HDD operations, the two pipeline sections will be connected mid span between HDD #1 exit and HDD #2 entrance holes. The connection will be welded and accomplished by picking up both ends of the pipeline sections above water. This operation is performed with a jackup or spud barge positioned over the open cut trench. The pipeline will be lowered back into the ditch after the tie-in is complete.

- Step 7: HDD entrance and exit holes and the open-cut trench are backfilled with washed gravel and rock.

  The washed rock will be installed from a barge with a downfall pipe. The rock will be installed in layers, with the layer at the bottom of the trench graded with a small (R-3) size, and the top layer being a larger size (R-6).

- Step 8: The pipeline is installed on the seabed between 120 FSW and the eastern limits of Florida state waters. Between 120 and 200 FSW (approximately 1,836 feet), the pipeline is covered with articulated concrete mats.

Based on existing data local to the proposed area, there are no foreseeable major technical difficulties in completing the horizontal directional drills. The actual feasibility and the detail plans of the proposed Onshore and Nearshore directional drills will be determined with data obtained with a comprehensive and site specific geotechnical drilling program.

Deep Water Pipelay

Where water depths exceed 120 FSW, the pipeline will be installed on the sea bottom from a lay barge. The lay barge will be an industry-standard third-generation design, in that the barge will likely be dynamically positioned and equipped for double-joint automatic welding operations.

A "tail" section of the pipeline about 1,000 to 1,500 feet long will be installed as a part of the HDD #2 pull string. The section will extend from the HDD #2 exit hole, in 120 FSW, to allow the lay barge the ability to back-under the pipeline for start of pipe lay operations.

The deep water lay barge will be supplied with forty-foot joints of pipe that have been corrosion and concrete coated as designed for bottom conditions. The pipe will be transported from an onshore coating facility located outside the state of Florida directly to the lay barge with marine pipe haul vessels.

Installation of the pipeline will have a controlled unsupported span from the barge stern to seabed. This span will be maintained to a configuration controlled with a "stinger" connected to the lay barge stern and tension will be applied to the pipeline by tension equipment on the deep water lay barge.

The length of pipeline extending from the second exit hole in 120 FSW to the 200 FSW contour, approximately 1,836 feet, will be covered with articulated concrete mats for pipeline stability and mechanical protection. For water depths greater than 200 FSW, the pipeline will not be covered.

Emergency procedures due to adverse weather conditions and installation situations will be developed to provide for the safety of construction spreads and pipeline during installation operations.

Figure 7 shows the pipeline route and proposed construction features.

3.0 BIOLOGICAL CHARACTERIZATION

3.1 Habitat Map

Video transects were collected along the proposed pipeline corridor as indicated in **Figure 9**. Approximately 15 km of the seafloor were IVMS transected. A total of eight habitat types were delineated in this study along the route from the northern edge of the Port Everglades channel out to the 200-foot water depth contour including:

1. First Reef
2. Submerged Breakwater/Spoil
3. Second Reef
4. Second Reef-Sand Complex
5. Sand
6. Third Reef
7. Third Reef-Sand Complex, and
8. Third Reef Transitional. (some video transects went to 250 feet depth in this habitat)

The location of each of the above habitat types along the route is shown in **Figure 10**. Also indicated on **Figure 10** is a layer underlying the video transects which is the LIDAR sunshaded bathymetric data collected by the U.S. Army Corps of Engineers. Each habitat appears to correlate well with distinct bottom changes/contours identified by the LIDAR data imagery. **Figure 11** shows the general habitat locations The First Reef habitat is shown on **Figure 11** for reference.

A general description of each habitat type follows.

3.1.1 First Reef

This habitat is avoided entirely by the proposed pipeline route and is only included in this report for completeness. The habitat is generally low relief, shallow water hardground which supports a community of hard corals, soft corals, and sponges as well as other fauna and marine flora. The habitat extends to about one kilometer from shore. **Figure 12** shows sample photographs of this habitat.

3.1.2 Submerged Breakwater/Spoil

This habitat classification designates an area containing two features: an old submerged breakwater on the north side of the Port Everglades channel and an adjacent area of spoil accumulation. The latter feature includes abundant rubble that appears to be from maintenance dredging of the ship channel. In the area in the immediate vicinity of the ship channel, the bottom depth rises to approximately 3 m. The spoil is immediately to the north of the breakwater. Both the old submerged breakwater and the spoil areas are high-energy environments when affected by wave action that occurs in conjunction with high seas often caused by storms and north/northeast winds.

The Submerged Breakwater / Spoil area is bounded to the south by the northern edge of the ship channel and to the north by an area of open sand that occurs on the western edge of the Second Reef (**Figure 11**). This Submerged Breakwater/Spoil area appears as a loosely consolidated bottom type with pieces of rubble estimated to range in size from very small (less than 20 centimeters diameter) up to 1 meter in diameter. A majority of the rubble appears to range in size from 20 to 30 centimeters diameter.

The relative proportion of rubble to sand along the proposed pipeline route is greatest (estimated to be approximately 100 percent rubble) near the edge of the ship channel. The proportion of rubble generally decreases with distance from the edge of the channel (with the exception of the crest of the spoil) until the bottom type becomes comprised completely of sand on the western side of the Second Reef.

The HDD (Horizontal Directional Drill) #1 exit hole along the proposed pipeline route occurs within this habitat, approximately midway between the old breakwater and spoil mounds. Four quantitative biological transects have been completed within the habitat: two were completed at the current proposed HDD #1 exit hole location and two were completed to the west of this location. **Tables 1-4** provide data and descriptive characteristics of these transects. There was an average density of 0.71 hard corals, 0.23 sponges, and 0.20 soft corals / m^2 within this habitat.

The substrate is a mixture of unconsolidated sand and partially buried rocks and rubble. Complexity is low, with few large structures. The diversity of biota within this habitat is low. Coral colonies are typically small in size. The community is dominated by algae, such as *Caulerpa* sp., *Dictyota* sp. and various macro chlorophyta and phaeophyta, attached to individual pieces of rubble. A few sponges are present. Hard corals present

include *Solenastrea* spp., *Siderastrea* spp. and *Porites* spp. Few soft coral colonies are present and include species such as *Psuedopterogorgia* sp. Specimens observed were generally less than 10 centimeters in height.

The northern portion of this habitat will contain a portion of the proposed 25-foot wide by 2,132-foot long trench to be constructed between the HDD #1 Exit hole to HDD #2 Entrance hole.

No specimens of the endangered seagrass, *Halophila johnsonii,* were observed in this habitat.

The proposed pipeline route will traverse approximately 1,977 feet of the Submerged Breakwater / Spoil area. Impacts to this habitat type will include excavation of the HDD #1 exit hole and the open cut trench (see Section 2.4 and Tables 5-11).

Figure 13 is representative of the bottom type and organisms at the transect site.

3.1.3 Second Reef

The Second Reef habitat occurs along and near the proposed pipeline route in two places: to the west of the HDD #2 Entrance hole north of the proposed pipeline trench and immediately to the east of the HDD #2 Entrance hole, approximately 100 meters east of the innermost sand area (**Figure 11**).

The Second Reef is characterized by alternating low relief reef spurs and thin sand channels that run in an east-west direction. The sand channels occur as narrow (1-2 meters in width) "fingerlike" breaks in the reef structure with a depth of 0.5-2 meters. The reef spur structures have vertical relief ranging from 0.5 to 2 meters. Complexity is lower on the crest than at the reef edges. At both the eastern and western edges of the Second Reef the sand bottom grades slowly up to the reef structure. No jagged, ledge-like features were observed along edges of the reef within the proposed route. Greater structural complexity of the reef appears to occur primarily along the sand channels and as small holes in the reef structure. Biota on the reef appears dominated by large soft corals and sponges. Some of the hard coral species observed included *Montastrea cavernosa, Stephanocoenia michellini, Diploria clivosa, Siderastrea* spp., and *Porites* spp. In general, hard corals are generally less than 0.5 meters in diameter, but may reach larger sizes in some areas. In sections of the Second Reef that are present within the pipe pull corridor, some large (20-70 centimeters in diameter) colonies of massive corals such as *Colpophyllia natans* and *Meandrina meandrites* are present together with often large (approximately 1 meter height) gorgonians.

Biological transects were surveyed within the Second Reef habitat. The density of sponges, soft corals, and hard corals occurring on the Second Reef are presented in **Tables 1-4**. There was an average density of 2.0 hard corals, 19.48 sponges, and 1.43 soft corals / m^2 within this habitat.

The proposed pipeline will be directionally drilled beneath the Second Reef, and no excavation will occur in this habitat type. Anticipated impacts to the Second Reef will be limited to an approximately 470-foot long by 10-foot wide portion of the pipe pull corridor for HDD #1 (see Section 2.4 and Tables 5-11).

Figure 14 is representative of the bottom type and organisms at the Second Reef.

3.1.4 Sand

Sand habitat occurs in several locations along the proposed pipeline. Expanses of sand occur in between two lobes of the Second Reef and on the east side of the Second Reef between the Second Reef-Sand Complex habitat and the Third Reef habitat (**Figure 11**). Sand also comprises a fraction of the habitats characterized as Second Reef-Sand Complex, Third Reef-Sand Complex and Third Reef Transitional habitat, and occupies areas where water depths are greater than 200 feet. It is not possible from the video record to determine the depth and volume of sand that is present.

Soft sediment communities dominate the sand habitat. Reef organisms are generally only present on infrequent rubble pieces or man-made debris that is occasionally seen in this area.

The proposed pipeline will traverse approximately 2,204 feet of sand habitat between the shoreline and the 200-foot contour. Anticipated impacts to sand habitat will include excavation of the HDD #2 entrance hole, approximately 230 feet of the open cut trench and impacts along two sections of the 10-foot wide pipe pull corridor for HDD #1, the first approximately 159 feet long and the second approximately 1,740 feet long (see Section 2.4 and Tables 5-11).

Figure 15 is representative of the bottom type of the Sand habitat.

3.1.5 Second Reef-Sand Complex

On the western edge of the Second Reef there is an area of sand and scattered reef that forms a zone between the Second Reef and the sand flat that extends to the Third Reef. The scattered reefs are present throughout the area and some are visible in the LIDAR imagery (**Figure 11**). The scattered reefs range in relief from nearly flat exposed rock that appears to be occasionally covered by sand to exposed reef structures with a relief of 1-2 m. Community composition on the reefs is similar to the Second Reef, consisting mainly of soft corals and sponges with sparse hard corals. Reefs with greater relief have the most significant biota community associated with them. The most complex reef structures appear to occur on the eastern edge of the habitat.

See **Tables 1-4** for characterization and data at the transect sites on the Second Reef-Sand Complex. When averaged across the entire habitat type (i.e., hardbottom and sand areas), there was an average density of 0.78 hard corals, 5.01 sponges, and 0.02 soft corals / m^2.

The proposed pipeline will be directionally drilled beneath the Second Reef-Sand Complex, and no excavation will occur in this habitat type. Anticipated impacts to the Second Reef-Sand Complex will be limited to an approximately 970-foot long by 10-foot wide portion of the pipe pull corridor for HDD #1 (see Section 2.4 and Tables 5-11).

Figure 16 is representative of the community of this habitat.

Halophila decipiens, a common subtropical seagrass (not threatened or endangered), is present in sand portion of this habitat. The seagrass was observed in approximately 15 meters of water depth within the pipe pull corridor. Based on the IVMS video surveys (see Section 2.3), we estimate the proportion of sand is 78% compared to reef structure. Within the sandy areas, we estimate approximately 5% has seagrass occurrence.

Figure 17 shows a sample of this seagrass species.

This Second Reef-Sand Complex habitat is present in the pipe pull corridor of the proposed pipeline.

3.1.6 Third Reef

The Third Reef rises from the eastern end of the sand habitat east of the Second Reef-Sand Complex. In the area of the proposed pipeline the Third Reef is of relatively low complexity. No jagged ledge-like features were observed along the proposed pipeline corridor. The Third Reef crest is a broad surface which begins to slope downwards towards the east. The eastern boundary of this habitat is at about 70 feet water depth. The Third Reef surface contains sponges and soft corals. Hard corals are also present, including *Montastrea cavernosa* and *Madracis* sp. The spiny lobster *Panulirus argus* was also observed on the Third Reef.

See **Tables 1-4** for characterization and data at the transect sites on the Third Reef. There was an average density of 3.0 hard corals, 15.77 sponges, and 11.85 soft corals / m^2 within this habitat.

The proposed pipeline will be directionally drilled beneath the Third Reef, and no excavation will occur in this habitat type. Anticipated impacts to the Third Reef will be limited to an approximately 350-foot long by 10-foot wide portion of the pipe pull corridor for HDD #1 (see Section 2.4 and Tables 5-11).

Figure 18 is representative of the Third Reef in the vicinity of the proposed pipeline centerline.

3.1.7 Third Reef-Sand Complex

Along the eastern edge of the Third Reef in depths approximately deeper than 70 feet, the Third Reef becomes a series of scattered, higher complexity patches broken by areas of sand (**Figure 11**). The proportion of sand is estimated from IVMS mapping to be 62%. The reef features are estimated to range in relief from 0.5-2 meters and occur at least down to about 120-foot water depth. Reef features have a variety of structural complexity ranging from smooth and nearly flat to jagged ledge-like features with craggy undercut holes. Biota on these reef features is similar to that on the Third Reef and includes sponges, soft corals, and hard corals. Due perhaps to the substantial relief and the structural complexity, considerable fishes were observed in this area, including red grouper, *Epinephelus morio* and grey snapper, *Lutjanus griseus*. The spiny lobster, *Panulirus argus* was also observed on this habitat.

The proportion of hardbottom to sand in the Third Reef-Sand Complex was determined from IVMS video survey data. Based on IVMS video surveys, we estimate that sand occupies approximately 62% of this community type, while hardbottom comprises approximately 38%. In addition, quantitative data were collected for this habitat type where water depths were within safe diving limits (i.e., less than 120 feet of water), and IVMS records confirm that similar bottom conditions exist to the lower limit of this defined habitat.

These habitats are within the pipe pull corridor of the proposed pipeline. **See Tables 1-4** for data and characteristics of the transect site on this habitat.

When averaged across the entire habitat type (i.e., hardbottom and sand areas), there was an average density of 1.09 hard corals, 7.60 sponges, and 1.93 soft corals / m^2.

The proposed pipeline will be directionally drilled beneath the Third Reef-Sand Complex, and no excavation will occur in this habitat type. Anticipated impacts to the Third Reef-Sand Complex will be limited to an approximately 641-foot long by 10-foot wide portion of the pipe pull corridor for HDD #1 (see Section 2.4 and Tables 5-11).

Figure 19 is representative of this habitat type in the vicinity of the proposed pipeline centerline.

3.1.8 Third Reef Transitional Complex

East of the Third Reef Sand Complex an area that we refer to as the Third Reef Transitional Complex occurs in water depths between approximately 100 to at least 200 feet. This habitat appears as a low relief, low structural complexity habitat. The bottom is relatively flat and has an underlying layer of hardbottom that is typically covered with a sand veneer. In a few instances areas of small rocks or exposed rock surfaces were observed. These exposed rock areas typically have a relief of less than 1 foot; however, a majority of the habitat is low relief hard substrate covered with a veneer of sand.

The greatest proportion of organisms that occur in this habitat appear to be soft corals and sponges. These species occur attached to the underlying hard substrate and protrude

upward through the overlying sand veneer. In areas where there is some exposed rock or small rocks the cover of these organisms appears somewhat greater and often there are fishes associated with the very low relief structure. Because this habitat type occurs at depths greater than safe diving limits, the biological characterization of the Third Reef-Sand Transitional Complex was developed from IVMS records. Based on IVMS data, the density of organisms appears to be lower in this habitat type than for the Third Reef-Sand Complex, and no zooxanthellate hard corals were observed in the Third Reef-Sand Transitional Complex. Small ahermatypic coral species are likely present but were not observed in the video record.

IVMS data allow an estimation that approximately 10% of this habitat is occupied by hard bottom in this habitat and 90% is occupied by sand.

The proposed pipeline will be directionally drilled beneath a portion of the Third Reef Transitional Complex. Anticipated impacts to the Third Reef Transitional Complex will include impacts along an approximately 800-foot long section of the 10-foot wide pipe pull corridor for HDD #1, excavation of the HDD #2 exit hole and the placement of approximately 1,836 feet of articulated concrete mats (see Section 2.4 and Tables 5-11).

3.2 Benthic Survey Quantitative Organism Data

The overall results of the quantitative benthic surveys are presented **Tables 1-4.**

Table 1 presents general transect site descriptions and locations.

Table 2 contains detailed transect summary data for each transect site.

Table 3 gives a summary by habitat of transect results.

Table 4 provides hard coral species occurring at each habitat.

3.3 Density and Percent Cover of Corals

Table 3 indicates that the mean density (# of corals per m^2) of hard corals along the pipeline route varied from 0.71 (Submerged Breakwater / Spoil area) to 3.00 corals/m^2 (Third Reef). For hard corals greater than 25 cm^2, density ranged from to 0.09 (Submerged Breakwater/Spoil Area) to 0.90 (Third Reef). Percent hard coral cover was lowest at the Submerged Breakwater/Spoil Area (0.16%) and highest in the Third Reef area (1.34%). Density and percent cover of hard corals are slightly higher at the Third Reef south of the proposed pipeline corridor (surveyed in January 2001, see **Table 2**).

The species of hard corals observed on the transects are generally representative of Broward County reef habitat. These included *Madracis decactis*, *Montastrea cavernosa*, *Scolymia* sp., *Agaricia* sp. *Siderastrea siderea,* and *Stephanocoenia michelinii*. Generally density and percent cover are greater in areas of higher complexity, such as the eastern portions of the Second and Third Reefs.

3.4 Sponge Density

Table 3 indicates that sponge density along the pipeline route was variable and ranged from 0.23 (Submerged Breakwater/Spoil area) to 19.48 colonies / m^2 (Second Reef zone). Biological transects were only conducted only on reef structures, not including sand channels.

3.5 Soft Coral Density

Table 3 indicates that soft coral density was lowest in the Second Reef-Sand Complex area (0.02 colonies / m^2) and highest at the Third Reef (11.85 colonies/m^2).

Both sponges and soft corals tended to increase in density with increasing depth.

3.6 First Reef

Table 3 also provides summary data for the First Reef (see **Figure 10**). This data is taken as the mean of eight (8) transects performed on this habitat throughout Broward County. This information is provided for completeness of this report. However, the proposed pipeline route completely avoids the First Reef zone. Consequently, a valuable habitat containing many organisms is not affected by the proposed pipeline.

3.7 General

Based on the benthic surveys and video data collected during this investigation, the habitat areas with the highest macro organism presence are the Second and Third Reefs and the associated hardbottom areas within the Reef-Sand Complex habitats. Although no excavation will occur in these areas, they will be affected along the proposed 10-foot wide pipe pull corridor. The Submerged Breakwater / Spoil habitat area includes the HDD #1 Exit hole and the trenching between HDD #1 Exit and HDD # 2 Entrance. This habitat is of lower organism occurrence and consists mainly of rubble. The protected seagrass *Halophila johnsonii* has not been observed on surveys in this area of the corridor. The HDD #2 Exit hole occurs in the Sand habitat. The presence of non-endangered seagrass *Halophila decipiens* has been detected at low frequency within the pull area of the pipeline corridor (Second Reef-Sand Complex).

4.0 IMPACT AREAS

Areas of direct impact were calculated along the proposed pipeline corridor within each of the designated habitats. impact was assessed in the physical impact category. Evaluation of temporary sedimentation / turbidity impact utilized computer model output and is also presented in this study.

4.1 Physical Impact

Assessment of physical impact involved utilizing the supplied dimensions of the anticipated exit and entrance holes, of the trench width, and of the laydown area width together with the length of impact within each habitat. These dimensions were:

- HDD #1 Exit hole dimensions were: 60 ft x 75 ft.
- HDD #2 Entrance hole dimensions were: 60 ft x 75 ft.
- HDD #2 Exit hole dimensions were: 60 ft x 75 ft.
- The dimensions of the pipe pull corridor was taken to be 10 ft x 5,130 from HDD #2 Entrance to HDD #2 Exit.
- The dimensions of the open trench was taken to be 25 ft by 2,132 ft from HDD #1 Exit to HDD #2 Entrance.
- The dimensions of the armor mat blanket from 120 ft depth to 200 ft depth was taken to be 20 ft by 1,836 ft.

Size of the physical impact within each habitat was estimated by multiplying the length and width of the holes or the length of the impact within the habitat times the width of the impact (e.g., 10 feet for laydown, 25 feet for trenches).

Table 5 provides the detailed calculations in feet and acres of possible physical impacts for each habitat. For the habitats of the Second Reef-Sand Complex, the Third Reef-Sand Complex, and the Third Reef Transitional Complex, habitat areas have been factored by the appropriate % of sand present.

Table 6 summarizes hardbottom direct impact by construction feature. **Table 7** summarizes hardbottom direct impact by habitat type. A total of 1.60 acres of habitat other than sand will be affected directly to 200 foot water depth by physical impact of the pipeline, assuming construction parameters discussed. In addition, we estimate that approximately 0.008 acres of habitat supporting the seagrass *Halophila decipiens* will also be directly impacted.

4.2 Sedimentation/Turbidity Impact

Temporary impact of sedimentation and turbidity was determined in a similar manner from dimensions supplied by results of a computer model. The model, developed and run by Chris Reed of URS, depicted the outer most contour from the source where 2 mm sediment deposition takes place or the 30 mg/L (= 29 NTU) contour (turbidity) over the span of construction. The sedimentation impact dominates the impact area. This 2 mm limit was chosen as inclusive of detrimental biological effects to the benthic community which may lie within. The simulations considered operations out to 200 feet. Details of the sedimentation and turbidity analysis are documented in a separate report.

Relevant to this work were the average trench width (total width) and exit hole diameter.

The results were:

- Average exit hole impact area radius = 139 feet
- Average impact area width along the trench = 92 feet

Table 8 provides the detailed calculations in feet and acres of possible indirect impacts for each habitat. For the habitats of the Second Reef-Sand Complex, the Third Reef-Sand Complex, and the Third Reef Transitional Complex, habitat areas have been factored by the appropriate % of sand present.

Table 9 summarizes indirect hardbottom impact by construction feature. **Table 10** summarizes indirect hardbottom impacts by habitat type. A total of 4.34 acres of habitat other than sand will be additionally affected to 200 feet of water depth by indirect impact of the pipeline, assuming construction parameters discussed.

4.3 Combined Physical and Sedimentation/Turbidity Impact

Table 11 summarizes habitat area results for direct, indirect, and total impacts. A total of 5.94 acres of habitat other than sand will be affected to 200 foot water depth by direct and indirect impact of the pipeline, assuming construction parameters discussed.

Table 1: General Transect Site Descriptions and Locations Along the Proposed Pipeline Route.

Survey	Name	Date of Survey	Habitat	Latitude/ Longitude	Depth (m)	# Replicates	Survey Area (m^2)	Organisms Surveyed[1]
Pipeline Route Survey May 01	3RN2	5/24/01	Third Reef	26 06'09.268" N/ 80 04'58.409" W	21	2	60	C, S, G
	3RC	5/30/01	Third Reef-Sand Complex	26 06'12.223" N/ 80 04'51.596" W	26	1	15	C, S, G
	2R	5/30/01	Second Reef	26 05'55.069" N/ 80 05'28.542" W	14	2	60	C, S, G
	2RC	5/31/01	Second Reef-Sand Complex	26 05'59.513" N/ 80 05'15.575" W	17	1	30	C, S, G
	SBS	5/25/01 6/8/01	Submerged Breakwater/Spoil	26 05'46.977" N/ 80 05'49.006" W	7	4	120	C, S, G
Initial Third Reef Survey Jan. 01 (not within Proposed Pipeline Corridor)	3RN1	1/12/01	Third Reef North of Inlet	26 05'54.00" N/ 80 04'58.50" W	17	4	120.75	C
	3RS	1/6/01	Third Reef South of Inlet	26 05'21.180" N/ 80 05'07.920" W	18	4	120	C

[1] C = Hard corals; S = Sponges; G = Gorgonians (soft corals).

Table 2: Detailed Transect Data for Each Benthic Survey Along the Proposed Pipeline Route.

Survey	Name[1]	Depth (m)	# Hard Corals/m^2	%Hard Coral Cover	# Hard Corals >25 cm^2/m^2	# Sponges/m^2	# Soft Corals/m^2
Pipeline Route Survey May 01	3RN2-1	21	1.10	0.26	0.23	15.17	8.80
	3RN2-2	18	1.13	0.82	0.53	16.37	14.90
	3RC	26	2.87	1.48	1.67	20.00	5.07
	2R-1	14	2.00	0.67	0.53	19.27	1.50
	2R-2	14	2.00	0.44	0.37	19.70	1.37
	2RC	17	3.53	1.39	1.30	22.77	0.07
	SBS-1	8	0.30	0.04	0.03	0.03	0.13
	SBS-2	8	0.20	0.03	0.03	0.20	0.27
	SBS-3	6	0.27	0.02	0.00	0.07	0.20
	SBS-4	6	2.07	0.54	0.30	0.63	0.19
Initial Third Reef Survey Jan. 01	3RN1-1	18	2.63	1.26	0.88	N/A	N/A
	3RN1-2	18	2.50	0.98	0.70	N/A	N/A
	3RN1-3	15	2.83	1.59	1.33	N/A	N/A
	3RN1-4	15	3.97	1.79	1.57	N/A	N/A
	3RS-1	18	3.30	1.05	0.73	N/A	N/A
	3RS-2	18	3.80	2.95	0.87	N/A	N/A
	3RS-3	17	3.27	1.29	1.17	N/A	N/A
	3RS-4	17	5.33	1.38	1.00	N/A	N/A

1 3RN2 = Third Reef, north of entrance channel (May '01 survey); 3RN1 = Third Reef, north of entrance channel (January '01 survey); 3RS = Third Reef, south of entrance channel; 3RC = Third Reef-Sand Complex; 2R = Second Reef; 2RC = Second Reef-Sand Complex; SBS = Submerged Breakwater / Spoil.

Unless otherwise noted, all transect data were collected on the north side of the Port Everglades entrance channel.

Table 3: Data Summary by Habitat Along the Proposed Pipeline Route

Values are means of all transects surveyed within that habitat. First Reef mean values obtained in a previous study are included as a comparison and represent the greater Broward County inshore area. N equals the number of transects surveyed at each habitat type. For Reef-Sand Complexes, values are averages across the habitat type (i.e., factoring in sand).

Habitat	N	Survey Area (m^2)	Depth (m)	Mean # Hard Corals /m^2	Mean # Hard Corals > 25cm^2/m^2	% Hard Coral Cover	Mean # Sponges /m^2	Mean # Soft Corals /m^2
Third Reef	10	300.75	15-21	3.00	0.9	1.34	15.77	11.85
Third Reef-Sand Complex	1	15	26	1.09	0.63	0.56	7.60	1.93
Second Reef	2	60	14	2.00	0.45	0.56	19.48	1.43
Second Reef-Sand Complex	1	30	17	0.78	0.29	0.31	5.01	0.02
Submerged Breakwater/ Spoil	4	120	6-8	0.71	0.09	0.16	0.23	0.20
Broward County First Reefs	8	240	4-6	1.70	0.63	3.42	10.73	6.27

Table 4: Hard Coral Species Occurring at Each Habitat

Hard coral species occurring at each habitat, including the hydrozoan *Millepora alcicornis*. "X" denotes presence on transect; " * " denotes presence at habitat but not on transect.

Coral Species	Third Reef May 2001	Third Reef –Sand Complex, May 2001	Second Reef, May 2001	Second Reef-Sand Complex, May 2001	Submerged Breakwater /Spoil Area, May 2001	Third Reef (north of inlet), Jan. 2001	Third Reef (South of Inlet), Jan. 2001
Acropora cervicornis							
Agaricia agaricites	x		x	x		x	x
Agaricia fragilis						x	x
Agaricia humilis				x			
Cladocora arbuscula				x	x		
Colpophyllia natans			x				
Diploria clivosa							
Diploria strigosa			x				x
Dichocoenia stokesii	x		x	x		x	x
Dilporia labyrinthiformis							x
Eusmilia fastigiata				x		x	x
Madracis decactis	x			x		x	x

Table 4. Continued

Coral Species	Third Reef May 2001	Third Reef –Sand Complex, May 2001	Second Reef, May 2001	Second Reef-Sand Complex, May 2001	Submerged Breakwater /Spoil Area, May 2001	Third Reef (north of inlet), Jan. 2001	Third Reef (South of Inlet), Jan. 2001
Montastrea cavernosa	x	x	x	x		x	x
Montastrea faveolata							x
Montastrea franksii				x		x	
Mussa angulosa			x				
Mycetophyllia ferox	x						
Mycetophyllia lamarckiana		x	x			x	
Porites astreoides	x	x	x	x	x	x	x
Porites porites					x		x
Scolymia sp.	x		x	x		x	x
Siderastrea radians	x		x	x	x	x	x
Siderastrea siderea	x	x	x	x	x	x	x
Solenastrea bournoni		x	x		x	x	
Solenastrea hyades	x				x		x

Table 4. Continued

Coral Species	Third Reef May 2001	Third Reef –Sand Complex, May 2001	Second Reef, May 2001	Second Reef-Sand Complex, May 2001	Submerged Breakwater /Spoil Area, May 2001	Third Reef (north of inlet), Jan. 2001	Third Reef (South of Inlet), Jan. 2001
Stephanocoenia michelinii	x	x	x	x	x	x	x
Madracis formosa				x			
Meandrina meandrites	x		x	x		x	x
Millepora alcicornis	x	x	x			x	x
Montastrea annularis	x				x	x	x

Table 5. Detailed Calculations of Direct Hardbottom Impact to the Nearshore Habitats.

Construction Component	Habitat Type	Width (ft)	Length (ft)	Area (sq ft)	% Hardbottom	Direct Hardbottom Impacts (sq ft)	Direct Sand Impacts (sq ft)	Total Direct Impacts (sq ft)
HDD #1 Exit Hole (Dimensions = 75 ft x 60 ft)	Submerged Breakwater Spoil	60	75	4,500	100	4,500	0	4,500
Open Cut Trench from HDD #1 Exit Hole to HDD #2 Entrance Hole (Dimensions = 2,132 ft x 25 ft)	Submerged Breakwater Spoil	25	1,902	47,550	100	47,550	0	47,550
	Sand	25	230	5,750	0	0	5,750	5,750
	Area Subtotal					*47,550*	*5,750*	*53,300*
HDD #2 Entrance Hole (Dimensions = 75 ft x 60 ft)	Sand	60	75	4,500	0	0	4,500	4,500
Pipe Pull Corridor from HDD #2 Entrance Hole to HDD #2 Exit Hole (Dimensions = 5,130 ft x 10 ft)	Sand	10	159	1,590	0	0	1,590	1,590
	Second Reef	10	470	4,700	100	4,700	0	4,700
	Second Reef-Sand Complex	10	970	9,700	22	2,134	7,566	9,700
	Sand	10	1,740	17,400	0	0	17,400	17,400

Table 5. Detailed Calculations of Direct Hardbottom Impact to the Nearshore Habitats.

Construction Component	Habitat Type	Width (ft)	Length (ft)	Area (sq ft)	% Hardbottom	Direct Hardbottom Impacts (sq ft)	Direct Sand Impacts (sq ft)	Total Direct Impacts (sq ft)
	Third Reef	10	350	3,500	100	3,500	0	3,500
	Third Reef-Sand Complex[3]	10	641	6,410	38	2,436	3,974	6,410
	Third Reef Transitional Complex	10	800	8,000	10	800	7,200	8,000
	Area subtotal					*13,570*	*37,730*	*51,300*
HDD #2 Exit Hole (Dimensions = 75 ft x 60 ft)	Third Reef Transitional Complex	60	75	4,500	10	450	4,050	4,500
Blanketing from HDD #2 Exit Hole to 200 FSW (Dimensions = 20 ft x 1,836 ft)	Third Reef Transitional Complex	20	1,836	36,720	10	3,672	33,048	36,720
TOTALS						**69,742 (1.60 ac)**	**85,328 (1.96 ac)**	**155,070 (3.56 ac)**

Table 6: Summary of Direct Hardbottom Impacts by Construction Feature

Construction Feature	**Area**	
	(sq ft)	**(acres)**
HDD Entrance/Exit Holes	4,950	0.11
Open Cut Trench	47,550	1.09
Pipe pull corridor	13,570	0.31
Concrete Blanketing	3,672	0.08
Total Direct Hardbottom Impacts	**69,742**	**1.60**

Table 7: Summary of Direct Hardbottom Impacts by Habitat Type

Habitat Type	**Area**	
	(sq ft)	**(acres)**
Submerged Breakwater Spoil	52,050	1.19
Second Reef	4,700	0.11
Second Reef-Sand Complex[1]	2,134	0.05
Third Reef	3,500	0.08
Third Reef-Sand Complex[2]	2,436	0.06
Third Reef Transitional Complex[3]	4,922	0.11
Total Direct Hardbottom Impacts	**69,742**	**1.60**

[1] Hardbottom accounts for 22% of total area; hardbottom impact area = length x width x 0.22
[2] Hardbottom accounts for 38% of total area; hardbottom impact area = length x width x 0.38
[3] Hardbottom accounts for 10% of total area; hardbottom impact area = length x width x 0.10

Table 8. Detailed Calculations of Indirect Hardbottom Impact to the Nearshore Habitats.

Construction Component	Habitat Type	Diameter (ft)[1]	Width (ft)[2]	Length (ft)	Area[3] (sq ft)	% Hardbottom	Indirect Hardbottom Impacts (sq ft)	Indirect Sand Impacts (sq ft)	Total Indirect Impacts (sq ft)
HDD #1 Exit Hole (Dimensions = 75 ft x 60 ft)	Submerged Breakwater Spoil	278	-	-	56,199	100	56,199	0	56,199
Open Cut Trench from HDD #1 Exit Hole to HDD #2 Entrance Hole (Dimensions = 2,132 ft x 25 ft)	Submerged Breakwater Spoil	-	92	1,902	127,434	100	127,434	0	127,434
	Sand	-	92	230	15,410	0	0	15,410	15,410
	Area Subtotal				*142,844*		*127,434*	*15,410*	*142,844*
HDD #2 Entrance Hole (Dimensions = 75 ft x 60 ft)	Sand	278	-	-	56,199	0	0	56,199	56,199
Pipe Pull Corridor from HDD #2 Entrance Hole to HDD #2 Exit Hole (Dimensions = 5,130 ft x 10 ft)	Sand	-	0	159	NA[4]	0	0	0	0
	Second Reef	-	0	470	NA[4]	100	0	0	0
	Second Reef-Sand Complex	-	0	970	NA[4]	22	0	0	0

Table 8. Detailed Calculations of Indirect Hardbottom Impact to the Nearshore Habitats.

Construction Component	Habitat Type	Diameter (ft)[1]	Width (ft)[2]	Length (ft)	Area[3] (sq ft)	% Hardbottom	Indirect Hardbottom Impacts (sq ft)	Indirect Sand Impacts (sq ft)	Total Indirect Impacts (sq ft)
	Sand	-	0	1,740	NA[4]	0	0	0	0
	Third Reef	-	0	350	NA[4]	100	0	0	0
	Third Reef-Sand Complex	-	0	641	NA[4]	38	0	0	0
	Third Reef Transitional Complex	-	0	800	NA[4]	10	0	0	0
HDD #2 Exit Hole (Dimensions = 75 ft x 60 ft)	Third Reef Transitional Complex	278	-	-	56,199	10	5,620	50,579	56,199
Blanketing from HDD #2 Exit Hole to 200 FSW (Dimensions = 20 ft x 1,836 ft)	Third Reef Transitional Complex	-	0	1,836	NA[4]	10	0	0	0
TOTALS							**189,253 (4.34 ac)**	**122,188 (2.81 ac)**	**311,441 (7.15 ac)**

[1] Limits of sedimentation/turbidity plume around HDD entrance/exit holes = 139 ft diameter.
[2] Limits of sedimentation/turbidity plume adjacent to open cut trench = 92 ft centered on the trench.
[3] Areas affected calculated as area affected by sedimentation/turbidity plume minus direct impact area.
[4] NA = not applicable because activity will not generate sedimentation or turbidity plumes.

Table 9: Summary of Temporary Indirect Hardbottom Impacts by Construction Feature

Construction Feature	**Area**	
	(sq ft)	**(acres)**
HDD Entrance/Exit Holes	61,819	1.42
Open Cut Trench	127,434	2.92
Pipe pull corridor	0	0
Concrete Blanketing	0	0
Total Indirect Hardbottom Impacts	**189,253**	**4.34**

Table 10: Summary of Temporary Indirect Hardbottom Impacts by Habitat Type

Habitat Type	**Area**	
	(sq ft)	**(acres)**
Submerged Breakwater Spoil	183,633	4.22
Second Reef	0	0
Second Reef-Sand Complex	0	0
Third Reef	0	0
Third Reef-Sand Complex	0	0
Third Reef Transitional Complex[1]	5,620	0.12
Total Indirect Hardbottom Impacts	**189,253**	**4.34**

[1] Hardbottom accounts for 10% of total area; hardbottom impact area = length x width x 0.10

Table 11: Summary of Direct and Indirect Hardbottom Impacts by Habitat Type

Habitat Type	Direct Hardbottom Impacts		Indirect Hardbottom Impacts		Total Hardbottom Impacts	
	(sq ft)	(acres)	(sq ft)	(acres)	(sq ft)	(acres)
Submerged Breakwater Spoil	52,050	1.19	183,633	4.22	235,683	5.41
Second Reef	4,700	0.11	0	0	4,700	0.11
Second Reef-Sand Complex	2,134	0.05	0	0	2,134	0.05
Third Reef	3,500	0.08	0	0	3,500	0.08
Third Reef-Sand Complex	2,436	0.06	0	0	2,436	0.06
Third Reef Transitional Complex	4,922	0.11	5,620	0.12	10,542	0.23
TOTALS	**69,742**	**1.60**	**189,253**	**4.34**	**258,995**	**5.94**

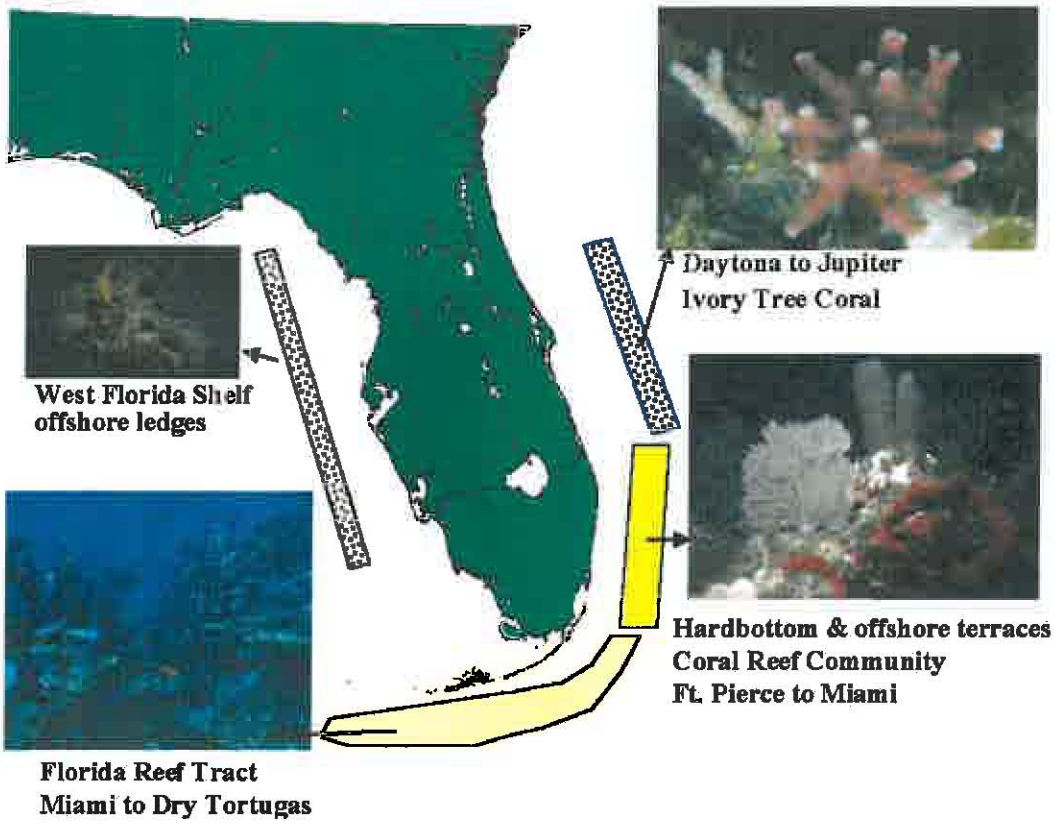

Figure 1. Florida's coral and hardground communities. (courtesy Jennifer Wheaton, FMRI).

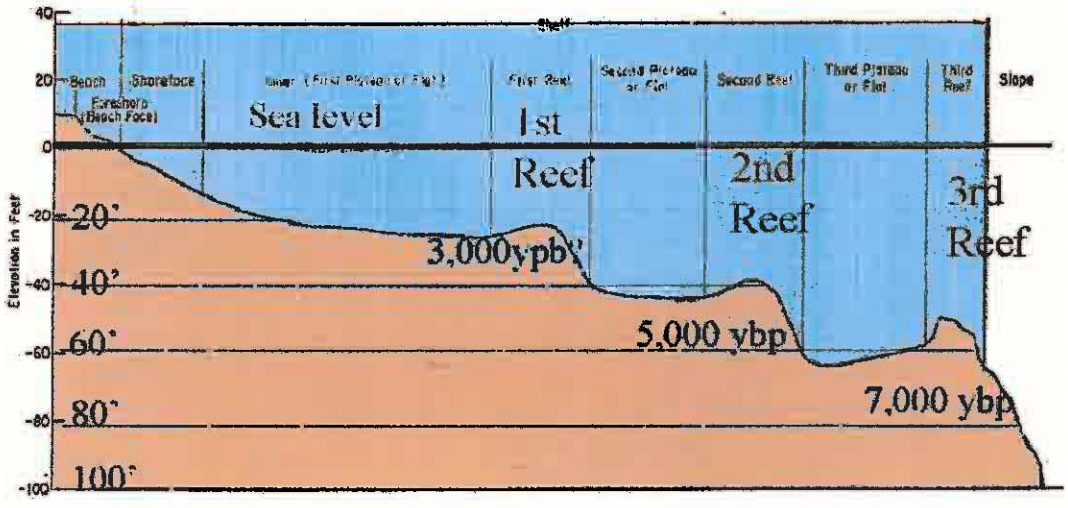

Figure 2. Typical cross-section of the coral reefs fringing West Palm, Broward and Dade Counties. ybp = years before present dated by C-14. ?=estimated date

Figure 3. Air photo mosaic (1:24000, NAPP, USGS) of Port Everglades Entrance Channel and environs. Depth contours are in meters.

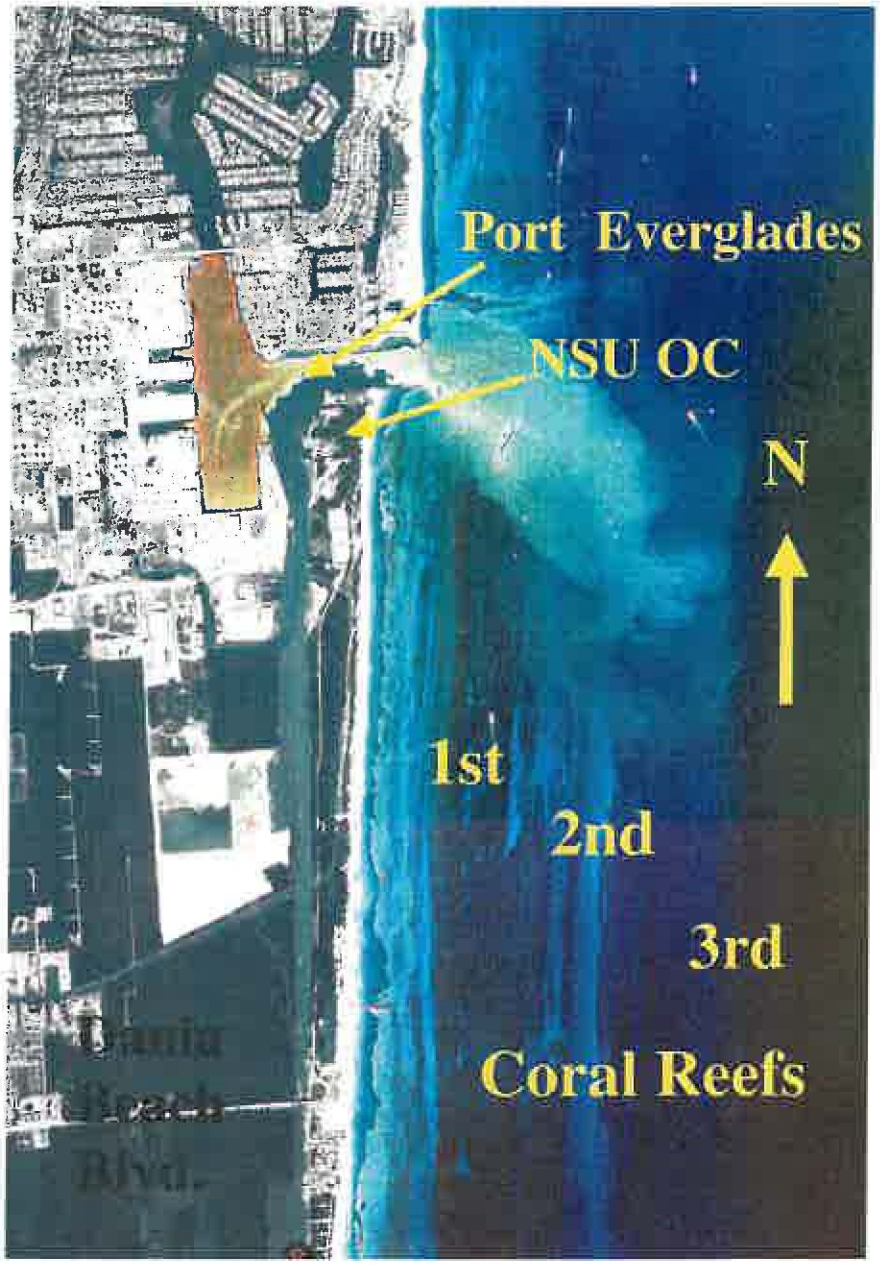

Figure 4. Detail of study area, including plume discharge from Port Everglades.

Figure 5. The sun-shaded bathymetric plot of Port Everglades Entrance Channel and nearby reefs. The Entrance Channel, reef systems, jetties and the spoil disposal area to the north of the north jetty are clearly discernable. Bathymetric data for this plot is from the U.S. Army Corps of Engineers 1998 LIDAR data set.

Figure 6. Oblique three-dimensional LIDAR data depictions with aerial photo overlays of the Port Everglades Entrance Channel and reef systems.

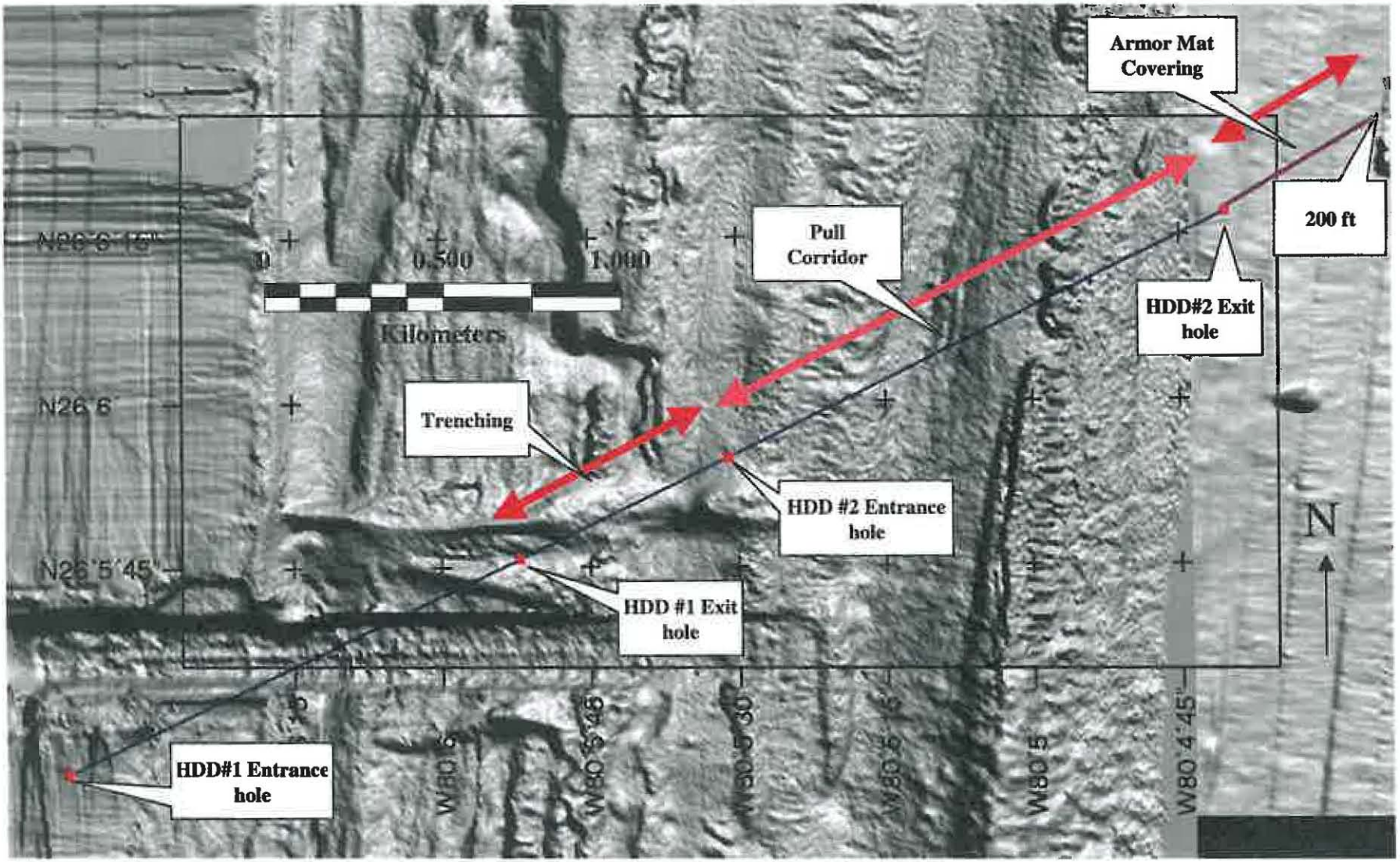

Figure 7. Locations of the proposed pipeline route, including pipeline pull corridor, trenching area, armor mat and drill holes.

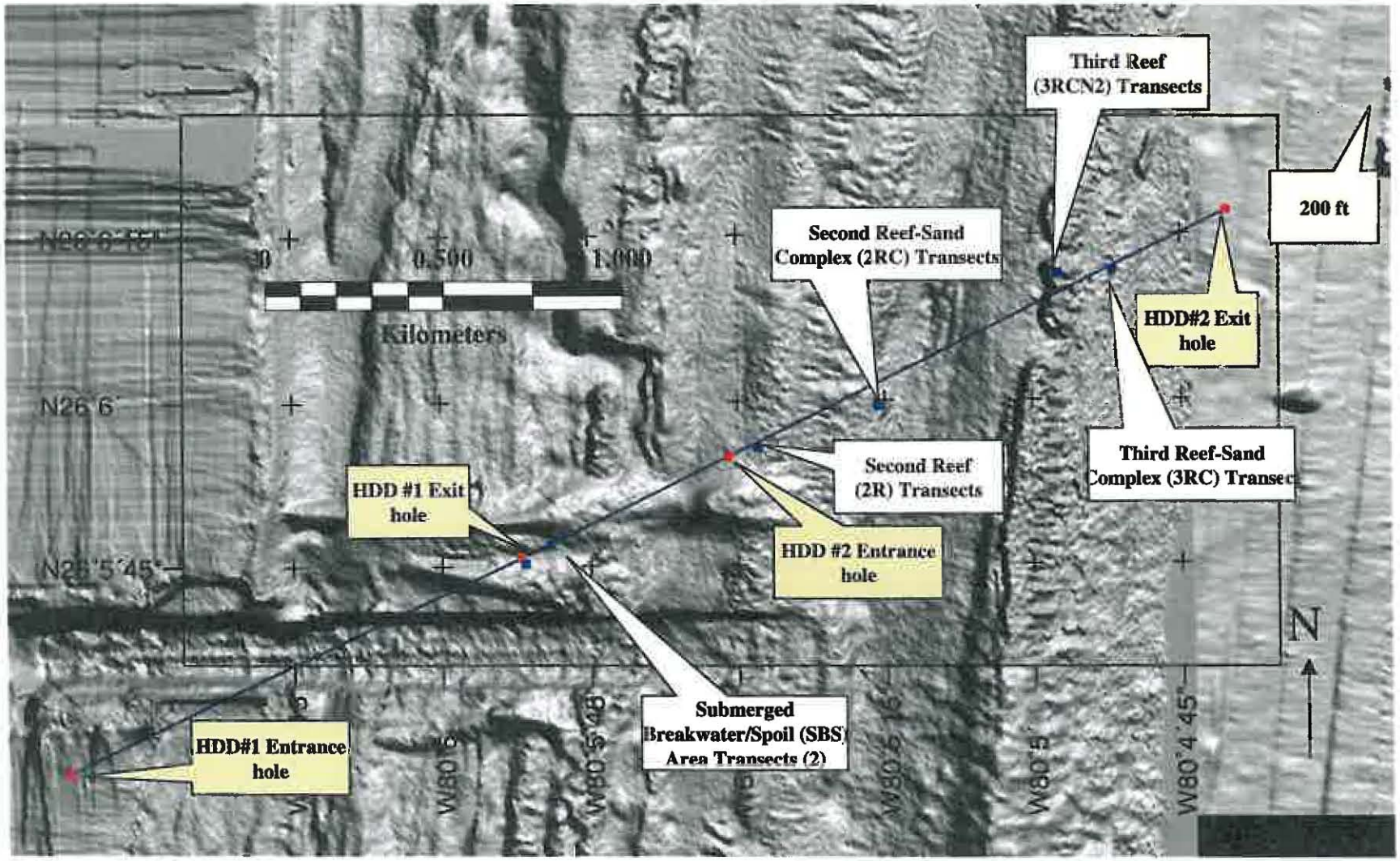

Figure 8. Location and descriptions of transects for biological surveys.

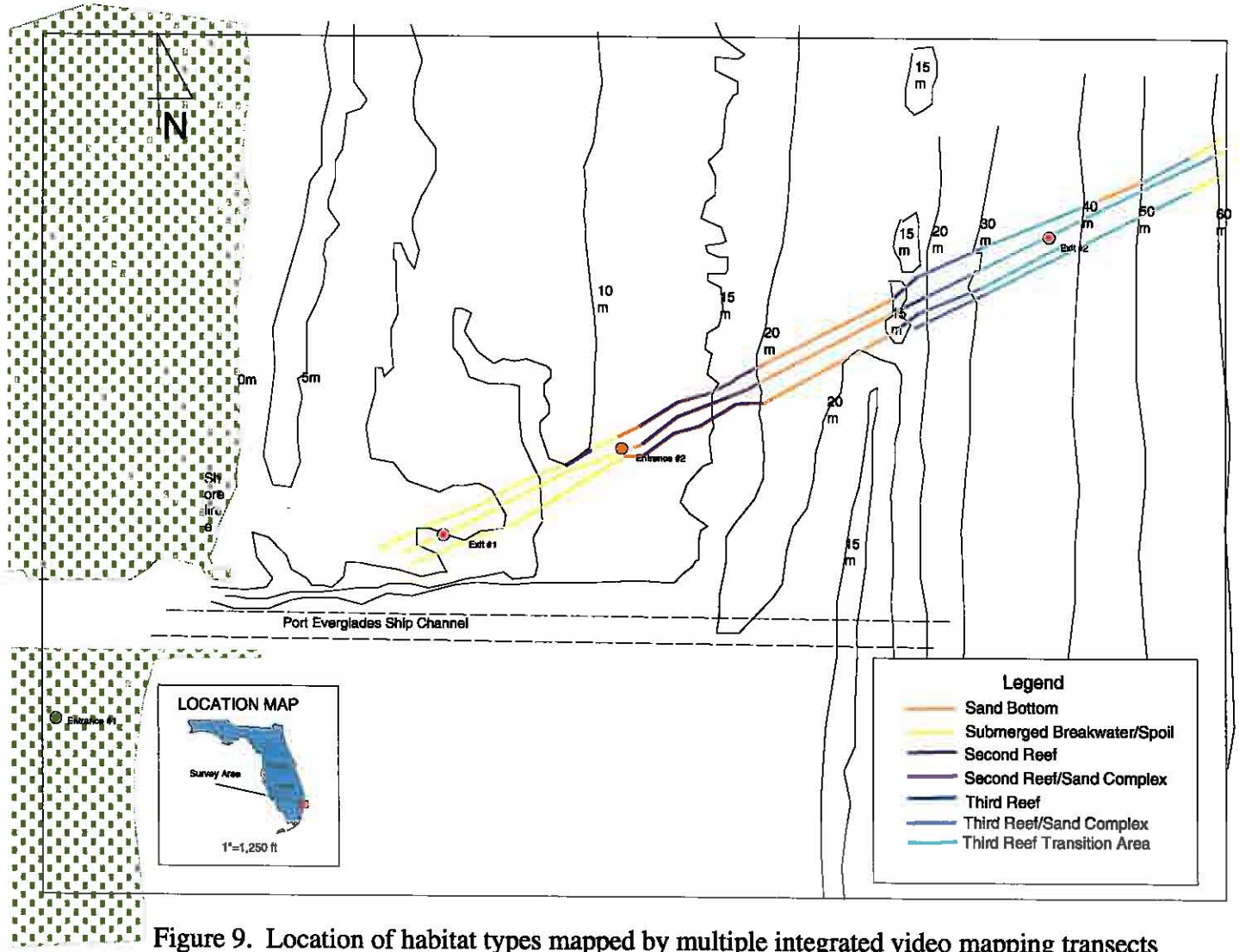

Figure 9. Location of habitat types mapped by multiple integrated video mapping transects along the proposed pipeline route. Lines are color coded by habitat designation.

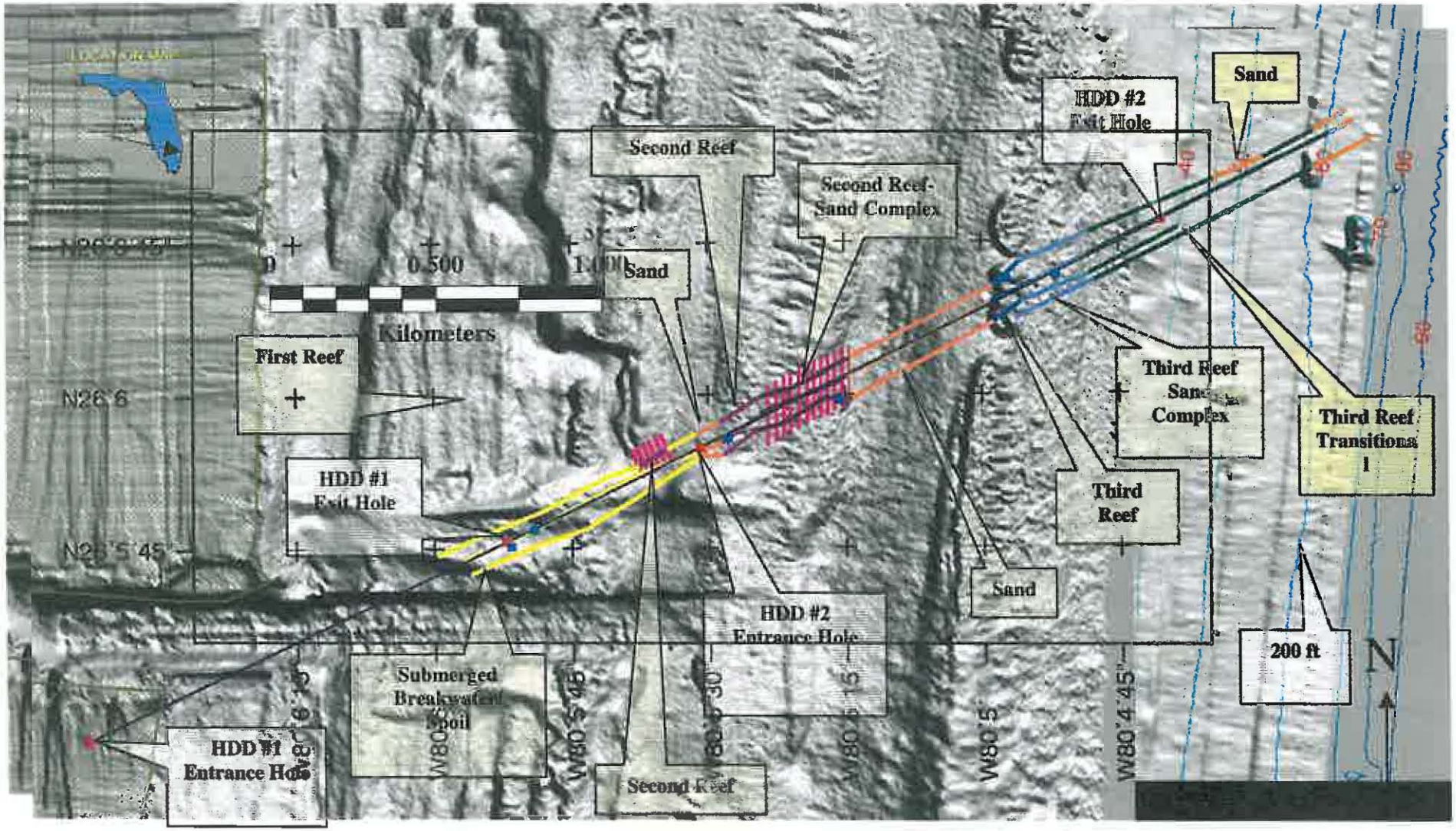

Figure 10. Location of habitat types mapped by multiple integrated video mapping transects. Transects are color coded by habitat. Background is sunshaded LIDAR imagery. HDD holes are shown in red. Blue dots represent biological transect locations of Fig. 9. Depth contours in m beyond the Third Reef.

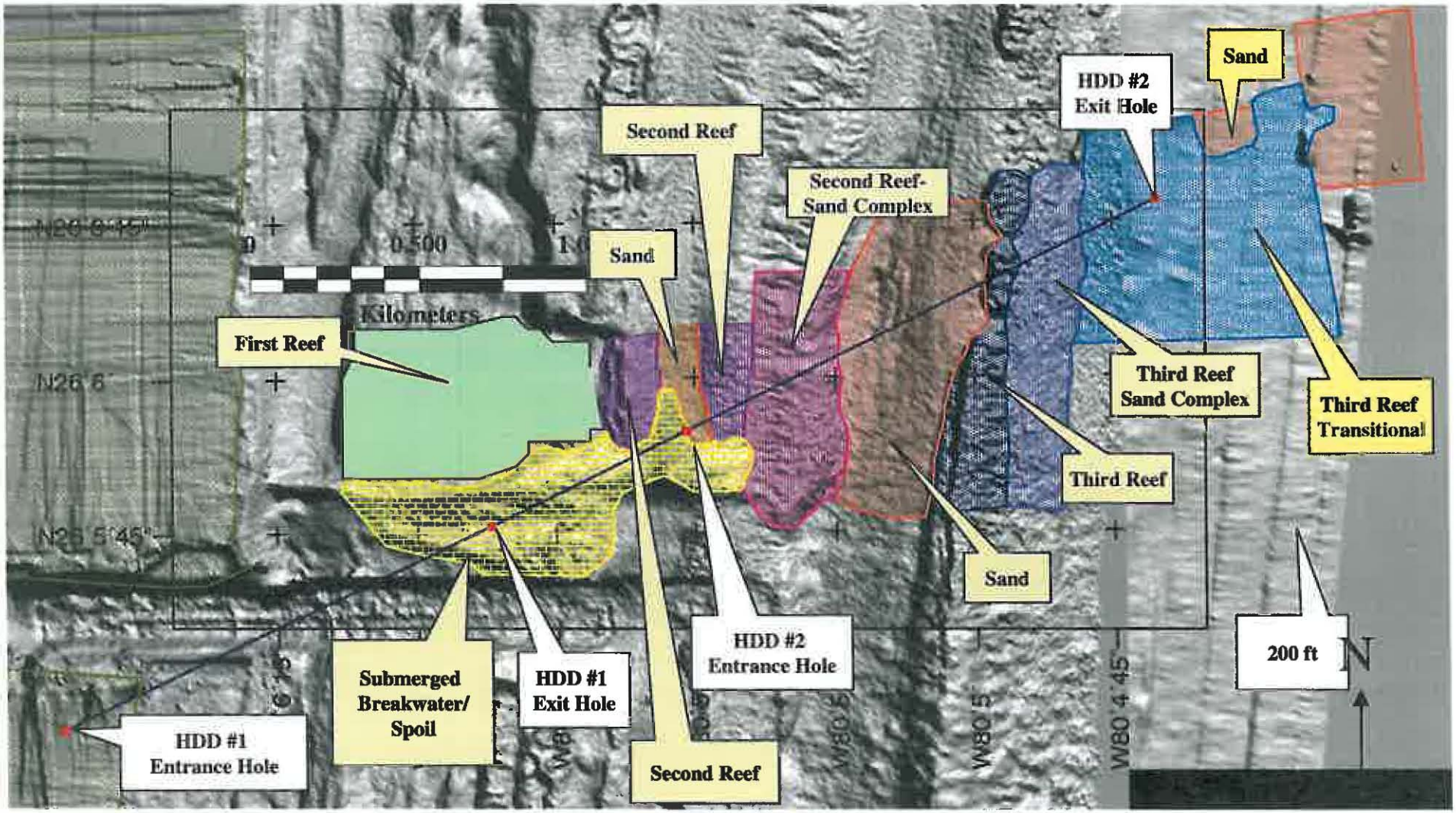

Figure 11. Spatial distribution of habitat types along the pipeline corridor.

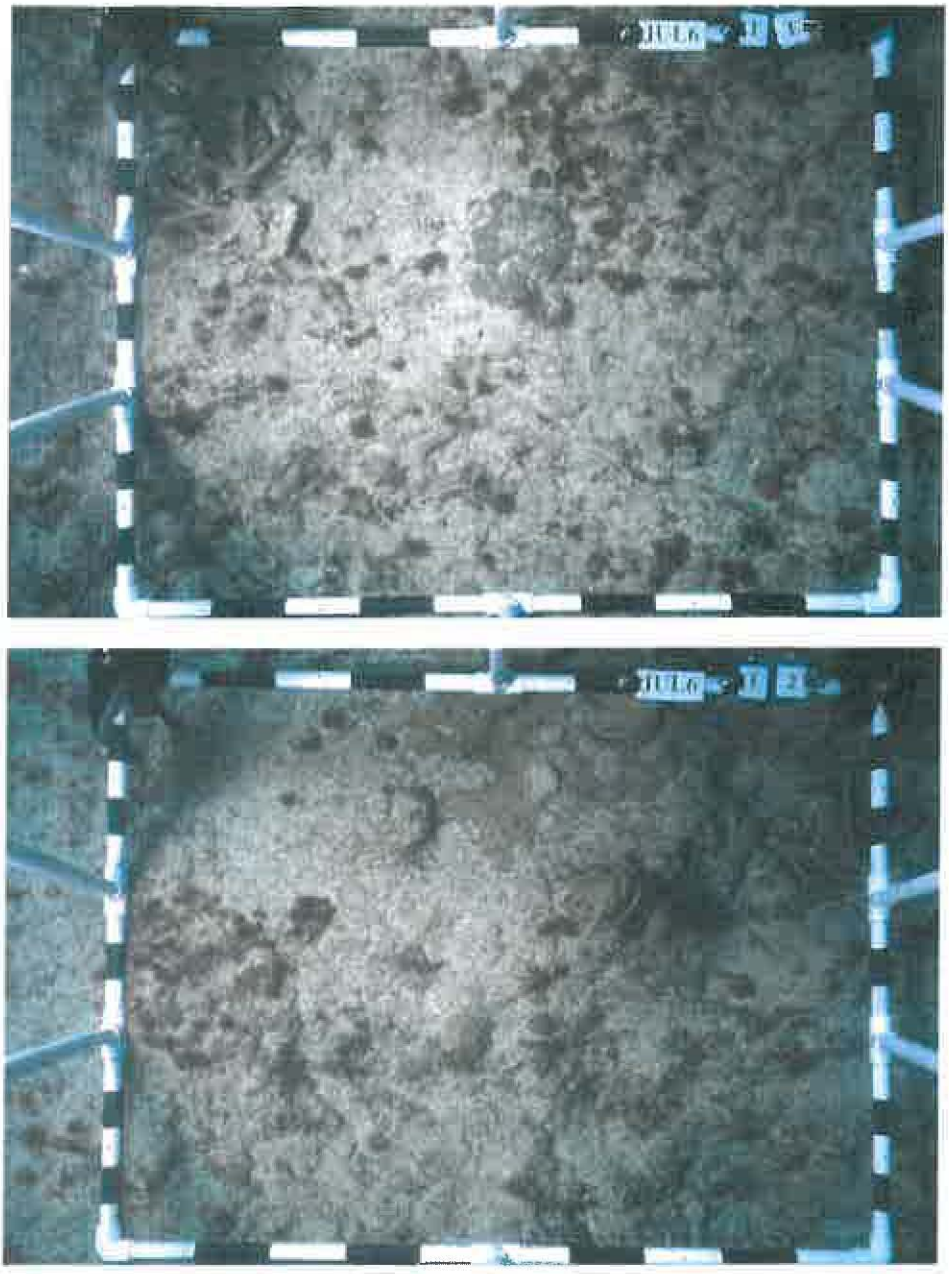

Figure 12. Top and Bottom panels) Sample underwater photographs of 1 m by .75 m quadrats of community structure of the First Reef habitat (approximately 4 m depth). Sponges, soft corals, and hard corals are present.

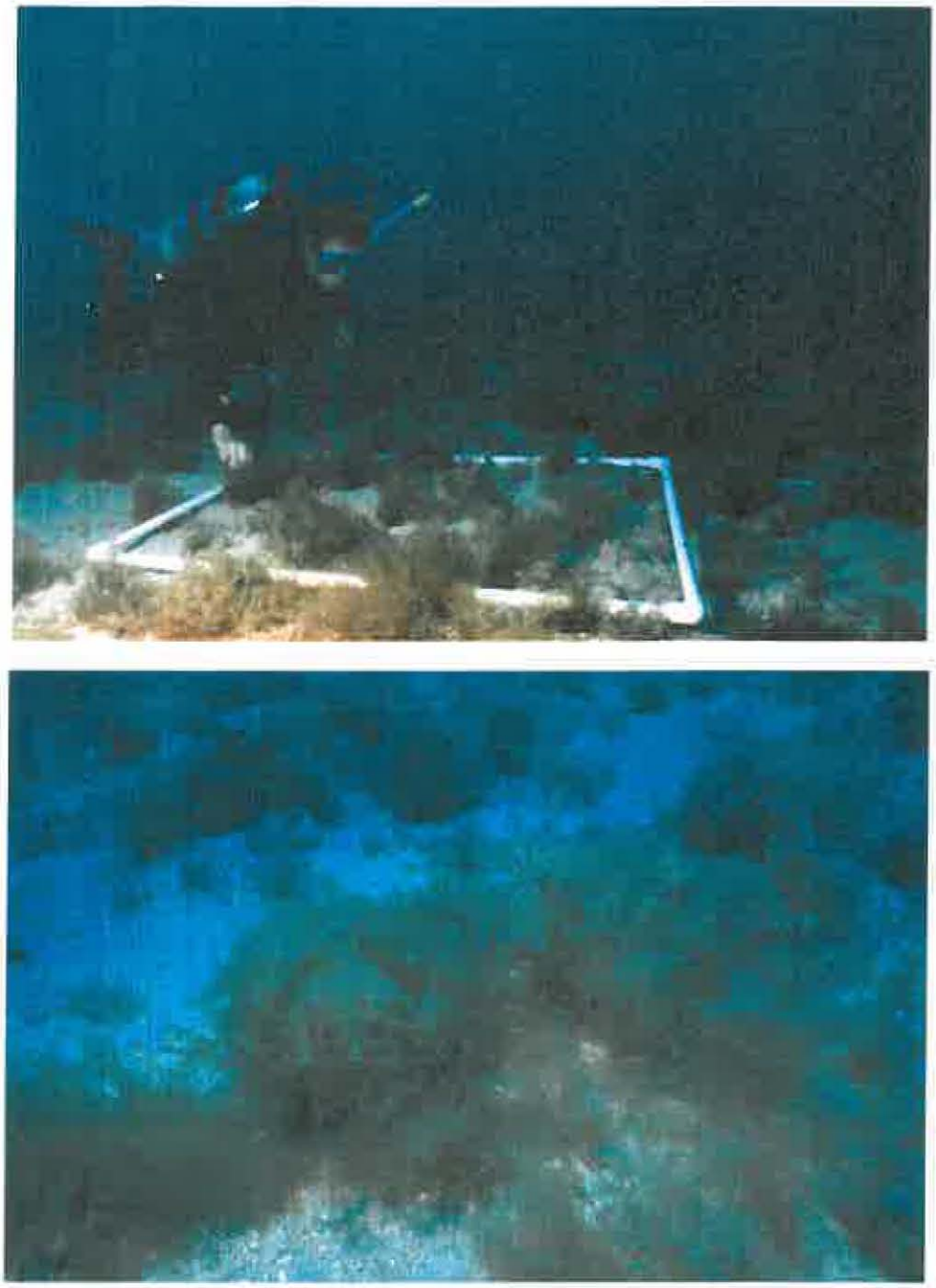

Figure 13. Top panel) Sample underwater photographs of community structure at the Submerged Breakwater/Spoil habitat area (7m depth), where the HDD #1 Exit hole is proposed, and where trenching will take place;
Bottom panel) The area is dominated by algae with some small hard corals and soft corals present.

Figure 14. Top panel) Diver surveying transects on the Second Reef habitat;
Bottom panel) Sample photograph of flora and fauna of the Second Reef habitat (14m depth). Sponges, soft corals, and stony corals are present.

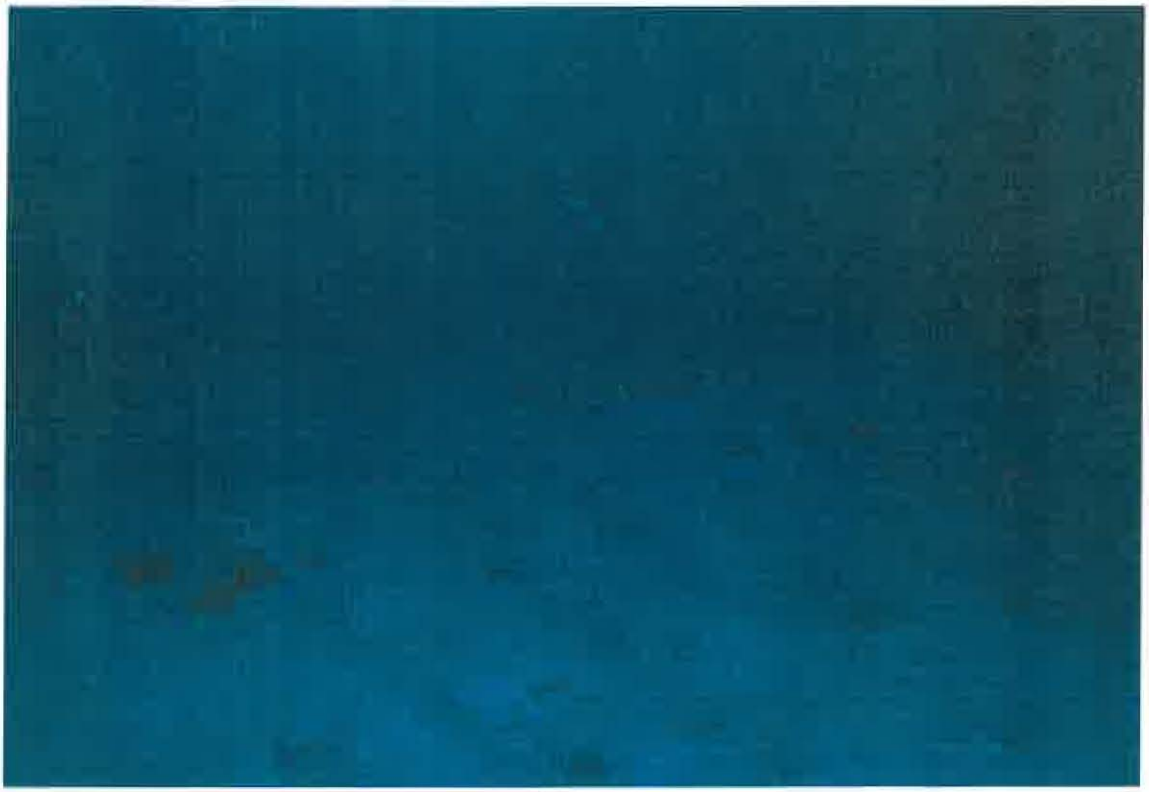

Figure 15. Sand habitat between the Second Reef and Second Reef–Sand Complex. Small colonies of algae are present, attached to loose rubble.

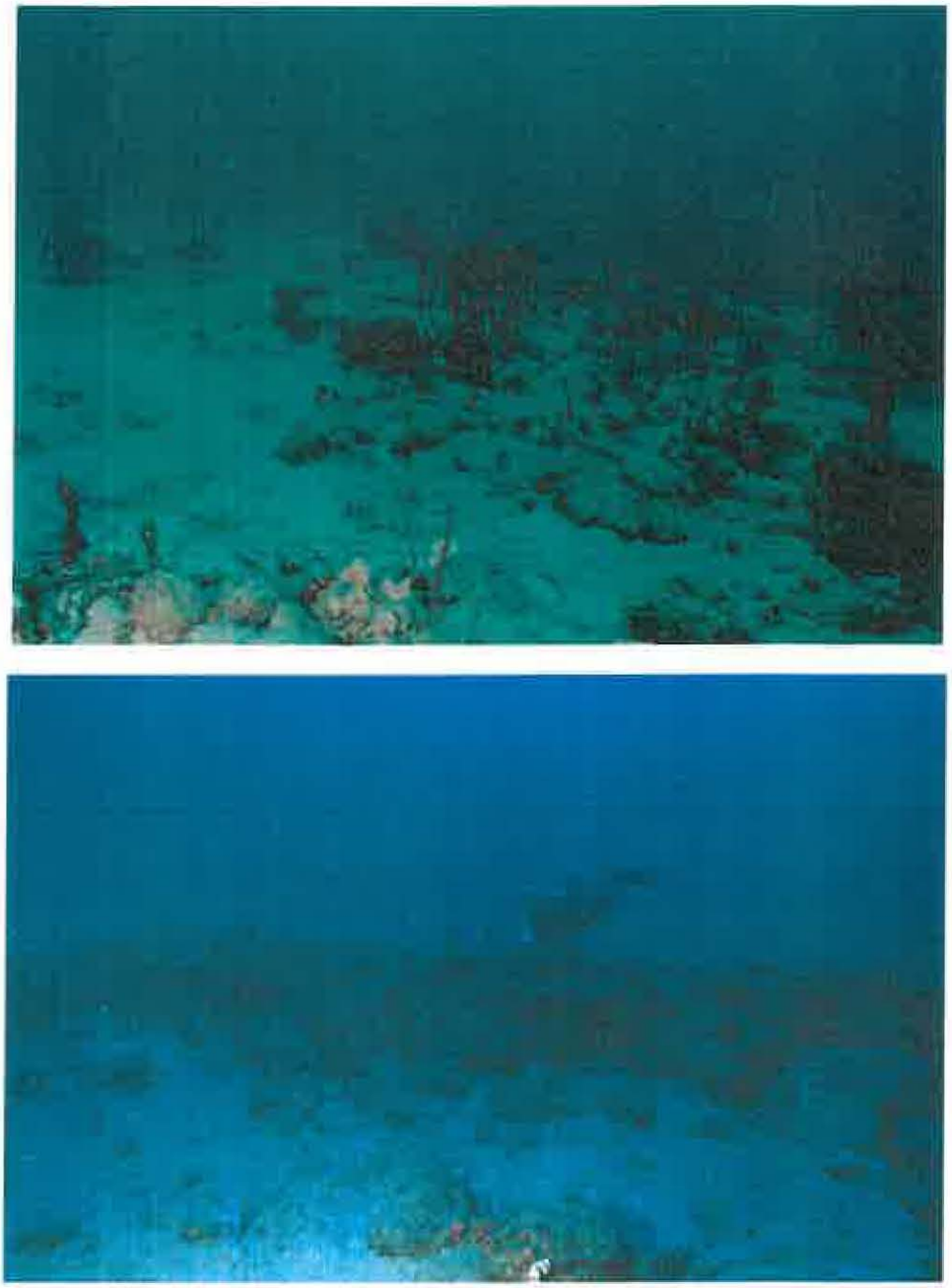

Figure 16. Top panel) Illustrative benthic habitat in the Second Reef-Sand Complex (17m depth); note the presence of reef and sand substrate;
Bottom panel) Oblique view of sponges, soft corals, and hard corals of the Second Reef-Sand Complex habitat.

Figure 17. A small patch of *Halophila decipiens*, a common, non-endangered seagrass, occupying sparse areas of sand in the Second Reef-Sand Complex (12m depth).

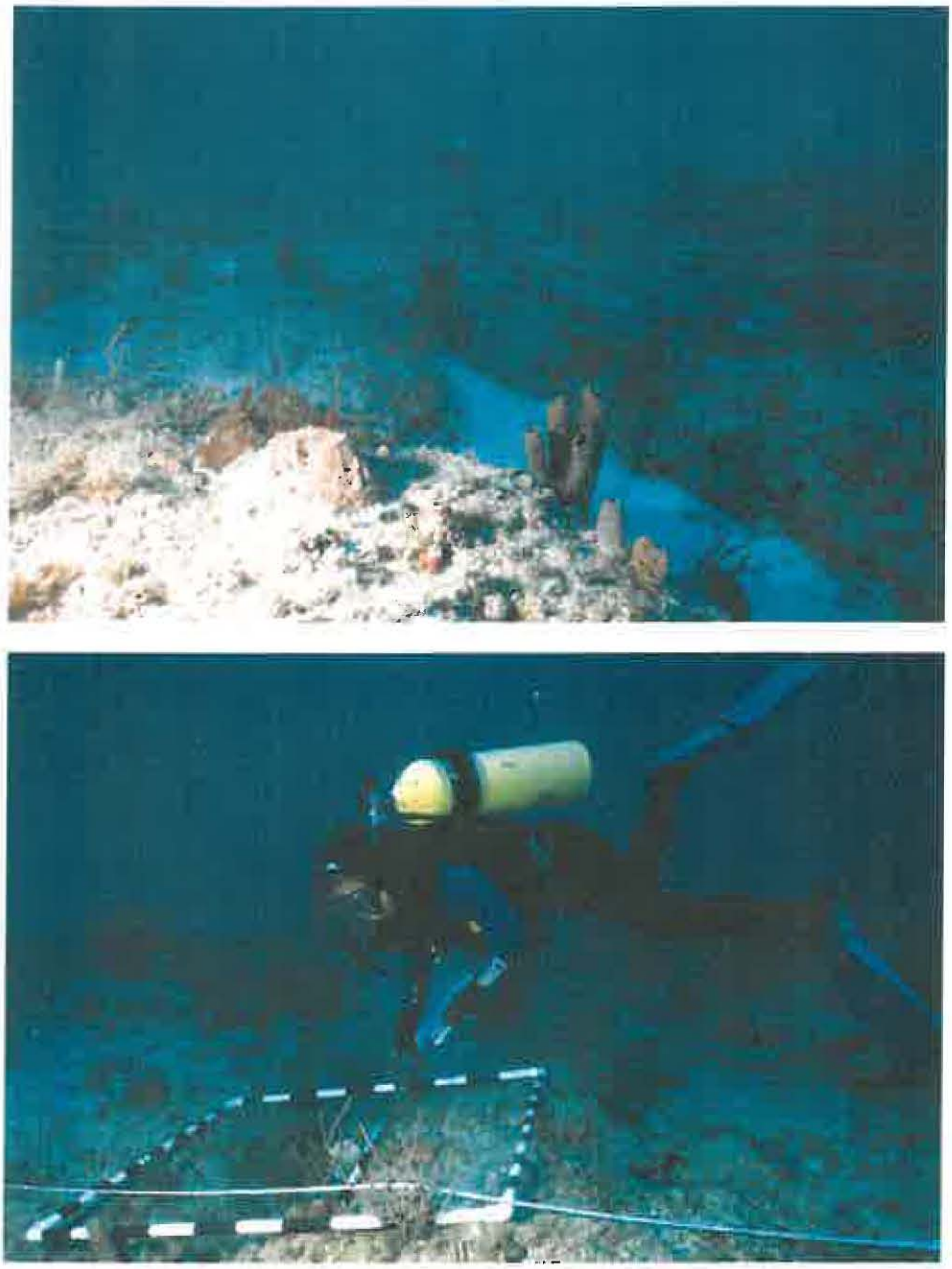

Figure 18. Top panel) Representative flora and fauna of the Third Reef (21m depth); deep water soft corals are present along with stony corals and sponges;
Bottom panel) Diver surveying a Third Reef transect; illustrative flora and fauna are shown.

Figure 19. Illustrative flora and fauna of the Third Reef-Sand Complex (26m depth). Sponges, hard corals, and soft corals are present.