Miami Ocean Dredged Material Disposal Site Tilefish (Malacanthidae) Habitat Identification and Characterization Study

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INTRODUCTION

Background

The Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA) assigns basic responsibility to the U.S. Environmental Protection Agency (USEPA) and the U.S. Army Corps of Engineers (USACE) for ensuring that ocean dredged material disposal activities will not unreasonably degrade or endanger human health, welfare, the marine environment, or economic potentialities (MPRSA Sections 102 and 103).

Section 102 of the MPRSA authorizes the USEPA to designate sites and times at which dumping may occur and to establish criteria for reviewing and evaluating permit applications, including those for dredged material. These site designations are published in the Federal Register at 40 CFR Part 228. Site designations include a description of the site, the type of material for which the site is designated, and any restrictions on site-use established by USEPA. It also authorizes the USEPA, in conjunction with USACE, to develop site management plans for dredged material disposal sites.

An Ocean Dredged Material Disposal Site (ODMDS) was created off the coast of Miami and has been used for dredged material disposal since 1957 (EPA/USACE, 2008). The center of the ODMDS site is located 4.7 nautical miles (nmi) offshore and measures approximately 1 nmi by 1 nmi square, centered at the coordinates 25°45.00'N latitude and 80°03.37'W longitude. In 2007, the ODMDS water depths ranged between 127 and 235 m (415–770 ft) with an average depth of 180 m (590 ft; EPA/USACE, 2008). The dredged material contained within the ODMDS includes clay, silt, sand, gravel, and limestone rubble (EPA/USACE, 2008). Between 1957 and 1986 (date of the ROV survey), 3,050,541 cubic yards of material was deposited at the ODMDS site, and additional 160,083 cu yd was deposited ~ 1 nmi west of the site. As part of the MPRSA (MPRSA§ 103(a)), the three primary management objectives for the Miami ODMDS are:

- Protection of the marine environment;
- Documentation of disposal activities and compliance;
- Maintenance of a long-term disposal alternative for dredged material generated in the vicinity of Miami (EPA/USACE, 2008).

As part of a continuing effort to meet these objectives, the USACE Jacksonville District contracted an underwater survey of the benthos in and adjacent to the ODMDS. The survey was conducted in January, 1986 by Conservation Consultants, Inc. utilizing a Remote Operated Vehicle (ROV) with video camera. The videographic data generated during the study, containing approximately 17.8 hours of recorded data, was submitted to the USACE Jacksonville District along with a brief summary of transects performed. The summary was included as Appendix A of a subsequent USACE document.

Objectives

The USACE Jacksonville District has identified a need to have the 1986 video dataset reviewed and analyzed for the possible presence of species of fisheries management interest. Preliminary review of the video records indicated possible tilefish (Malacanthidae) habitat evidenced by the presence of large burrows in soft substrate. The main objective of this project is to confirm or deny the presence of tilefish or tilefish burrows in the Miami ODMDS based on the 1986 video transects. In the event that the presence of tilefish is confirmed (based on video evidence), analyses will include an estimation of distribution and abundance within the ODMDS and surrounding area. If results suggest the absence of tilefish, then best scientific judgment will be used to suggest the organism(s) responsible for the mounds and burrows. In addition, habitat type and biota will be characterized to the degree possible based on the video. It must be noted that these videotape surveys were conducted 24 years ago and are not indicative of the current presence or absence of tilefish or the current presence of hard/live bottom or anthropogenic debris.

This report includes detailed analysis of the original videotapes with documentation of substrate, habitat, bioturbation, burrows, and fauna along with photographs (from video frame grabs). Results are illustrated spatially on figures generated using ArcView GIS software. This final report to the USCOE includes this hard copy and a DVD containing a PDF copy of this report with the complete videotape annotations (Appendix 2), and JPEG images from the video frame grabs documenting the dominant habitat types and fauna.

This study is intended to provide a basis for further research into the occurrence of tilefish within the Miami ODMDS. In this way, it is hoped that future management decisions affecting the ODMDS and its economically important inhabitants can be made using sound scientific judgment.

Task Descriptions

Characterization of Benthic Habitats: Quantitative and qualitative assessments of benthic habitats to be conducted by analyzing the videotapes provided by the Conservation Consultants (1986) ROV survey. Substrate and habitat categories include those which could be likely found in this region based on previous surveys of the Miami Terrace region (Reed, 2002 a,b, 2004; Reed et al., 2005 a,b, 2006; Messing et al., 2006 a,b; Reed et al., 2006, 2007, 2008).

Geographic Information Systems (GIS) Mapping of Habitats: The original ROV tracks will be imported into ArcView GIS software and the various parameters (substrate, burrows, and fish) will be plotted along the ROV transect lines. The GIS maps will show the presence of tilefish and potential tilefish burrows along each video transect.

Quantification of Tilefish Population: Tilefish and apparent tilefish burrows will be quantified and plotted in GIS.

Estimation of Prey Availability: Benthic macrofauna which can be potential tilefish prey organisms (e.g., mollusks, echinoderms, crustaceans, fish) will be identified to the lowest possible taxonomic level from the videotapes.

Literature Review of Golden and Blueline Tilefish

Three tilefish species occur in this region—*Caulolatilus microps* (blueline tilefish), *Lopholatilus chamaeleonticeps* (golden tilefish), and *Malacanthus plumieri* (sand tilefish). Due to water depth and substrate composition at the Miami ODMDS, *M. plumieri*, which prefers shallower water over coral rubble, is not expected in the project area (Dooley, 2002; McEachran and Fechhelm, 2005) and thus will not be discussed further in this document. Due to their commercial importance as food and game fish, *C. microps* and *L. chamaeleonticeps* are important in a fisheries-management perspective (South Atlantic Fishery Management Council, 2009).

The ranges of both tilefish species include the outer continental shelf and slope waters of the western central Atlantic, including southeast Florida (Dooley, 2002; McEachran and Fechhelm, 2005). *Caulolatilus microps* occurs in water 30–236 m (98.4–774.1 ft) deep (usually 50–200 m [164–656 ft]) over soft or rubble-covered substrates (Dooley, 2002; McEachran and Fechhelm, 2005). Prey taxa for *C. microps* include mainly benthic invertebrates (e.g., polychaete worms, mollusks, portunid crabs) and to a lesser extent, fishes (Dooley, 2002). This species is not known to migrate (Dooley, 2002).

Off Florida's east coast, *L. chamaeleonticeps* shows strong preference for substrates having high clay and/or silt content, in water 137–290 m (449.4–951.2 ft) deep, with an average bottom temperature of between 8.6 and 15.4°C (Able et al., 1993). This species has been shown to tolerate brief, abrupt fluctuations in temperature (Able et. al., 1993). Off New England, *L. chamaeleonticeps* is known to utilize both burrow and non-burrow microhabitats. Non-burrow habitats included horizontal cavities in clay walls of submarine canyons, rock shelves, and rocks and boulders (Grimes et al., 1986). Similar to those found off Florida's east coast, the New England populations of *L. chamaeleonticeps* utilize areas having stable bottom temperatures and mud substrate (Grimes et al., 1986). Off New England, crustaceans and fishes were more abundant within the vicinity of tilefish burrows than away from burrows, even though the burrow community may be strongly affected by tilefish predation (Grimes et al., 1986). Burrow diameter ranged to 1.5 m (4.9 ft) off the east coast of Florida (Able et al., 1993) and up to 5 m (16.4 ft) in the mid-Atlantic Bight (Grimes et al., 1986). Prey taxa for *L. chamaeleonticeps* include mainly crab and shrimp species, although other invertebrates (e.g., bivalves, squids, polychaete worms) along with elasmobranchs (i.e., spiny dogfish) and teleost fishes (e.g., eels, myctophids, butterfish, hake) are sometimes consumed (McEachran and Fechhelm, 2005). *Lopholatilus chamaeleonticeps* is not known to migrate, and mark-recapture data indicates fish exhibit long-term residence, as all recaptures after up to 20 months at liberty were made < 1 nmi from the release location (Grimes et al., 1986).

METHODS

Historical Data

Conservation Consultants, Inc. was contracted by USACE Jacksonville District to complete an underwater survey of the benthos in and adjacent to the ODMDS in 1985. The first survey was competed in 1985 which was an environmental survey of nine stations (three within the ODMDS and six adjacent) for the following parameters: physical, biological, geological, bathymetry, hydrography, sediment granulometry, water quality, and sediment chemistry (Conservation Consultants, 1985). These stations are shown in Map 1. The biological benthic surveys collected benthic meiofauna and macroinvertebrates using a ponar dredge (0.054 m^{-2}, 5 samples/station). Macroepifauna including benthic fish were collected at four stations using a 3.1 m trawl net (two 15-min tows/station). We used these data to compare to our species lists and to determine sediment characteristics and bottom temperatures which would be useful in determining the presence of tilefish species. The second survey by Conservation Consultants (1986) was completed January 25-26, 1986 utilizing a Remote Operated Vehicle (ROV) with a video camera. Four S-N video transects were conducted within and adjacent to the ODMSD. Although there was no metadata provided from this ROV report, only few seconds of audio was recorded on the videotapes which provided the following information regarding the ship and ROV:

1. ROV operations- conducted by International Underwater Contractors
2. ROV- Recon IV
3. Video survey- conducted by Conservation Consultants, Inc.
4. Ship- *Seward Explorer*
5. ROV navigation- Hydrostar Underwater Navigation System.

ROV Navigation, Video Transects

The only data that was provided from the ROV video survey was Appendix A of the Conservation Consultants (1986) video report which included the following data: video transect number, time, ship position coordinates (degrees, decimal minutes to 0.01), and the relative position of the ROV (range, bearing) (each in two-minute increments). The coordinates recorded from the original ROV survey (Appendix A, Conservation Consultants, 1986) were converted by ANAMAR from degrees decimal minutes into decimal degrees for importing into Arcview GIS (Appendix 2). QA/QC was completed on these data to verify the conversion. The original videotapes generated during the study had been copied to ten DVDs (ca. 17.8 hours total) which we used in this study. The video has an overlay of the following data: date, time, depth (feet), and ROV heading (degrees). The date on the overlay is incorrect; it reads January 1985 rather than 1986.

Unfortunately, metadata regarding the video transects from the original ROV survey was not provided (Conservation Consultants, 1986), and there was no written report other than the ship position, and the relative position of the ROV range and bearing in two-minute increments (Appendix A, Conservation Consultants, 1986). For example, the range given in the report could either be slant range from the ship to the ROV or horizontal range. According to Jim Sullivan (HBOI submersible electronic specialist), the Hydrostar Navigation System that was used in that time period could have provided a slant range. Also the ROV heading could either be relative to North or to the ship, but is likely relative to the ship given the readings. The Hydrostar Underwater Navigation System used Ultra-short Baseline Sonar (USBL) and was the predecessor for the same technology that is currently used in ORE Trackpoint II Acoustic Positioning System which Harbor Branch Oceanographic Institute (HBOI) uses to track the *Johnson-Sea-Link* submersibles. Currently, submersible or ROV navigation using USBL technology with Trackpoint and Integrated Positioning System (IPS) software integrates the ROV's position relative to the ship and calculates the ROV's real time DGPS position throughout each dive. Analysis of USBL tracking accuracy for a worst-case tracking scenario estimated a maximum statistical positioning error of 9.6 m at a depth of 500 m (Reed et al., 2006). Also, no metadata was provided regarding what positioning was used. During that period they likely used LORAN C. Although the LORAN TD's would be measurable and repeatable when using the same navigation hardware, but when converted to latitude/longitude, it could be significantly offset. For example, HBOI mapped deep-water reef sites off central Florida in the 1970s and 80s using LORAN C (Avent and Stanton, 1979). At that time TDs could be used to find a target or reef, but when we later converted to GPS, we had to survey the region to find the feature. We found that in this region of eastern Florida LORAN C had navigational accuracy of +- 100-300 m (Reed et al., 2005).

Video Analysis

An Excel spreadsheet was developed in order to record and annotate data from each ROV transect regarding substrate type, benthic species, and presence or evidence of tilefish burrows. The DVD videotapes were played on Cyberlink Play DVD. The following data were annotated into the Excel spreadsheet (Appendix 2) in two-minute increments: date, ROV dive number, DVD number, Latitude/Longitude (converted decimal degrees), time (from ROV overlay), ROV heading (ROV overlay), depth (feet, ROV overlay), depth (m, converted), bottom type, bioturbation, hard/soft bottom, tilefish borrows, number of burrows, activity of burrows, number of individuals of each identified benthic species, habitat and faunal notes, and photo capture log. Frame grabs were captured from the video as JPEG images (720x480 pixel, ~1.0 MB files) to document each specific habitat type, bioturbation, tilefish burrows, as well as macroinvertebrate and fish taxa.

<u>Field of View Estimation</u>

Unfortunately, the videotapes did not show any scale, either ruler or parallel beam lasers, which is often used in modern ROV or submersible video surveys in order to estimate the size of geological features and taxa. Other problems also occurred during the video transects, making estimates of the width of the field of view difficult. Ideally the ROV video camera should be at a relatively constant angle and height off the bottom. For quantitative calculations of densities, the camera should be straight down to prevent parallax. In these video transects the ROV did not maintain a constant height off the bottom. It frequently moved up or down making viewing the bottom difficult. Secondly, the camera angle was not constant, therefore in some cases the ROV was on or very near the bottom with the camera almost pointing directly forward whereas in other cases it was higher off the bottom (1-2 m) with the camera angled out providing a relatively wide field of view. As a result the PI had to guesstimate the field of view and size of objects based on 30 years of experience of deep-water ROV and submersible dives in the Straits of Florida which started with extensive surveys of the continental shelf off Florida with the *Johnson-Sea-Link* submersible, when the PI assisted with benthic photographic surveys from depths of 30 m to 900 m over twelve transects from Cape Canaveral to West Palm, documenting substrate type, macrofauna, and including dense bioturbation features and tilefish (both golden tile and blueline tilefish; Avent and Stanton, 1979).

To determine the estimated field of view of the video, first, the size of know taxa provided a relative size estimate, that is, certain crabs such as *Cancer* and fish such as *Laemonema* codlings that the PI is familiar with in this region are of limited size ranges. Also the size of bioturbation features such as the conical mounds are very common throughout this depth range along the Florida coast. These are very typically from smaller sizes of 10-20 cm diameter to larger sizes of 20-50 cm.

Secondly, when the ROV was in a relatively good viewing position (near the bottom and the camera about 45 degrees down), the PI measured an object of known size that was viewed in the video. For example, in several cases a common beer can was clearly observed in the lower central field of view. The length of each can was measured with calipers and compared to the sizes of several common beer cans that were measured. This relative can size was compared to the screen width at that horizontal point on the video screen, thus calculating the field of view. In this case a 2.54 cm width in the lower third of the screen was approximately equivalent to 10 cm, and the screen width of 25.4 cm was equivalent to ~ 1 m. This assumption was used for size estimates when the camera was near the bottom (<1 m) so the bottom third field of view may be ~1 m wide whereas the top part could be 2 m or greater. Overall the video was too blurry to identify organisms smaller that 5-10 cm.

Habitat Characterization

Substrates were differentiated and categorized based on observed physical properties. Habitat categories included the following listed below which could be likely found in this region based on previous surveys of the Miami Terrace region (Reed, 2002 a,b, 2004; Reed et al., 2005 a,b, 2006; Messing et al., 2006 a,b; Reed et al., 2006, 2007, 2008). The habitats were coded in an MS Excel spreadsheet for presence/absence during each 2-minute ROV transect time interval (Appendix 2). Percent cover of each substrate type (i.e., soft bottom, hard bottom) was determined by dividing the number of 2-minute intervals by the total number of intervals of each transect.

Faunal Characterization

The dominant benthic macroinvertebrate and fish fauna were counted for each 2-minute increment and identified where possible. Due to the very poor quality of the video many could not be identified beyond phylum and most smaller than 5-10 cm could not be identified. Fauna were numerated for the following taxa:

- Fish- golden tilefish, eel, codling, snowy grouper, other identified species, unidentified species.
- Macroinvertebrates

- Crustacea- crab, galatheid crab
- Echinoid- sea urchin, starfish
- Ophiuroid (brittlestar)
- Cerianthid (burrowing anemone)
- Other unidentified species

Deep-water Habitat Survey Protocol

According to the South Atlantic Fisheries Management Council (SAFMC), hard bottom refers to a class of coral communities occurring in temperate, subtropical, and tropical regions (SAFMC 1998a). These communities lack the diversity, density and reef building capabilities of other classes of coral communities, and are the most widespread of the coral communities within the South Atlantic Bight (SAFMC 1998a). Hard bottom varies in topography and can range from a relatively flat surface to several meters in relief. Hard bottom is sometimes referred to as live bottom due to the amount of living organisms attached to or inside these hard substrates.

The Southeast Area Monitoring and Assessment Program (SEAMAP) deep-water mapping project documented deep-water, hard-bottom habitat from existing data throughout the South Atlantic Bight and Straits of Florida (Arendt et al., 2003). The SEAMAP bottom mapping workgroup defined deep-water hard-bottom as including the following subcategories of habitat types: coral, rock rubble, coral rubble, exposed hard pavement, thinly covered hard substrate, and artificial structures. In addition, a category of 'Special Habitats' included various subcategories: canyons, tilefish burrows, consolidated mud, methane seeps, sinkholes, and coral banks. Although the SAFMC has not yet completed the deep-water coral component of SAFMC Fishery Ecosystem Plan, they define deep-water corals as including Scleractinia (hard corals), Octocorallia (soft corals), Hydrocoral (hydro corals and stylasterine corals), and Antipatharia (black corals).

Terminology and Definitions

Various parameters regarding substrate type, bioturbation, and burrows were documented in the video annotation and are defined below (Appendix 2). These are typical features that we have documented elsewhere on the Florida shelf and Straits of Florida and have used in various other deep-water benthic surveys.

Substrate Types (S= sediment; Ru= coral/rock rubble; Ro= rock pavement, ledges; Co= standing coral)

- Soft bottom (S)- mud, sand; with or without bioturbation, sand waves, or sand ripples

- Hard bottom (H)
  - Consolidated hard bottom (rock pavement, ledges)
  - Unconsolidated rock substrate (rock slabs, rubble)
  - Coral (standing live/dead scleractinian coral, coral rubble
  - Artificial rock substrate (cement rubble, concrete pieces, gravel)

<u>Bioturbation</u>

Typically these are pits, craters, mounds, burrows made by various organisms including worms (echiurans, sipunculids, polychaetes, etc.), bivalve mollusks, echinoids, crustaceans, and fish.

- Density- D= dense (present in virtually every frame of the video), S= sparse (only few seen over space of 2-minute video increment), N= none (none present over 2-minute increment).
- Mounds- conical mounds often with an apical hole which maybe excurrent vents from which sediment is occasionally seen shooting out. These were documented as small (5-15 cm diameter at base), medium (15- 30 cm), or large (30-50 cm).
- Depressions (burrows)- conical to oval scours in the sediment, some with vertical or oblique shaft or hole in the bottom which is the actual burrow of the organism making the depression. These were documented as small (<30 cm in diameter), medium (30-50 cm), or large craters (50- >100 cm).
- Tilefish burrows- based on characteristics of the medium and large depressions (>30 cm diameter), some were characterized as apparent tilefish burrows. These characteristics are based on descriptions of both blueline tilefish and golden tilefish in the literature, review of videotapes by experts in the field, and review of previous submersible photographs of known blueline and golden tilefish by the PI (Avent and Stanton, 1979). These were recorded in 2-minute increments in Appendix 2 as: Bu= apparent tilefish borrows; Bu?= possible burrows, but not as certain; Mo= area of dense mounds, tilefish burrows not likely, no active tilefish mounds are present; n/a= video out of view, unable to score bottom. Every 10-15 minutes, exact counts of the medium and large burrows were recorded for a 2-minute interval. Of these, they were also documented as being either active (A) or inactive (N) within that interval. Based on literature and comments from tilefish experts the active burrows would have a vertical or oblique shaft at the bottom of the burrow, often the sides of the depression are steep and eroded with other occupants which have bored into the sides (crabs, fish), and the top edge often has a slightly raised rim from the tilefish scouring out the sediment. Inactive depressions may be older burrows where the tilefish has left and is not actively maintaining the burrow. As such the shaft would fill in fairly quickly, and the sides tend to be smooth and less steep. The mean number of burrows was calculated for each transect based on averaging the individual 2-minute burrow counts. Burrow density was calculated by taking the mean counts divided by the total transect length times the estimated average field of view of 1 m.

QA/QC

Numerous and various scientists were contacted for their expertise. Many of them kindly reviewed excerpts of the video or video grabs for their opinions and to verify the PI's identifications regarding: the sources of bioturbation, identification of tilefish burrows, and macroinvertebrate and fish identifications. The following specialists were contacted:

Table 1. List of specialists (benthic ecologists, fish and invertebrate taxonomists) contacted to review video excerpts.

Name	Organization	Pertinent Field of Expertise
Dr. Robert Jones	Director (retired), Harbor Branch Oceanographic Institution; Associate Professor, University of Guam; Director, University of Texas Marine Science Institute; Deputy Director, Bermuda Biological Station for Research	Fish ecology and taxonomy, publications on deep-water tilefish
Dr. Churchill Grimes	Director, Southwest Fisheries Science Center, NOAA Fisheries	Fish ecology and taxonomy, publications on deep-water tilefish
Dr. Ken Able	Research Fish Biologist, Rutgers University	Fish ecology and taxonomy, publications on deep-water tilefish
Dr. Andy David	Research Fishery Biologist, NOAA Fisheries	Fish ecology and taxonomy, characterization of shelf-edge hard bottom habitat and fish
Dr. George Sedberry	Manager, Gray's Reef National Marine Sanctuary, NOAA Sanctuaries Program	Fish ecology and taxonomy of deep-water fish
Dr. Kenneth Sulak	Research Fish Biologist, U.S. Geological Survey	Fish ecology and taxonomy of deep-water fishes
Dr. Chris Koenig	Research Fish Biologist, Florida State University	Fish ecology and taxonomy, shelf-edge fish and habitat characterization
Dr. Anson Hines	Director, Smithsonian Environmental Research Center	Decapod crustaceans, deep-water geryonid crabs, golden crab
Dr. William Lindberg	Research Biologist, University of Florida	Benthic ecology, deep-water geryonid crabs, golden crabs
Dr. Charles Messing	Research Professor, NOVA Southeastern University, Oceanographic Center	Deep-water benthos, macroinvertebrates
Dr. Robert Virnstein	Director (retired), St. John's Water Management District	Benthic ecology, infauna, macrofauna
Dr. Robert George	President, George Institute for Biodiversity and Sustainability (GIBS)	Deep-sea ecology, macroinvertebrates
Dr. Mary Rice	Director (emeritus), Smithsonian Marine Station, Curator of Invertebrates, U.S. Museum of Natural History	Benthic ecology and taxonomy of vermes (polychaetes, sipunculids, etc.)
Dr. Kathryn Scanlon	Geologist, U.S. Geological Survey	Geologist, benthic habitat studies of deep-water coral reefs
Dr. Robert Ginsburg	Professor of Marine Geology, Rosenstiel School of Marine and Atmospheric Science, University of Miami	Deep-sea geology, sediment characterization
Dr. Bjorn Turnberg	Research Biologist, Smithsonian Marine Station	Benthic ecology, macroinvertebrates
Dr. Paula Mikkelsen	Associate Director for Science, Paleontological Research Institution	Taxonomy of mollusks

RESULTS

Historical Data

The environmental report by Conservation Consultants (1985) provided various physical, chemical and biological data which are useful here and pertinent to the potential occurrence of tilefish species (Table 1). These benthic sampling stations were generally within the ODMDS and near the transect lines VT-1 through VT-3 (Map 1). Transect VT-3 was east of these stations so we do not have representative temperature or sediment data for this site.

Table 2. Benthic sampling stations near ROV transects during the 1985 environmental survey (Conservation Consultants, 1985). See Map 1 for locations.

Station #	**Depth (m)**	**Bottom Temperature (^{o}C)**	**Sediment Composition (% S-sand, Si-silt, C-clay)**
M-2	183	16.0	74/25/0
M-5	70	27.0	76/9/14
M-6	140	18.0	72/28/0
M-7	226	10.0	76/24/0
M-8	174	16.0	76/24/0

ROV Video Quality

Overall the black and white ROV video was very poor, grainy, and often blurry. The lighting was poor; the video light position caused backscatter from plankton or nephloid particles in water column and often the field of view was obscured by white flare-ups on the video apparently from the light colored bottom with a wide iris aperture. Average speed over ground for the transects was calculated by averaging the time/distance of the transects; it averaged about 0.8 kn, which is too fast for acceptable video (should be <0.5 kn). Also the ROV speed surged from fast (estimated up to 2 kn) to slow or even moving backward from the pull of the umbilical cord. In addition, the ROV and camera height off the bottom varied constantly ranging from on bottom to 2 m or greater off bottom. When the ROV was high the bottom was nearly out of view or too dark to see. Much of the time the video is either unusable due to flare up, too high off bottom, or surging causing blurring.

ROV Transect Summary

Map 1 shows the plotted ROV transect lines and benthic stations from the original report (Conservation Consultants, 1985, 1986) and ODMDS boundaries. Dots for each transect indicate coordinates of the ship plotted with GIS in 2-minute increments (Appendix 1). The four transects generally go south to north and range in length from 3.8 km to 7.0 km at depths ranging from 122 m to 253 m (Table 3). Transects VT-1 and VT-2 go directly through the ODMDS while VT-4 skirts along the western boundary and VT-3 is well to the east of the eastern boundary. Of the total 17.8 hours of video time recorded on the 10 DVDs, 14.3 hours were recorded with the ROV on bottom during the video transects. The number of records refer to the number of 2-minute increments that the ship position was recorded (Appendices 1, 2). The video overlay recorded depth in feet which we converted to meters.

INSERT MAP 1.

Table 3. Video transect summary. Transect length, depth, and number of 2-minute interval records.

Transect No.	No. of Records	Total Time (Hr:Min)	Total Transect Length[1] nmi (km)	Transect Length[2] within ODMDS nmi (km)	Min Depth ft (m)	Max Depth ft (m)
VT-1	135	4:24	3.76 (6.95)	0.42 (0.78)	401 (122.2)	517 (157.6)
VT-2	111	3:40	3.78 (7.00)	1.17 (2.17)	501 (152.7)	802 (244.4)
VT-3	95	3:08	2.71 (5.01)	0.00 (0.00)	811 (247.2)	830 (253.0)
VT-4	95	3:08	2.07 (3.83)	1.47 (2.72)	454 (138.4)	767 (233.8)
Total	436	14:20	12.30 (22.79)	3.06 (5.67)	401 (122.2)	830 (253.0)

[1]Transect lengths were calculated by importing the original ROV transect lines (Appendix A, Conservation Consultants 1986) into GIS and measuring the length of each line in meters. [2]Transect lengths within the ODMDS boundaries were measured in the same manner, except that only the lines within the ODMDS were measured.

ROV Navigation and Transects

The ROV transect lines shown in Map 1 from the original report (Appendix A, Conservation Consultants, 1986) appear to be smoothed when compared to the actual coordinates that were recorded in 2-minute increments to decimal degrees (Appendix 1). There is no metadata provided in the original report regarding how they plotted these transect data. As described in Methods, the navigation records could have positioning errors of up to 100-300 m. Even with modern tracking of submersibles at these depths we estimate a positioning error of 10 m under good conditions and that can often be tens of meters. Therefore, when the positions of the 2-minute intervals were plotted, they show an unrealistic zigzag pattern which the original authors apparently smoothed out for their plots of the transect lines (Fig. 1, Map 1). This is not to be unexpected given the tracking and positioning being used. It could also be due in part to the rocking of the ship. Even if the ROV remained stationary on the bottom for a period of time, there would be variability in the signals and position recorded. Due to the erratic nature of the 2-minute position plots, we had to resort to using the original ROV transects plots (Map 1) as the background data in order to overlay our various data of bottom types and taxa in the Maps 2-3. This also prevents us from determining actual densities of features or fauna since we can not calculate exactly the distance the ROV traveled during any particular 2-minute increment.

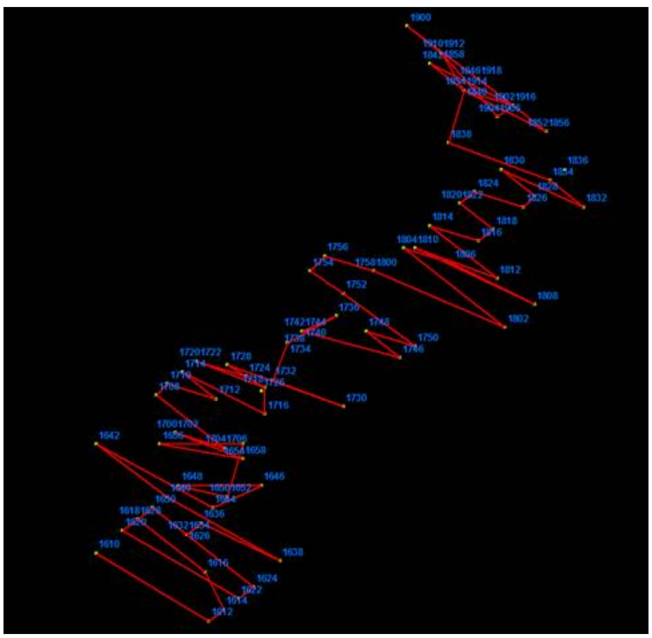

Figure 1. Transect 4 of the 1986 Miami ODMDS ROV survey as plotted using the coordinates given in original document (Appendix A, Conservation Consultants, 1986).

ROV Transect Notes

Descriptions of the benthic habitats and biota for each ROV video transect are summarized below and described in detail in Appendix 2 which documents during each 2-minute increment, the position coordinates, depth, habitat, bioturbation, fauna, debris, and photographic log (video grabs).

Transect VT-1

The video of this transect was very poor, black and white, grainy, blurry, and the lighting poor. Average speed over ground calculated from time/distance of total transect was 0.82 kn, which is too fast for acceptable video. ROV speed appeared to surge from fast (estimated up to 2 kn) to slow. The height off bottom varied constantly and backscatter from light hitting plankton or nephloid particles in the water column as well as iris problems often caused white flare-up obscuring the field of view.

ODMDS: VT-1 was within the ODMDS boundaries from ~10:00 to 11:16.

Time 08:42- 12:32: Depth 143-137 m; The bottom was 100% mud sediment with dense to moderate bioturbation consisting of 10-30 cm diameter, crater-shaped depressions, and occasional 50-100 cm diameter craters, some of which had horizontal burrows at the bottom. Conical mounds, 5-10 cm diameter were common, and some had holes at the top and smoking sediment. Some mounds were 20-30 cm diameter. The quantitative 2-minute counts of burrows indicate that they appeared to have apparent tilefish activity (active) and cerainthid burrowing anemones were dense.

12:34-12:46: Start of video tape 3 was missing 16 minutes of the transect.

12:48-13:06: Depth 148-156 m; the bottom appears similar as before but most of the larger burrows appear smooth and inactive. End of transect.

Transect VT-2

Tape 3 continues at time 15:50, but this is not transect VT-2 which is supposed to start at 17:32. Tape 3 continues to 16:05 then starts VT-2. The video is very poor with the ROV often flying 2 m off bottom, barely seeing the bottom, and often changing tilt angle of camera.

ODMDS: VT-2 was within the boundaries of ODMDS from ~17:56 to 18:58.

17:32-18:36: Depth 175-157 m; the bottom was 100% soft mud sediment with dense bioturbation consisting of moonscape-like, dense mounds 10-25 cm diameter, and depressions 10-30 cm diameter. Most larger craters appeared inactive, smooth walled, with no obvious large shaft, and no raised rims. These are not likely tilefish burrows. Cancer crabs were fairly common but other macrofauna were sparse.

18:38-19:18: Depth 156-167 m; there was a definite change in habitat from beginning of VT2; bioturbation was moderate, and the mounds were less dense but the depressions were more abundant, 15-50 cm with occasional 100 cm depression. None of the large burrows appeared active.

19:20-19:58: Depth 167-203 m; the bottom was again dominated by mounds, and most depressions were associated with mounds, making it difficult to differentiate craters from valleys between mounds. Most larger craters appeared inactive, smooth walled, with no obvious large shaft, and no raised rims. These are not likely tilefish burrows.

20:00-21:00: Depth 205-243 m; the conical mounds were less dense and the smooth depressions, 30-50 cm in diameter were common. Some had very small 5-cm burrows in the bottom, but no raised rim. These were possible tilefish burrows, but probably not active. Various fish, conger eels, and crabs were quite common in this region.

21:02-21:12: ROV was pulled off bottom, unable to see bottom. End of transect.

<u>Transect VT-3</u>

The next Tape 5 started at 00:27 AM, 1/26/86; this was not the correct time for VT-3. The ROV appeared on bottom at 00:31 then the tape jumped to 5:43, in midwater. It appeared that the ROV pilots were trying to get kinks out of the umbilical cord. There was a view of tether management system at 100 ft then back to 800 ft. At 6:23 the ROV was on deck, then at 7:16 on bottom. Tape 5 ended at 08:08; these data were not logged or annotated as to bottom type since it was out of range and no position coordinates were available. Tape 6 started at 8:09; therefore, we started logging VT-3 at the position coordinates starting time of 08:16. During much of the transect the ROV was high off the bottom; apparently operated by a different ROV pilot.

ODMDS: VT-3 did not enter the ODMDS boundaries.

8:16-10:00: Depth 251-252 m; the bottom was 100% soft sediment with moderate bioturbation, conical mounds 10-30 cm diameter, and most with apical 1 cm hole. The depressions were 10-30 cm, with occasional to 50+ cm diameter, and some had 5-cm burrow in bottom, with no raised rim. These appeared to be potential tilefish burrows and few appeared to be active. The ROV often was too high and difficult to see bottom. Some depressions were to 100 cm diameter with raised rim, some were elongate with rim, and some had burrow in bottom. Unidentified small fish and crabs were abundant.

10:02 Depth 252 m: a tilefish (identified as *L. chamaeleonticeps*) was observed diving into a burrow. The 50+ cm tilefish probably went inside a large depression, ~1.5 m diameter, which was elongate, with no distinct raised rim. The sides of the burrow were steep with an apparent oblique burrow at the bottom. There were numerous 1-3 cm associated burrows around the sides of the depression.

10:04-11:14: Depth 253-248 m; bottom was the same, with bioturbation consisting of mounds 10-30 cm diameter, and large depressions which appeared active, most were elongate, with steep eroded sides, but could not see a definite burrow at bottom. A small debris field at 11:12 included numerous unidentified objects, possibly concrete rubble, covering about 10% of the bottom over a 10-m area.

11:16: Depth 247 m; a second golden tilefish, ~30-50 cm was observed diving into a burrow. It had a bump or flap typical of *L. chamaeleonticeps* on its forehead. The burrow was round, ~75 cm diameter, and had a slight rim.

11:18-11:24: Depth 248 m; bottom same as before. End of transect.

Transect VT-4

Tape 8 started at time 13:59, but the coordinate log did not start until 16:10; therefore, we did not process the data that did not have coordinates as there was no way to determine where the ROV was during that time. Pilot control of the ROV was terrible, constantly going up and down, with the bottom in and out of view, and much too dark to see. Electronic interference or noise made the video extremely blurry and numerical overlay of depth and time difficult to read.

ODMDS: VT-4 was within the ODMDS boundaries from ~17:54 to 18:58.

16:10-17:28: Depth 140-158 m; the bottom is 100% soft sediment with moderate to dense bioturbation, dominated by depressions 5-50 cm diameter, and some to 50-100 cm, and few conical mounds. Many of the larger depressions appeared active, with high rim and steep sides, circular to oblong, and some with oblique burrow shafts. Cerianthid burrowing anemones and unidentified small fish were common.

17:30-18:12: Depth 163-218 m; bioturbation was increasing, moonscape-like, with dense, large 25-50 cm conical mounds. It was difficult to differentiate craters from valleys between mounds. Depressions 30-100 cm were common, but most were smooth and worn and probably not active tilefish burrows. There were no obvious shafts in larger craters or raised rims. The cerianthids had disappeared.

18:14-19:00: Depth 219-233 m; bioturbation was decreasing, moderate density of 15-30 cm diameter mounds, few to 50 cm, and depressions 10-50 cm, and occasional 50-100 cm. All appeared smooth and worn, and only a few were seen with small burrow, raised rim or steep sides, but none appeared to be active tilefish burrows. *Cancer* and *Chaceon* crabs were common.

19:02-19:04: Depth 233 m; Habitat was the same but bottom appeared lumpy, possibly from rubble material under sediment. A small debris field appeared ~10 m wide, with 10-cm diameter rocks or mud clumps.

19:06-19:21: ROV pulled off bottom by umbilical cord. End of transect.

Faunal Identifications and Distribution

Appendix 2 lists the numbers of individuals for each taxa of macroinvertebrate and fish that were identified during each 2-minute interval for each transect. Table 4 lists the taxa of all species identified from the videotapes. A total of 14 taxa of fish were identified and 11 taxa of benthic macroinvertebrates. As discussed above, the poor quality of the video made positive identifications difficult to impossible for many cases and smaller objects (<5-10 cm) could not be identified. Taxonomic names preceded by ‘cf’ are tentative, but are likely candidates based on their morphology and known distribution in the region.

Table 4. Species list of taxa identified from videotapes of ROV transects.

Phylum CNIDARIA
Subphylum Anthozoa
    Class Hexacorallia
        Order Ceriantharia
            Family Cerianthidae (unidentified burrowing anemones)

Phylum MOLLUSCA
    Class Gastropoda
            Family Paguridae (unidentified hermit crabs)
    Class Cephalopoda
            Family Sepiolidae (unidentified squid)

Phylum ARTHROPODA
Subphylum Crustacea
        Order Decapoda
            Family Galatheidae
                Munida sp. (squat crab)
            Family Cancridae
                Cancer (=*Metacarcinus*) cf. *borealis* (Jonah crab)
            Family Pisidae
                Rochinia crassa (giant spider crab)
            Family Geyonidae
                Chaceon fenneri (golden crab)
            Family Portunidae
                Bathynectes cf. *longispina* (red crab)
            Unidentified decapod crabs

Phylum ECHINODERMATA
    Class Ophiuroidea
            Unidentified ophiuroids
    Class Asteroidea
            Family Astropectinidae
                Tethyaster grandis (giant orange starfish)
    Class Echinoidea
            Family Diadematidae
                cf. *Centrostephanus longispinus* (long-spined urchin)
            Family Echinothuriidae
                Araeosoma sp. (pancake poison urchin)
            Unidentified echinoids

Phylum CHORDATA
    Class Chondrichthyes
            Family Dasyatidae
                cf. *Dasyatus centroura* (roughtail stingray)
    Class Osteichthyes

Family Congridae
Conger cf. *oceanicus* (conger eel)
Unidentified eels
Family Chlorophthalmidae
Chlorophthalmus agassizi (shortnose greeneye)
Family Moridae
Laemonema sp. (codling)
Family Ogcocephalidae
Unidentified batfish
Family cf. Paralichthyidae
Unidentified flounder
Family Peristeidiidae
Unidentified searobin
Family Gadidae
cf. *Urophycis* sp. (hake)
Family Malacanthidae (Branchiostegidae)
Lopholatilus chamaeleonticeps (golden tilefish)
Caulolatitus microps (blueline tilefish; none observed)
Family Lutjanidae
cf. *Lutjanus vivanus* (silk snapper)
Family Serrandiae
Epinephelus niveatus (snowy grouper)

<u>Fish Abundance and Distribution</u>

Eleven species of fish which could be identified were commonly seen during the transects and a total of 240 individuals were counted (Tables 4 and 5). Several fish experts were kind enough to view some of the video excerpts and assisted with identifications of some of the taxa including the tilefish observations (R. Jones, G. Sedberry, K. Able, K. Sulak, C. Grimes, C. Koenig, W. Lindberg, pers. comm.). Table 6 documents the photographs used in Figures 2 and 3 showing the dominant fish fauna. Although the frame grabs of the video are very poor to make identifications, in some cases, viewing of the moving video enhanced the view. Numerous unidentified fish (212 total) were observed. These were mostly small (5-10 cm Total Length, TL) benthic species, some of which could be juveniles. Often these darted off in a cloud of sediment as the ROV approached or individuals shot across the field of view in a blur. The dominant large fish consisted of *Conger oceanicus*, *Laemonema* sp., *Epinephelus niveatus*, *Lopholatilus chamaeleonticeps*, Ogcocephalidae, Paralichthyidae, and *Urophycis* sp. The great majority of the sightings of the benthic fish were in the vicinity of depressions, since the bioturbation was common throughout all transects; however, only in a few cases were they actually inside a depression. Both *Laemonema* sp. and *E. niveatus* were always associated with some debris, such as a ladder.

Table 5. Number and distribution of fish recorded in ROV video transects. See Methods for substrate codes. (See Appendix 2 for locations).

Fish Taxa	Transect No.	Depth Range (m)	Substrate Type	Total Number of

				Individuals
Lopholatilus chamaeleonticeps	VT-3	247-252	Bu	2
Epinephelus niveatus	VT-1	123-130	Bu	3
Laemonema sp.	VT-3	249-252	Bu?	5
Chloropthalmus agassizi	VT-3	253	Bu?	1
cf. *Dasyatis centroura*	VT-3	251	Bu?	1
cf. *Lutjanus vivanus*	VT-3	248	Bu?	1
Ogcocephalidae	VT-1,-4	137-138	Bu	2
cf. Paralichthyidae	VT-4	138-140	Bu	2
Peristeidiidae	VT-2	209	Bu?	1
cf. *Urophycis* sp.	VT-1,-2	123-231	Bu, Bu?	2
Conger cf. *oceanicus*, unid. eels	VT-1, -2	148-236	Bu, Bu?	8
Unidentified fish (<15 cm TL)	VT-1,-2,-3,-4	122-253	Bu,Bu?,Mo	212

<u>Tilefish Observations</u>

Of the total 17.8 hours of video transects and thousands of burrows which potentially could have been made by tilefish, only 2 observations were made of tilefish: both were of the golden tilefish *Lopholatilus chamaeleonticeps* at depths of 247 and 252 m during transect VT-3 (Map 2). Identifications which were verified by several specialists (R. Jones, C. Grimes, pers. comm.) were based on general shape and size, and the one specimen had a pronounced bump on the forehead, characteristic of the golden tilefish. Also the depth of occurrence was typical for the golden tilefish and the burrow construction was typical. Transect VT-3 is generally too deep and too cold for the blueline tilefish *Caulolatitus microps.*

The first tilefish sighting was at 10:02 and 252 m depth (VT-3, Appendix 2). The bottom was dense to moderate bioturbation- mostly small to medium mounds 10-30 cm, with small depressions 10-20 cm, and few medium depressions 30-50 cm. During the 2-minute interval four small (<15 cm) unidentified fish were recorded. One golden tilefish (*L. chamaeleonticeps*), approximately 50 cm TL, was observed inside a large depression ~1.5 m diameter. The depression was elongate, with no distinct raised rim, and the sides were steep. At the bottom was an oblique shaft or burrow that the fish darted into head first upon approach of the ROV. Numerous 1-3 cm diameter burrows were around the entrance of main burrow. There was an ~75-cm depression beside the larger burrow, and no mounds were associated with depressions. The tilefish depression was slightly larger than all the rest observed in this portion of the transect.

The second sighting of a golden tilefish was again on transect VT-3, at 11:16 am and 247 m depth. The bottom in that 2-minute increment had moderate bioturbation- mostly small to medium mounds 10-30 cm, small depressions 10-20 cm, and few medium depressions 30-50 cm. When the tilefish was first observed far in the distance, it was sitting at the top edge of a 75-cm diameter burrow. Upon approach of the ROV the fish dived into an apparent burrow shaft at the bottom of the depression. The tilefish was ~30-50 cm TL, and had a visible bump on the forehead confirming its identification as *L. chamaeleonticeps*. The depression was round with a slightly raised rim. There were no adjacent mounds and the immediately surrounding bottom was relatively flat bottom. One other unidentified 10-cm fish was seen during the 2-minute interval.

Table 6. Select photographs (from video frame grabs) of fish identified from ROV transects. Identifications to species are tentative without specimens, and sizes are estimates. Figure No. refers to Figures 2 and 3. See Appendix 2 for locations- DVD and Photo No.

Transect No.	**DVD No.**	**Photo No.**	**Description**	**Depth (m)**	**Fig. No.**
1	1	21	Ogcocephalidae, batfish	137	3-D
1	1	26	*Epinephelus niveatus*, snowy grouper, 25 cm, and *Chaceon fenneri*, golden crab, with pipe debris	122	2-B
2	4	8	cf. *Urophycis* sp., hake	229	2-D
2	4	9	*Conger* cf. *oceanicus*, conger eel, 30 cm	239	3-C
3	6	6	*Laemonema* sp., codling, ladder debris	249	3-B
3	6	12	cf. *Lutjanus vivanus*, silk snapper	248	3-A
3	7	0	cf. *Dasyatis centroura*, 50+ cm	251	2-C
3	7	12	*Lopholatilus chamaeleonticeps*, golden tilefish, 50 cm, in burrow	247	2-A

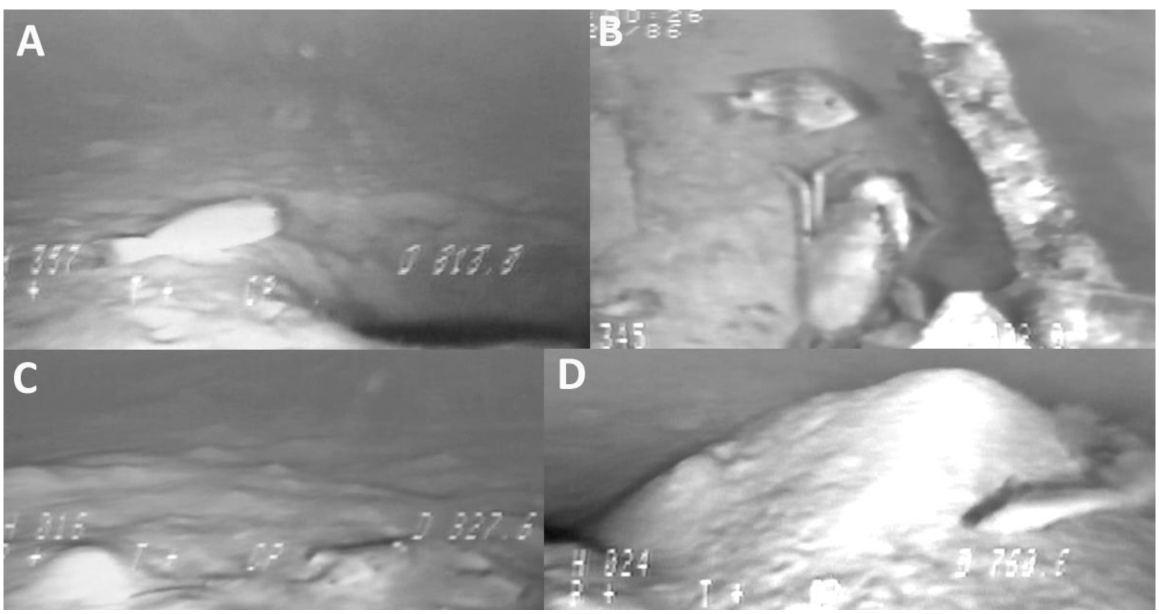

Figure 2. Photographs (from video frame grabs) of fish from ROV video transects. A. *Lopholatilus chamaeleonticeps* (golden tilefish); B. *Epinephelus niveatus* (snowy grouper) with *Chaceon fenneri* (golden crab); C. cf. *Dasyatis centroura* (roughtail stingray); D. cf. *Urophycis* sp. (hake). Refer to Table 6 for location and size of images.

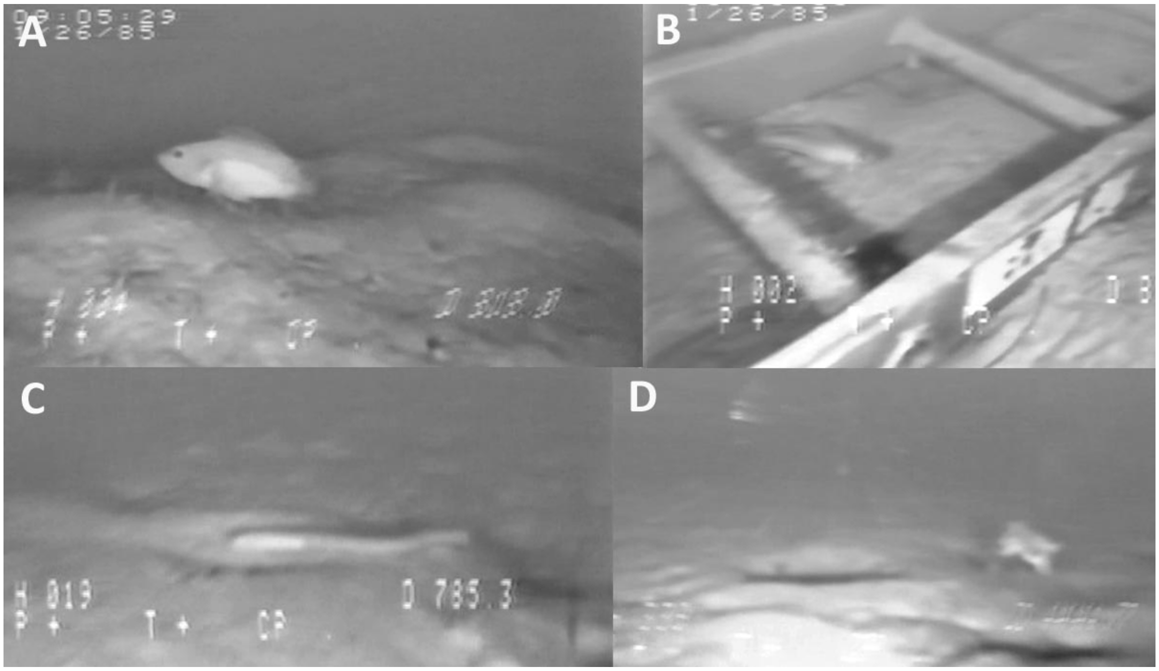

Figure 3. Photographs (from video frame grabs) of fish from ROV video transects. A. *Lutjanus vivanus* (silk snapper); B. *Laemonema cf. barbatulum* (codling); C. *Conger oceanicus* (conger eel); D. Ogcocephalidae (batfish). Refer to Table 6 for location and size of images.

<u>Benthic Macroinvertebrate Abundance and Distribution</u>

A total of 11 taxa were identified from the videotapes (Tables 3 and 7). Several experts confirmed the identifications of some of the taxa from the video (A. Hines, W. Lindberg, C. Messing, pers. comm.). Table 8 documents the photographs used in Figures 4 and 5 of the dominant macroinvertebrate taxa. The dominant macroinvertebrate that could be identified was cerianthid burrowing anemones which were present in all transects but dominated VT-1 and VT-4 at depths of 124-158 m (Table 7). A few were seen to 252 m on VT-3. Only the larger specimens (>10 cm) were enumerated while there were many more small individuals intermixed. The second most dominant taxa were decapod crustaceans (70 individuals total). The dominant genus was *Cancer* (most like *C. borealis*, the Jonah crab) with 28 individuals sighted over all transects and depth ranges. The golden crab, *Chaceon fenneri*, was relatively common (16 individuals) on all transects from 122 to 252 m but dominated on VT-3 which was deeper. The shallow observations are relatively unusual for the species. A galatheid crab *Munida* sp. was common at depths of 242-253 m, but only on transects VT-2 and -3. The large spider crab *Rochinia crassa* was also common at depths of 130-243 m on all transects except VT-3. The only other macroinvertebrate taxa observed were echinoids and several ophiuroid brittle stars. A large black spiny species that we believe is an echinoid and possibly *Centrostephanus longispinus* was recorded 28 times at depths of 132-166 m. One large orange starfish *Tethyaster grandis* was observed and one other urchin *Araeosoma* sp. The great majority of the sightings of the benthic motile invertebrates were in the vicinity of depressions, since the bioturbation was common throughout all transects; however, only in a few cases were they actually inside a depression such as *Cancer* sp.

Table 7. Number and distribution of benthic macroinvertebrates observed in ROV video transects. *Cerianthidae- counts for large (>5 cm), abundant small not counted. See Methods for substrate codes. (See Appendix 2 for locations).

Macroinvertebrate Taxa	**Transect No.**	**Depth Range (m)**	**Substrate Type**	**Total No. of Individuals**
Chaceon fenneri	VT-1	122	Bu	1
	VT-2	159	Bu?	1
	VT-3	248-252	Bu, Bu?	10
	VT-4	207-228	Mo, Bu?	4
	Total	122-252	Bu,Bu?,Mo	16
Cancer cf. *borealis*	VT-1	136-156	Bu	3
	VT-2	157-243	Bu, Mo	10
	VT-3	248-250	Bu, Bu?	12
	VT-4	166-213	Mo	3
	Total	136-250	Bu,Bu?,Mo	28
Rochinia crassa	VT-1	130-149	Bu	5
	VT-2	205-243	Bu?	2
	VT-4	158	Bu	1
	Total	130-243	Bu, Bu?	8
Bathynectes cf. *longispina*	VT-1	123	Bu	1
	VT-2	192	Mo	1
	Total	123-192	Bu, Mo	2
Munida sp.	VT-2	242-243	Bu?	2
	VT-3	250-253	Bu, Bu?	10
	Total	242-253	Bu, Bu?	12
Unid. Paguridae	VT-3	249-252	Bu?	4
cf. *Centrostephanus longispinus*	VT-1,-2,-4	132-166	Bu,Bu?,Mo	28
Tethyaster grandis	VT-4	139	Bu	1
Araeosoma sp.	VT-1	150	Bu	1
Ophiuroidea	VT-3	250-251	Bu?	3
Cerianthidae	VT-1	124-158	Bu	201
	VT-2	154-229	Bu?, Mo	5
	VT-3	251-252	Bu	3
	VT-4	138-149	Bu	66
	Total	124-252	Bu,Bu?,Mo	275*

Table 8. Select photographs (from video frame grabs) of benthic macroinvertebrates identified from ROV transects. Identifications to species are tentative without specimens, and sizes are estimates. Figure No. refers to Figures 4 and 5. See Appendix 2 for locations- DVD and Photo No.

Transect #	**DVD #**	**Photo #**	**Description**	**Depth (m)**	**Fig. No.**
1	2	5	cf. *Centrostephanus longispinus*, sea urchin	134	5-D
2	4	4	*Bathynectes* cf. *longispina*, Portunidae, in crater	192	5-A

2	4	10	*Munida* sp., Galatheidae, squat crab	242	4-D
2	4	12	*Rochinia crassa*, spider crab	243	4-C
3	6	1	*Chaceon fenneri*, golden crab	251	4-A
3	6	2	Ophiuroidea, brittlestar	251	5-E
3	6	17	*Cancer* cf. *borealis*	252	4-B
4	8	5	Cerianthidae, burrowing anemone	138	5-B
4	8	7	*Tethyaster grandis*, giant orange starfish	139	5-C

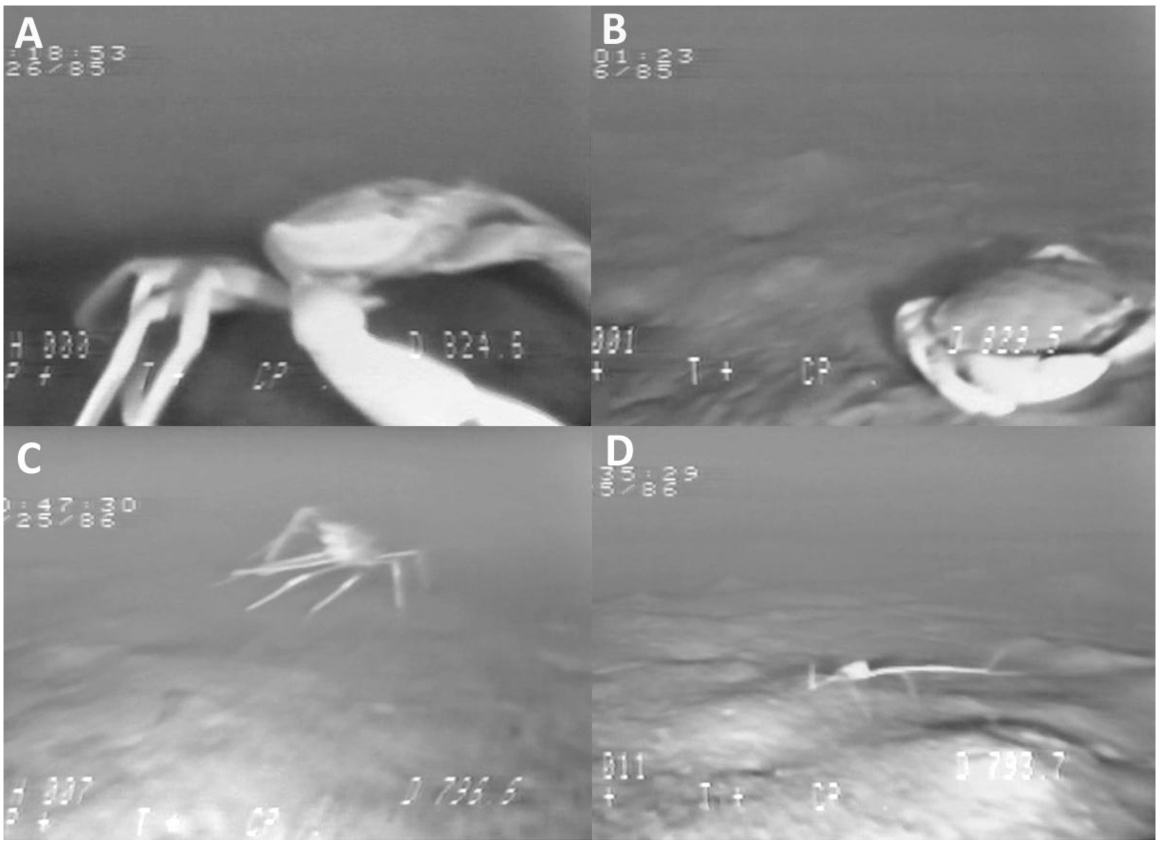

Figure 4. Photographs (from video frame grabs) of fish from ROV video transects. A. *Chaceon fenneri* (golden crab); *Cancer* cf. *borealis* (Jonah crab); C. *Rochinia crassa* (spider crab); D. *Munida* sp. (galatheid squat crab). Refer to Table 7 for location and size of images.

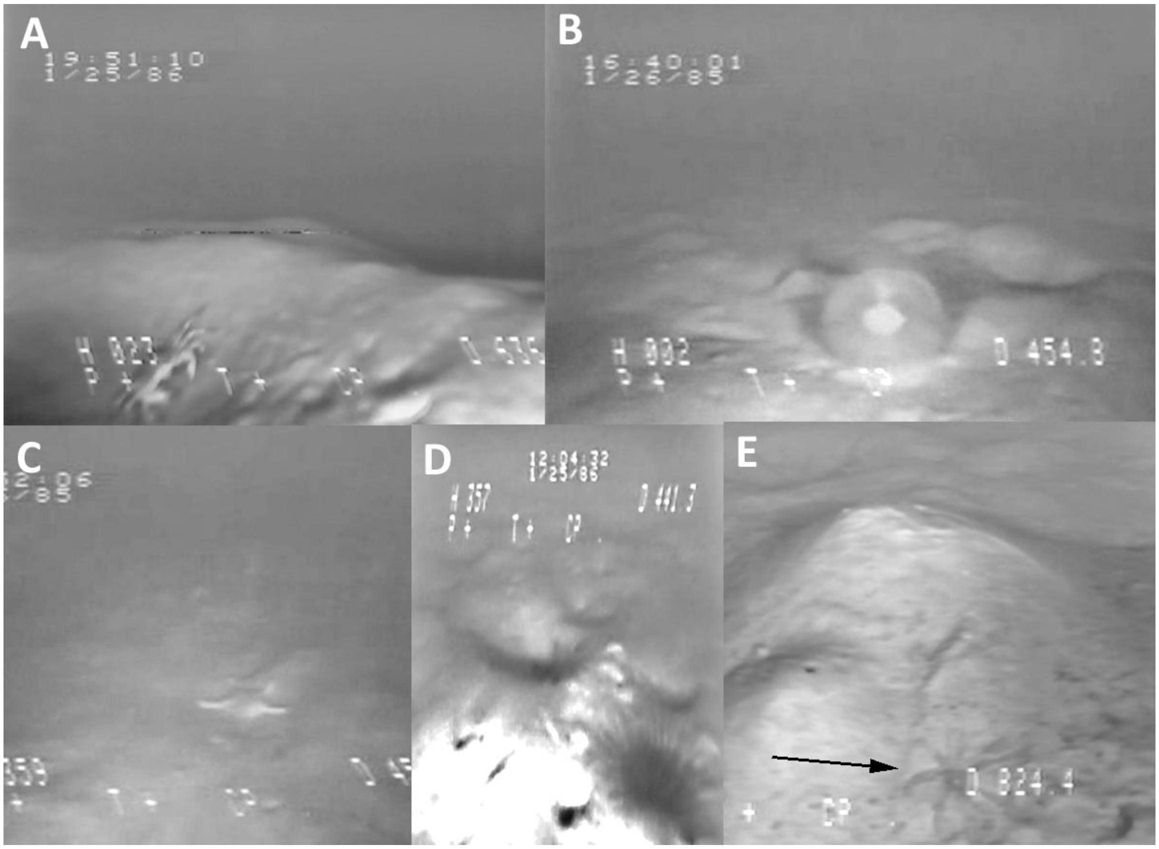

Figure 5. Photographs (from video frame grabs) of fish from ROV video transects. A. *Bathynectes longispina* (red crab); B. Cerianthidae (burrowing anemone); C. *Tethyaster grandis* (giant orange starfish); D. cf. *Centrostephanus longispinus* (long-spined sea urchin); E. Ophiuroidea (brittle star). Refer to Table 7 for location and size of images.

Bottom Types

Various parameters regarding substrate type were used for the Excel annotation template (Appendix 2) that were based on the geological features typically found on the outer shelf in the Straits of Florida. These included designations for soft bottom (S) and hard bottom (H). Hard bottom was further categorized into rock pavement, ledges, rock rubble, standing coral, coral rubble, and artificial substrate (concrete debris, rubble, metal). Considering the depth of this survey area and that it was a disposal site for the EPA we had expected to find considerable amounts of concrete debris over mud and or hard bottom substrate.

However, what we found in the 14.3 hours of transects was 100% soft bottom consisting of sand/mud substrate (Fig. 6). Sediment analysis (Table 2) from the 1985 environmental assessment (Conservation Consultants, 1985) shows that the stations near the center of the ODMDS were primarily fine sand (~75%) and silt (~25%); these stations were closest to transects VT-1 and VT-2. Although there was some very minor debris scattered throughout the area, only two 2-minute intervals showed any significant concrete debris (Table 9). One small debris field was observed in transect VT-3 and consisted of 10-20 cm pieces of apparent concrete or rock which covered ~10% of the mud bottom over an area of ~10 m^2. A second small debris field was found in VT-4 and consisted of ~10 cm rocks or mud or concrete covering about 10%

of the mud substrate over an area of ~10 m^2. One portion of transect VT-4 appeared to have a lumpy sediment surface that was not typical of the other bioturbation features, and this could indicate some underlying debris. Other debris was small pieces scattered here and there of bottles, cans, cables, rope, pipe and a fuel tank. These are probably just random debris scattered by boaters and not deposited as part of the disposal site. The largest piece of debris was an outboard small boat (~6 m) that was overturned and lying on the bottom.

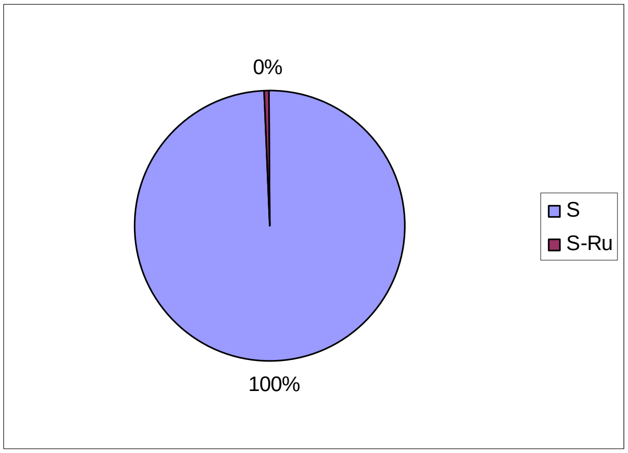

Figure 6. Percent cover of bottom types over all ROV transects. S=soft sediment, S-RU= sediment with apparent concrete rubble.

Table 9. Anthropogenic and other debris recorded during ROV video transects. (See Appendix 2 for locations).

Transect No.	No. of Bottles	No. of Drink Cans	Unidentified Debris	Other
VT-1	4	3	9	5-cm diameter cable, 6-m outboard boat, pile of wire, rope, pipe
VT-2	2	5	4	wires, tree branch, 50-cm fuel tank, small box
VT-3	7	4	3	can, stick, cloth, glass, 6-m long rope, 1-m pipe, 20-cm rock; debris field: pieces of 10-20 cm concrete or rock, ~10% cover of debris on mud over ~10 m^2 area
VT-4				cup, bucket, 50-cm pipe, 1-m cable; debris field: 10-cm rocks or mud or concrete?, 10% cover of debris on mud over 10m^2 area

Bioturbation

As described in Methods, the various types of bioturbation were found throughout the video transects. Typically these were pits, craters, mounds, burrows made by various organisms including worms (echiurans, sipunculids, polychaetes, etc.), bivalve mollusks, echinoids, crustaceans, and fish. Dense bioturbation was recorded during every 2-minute interval of every transect (Appendix 2). In between the bioturbation features the bottom was relatively flat mud. The dominant bioturbation features consisted of conical mounds, some of which had an apical burrow or hole from which sediment was seen occasionally spurting out. These undoubtedly were the excurrent hole for some infauna such as a worm or mollusk. These were documented in Appendix 2 as small (5-15 cm diameter at base), medium (15-30 cm), and large (30-50 cm) with the sizes being a gross estimate as described in the Methods. The other dominant bioturbation features were depressions and burrows. These were conical to oval scours in the sediment and some had vertical or oblique shaft or hole in the bottom which was the actual burrow of the organism making the depression. These were estimated in Appendix 2 as small (<30 cm in diameter), medium (30-50 cm), and large craters (50- >100 cm). Table 10 documents the photographs used in Figure 7 of the dominant substrate types including debris and bioturbation.

Table 10. Select photographs (from video frame grabs) of substrate and bioturbation from ROV transects. Identifications to species are tentative without specimens, and sizes are estimates. Figure No. refers to Figures 7, 9. See Appendix 2 for locations- DVD and Photo No.

Transect No.	DVD No.	Photo No.	Description	Depth (m)	Fig. No.
1	1	15	Bioturbation- 30 cm mounds, 50 cm depressions	144	7-B
1	1	18	Debris- bottle, cans	141	7-G
1	1	19	Bioturbation- active burrow, probable tilefish, 75-100 cm diameter round shaped depression with vertical burrow shaft in bottom	140	9-C
1	1	20	Bioturbation- active burrow, probable tilefish, 75-100 cm diameter oblong shaped depression with oblique burrow shaft in bottom	140	9D
1	1	28	6 m outboard boat overturned on bottom	130	7-F
2	3	1	Bioturbation- moonscape, high density mounds and depressions	176	7-C
2	4	0	Bioturbation- non-active burrow, large depression with smoothed sides and eroded	156	9-B
2	4	11	Bioturbation- 100 cm diameter depression with three active burrow shafts in bottom	243	7-D
3	7	5	Manmade debris- scattered rocks or concrete (10-20 cm pieces) over 10 m of bottom	249	7-E
4	8	0	Bioturbation- flat sediment with 5-10 cm diameter depressions	140	7-A
4	8	3	Bioturbation- 50-75 cm diameter, active burrow with raised rim, probable tilefish	138	9-A

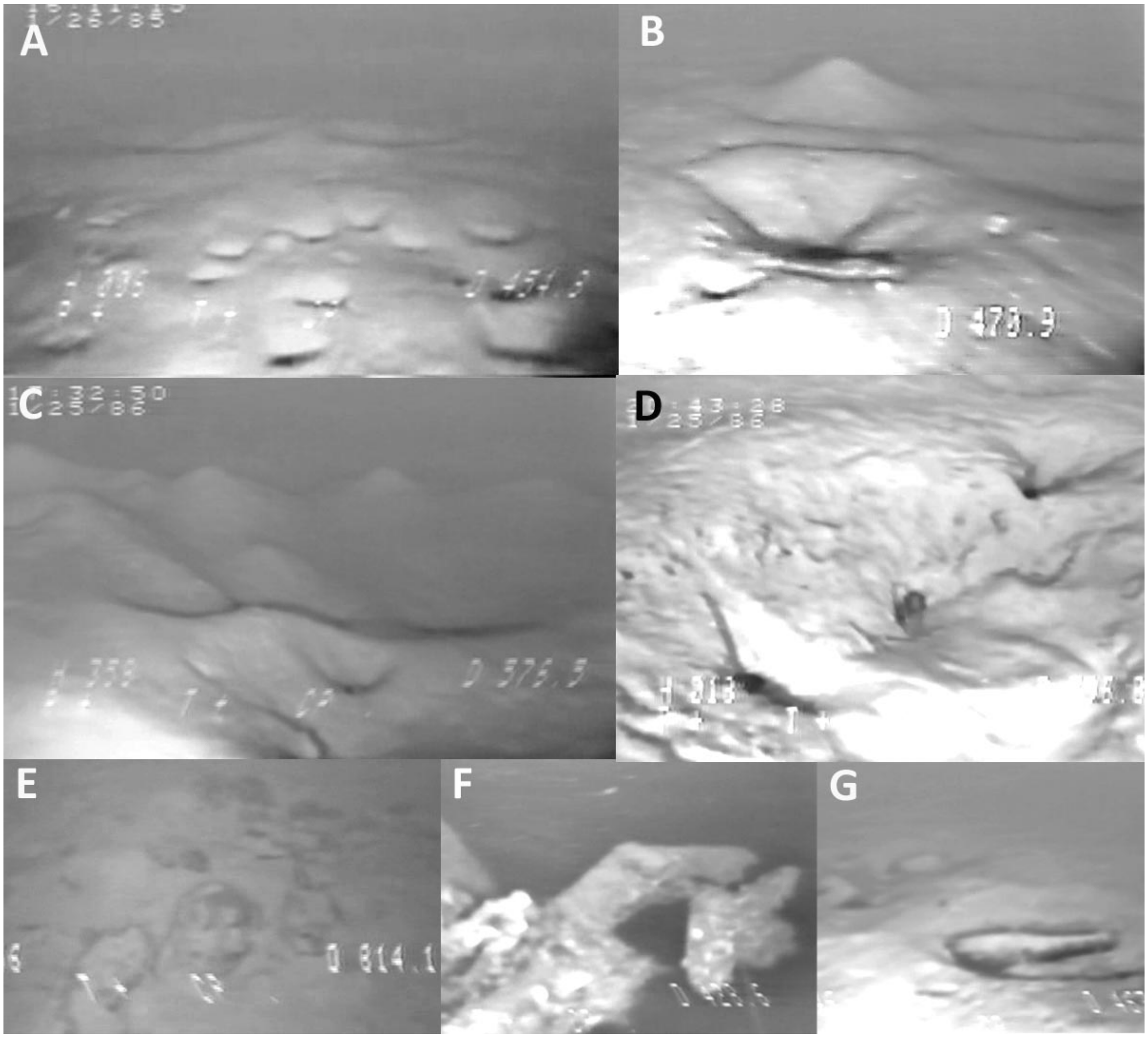

Figure 7. Photographs (from video frame grabs) of substrate, bioturbation, and debris from ROV video transects. A. Bioturbation in sand-mud sediment, small and large depressions; B. Bioturbation of large mounds and depressions; C. 'Moonscape' bioturbation with dense mounds and depressions; D. Large elongate depression with three burrow in bottom; E. Small debris field of rock or concrete; F- Overturned outboard boat showing prop; G. Bottles and cans. Refer to Table 10 for location and size of images.

Tilefish Burrows

Since only two tilefish were actually seen during all 14.3 hours of the ROV video transects, the determination of whether the remaining thousands of depressions could be tilefish burrows is a judgment call based on the PIs experience and collaboration with numerous experts in the field (see list of contacts in Methods, QA/QC). Based on the characteristics of some of the medium and large depressions (>30 cm diameter), some were characterized as apparent tilefish burrows. These characteristics were based on descriptions of blueline tilefish and golden tilefish burrows in the literature (Grimes et al. 1986, Able et al. 1987 b, 1993), review of videotapes by experts in the field, and review by the PI of previous submersible photographs of known blueline and golden tilefish (Avent and Stanton, 1979).

The presence or absence of apparent tilefish burrows were recorded for during each 2-minute increment of each transect (Appendix 2, Table 11, Map 2). The code 'Bu' indicates that medium (ca. 30-50 cm) to large (>50-150 cm) tilefish-like burrows were observed during that 2-minute interval (Fig. 9). Where these depressions exceeded 30 cm in diameter and had the shape and characteristics of tilefish burrows as described in the literature, these were coded as 'Bu'. The 'Mo' code was for bioturbation that was predominately mounds along with various size depressions but were not likely made by tilefish. Excerpts of videotapes of this 'Mo' habitat type were shown to various experts (R. Jones, K. Able, C. Grimes, G. Sedberry, C. Koenig, K. Sulak, pers. comm.), all of whom agreed that the depressions here were not made by tilefish. In some intermediate areas between 'Mo' habitat and 'Bu' habitat, it appeared less certain that the medium and large craters were tilefish burrows, so these were coded as Bu?, or possible tilefish burrows. Overall 81.7% of all transects had apparent tilefish burrows (Bu and Bu?), ranging from 49.5% for transect VT-2 to 100% for both VT-1 and VT-3 (Fig. 8, Table 11). Only transect VT-3 had actual tilefish sightings.

Table 11. Number of 2-minute intervals with sighting of apparent tilefish burrows (>30 cm diameter). Codes: [1] Bu= probable tilefish burrows; [2] Bu?= possible tilefish burrows; [3] Mo= dense mound bioturbations, but tilefish burrows unlikely; [4] visual sighting of golden tilefish, *Lopholatilus chamaeleonticeps*. Percent of transect with possible tilefish burrows (Bu + Bu?/ total number of 2-minute increments).

Transect No.	**Tilefish Burrows (Bu)[1]**	**Tilefish Burrows (Bu?)[2]**	**Burrows Not Tilefish (Mo)[3]**	**Percent of Transect with Possible/Probable Tilefish Burrows**	**Visual Sighting of Golden Tilefish[4]**
VT-1	125	2	0	100	0
VT-2	0	52	53	49.5	0
VT-3	11	81	0	100	2
VT-4	39	25	22	74.4	0
Total	175	160	75	81.7	2

INSERT MAP 2- GIS OF BURROWS AND TILEFISH

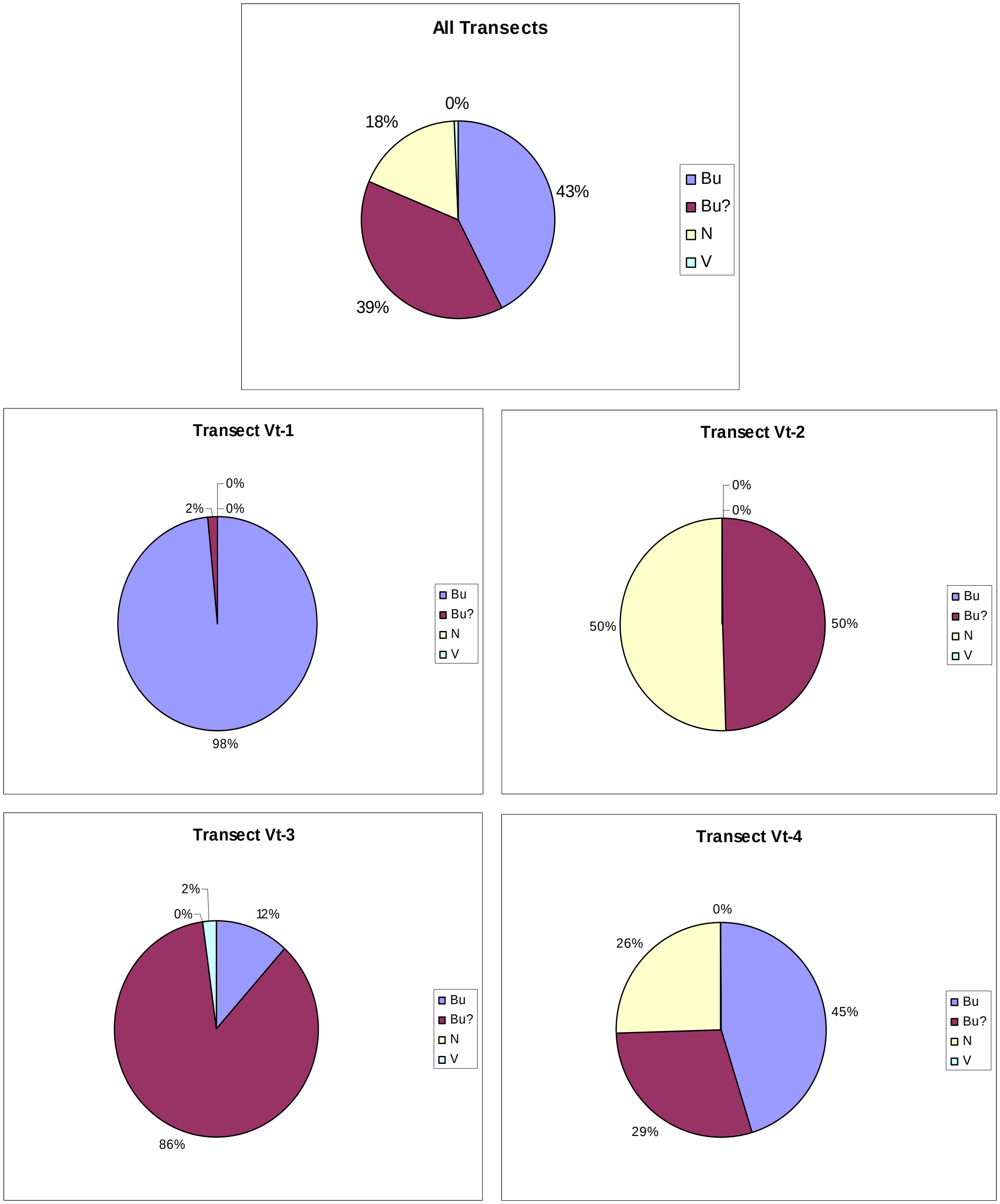

Figure 8. Percentage of 2-minute intervals with sightings of apparent tilefish burrows (>30 cm diameter). Bu= probable tilefish burrows; Bu?= possible tilefish burrows; N (Mo)= dense mound bioturbations, tilefish burrows unlikely; T= visual sighting of golden tilefish.

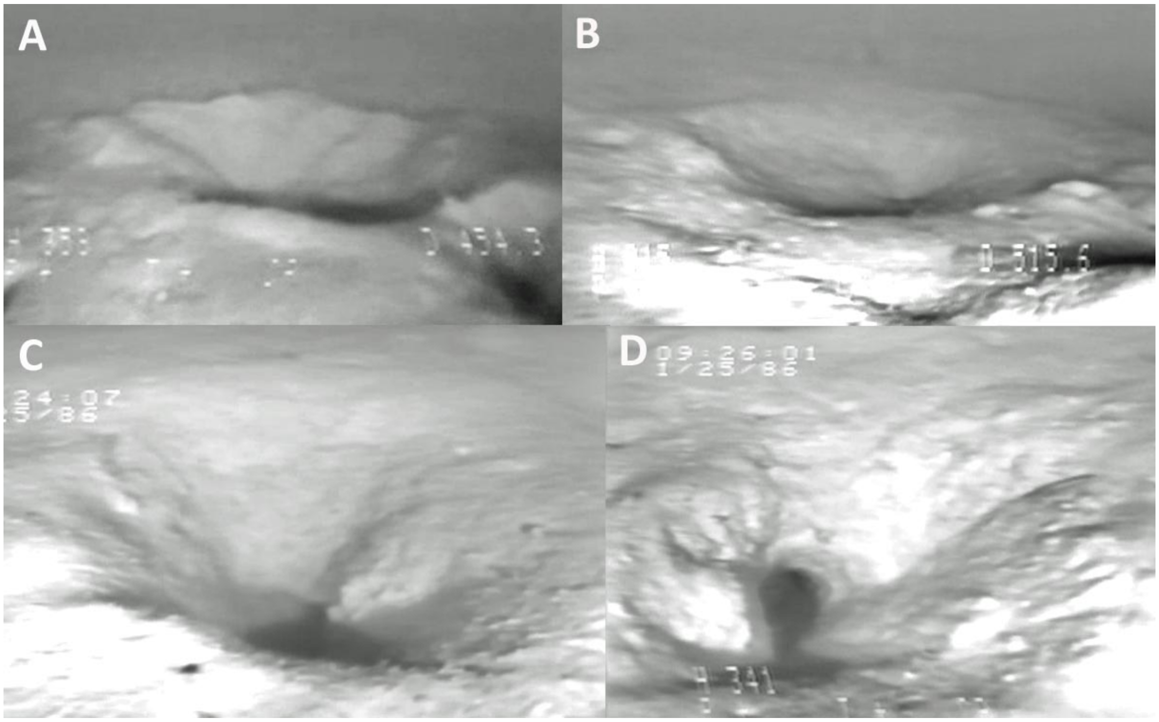

Figure 9. Photographs (from video frame grabs) of apparent tilefish burrows from ROV video transects. A. Large (~75-100 cm diameter) burrow with raised rim and steep sides; B. Inactive burrow that appears as smoothed, filled in depression; C. Large burrow (ca. 75 cm diameter) with apparent vertical shaft at bottom; D. Large burrow (ca. 75 cm) with oblique shaft at bottom. Refer to Table 10 for location and size of images.

In addition to the qualitative presence/absence documentation of burrows, the actual numbers of medium and large burrows were quantified and enumerated during 2-minute intervals every 15 minutes (Appendix 2) and are summarized for each individual transect (Table 12). These were also recorded as either active (A) or inactive (N) for each time interval (Appendix 2). Based on literature and comments from tilefish experts, active mounds would have a vertical or oblique shaft (burrow) at the bottom of the depression, the sides of the depression would be steep, and sometimes (but not always) the top edge would have a slightly raised rim from the tilefish scouring out the sediment (Fig. 9 A). Inactive depressions would be older burrows where the tilefish has left and is not actively maintaining the burrow (Fig. 9 B). As such the shaft would fairly quickly fill in, more quickly in sand/silt sediment than sand/clay sediment, and the sides would tend to be smooth and less steep. Since the video was of such poor quality and the video camera varied in position angle and height during the transects, only some of the depressions could be viewed for the presence of burrows at the bottom. If any active burrows were observed during the interval then that interval was recorded as active. As such, if some of the depressions were determined to be 'active' burrows during a 2-minute interval, then that interval was logged as having active burrows.

The mean number of tilefish burrows per 2-minute interval was calculated for each transect by averaging the number of tilefish burrows that were counted during each 2-minute interval every 10-15 minutes (Table 12, Fig. 10). These maximum density of 21.6 burrows per 2-minute interval occurred at VT-1 in which nearly 100% of the intervals counted had apparent active burrows. VT-4 had a mean of 13.5 burrows per 2-minute interval and ~50% of these intervals had active burrows. Transect VT-3 in which the only two tilefish were observed had 6.1 burrows per 2-minute interval of which ~75% were active. While transect VT-2 had 7.5 burrows but 100% appeared inactive, that is they appeared smooth, worn, and no burrows were seen at the bottom of the depressions.

Tilefish burrow densities (mean number of burrows/1000m^2) were determined for each transect by taking the mean number of burrows per 2-minute increment and multiplying by the total number of 2-minute increments for that transect, then dividing by the total transect length in kilometers times 1-m width field of view (Table 11). For example, for transect VT-1: [(21.59 burrows per 2-minute interval) x (135 2-minute intervals total)] / [6.95 km length x 1 m] = 419 burrows/1000m^2. Because of the uncertainty in determining the size of the field of view we used the average width of 1 m for the field of view for the bottom portion of the video; however, the top of the video view could possibly range from 2-5 m in width depending on the height of the ROV off bottom. The mean burrow density ranged from 115 burrows/1000m^2 at transect VT-3 to 419 burrows/1000m^2 at VT-1 and averaged overall at 244.

Table 12. Tilefish burrow numbers (actual counts/2-min intervals); medium burrows (~30-50 cm), large burrows (>50-100+ cm); mean No. burrows= average of 2-minute increments; mean burrow density= mean number of burrows/1000m^2; active burrows: Yes= signs of activity by tilefish, such as open shaft at bottom, raised rim, or rugged internal sides; No= not active, no open shaft at bottom, smoothed or eroded burrow.

Transect No.	**Depth (m)**	**Time**	**No. of Medium Burrows**	**No. of Large Burrows**	**Total Burrows**	**Mean No. of Burrows/2-min.**	**Mean Burrow Density (No./ 1000m^2)**	**Active Burrows (Yes/No)**
VT-1	147	848	4	2	6			Y?
	148	900	4	1	5			N
	144	910	20	6	26			Y
	139	932	4	5	9			Y
	133	944	22	8	30			Y
	122	1002	8	7	15			Y
	124	1016	13	4	17			Y
	126	1030	22	5	27			Y
	133	1048	15	10	25			Y
	135	1100	21	7	28			Y
	133	1116	30	3	33			Y
	133	1130	16	3	19			Y
	135	1144	16	8	24			Y
	134	1200	15	11	26			Y
	135	1214	18	10	28			Y

	136	1230	20	3	23			Y
	149	1250	22	4	26			N?
Total VT-1						21.59	419	
VT-2	175	1734	4	1	5			N
	178	1746	1	4	5			N
	180	1800	9	0	9			N
	173	1816	5	1	6			N
	161	1830	2	0	2			N
	154	1844	3	0	3			N
	156	1900	1	1	2			N
	165	1916	2	2	4			N
	175	1930	4	2	6			N
	187	1944	7	3	10			N
	205	2000	8	4	12			N?
	231	2016	11	4	15			N?
	243	2030	6	4	10			N?
	242	2036	10	0	10			N?
	243	2058	12	2	14			N?
Total VT-2						7.53	120	
VT-3	250	830	6	5	11			Y?
	249	844	4	3	7			Y
	249	902	5	2	7			N
	250	914	5	0	5			N?
	252	936	3	2	5			Y
	252	948	5	6	11			Y?
	252	1002	4	2	6			Y
	252	1018	4	6	10			Y
	252	1026	3	2	5			Y?
	251	1044	0	1	1			Y?
	251	1100	2	1	3			N
	247	1116	1	1	2			Y
Total VT-3						6.08	115	
VT-4	140	1610	25	5	30			Y
	141	1620	22	7	29			Y

	140	1630	15	3	18			Y
	139	1644	13	14	27			Y
	140	1700	6	8	14			Y
	147	1714	11	5	16			Y
	163	1730	0	4	4			N
	180	1744	0	3	3			N
	204	1800	1	6	7			N?
	219	1814	3	1	4			N?
	230	1830	2	1	3			N?
	233	1838	1	6	7			N
Total VT-4						13.50	336	
Total All Transects						12.77	244	

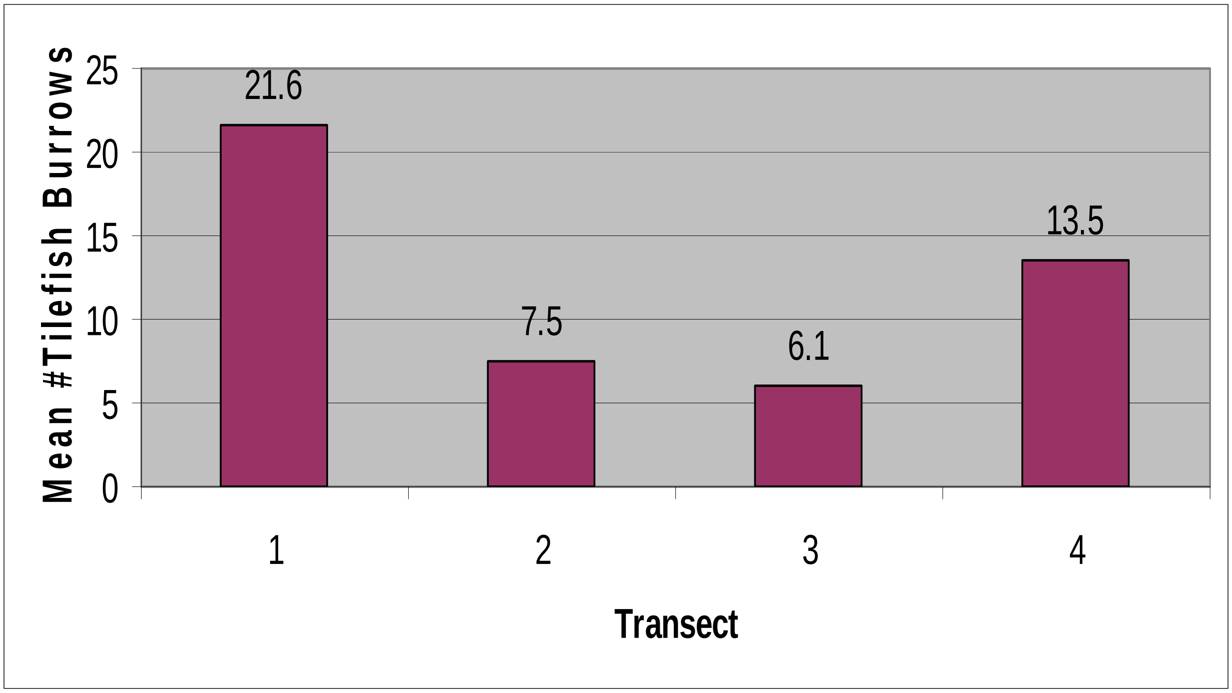

Figure 10. Mean number of apparent tilefish burrows per 2-minute increment for each ROV video transect.

DISCUSSION

Determination of Bioturbators

Conical Mounds, Depressions, and Craters

Excerpts of the videotapes were given to numerous experts (see Methods) for their opinions on what could have made the various types of mounds, depressions and burrows that are common to all the video transects. Most of the invertebrate and infaunal specialists believed that the mounds and the smaller depressions could be made by various worms including polychaetes, hemichordates, echiurans, sipunculids;, bivalve mollusks, decapod crustaceans, and fish (R. Virnstein, M. Rice, C. Messing, A. Hines, pers. comm.). None could positively state that a particular mound or depression was made by any specific species. Some of the conical mounds were clearly fecal mounds since they often had an apical aperture or hole that were seen venting plumes of sediment. Dr. R. Virnstein (pers. comm.) studied the benthic ecology of infauna on the continental shelf off central eastern Florida using the *Johnson-Sea-Link* submersible in similar habitat (silt/clay mud) and depths (124-311 m). Settlement traps and grab samples found up to 1,600 individual of infauna/ m^2, 2/3 of which were polychaetes, and 22/m^2 were sipunculids. Using the submersible they specifically tried to sample the large mounds with a Smith-McIntyre grab, but were unable to determine what species made the mound. During submersible studies of tilefish, Dr. K. Able (pers. comm.) also attempted to suction the mounds and depressions but were unsuccessful in retrieving the animals. Dr. R. George (pers. comm.)

mentioned that burrowing anemones may make mounds and trails. Cerianthid anemones were certainly common in most of our transects. Dr. M. Rice (pers. comm.) did not believe that sipunculans made the large mounds and Dr. R. Ginsburg (pers. comm.) suggested the possibility of some mud shrimp-like *Callianassa* crustaceans which form similar size and shape mounds in shallow waters of south Florida and the Bahamas. Dr. W. Lindberg (pers. comm.) conducted submersible studies in similar habitat on the upper slope in the Gulf of Mexico and saw similar bioturbation mounds which they attributed to vermes. Although they saw red crabs, galatheid crabs and tripod fish occasionally in the pits or on the mounds, they saw no evidence that the features were made by them. Where the craters and mounds were together, Dr. P. Mikkelsen (pers. comm.) suggested that the mounds are of vermes nature with the depression formed by the intake of the worm and the opposite end forming a fecal mound. In addition to various vermes, Dr. G. Sedberry (pers. comm.) suggested that hakes, skates, and decapod crustaceans such as *Cancer* and *Chaceon* could make some of the depressions.

The infaunal and epibenthic trawls and grabs made at the ODMDS site by Conservation Consultants (1985) listed a variety of invertebrates and fish that could contribute to the bioturbation. They listed various species of decapod crustaceans, some of which we observed, including galatheids (*Munida* sp.), spider crabs (*Nibilia* sp.), Jonah crabs (*Cancer* sp.), and portunids (*Portunus* sp.). They listed 8 families of Pelecypoda (bivalves), 26 families of Polychaeta, 2 sipunculids, and 20 species of fish. It is interesting that they did not list either tilefish or the golden crab, both of which we found in the videotapes. The tilefish, however, could easily avoid the trawl by diving into their burrows.

Determination of Tilefish Burrows

Various parameters could help determine the identity of the potential tilefish burrows that were observed in the ROV videos. However, can we identify to species based on burrow characteristics such as shape and size, sediment characteristics, and preferences of depth and temperature for the two likely tilefish in this region? In general, as described below, we can not determine the species of tilefish burrows based only on these parameters from this study. Only by direct observation of tilefish at two burrow sites were we able to confirm the identity of these two particular burrows as golden tilefish.

<u>Shape and Size of Burrows</u>

Whereas the smaller depressions could easily be made by any number of worms, mollusks, crabs, or fish, the larger depressions formed crater-like structures of 30 cm to >100 cm in diameter and have some characteristics of tilefish burrows. Numerous observational studies with submersibles of deep-water tilefish (blueline tilefish *Caulolatitus microps,* and golden tilefish *Lopholatilus chamaeleonticeps*) have documented the morphology of the tilefish burrows and have compared the two species. For the larger *L. chamaeleonticeps,* burrows as large as 4-5 m diameter at the top of the cone-shaped depression and 2-3 m deep, have been observed in the clay sediments of Hudson Submarine Canyon, but average burrow size in the canyon was 0.88 to 1.6 m (Able et al., 1982; Twitchell et al., 1985). In these clay substrates off Mid-Atlantic and southern New England the golden tilefish form three types of burrows: horizontal excavations in clay outcrops on wall of submarine canyons, scour depressions under boulders, and the primary habitat of funnel-shaped vertical burrows in clay substrates (Grimes et al., 1986). The burrows are believed to be formed by a combination of oral excavations by the fish and finning motions by the tilefish to flush fine sediments from the burrow, and bioerosion by associated fauna (crabs, fish), (Grimes et al., 1986).

However off eastern Florida the sediments on the upper slope are siltier and the burrows of *L. chamaeleonticeps* are smaller 0.3- 1.5 m diameter (Able et al., 1993). The largest burrows of *C. microps* observed by submersible off Florida were 1.5 x 0.5 m diameter, although sidescan sonar records of the area showed apparent tilefish burrows as large as 3 x 1.5 m (Able et al. 1987, a,b). Smaller burrows attributed to *C. microps* ranged from 0.3 to 0.6 m diameter and averaged 48 cm. The larger burrows tended to be elongate to elliptical. This is thought to have been caused by the erosion and slumping of the sandy/silt sediment into the shaft burrow which then needs to be repeatedly burrowed out causing the elongate feature. Sidescan sonar has been shown to be able to detect burrows as small as 0.5 m diameter of both blueline and golden tilefish in both clay sediments off New England and softer carbonate sediments off east coast Florida (Able et al., 1987 a).

The burrows of both *L. chamaeleonticeps* and *C. microps* are relatively similar and in fact both species have been observed in the same burrow (Able et al., 1987 b). Both species construct burrows in areas of malleable, relatively soft sediment. Burrows of both form cone shaped depressions that narrow to a single oblique or vertical shaft which is the actual burrow of the tilefish. Smaller secondary burrows of associated crustaceans and fish are common around the upper wall of the cone.

Based on burrow shape and size alone, we can not positively identify the burrows in this study as definitely made by either the golden or blueline tilefish. Both have very similar shapes and sizes especially in the siltier carbonate sediments of south Florida. Other parameters must be considered.

<u>Depth and Distribution</u>

The golden tilefish *L. chamaeleonticeps* generally occurs deeper >200 m than *C. microps* and has a wider distribution from Nova Scotia to South America, but apparently is excluded from the Caribbean (Dooley, 1978; Able et al., 1993). Off southeastern U.S. there are two stocks: Mid-Atlantic Bight to southern New England, and Cape Hatteras to Gulf of Mexico and Yucatan. Grimes et al. (1986) has reported it at depths of 80-305 m off eastern U.S. and McEachran and Fechman (2005) reported it at depths of 81-540 m over its entire range.

In detailed submersible surveys from depths of 30 m to 300 m off central eastern Florida slope, *C. microps* was documented at depths of 76-269 m, but most were within 100 and 200 m (Avent and Stanton, 1979). They had only a few sightings of *L. chamaeleonticeps* and at depths of 180-250 m. In other studies off southeastern U.S. *C. microps* was generally found at depths of 90-150 m, but burrows were documented from 57 to 211 m (Able et al., 1987 b). In other studies the blueline tilefish has been reported from southeastern U.S. to Campeche, Mexico at depths of 75-236 (Ross and Huntsman, 1982) and from 30-130 m by McEachran and Fechhelm (2005).

Based on the total known depth range reported for *C. microps* (57-236 m) and for *L. chamaeleonticeps* (80-540 m), either species could occur on any of the four ROV transects where burrows were recorded from 122 to 252 m and where the golden tilefish were observed at 247-252 m. However, the shallower burrows in the sandy-silty sediments of transects VT-1, -2, and -4 (122-200 m) could likely be from *C. microps* and the deeper burrows of VT-2, -3, and -4 (>200 m) could be L. *chamaeleonticeps*.

Temperature Preferences

C. microps was reported off central eastern Florida at bottom temperatures of 13.8-18.0^{o} C (Able et al., 1987 b); however, Avent and Stanton (1979) recorded average temperatures of 12-18^{o} C at similar sites on the upper slope with occasional upwellings to 10^{o} C and even as low as 6-9^{o} C. *L. chamaeleonticeps* can also endure abrupt temperature changes from upwelling to below 8.0^{o} C for a short time (Able et al., 1993). In general, the golden tilefish is known to prefer temperatures of 9-14^{o} C (Grimes et al., 1986; Matlock et al., 1991) and was recorded off eastern Florida at temperatures of 8.6-15.4^{o} C (Able et al., 1993).

The only temperature records we have from the environmental survey by Conservation Consultants (1985) recorded bottom temperatures ranging from 10-18^{o}C at depths of 140-226 m within the central part of the ODMDS (Table 2) and near transects VT-1, -2, and -4. We have no records for the deeper transect VT-3, but from submersible dives elsewhere in this region, temperatures of 8-10^{o}C are likely. As such, C. microps could occur at VT-1, -2, and -4 and within their preferred range of 12-18^{o}C. The deeper parts of VT-2, -3, and -4 at depths >200 m could have temperatures at 10^{o}C or possibly lower where *L. chamaeleonticeps* would prefer.

Sediment Preferences

The primary differences in Florida are that *C. microps* burrows tend to be in sandier sediments which tend to collapse on the oblique burrow shaft so the larger burrows are often elongate. Since the sandy/silt sediment is less cohesive the burrow shafts are often oblique rather than vertical which can be maintained in the more malleable clay sediment preferred by *L. chamaeleonticeps* (Able et al., 1987 b). Analysis of sediments on the upper slope off central eastern Florida found *C. microps* at depths of 150 m in sediments of 50-82% sand/5-11% clay and *L. chamaeleonticeps* at 238 m was in 24% sand and 28% clay (Able et al. 1987 b, 1993).

During the environmental survey of the ODMDS site by Conservation Consultants (1985), sediment analysis at sites along the central part of the ODMDS found sandy silt sediment (61-75% fine sand/22-38% silt/0% clay) (Table 2). This was generally along transects VT-1 and VT-2. This original survey had no stations near VT-3. The only station that had relatively high clay (M-5; 76% sand/9% silt/14% clay) was ~0.l5 nm west of transect VT-4. Therefore, we can conclude that VT-1, -2, and -4 are likely fine sandy-silt which is generally preferred by *C. microps*. However, we have no sightings of *C. microps* in the videotapes to confirm this possibility. Since we have no sediment data for VT-3 we can only assume it had higher clay content preferable to *L. chamaeleonticeps* which were observed there.

Active vs. Inactive Burrows

Exclusion experiments off eastern Florida with submersibles blocked tilefish from entering their burrows by placing a screen over the hole (Able et al., 1993). Within 173 days the cone-shaped depressions were nearly completely filled. Inactive burrows fill in varying degrees starting with the shaft filling in, erosion of the upper cone, loss of associated burrows around the upper cone, and finally resulting in a relatively smooth, shallow depression (Grimes et al., 1986; Matlock et al., 1991). Sidescan sonar can not differentiate bertween active and inactive burrows (Able et al., 1987 a). Abandoned burrows quickly occurred in the 1980s along the southeastern U.S. from the expansion of the commercial longline tilefish fishery (Grimes et al., 1986). Data from South Carolina fishery showed substantial declines in catch rate and mean fish size in just 4-5 years with low to moderate fishing effort (Low et al., 1983).

Due to the poor video quality of this study it was difficult to determine the frequency of occurrence of active versus inactive burrows. Only when the ROV was near the bottom and the camera was angled down and passing directly over a burrow could we observe the presence of a shaft in the bottom of a depression, indicating and active burrow. As such, instead of quantifying each burrow, we could only quantify the presence of active burrows within a 2-minute time interval. Although all transects had what appeared to be tilefish burrows (Table 11), some areas appeared to have more active burrows than others. For example, Transect VT-2 appeared to have numerous tilefish size depressions (49% of the transect) but none appeared to be active (Table 12). Whereas Transect VT-1 appeared to have the greatest activity: nearly 100% of the transect had tilefish-like burrows and most intervals had active-appearing burrows. Transects VT-3 and VT-4 had burrows over 100% and 74% of the transect, respectively, but each had active burrows over only ~50% of the transect.

Tilefish Identifications

The identifications of the two tilefish observations from the ROV transects were based on descriptions of *L. chamaeleonticeps* and *C. microps* (Dooley 1978, 2002; McEachran and Fechhelm 2005), and confirmation by fish specialist (R. Jones, pers. comm.). Both fish were identified as golden tilefish which is noted by having an elevated pre-dorsal ridge forming an enlarged flap and truncate caudal fin. In contrast, the blueline tilefish has a dorsal head profile that is moderately convex, deeply emarginated caudal fin, and a blue line from the snout to eye. Katz et al. (1983) also noted that the golden tilefish is sexually dimorphic with males having larger or more prominent adipose flaps. In addition, both fish were observed at depths of 247-252 m which is a more common deeper depth for *L. chamaeleonticeps*.

Associated Fauna

Potential Tilefish Prey

During extensive submersible photo transects from 30 to 300 m depths off central eastern Florida (Avent and Stanton, 1979), the dominant macrobenthic fauna associated with the tilefish zone on the upper slope included various decapod crustaceans (*Cancer* sp., *Rochinia* sp., *Bathynectes* sp., galatheid crabs, and *Chaceon* [*Geryon*] sp.), and fish including sea robins, gadids, and *Urophycis* spp. These same species were prevalent in this ROV survey and are likely food items for either the blueline or golden tilefish. Surveys of *L. chamaeleonticeps* and *C. microps* habitat off the southeastern U.S. (Able et al. 1987, b, 1993) noted that the smaller burrows which honeycomb the upper wall of tilefish burrows were made by various crustaceans and fish. Dominant fish and macroinvertebrates in the vicinity of the burrow which could be prey items included the decapod crustaceans- *Munida* sp., *Cancer* sp., and *Libinia* sp. and fish- various unidentified juvenile fish, *Anthias* sp., *Laemonema* sp., and *Conger oceanicus*. Grimes et al. (1986) noted that 60-80% of galatheid and cancer crabs were associated with burrows, presumably for shelter. They believe that for some of these associated species such as galatheids, it may be easier to maintain a burrow inside the slope of the tilefish burrow than on open, flat bottom. Also the trophic rewards (scavenging leftover food from tilefish) must outweigh the potential disadvantages of predation by the tilefish, since all of these species are food items for tilefish. In addition to these larger prey items, McEachran and Fechhelm (2005) noted various infaunal prey items for *L. chamaeleonticeps* such as bivalves, polychaetes, and holothurians.

Our videotape analyses noted numerous macroinvertebrates and fish in nearby association with the burrows over all transects which certainly could be food items for any tilefish. The dominant taxa overall (212 total individuals) were various unidentified small fish (5-15 cm) which could be juvenile fish but were too small and blurry to identify. Other large fish such as *Epinephelus niveatus, Lutjanus vivanus, Dasyatis centroura*, Peristeidiidae, and Ogcocephalidae were only rarely seen. The dominant larger fish were *Conger* sp. and *Laemonema* sp., both of which are noted as food items for tilefish. The larger macroinvertebrates such as the decapod crustaceans *Cancer*, *Chaceon*, *Munida*, *and Rochinia* were found at all transects but in relatively low numbers. Only a few individuals of either fish or invertebrates were actually seen inside the burrows. A few *Cancer* individuals were seen the most. All of the species, however, were within a few meters of any potential tilefish burrow since most transects had burrows in most every field of view.

<u>Commercial Species</u>

In addition to the potential fisheries for blueline and golden tilefish in this region, various taxa were observed in the ROV videos which have potential commercial fisheries (Map 3). These include the larger fish, snowy grouper (*E. niveatus*), and golden crab (*C. fenneri*). However, all of these were in very small numbers considering the total length of the transects. It should be noted that observations of this crab from submersibles is much lower than catch records for a given area which indicates that the crabs are drawn to the traps over a wide area (Wenner, 1990). Depth records from golden crab fisheries for the southeastern U.S. range from 240 to 915 m (Kendall, 1990; Wenner, 1990; Wenner and Barans, 1990). Distribution records show the shallowest record of 183 m off Tortugas (Boone, 1938 in Manning and Holthius, 1986) and the deepest of 1,462 m off Bermuda (Wenner and Barans, 1990). We observed 16 individuals of *C. fenneri* from 122-252 m over all transects which would be a new shallow depth record although A. Hines (pers. comm.) did not think this would be uncommon if the species were surveyed shallower.

INSERT MAP 3- GIS COMMERCIAL FISH

Tilefish Burrow Densities

In surveys of densities of tilefish off central eastern Florida, *L. chamaeleonticeps* burrow densities ranged from 0.44 to 8.10 burrows/1000m^2 (Able et al., 1993). Off the Mid-Atlantic and southern New England region, Grimes et al. (1986) reported densities of 145 to 1,234 burrows/1000m^2 and Matlock et al. (1991) reported 1,600/1000m^2 off Texas. These counts were based on total number of burrows and not necessarily active burrows. Average densities of *C. microps* off southeastern U.S. were 0.5-1.5/1000m^2 with maximum density of 13/1000m^2 (Able et al., 1987 b). They also noted that for small burrows (0.3-0.6 m diameter) of *C. microps*, burrow densities could be as high as 0.5-1.0/m^2 (=1000/1000m^2). Our estimates of apparent tilefish burrow density ranged from 115 to 419 burrows/1000m^2 and averaged 244 which are within the ranges reported elsewhere.

Estimated Area of Tilefish Habitat

Based on the occurrence of apparent tilefish burrows for each transect (Map 2) and by using GIS, we estimated the area of potential tilefish habitat occurring within the ODMDS. During the time of this survey, the muddy substrate (sandy-silt) that was found throughout all transects appears suitable for tilefish as evidenced by the dense occurences of their apparent burrows. For reasons unknown, the regions that were dominated by high densities of mound-like bioturbation, had few or no apparent tilefish burrows. The depressions that were intermixed with these dense mounds were mostly very smoothed and eroded and definitely not active tilefish burrows. This mound habitat occurred mostly within the lower central part of the ODMDS (transects VT-2, VT-4). Perhaps this area had tilefish previously but was fished out, allowing the mound-makers to dominant. Elsewhere within the ODMDS the bioturbation was dominated by the medium and large depressions which appear to be tilefish burrows. Extrapolating to the entire area of the ODMDS we estimate a potential area of tilefish habitat of 3.43 km^2. Of course not all of the burrows in the area would be active and should not be used to estimate total tilefish population potential.

However, it is important to understand that these video transects were made nearly 25 years ago and can not be used to estimate the current status of the site or potential for tilefish. First, any commercial longline fishery for tilefish quickly modifies the numbers and size of fish within just a few years (Low et al. 1983). Second, during this ROV survey there were no apparent surficial rubble or artificial debris to any extent over the area surveyed. In fact, 100% of the bottom was soft sediment. Only a small area within transect VT-4, appeared lumpy which may indicate the presence of underlying rubble. Since 1986 to 2006, there has been extensive dumping (4,893,300 cu yd) of dredged material including gravel, limerock rubble, rock, and blasted rock (U.S. EPA 2008) which would change the habitat and substrate of the disposal site.

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APPENDIX 1

Transect times and coordinates in decimal degrees converted from the original degrees decimal minutes in two-minute increments

APPENDIX 2

Annotations of ROV videotransects in two-minute increments. Yellow rows indicate start of new transect. Red rows indicate sighting of tilefish. Gray rows indicate that the ROV is within the boundaries of the ODMDS.