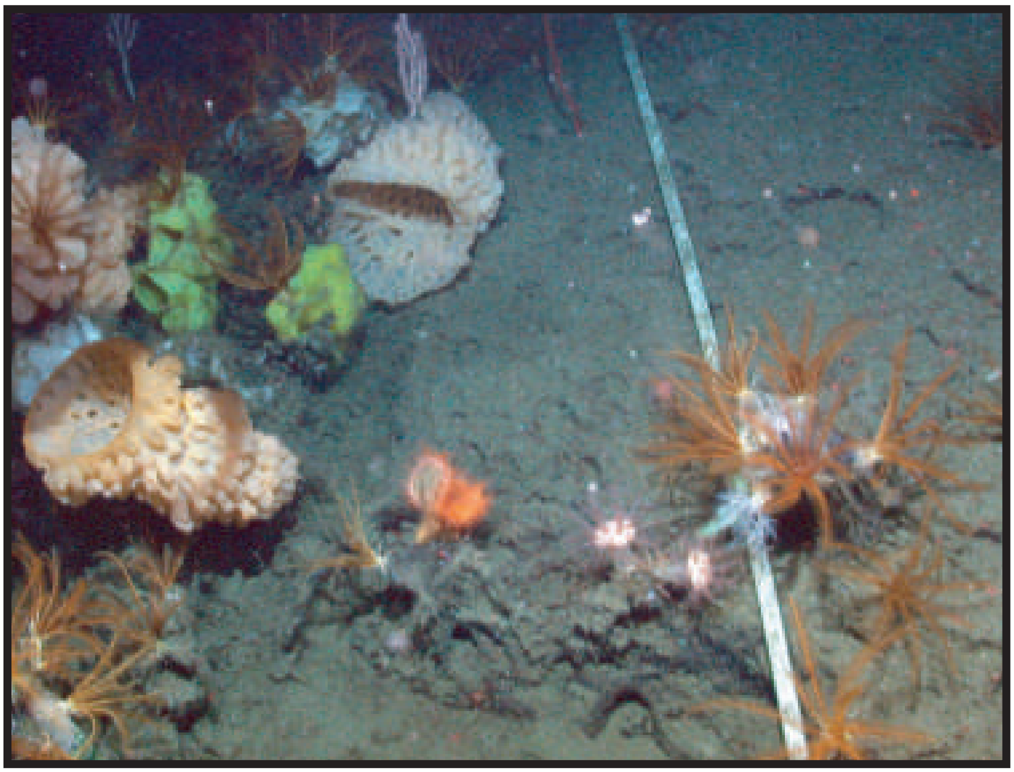
Environmental Impact of the ATOC/Pioneer Seamount Submarine Cable



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Acknowledgements

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Executive Summary

A submarine cable extends between Pioneer Seamount and the Pillar Point Air Force Station in Half Moon Bay, California (Howe 1996). The cable is known as both the ATOC (Acoustic Thermometry of Ocean Climate) and Pioneer Seamount cable. The cable was used to transmit data from a passive, acoustic hydrophone array on Pioneer Seamount to shore. Approximately two thirds of the cable lies within the Monterey Bay National Marine Sanctuary and is permitted (MBNMS-2001-031) through December 31, 2003. This report documents cable surveys performed by the Monterey Bay Aquarium Research Institute (MBARI) in 2002-2003. Survey objectives were to describe the state of the cable and document its effect on the seafloor and on benthic organisms.

MBARI carried out this study in partnership with NOAA-OAR (National Oceanic and Atmospheric Administration - Oceanic and Atmospheric Research) and NOAA-NOS (National Ocean Service). MBARI researchers were interested in documenting the environmental impacts of submarine cables, a topic of importance to the scientific community for which little data is published and publicly available. NOAA-OAR has responsibility over this particular cable and the requirement to survey it prior to permit expiration. NOAA-NOS interest in this survey was in assessing the environmental impact of submarine cables and general seafloor characterization within the Monterey Bay National Marine Sanctuary.

The Pioneer Seamount cable was installed in October 1995 as part of the Acoustic Thermometry of Ocean Climate (ATOC) project. NOAA-OAR installed a hydrophone array on Pioneer Seamount to passively record sound in the ocean and officially took responsibility for the cable on December 7, 2001. The presence of this cable has resulted in 80 references consisting of presentations, scientific publications, articles for the general public, and student projects. The cable is currently damaged and has not been transmitting data from the seamount since September 25, 2002.

A total of 13 sites along the 95 km cable route were surveyed using MBARI ROVs *Ventana* and *Tiburon* equipped with cable-tracking tools during research cruises on February10-14, 2003 and July 28–August 1, 2003. Quantitative comparison between cable and control sites was performed at nine stations. Survey locations were chosen to target representative substrate and habitat types, features of interest, and for logistical reasons. Side scan sonar data collected on October 21-25, 2002 from the *R/V Zephyr* helped select these sites. A total of 42 hours of video footage and 138 push cores were collected over 15.1 km of seafloor. Approximately 12.1 km of the cable was observed (13% of the cable route).

Video observations indicated the nature of interaction between the cable and seafloor. Most of the cable has become buried with time in sediment substrates on the continental shelf (water depths <120 m) whereas much of the cable remains exposed on the seafloor at deeper depths. Burial depth on the continental shelf ranged from 0 to 27 cm and averaged approximately 10 cm. Burial depth may fluctuate due to shifting substrate and buried cable may become exposed during storms. The cable is exposed in rocky environments of the nearshore region and on all of Pioneer Seamount.

Where the cable was exposed, its condition was assessed. Video images from the rocky nearshore areas, where wave energies are greatest, showed clear evidence that the cable has been damaged. Here, evidence of abrasion included frayed and unraveled portions of the cable's armor. In many places the cable occupied vertical grooves in the rock that were apparently cut by the cable. Incisions ranged from 6.6 cm (diameter of double armored cable) to 45 cm wide. The greatest incision and armor damage occurred on ledges between spans in rocky areas with irregular bathymetry. Snagged kelp was seen intertwined with frayed cable in the near shore areas.

The most notable suspensions were in rocky areas with irregular bathymetry. Such rocky areas occur at both ends of the cable. Suspensions up to 40 m long and greater than 1 m high were seen in the nearshore rocky area and up to 25 m long and 2 m high were seen on Pioneer Seamount. Unlike the nearshore rocky region, neither the rocks nor the cable appeared damaged along outcrops on Pioneer Seamount. Short (~10 cm) suspensions were also common bridging low spots associated with irregular topography in sediment substrate areas. Multiple loops of slack cable, added during a 1997 cable repair operation, were found lying flat on the seafloor at 950 m water depths. Several sharp kinks in the cable were seen at 240 m water depths in an area subjected to intense trawling activity. Cable crossings were seen in 13 m water depth at 37° 29' 50" N, 122° 33' 04" W and in 344 m water depth at 37° 29' 54" N, 122° 30' 30" W.

The main observed biological differences between cable and control areas were the number of organisms attached or adjacent to the cable. Anemones colonized the cable and were more abundant in cable transects at most soft sediment sites. Where the cable was buried, the presence of linear rows of anemones proved to be a reliable indicator of the cable's position. Coarse extrapolation of transect data suggests over 50,000 anemones may live in the modified habitat created by the cable. Echinoderms and sponges were also seen living on the cable. At three of nine stations, flatfish and rockfish congregated near the cable. The cable has had no apparent effect on infaunal abundance. Other differences between cable and control sites were probably due to patchiness of animals. Considerable care was taken to count megafauna in video transects and macrofauna from the top 5 cm of push cores. Few differences were found between cable and control sites at the 95% confidence level. The cable may also subtly affect local hydrodynamic conditions that concentrate shell hash and drift kelp near the cable.

Introduction

A submarine cable extends between Pioneer Seamount and the Pillar Point Air Force Station in Half Moon Bay, California (Howe 1996; Figure 1). The cable is known as both the ATOC (Acoustic Thermometry of Ocean Climate) and Pioneer Seamount cable. The cable was used to transmit data from a passive, acoustic hydrophone array on Pioneer Seamount to shore. Approximately two thirds of the cable lies within the Monterey Bay National Marine Sanctuary and is permitted (MBNMS-2001-031) through December 31, 2003. This report documents cable surveys performed by the Monterey Bay Aquarium Research Institute (MBARI) in 2002-2003 of the ATOC/Pioneer Seamount cable. Survey objectives were to describe the state of the cable and document its effect on the seafloor and on benthic organisms. The survey data will also be used to address components of permit special condition #4 (Appendix A).

MBARI carried out this study in partnership with NOAA-OAR (National Oceanic and Atmospheric Administration - Oceanic and Atmospheric Research) and NOAA-NOS (National Ocean Service). MBARI researchers were interested in documenting the environmental impacts of submarine cables, a topic of importance to the scientific community for which little data is published and publicly available. NOAA-OAR has responsibility over this particular cable and the requirement to survey it prior to permit expiration. NOAA-NOS interest in this survey was in assessing the environmental impact of submarine cables and general seafloor characterization within the Monterey Bay National Marine Sanctuary. We intend to refine the essence of this initial report into a journal publication.

Background

Cable History

The Pioneer Seamount cable was installed in October 1995 as part of the Acoustic Thermometry of Ocean Climate (ATOC) project by a research consortium consisting of four institutions: University of California, San Diego - Scripps Institute of Oceanography (SIO-UCSD), University of Washington – Applied Physics Laboratory (APL-UW), University of Michigan (UM), and Massachusetts Institute of Technology (MIT). An environmental impact report was completed for the ATOC project and its associated Marine Mammal Research Program (ARPA and NMFS 1995). The 95 km submarine coaxial cable initially connected an acoustic source on Pioneer Seamount to a shore location on Pillar Point Air Force Station in Half Moon Bay, California (Howe 1996; Figure 1). The acoustic source operated from December 1995 to December 1998 with attempted recovery in August 1999 and August 2000 (Chris Fox, personal communication; *http://atoc.ucsd.edu/MMRP_page.html*). The source was dropped and broken during the last recovery attempt. A safe recovery was not practical and the inoperable source was abandoned on Pioneer Seamount (Worcester 2000).

NOAA-OAR installed a hydrophone array on Pioneer Seamount to passively record sound in the ocean (*http://oceanexplorer.noaa.gov/explorations/sound01/sound01.html*) and officially took responsibility for the cable on December 7, 2001 (John Armor, personal communication). The live web link to the seamount was very popular with the general public and received tens of thousands of internet hits in the first few months of operation which was followed by two large spikes of activity following CNN and ABC coverage (Sharon Nieukirk, personal

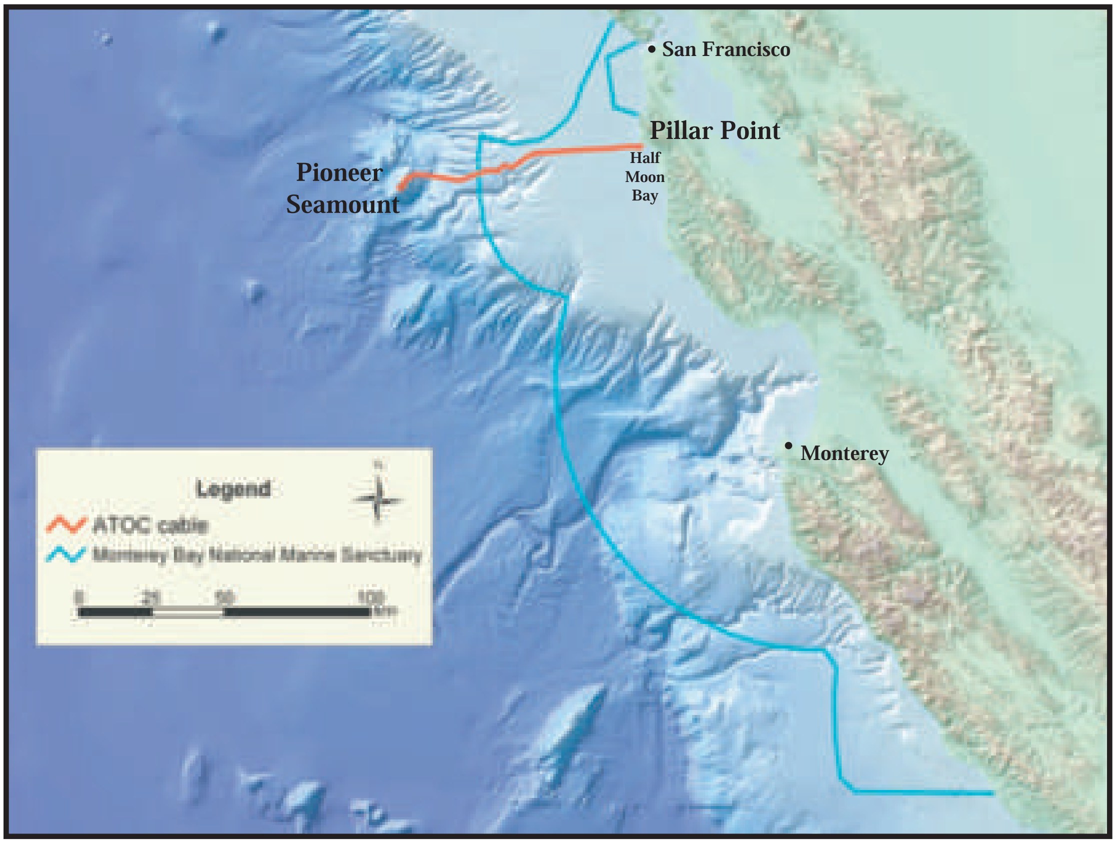


Figure 1: A map showing the ATOC/Pioneer Seamount cable path from Pillar Point to Pioneer Seamount offshore central California. Image courtesy of Chad King, Sanctuary Integrated Monitoring Network - Monterey Bay National Marine Sanctuary.

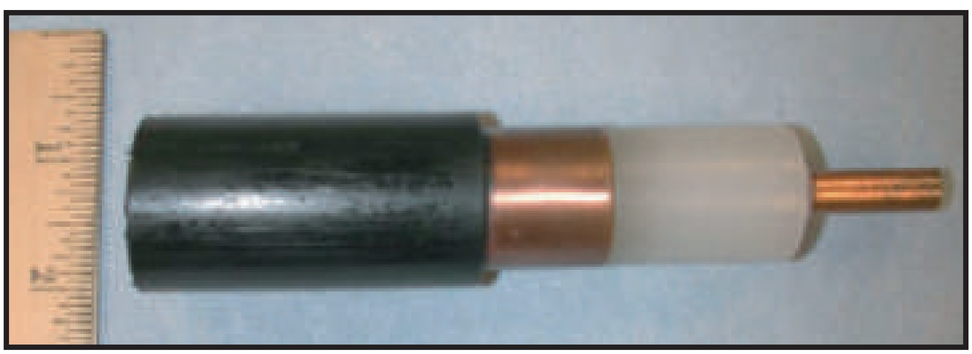


Figure 2: A photograph of a piece of cable similar to the Pioneer Seamount cable. The coaxial cable has an outside diameter of 3.2 cm (1.25 in) and has 4 main layers (from inner to outer): copper inner conductor that contains steel wires, a white polyethelyne insulating material, an outer copper sheath, and a black, high density, polyethelyne jacket. Cable specification information from University of Washington, 1995. Sample courtesy of UCSD-SIO.

communication). Data obtained via the cable since NOAA-OAR took responsibility for it has resulted in: 7 scientific talks, 4 poster presentations, 12 student projects, 2 science news articles, a manuscript in preparation, and a student award from the San Francisco Bay Chapter of the Cetacean Society. Taking into account the 53 citations resulting from the California ATOC project, the presence of this cable has resulted in 80 references consisting of presentations, scientific publications, articles for the general public, and student projects (Appendix B).

The cable is currently damaged and has not been transmitting data from the seamount since September 25, 2002. This is the second failure in the cable's history. The first failure and repair occurred in 1997 in about 900 m water depth (*http://atoc.ucsd.edu/cablefaultpg.html*).

Cable Description and Route Overview

The Pioneer Seamount cable is approximately 95 km long and is a combination of 3 coaxial cable sections spliced from previously used cables (Howe 1996). The first 5.6 km of cable (out to a water depth of 46 m) is double armored (6.6 cm (2.6 in) outer diameter) in order to increase cable density and aid self-burial. The armor is tapered over a 15 m interval. The seaward 90 km of cable is unarmored (outside diameter of 3.2 cm (1.25 in)) from the 46 m isobath to its termination on Pioneer Seamount (Figures 2 and 3; Mercer 1999, Howe 1996).

The shore landing is in a maintenance building on a 35 m high bluff overlooking the ocean that is within the Pillar Point Air Force Station. The cable extends from the maintenance shed along a conduit that parallels a drainage ditch terminating at the beach (Figure 4). At the end of the conduit, the cable lies within a deadman anchor that was set 1.2 m below ground surface during installation. The cable was buried 0.6 m below the beach and the double armor was intended to aid self-burial in the intertidal and nearshore marine areas (Jim Mercer, personal communication). The beach and intertidal area are part of the James V. Fitzgerald Marine Reserve (*http://www.eparks.net/Parks/Fitzgerald/*), an Area of Special Biological Significance that is managed by San Mateo County and the California Department of Fish and Game.

A post installation diver survey confirmed burial out to a water depth of 3 m (~ 100 m from the beach) but burial depth was not specified. The presence of rocky outcrops prevented further burial. The diver survey described the rocky area as smooth-topped rocky reefs separated by 1.5 to 2.4 m deep, 12 m wide troughs (Howe 1996). Cable suspensions with up to 7.6 m long spans with the cable hanging up to 0.6 m off the seabed were noted (Howe 1996). The cable was not buried from this location out to its termination on Pioneer Seamount (95 km of exposed cable) (Figures 1 and 3).

From the nearshore rocky area, the cable path continues across the 35 km broad continental shelf (in this region, the shelf/slope break is at a water depth of ~120 m), descends the continental slope to a maximum depth of approximately 2,000 m, and climbs back upslope to near the crest of Pioneer Seamount and onto where the NOAA-OAR hydrophone array is located at 998 m. The western edge of the Sanctuary boundary is within the outer continental slope at about 900 m water depth (Figure 1).

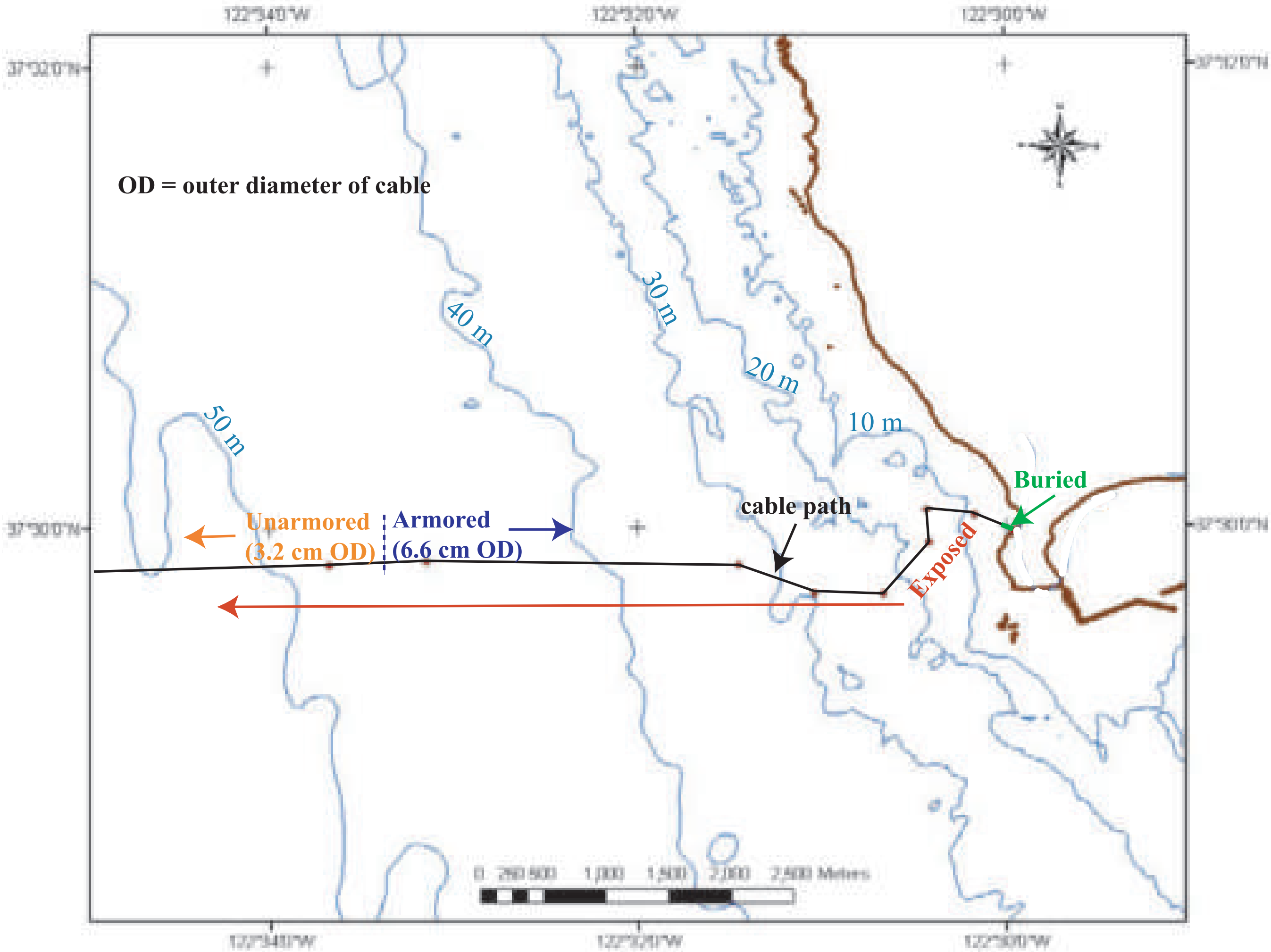


Figure 3: A map of the nearshore area showing the ATOC/Pioneer Seamount cable path, bathymetry, and locations where the cable was buried, exposed, armored, and unarmored during installation (Howe 1996).

Figure 4: A photograph looking south showing the shore landing of the ATOC/Pioneer Seamount cable. Note inset map showing the photograph location in northern Half Moon Bay, California. The red dashed line represents the location of the cable that is within an underground conduit that parallels the drainage ditch. The cable is buried below the beach (Howe 1996).

Methods

Side Scan Sonar Survey

Side scan sonar data were collected from the MBARI *R/V Zephyr* on October 22-24, 2002 along the continental shelf portion of the cable route. The survey path was based on cable coordinates given in Appendix C. The main objectives of the side scan survey were to characterize seafloor type along the cable path, identify representative benthic environments for future detailed ROV surveys, and to look for any large objects that may have become entangled on the cable since installation in October 1995. Data were collected using a 100 kHz, single-frequency tow-fish deployed side scan sonar imaging system (Klein System 595). The instrument was towed behind the vessel and tow cable length was manually adjusted to keep the tow-fish approximately 20 m above the seabed. Due to increased drag on the tether at increased water depths, the tow-fish could not be kept within 20 m of the seabed in water depths >80 m. Thus the data quality deteriorated in water depths >80 m. Swath range was approximately 100 m per side. Horizontal and vertical beam widths were 1 degree and 40 degrees, respectively. Two to four separate swaths covered a corridor around the cable's path that was 400-800 m wide. Five focused surveys ranging in width from 500 m to 1.5 km wide and 1 to 2.5 km long were performed perpendicular to the cable path in areas of interest based on shipboard images of the along-cable surveys (Figure 5).

Differential GPS navigation and side scan data were time synchronized and the raw survey lines (in *.xtf format) processed using Triton-Elics International Isis Sonar v5.75 software into separate, geo-referenced, tiff format images at a pixel resolution of 0.2 m. The separate survey lines were then imported into TNTmips 6.7 for line editing, contrast enhancement, and for creating mosaiced images of the seafloor. Due to homogeneity of the majority of the survey, only the nearshore portion of the survey was mosaiced. The final geo-referenced, nearshore seafloor mosaic (UTM later re-sampled to latitude-longitude) and the separate survey lines of the homogeneous portion of the survey were then exported to Arcview 3.3 to produce maps for visual interpretation and presentation.

ROV Surveys

A total of 13 sites along the cable route were surveyed using ROVs during research cruises on February10-14, 2003 and July 28–August 1, 2003. The goals of the ROV surveys were to describe the state of the cable (e.g. buried, suspended, contains snags, damaged) and to document the effect of the cable on the seafloor (e.g. evidence of strumming, effect on benthic organisms). Quantitative comparison between cable and control sites was performed at nine stations. The remaining four sites were used for qualitative information and are termed 'video-only transects' in this report. Four stations (43 m, 67 m, 70 m, 240 m), named by survey water depth, and one video-only transect (20 m) were studied on the February 2003 cruise from the MBARI *R/V Point Lobos* using the *ROV Ventana*. Five additional stations (140 m, 240 m, 950 m, 1800 m, 1930 m, seamount 900 m) and three video-only transects (250-415 m, 1040-1580 m, 1710-1890 m) were studied in July 2003 from the MBARI *R/V Western Flyer* using the *ROV Tiburon*. Survey locations were chosen to target representative substrate and habitat types (e.g. nearshore rock outcrops, continental shelf silt belt, sandy sediments), features of interest (e.g. location of cable fault, location of linear feature seen on side scan sonar survey), and logistical reasons (e.g. avoiding crab pots, shipping lanes, hydrophone array on Seamount).

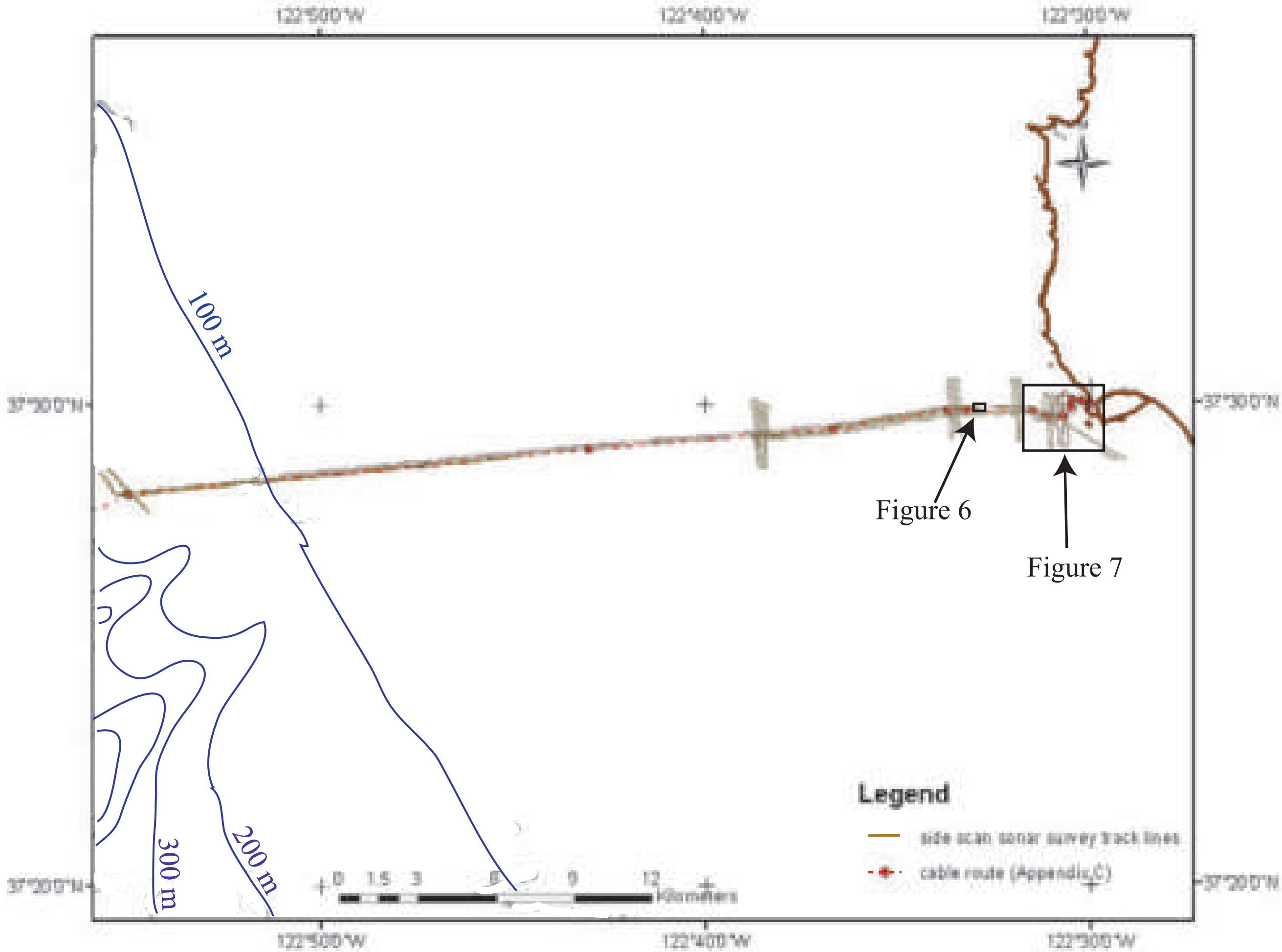


Figure 5: A map showing the side scan sonar survey tracklines superimposed on the ATOC/Pioneer Seamount cable route listed in Appendix C. Boxes show locations of Figures 6 and 7.

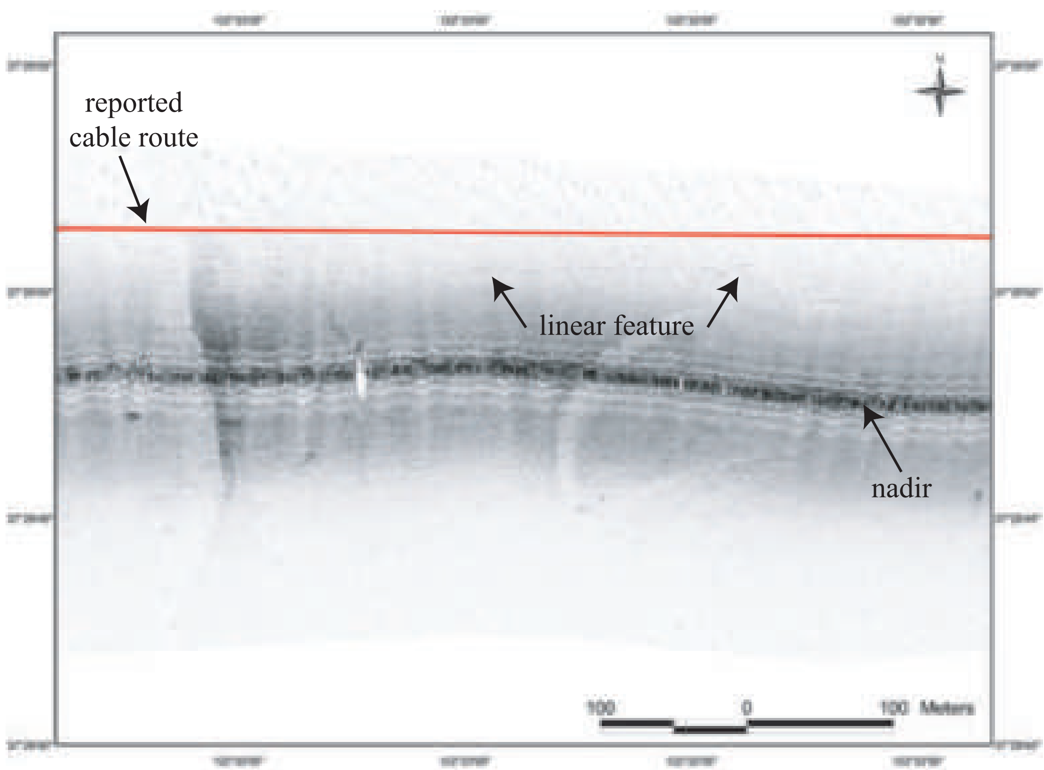


Figure 6: Side scan sonar image showing a linear reflection. Red line is the reported path of the ATOC/ Pioneer Seamount cable (Appendix C). The nadir is an artifact. Linear feature extends from 37º29'50"N, 122º33'04"W to 37º29'51"N, 122º32'53"W.

Navigation
ROV locations were determined relative to the ship using ultra-short base line tracking systems, which measure range and bearing from the vessel to the ROV. This data and ROV water depth, measured with Paroscientific quartz pressure gauges, allow the vehicle's position to be calculated with respect to geographic coordinates. Ship positions are based on differential-GPS navigation. ROV latitude, longitude, and depth are logged every five seconds. Raw ROV navigation data often contain spurious fixes. To minimize these errors, raw navigation data for each dive was reprocessed by first removing obvious outlier positions and smoothed using MB-System (mbnavedit) software that forces changes in the ROV position to be plausible.

Cable Location and Burial
Two different cable-tracking systems were utilized during these surveys to locate the cable and measure burial depth: an Innovatum Ultra 44 was installed on the *ROV Ventana* during the February 2003 survey and a TSS 350 was installed on the *ROV Tiburon* during the July 2003 cruise. Tone generators were connected to the shore end of the cable during each cruise and used to send a 25 Hz signal along the cable that would be located by the cable-tracking apparatus installed on the ROVs. Cable burial depth measurement was recorded using both tools, however the Innovatum tool provided consistent, reasonable readings whereas the TSS tool provided widely variable data with unreasonable values (e.g. 90 and 180 cm burial depth readings at one location while sitting on the seafloor in an area where the cable was exposed). Mechanical problems with the energy converter powering the Innovatum Ultra 44 cable tracker tool prevented collection of burial depth information at the 240 m station.

Data Collection Procedure
In order to compare the impact of the cable on epifaunal and infaunal organisms, video, digital still images and shallow push core data were collected along transects near (<1 m) and distant (~100 m) from the cable. Transect lengths at sites where cable and control date were collected ranged from 30 to 870 m with most transects 200 to 500 m long. Where the cable was buried, a cable-tracker was used to locate and follow the cable. To measure cable burial depth, the ROV periodically landed on the seafloor to collect data at sites that were selected in a statistically haphazard fashion. If the substrate was soft sediment, push cores were collected within an estimated 30 cm of the cable. A similar procedure of collecting video/photo data and push cores was repeated in control transects approximately 100 m away from the cable.

Laser Calibration
Lasers mounted on the ROVs were used to define the size of the area covered in the video images. Four lasers were mounted on the *ROV Ventana* with the two bottom beams nearly parallel and spaced 25 cm apart. A standard, parallel laser configuration where two lasers are 30.5 cm apart was set-up on the *ROV Tiburon*.

Video Data Analysis
Forty-two hours of video footage were annotated and analyzed to assess the environmental impact of the cable on epifaunal organisms and the seafloor. All available video footage was annotated using MBARI's computer annotation system (http://www.mbari.org/vars), Video Information Management System (VIMS), which uses the graphical user interface application Video Information Capture with Knowledge Inferencing (VICKI). Annotations included all

epifaunal animals large enough to be seen on the video. Taxonomic identification was performed to the lowest practical taxonomic level. Additional annotations included: where the cable was visible, general description of the substrate (e.g. rock outcrop, sand, presence and relative size of ripples, presence and relative density of shell hash), cable condition (e.g. frayed, bent), whether organisms were attached to the cable and the type of organisms, areas where the cable was suspended, and areas where there was visual evidence of cable strumming on the seabed.

For statistical analysis, care was taken to screen video footage and exclude video acquired in the following instances: 1) where ROV track crossed upon itself, 2) during transit to cable or control sites, and 3) during core collection. For each station, the cable and control transects were subdivided into 30 m bins (i.e. lengths) to describe organism variability within each transect and analyze the distribution of animals. Bin size was determined using several criteria: 1) maximizing the number of bins within each transect, 2) minimizing the number of bins with zero taxa, and 3) choosing a bin size above the resolution of ROV navigation. Analyzed cable and control transect lengths are affected by the sinuosity of the ROV track and exclusion of video data as described above. Organisms were grouped into the following 10 taxonomic categories: algae, cnidarian (e.g. anemones, sea pens), crustacean (e.g. crabs), echinoderm (e.g. sea stars, urchins), mollusc (e.g. clams, snails), elasmobranch (sharks and rays), ostheichthyes (bony fishes), agnatha fishes (hagfish), porifera (sponges), and other. Faunal abundance was determined for each of these groups and a mean abundance was calculated for each transect.

A two-sample t-test was used to compare abundance between cable and control transects at each site. Prior to conducting a t-test, an F-test was used to test for homogeneity of variances. If variances were not equal, data were transformed (square root) and tested again. If variances were equal, data were analyzed. If data transformation was unsuccessful, a non-parametric Mann-Whitney U test was used (Zar 1984).

Percent Cover Analysis

Percent cover analysis was used to detect and quantify potential differences in biotic and physical features close to the cable as compared to the control area. Twenty randomly chosen still frames were analyzed from video footage. Due to the short transect lengths at the 1930 m station, four still frames were analyzed from the cable transect and 16 from the control. The criteria for usable video images were visible lasers and substratum. A 48 x 66 cm region of interest (ROI) was determined for each still frame using the ROV lasers as a scale for distance. If the cable was visible in the frame, the ROI was centered on it. The random point contact method was used for data analysis (Coyer et al. 1999, Foster et al. 1991). The organism or feature appearing at 50 randomly chosen coordinates within the ROI was recorded for each frame.

Infaunal Organism Analysis

In order to evaluate the impact of the cable on infaunal organisms, a total of 138 push cores were collected and analyzed from cable and control transects where soft sediments were present. The top 5 cm from the 7.5 cm diameter cores was gently washed through a 0.3 mm mesh sieve using cold seawater. Organisms were relaxed using a 7% solution of magnesium chloride ($MgCl_2$), and subsequently preserved in a 4% formaldehyde (10% formalin) solution for several days. Samples were then rinsed with de-ionized water and stored in 70% ethanol. Sieved samples were sorted to the lowest practical taxonomic category and the number of taxa was estimated based on obvious morphological characteristics. Mean organism abundance and number of different taxa were calculated and a two-sample t-test was used to compare cable and control transects.

Results and Interpretations

Side Scan Sonar Survey

A total of 150 km of side scan survey data were collected from 14 to 120 m water depths (Figure 5). Data quality was good from water depths less than 80 m and deteriorated in greater water depths. No significant entanglements with the cable large enough to be resolved by side scan sonar data were seen. Three areas/features of interest were identified on the side scan survey data:

(1) The majority of the survey area was associated with bland sonargrams extending from 122° 32' 00" W in 37 m water depth to the western edge of the survey at 120 m water depth (e.g. most of Figure 6).
(2) The nearshore side scan sonar data shows reflection patterns that appear to form "S-curves" of varying amplitude (Figure 7). The S-curves cover a region approximately 2.5 km wide from just offshore Pillar Point westward and correlate with areas of known rock outcrops (Howe 1996). Water depths range from 10 to 30 m.
(3) A 330 m long, linear reflection was imaged in 43 m water depth parallel to and 20-40 m south of the cable's reported position in Appendix C. This reflection is from a feature seaward of the S-curves area (Figure 6).

Side Scan Sonar Areas/Features of Interest - Interpretation

The bland sonar images seen from the majority of the survey route probably result from rather uniform, unconsolidated, sediment substrates. The presence of sand and silt-dominated sediments are known to occur at the 43 m, 67 m, and 75 m stations (Edwards 2002).

The reflection patterns of "S-curves" imaged in the nearshore side scan sonar data are interpreted as rock outcrops of three plunging folds in the underlying strata (Figure 7). These rock outcrops apparently underlie approximately 3.5 km of the cable path. The 20 m station occurs within the area associated with the S-curves in the side scan sonar data and further discussion can be found in the ROV Surveys section of the report.

The feature in 43 m water depth that produced the linear reflection pattern in the side-scan data is probably associated with the ATOC/Pioneer Seamount cable. Cable tracker data collected at the 43 m station confirms that the cable is located in the same area. The linear feature is not an artifact of the data since it was imaged on two different swaths collected from two different directions. Video showed that at least a portion of the cable's steel armor has unraveled in this location. Whether the reflectivity is associated with the acoustic impedence contrast between the metal cable and the soft sediments or whether the cable is imaged due to enhanced reflectivity of exposed material in the unraveling cable is unclear.

Although burial conditions may have changed somewhat between the October 2002 side-scan sonar and February 2003 video survey, the presence of exposed cable is not believed to be the controlling factor in predicting if the cable will be detected on side scan data. Unarmored cable is

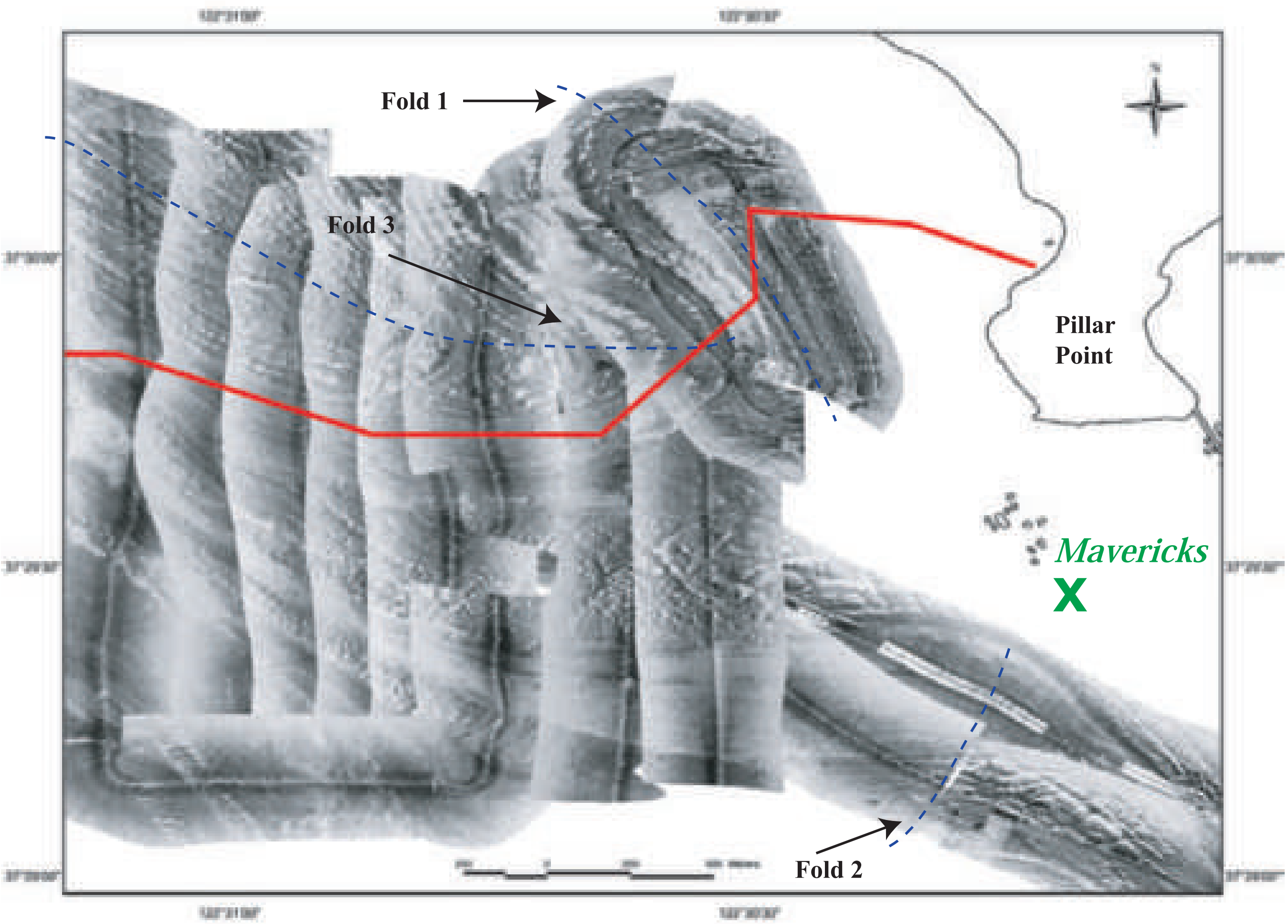


Figure 7: Side scan sonar mosaic of the seafloor in the nearshore area showing three plunging folds in underlying strata. Rhythmic reflections represent rock layers where bathymetric high spots appear light and valleys appear dark. Dashed blue lines are drawn in the fold axes. The location of the Maverick's surfing site is indicated. Red line represents reported path of the ATOC/Pioneer Seamount cable (Appendix C).

intermittently exposed seaward of the linear feature area but is not imaged by the side scan data. Moreover the rocky area landward of the linear feature is known to contain long sections of exposed, armored cable that was also not resolved in the side-scan sonar data.

ROV Surveys

The results and interpretations will be described by station along the Pioneer Seamount / ATOC cable route from shallow to deeper water depths and from east to west (Figure 8).

<u>20 m Station (Video-only Cable Transect)</u>

A 1,170 m long section of cable was viewed in water depths ranging from 10 to 20 m. (Figures 9 and 10). The cable was located within 60 m to the north and west of its position reported in Appendix C. The substrate consisted of rock outcrops with numerous ledges and overhangs. Isolated areas of thin sediment cover were seen in troughs between outcrops. During the survey operation, considerable wave surge was experienced at this station. No control transect was performed due to concerns about the safety of the ROV in shallow, surging water and rough terrain.

Nearly 100% of the double armored cable in the 20 m station was exposed on the seafloor. The exposed cable showed a number of features indicative of its interaction with the seafloor environment. Loose steel wires or fraying material were seen on the cable in four locations (Figure 10). Eighteen suspensions were noted ranging in length from a few cm to 40 m and in height off the bottom from a few cm to more than 1 m. The cable was incised into the rock in 12 locations. Incisions varied in depth from surficial scrapes to vertical grooves (Figure 10). Observed areas of impact ranged from 6.6 cm (diameter of cable) to 45 cm wide. The ATOC/Pioneer Seamount cable was documented crossing over another cable of unknown origin (Figure 10). Ninety-one instances of kelp snagged on the cable or laying next to the cable were annotated. Frayed cable was seen intertwined with the snagged kelp.

Quantification of the fauna resulted in a total of 507 organisms in the 20 m cable transect, representing 18 taxa (Table 1 and Appendix D). Of the ten taxonomic groups analyzed in this study, six were observed at this station (Appendix D). Echinoderms were the most abundant taxonomic group comprising 87% of the observed megafauna. The most abundant organism was a *Pisaster sp.* (sea star). The five other taxonomic groups were present in relatively small numbers. Due to lack of loose sediments from which cores could be collected, no infaunal data was acquired at this station.

<u>20 m Station - Interpretation</u>

The area off Pillar Point, where the ATOC/Pioneer Seamount cable is located, is known to experience very high waves. Mavericks, a world-class surfing location, is ~1 km south of the cable path. Wave heights greater than 10 m have been photographed and a big-wave surfing contest is held at this site. The seafloor in this area does not contain any significant loose sediment cover, which also indicates the magnitude and severity of the waves.

Damage to the cable has occurred in this high-energy area. The armor is coming apart (Figure 10), and one layer of steel armor appears missing and the underlying layers unraveled (Figure 10). The cable apparently cut incisions in the rock. The presence of two or more separate grooves

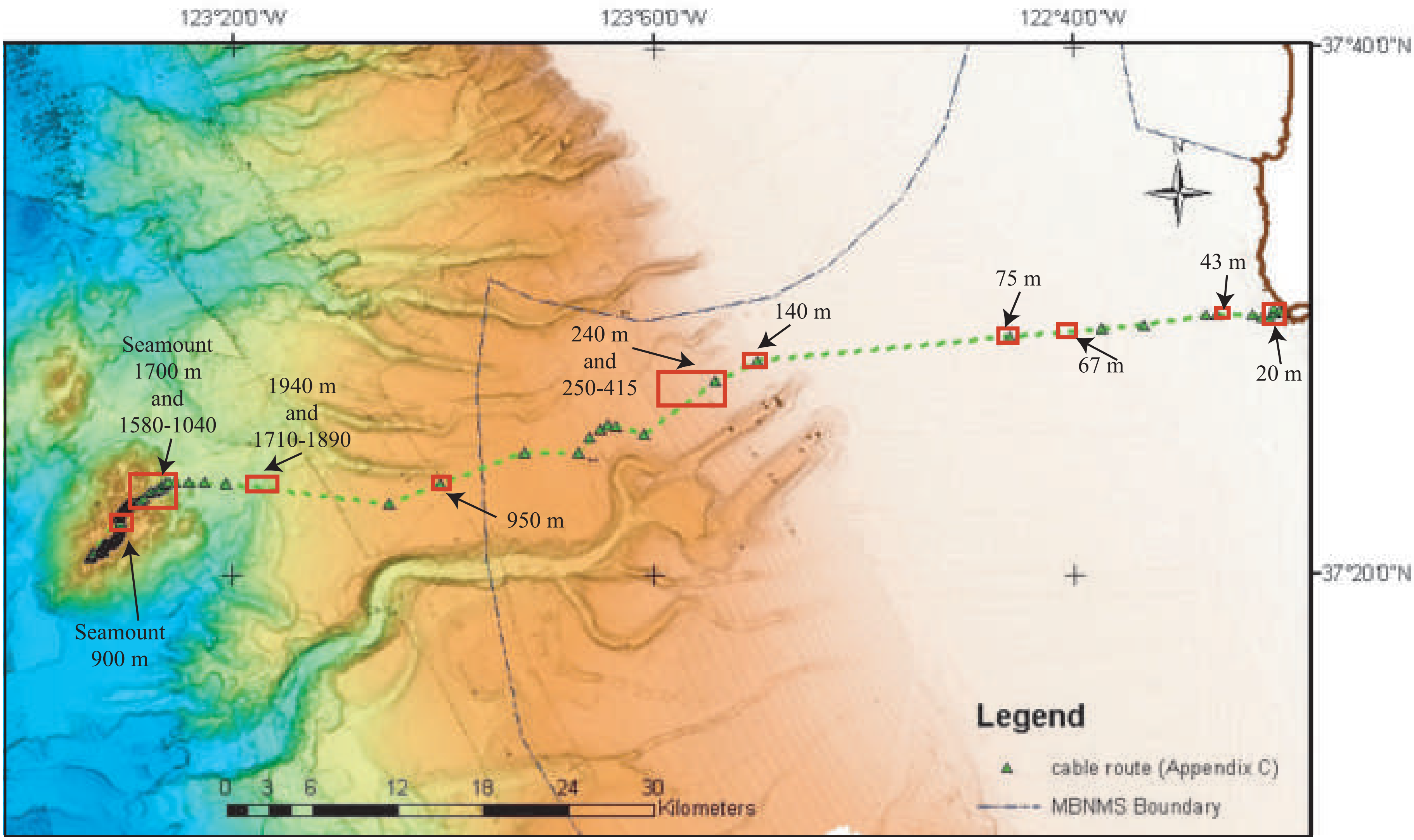


Figure 8: Map showing locations of 13 survey sites, reported cable path, and Monterey Bay National Marine Sanctuary boundary overlying seafloor bathymetry. Bathymetric image from Dave Caress, MBARI.

20 m Station

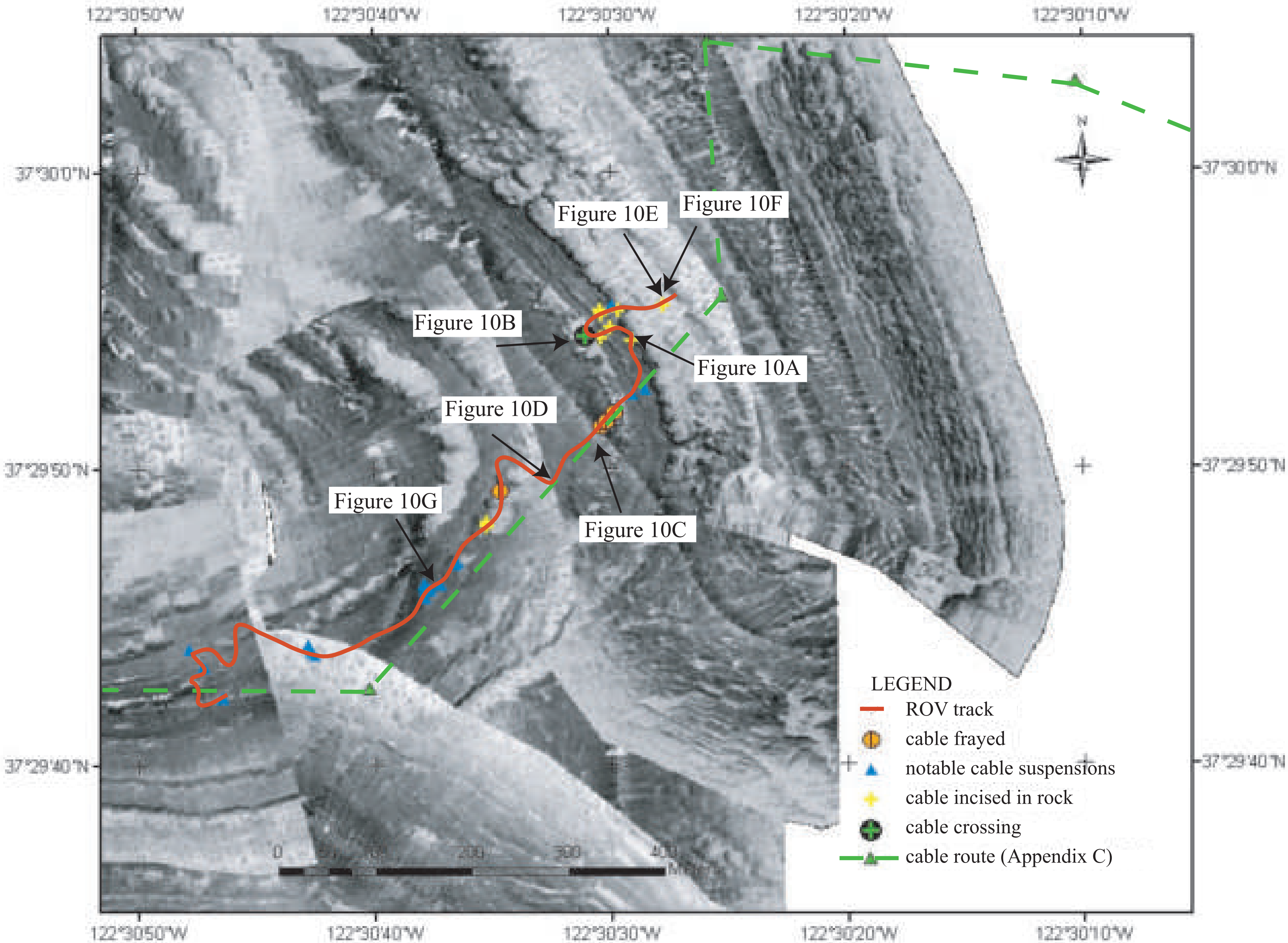


Figure 9: Map showing reported path of ATOC/Pioneer Seamount cable superimposed on a side scan sonar mosaic of the seafloor, ROV navigation, locations of specific observed features of interest, and locations of still frames shown in Figure 10. The cable crossing between the ATOC/Pioneer Seamount cable and another cable occurs in 13 m water depth at 37º29'54"N, 122º30'30"W.

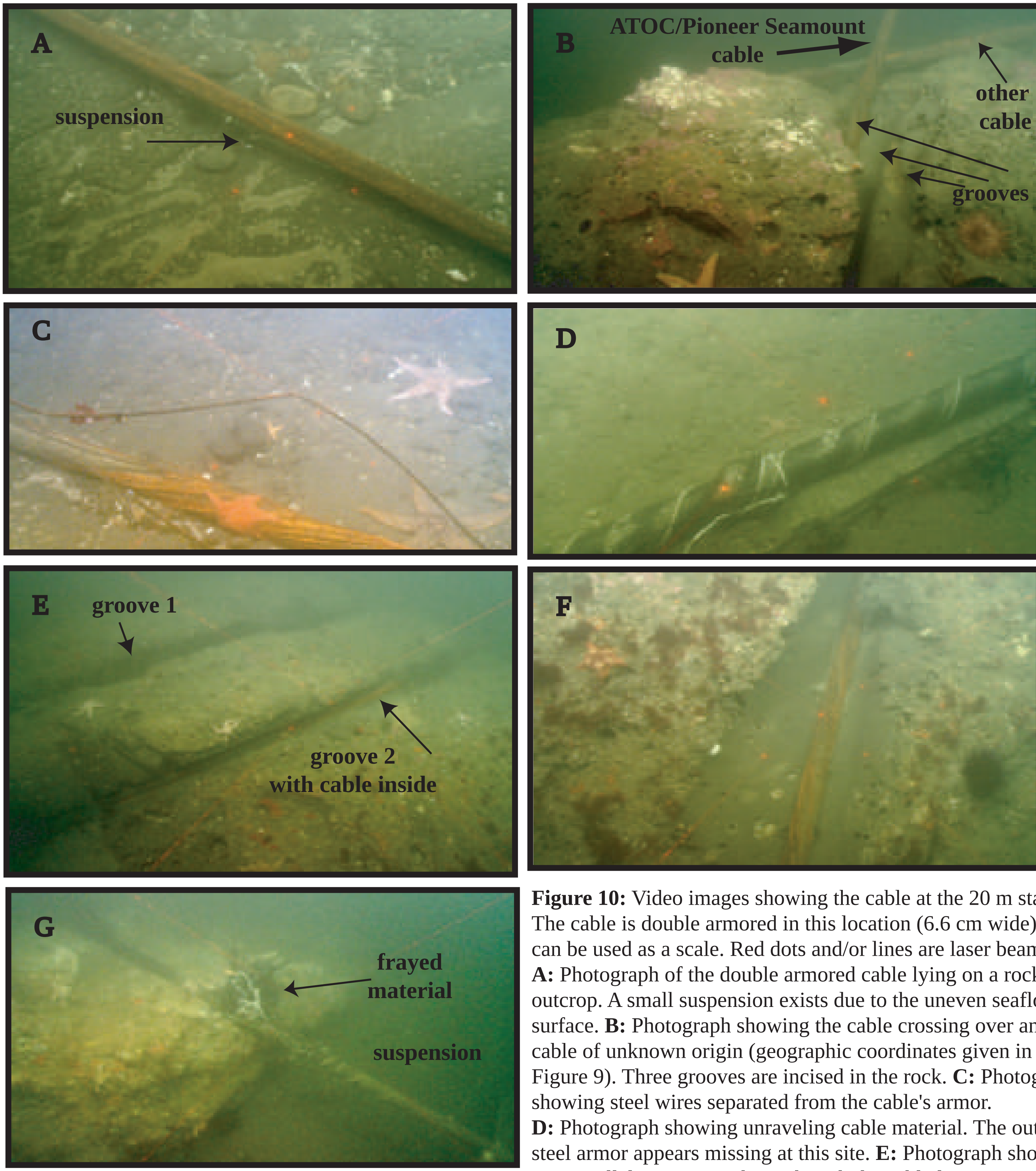


Figure 10: Video images showing the cable at the 20 m station. The cable is double armored in this location (6.6 cm wide) and can be used as a scale. Red dots and/or lines are laser beams. **A:** Photograph of the double armored cable lying on a rock outcrop. A small suspension exists due to the uneven seafloor surface. **B:** Photograph showing the cable crossing over another cable of unknown origin (geographic coordinates given in Figure 9). Three grooves are incised in the rock. **C:** Photograph showing steel wires separated from the cable's armor. **D:** Photograph showing unraveling cable material. The outer steel armor appears missing at this site. **E:** Photograph showing two parallel grooves in the rock with the cable lying in groove 2. **F:** Photograph showing a cone shaped groove apparently generated by cable strumming. The incision is approximately 40 cm wide at the bottom two lasers. **G:** Photograph showing a cable suspension over a rock ridge. Note frayed material at the rock outcrop's edge. Kelp may be intertwined with cable material however, the white strands are anthropogenic.

Table 1 - Quantified Observations

	20 m	43 m station		67 m Station		75 m Station		140 m Station		240 m Station		250-415	950 m Station		1710-1890	1940 m Station		Seamount 1700 m Station		Seamount 1040-1580	Seamount 900 m Station		Seamount 900-800
	Cable	Cable	Control	Cable	Control	Cable	Control	Cable	Control	Cable	Control	Cable	Cable	Control	Cable	Cable	Control	Cable	Control	Cable	Cable	Control	Cable
Transect length (m)	1170	360	210	360	210	240	390	690	660	330	600	3547	420	510	1321	30	90	870	180	2296	180	210	240
Burial (%)	0%	73%		100%		100%		65%		83%		37%	58%		1%	0%		0%		0%	0%		0%
mean burial depth (cm)	N/A	12±8 (n=10)		9±6 (n=10)		13±6 (n=10)		N/A		N/A		N/A	N/A		N/A	N/A		N/A		N/A	N/A		N/A
Taxonomic groups	6	6	3	5	4	6	6	7	6	6	5	9	6	6	8	3	5	8	7	8	5	5	5
# Taxa	18	8	3	9	10	9	10	20	18	18	15	34	18	17	28	10	10	24	20	34	20	21	23
Overall organism density ratio	N/A	3.5 : 1		0.3 : 1		2.0 : 1		1.4 : 1		1.2 : 1		N/A	1.8 : 1		N/A	1.2 : 1		0.4 : 1		N/A	1.8 : 1		N/A
Actiniaria abundace	7	5	0	19	7	95	4	124	1	31	1	1478	571	259	2177	76	112	19	0	44	3	4	7
Actiniaria density	0.006	0.014	0	0.053	0.033	0.396	0.010	0.180	0.002	0.094	0.002	0.417	1.360	0.508	1.648	2.533	1.244	0.022	0	0.019	0.017	0.019	0.029
Actiniaria density ratio	N/A	N/A		2 : 1		39 : 1		119 : 1		56 : 1		N/A	3 : 1		N/A	2 : 1		N/A		N/A	1 : 1		N/A
Statistically Significant Results																							
Video analysis (mean abundance)	N/A	Ostheichthyes 2.6±2.5 (p<0.001) (n=12)	0.1±0.4 (n=7)	Echinoderms 242.1±116.4 (p<0.001) (n=12)	715.3±219.5 (n=7)	Cnidarians 13.5±14.3 (p<0.001) Echinoderms 652.2±273.5 (p=0.030) Ostheichthyes 43.1±35.3 (p=0.002) (n=8)	0.6±1.0 347.5±182.0 8.7±5.5 (n=13)	Cnidarians 130.2±65. (p=0.040) Drift Kelp 0.4+0.6 (p=0.040) (n=23)	94.7±47. 0.0+0.2 (n=22)	Cnidarians 4.5±3.1 (p=0.010) Ostheichthyes 4.1±2.6 (p=0.026) (n=11)	1.4±1.6 2.0±1.9 (n=20)	N/A	Cnidarians 46.5±22.8 (p=0.004) Echinoderms 1.9+1.1 (p=0.012) Crustaceans 3.4+3.4 (p=0.029) Drift Kelp 0.7+0.8 (p=0.021) (n=14)	24.7±11.0 0.9+1.0 1.2+1.0 0.1+0.3 (n=17)	N/A	N/A Not enough data (n=1)		none	none	N/A	none	none	N/A
Percent cover analysis	N/A	Shell hash 3.6±3.5 (p=0.038) (n=20)	1.1±1.2 (n=20)	Ripple marks 28.3±4.4 (p<0.001) (n=20)	93.6±3.8 (n=20)	Ripple marks 24.0±42.7 (p=0.001) (n=20)	70.0±41.6 (n=20)	none	none	Sediment 91.2±5.2 (p<0.001) (n=20)	98.4±2.0 (n=20)	N/A	Sediment 93.8±2.9 (p<0.001) (n=20)	99.7±0.7 (n=20)	N/A	Sediment 88.0±5.2 (p=0.048) (n=4)	96.0±2.9 (n=16)	Sediment 88.8±3.9 (p=0.011) (n=20)	92.4±4.6 (n=20)	N/A	Sediment cover 92.9±4.5 (p<0.001) (n=20)	98.4±3.6 (n=20)	N/A
Infauna analysis	N/A	none	none	none	none	Nemertea # taxa 0.7±0.7 p=0.028 (n=9)	1.5±0.9 (n=11)	none	none	none	none	N/A	Polychaete # taxa 11.2±2.6 p=0.010 Polychaete abundance 14.2±1.8 p=0.002 (n=10)	8.5±1.1 9.8±0.8 (n=10)	N/A	none	none	Isopods # taxa 0.6±0.5 p=0.050 Isopods abundance 0.6±0.5 p=0.032 (n=5)	1.4±0.5 1.8±0.8 (n=5)	N/A	none	none	N/A

Table 1: Table showing summary of quantified observations. Transect lengths are determined as described in Methods section. Burial depth is from cable-tracking tool measurements and burial percentage is from video annotations. Mean burial depth and statistically significant results are represented as mean ± 1 standard deviation. Density = total abundance / meter transect length. Density ratio = (abundance along cable/cable transect length) / (abundance along control/control transect length). Ratios are calculated from raw data and not from rounded off numbers. Ratios could not be calculated where control transects not performed and at stations where density at control = 0. Actiniaria (anemone) is an Order of Cnidaria and includes *Metridium farcimen*, *Stomphia sp.*, Hormathiidae, *Liponema brevicornis*, and other Actinaria spp. Statistical significance is at 95% confidence level. Video analysis data can be found in Appendix E, Percent cover data can be found in Appendix G, and Infauna data can be found in Appendix F.

in a single location (Figure 10) is evidence that the cable can shift position with time and cut more than one groove. The rock outcrops are likely of the Purisima Formation, a relatively young, poorly consolidated sedimentary unit.

The 20 m station coincides with the portion of the side scan sonar data where S-curved reflections were imaged and underlie approximately 3,500 m of the cable path. Of the 3,500 m of rocky substrate, the 1,169 m section surveyed in this study was biased toward the nearshore area characterized by side scan sonar data with the stronger, irregular reflections containing long shadows and indicating rougher topography and the presence of tall ledges (Figure 7). The suspensions seen during the ROV survey occur where the taught cable spans between topographic highs in this area of irregular bathymetry. Similar suspensions are probable throughout the entire nearshore rocky outcrop region but due to smaller outcrops, may be less frequent and may have smaller dimensions than the ones documented nearer to shore.

43 m station

A 360 m long section of the Pioneer Seamount / ATOC cable was viewed at the 43 m station (Figure 11). Water depths ranged from 42 to 44 m. ROV navigation data shows that the cable's path is sinuous and that the cable was located within 45 m to the south of its reported position. The substrate consisted of sand waves with shell hash deposits in intervening low spots. The cable tended to be buried within the sand wave crests and exposed in the troughs. The armored cable was buried along 73% of the cable transect. Burial depth ranged from 0 to 27 cm (± 5 cm cable tracker error range) with a mean and standard deviation of 12 cm ± 8 cm. A parallel control transect 210 m long was performed 120 m north of the cable. A total of 19 push cores were collected for infaunal analysis: 9 along the cable and 10 along the control.

Video data showed a number of features indicative of the cable's interaction with the seafloor environment. Fraying material was seen on the cable in 5 locations and 76 instances of kelp snagged on the cable or laying next to the cable were annotated (Figure 11). Frayed cable was frequently seen intertwined with snagged kelp. Only one instance of kelp on the seafloor was annotated in the 43 m station control transect. The percentage of the seafloor covered by shell hash was higher ($p<0.05$) in the cable area than along the control transect (Table 1).

The 43 m station had the lowest overall organism abundance of all stations surveyed (approximately 0.1 organisms per meter; Appendix D). The overall density of organisms was 3.5 times greater near the cable than along the control transect (Table 1). Ostheichthyes, especially pleuronectiforms (flatfishes) were the most abundant taxon in the cable transect (65% of observed megafauna), and were significantly more abundant than in the control area, where only a single individual (13% of megafauna) was observed. Increased abundance of flatfish near the cable remains unexplained, but could be related to the increased habitat heterogeneity caused by the cable. Crustacea ranked second in abundance among major taxa, at this site and were equally abundant among cable and control transects (Appendix D). The remaining cable and control transect taxonomic groups were represented by fewer than 5 individuals. No statistically significant differences were found between cable and control sites with regard to infauna (Appendix F).

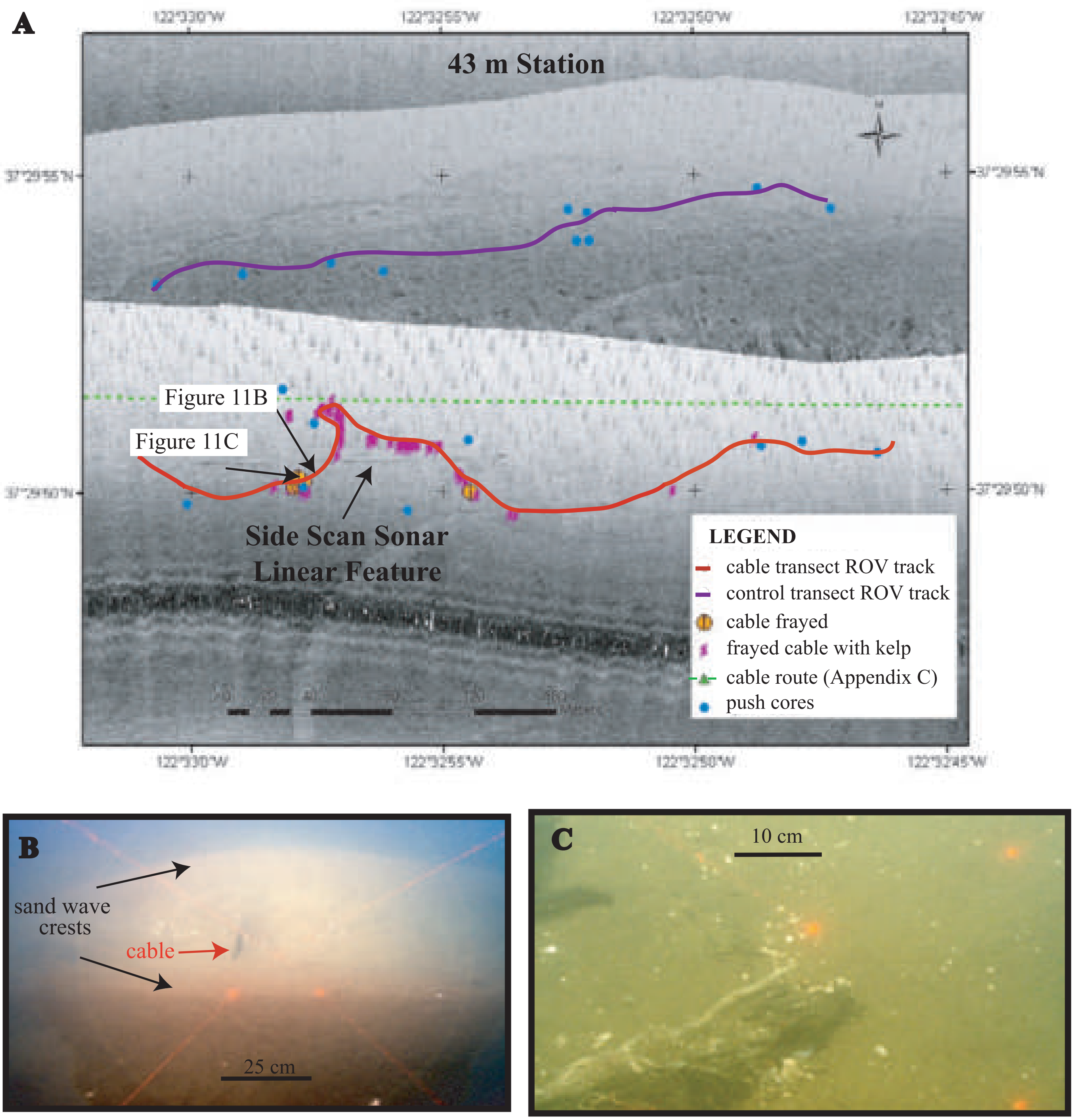


Figure 11 A: Map showing reported cable path superimposed on a side scan sonar image of the seafloor, ROV navigation, locations of specific observed features of interest, push core locations, and locations of photographs at the 43 m station. Note that occurences of intertwined kelp and frayed cable occur in proximity to the linear feature seen on side scan sonar data. The side scan sonar image seen in this figure was from a different swath than the side scan image showing the linear feature in Figure 6. **B:** Photograph showing sand waves representative of the substrate at this site. The cable is exposed in the trough and buried in the crests. Note the white, specks of shell hash material clustered in the trough. **C:** Photograph showing white strands that are likely frayed cable material intertwined with dark frayed cable material and kelp. White specks are shell hash. Red dots and/or lines in B and C are laser beams.

43 m Station – Interpretation

The 43 m station is located within a dynamic seafloor environment where high wave energies regularly move sediment. The 43 m station also coincides with the transition in cable armor from double-armored to unarmored. The frayed material observed on the cable at this station, like that seen at the 20 m station, is probably damage to the cable's armor. The damage may occur during high-energy events when the cable moves on the seafloor and is abraded in the process. The transitional nature of the cable's armor in this location is an inherent zone of weakness. Kelp is snagged on the exposed cable and frayed armor. The dynamic nature of seabed conditions at this site may also explain the low organism abundance counted here. The cable tended to be exposed in the sand wave troughs and buried in the crests (Figure 11). The positions of exposure and burial are likely to change with time as the substrate shifts.

A statistically significant, larger mean percentage of area with shell hash was found along the cable transect, with the majority of shell hash being observed in troughs between sand wave crests. Shell-producing molluscs were not seen in large numbers nor were they encountered in cores in great enough numbers to produce the shell hash *in situ*. Thus, hydrodynamic forces that transport and concentrate the shell material and winnow other materials away probably produce shell hash patches near and away from the cable. The larger mean percentage of area with shell hash suggests that the cable subtly affects local hydrodynamic conditions that focus shell hash deposition in proximity to the cable.

67 m Station

A 360 m long section of cable was viewed along the Pioneer Seamount / ATOC cable route at the 67 m station (Figure 12). Water depths ranged from 66 to 68 m. ROV navigation data show that the cable's path is sinuous. Throughout the survey transect, the cable was located within 50 m of its reported position and was found within 15 m of it reported path in most locations. The cable was tracked with the cable tracking tool as it was buried for all of the transect length. Burial depth ranged from 0 to 20 cm (± 5 cm cable tracker error range) with a mean and standard deviation of 9 cm ± 6 cm. Efforts to probe with the mechanical arm of the ROV confirmed that the recorded burial depths were reasonable and showed that the cable's exterior is black in this location. The ROV pilots also used the frequent, linear distribution of *Metridium farcimen* (anemone), often found attached to the cable, as a practical navigational aid to follow the cable's path (Figure 12). The substrate consisted of silty sand with ripple marks. A parallel control transect 210 m long was performed 110 m south of the cable. A total of 20 push cores were collected for infaunal analysis: 10 along the cable and 10 along the control.

Echinoderms were the most abundant megafauna at this site, comprising 96% of the observed megafauna along the cable transect and 99% along the control transect. Within the echinoderms, ophiuroids (brittlestars) were the most abundant taxon in cable and control transects, and were more abundant than pleuronectiformes (flatfish), which ranked second overall (Appendix D). Other megafaunal groups were relatively uncommon. Counts of megafauna along the video transects showed that the total density of megafauna was low near the cable compared to the control transect (Table 1). However, *M. farcimen* was approximately twice as dense along the cable transect relative to the control (Table 1 and Appendix D). *M. farcimen* commonly recruits to hard substrata on the continental shelf (Fautin and Hand 2000, Fautin et al. 1989) and clearly has recruited to the cable at this station. Even though Metridium was abundant on the cable, the

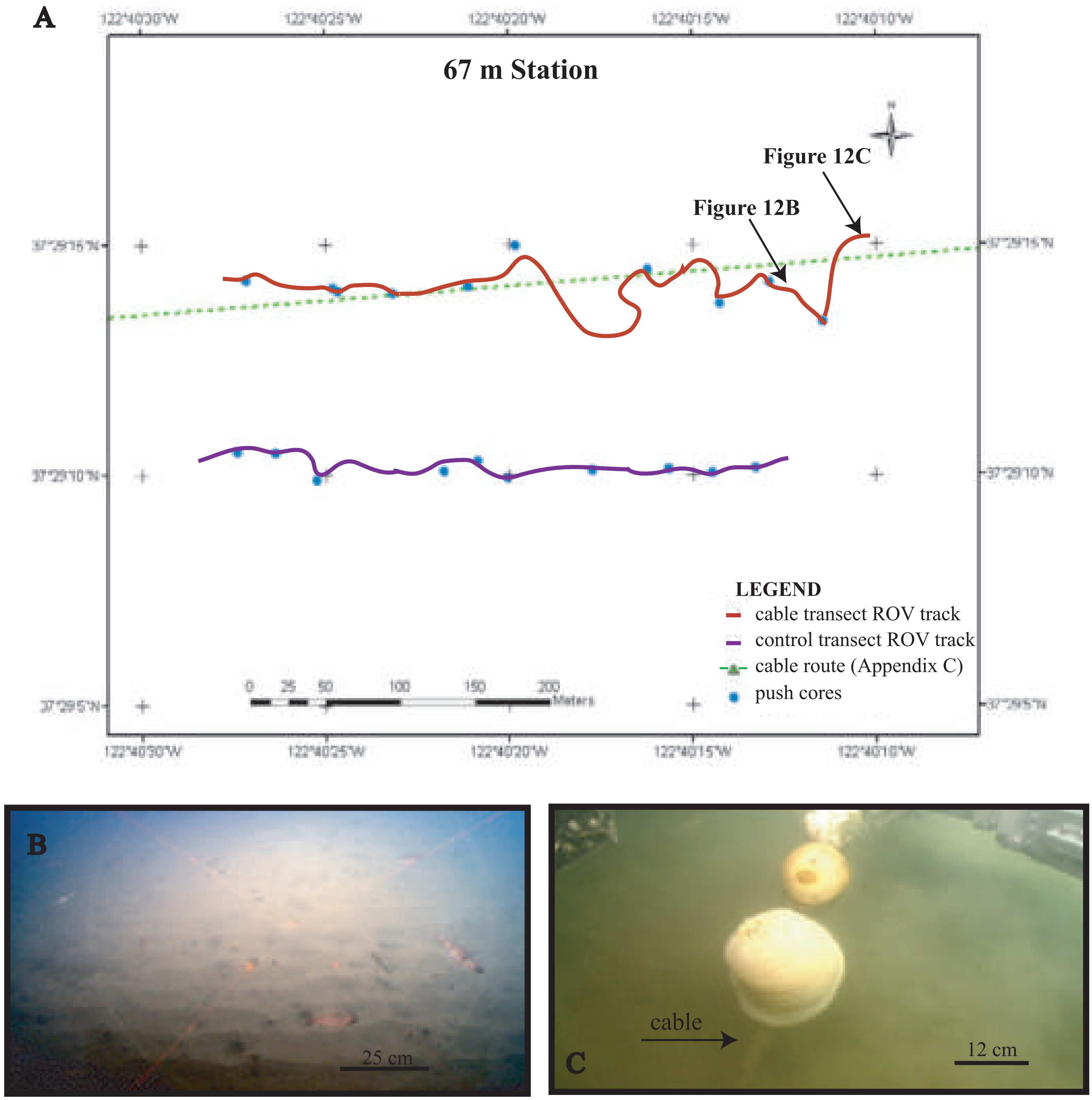


Figure 12 A: Map showing the reported cable path, ROV navigation, push core locations, and locations of photographs at the 67 m station. **B:** Photograph showing unconsolidated sandy sediment with ripple marks that is representative of the substrate at this site. The cable is buried in this photograph and along all of the 67 m transect. Red dots and/or lines are lasers.**C:** Photograph showing the ROV *Ventana*'s mechanical arm in the process of lifting the cable to verify that the *M. farcimen* (anemones) are attached to the cable.

relative abundance of megafaunal cnidarians was not statistically different between cable and control transects, due to the presence of several types of Pennatulaea (sea pens), which are also cnidarians on the control route.

Analyses of the percentage cover of organisms detected no significant difference between the two transects with respect to any biological parameters in the percent cover analysis. Ripple marks, however, covered a lower percentage of seafloor in the cable area than the control ($p<0.05$; Table 1). This result appears to be related to greater height of the ROV above the seafloor and greater turbidity during the cable transects, rather than any affect of the cable on ripple formation. Nor were any statistically significant differences in the density of infaunal organisms detected between cable and control sites (Appendix F).

<u>*67 m Station – Interpretation*</u>

The 67 m station is clearly dominated by ophiuroids, which are densely distributed as a "sea of arms" protruding from the seafloor. Abundance of very dense, small organisms is difficult to estimate on moving video over long distances. Percent cover and infaunal analyses are more refined tools for estimating the density of this type of animal and no statistically significant difference with respect to ophiuroids in the percent cover analysis or infaunal data were found.

<u>*75 m Station*</u>

A 240 m long section of cable was viewed along the Pioneer Seamount / ATOC cable route at the 75 m station (Figure 13). Water depths ranged from 73 to 75 m. ROV navigation data shows that the cable was located within 20 m of its reported position. The cable was tracked with the cable tracking tool as it was buried in 100% of the transect length. The ROV pilots also used the frequent, linear patches of *M. farcimen*, believed to be living on the cable, as a navigational aid. Burial depth ranged from 3 to 20 cm (± 5 cm cable tracker error range) with a mean and standard deviation of 13 cm ± 6 cm. The substrate consisted of silty sand with ripple marks. A parallel 390 m long control transect was performed 125 m south of the cable. A total of 20 push cores were collected for infaunal analysis: 9 along the cable and 11 along the control.

Organisms that are members of six of the counted taxonomic groups were observed on both the cable and control transects. Similar to the 67 m station, echinoderms were the most abundant taxonomic group comprising 91% of cable and 97% of control transect megafauna. The most abundant organisms in both the cable and control transects were ophiuroids (brittlestars) with two orders of magnitude more individuals than the second most abundant organism, pleuronectiformes (flatfish) (Appendix D). *M. farcimen* density was approximately 40 times greater on the cable transect relative to the control (Table 1). The other taxonomic groups were present in relatively small numbers. Cnidarians, ostheichthyes, and echinoderms, and ripple marks were observed to be more abundant along the cable route in comparison to the control ($p<0.05$; Table 1). Analysis of infauna indicated that there were fewer taxa of nemertea (ribbon worms) near the cable (Appendix F).

<u>*75 m Station – Interpretation*</u>

Cnidarians are more abundant on the cable transect because *M. farcimen* were attached to the cable. Ostheichthyes, flatfish at this site, were more abundant possibly because the cable provided substrate heterogeneity. As in the 67 m station the observed increase in echinoderms

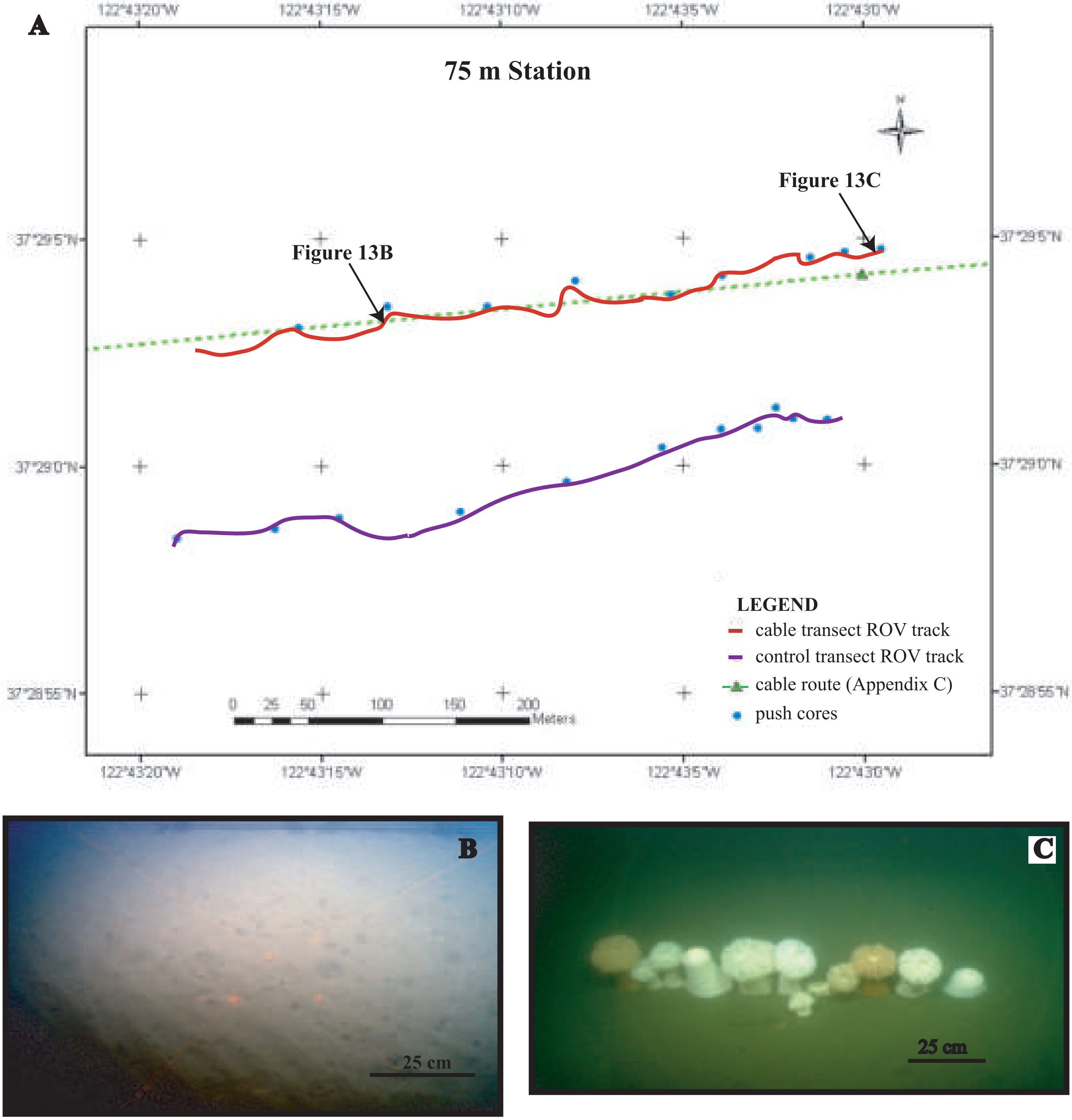


Figure 13 A: Map showing the reported cable path, ROV navigation, push core locations, and locations of photographs at the 75 m station. **B:** Photograph showing unconsolidated sandy sediment with ripple marks that are representative of the substrate at this site. The cable is buried in this photograph and along all of the 75 m transect. Red dots and/or lines are lasers. **C:** Photograph showing a line of *M. farcimen* colonizing the cable. Cable position was verified using an Innovatum Ultra44 cable-tracking tool.

and ripple marks are believed to be an artifact associated with the difficulty of video estimates. The reason for the difference in the number of nemertea taxa between cable and control transects is uncertain and is probably due to patchiness.

140 m Station

A 690 m long section of cable was viewed along the Pioneer Seamount / ATOC cable route at the 140 m station (Figure 14). Water depths ranged from 134 to 145 m. ROV navigation data shows that the cable was located between 40 and 70 m north of its reported position. The cable was tracked with the cable tracking tool as it was buried in 65% of the transect length. The substrate consisted of unconsolidated silt and clay. Where exposed, the cable's exterior was white at this station. The frequent occurrence of *M. farcimen* was used as a cable location (Figure 14) and navigational aid. The substrate consisted of silty sand. A parallel 660 m long control transect was performed 100 m south of the cable. A total of 20 push cores were collected for infaunal analysis: 10 along the cable and 10 along the control.

Cnidarians were the most abundant megafauna, comprising 91% of cable and 94% of control transect megafauna, and were significantly more abundant along the cable ($p<0.05$). *Halipteris sp.* (sea pen) were the most abundant taxon along both the cable and control transects, and were ten times more abundant than *M. farcimen,* the second most abundant organism in the cable transect. *M. farcimen* density was approximately 120 times greater on the cable transect relative to the control (Appendix D). All 121 instances of *M. farcimen* on the cable transect were of organisms believed to be living on the cable. In contrast, only one *M. farcimen* was seen on the control transect because of the presence of cobble or other piece of isolated, hard material that provided an adequate substrate. *Halipteris sp*. was two orders of magnitude more abundant than *Rathbunaster californicus* (sea star), the second most abundant organism in the control transect (Appendix D). Even though the relative rank of *R. californicus* was different between the two sites, organism abundance normalized to transect length was similar (Appendix D). The other taxonomic groups were present in relatively smaller numbers. Drift kelp was observed in higher ($p<0.05$) abundance on the cable transect (Table 1 and Appendix E). No statistical difference was observed between the cable and control sites with regard to infauna or percent cover (Appendices F and G).

140 m Station – Interpretation

Drift kelp was statistically more abundant along the cable than the control transect. However, drift kelp occurrence was relatively low in both sites. Unlike the 20 m and 43 m stations where the majority of annotated kelp was intertwined with the cable, none of the recorded counts of kelp at this station were on or underneath the cable. Perhaps the cable effects the local hydrodynamics that results in more drift kelp in proximity to the cable compared to the control sites.

Higher cnidarian abundance along the cable is associated with two taxa: *M. farcimen* and *Halipteris sp*. Again, *M. farcimen* are attached to the cable. The reason for the greater abundance of *Halipteris sp.* is uncertain.

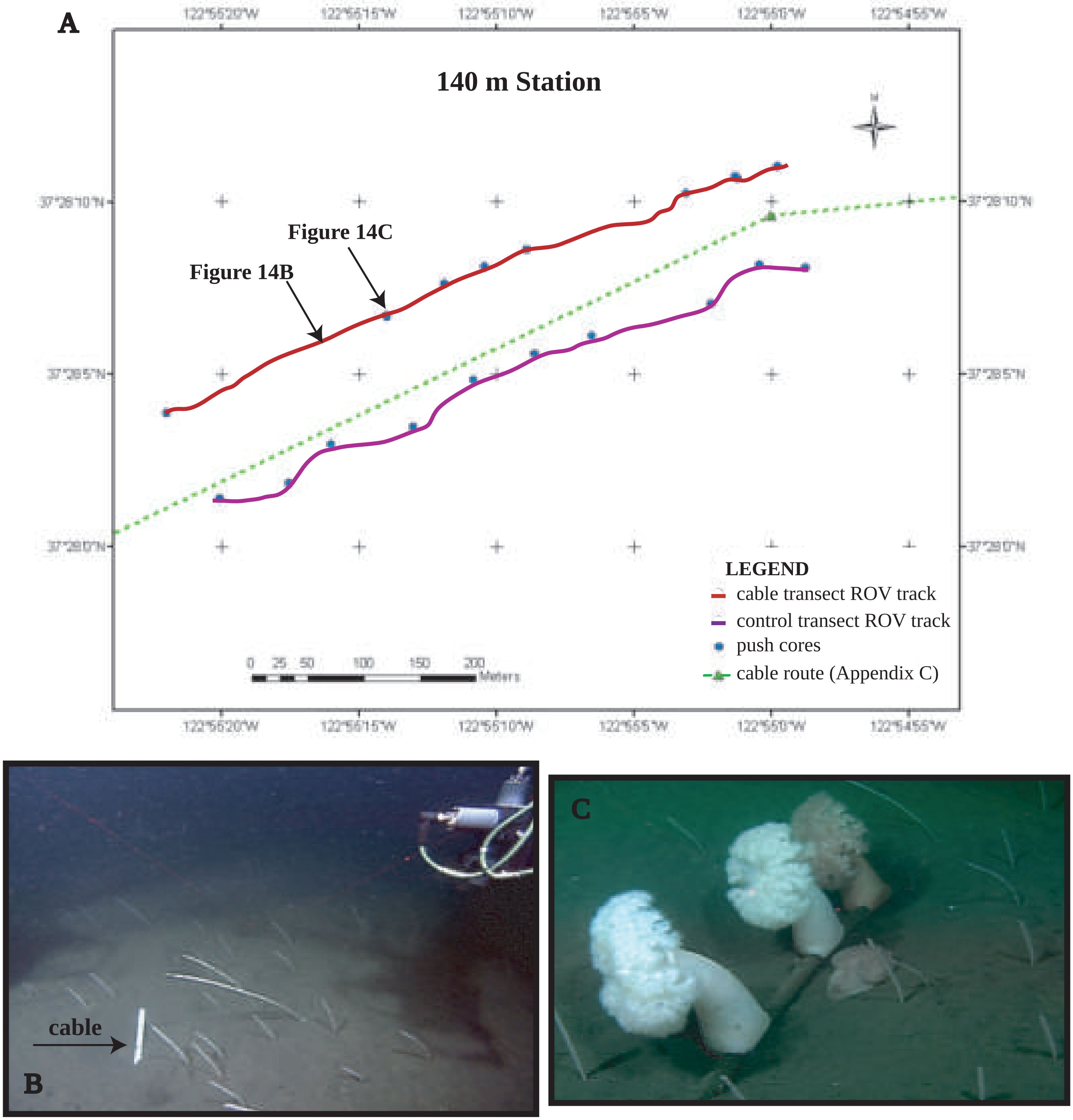


Figure 14 A: Map showing the reported cable path, ROV navigation, push core locations, and locations of photographs at the 140 m station. **B:** Photograph showing a short segment of exposed cable in the unconsolidated sediment substrate characteristic of this site. The abundant, thin, white organisms are *halipteris sp.* (sea pens). A portion of the TSS350 cable-tracking system mounted on the *ROV Tiburon* is seen on the upper right corner. **C:** Photograph showing three *M. farcimen* colonizing the cable. The organism on the sediment substrate next to the cable is a pleurobranch (type of mollusc). Halipteris are also seen in this photograph.The cable is 3.2 cm wide and can be used as a scale. Red dots and/or lines are lasers.

240 m Station
The 240 m station was surveyed during both the February and July 2003 ROV cruises. Data presented in this report is based solely on samples and video collected during the February cruise. An earlier dive during the July cruise in 300 m of water failed to locate the cable near its reported position and prompted a second visit to the 240 m site. The objective of this replicate dive was to relocate the cable and follow it down-slope. Additional video and core data were collected to complement the initial dataset but not processed for this report due to time-constraints and work effort prioritization.

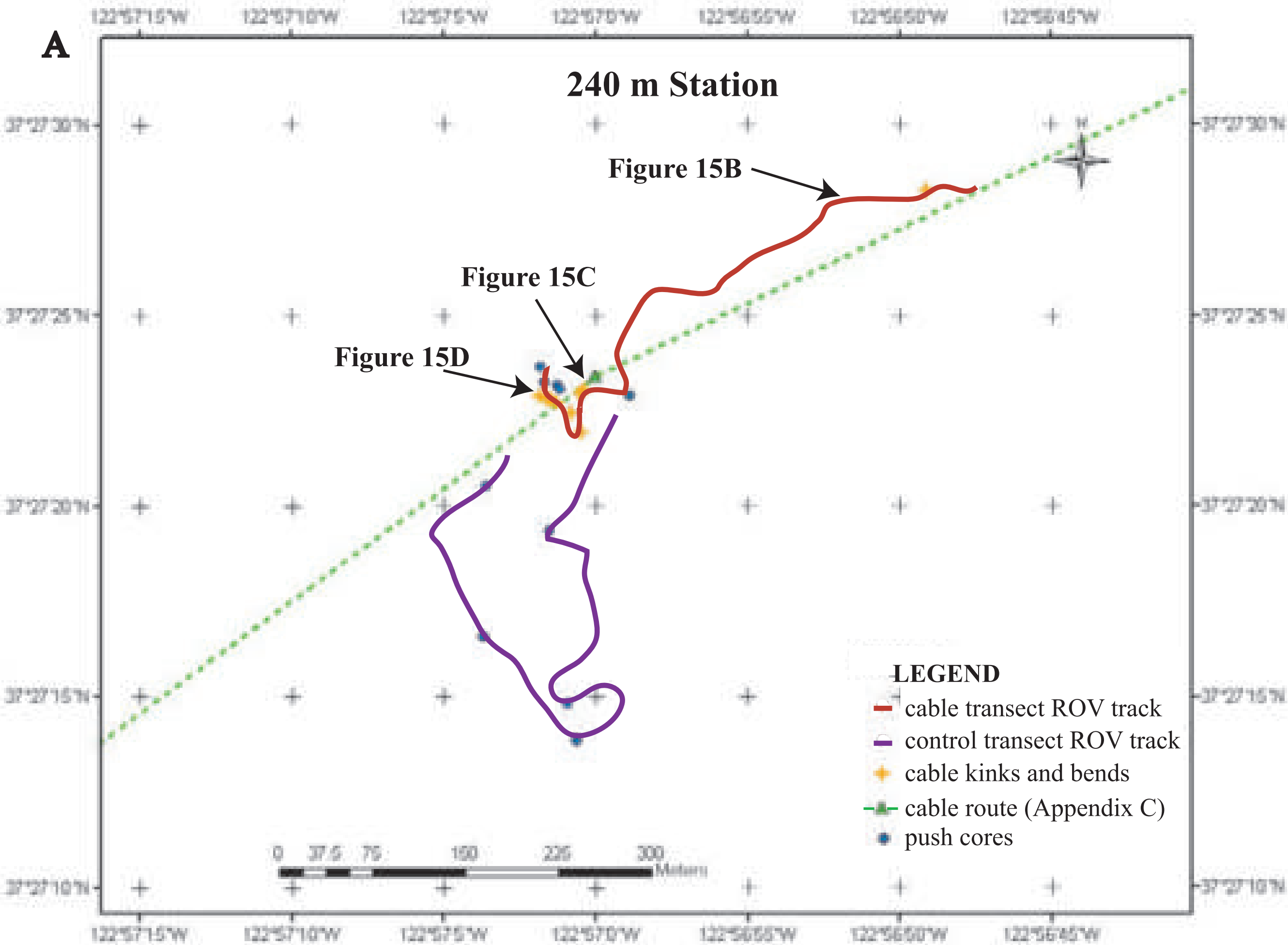
A 330 m long section of cable was viewed along the Pioneer Seamount / ATOC cable route at the 240 m station (Figure 15). Water depths ranged from 229 to 246 m. ROV navigation data shows that the cable was located within 45 m to the north of its reported position. The power supply for the Innovatum Ultra 44 cable tracker tool failed at this station. Thus, the cable was located and tracked visually. The cable's exterior was white at this location and the cable was buried along 83% of the transect length. Twelve kinks (two of which were tight ~ 90° bends) and 14 lower angle bends were seen in the cable (Figure 15). The apex of the kinks tended to be exposed and slightly suspended whereas the apex of the low angle bends were frequently buried. A white cable was identified as the Pioneer Seamount / ATOC cable using a TSS 350 cable tracking system in July 2003. The substrate consisted of silty sediment with occasional outcrops of flat slabs of rock. A 600 m long control transect was performed south of the cable and perpendicular to the cable's path. A total of 10 push cores were collected for infaunal analysis: 5 along the cable and 5 along the control.

Six taxonomic groups were observed on the cable transect and five were observed on the control. Echinoderms were the most abundant taxonomic group comprising 78% of cable and 91% of control transect megafauna. The most abundant organism in both the cable and control transects was *Allocentrotus fragilis* (urchin) with one order of magnitude more individuals than the second most abundant organism, *R. californicus* (Appendix D). Cnidarians and ostheichthyes were relatively abundant in both transects. The other taxonomic groups were present in smaller numbers. Total organism abundance values (normalized to transect length) were similar between cable and control transects (Table 1).

Statistical comparison of video data between cable and control sites showed higher mean abundances of cnidarians and ostheichthyes on the cable transect. A lower mean percentage of area covered with unconsolidated sediment in the cable transect is statistically significant also (Table 1). No difference was observed between the cable and control sites with regard to infauna (Appendix F).

240 m Station- Interpretation
A cable at the 240 m station was visited by both *ROVs, Ventana and Tiburon.* ROV navigation placed the two transects approximately 50 m apart. Analysis of ship and ROV navigation data and discussion with MBARI technical staff failed to identify an error explaining this unexpectedly large offset. The cable's position may have shifted between the February and July surveys. Alternatively, there could be two white cables in the area.

A



B

C

D

Figure 15 A: Map showing the reported cable path, ROV navigation, push core locations, locations of photographs, and features of interest at the 240 m station. **B:** Photograph showing a small cable suspension in a mixed substrate environment consisting of rock slabs covered by a thin veneer of unconsolidated sediment. **C:** Photograph showing the cable intermittently buried. **D:** Photograph showing a sharp kink in the cable in which the apex of the fold is exposed with a small suspension whereas the limbs are buried. The substrate is dominantly unconsolidated sediment.The cable is 3.2 cm wide at this station and can be used as a scale.

The higher mean abundance of cnidaria on the cable transect was due to *M. farcimen* presence on the cable. Eighty-three percent of *M. farcimen* appear to be living directly on the cable. The cable provides hard substrate habitat for these cnidarians in an otherwise sediment covered seafloor.

Ostheichthyes abundance on the cable transect was due to a combination of fishes and not to any one group (Appendix D). Rockfishes dominated abundance counts at both cable and control sites. The cable's presence may create habitat that is suitable for some rockfishes. Conversely, these variations may simply reflect patchiness.

A statistically higher mean percentage of area was characterized as 'sediment' in the control transect relative to the cable (Table 1). However, this result is a consequence of the cable occupying space on the seafloor (Appendix G). Similar results are seen in all the deeper stations (Table 1).

250 - 415 m Station (Video-only Cable Transect)

The goal of this dive was to locate the September 25, 2002 cable fault. Tests performed by UW-APL personnel on October 4, 2002 indicated that the fault is located 47 to 51 km along the cable from Pillar Point (Jim Mercer, personal communication). Based on cable installation information from Howe, 1995, it was estimated that the fault is located in 300 to 500 m water depths. Because the cable path had been observed to be relatively sinuous, the expectation was that the fault location would be in the shallower portion of the estimated depth range.

An 3,547 m long section of cable was viewed in water depths ranging from 250 to 415 m (Figure 16). The cable was farthest away from its reported position at this station and varied from 185 m north of the reported position at the east end of the transect to 975 m north of the reported position at the west end of the transect (Figure 16). The cable's exterior was black in this transect and the cable was buried along 37% of the transect length. Locations where a superficial veneer of sediment coated the cable but the cable's shape remained visible on the seabed were considered exposed cable. Numerous suspended segments where the cable was less than 10 cm off the seabed were seen (Figure 16). A cable crossing was observed at 37° 26' 57" N, 122° 58' 27" W (Figure 16). The substrate consisted of homogeneous, silty sediment.

Quantification of the fauna resulted in a total of 3,017 organisms representing 9 taxonomic groups (Table 1 and Appendix D). Cnidarians were the most abundant taxonomic group comprising 49% of observed megafauna. The most abundant organisms were Actiniaria (sea anemones). Echinoderms, ostheichthyes, and crustaceans were also represented in relatively high numbers (Appendix D). Thirty one percent of all counted organisms at this transect were observed living directly on the cable and nearly all of these organisms were Actiniaria. Cnidarians (especially Actinarians) colonizing the cable is consistent with observations from previous stations (e.g. 75m, 140 m, and 240 m). A few fishes were observed hovering directly underneath the cable in regions where the cable was suspended several cm off the seabed (Figure 16).

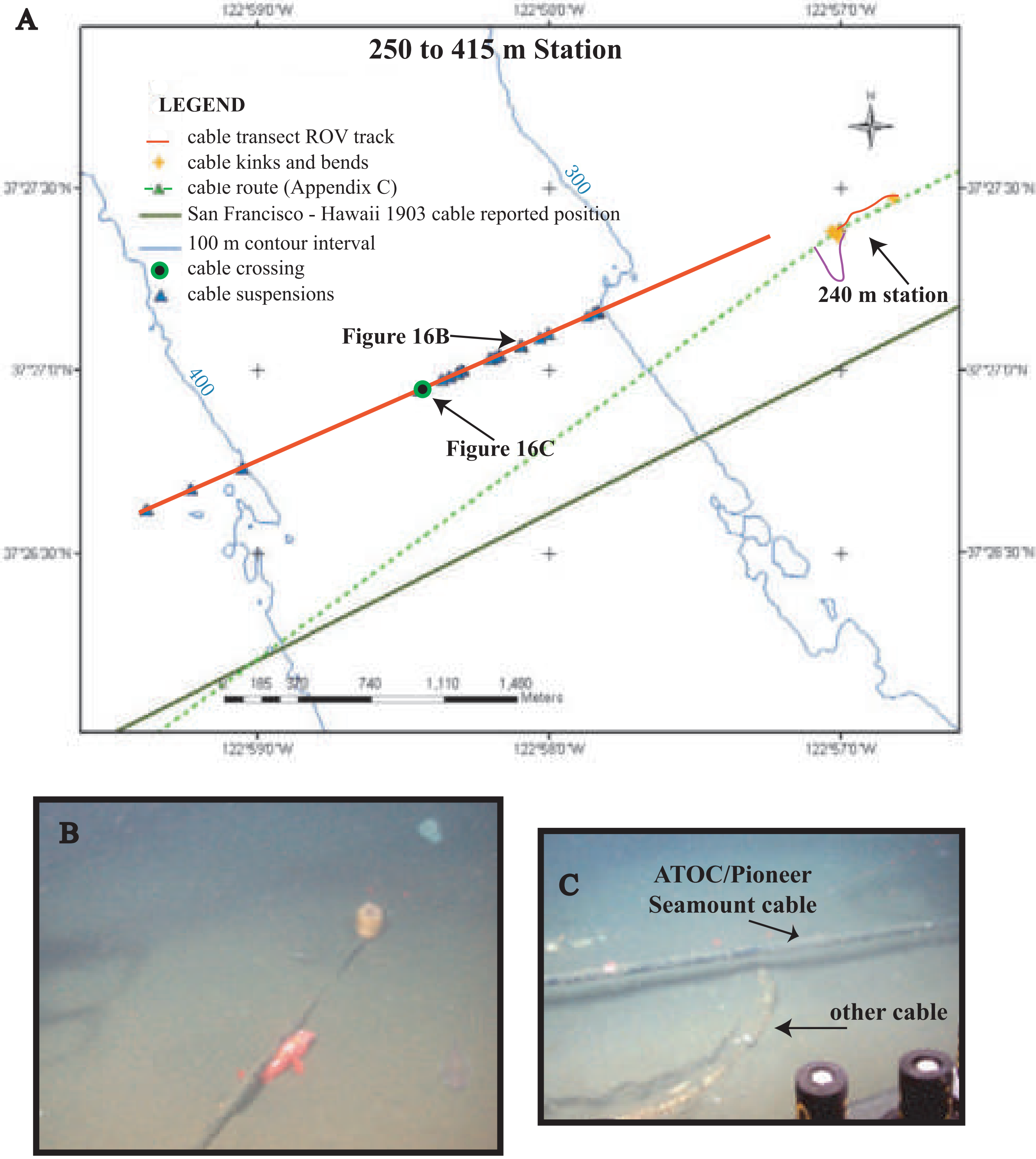


Figure 16 A: Map showing the reported cable path, ROV navigation, locations of photographs, specific observed features of interest, location of 240 m station transects, bathymetry, and path of San Francisco - Hawaii cable at the 250 - 415 m station. **B:** Photograph showing a segment of exposed cable in the unconsolidated sediment substrate characteristic of this site. Note cnidarians attached to the cable and the sebastolobus (rockfish) under it. **C:** Photograph showing the ATOC/Pioneer Seamount cable crossing a cable that may be the 1903 San Francisco - Hawaii Telegraph cable. Location of the crossing occurs in 344 m water depth at 37º26'57"N, 122º58'27"W. Note the small cable suspensions in both photographs. The cable is 3.2 cm wide and can be used as a scale in the photographs. Red dots are lasers.

250 - 415 m Station - Interpretation

The location of the cable fault was not identified and may not be obvious. In theory, if a cable is severed, the location of the break could be identified visually and/or the tone carried by the cable could not be transmitted past the break. However, a short in the cable or a partial cable break could allow tone transmission but with strength loss with distance away from the fault. The latter was the predicted scenario based on tests performed by UW-APL in October 2002 (Jim Mercer, personal communication). The tone carried by the ATOC/Pioneer Seamount cable did not noticeably decrease in strength throughout this transect. However, we are not confident that this transect was updip of the actual fault location. Observations of sharp kinks at this station and in the 240 m station indicate that these are possible locations where the cable may be faulted.

The currently decommissioned 1903 Hawaii – San Francisco Telegraph cable is known to be located near this region and its reported path is shown in Figure 16 (Sarah Wilson – WA-EMAP, personal communication). The reported location is approximately 865 m south of the cable crossing observed in this transect. Considering the early installation date and relatively crude navigation techniques of the time, it is possible that the identity of the cable crossing underneath the ATOC/Pioneer Seamount cable is the 1903 Hawaii – San Francisco Telegraph cable. If so, the telegraph cable has remained exposed on the seafloor for 100 years at this location.

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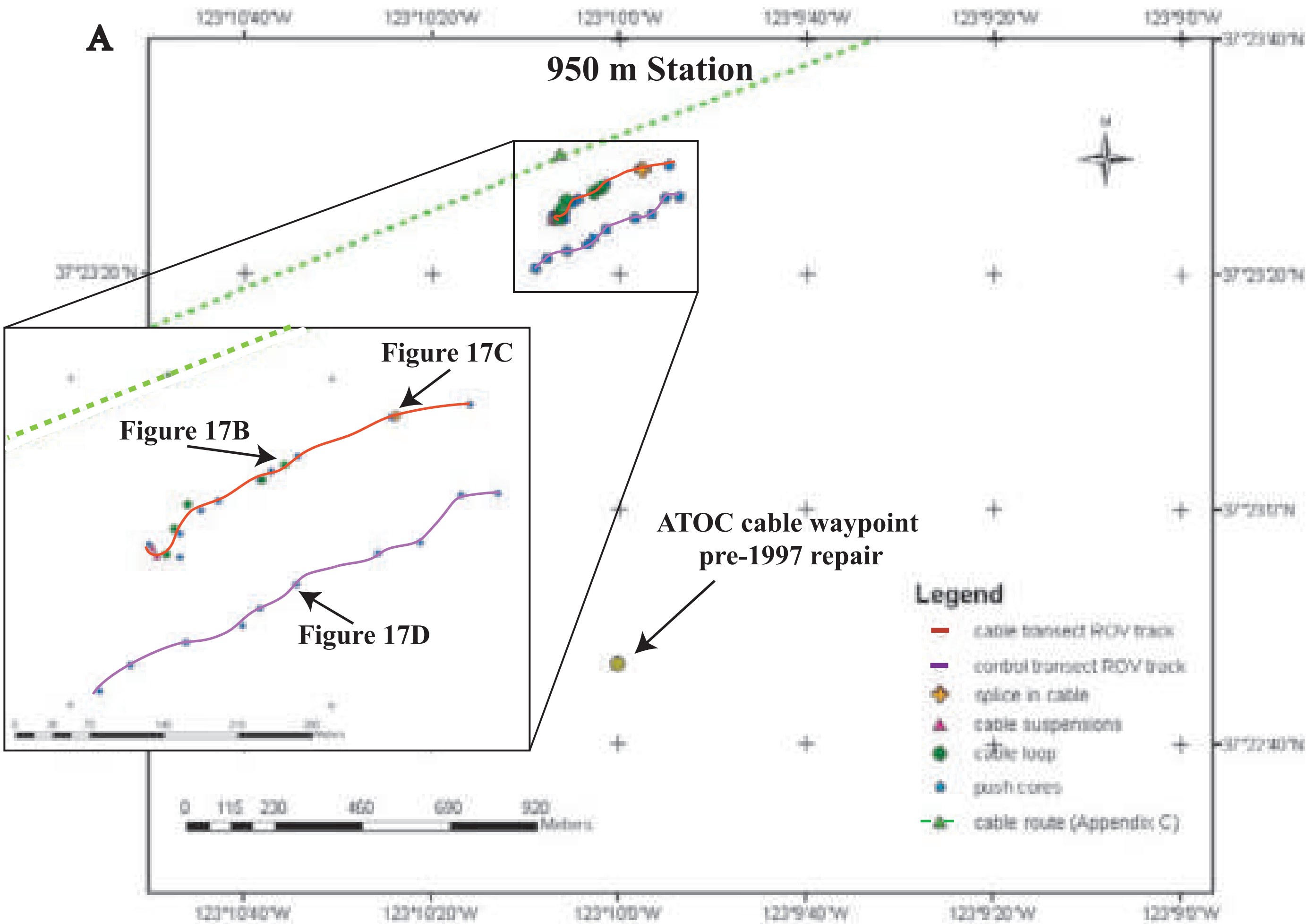
The following transects are outside the Monterey Bay National Marine Sanctuary (Figure 8).

950 m Station

A 420 m long section of cable was viewed along the Pioneer Seamount / ATOC cable route at the 950 m station (Figure 17). Water depths ranged from 947 to 960 m. ROV navigation data shows that the cable was located within 130 m south of its reported position (Appendix C). The cable was buried in 58% of the transect. Five nearly flat-lying loops were observed where the cable crossed itself (Figure 17). A splice in the cable was found in 956 m water depth where the cable's exterior changed from white to black (Figure 17). ROV sonar indicated the presence of long, rectangular patches on the seafloor whose trend was perpendicular to the cable path (Figure 17). No visible seabed differences were observed between the rectangular patch areas and the seafloor near them. Numerous short cable suspensions were observed at this station. A parallel 510 m long control transect was performed 115 m south of the cable. A total of 20 push cores were collected for infaunal analysis: 10 along the cable and 10 along the control.

Organisms that are members of six of the counted taxonomic groups were observed on both the cable and control transects. Cnidarians were the most abundant taxonomic group comprising 76% of cable and 71% of control transect megafauna (Appendix D). The most abundant organism type in both transects was Actiniaria (sea anemones). *Pennatula sp.* (sea pen) and *Sebastolobus sp*. Were the second and third most abundant organism types, respectively and were represented in similar quantities (per meter) in cable and control transects. Ninety-eight individuals of *Stomphia sp.,* a type of Actiniaria*,* were counted in the cable transect and none were counted on the control (Table 1).

Comparisons of biological and physical parameters at this station shows differences at the 95% confidence level for seven parameters, the most differences of all stations surveyed. Video data



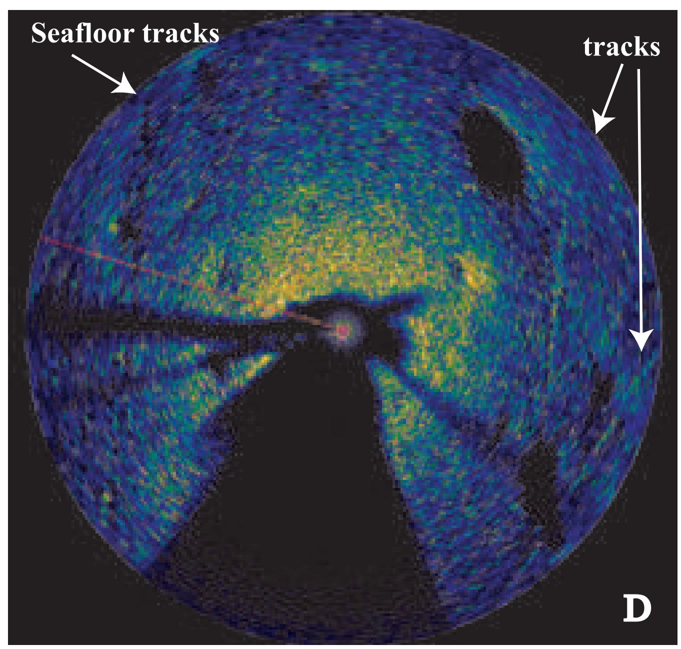


Figure 17 A: Map showing the reported cable path, ROV navigation, push core locations, locations of photographs and images, and features of interest at the 950 m station.
B: Photograph showing a nearly flat-lying loop in the cable.
C: Photograph showing what appears to be a splice in the cable. The cable color changes from black to white in this location. The cable is 3.2 cm wide for scale. Red dots are lasers.
D: Image of ROV Tiburon scanning SONAR showing reflection pattern relative to ROV's heading (252¡) at a range of 50 m.

analysis indicated a higher mean abundance of cnidarians, echinoderms, crustaceans, and drift kelp in the cable transect (Table 1). Analysis of infauna indicated that a higher abundance and larger number of polychaete (worms) taxa were found near the cable (Appendix F). A lower percentage of area covered by unconsolidated sediment in the cable transect was statistically significant also (Table 1 and Appendix G).

950 m Station – Interpretation

The ATOC/Pioneer Seamount cable was faulted and repaired in about 900 m water depth in 1997. The cable splice seen at this site is likely a result of that repair operation and the nearly flat-lying loops are a result of extra cable typically introduced during repair operations. Figure 17 shows that there is a 1,240 m change in the cable's position between installation and post-1997 repair at this site. Extra cable was spread over the larger area and some of the slack was in loops (Figure 17). The linear shadows seen on ROV sonar are likely anthropogenic seabed alteration such as relic trawl marks or another type of alteration that produces similar track prints (Figure 17). The lack of a difference to the human eye between track areas and surrounding seafloor implies that the alteration has superficially recovered but, instruments capable of distinguishing subtle, local slope and depth changes are still able to detect it. The coincidence of tracks running perpendicular to the cable path in the location of the 1997 cable break suggests that what produced the tracks may have been responsible for damaging the cable.

Higher mean abundance of cnidarians on the cable transect is largely due to greater numbers of *Stomphia sp.* and other Actiniaria on the cable transect (Table 1 and Appendix E). Eleven percent of *Stomphia sp*. colonized the cable and 73% of other Actiniaria organisms were also seen directly on the cable at this site. The mean abundance of Actiniaria on the cable was approximately twice that of the control. The consistently higher abundance of Actiniaria such as *M. farcimen* and *Stomphia sp.* on the cable throughout this study indicate that the cable's presence on the seafloor may be affecting the distribution of these organisms (Table 1).

The statistically higher mean abundance of echinoderms and crustaceans on the cable transect is largely due to greater numbers of asteroidea (sea stars) and diogenidae (hermit crabs) near the cable. None of the occurrences were of organisms directly on or under the cable. The reason for the greater abundance is uncertain however diogenidae were seen in aggregations and their abundance may be due to patchiness. The higher polychaete abundance and number of taxa in sediments along the cable transect is also probably due to patchiness.

Similar to the 140 m station, drift kelp was statistically more abundant along the cable and its occurrence was relatively low in both cable and control sites. None of the recorded counts of kelp at this station were on or underneath the cable. Perhaps the cable effects the local hydrodynamics that results in more drift kelp in proximity to the cable.

1,710 – 1,890 m Station (Video-only Cable Transect)

This transect was the last site of the July 2003 survey and its goals were to determine if the cable was still transmitting the 25 Hz tone sent from the tone generator set-up at the Pillar Point shore facility. The decision to perform this transect followed completion of the 1,930 m station. The amount of time remaining for the cruise precluded dives in additional locations and this transect was performed to maximize the information collected regarding the cable's status.

A 1,321m long section of cable was viewed in water depths ranging from 1,709 to 1,891 m (Figure 18). The cable was found between 125 and 170 m north from its reported position. The substrate consisted of unconsolidated fine-grained sediment. The cable's exterior was white in this transect with black wrapping observed at *37°23' 23" N, 123°18' 28" W* (Figure 18). The cable path was highly sinuous (Figure 18). The cable was exposed on the seabed along nearly the entire transect length and short suspensions were also observed. The cable-tracker detected a weak tone carried by the cable. A test performed by turning the shore-based tone generator off and on confirmed that the weak signal was indeed transmitted via the cable. The cable tracking tool detected an output voltage over the cable that was distinctly less than output at stations closer to shore.

Quantification of the fauna resulted in a total of 3,729 organisms representing 8 taxonomic groups (Table 1 and Appendix D). Cnidarians were the most abundant taxonomic group comprising 62% of the observed megafauna. The most abundant organisms were Actiniaria. Cnidarians constituted 86% of organisms observed living directly on the cable. Organisms colonizing the cable constituted 6% of all organisms counted on this transect. Echinoderms were the second most abundant taxonomic group comprising 32% of observed megafauna largely due to *Pannychia moseleyi* (sea cucumbers). The five other taxonomic groups were present in relatively small numbers. The substrate consisted of unconsolidated, fine-grained sediment.

1,710 - 1,890 m Station - Interpretation

The considerable drop in the strength of the cable tracking tools signal on this transect, compared to stations closer to shore, is evidence of a cable fault updip of this transect location. The exact location of the fault is not clear.

1,940 m Station

The 1940 m station was the last cable/control site of the July 2003 survey. The location was picked based on interest in surveying a location where the cable crosses a submarine gully. A secondary goal was to determine if the cable was still carrying the 25 Hz tone at this site.

A 30 m long section of cable was viewed along the Pioneer Seamount / ATOC cable route at the 1,940 m station (Figure 18). Water depths ranged from 1,930 to 1,958 m. ROV navigation data shows that the cable was located within 55 m north of its reported position. The cable was exposed throughout the entire transect and its exterior was white. The cable-tracking tool detected a weak tone carried by the cable. The cable path is sinuous. A 90 m long control transect was performed south of the cable and oblique to the cable's path (Figure 18). A total of 10 push cores were collected for infaunal analysis: 5 along the cable and 5 along the control.

Organisms representing three taxonomic groups were observed on the cable transect and five were observed on the control. Cnidarians were most abundant (65% of megafauna) and echinoderms were second most abundant (33% of megafauna) in the cable transect (Appendix D). The order is reverse in the control transect (59% echinoderms and 39% cnidarians). The most abundant cnidarian in both transects was Actiniaria and the most abundant echinoderm was *P. moseleyi*. The other taxonomic groups were present in relatively small numbers.

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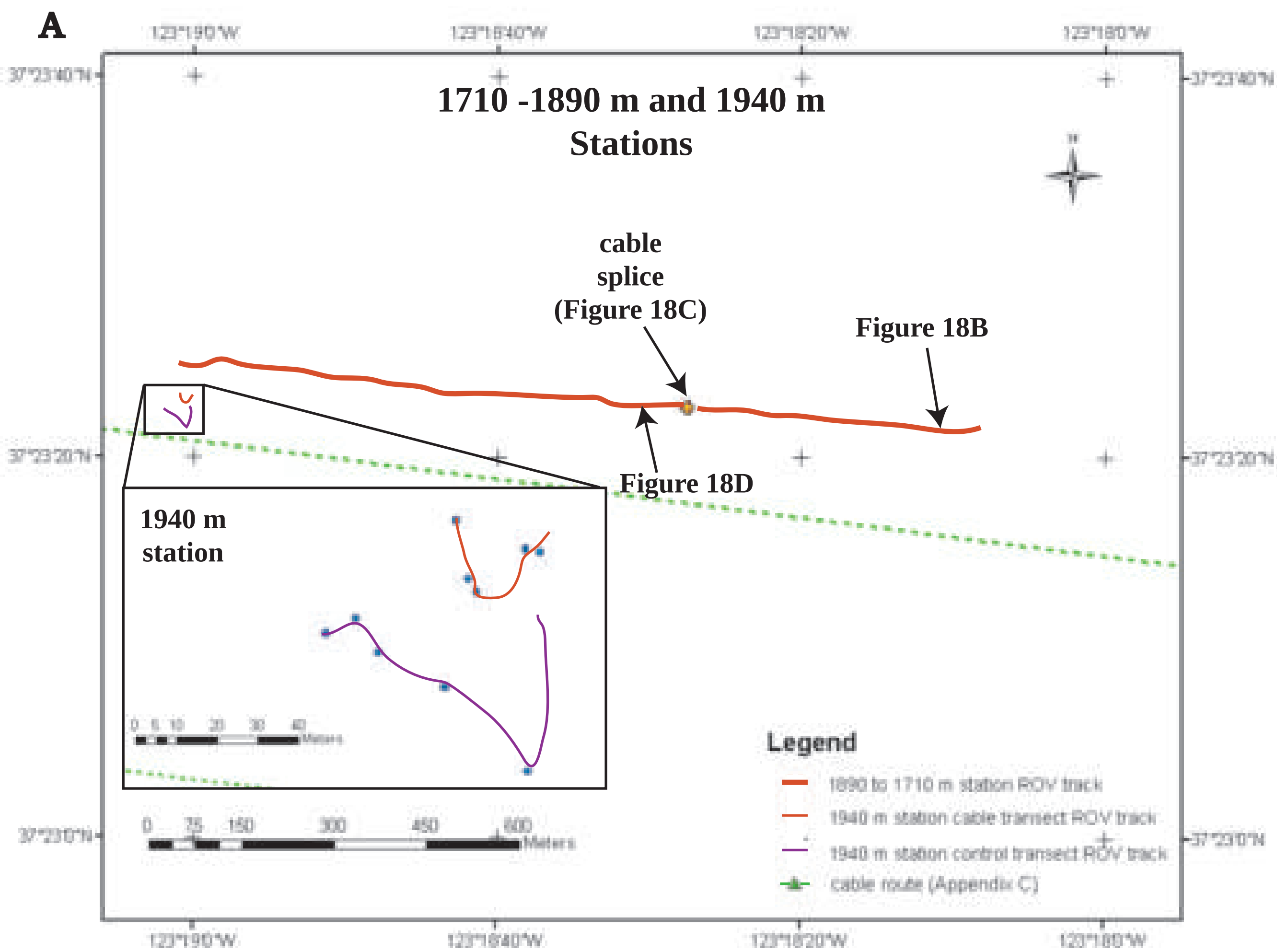
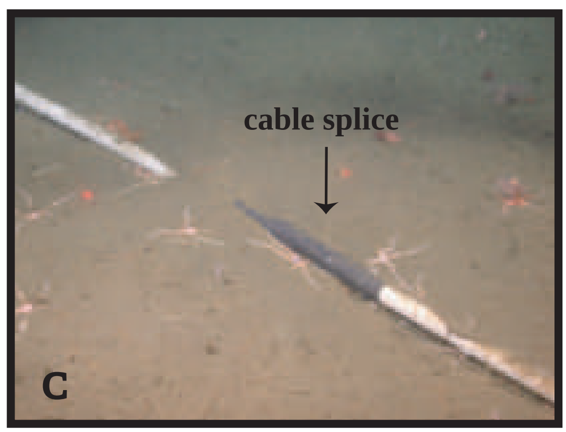




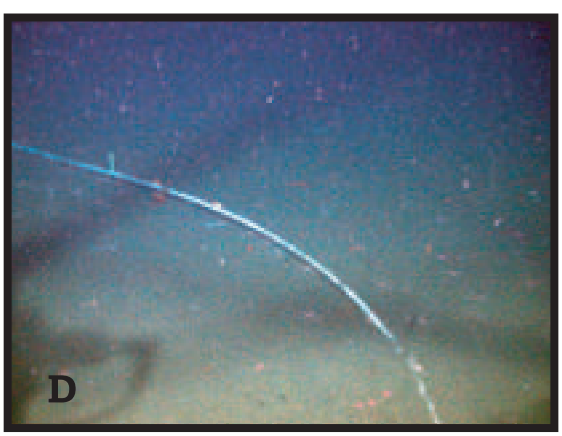


Figure 18 A: Map showing the reported cable path, ROV navigation, locations of photographs, location of cable splice, and inset with close-up of 1940 m station ROV track and location of push cores (blue closed circles). **B:** Photograph showing anemones and sea star on the cable. **C:** Photograph showing a splice in the cable. **D:** Photograph showing a turn in the cable illustrating the generally sinuous cable path in this area. The cable is 3.2 cm wide and can be used as a scale in the photographs. Red dots are lasers.

A statistical comparison of video data between cable and control sites could not be performed due to the short transect along the cable comprising only one transect bin. Percent cover analysis indicated that unconsolidated sediment covered a statistically higher area in the cable transect (Table 1 and Appendix G). No statistical difference was observed between cable and control sites with regard to infauna (Appendix F).

1,940 m Station-Interpretation

The lack of suspensions at this site indicates that the cable was able to conform to the submarine gully topography. However, the submarine channel is relatively minor compared to some located in this region (Figure 8).

Seamount 1,700 m Station

An 870 m long section of cable was viewed along the Pioneer Seamount / ATOC cable route at the base of Pioneer Seamount 1,700 m station (Figure 19). Water depths ranged from 1,811 to 1,610 m. ROV navigation data shows that the cable crosses the reported location and was located within 60 m south in the eastern portion of the transect and within 210 m north of its reported position in the western portion (Figure 19). The cable was exposed over the entire transect length and its exterior was white. The cable path was highly sinuous. The substrate consisted of unconsolidated sediment with occasional rock outcrops. A 180 m control transect perpendicular to the cable path was performed north of the cable. A total of 10 push cores were collected for infaunal analysis: 5 along the cable and 5 along the control.

The Seamount 1,700 m station had the second lowest organism abundance of all stations surveyed (approximately 0.3 organisms per meter) however, it had the greatest diversity in the number of individual taxa identified (Appendix D). Organisms that are members of eight of the counted taxonomic groups were observed on the cable transect and seven were observed on the control. Echinoderms were the most abundant taxonomic group, however ostheichthyes, cnidarians, crustaceans, and molluscs were present in both transects in comparable quantities. The other taxonomic groups were represented in relatively smaller numbers.

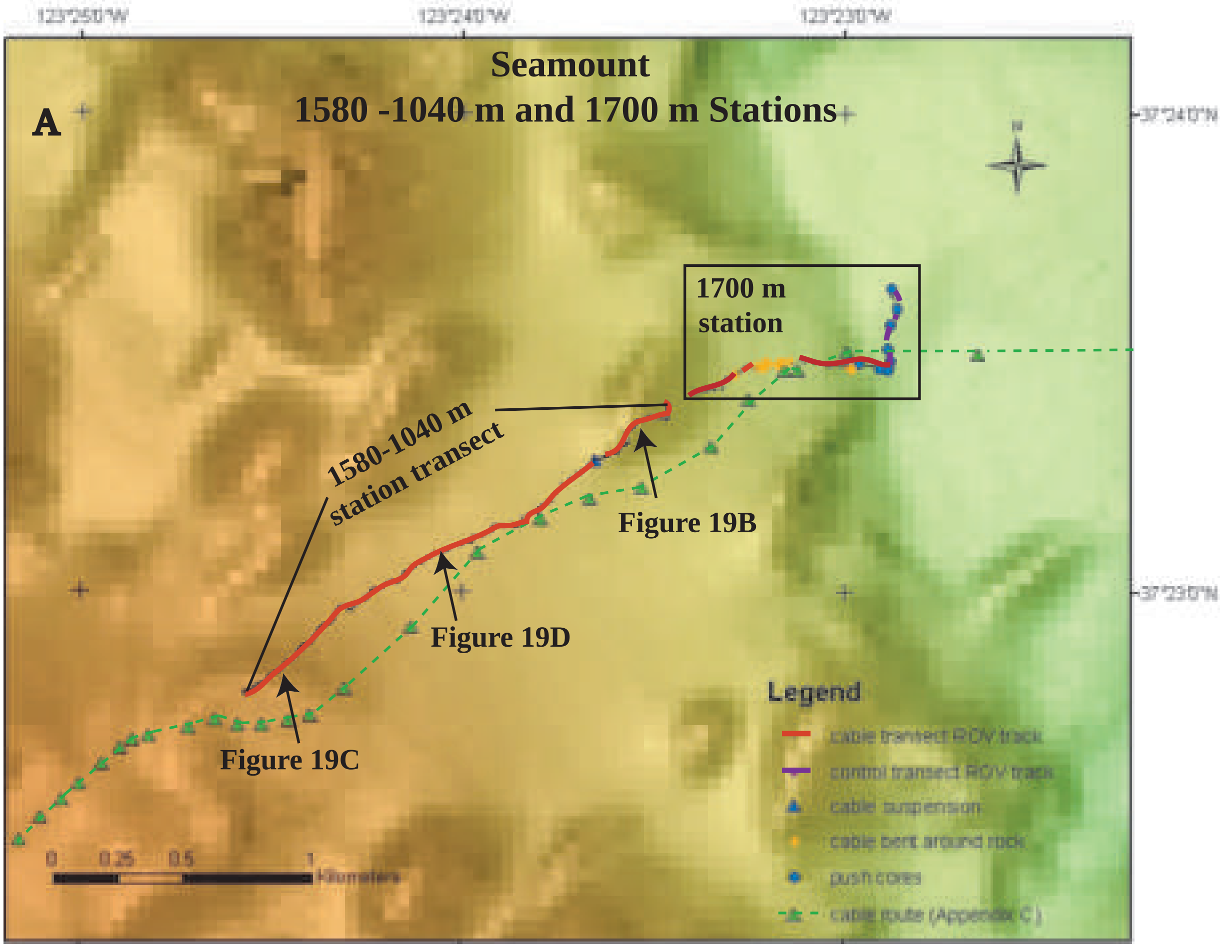
Comparisons of biological and physical parameters between cable and control sites shows a statistically lower abundance and number of isopod (crustacean) taxa near the cable (Appendix F). Percent cover analysis indicated that unconsolidated sediment covered a greater area in the cable transect (Table 1 and Appendix G). No statistical difference was observed between the cable and control sites with regard to video analysis (Appendix D).

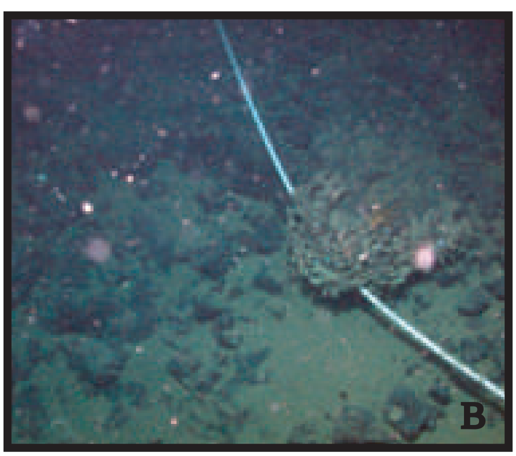
Seamount 1,700 m Station - Interpretation

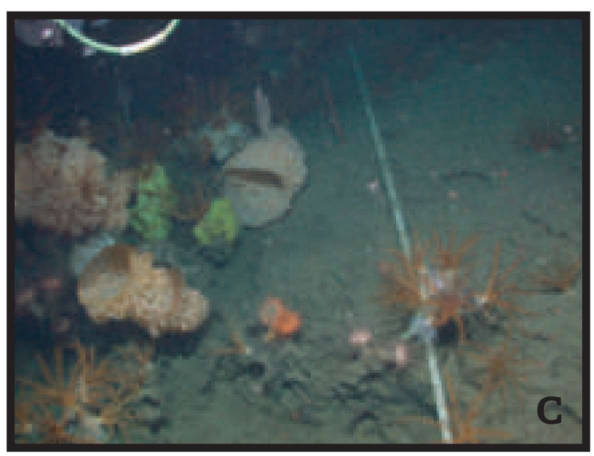
The reason for lower isopod abundance and number of taxa in sediments along the cable transect is uncertain and is probably due to patchiness.

Seamount 1,580 – 1,040 m Station (Video-only Cable Transect)

A 2,296 m long section of cable was viewed in water depths ranging from 1,580 to 1,040 m (Figure 19). The cable was up to 240 m northwest of its reported position. The cable's exterior was white in this transect and it was exposed on the seafloor along the transect length (Figure 19). The cable-tracker detected a very weak signal that was too diffuse to serve as a useful aid for following the cable. Because the cable was exposed on the seafloor, it was easily located. The







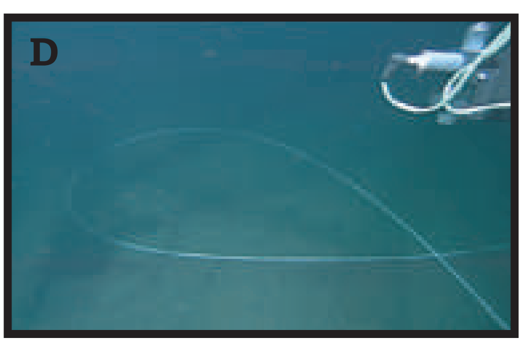


Figure 19 A: Map showing the reported cable path, ROV navigation, locations of photographs, location of features of interest, and location of push cores overlain on shaded bathymetry image of the seafloor at the 1580 - 1040 m and 1700 m stations on Pioneer Seamount. Note warm colors signify shallower water depths. **B:** Photograph showing the cable bent underneath a porifera attached to a rock. Note shadows below cable indicating a suspension. **C:** Photograph showing the cable near Seamount megafauna consisting of *F. serratissima* and various porifera. **D:** Photograph showing a loop in the cable. The cable is 3.2 cm wide and can be used as a scale in the photographs.

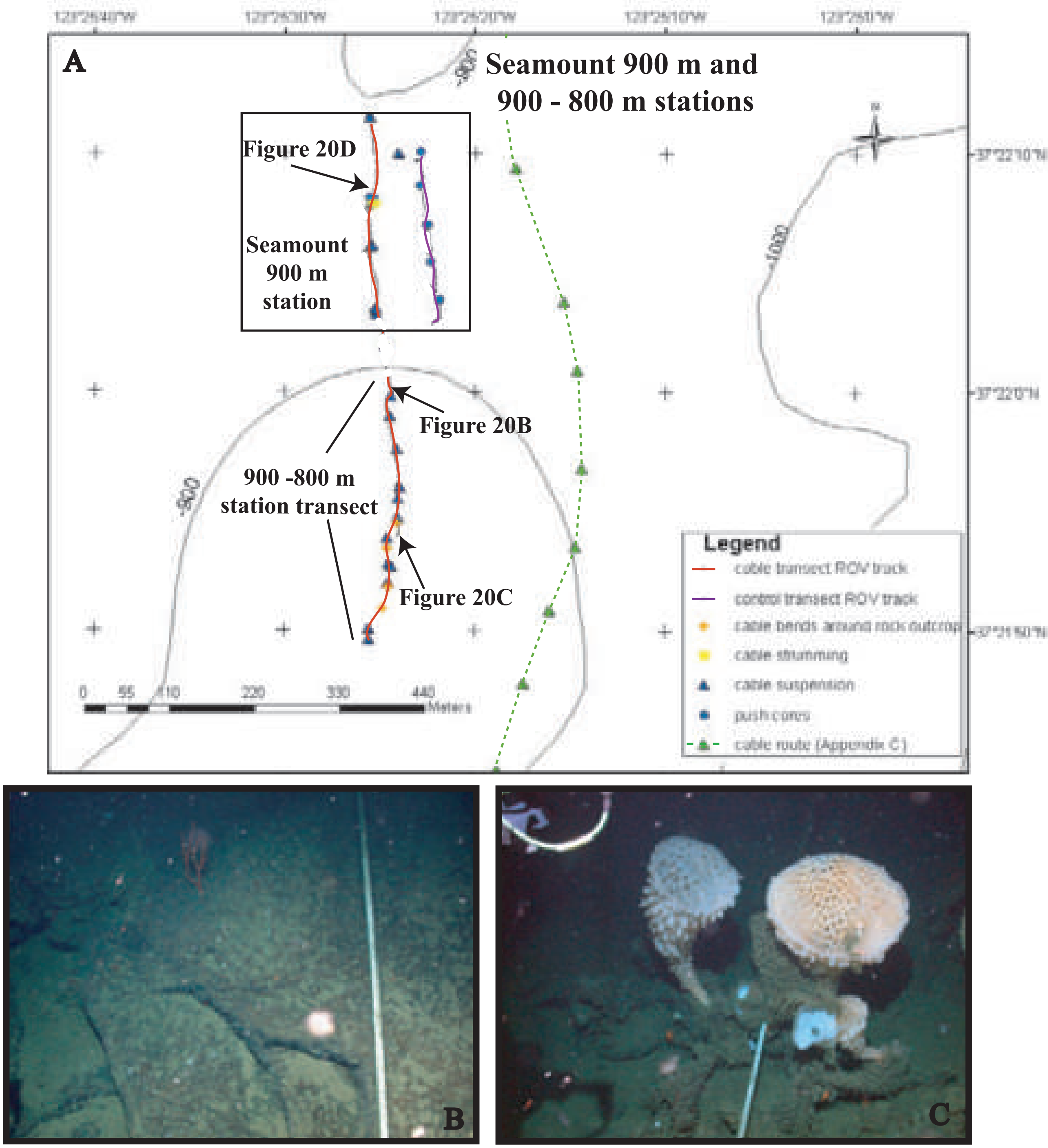
substrate consisted of volcanic (basalt and hyaloclastite) rock outcrops with intervening areas of heavily burrowed sediment cover. The cable path was highly sinuous and numerous suspensions were seen ranging from a few cm to greater than 2 m off the seabed. The cable conformed to irregular contours and no cable suspensions were seen where slack cable was present. One loop where the cable crossed itself was observed (Figure 19). Bends in the cable around rock outcrops were also seen (Figure 19). A few instances of porifera bent under the cable were documented. Unlike the 20 m station where rock outcrops were also abundant, frayed cable material and cable incisions into the rock were not observed.

Quantification of the fauna resulted in a total of 5,097 organisms representing eight taxonomic groups (Table 1 and Appendix D). Echinoderms were the most abundant taxonomic group comprising 66% of observed megafauna. The most abundant organism was *Florometra serratissima* (crinoids) with one order of magnitude more individuals than the second most abundant organism type, porifera. *F. serratissima* living directly on the cable constituted nearly all instances of organisms seen on top of the cable and 20% of annotations at this site. The six other taxonomic groups were present in relatively small numbers.

Seamount 900 m Station
A 420 m long section of cable was viewed along the Pioneer Seamount / ATOC cable route near the top of Pioneer Seamount in 800 to 930 m water depth (Figure 20). The cable-tracker did not detect a signal from the cable at this station, even when the ROV was sitting on top of the cable. The cable's exterior was white in this transect and it was entirely exposed on the seafloor. ROV navigation data shows that the cable is 200 m to the west of the reported location (Figure 20). The substrate consisted of rock outcrops on the crest of Pioneer Seamount and rock outcrops with areas of sediment cover in the saddle between peaks.

Video analysis, percent cover analysis, and infaunal analysis were performed from the northern 180 m long section of cable from 930 to 900 m water depths (Figure 20). Statistical comparison was performed only on data from the bathymetric saddle in order to compare data from similar substrate types. A total of 10 push cores were collected for infaunal analysis: 5 along the cable and 5 along a control transect 80 m to the east of the cable. A 16 cm wide furrow underneath and adjacent to the cable (Figure 20), suggests that cable strumming has affected the bottom. Numerous suspensions less than 10 cm tall and up to 25 m long were observed in sediment-covered areas. Cable suspensions were tallest (up to approximately 50 cm above seafloor) in areas of irregular bathymetry at the seamount crest. The cable was bent around some rock outcrops. No abrasion of rock underneath the cable or frayed cable was observed.

Organisms that are members of five of the counted taxonomic groups were observed on the cable, control, and seamount crest sites. Cnidaria was the most abundant taxonomic group on all three transects due to the presence of *Anthomastus ritteri* (mushroom coral). Porifera and echinoderms were also present in significant quantities. The other taxonomic groups were represented in relatively smaller numbers. Comparisons of biological and physical parameters between cable and control sites in the sediment-covered saddle shows a statistically lower area covered by unconsolidated sediment in the cable transect relative to the control (Table 1 and Appendix G). No statistical difference was observed between the cable and control sites with regard to video analysis (Appendix E).



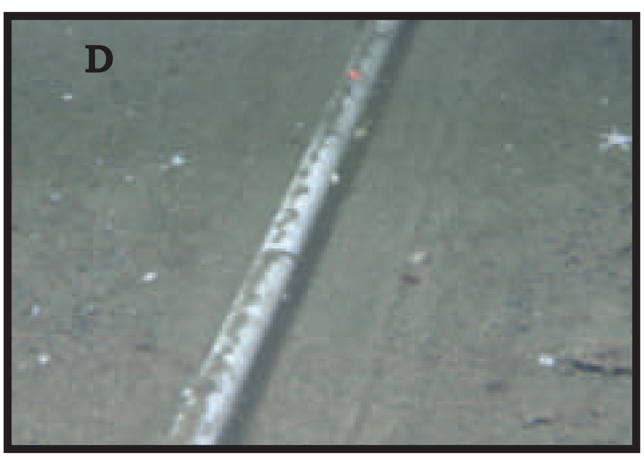


Figure 20 A: Map showing the reported cable path, ROV navigation, locations of photographs, location of features of interest, location of push cores, and bathymetry at the Seamount 900 m and 900 - 800 m stations. **B:** Photograph showing the cable on rock substrate. Note that cable and rock do not appear damaged. **C:** Photograph showing the cable lying among porifera. **D:** Photograph showing evidence of cable strumming on sediment substrate. The cable is 3.2 cm wide and can be used as a scale.

Seamount 900 m Station - Interpretation
Observations at the three seamount sites indicate that suspensions occur in areas of irregular, rocky topography. However, there is no evidence that this noticeably damages the cable or the rocks.

Summary and Conclusions

A total of 42 hours of video and 138 push cores were collected from 13 stations using the *ROVs Ventana* and *Tiburon* equipped with cable-tracking tools. A cumulative distance of 15.1 km of seafloor was surveyed along 13 cable and nine control transects. Thirteen percent (12.1 km) of the cable route was observed.

Video observations indicated the nature of interaction between the cable and seafloor. Most of the cable has become buried with time in sediment substrates on the continental shelf (water depths <120 m) whereas much of the cable remains exposed on the seafloor at deeper depths. Burial depth on the continental shelf ranged from 0 to 27 cm and averaged approximately 10 cm. Burial depth may fluctuate due to shifting substrate and buried cable may become exposed during storms. The cable is exposed in rocky environments of the nearshore region and on all of Pioneer Seamount.

The cable's condition was assessed where it was exposed on the seafloor. Video images from the rocky nearshore areas, where wave energies are greatest, show the clearest evidence that the cable has been damaged. Here, evidence of abrasion included frayed and unraveled portions of the cable's armor. In many places the cable occupies vertical grooves in the rock that were apparently cut by the cable. Incisions ranged from 6.6 cm (diameter of double armored cable) to 45 cm wide. The greatest incision and armor damage occurred on ledges between spans in rocky areas with irregular bathymetry. Snagged kelp was seen intertwined with frayed cable in the near shore areas.

The most notable suspensions were in rocky areas with irregular bathymetry. Such rocky areas occur at both ends of the cable. Suspensions up to 40 m long and greater than 1 m high were seen in the nearshore rocky area and up to 25 m long and 2 m high were seen on Pioneer Seamount. Unlike the nearshore rocky region, neither the rocks nor the cable appeared damaged along outcrops on Pioneer Seamount. Short (~10 cm) suspensions were also common bridging low spots associated with irregular topography in sediment substrate areas. Multiple loops of slack cable, added during a 1997 cable repair operation, were found lying flat on the seafloor at 950 m water depths. Several sharp kinks in the cable were seen at 240 m water depths in an area subjected to intense trawling activity (NRC 2002). Cable crossings were seen in 13 m water depth at 37° 29' 50" N, 122° 33' 04" W and in 344 m water depth at 37° 29' 54" N, 122° 30' 30" W.

The main observed biological differences between cable and control areas were the number of organisms attached or adjacent to the cable. Anemones colonized the cable and were more abundant in cable transects at most soft sediment sites. Where the cable was buried, the presence of linear rows of anemones proved to be a reliable indicator of the cable's position. Coarse extrapolation of transect data suggests over 50,000 anemones may live in the modified habitat created by the cable. Echinoderms and sponges were also seen living on the cable. At three of nine stations, flatfish and rockfish congregated near the cable. The cable has had no apparent effect on infaunal abundance. Other differences between cable and control sites were probably due to patchiness of animals. Considerable care was taken to count megafauna in video transects and macrofauna from the top 5 cm of push cores. Few differences were found between cable and control sites at the 95% confidence level. The cable may also subtly affect local hydrodynamic conditions that concentrate shell hash and drift kelp near the cable.

Long-term impacts of leaving the cable on the seafloor are likely continued abrasion of nearshore rock outcrops by the cable, the potential for additional organisms (e.g. Actiniarians (sea anemones)) to colonize the cable, potential impacts of cable-repair operations, and that the cable is a potential snag for fishing gear (Appendix A).

The potential effects of removing the cable include organism mortality and disturbance, rock breakage, beach impacts, and elimination of an obstacle to trawling. Coarse extrapolation of megafauna data suggests approximately 500,000 organisms may live on or near the cable. Cable removal would kill organisms living directly on the cable and would disturb or kill some organisms in the vicinity. Turbidity introduced by the cable removal process could also be disruptive and potentially fatal to non-mobile, filter feeding organisms. Rock breakage is likely in the nearshore region and on Pioneer Seamount where the cable bends around outcrops or is incised in narrow grooves. Extracting the buried cable from the shoreface would potentially destabilize the affected area. Cable removal would eliminate an obstacle to trawling and may increase trawling activity in the area.

A discussion regarding a cable exposed on the beach near the reported position of the ATOC/Pioneer Seamount cable is in Appendix H. The costs associated with this survey are included in Appendix I.

References Cited

ARPA & NMFS. (1995). Final Environmental Impact Statement/Environmental Impact Report for the California Acoustic Thermometry of Ocean Climate Project and its associated Marine Mammal Research Program (Scientific Research Permit Application [P557B]: Advanced Research Projects Agency, Arlington, VA and National Marine Fisheries Service, Silver Spring, MD

California Coastal Commission, 2002, California Coastal Commission Project Conditions on Tyco Fiber optic Cable Project, Final Adopted Commission Findings, Appendix C-1, (CDP# E-01-029), 73 p.

California Department of Fish and Game, 2003, Notice to California Fishermen and Processors: September 1, 2003. (*http://www.dfg.ca.gov/mrd/notice_trawl.pdf*)

Coyer, J., D. Steller and J.D. Witman 1999. The underwater catalog: a guide to methods in underwater research, 2nd Edition. 151 pp. Shoals Marine Laboratory Press. Ithaca, NY

Edwards, B.D., 2002, Variations in Sediment Texture on the Northern Monterey Bay National Marine Sanctuary Continental Shelf: Marine Geology, v. 181, n. 1-3, p. 83-100.

Fautin, D., Hand C., 2000, *Metridium farcimen*, the valid name of a common North Pacific sea anemone(Cnidaria:Actiniaria: Acontiaria): Proceedings of the Biological Society of Washington, v. 114, n. 4, p.1151-1161.

________, Bucklin, A., Hand, C., 1989, Systematics of sea anemones belonging to the genus Metridium (Coelenterata: Actinaria), with a description of M. giganteum new species: Wasman Journal of Biology, v. 47, n.1-2, p. 77-85.

Featherstone, J., Cronin, A., Kordahi, M., and Shapiro, S., 2001, Recent Trends in submarine Cable System Faults: SubOptic 2001 International Convention, May 20-24, 2001, Kyoto, Japan. *URL: http://www.scig.net/section10.html*

Foster, M.S., Harold, C., Hardin, D., 1991, Point vs. photo quadrat estimates of the cover of sessile marine organisms: Journal of Experimental Marine Biology and Ecology, v. 146, n. 2, p. 193-203.

Heezen, B.C., 1957, Whales Entangled in Deep sea Cables: Deep-Sea Research, v. 4, p. 105-115.

Howe, B. M., 1996, Acoustic Thermometry of Ocean Climate (ATOC): Pioneer Seamount Source Installation: University of Washington Applied Physics Laboratory Technical Memorandum 3-96, 67 p.

Mercer, J.A., 1999, Technical Specification for the Recovery of the ATOC Acoustic source and Undersea Cable: University of Washington Applied Physics Laboratory, 27 p.

National Research Council, 2002, Effects of Trawling and Dredging on Seafloor Habitat, 126 p.

Seafloor Surveys International, 1993, Cable Route Selection Survey for the Acoustic Thermometry of Ocean Climate (ATOC) California Site. Final report.

Smith, S.O., and J. Hunter, 2003, Monterey Bay National Marine Sanctuary Submerged Cultural Resources Study: 2001, Database and Final Report, 98 p.

University of Washington, 1995, Technical Specification for Installation of an ATOC Acoustic Source on Pioneer Seamount and Cable to Shore, 14 p.

Worcester, Peter, 2000, UCSD letter to Settlement Agreement Signatories Regarding ATOC Pioneer Seamount Sound Source: 1995 Settlement Agreement, November 20.

Zar, J.H., 1984, Biostatistical Analysis, 2nd Ed., Prentice Hall, Engelwood Hills, New Jersey, USA.

Appendix A: Special Permit Condition #4

The report is a product of cooperative effort between NOAA-OAR, NOAA-NOS, and MBARI. The collaboration resulted from the needs of NOAA to have information from such surveys and MBARI's interest in studying and documenting the impact of submarine cables. Because we are familiar with the cable, we have provided our opinions as to the regulatory questions that need to be addressed by NOAA-OAR in regard to Special Permit Condition #4. However, we have no official capacity to address these questions.

(a) A discussion of this topic is in the summary/conclusions section of this report.

(b) The only entanglement encountered in this study was kelp entangled with the cable in the nearshore region at the 20 m and 43 m stations. Side-scan sonar data collected on the continental shelf portion of the cable route from water depths less than 80 m also did not image any other entanglements. No entanglements with marine mammals or fishing gear were observed.

(c) No historical or cultural resources were encountered during this study. Shipwreck data from Smith and Hunter, 2003 indicate that there are approximately 46 shipwrecks in vicinity of the Pioneer ATOC/Seamount cable path. However, the locations of most of the shipwrecks are not well known. Twelve of these shipwrecks are believed to be within 8 km (5 miles) of the Pioneer ATOC/Seamount cable path. The closest documented shipwreck, the *Rydall Hall*, is within 300 m of the cable near Pillar Point. The *Rydall Hall* sank in the late 1800s and has been salvaged by sport divers. Probably little remains of this particular vessel and cable related operations are thus unlikely to affect it. Remaining entries were chosen based on landmark data (e.g. Half Moon Bay, Pillar Point, Montera Point). The shipwreck data are not public domain and are therefore not itemized in this report. For more information, contact Erica Burton (Research Specialist), Monterey Bay National Marine Sanctuary.

A world-class surfing site called Mavericks is located within 1 km to the south of the cable path near Pillar Point (Figure 7). Mavericks represents a cultural resource. Surfing contests are held at this site. Surfers typically tether their surfboards to their ankles. A surfer diving towards the seafloor to avoid breaking waves could get entangled in a suspended cable. However, the cable is sufficiently far from the actual surf site that neither the cable's presence nor any cable-related operations are likely to impact surfers. The substrate in this area is rocky with numerous ledges where the cable is suspended (Figure 9). If any cable re-routing is considered in the future, the presence of the Mavericks should be considered.

URL addresses to a January 29, 1998 San Francisco Chronicle article about the Mavericks and video from Mavericks surfing competitions are provided below:
http://www.sfgate.com/cgi-bin/article.cgi?file=/chronicle/archive/1998/01/29/SP40165.DTL
http://www.mavsurfer.com/mavsurfer_00/video_gallery.html

(d) The permit requests a discussion of "… potential long-term impacts of leaving the cable on the seafloor for the duration of the project…" Given that the current permit expires three months from the writing of this report, we will consider long-term impacts on the scale of years.

Long-term impacts of leaving the cable on the seafloor are: (1) likely continued abrasion of nearshore rock outcrops by the cable, (2) the potential for additional organisms (e.g. Actiniarians (sea anemones)) to colonize the cable, (3) potential impacts of cable-repair operations, and (4) that the cable is a potential snag for fishing gear.

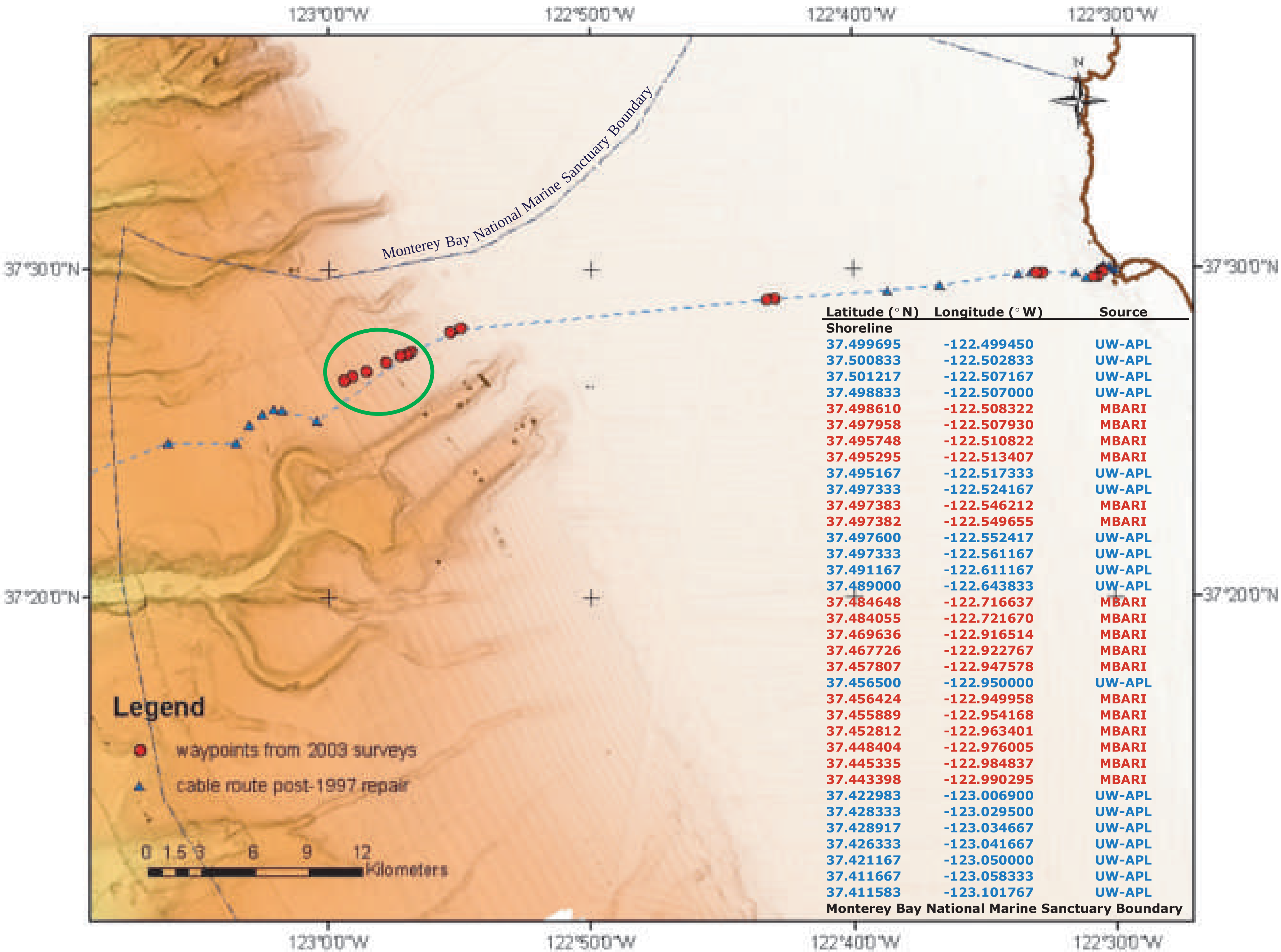
(1) Rock outcrops in the nearshore region appear to have been abraded by the cable and some further rock abrasion is likely. As the cable becomes more embedded into the rocks, it also becomes less prominent on the surface and may not be as affected by the waves. Therefore, the rate of incision may decrease with time. However, as seen in Figure 10, the cable can shift position and cut new grooves.

(2) Organisms such as Actiniarians (anemones) were observed to colonize the cable throughout most sites surveyed. Continued burial of the cable in areas of active sediment deposition such as the continental shelf, may result in reduced surface area available for new colonization. Areas with low sediment deposition rates or where net erosion is occurring are likely to experience additional colonization.

(3) The ATOC/Pioneer Seamount cable is currently faulted and would need to be repaired to be functional. Potential environmental impacts of repair operations are benthic disturbance due to grappling, destruction of organisms living on or near affected cable segments, the introduction of loops and slack cable in which marine mammals may become entangled, and other potential impacts of shipboard operations (Heezen 1957).

(4) The cable is a potential entanglement hazard for fishing gear and fishing is the main cause of submarine cable faults worldwide (Featherstone et al. 2001). Trawling is thought to have caused the 1997 ATOC cable break (Jim Mercer, personal communication). Currently trawling offshore Half Moon Bay is prohibited in water depths between 110 and 366 m (60-200 fathoms) but is allowed in other parts of the shelf and slope (California Department of Fish and Game 2003). Most trawling on the US Pacific Coast occurs between 15 and 1000 m water depth (NRC 2002). If the current cable fault is repaired, a potential remains for further breaks because the cable is either exposed or not deeply buried and may be caught by trawling gear.

(e) See Figure 21



Latitude (° N)	Longitude (° W)	Source
Shoreline		
37.499695	-122.499450	UW-APL
37.500833	-122.502833	UW-APL
37.501217	-122.507167	UW-APL
37.498833	-122.507000	UW-APL
37.498610	-122.508322	MBARI
37.497958	-122.507930	MBARI
37.495748	-122.510822	MBARI
37.495295	-122.513407	MBARI
37.495167	-122.517333	UW-APL
37.497333	-122.524167	UW-APL
37.497383	-122.546212	MBARI
37.497382	-122.549655	MBARI
37.497600	-122.552417	UW-APL
37.497333	-122.561167	UW-APL
37.491167	-122.611167	UW-APL
37.489000	-122.643833	UW-APL
37.484648	-122.716637	MBARI
37.484055	-122.721670	MBARI
37.469636	-122.916514	MBARI
37.467726	-122.922767	MBARI
37.457807	-122.947578	MBARI
37.456500	-122.950000	UW-APL
37.456424	-122.949958	MBARI
37.455889	-122.954168	MBARI
37.452812	-122.963401	MBARI
37.448404	-122.976005	MBARI
37.445335	-122.984837	MBARI
37.443398	-122.990295	MBARI
37.422983	-123.006900	UW-APL
37.428333	-123.029500	UW-APL
37.428917	-123.034667	UW-APL
37.426333	-123.041667	UW-APL
37.421167	-123.050000	UW-APL
37.411667	-123.058333	UW-APL
37.411583	-123.101767	UW-APL
Monterey Bay National Marine Sanctuary Boundary		

Figure 21: Map showing cable path waypoints as determined during the MBARI 2003 surveys, cable path waypoints post-1997 cable repair (Appendix C), and MBNMS boundary line superimposed on bathymetric image of the area. The 2003/1997 coordinates are generally similar with the exception of cable segment within the green circle. Maximum discrepancy was 975 m. A table of geographic coordinates updated with the MBARI 2003 data is included.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Silver Spring, Maryland 20910

PERMIT
MBNMS-2001-031

TO CONDUCT RESEARCH WITHIN THE MONTEREY BAY NATIONAL MARINE SANCTUARY

This permit is issued in accordance with the National Marine Sanctuaries Act (NMSA), 16 USC 1431 et seq., and regulations thereunder (15 CFR Part 922). All activities shall be conducted in accordance with those regulations and law. No activity listed in 15 CFR § 922. 132(a)(2) through (8) and (10) is allowed except the alteration of, or construction or placement on, the seabed, as specified below.

Subject to the terms and conditions of this permit, David L. Evans, acting as agent for the National Oceanic and Atmospheric Administration (NOAA) Office of Ocean and Atmospheric Research, is hereby granted permission to use, maintain, repair, and, if directed by the Director of NOAA's National Marine Sanctuary Program (hereafter, the Director), remove a previously installed submarine cable for passive acoustic monitoring within the Monterey Bay National Marine Sanctuary (MBNMS). All activities are to be conducted in accordance with the permit application dated June 22, 2001, unless otherwise indicated herein. This document is incorporated by reference into this permit and made a part hereof; provided, however, that if there are any conflicts between the permit application and the terms and conditions of this permit, the terms and conditions of this permit shall be controlling.

In addition to the above terms and conditions, the following terms and conditions apply to this permit:

Special Conditions

1. This permit is effective as of December 1, 2001 and expires on December 31, 2003.

2. The permittee is authorized to use, maintain, repair, and, if directed by the Director, remove as indicated herein that portion of the submarine cable within the boundaries of MBNMS previously installed pursuant to permit number MBNMS-12-95 issued to Dr. Peter Worcester of the Scripps Institute of Oceanography (hereafter known as "the cable") for a passive acoustic monitoring program. No further disturbance of cultural or natural resources of the Sanctuary is allowed.

3. The cable shall not be used to produce acoustic signals of any kind.

4. Prior to the expiration date of this permit, the permittee, in cooperation with the Director, shall arrange and conduct a survey of the cable to determine the extent and location of cable burial and non-burial beneath the seafloor sediment along the cable route (i.e., lying exposed on the seafloor or suspended above the seafloor). If it is determined by the Director that surveying the entire length of cable within the MBNMS is not practicable, the survey shall be a stratified random sample based upon the types of sediment through which the cable runs. Within 60 days of the completion of this survey, the permittee shall submit a report to the Director that includes, at a minimum, all of the following:
   a. An evaluation, based on the survey data, approximating the relative amounts and locations of buried and exposed cable along the route. If possible, this approximation shall include any possible correlations between sediment type and cable exposure or burial.
   b. A detailed description of any entangled fishing gear or other objects observed during the survey. This shall include a description of the entangled object, the precise location of the entanglement, and a description of any living organisms affected by the entanglement.
   c. A detailed description of any historical or cultural resources observed along the cable route. This shall include the location of the historical or cultural resource observed, the distance of the resource to the cable, and an assessment as to whether or not any cable movement or repair operation would adversely affect that resource.
   d. An evaluation describing the potential long-term impacts of leaving the cable on the seafloor for the duration of the project given the results of the survey. In addition to the data obtained from the survey, this evaluation shall use data (both published and unpublished) from other surveys of submarine cables that may assist in determining the nature of the impacts of submarine cables on MBNMS resources.
   e. A map of the route of the cable through the MBNMS. The map should use precise coordinates obtained from the survey and, if necessary, coordinates from the post-lay report submitted by Scripps (Howe, 1995) in compliance with permit number MBNMS-12-95.

5. Within 30 days of submitting the report required pursuant to special condition 4, the permittee shall provide the map required pursuant to special condition 4.e. to the US Coast Guard, the California Coastal Commission (hereafter, the Commission), and the Coast Survey. The permittee shall request that the US Coast Guard incorporate this map into a Notice to Mariners to provide members of the public with the location of the cable.

6. Within 90 days of receipt of the report required pursuant to special condition 4, the Director will decide if the long-term presence of the cable on the seafloor of MBNMS is appropriate. The Director will base his decision in part on the report submitted pursuant to special condition 4 and also on other appropriate factors such as MBNMS regulations, the NMSA, and input from experts in the field of submarine cables both within and outside of the NMSP.
   a. If the Director finds the cable is having impacts that are greater than short-term and negligible, he will either-
      i. require the permittee to take remedial action to reduce the impacts the cable is having on MBNMS resources and qualities at or below the short-term and negligible cap, or

ii. require the permittee to remove the cable from the MBNMS pursuant to a removal plan developed by the Director in consultation with the permittee and the Commission.

b. If the Director finds the cable is having impacts that are equal to or less than short-term and negligible, he will amend this permit to-
   i. allow the cable to remain in place for the life of the project, and
   ii. insert cable monitoring and cable removal protocols in consultation with the permittee and the Commission that are consistent with Program policy and regulations.

7. At least 90 days prior to the expiration date of this permit or at such time the cable is no longer in use, whichever comes first, the NMSP Director will, in consultation with the Commission, decide whether or not to require that the cable be removed from the MBNMS. The decision will be based in part on the report submitted pursuant to special condition 4.
   a. Should the Director require removal, the permittee, in consultation with the Director and the Commission, shall devise a cable removal plan that will dictate the appropriate methodology and schedule for removing the cable in such a manner so as to minimize impacts to MBNMS resources and qualities. The plan is subject to the Director's approval. The permittee is responsible for the actual cable removal should removal be deemed appropriate by the Director.
   b. Should the Director allow the permittee to leave the cable in place following the end of its useful life, this permit would have to be renewed in perpetuity. In this case, the Director may, subject to additional terms and conditions as he deems necessary, amend this permit to extend the expiration date 5 years and to automatically renew every five years thereafter.

8. In the event repair of the cable becomes necessary, the following additional conditions shall apply to such repair:
   a. The permittee shall notify the individuals listed in General Condition # 3 in writing immediately upon discovering that a repair operation is necessary. At this time the Director, in consultation with the permittee, will decide if burial of the repaired portions will be required.
   b. The permittee shall allow an NMSP observer to be on board the repair vessel.
   c. Prior to the commencement of any repair activity the permittee shall broadcast information about the repair on maritime radio channels to notify vessels.
   d. If the repair activity is to be conducted in a shipping lane or any other potentially high marine traffic area, the US Coast Guard shall be informed in a timely manner and support vessels shall be deployed at a distance allowing a wide berth to the repair vessel.
   e. The permittee shall notify fishers, the Commission, the US Coast Guard, and the Coast Survey of the locations of post-repair cable locations (i.e. the coordinates of the spliced in section of cable) and request that the US Coast Guard publish a revised Notice to Mariners.
   f. During the repair operations, the repair vessel shall use all appropriate navigational and deck lights and communication in order to publicize its location.
   g. Within 4 weeks of the completion of the repair project, the permittee shall provide the Director with a report describing repair operations within the MBNMS. The report will include at a minimum a chronology of activities authorized herein including any

difficulties with the operation, the location of any exposed cable, the location and depth of any buried cable, the relocation of any cable as a result of the repair, the location and identity of any obstruction or unusual conditions or materials encountered (bottom and surface), information on the bottom types encountered, any vessel traffic incidents (either involving the repair vessel or other traffic) and any other information that may be of interest to the Director.

General Conditions

1. All persons participating in the permitted activity shall be under the supervision of NOAA- Office of Ocean and Atmospheric Research (the permittee) and the permittee shall be responsible for any violation of this permit, the NMSA, or the MBNMS regulations. The permittee shall ensure that all persons performing activities under this permit are fully aware of the conditions herein.

2. The NMSP Director reserves the right to place an observer aboard any ship engaged in operations conducted under this permit.

3. The permittee shall maintain a cruise log. The log shall contain a description of cruise activities and geographic locations. Within 30 days of the expiration of this permit, the permittee shall submit a 1-2 page summary of all activities conducted under this permit and copies of the cruise log to the persons listed below:

   William Douros
   Superintendent
   Monterey Bay National Marine Sanctuary
   299 Foam Street
   Monterey, CA 93940

   John Armor
   Permit Coordinator
   NOAA/NMSP (N/ORM6)
   1305 East-West Highway #11504
   Silver Spring, MD 20910

4. This permit is non-transferable and shall be carried by the permittee at all times while engaging in any activity authorized by this permit.

5. This permit may be suspended, revoked, or modified for violation of the terms and conditions of this permit, the regulations at 15 CFR Part 922, the NMSA, or for other good cause. Such action shall be communicated in writing to the applicant or permittee, and shall set forth the reason(s) for the action taken.

6. This permit may be suspended, revoked or modified if requirements from previous permits or authorizations issued to the permittee are not fulfilled by their due date. Permit or authorization applications for any future activities in the Sanctuary by the permittee may not be considered until all requirements from this permit are fulfilled.

7. If the permittee or any person acting under its supervision conducts, or causes to be conducted, any activity in the Sanctuary not in accordance with the terms and conditions set forth in this permit, or otherwise violates such terms and conditions, the permittee

shall be subject to civil penalties, forfeiture, costs, and all other remedies under the NMSA and the regulations at 15 CFR Part 922.

8. Any publications and/or reports resulting from these activities shall include the notation that the activity was conducted under National Marine Sanctuary Permit MBNMS-2001-031 and be sent to the individuals listed in General Condition #3.

9. This permit does not relieve the permittee of responsibility to comply with all other Federal, State and local laws and regulations, and this permit is not valid until all other necessary permits and/or authorizations are obtained.

10. This permit is not valid until the permittee submits a copy of the signed permit to the individuals listed in General Condition #3.

11. Any question of interpretation of any term or condition of this permit shall be resolved by NOAA's National Ocean Service.

This permit is effective as of the date it is signed by the Director of the National Marine Sanctuary Program.

David L. Evans — 12/7/01 (Date)
Assistant Administrator
Office of Ocean and Atmospheric Research

Daniel J. Basta — 12/7/01 (Date)
Director
National Marine Sanctuary Program

APPENDIX B – Reference List of Scholarly Endeavors attributed to presence of ATOC/Pioneer Seamount Cable

The benefits of the ATOC/Pioneer Seamount cable to the community include (1) new scientific data collected via the cable, (2) additional information regarding the marine environment, (3) involvement of students in scientific projects, and (4) public outreach and education.

Information in this appendix was provided by Susie Pike (UCSD-SIO regarding California ATOC related publications), Sharon Nieukirk and David Mellinger (Oregon State University and NOAA-Pacific Marine Environmental Laboratories), and Roger Bland (San Francisco State University).

San Francisco State University

Poster Presentations

Hoffman, Michael D., Newell Garfield, and Roger Bland, "Observation of Blue Whale Calls from Pioneer Seamount," paper to be presented at the First International Conference on Acoustic Communication by Animals, July 27-30, 2003, University of Maryland, College Park, Maryland

Vuosalo, Carl O., Craig Huber, Michael D. Hoffman, Newell Garfield, and Roger Bland, "Analysis of Acoustic Signals from Ship Traffic at Pioneer Seamount," Poster presented at the San Francisco meeting of the American Geophysical Union, December 8, 2002.

Hoffman, Michael D., Carl O. Vuosalo, Newell Garfield, and Roger Bland, "Blue-Whale Calls Detected at the Pioneer Seamount Underwater Observatory," Poster presented at the San Francisco meeting of the American Geophysical Union, December 8, 2002.

Bland, Roger W., Newell Garfield, and Joe M. Adolfo, "Analysis Of Sound Speed Measurements From Acoustic Sources Observed At Pioneer Seamount," poster presented at the Feb. 2002 Ocean Sciences Meeting, Honolulu, Hawaii.

Paper in Preparation

Hoffman, Michael D., Newell Garfield, and Roger Bland, "Blue-whale calls recorded at Pioneer Seamount," paper to be submitted to the Journal of the Acoustical Society of America

Popular articles

Bland, Roger, and Newell Garfield, "One Year on Pioneer Seamount," in Ecosystem Observations for the Monterey Bay National Marine Sanctuary, 2002, a publication of the NOAA Monterey Bay National Marine Sanctuary, 299 Foam Street, Monterey, Calif., 93940

White, Charlotte, "The other end of the line," article to be published in the SFSU College of Engineering and Science magazine @Science.

Talks

Bland, Roger W., "Acoustic Research at Pioneer Seamount," talk presented to the Monterey Bay National Marine Sanctuary Research Activities Panel, July 12, 2002.

Bland, Roger W., "First Results from Pioneer Seamount," presented in the SFSU Physics and Astronomy colloquium series, April 22, 2002.

Master's Thesis

Vuosalo, Carl O., "Analysis Of Underwater Ship Sounds Recorded At Pioneer Seamount," master's thesis, Physics and Astronomy Department, San Francisco State University, July 2003.

[Note: Mr. Vuosalo has been admitted to the PhD program in physics at the University of Wisconsin for Fall 2003.]

Student prizes and awards

Michael Hoffman, award of $1000 from the Cetacean Society, San Francisco Bay Chapter, for research on blue-whale calls at Pioneer Seamount

Related special-study projects by San Francisco State students

Carl Vuosalo, graduate physics major, Spring 2002: "Frequency analysis of acoustic time series using FFT."

Michael Hoffman, undergraduate physics major, Spring 2002: "Design of acoustic phased array for Pioneer Seamount."

Michael Hoffman, undergraduate physics major, Spring 2002: "Wavelet analysis and FFT; non-linear dynamics."

Carl Vuosalo, graduate physics major, Spring 2002: "Analysis of hearing of large marine mammals and frequency response."

Carl Vuosalo, graduate physics major, Spring 2002: "Java and Javascript programming; web page construction; interactive data display."

Craig Huber, undergraduate physics major, Fall 2002: "Study of sound propagation underwater."

Craig Huber, undergraduate physics major, Spring 2003: "Study of interference patterns seen in sound signals from marine traffic by underwater microphones."

Michael Hoffman, undergraduate physics major, Spring 2003: "Assessment of literature on Blue-whale calls in acoustic measurement."

Michael Hoffman, undergraduate physics major, Spring 2003: "Parameter estimation by non-linear least squares."

Oregon State University and
NOAA-Pacific Marine Environmental Laboratory

Presentations:

Haru Matsumoto, Sharon Nieukirk, Matt Fowler, Joe Haxel, Sara Heimlich, David K. Mellinger, Robert Dziak, and Christopher G. Fox. “Sound in the Sea: Hands-on Experience with the NOAA VENTS Program”. September 2003.

Mellinger, D.K. "Large-scale, Long-term Acoustic Surveys of Marine Mammals." Presentation to the College of Oceanic and Atmospheric Sciences, Oregon State University, 4 June 2002.

Mellinger, D.K. "New Technology for Marine Mammal Research and Monitoring." Presentation to the New Technologies technical committee of the Scientific Committee on Oceanic Research. Lima, Peru, 28 October 2002.

Mellinger, D.K. "Acoustic Surveys and Acoustic Detection Distance." Presentation to the Workshop on Acoustic Marine Mammal Assessment. La Jolla, CA, 20 November 2002.

"Mellinger, D.K. “Applications of Neptune: Large-scale, Long-term Acoustic Research on Marine Mammals." Presentation to the NEPTUNE Pacific Northwest Workshop. Portland, OR 23 April 2003

Internships:

Summer 2003 - Walter Hannah (Oregon State University/CIMRS intern) - computer science project "Application Development of a Digital Acquisition System for Cabled Hydrophone Arrays"

Summer 2002 - Erin Jackson (Oregon State University/CIMRS intern) - "Acoustic monitoring of four whale species at Pioneer Seamount"

Acoustic Thermometry of Ocean Climate
ATOC

Thermometry Peer Reviewed Publications

ATOC Consortium (A.B. Baggeroer, T. G. Birdsall, C. Clark, J.A. Colosi, B.D. Cornuelle, D. Costa, B.D. Dushaw, M. Dzieciuch, A.M.G. Forbes, C. Hill, B.M. Howe, J. Marshall, D. Menemenlis, J.A. Mercer, K. Metzger, W. Munk, R.C. Spindel, D. Stammer, P.F. Worcester and C. Wunsch). (1998). Ocean climate change: Comparison of acoustic tomography, satellite altimetry, and modeling. *Science, 281*, 1327-1332.

ATOC Consortium (A.B. Baggeroer, T. G. Birdsall, C. Clark, J.A. Colosi, B.D. Cornuelle, D. Costa, B.D. Dushaw, M. Dzieciuch, A.M.G. Forbes, C. Hill, B.M. Howe, J. Marshall, D. Menemenlis, J.A. Mercer, K. Metzger, W. Munk, R.C. Spindel, D. Stammer, P.F. Worcester and C. Wunsch). (1999). Reply to 'Heat content changes in the Pacific Ocean' by Kelly et al. *Science, 284*, 1735a.

Colosi, J. A. & The ATOC Group. (1999). A review of recent results on ocean acoustic wave propagation in random media: Basin scales. *IEEE Journal of Oceanic Engineering, 24*(2), 138-155.

Colosi, J. A. & Flatté, S. M. (1996). Mode coupling by internal waves for multimegameter acoustic propagation in the ocean. *Journal of the Acoustical Society of America, 100*(6), 3607-3620.

Dushaw, B. D. (1999). Inversion of multimegameter-range acoustic data for ocean temperature. *IEEE Journal of Oceanic Engineering, 24*(2), 215-223.

Dushaw, B. D., Bold, G., Chui, C.-S., Colosi, J., Cornuelle, B., Desaubies, Y., Dzieciuch, M., Forbes, A., Gaillard, F., Gould, J., Howe, B., Lawrence, M., Lynch, J., Menemenlis, D., Mercer, J., Mikhalevsky, P., Munk, W., Nakano, I., Schott, F., Send, U., Spindel, R., Terre, T., Worcester, P. & Wunsch, C. (2001). Observing the ocean in the 2000's: A strategy for the role of acoustic tomography in ocean climate observation. In C. J. Koblinsky and N. R. Smith (Eds.) *Observing the Oceans in the 21st Century*, 391-418. GODAE Project Office, Bureau of Meteorology: Melbourne

Dushaw, B. D., Howe, B. M., Mercer, J. A., Spindel, R. C. & The ATOC Group. (1999). Multimegameter-range acoustic data obtained by bottom-mounted hydrophone arrays for measurement of ocean temperature. *IEEE Journal of Oceanic Engineering, 24*(2), 202-214.

Dzieciuch, M., Worcester, P. & Munk, W. (2001). Turning point filters: Analysis of sound propagation on a gyre-scale. *Journal of the Acoustical Society of America, 110*(1), 135-149.

Grabb, M. L., Wang, S. Z. & Birdsall, T. G. (1996). Deterministic three-dimensional analysis of long-range sound propagation through internal-wave fields. *IEEE Journal of Oceanic Engineering, 21*(3), 260-272.

Heaney, K. D. & Kuperman, W. A. (1998). Very long-range source localization with a small vertical array. *Journal of the Acoustical Society of America, 104*(4), 2149-2159.

Kuperman, W. A., D'Spain, G. L. & Heaney, K. D. (2001). Long range source localization from single hydrophone spectrograms. *Journal of the Acoustical Society of America, 109*(5) Pt.1, 1935-1943.

Menemenlis, D. & Chechelnitsky, M. (2000). Error estimates for an ocean general circulation model from altimeter and acoustic tomography data. *Monthly Weather Review, 128*(3), 763-778.

Shang, E. C. & Wang, Y. Y. (1999). Subarctic frontal effects on long-range acoustic propagation in the North Pacific Ocean. *Journal of the Acoustical Society of America, 105*(3), 1592-1595.

Tindle, C. T. & Bold, G.E. (1999). ATOC and other acoustic thermometry observations in New Zealand. *Marine Technology Society Journal, 33*(1), 55-60.

Wage, K.E., Baggeroer, A.B. & Preisig, J.C. (2003). Modal analysis of broadband acoustic receptions at 3515-km range in the North Pacific using short-time Fourier techniques. *Journal of the Acoustical Society of America, 113 (2*), 801-817.

Thermometry Other Publications

ATOC Instrumentation Group: B.M. Howe, S. G. Anderson, A.B. Baggeroer, J.A. Colosi, K.R. Hardy, D. Horwitt, F.W. Karig, S. Leach, J.A. Mercer, K. Metzger, L.O. Olson, D.A. Peckham, D.A. Reddaway, R.R. Ryan, R.P. Stein, K. von der Heydt, J.D. Watson, S.L. Weslander & P.F. Worcester. (1995). Instrumentation for the Acoustic Thermometry of Ocean Climate (ATOC) prototype Pacific Ocean network. *OCEANS 95 MTS/IEEE Proceedings*, 1483-1500, San Diego, CA, October 9-12, 1995.

Colosi, J.A. (1997). Random media effects in basin-scale acoustic transmissions. *Proceedings Áha Hulikoá Hawaiian Winter Workshop*, 157-166, Honolulu, HI, January 14-17, 1997.

Colosi, J.A. (1999). Basin-scale internal wave tomography: Some first steps. *International Symposium Acoustic Tomography and Acoustic Thermometry Proceedings*, 39-48, Tokyo and Yokosuka, Japan, February 8-10, 1999.

Dushaw, B.D. & The ATOC Group. (1999). The Acoustic Thermometry of Ocean Climate (ATOC) Project: Towards depth-averaged temperature maps of the North Pacific Ocean. *International Symposium Acoustic Tomography and Acoustic Thermometry Proceedings*, 88-97, Tokyo and Yokosuka, Japan, February 8-10, 1999.

Forbes, A. (1994). Acoustic monitoring of global ocean climate. *Sea Technology, 5*, 65-67.

Howe, B. M. (1993). Acoustic Thermometry of Ocean Climate (ATOC): Selection of California source site (*Technical Memorandum APL-UW 30-93*): Applied Physics Laboratory - University of Washington.

Howe, B. M. (1996). Acoustic Thermometry of Ocean Climate (ATOC): Pioneer Seamount source installation (*Technical Memorandum APL-UW 3-96*): Applied Physics Laboratory - University of Washington.

Howe, B. M. & Mercer, J. A. (1997). Cabled sources and receivers for ATOC. *JAMSTEC International Workshop on Scientific Use of Submarine Cables*. Okinawa, Japan, February 25-28, 1997.

Howe, B. M., Leach, S. W., Mercer, J. A. & Odom, R. I. (1993). Designing the ATOC global array. *IEEE Oceans 93 Conference Proceedings,* I-258-I-262, Victoria, British Columbia, Canada, October 18-21, 1993.

Hyde, D. W. (1993). ATOC network definition. *IEEE Oceans 93 Conference Proceedings,* I-249-I-252, Victoria, British Columbia, Canada, October 18-21, 1993.

Menemenlis, D. (1999). Acoustic tomography and ocean data assimilation: Past results and future prospects. *International Symposium Acoustic Tomography and Acoustic Thermometry Proceedings*, 199-204, Tokyo and Yokosuka, Japan, February 8-10, 1999.

Menemenlis, D., Stammer, D., Wunsch C., Dushaw B.D. & The ATOC Group (A.B. Baggeroer, T.G. Birdsall, C. Clark, J.A. Colosi, B.D. Cornuelle, D. Costa, B.D. Dushaw, M. Dzieciuch, A.M.G. Forbes, B.M. Howe, D. Menemenlis, J.A. Mercer, K. Metzger, W.H. Munk, R.C. Spindel, P.F. Worcester and C. Wunsch). (1997). Preliminary estimates of North Pacific circulation from combined altimetry, acoustic tomography and a general circulation model. *International WOCE Newsletter, 25,* 7-10.

Munk, W. (2000). Listening to Ocean Climate. *Reimar Lüst Lecture*. Presented at the 25th anniversary colloquium of the Max-Planck-Institut für Meteorologie, Hamburg, Germany, March 31, 2000.

Staten, R. A., Chiu, C.-S. & Semtner, A. J. (1996). A simulation study of the variability of acoustic transmissions from Hawaii to Monterey. In D. Lee, Y.-H. Pao, M.H. Schultz and Y.-C. Teng (Eds.) *Theoretical and Computational Acoustics '95,* 505-525, Honolulu, Hawaii, August 21-25, 1995. World Scientific: Singapore.

Wage, K. E., Baggeroer, A. B. & Preisig, J. C. (2000). Modal analysis of broadband acoustic receptions at megameter ranges. *IEEE Sensor Array and Multichannel (SAM) Signal Processing Workshop Proceedings*, 102-106, Cambridge, Massachusetts, March 16-17, 2000.

Worcester, P. F., Dushaw, B.D. & The ATOC Group (A.B. Baggeroer, T.G. Birdsall, C. Clark, J.A. Colosi, B.D. Cornuelle, D. Costa, B.D. Dushaw, M. Dzieciuch, A.M.G. Forbes, B.M. Howe, D. Menemenlis, J.A. Mercer, K. Metzger, W. Munk, R.C. Spindel, P.F. Worcester and C. Wunsch). (2000). A comparison of acoustic thermometry, satellite altimetry, and other observations of ocean temperatures in the North Pacific Ocean. *PORSEC Proceedings*, Vol. I: 1-4, Goa, India, December 5-8, 2000.

MMRP Peer Reviewed Publications

Costa, D. P., Crocker, D. E., Gedamke, J., Webb, P. M., Houser, D. S., Blackwell, S. B., Waples, D., Hayes, S. A. & Le Boeuf, B. J. (2003). The effect of a low-frequency sound source (acoustic thermometry of the ocean climate) on the diving behavior of juvenile northern elephant seals, *Mirounga angustirostris*. *Journal of the Acoustical Society of America,* 113(2), 1155-1165.

Fletcher, S., Le Boeuf, B. J., Costa, D. P., Tyack, P. L. & Blackwell, S. B. (1996). Onboard acoustic recording from diving northern elephant seals. *Journal of the Acoustical Society of America, 100*(4), 2531-2539.

MMRP Other Publications

Costa, D. P., Crocker, D. E., Waples, D. M., Webb, P. M., Gedamke, J., Houser, D. S., Goley, P. D., Le Boeuf, B. J. & Calambokidis, J. (1997). The California Marine Mammal Research Program of the Acoustic Thermometry of Ocean Climate Experiment. In O.T. Magoon *et al. (*Eds.*) California and the World Ocean '97*, 1542-1553, San Diego, CA, March 24-27, 1997. American Society of Civil Engineers: Reston, Virginia.

Harvey, J. T. & Eguchi, T. (1997). Effects of ATOC sounds on the Harbor Seal, *Phoca Vitulina Richardsi*, in Monterey Bay (*Moss Landing Marine Laboratories Technical Publication No. 97-1):* Moss Landing, California.

Harvey, J. T., Raum-Suryan, K. L. & Suryan, R. M. (1996). Distribution and abundance of marine mammals near Sur Ridge, California, the former proposed site of the ATOC sound source (*Moss Landing Marine Laboratories Technical Publication No. 96-2*): Moss Landing, California.

Thermometry Unpublished Reports

Available from the Scripps Institution of Oceanography Library

APL-UW. (1995). *Technical Specification for Installation of an ATOC Acoustic Source on Pioneer Seamount and Cable to Shore*: Applied Physics Laboratory - University of Washington.

Bold, G., C.-S. Chiu, J. Colosi, B. Cornuelle, B. Dushaw, M. Dzieciuch, A. Forbes, F. Gaillard, J. Gould, B. Howe, M. Lawrence, J. Lynch, D. Menemenlis, J. Mercer, P. Mikhalevsky, W. Munk, I. Nakano, F. Schott, U. Send, R. Spindel, T. Terre, P. Worcester, C. Wunsch. (1999). Observing the ocean in the 2000's: A strategy for the role of acoustic tomography in ocean climate observation. *Proc. of the Intl. Conf. on the Ocean Observing System for Climate (OCEANOBS99)*, St. Raphael, France, October 18-22, 1999.

Dushaw, B. D. & The ATOC Group. (1999). A comparison of acoustic thermometry, XBT, TOPEX, and HOT observations of ocean temperature in the Northeast Pacific Ocean. *Proc. of the Intl. Conf. on the Ocean Observing System for Climate (OCEANOBS99)*, St. Raphael, France, October 18-22, 1999.

Howe, B. (1995). *Cruise Plan: ATOC Pioneer Seamount Source Deployment*: Applied Physics Laboratory - University of Washington.

Howe, B. (1995). *Summary Cruise Report: ATOC Pioneer Seamount Source Installation*: Applied Physics Laboratory - University of Washington.

Mercer, J. A. (1997). *ATOC Cruise Plan: Pioneer Seamount Source Cable Repair*: Applied Physics Laboratory - University of Washington.

Mercer, J.A. (1999). *Acoustic Thermometry of Ocean Climate Cruise Plan: Recovery of the Pioneer Seamount Source.* Applied Physics Laboratory - University of Washington.

Mercer, J.A. (1999). *Technical Specification for the Recovery of the ATOC Acoustic Source and Undersea Cable.* Applied Physics Laboratory - University of Washington.

Mercer, J., Dushaw, B., Howe, B. & Spindel, R. (1999). Acoustic ocean monitoring in the NE Pacific at megameter ranges (SECRET). *Navy Symposium on Underwater Acoustics Conference Proceedings*, San Diego, CA, February, 22-26, 1999.

SAIC. (1995). *Cultural Resources Baseline Study and Sensitivity Assessment for the ATOC Onshore/Submarine Cable Route Pt. Sur, California*.

Seafloor Surveys Intl., Inc. (1993). Final Report: Cable Route Selection Survey for the Acoustic Thermometry of Ocean Climate (ATOC) California Site.

Marine Mammal Research Program Unpublished Reports
Available from the Scripps Institution of Oceanography Library

ARPA & NMFS. (1994). *Draft Environmental Impact Statement/Environmental Impact Report for the California Acoustic Thermometry of Ocean Climate Project and its associated Marine Mammal Research Program*: Advanced Research Projects Agency, Arlington, VA and National Marine Fisheries Service, Silver Spring, MD.

ARPA & NMFS. (1995). *Final Environmental Impact Statement/Environmental Impact Report for the California Acoustic Thermometry of Ocean Climate Project and its associated Marine Mammal Research Program (Scientific Research Permit Application [P557B]*: Advanced Research Projects Agency, Arlington, VA and National Marine Fisheries Service, Silver Spring, MD

ATOC/MMRP. (1996). *ATOC/MMRP "Quick Look" Report for the period December 1995 - June 1996 (California MMRP).*

ATOC/MMRP. (1996 - 1998). *MMRP/ATOC Bi-Monthly Reports #1 - 17.*

Calambokidis, J. (1996). *Preliminary (Quick-Look) Analysis of Aerial Survey Data, Surveys Conducted Through March 1996.*

APPENDIX C - ATOC/Pioneer Seamount Cable Route Waypoints Post-1997 Repair
(data from Bruce Howe, UW-APL)

	Latitude	Longitude
	Pioneer Seamount	
1	37.344222	-123.444806
2	37.344896	-123.444320
3	37.345723	-123.443738
4	37.346203	-123.442513
5	37.346475	-123.441080
6	37.346848	-123.438898
7	37.347468	-123.437156
8	37.348174	-123.435965
9	37.349091	-123.435561
10	37.349981	-123.435474
11	37.350754	-123.435246
12	37.351651	-123.434921
13	37.352129	-123.434235
14	37.352212	-123.433239
15	37.352161	-123.432220
16	37.352383	-123.430786
17	37.352604	-123.429749
18	37.353825	-123.428406
19	37.354382	-123.427689
20	37.355045	-123.426773
21	37.355602	-123.425842
22	37.356270	-123.424805
23	37.356823	-123.424301
24	37.357376	-123.423782
25	37.358486	-123.423065
26	37.359563	-123.422954
27	37.360321	-123.422408
28	37.361296	-123.421959
29	37.362248	-123.421866
30	37.363272	-123.421491
31	37.364125	-123.421116
32	37.364853	-123.420728
33	37.365768	-123.420649
34	37.366912	-123.420708
35	37.367718	-123.420902
36	37.369272	-123.421622
37	37.370267	-123.421832
38	37.371127	-123.421902
39	37.371975	-123.421733
40	37.372854	-123.421114
41	37.373692	-123.420381
42	37.374642	-123.419209
43	37.375423	-123.418283
44	37.376044	-123.417406
45	37.376593	-123.416644
46	37.377288	-123.415635

	Latitude	Longitude
47	37.377857	-123.414819
48	37.378110	-123.414307
49	37.378246	-123.413589
50	37.378548	-123.411865
51	37.378830	-123.410690
52	37.378670	-123.409698
53	37.378670	-123.408661
54	37.378788	-123.407516
55	37.378990	-123.406601
56	37.379917	-123.405060
57	37.382050	-123.402176
58	37.384674	-123.399277
59	37.385838	-123.396515
60	37.386536	-123.394394
61	37.386944	-123.392105
62	37.388382	-123.389099
63	37.390030	-123.387466
64	37.391033	-123.385895
65	37.391033	-123.385361
66	37.391678	-123.383209
67	37.391605	-123.377502
68	37.391605	-123.366562
69	37.391678	-123.354263
70	37.391117	-123.337402
71	37.378333	-123.208333
72	37.391700	-123.168400
73	37.411583	-123.101767
74	37.411667	-123.058333
75	37.421167	-123.050000
76	37.426333	-123.041667
77	37.428917	-123.034667
78	37.428333	-123.029500
79	37.422983	-123.006900
80	37.456500	-122.950000
81	37.469333	-122.916667
82	37.484500	-122.716667
83	37.489000	-122.643833
84	37.491167	-122.611167
85	37.497333	-122.561167
86	37.497600	-122.552417
87	37.497333	-122.524167
88	37.495167	-122.517333
89	37.495167	-122.511167
90	37.498833	-122.507000
91	37.501217	-122.507167
92	37.500833	-122.502833
93	37.499695	-122.499450
	Pillar Point, California	

APPENDIX D: Video Data Biological Abundance

Appendix contains a table with rows of taxonomic information and columns of biologic abundance data for the different stations. Cable and control transects are separated. Length of transects given. Individual columns for each station contain abundance of lowest taxonomic unit (LT abund), abundance of lowest taxonomic unit normalized per meter of transect length (LT/m), a summation of lowest taxa within each taxonomic group (TG Abund), and the taxonomic group abundance normalized per meter of transect length (TG/m). Summary information for each transect includes total number of organisms seen (transect abundance), transect abundance normalized by distance (transect abundance per m), total number of lowest taxa seen along the transect, and total number of taxonomic groups seen along the transect.

APPENDIX D
Video Data Biological Abundance

		20 m station				43 m station							
	Transect type:	**cable**				**cable**				**control**			
	Transect Length (m):	**1170**				**360**				**210**			
Taxonomic Group (TG)	**Lowest Taxon (LT)**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**
Algae and eel grass	Phaeophyceae	3	0.003	10	0.009	0	0	1	0.003	0	0	0	0.000
	Phyllospadix	0	0			1	0.003			0	0		
	Rhodophycota	7	0.006			0	0			0	0		
	Kelp	0	0			0	0			0	0		
Agnatha	*Eptatretus stoutii*	0	0	0	0	0	0	0	0.000	0	0	0	0.000
Cnidarian	Actiniaria	7	0.006	8	0.007	1	0.003	5	0.014	0	0	0	0.000
	Anthomastus ritteri	0	0			0	0			0	0		
	Anthoptilum grandiflorum	0	0			0	0			0	0		
	Antipatharia	0	0			0	0			0	0		
	Caryophylliicae	1	0.001			0	0			0	0		
	Cerianthidae	0	0			0	0			0	0		
	Halipteris sp .	0	0			0	0			0	0		
	Hormathiidae	0	0			0	0			0	0		
	Isidella sp.	0	0			0	0			0	0		
	Liponema brevicornis	0	0			0	0			0	0		
	Metridium farcimen	0	0			4	0.011			0	0		
	Paragorgia sp.	0	0			0	0			0	0		
	Pennatula sp.	0	0			0	0			0	0		
	Pennatulacea	0	0			0	0			0	0		
	Ptilosarcus gurneyi	0	0			0	0			0	0		
	Stomphia spp.	0	0			0	0			0	0		
Crustacean	Brachyura	0	0	0	0	0	0	6	0.017	0	0	5	0.024
	Cancer sp.	0	0			6	0.017			5	0.024		
	Chionoecetes tanneri	0	0			0	0			0	0		
	Chorilia longipes	0	0			0	0			0	0		
	Diogenidae	0	0			0	0			0	0		
	Munida sp.	0	0			0	0			0	0		
	Munnopsidae	0	0			0	0			0	0		
	Mysidae	0	0			0	0			0	0		
	Pandalidae	0	0			0	0			0	0		
	Paralomis spp.	0	0			0	0			0	0		
	Pycnogonida	0	0			0	0			0	0		
Echinoderm	*Allocentrotus fragilis*	0	0	443	0.379	0	0	4	0.011	0	0	2	0.010
	Asteroidea	42	0.036			0	0			0	0		
	Asteronyx loveni	0	0			0	0			0	0		
	Ceremaster sp.	8	0.007			0	0			0	0		
	Crinoidea	0	0			0	0			0	0		
	Florometra serratissima	0	0			0	0			0	0		
	Henricia sp.	0	0			0	0			0	0		
	Gorgonocephalidae	0	0			0	0			0	0		
	Holothurian	0	0			0	0			0	0		
	Laetmogone sp.	0	0			0	0			0	0		
	Luidia foliolata	3	0.003			3	0.008			2	0.010		
	Mediaster sp.	1	0.001			0	0			0	0		
	Ophiurida	0	0			0	0			0	0		
	Paelopadites confundus	0	0			0	0			0	0		
	Pannychia moseleyi	0	0			0	0			0	0		
	Parastichopus californicus	0	0			0	0			0	0		
	Pisaster sp.	355	0.303			1	0.003			0	0		
	Psolus sp.	0	0			0	0			0	0		
	Rathbunaster californicus	0	0			0	0			0	0		
	Solaster sp.	0	0			0	0			0	0		
	Strongylocentrotus purpuratus	34	0.029			0	0			0	0		
	Tromikosoma	0	0			0	0			0	0		
Elasmobranchs	Rajiformes	0	0	0	0	0	0	0	0.000	0	0	0	0.000
	Squalus acanthias	0	0			0	0			0	0		
Mollusc	Bivalve Siphon	0	0	13	0.011	0	0	0	0.000	0	0	0	0.000
	Cirripedia	12	0.010			0	0			0	0		
	Gastropod	1	0.001			0	0			0	0		
	Graneledone sp.	0	0			0	0			0	0		
	Neptunea sp.	0	0			0	0			0	0		
	Octopus	0	0			0	0			0	0		
	Pleurobranchaea californica	0	0			0	0			0	0		
Ostheichthyes	Agonidae	0	0	14	0.012	0	0	31	0.086	0	0	1	0.005
	Anoplopoma fimbria	0	0			0	0			0	0		
	Antimora microlepis	0	0			0	0			0	0		
	Citharichthys sp.	1	0.001			0	0			0	0		
	Careproctus melanurus	0	0			0	0			0	0		
	Cottidae	7	0.006			0	0			0	0		
	Glyptocephalus zachirus	0	0			0	0			0	0		
	Gobiidae	3	0.003			0	0			0	0		
	Liparidae	0	0			0	0			0	0		
	Lycenchelys sp.	0	0			0	0			0	0		
	Lycodes sp.	0	0			0	0			0	0		
	Macrourid	0	0			0	0			0	0		
	Merluccius productus	0	0			0	0			0	0		
	Microstomus pacificus	0	0			0	0			0	0		
	Ophiodon elongatus	1	0.001			0	0			0	0		
	Perciformes	0	0			0	0			0	0		
	Pleuronectiformes	0	0			31	0.086			1	0.005		
	Salmon	0	0			0	0			0	0		
	Scorpaenid	0	0			0	0			0	0		
	Sebastes spp.	2	0.002			0	0			0	0		
	Sebastolobus sp.	0	0			0	0			0	0		
	Teleost	0	0			0	0			0	0		
	Zoarcidae	0	0			0	0			0	0		
Other	Bryozoa	0	0	0	0	0	0	0	0.000	0	0	0	0.000
	Echiura	0	0			0	0			0	0		
	Polychaeta	0	0			0	0			0	0		
Porifera	Porifera	19	0.016	19	0.016	1	0.003	1	0.003	0	0	0	0.000
	White Goiter sponge	0	0			0	0			0	0		
	White Ruffled sponge	0	0			0	0			0	0		
	White Trumpet sponge	0	0			0	0			0	0		
	Yellow Goiter sponge	0	0			0	0			0	0		
	Yellow Picasso sponge	0	0			0	0			0	0		

	20 m station cable	43 m station cable	43 m station control
Transect Abundance:	**507 (0.4 per m)**	**48 (0.1 per m)**	**8 (0.0 per m)**
Number of Lowest Taxa:	**18**	**8**	**3**
Number of Taxon Groups	**6**	**6**	**3**

APPENDIX D
Video Data Biological Abundance

		67 m station							
	Transect type:	cable				control			
	Transect Length (m):	360				210			
Taxonomic Group (TG)	Lowest Taxon (LT)	LT Abund	LT/m	TG Abund	TG/m	LT Abund	LT/m	TG Abund	TG/m
Algae and eel grass	Phaeophyceae	0	0	3029	8.414	0	0	0	0.000
	Phyllospadix	1	0.003			0	0		
	Rhodophycota	0	0			0	0		
	Kelp	0	0			0	0		
Agnatha	*Eptatretus stoutii*	0	0	0	0.000	0	0	0	0.000
Cnidarian	Actiniaria	0	0	23	0.064	2	0.010	24	0.114
	Anthomastus ritteri	0	0			0	0		
	Anthoptilum grandiflorum	0	0			0	0		
	Antipatharia	0	0			0	0		
	Caryophylliicae	0	0			0	0		
	Cerianthidae	0	0			3	0.014		
	Halipteris sp .	0	0			0	0		
	Hormathiidae	0	0			0	0		
	Isidella sp.	0	0			0	0		
	Liponema brevicornis	0	0			0	0		
	Metridium farcimen	19	0.053			5	0.024		
	Paragorgia sp.	0	0			0	0		
	Pennatula sp.	0	0			0	0		
	Pennatulacea	4	0.011			14	0.067		
	Ptilosarcus gurneyi	0	0			0	0		
	Stomphia spp.	0	0			0	0		
Crustacean	Brachyura	0	0	6	0.017	0	0	0	0.000
	Cancer sp.	6	0.017			0	0.000		
	Chionoecetes tanneri	0	0			0	0		
	Chorilia longipes	0	0			0	0		
	Diogenidae	0	0			0	0		
	Munida sp.	0	0			0	0		
	Munnopsidae	0	0			0	0		
	Mysidae	0	0			0	0		
	Pandalidae	0	0			0	0		
	Paralomis spp.	0	0			0	0		
	Pycnogonida	0	0			0	0		
Echinoderm	*Allocentrotus fragilis*	0	0	2905	8.069	0	0	5000	23.810
	Asteroidea	0	0			0	0		
	Asteronyx loveni	0	0			0	0		
	Ceremaster sp.	0	0			0	0		
	Crinoidea	0	0			0	0		
	Florometra serratissima	0	0			0	0		
	Henricia sp.	0	0			0	0		
	Gorgonocephalidae	0	0			0	0		
	Holothurian	0	0			0	0		
	Laetmogone sp.	0	0			0	0		
	Luidia foliolata	5	0.014			0	0		
	Mediaster sp.	0	0			0	0		
	Ophiurida	2900	8.056			5000	23.810		
	Paelopadites confundus	0	0			0	0		
	Pannychia moseleyi	0	0			0	0		
	Parastichopus californicus	0	0			0	0		
	Pisaster sp.	0	0			0	0		
	Psolus sp.	0	0			0	0		
	Rathbunaster californicus	0	0			0	0		
	Solaster sp.	0	0			0	0		
	Strongylocentrotus purpuratus	0	0			0	0		
	Tromikosoma	0	0			0	0		
Elasmobranchs	Rajiformes	0	0	0	0.000	0	0	0	0.000
	Squalus acanthias	0	0			0	0		
Mollusc	Bivalve Siphon	0	0	0	0.000	1	0.010	1	0.005
	Cirripedia	0	0			0	0		
	Gastropod	0	0			0	0		
	Graneledone sp.	0	0			0	0		
	Neptunea sp.	0	0			0	0		
	Octopus	0	0			0	0		
	Pleurobranchaea californica	0	0			0	0		
Ostheichthyes	Agonidae	0	0	94	0.261	0	0	47	0.224
	Anoplopoma fimbria	0	0			0	0		
	Antimora microlepis	0	0			0	0		
	Citharichthys sp.	0	0			0	0		
	Careproctus melanurus	0	0			0	0		
	Cottidae	0	0			1	0.005		
	Glyptocephalus zachirus	0	0			0	0		
	Gobiidae	2	0.006			5	0.024		
	Liparidae	0	0			0	0		
	Lycenchelys sp.	0	0			0	0		
	Lycodes sp.	0	0			1	0.005		
	Macrourid	0	0			0	0		
	Merluccius productus	0	0			0	0		
	Microstomus pacificus	0	0			0	0		
	Ophiodon elongatus	0	0			0	0		
	Perciformes	0	0			0	0		
	Pleuronectiformes	91	0.253			40	0.190		
	Salmon	0	0			0	0		
	Scorpaenid	0	0			0	0		
	Sebastes spp.	1	0.003			0	0		
	Sebastolobus sp.	0	0			0	0		
	Teleost	0	0			0	0		
	Zoarcidae	0	0			0	0		
Other	Bryozoa	0	0	0	0.000	0	0	0	0.000
	Echiura	0	0			0	0		
	Polychaeta	0	0			0	0		
Porifera	Porifera	0	0	0	0.000	0	0	0	0.000
	White Goiter sponge	0	0			0	0		
	White Ruffled sponge	0	0			0	0		
	White Trumpet sponge	0	0			0	0		
	Yellow Goiter sponge	0	0			0	0		
	Yellow Picasso sponge	0	0			0	0		
		Transect Abundance:		3029 (8.4 per m)		Transect Abundance:		5072 (24.2 per m)	
		Number of Lowest Taxa:		9		Number of Lowest Taxa:		10	
		Number of Taxon Groups:		5		Number of Taxon Groups:		4	

APPENDIX D
Video Data Biological Abundance

		75 m station							
	Transect type:		cable				control		
	Transect Length (m):	240				390			
Taxonomic Group (TG)	**Lowest Taxon (LT)**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**
Algae and eel grass	Phaeophyceae	0	0	0	0.000	0	0	1	0.003
	Phyllospadix	0	0			1	0.003		
	Rhodophycota	0	0			0	0		
	Kelp	0	0			0	0		
Agnatha	*Eptatretus stoutii*	0	0	0	0.000	0	0	0	0.000
Cnidarian	Actiniaria	0	0	108	0.450	0	0	8	0.021
	Anthomastus ritteri	0	0			0	0		
	Anthoptilum grandiflorum	0	0			0	0		
	Antipatharia	0	0			0	0		
	Caryophylliicae	0	0			0	0		
	Cerianthidae	0	0			0	0		
	Halipteris sp .	0	0			0	0		
	Hormathiidae	0	0			0	0		
	Isidella sp.	0	0			0	0		
	Liponema brevicornis	0	0			0	0		
	Metridium farcimen	95	0.396			4	0.010		
	Paragorgia sp.	0	0			0	0		
	Pennatula sp.	0	0			0	0		
	Pennatulacea	13	0.054			4	0.010		
	Ptilosarcus gurneyi	0	0			0	0		
	Stomphia spp.	0	0			0	0		
Crustacean	Brachyura	0	0	5	0.021	0	0	3	0.008
	Cancer sp.	5	0.021			3	0.008		
	Chionoecetes tanneri	0	0			0	0		
	Chorilia longipes	0	0			0	0		
	Diogenidae	0	0			0	0		
	Munida sp.	0	0			0	0		
	Munnopsidae	0	0			0	0		
	Mysidae	0	0			0	0		
	Pandalidae	0	0			0	0		
	Paralomis spp.	0	0			0	0		
	Pycnogonida	0	0			0	0		
Echinoderm	*Allocentrotus fragilis*	0	0	5218	21.742	0	0	4517	11.582
	Asteroidea	0	0			1	0.003		
	Asteronyx loveni	0	0			0	0		
	Ceremaster sp.	0	0			0	0		
	Crinoidea	0	0			0	0		
	Florometra serratissima	0	0			0	0		
	Henricia sp.	0	0			0	0		
	Gorgonocephalidae	0	0			0	0		
	Holothurian	0	0			0	0		
	Laetmogone sp.	0	0			0	0		
	Luidia foliolata	18	0.075			16	0.041		
	Mediaster sp.	0	0			0	0		
	Ophiurida	5200	21.667			4500	11.538		
	Paelopadites confundus	0	0			0	0		
	Pannychia moseleyi	0	0			0	0		
	Parastichopus californicus	0	0			0	0		
	Pisaster sp.	0	0			0	0		
	Psolus sp.	0	0			0	0		
	Rathbunaster californicus	0	0			0	0		
	Solaster sp.	0	0			0	0		
	Strongylocentrotus purpuratus	0	0			0	0		
	Tromikosoma	0	0			0	0		
Elasmobranchs	Rajiformes	1	0.004	8	0.033	0	0	2	0.005
	Squalus acanthias	7	0.029			2	0.005		
Mollusc	Bivalve Siphon	0	0	1	0.004	0	0	0	0.000
	Cirripedia	0	0			0	0		
	Gastropod	1	0.004			0	0		
	Graneledone sp.	0	0			0	0		
	Neptunea sp.	0	0			0	0		
	Octopus	0	0			0	0		
	Pleurobranchaea californica	0	0			0	0		
Ostheichthyes	Agonidae	0	0	345	1.438	0	0	113	0.290
	Anoplopoma fimbria	0	0			0	0		
	Antimora microlepis	0	0			0	0		
	Citharichthys sp.	0	0			0	0		
	Careproctus melanurus	0	0			0	0		
	Cottidae	0	0			0	0		
	Glyptocephalus zachirus	0	0			0	0		
	Gobiidae	0	0			0	0		
	Liparidae	0	0			0	0		
	Lycenchelys sp.	0	0			0	0		
	Lycodes sp.	0	0			0	0		
	Macrourid	0	0			0	0		
	Merluccius productus	0	0			0	0		
	Microstomus pacificus	0	0			0	0		
	Ophiodon elongatus	0	0			0	0		
	Perciformes	0	0			0	0		
	Pleuronectiformes	345	1.438			112	0.287		
	Salmon	0	0			0	0		
	Scorpaenid	0	0			1	0.003		
	Sebastes spp.	0	0			0	0		
	Sebastolobus sp.	0	0			0	0		
	Teleost	0	0			0	0		
	Zoarcidae	0	0			0	0		
Other	Bryozoa	0	0	0	0.000	0	0	0	0.000
	Echiura	0	0			0	0		
	Polychaeta	0	0			0	0		
Porifera	Porifera	0	0	0	0.000	0	0	0	0.000
	White Goiter sponge	0	0			0	0		
	White Ruffled sponge	0	0			0	0		
	White Trumpet sponge	0	0			0	0		
	Yellow Goiter sponge	0	0			0	0		
	Yellow Picasso sponge	0	0			0	0		
		Transect Abundance:		**5685 (23.7 per m)**		**Transect Abundance:**		**4644 (11.9 per m)**	
		Number of Lowest Taxa:		**9**		**Number of Lowest Taxa:**		**10**	
		Number of Taxon Groups:		**6**		**Number of Taxon Groups:**		**6**	

APPENDIX D
Video Data Biological Abundance

140 m station

Taxonomic Group (TG)	Lowest Taxon (LT)	LT Abund	LT/m	TG Abund	TG/m	LT Abund	LT/m	TG Abund	TG/m
	Transect type:		cable				control		
	Transect Length (m):	690				660			
Algae and eel grass	Phaeophyceae	0	0	8	0.012	0	0	1	0.002
	Phyllospadix	0	0			0	0		
	Rhodophycota	0	0			0	0		
	Kelp	8	0.012			1	0.002		
Agnatha	*Eptatretus stoutii*	0	0	0	0.000	0	0	0	0.000
Cnidarian	Actiniaria	3	0.004	2994	4.339	0	0	2083	3.156
	Anthomastus ritteri	0	0			0	0		
	Anthoptilum grandiflorum	1	0.001			0	0		
	Antipatharia	0	0			0	0		
	Caryophylliicae	0	0			0	0		
	Cerianthidae	3	0.004			1	0.002		
	Halipteris sp .	2863	4.149			2076	3.145		
	Hormathiidae	0	0			0	0		
	Isidella sp.	0	0			0	0		
	Liponema brevicornis	0	0			0	0		
	Metridium farcimen	121	0.175			1	0.002		
	Paragorgia sp.	0	0			0	0		
	Pennatula sp.	0	0			0	0		
	Pennatulacea	0	0			0	0		
	Ptilosarcus gurneyi	3	0.004			5	0.008		
	Stomphia spp.	0	0			0	0		
Crustacean	Brachyura	0	0	3	0.004	0	0	4	0.006
	Cancer sp.	3	0.004			4	0.006		
	Chionoecetes tanneri	0	0			0	0		
	Chorilia longipes	0	0			0	0		
	Diogenidae	0	0			0	0		
	Munida sp.	0	0			0	0		
	Munnopsidae	0	0			0	0		
	Mysidae	0	0			0	0		
	Pandalidae	0	0			0	0		
	Paralomis spp.	0	0			0	0		
	Pycnogonida	0	0			0	0		
Echinoderm	*Allocentrotus fragilis*	0	0	64	0.093	0	0	78	0.118
	Asteroidea	4	0.006			0	0		
	Asteronyx loveni	0	0			2	0.003		
	Ceremaster sp.	0	0			0	0		
	Crinoidea	0	0			0	0		
	Florometra serratissima	0	0			0	0		
	Henricia sp.	0	0			0	0		
	Gorgonocephalidae	0	0			0	0		
	Holothurian	0	0			0	0		
	Laetmogone sp.	0	0			0	0		
	Luidia foliolata	10	0.014			15	0.023		
	Mediaster sp.	5	0.007			8	0.012		
	Ophiurida	0	0			0	0		
	Paelopadites confundus	0	0			0	0		
	Pannychia moseleyi	0	0			0	0		
	Parastichopus californicus	1	0.001			1	0.002		
	Pisaster sp.	0	0			0	0		
	Psolus sp.	0	0			0	0		
	Rathbunaster californicus	44	0.064			52	0.079		
	Solaster sp.	0	0			0	0		
	Strongylocentrotus purpuratus	0	0			0	0		
	Tromikosoma	0	0			0	0		
Elasmobranchs	Rajiformes	0	0	0	0	0	0	0	0.000
	Squalus acanthias	0	0			0	0		
Mollusc	Bivalve Siphon	0	0	7	0.010	0	0	2	0.003
	Cirripedia	0	0			0	0		
	Gastropod	1	0.001			0	0		
	Graneledone sp.	0	0			0	0		
	Neptunea sp.	0	0			0	0		
	Octopus	0	0			0	0		
	Pleurobranchaea californica	6	0.009			2	0.003		
Ostheichthyes	Agonidae	1	0.001	52	0.075	3	0.005	42	0.064
	Anoplopoma fimbria	0	0			0	0		
	Antimora microlepis	0	0			0	0		
	Citharichthys sp.	0	0			0	0		
	Careproctus melanurus	0	0			0	0		
	Cottidae	0	0			0	0		
	Glyptocephalus zachirus	1	0.001			0	0		
	Gobiidae	0	0			0	0		
	Liparidae	0	0			0	0		
	Lycenchelys sp.	0	0			1	0.002		
	Lycodes sp.	0	0			0	0		
	Macrourid	0	0			0	0		
	Merluccius productus	0	0			0	0		
	Microstomus pacificus	0	0			0	0		
	Ophiodon elongatus	0	0			0	0		
	Perciformes	0	0			1	0.002		
	Pleuronectiformes	6	0.009			10	0.015		
	Salmon	0	0			1	0.002		
	Scorpaenid	0	0			0	0		
	Sebastes spp.	44	0.064			26	0.039		
	Sebastolobus sp.	0	0			0	0		
	Teleost	0	0			0	0		
	Zoarcidae	0	0			0	0		
Other	Bryozoa	1	0.001	1	0.001	0	0	0	0.000
	Echiura	0	0			0	0		
	Polychaeta	0	0			0	0		
Porifera	Porifera	0	0	0	0	0	0	0	0.000
	White Goiter sponge	0	0			0	0		
	White Ruffled sponge	0	0			0	0		
	White Trumpet sponge	0	0			0	0		
	Yellow Goiter sponge	0	0			0	0		
	Yellow Picasso sponge	0	0			0	0		

	Cable	Control
Transect Abundance:	**3129 (4.5 per m)**	**2210 (3.3 per m)**
Number of Lowest Taxa:	**20**	**18**
Number of Taxon Groups:	**7**	**6**

APPENDIX D
Video Data Biological Abundance

		240 m station (Feb 2003)								250 to 415 m station			
	Transect type:	cable				control				cable			
	Transect Length (m):	330				600				3547			
Taxonomic Group (TG)	Lowest Taxon (LT)	LT Abund	LT/m	TG Abund	TG/m	LT Abund	LT/m	TG Abund	TG/m	LT Abund	LT/m	TG Abund	TG/m
Algae and eel grass	Phaeophyceae	0	0	0	0.000	0	0	0	0	0	0	8	0.002
	Phyllospadix	0	0			0	0			0	0		
	Rhodophycota	0	0			0	0			0	0		
	Kelp	0	0			0	0			8	0.002		
Agnatha	*Eptatretus stoutii*	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000
Cnidarian	Actiniaria	2	0.006	53	0.161	1	0.002	28	0.047	1268	0.357	1483	0.418
	Anthomastus ritteri	0	0			0	0			0	0		
	Anthoptilum grandiflorum	0	0			0	0			0	0		
	Antipatharia	0	0			0	0			0	0		
	Caryophylliicae	0	0			0	0			0	0		
	Cerianthidae	0	0			0	0			0	0		
	Halipteris sp .	0	0			0	0			0	0		
	Hormathiidae	0	0			0	0			2	0.001		
	Isidella sp.	0	0			0	0			0	0		
	Liponema brevicornis	0	0			0	0			77	0.022		
	Metridium farcimen	29	0.088			0	0			118	0.033		
	Paragorgia sp.	0	0			0	0			0	0		
	Pennatula sp.	0	0			0	0			0	0		
	Pennatulacea	18	0.055			27	0.045			5	0.001		
	Ptilosarcus gurneyi	0	0			0	0			0	0		
	Stomphia spp.	0	0			0	0			13	0.004		
Crustacean	Brachyura	0	0	3	0.009	0	0	1	0.002	0	0	258	0.073
	Cancer sp.	1	0.003			0	0			0	0		
	Chionoecetes tanneri	0	0			0	0			0	0		
	Chorilia longipes	0	0			0	0			0	0		
	Diogenidae	0	0			0	0			243	0.069		
	Munida sp.	0	0			0	0			0	0		
	Munnopsidae	0	0			1	0.002			0	0		
	Mysidae	0	0			0	0			0	0		
	Pandalidae	2	0.006			0	0			15	0.004		
	Paralomis spp.	0	0			0	0			0	0		
	Pycnogonida	0	0			0	0			0	0		
Echinoderm	*Allocentrotus fragilis*	302	0.915	378	1.145	628	1.047	719	1.198	253	0.071	620	0.175
	Asteroidea	1	0.003			2	0.003			163	0.046		
	Asteronyx loveni	0	0			0	0			0	0		
	Ceremaster sp.	0	0			0	0			0	0		
	Crinoidea	0	0			0	0			2	0.001		
	Florometra serratissima	0	0			0	0			0	0		
	Henricia sp.	0	0			0	0			0	0		
	Gorgonocephalidae	4	0.012			0	0			0	0		
	Holothurian	0	0			0	0			2	0.001		
	Laetmogone sp.	0	0			0	0			0	0		
	Luidia foliolata	27	0.082			9	0.015			37	0.010		
	Mediaster sp.	0	0			0	0			22	0.006		
	Ophiurida	0	0			0	0			0	0		
	Paelopadites confundus	0	0			0	0			0	0		
	Pannychia moseleyi	0	0			0	0			0	0		
	Parastichopus californicus	5	0.015			5	0.008			11	0.003		
	Pisaster sp.	0	0			0	0			0	0		
	Psolus sp.	0	0			0	0			0	0		
	Rathbunaster californicus	43	0.130			75	0.125			130	0.037		
	Solaster sp.	0	0			0	0			0	0		
	Strongylocentrotus purpuratus	0	0			0	0			0	0		
	Tromikosoma	0	0			0	0			0	0		
Elasmobranchs	Rajiformes	1	0.003	1	0.003	3	0.005	4	0.007	37	0.010	37	0.010
	Squalus acanthias	0	0			1	0.002			0	0		
Mollusc	Bivalve Siphon	0	0	4	0.012	0	0	0	0	0	0	17	0.005
	Cirripedia	0	0			0	0			0	0		
	Gastropod	0	0			0	0			0	0		
	Graneledone sp.	0	0			0	0			0	0		
	Neptunea sp.	0	0			0	0			7	0.002		
	Octopus	0	0			0	0			4	0.001		
	Pleurobranchaea californica	4	0.012			0	0			6	0.002		
Ostheichthyes	Agonidae	0	0	45	0.136	0	0	39	0.065	5	0.001	583	0.164
	Anoplopoma fimbria	0	0			0	0			1	0.000		
	Antimora microlepis	0	0			0	0			0	0		
	Citharichthys sp.	0	0			0	0			0	0		
	Careproctus melanurus	0	0			0	0			10	0.003		
	Cottidae	0	0			0	0			0	0		
	Glyptocephalus zachirus	0	0			0	0			0	0		
	Gobiidae	0	0			0	0			0	0		
	Liparidae	0	0			0	0			1	0.000		
	Lycenchelys sp.	0	0			0	0			11	0.003		
	Lycodes sp.	7	0.021			2	0.003			27	0.008		
	Macrourid	0	0			0	0			0	0		
	Merluccius productus	0	0			0	0			93	0.026		
	Microstomus pacificus	0	0			0	0			0	0		
	Ophiodon elongatus	1	0.003			0	0			0	0		
	Perciformes	0	0			0	0			0	0		
	Pleuronectiformes	3	0.009			5	0.008			319	0.090		
	Salmon	0	0			0	0			0	0		
	Scorpaenid	0	0			0	0			0	0		
	Sebastes spp.	29	0.088			6	0.010			4	0.001		
	Sebastolobus sp.	5	0.015			15	0.025			110	0.031		
	Teleost	0	0			3	0.005			0	0		
	Zoarcidae	0	0			8	0.013			2	0.001		
Other	Bryozoa	0	0	0	0	0	0	0	0	6	0.002	6	0.002
	Echiura	0	0			0	0			0	0		
	Polychaeta	0	0			0	0			0	0		
Porifera	Porifera	0	0	0	0	0	0	0	0	5	0.001	5	0.001
	White Goiter sponge	0	0			0	0			0	0		
	White Ruffled sponge	0	0			0	0			0	0		
	White Trumpet sponge	0	0			0	0			0	0		
	Yellow Goiter sponge	0	0			0	0			0	0		
	Yellow Picasso sponge	0	0			0	0			0	0		

240 m station – cable		240 m station – control		250 to 415 m station – cable	
Transect Abundance:	**484 (1.5 per m)**	**Transect Abundance:**	**791 (1.3 per m)**	**Transect Abundance:**	**3017 (0.9 per m)**
Number of Lowest Taxa:	**18**	**Number of Lowest Taxa:**	**15**	**Number of Lowest Taxa:**	**34**
Number of Taxon Groups:	**6**	**Number of Taxon Groups:**	**5**	**Number of Taxon Groups:**	**9**

APPENDIX D
Video Data Biological Abundance

		950 m station								1710 to 1890 m station			
	Transect type:	cable				control				cable			
	Transect Length (m):	420				510				1321			
Taxonomic Group (TG)	**Lowest Taxon (LT)**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**
Algae and eel grass	Phaeophyceae	0	0	10	0.024	0	0	2	0.004	0	0	8	0.006
	Phyllospadix	0	0			0	0			2	0.002		
	Rhodophycota	0	0			0	0			0	0		
	Kelp	10	0.024			2	0.004			6	0.005		
Agnatha	*Eptatretus stoutii*	3	0.007	3	0.007	4	0.008	4	0.008	0	0	0	0.000
Cnidarian	Actiniaria	471	1.121	677	1.612	258	0.506	420	0.824	2098	1.588	2341	1.772
	Anthomastus ritteri	0	0			0	0			0	0		
	Anthoptilum grandiflorum	0	0			0	0			0	0		
	Antipatharia	0	0			0	0			0	0		
	Caryophylliicae	0	0			0	0			0	0		
	Cerianthidae	0	0			0	0			0	0		
	Halipteris sp .	0	0			0	0			0	0		
	Hormathiidae	0	0			0	0			58	0.044		
	Isidella sp.	0	0			0	0			0	0		
	Liponema brevicornis	1	0.002			1	0.002			3	0.002		
	Metridium farcimen	0	0			0	0			0	0		
	Paragorgia sp.	0	0			0	0			0	0		
	Pennatula sp.	106	0.252			161	0.316			152	0.115		
	Pennatulacea	0	0			0	0			12	0.009		
	Ptilosarcus gurneyi	0	0			0	0			0	0		
	Stomphia spp.	99	0.236			0	0			18	0.014		
Crustacean	Brachyura	0	0	50	0.119	0	0	20	0.039	0	0	28	0.021
	Cancer sp.	0	0			0	0			0	0		
	Chionoecetes tanneri	3	0.007			4	0.008			11	0.008		
	Chorilia longipes	0	0			0	0			0	0		
	Diogenidae	47	0.112			16	0.031			0	0		
	Munida sp.	0	0			0	0			0	0		
	Munnopsidae	0	0			0	0			0	0		
	Mysidae	0	0			0	0			0	0		
	Pandalidae	0	0			0	0			15	0.011		
	Paralomis spp.	0	0			0	0			0	0		
	Pycnogonida	0	0			0	0			2	0.002		
Echinoderm	*Allocentrotus fragilis*	0	0	28	0.067	0	0	15	0.029	0	0	1303	0.986
	Asteroidea	17	0.040			2	0.004			121	0.092		
	Asteronyx loveni	0	0			0	0			21	0.016		
	Ceremaster sp.	0	0			0	0			0	0		
	Crinoidea	0	0			0	0			0	0		
	Florometra serratissima	1	0.002			0	0			128	0.097		
	Henricia sp.	0	0			0	0			1	0.001		
	Gorgonocephalidae	0	0			0	0			0	0		
	Holothurian	3	0.007			0	0			12	0.009		
	Laetmogone sp.	0	0			0	0			0	0		
	Luidia foliolata	0	0			0	0			0	0		
	Mediaster sp.	0	0			0	0			0	0		
	Ophiurida	0	0			0	0			0	0		
	Paelopadites confundus	0	0			0	0			2	0.002		
	Pannychia moseleyi	6	0.014			10	0.020			998	0.755		
	Parastichopus californicus	0	0			0	0			0	0		
	Pisaster sp.	0	0			0	0			0	0		
	Psolus sp.	0	0			0	0			0	0		
	Rathbunaster californicus	1	0.002			3	0.006			19	0.014		
	Solaster sp.	0	0			0	0			0	0		
	Strongylocentrotus purpuratus	0	0			0	0			0	0		
	Tromikosoma	0	0			0	0			1	0.001		
Elasmobranchs	Rajiformes	0	0	0	0.000	0	0	0	0.000	1	0.001	1	0.001
	Squalus acanthias	0	0			0	0			0	0		
Mollusc	Bivalve Siphon	0	0	0	0.000	0	0	0	0.000	0	0	2	0.002
	Cirripedia	0	0			0	0			0	0		
	Gastropod	0	0			0	0			0	0		
	Graneledone sp.	0	0			0	0			1	0.001		
	Neptunea sp.	0	0			0	0			0	0		
	Octopus	0	0			0	0			0	0		
	Pleurobranchaea californica	0	0			0	0			1	0.001		
Ostheichthyes	Agonidae	0	0	128	0.305	0	0	130	0.255	0	0	45	0.034
	Anoplopoma fimbria	0	0			1	0.002			0	0		
	Antimora microlepis	0	0			0	0			5	0.004		
	Citharichthys sp.	0	0			0	0			0	0		
	Careproctus melanurus	0	0			0	0			0	0		
	Cottidae	0	0			0	0			0	0		
	Glyptocephalus zachirus	0	0			0	0			0	0		
	Gobiidae	0	0			0	0			0	0		
	Liparidae	0	0			2	0.004			0	0		
	Lycenchelys sp.	16	0.038			18	0.035			8	0.006		
	Lycodes sp.	0	0			0	0			0	0		
	Macrourid	0	0			0	0			26	0.020		
	Merluccius productus	0	0			0	0			0	0		
	Microstomus pacificus	4	0.010			2	0.004			0	0		
	Ophiodon elongatus	0	0			0	0			0	0		
	Perciformes	0	0			0	0			0	0		
	Pleuronectiformes	2	0.005			5	0.010			0	0		
	Salmon	0	0			0	0			0	0		
	Scorpaenid	0	0			0	0			0	0		
	Sebastes spp.	0	0			0	0			0	0		
	Sebastolobus sp.	105	0.250			101	0.198			0	0		
	Teleost	0	0			0	0			0	0		
	Zoarcidae	1	0.002			1	0.002			6	0.005		
Other	Bryozoa	0	0	0	0.000	0	0	0	0.000	0	0	1	0.001
	Echiura	0	0			0	0			1	0		
	Polychaeta	0	0			0	0			0	0		
Porifera	Porifera	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000
	White Goiter sponge	0	0			0	0			0	0		
	White Ruffled sponge	0	0			0	0			0	0		
	White Trumpet sponge	0	0			0	0			0	0		
	Yellow Goiter sponge	0	0			0	0			0	0		
	Yellow Picasso sponge	0	0			0	0			0	0		
		Transect Abundance: 896 (2.1 per m)				Transect Abundance: 591 (1.2 per m)				Transect Abundance: 3729 (2.8 per m)			
		Number of Lowest Taxa 18				Number of Lowest Ta: 17				Number of Lowest Taxa: 28			
		Number of Taxon Grour 6				Number of Taxon Gro 6				Number of Taxon Groups: 8			

APPENDIX D
Video Data Biological Abundance

		1940 m station							
	Transect type:		**cable**				**control**		
	Transect Length (m):	**30**				**90**			
Taxonomic Group (TG)	**Lowest Taxon (LT)**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**
Algae and eel grass	Phaeophyceae	0	0	0	0.000	0	0	1	0.011
	Phyllospadix	0	0			0	0		
	Rhodophycota	0	0			0	0		
	Kelp	0	0			1	0.011		
Agnatha	*Eptatretus stoutii*	0	0	0	0.000	0	0	0	0.000
Cnidarian	Actiniaria	73	2.433	77	2.567	111	1.233	113	1.256
	Anthomastus ritteri	0	0			0	0		
	Anthoptilum grandiflorum	0	0			0	0		
	Antipatharia	0	0			0	0		
	Caryophylliicae	0	0			0	0		
	Ceriantihidae	0	0			0	0		
	Halipteris sp .	0	0			0	0		
	Hormathiidae	3	0.100			0	0		
	Isidella sp.	0	0			0	0		
	Liponema brevicornis	0	0			1	0.011		
	Metridium farcimen	0	0			0	0		
	Paragorgia sp.	0	0			0	0		
	Pennatula sp.	0	0			0	0		
	Pennatulacea	1	0.033			1	0.011		
	Ptilosarcus gurneyi	0	0			0	0		
	Stomphia spp.	0	0			0	0		
Crustacean	Brachyura	0	0	2	0.067	0	0	4	0.044
	Cancer sp.	0	0			0	0		
	Chionoecetes tanneri	0	0			0	0		
	Chorilia longipes	1	0.033			4	0.044		
	Diogenidae	0	0			0	0		
	Munida sp.	0	0			0	0		
	Munnopsidae	0	0			0	0		
	Mysidae	0	0			0	0		
	Pandalidae	1	0.033			0	0		
	Paralomis spp.	0	0			0	0		
	Pycnogonida	0	0			0	0		
Echinoderm	*Allocentrotus fragilis*	0	0	39	1.300	0	0	173	1.922
	Asteroidea	6	0.200			16	0.178		
	Asteronyx loveni	0	0			0	0		
	Ceremaster sp.	0	0			0	0		
	Crinoidea	0	0			0	0		
	Florometra serratissima	1	0.033			10	0.111		
	Henricia sp.	0	0			0	0		
	Gorgonocephalidae	0	0			0	0		
	Holothurian	0	0			0	0		
	Laetmogone sp.	0	0			0	0		
	Luidia foliolata	0	0			0	0		
	Mediaster sp.	0	0			0	0		
	Ophiurida	0	0			0	0		
	Paelopadites confundus	1	0.033			1	0.011		
	Pannychia moseleyi	30	1.000			146	1.622		
	Parastichopus californicus	0	0			0	0		
	Pisaster sp.	0	0			0	0		
	Psolus sp.	0	0			0	0		
	Rathbunaster californicus	1	0.033			0	0		
	Solaster sp.	0	0			0	0		
	Strongylocentrotus purpuratus	0	0			0	0		
	Tromikosoma	0	0			0	0		
Elasmobranchs	Rajiformes	0	0	0	0.000	1	0.011	1	0.011
	Squalus acanthias	0	0			0	0		
Mollusc	Bivalve Siphon	0	0	0	0.000	0	0	0	0.000
	Cirripedia	0	0			0	0		
	Gastropod	0	0			0	0		
	Graneledone sp.	0	0			0	0		
	Neptunea sp.	0	0			0	0		
	Octopus	0	0			0	0		
	Pleurobranchaea californica	0	0			0	0		
Ostheichthyes	Agonidae	0	0	0	0.000	0	0	0	0.000
	Anoplopoma fimbria	0	0			0	0		
	Antimora microlepis	0	0			0	0		
	Citharichthys sp.	0	0			0	0		
	Careproctus melanurus	0	0			0	0		
	Cottidae	0	0			0	0		
	Glyptocephalus zachirus	0	0			0	0		
	Gobiidae	0	0			0	0		
	Liparidae	0	0			0	0		
	Lycenchelys sp.	0	0			0	0		
	Lycodes sp.	0	0			0	0		
	Macrourid	0	0			0	0		
	Merluccius productus	0	0			0	0		
	Microstomus pacificus	0	0			0	0		
	Ophiodon elongatus	0	0			0	0		
	Perciformes	0	0			0	0		
	Pleuronectiformes	0	0			0	0		
	Salmon	0	0			0	0		
	Scorpaenid	0	0			0	0		
	Sebastes spp.	0	0			0	0		
	Sebastolobus sp.	0	0			0	0		
	Teleost	0	0			0	0		
	Zoarcidae	0	0			0	0		
Other	Bryozoa	0	0	0	0.000	0	0	0	0.000
	Echiura	0	0			0	0		
	Polychaeta	0	0			0	0		
Porifera	Porifera	0	0	0	0.000	0	0	0	0.000
	White Goiter sponge	0	0			0	0		
	White Ruffled sponge	0	0			0	0		
	White Trumpet sponge	0	0			0	0		
	Yellow Goiter sponge	0	0			0	0		
	Yellow Picasso sponge	0	0			0	0		

Cable			Control		
Transect Abundance:	**118**	**(3.9 per m)**	**Transect Abundance:**	**292**	**(3.2 per m)**
Number of Lowest Taxa:	**10**		**Number of Lowest Taxa:**	**10**	
Number of Taxon Groups:	**3**		**Number of Taxon Groups:**	**5**	

APPENDIX D
Video Data Biological Abundance

Taxonomic Group (TG)	Lowest Taxon (LT)	Seamount Base 1700 m station: cable (Transect Length 870 m) LT Abund	LT/m	TG Abund	TG/m	Seamount Base 1700 m station: control (Transect Length 180 m) LT Abund	LT/m	TG Abund	TG/m	Seamount 1580 to 1040 m station: cable (Transect Length 2296 m) LT Abund	LT/m	TG Abund	TG/m
Algae and eel grass	Phaeophyceae	0	0	1	0.001	0	0	2	0.011	0	0	1	0.000
	Phyllospadix	0	0			0	0			0	0		
	Rhodophycota	0	0			0	0			0	0		
	Kelp	1	0.001			2	0.011			1	0.000		
Agnatha	*Eptatretus stoutii*	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000
Cnidarian	Actiniaria	2	0.002	28	0.032	0	0	9	0.050	21	0.009	272	0.118
	Anthomastus ritteri	0	0			0	0			80	0.035		
	Anthoptilum grandiflorum	0	0			0	0			0	0		
	Antipatharia	0	0			0	0			0	0		
	Caryophylliicae	0	0			0	0			0	0		
	Cerianthidae	0	0			1	0.006			0	0		
	Halipteris sp .	1	0.001			7	0.039			0	0		
	Hormathiidae	17	0.020			0	0			23	0.010		
	Isidella sp.	0	0			0	0			66	0.029		
	Liponema brevicornis	0	0			0	0			0	0		
	Metridium farcimen	0	0			0	0			0	0		
	Paragorgia sp.	0	0			0	0			0	0		
	Pennatula sp.	5	0.006			0	0			0	0		
	Pennatulacea	3	0.003			1	0.006			82	0.036		
	Ptilosarcus gurneyi	0	0			0	0			0	0		
	Stomphia spp.	0	0			0	0			0	0		
Crustacean	Brachyura	0	0	28	0.032	3	0.017	7	0.039	2	0.001	18	0.008
	Cancer sp.	0	0			0	0			0	0		
	Chionoecetes tanneri	23	0.026			1	0.006			0	0		
	Chorilia longipes	0	0			0	0			0	0		
	Diogenidae	0	0			0	0			0	0		
	Munida sp.	0	0			0	0			0	0		
	Munnopsidae	0	0			0	0			2	0.001		
	Mysidae	0	0			0	0			1	0.005		
	Pandalidae	4	0.005			1	0.006			1	0.000		
	Paralomis spp.	1	0.001			2	0.011			12	0.005		
	Pycnogonida	0	0			0	0			0	0		
Echinoderm	*Allocentrotus fragilis*	0	0	34	0.039	0	0	29	0.161	0	0	3789	1.650
	Asteroidea	8	0.009			6	0.033			91	0.040		
	Asteronyx loveni	8	0.009			2	0.011			0	0		
	Ceremaster sp.	0	0			0	0			0	0		
	Crinoidea	0	0			0	0			0	0		
	Florometra serratissima	2	0.002			0	0			3065	1.335		
	Henricia sp.	4	0.005			6	0.033			0	0		
	Gorgonocephalidae	0	0			0	0			437	0.190		
	Holothurian	0	0			1	0.006			47	0.020		
	Laetmogone sp.	11	0.013			14	0.078			0	0		
	Luidia foliolata	0	0			0	0			0	0		
	Mediaster sp.	0	0			0	0			0	0		
	Ophiurida	0	0			0	0			1	0.000		
	Paelopadites confundus	0	0			0	0			0	0		
	Pannychia moseleyi	0	0			0	0			110	0.048		
	Parastichopus californicus	0	0			0	0			0	0		
	Pisaster sp.	0	0			0	0			0	0		
	Psolus sp.	0	0			0	0			33	0.014		
	Rathbunaster californicus	0	0			0	0			2	0.001		
	Solaster sp.	1	0.001			0	0			3	0.001		
	Strongylocentrotus purpuratus	0	0			0	0			0	0		
	Tromikosoma	0	0			0	0			0	0		
Elasmobranchs	Rajiformes	1	0.001	1	0.001	0	0	0	0.000	9	0.004	9	0.004
	Squalus acanthias	0	0			0	0			0	0		
Mollusc	Bivalve Siphon	0	0	15	0.017	0	0	7	0.039	18	0.008	33	0.014
	Cirripedia	0	0			0	0			0	0		
	Gastropod	4	0.005			3	0.017			0	0		
	Graneledone sp.	0	0			1	0.006			3	0.001		
	Neptunea sp.	11	0.013			3	0.017			12	0.005		
	Octopus	0	0			0	0			0	0		
	Pleurobranchaea californica	0	0			0	0			0	0		
Ostheichthyes	Agonidae	0	0	29	0.033	0	0	11	0.061	0	0	141	0.061
	Anoplopoma fimbria	0	0			0	0			0	0		
	Antimora microlepis	1	0.001			1	0.006			12	0.005		
	Citharichthys sp.	0	0			0	0			0	0		
	Careproctus melanurus	0	0			0	0			0	0		
	Cottidae	0	0			0	0			0	0		
	Glyptocephalus zachirus	0	0			0	0			0	0		
	Gobiidae	0	0			0	0			0	0		
	Liparidae	0	0			0	0			1	0.000		
	Lycenchelys sp.	2	0.002			0	0			6	0.003		
	Lycodes sp.	0	0			0	0			0	0		
	Macrourid	10	0.011			9	0.050			106	0.046		
	Merluccius productus	0	0			0	0			0	0		
	Microstomus pacificus	0	0			0	0			0	0		
	Ophiodon elongatus	0	0			0	0			0	0		
	Perciformes	0	0			0	0			0	0		
	Pleuronectiformes	0	0			0	0			0	0		
	Salmon	0	0			0	0			0	0		
	Scorpaenid	14	0.016			0	0			0	0		
	Sebastes spp.	0	0			0	0			0	0		
	Sebastolobus sp.	0	0			0	0			12	0.005		
	Teleost	0	0			0	0			1	0.000		
	Zoarcidae	2	0.002			1	0.006			3	0.001		
Other	Bryozoa	0	0	0	0.000	0	0	1	0.006	0	0	0	0.000
	Echiura	0	0			0	0			0	0		
	Polychaeta	0	0			1	0.006			0	0		
Porifera	Porifera	4	0.005	4	0.005	0	0	0	0.000	590	0.257	834	0.363
	White Goiter sponge	0	0			0	0			0	0		
	White Ruffled sponge	0	0			0	0			13	0.006		
	White Trumpet sponge	0	0			0	0			21	0.009		
	Yellow Goiter sponge	0	0			0	0			1	0.000		
	Yellow Picasso sponge	0	0			0	0			209	0.091		

	Seamount Base 1700 m station: cable	Seamount Base 1700 m station: control	Seamount 1580 to 1040 m station: cable
Transect Abundance:	140 (0.2 per m)	66 (0.4 per m)	5097 (2.2 per m)
Number of Lowest Taxa:	24	20	36
Number of Taxon Groups:	8	7	8

APPENDIX D
Video Data Biological Abundance

		Seamount 900 m station								Seamount 800-900 m station			
	Transect type:	cable				control				cable			
	Transect Length (m):	180				210				240			
Taxonomic Group (TG)	**Lowest Taxon (LT)**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**	**LT Abund**	**LT/m**	**TG Abund**	**TG/m**
Algae and eel grass	Phaeophyceae	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000
	Phyllospadix	0	0			0	0			0	0		
	Rhodophycota	0	0			0	0			0	0		
	Kelp	0	0			0	0			0	0		
Agnatha	*Eptatretus stoutii*	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000
Cnidarian	Actiniaria	2	0.011	376	2.089	2	0.010	356	1.695	4	0.017	1115	4.646
	Anthomastus ritteri	355	1.972			316	1.505			1026	4.275		
	Anthoptilum grandiflorum	0	0			0	0			0	0		
	Antipatharia	2	0.011			5	0.024			0	0		
	Caryophylliicae	0	0			0	0			0	0		
	Cerianthidae	0	0			0	0			0	0		
	Halipteris sp .	0	0			0	0			0	0		
	Hormathiidae	1	0.006			2	0.010			3	0.013		
	Isidella sp.	3	0.017			0	0			1	0.004		
	Liponema brevicornis	0	0			0	0			0	0		
	Metridium farcimen	0	0			0	0			0	0		
	Paragorgia sp.	3	0.017			9	0.043			74	0.308		
	Pennatula sp.	0	0			0	0			0	0.000		
	Pennatulacea	10	0.056			22	0.105			7	0.029		
	Ptilosarcus gurneyi	0	0			0	0			0	0		
	Stomphia spp.	0	0			0	0			0	0		
Crustacean	Brachyura	0	0	10	0.056	0	0	11	0.052	0	0	31	0.129
	Cancer sp.	0	0			0	0			0	0		
	Chionoecetes tanneri	0	0			0	0			0	0		
	Chorilia longipes	0	0			0	0			2	0.008		
	Diogenidae	0	0			0	0			0	0		
	Munida sp.	0	0			0	0			22	0.092		
	Munnopsidae	0	0			0	0			0	0		
	Mysidae	0	0			0	0			0	0		
	Pandalidae	0	0			0	0			0	0		
	Paralomis spp.	10	0.056			11	0.052			7	0.029		
	Pycnogonida	0	0			0	0			0	0		
Echinoderm	*Allocentrotus fragilis*	1	0.006	222	1.233	0	0	125	0.595	0	0	403	1.679
	Asteroidea	28	0.156			21	0.100			30	0.125		
	Asteronyx loveni	0	0			0	0			0	0		
	Ceremaster sp.	0	0			0	0			0	0		
	Crinoidea	0	0			0	0			0	0		
	Florometra serratissima	44	0.244			26	0.124			117	0.488		
	Henricia sp.	0	0			0	0			0	0		
	Gorgonocephalidae	6	0.033			2	0.010			19	0.079		
	Holothurian	0	0			0	0			0	0		
	Laetmogone sp.	0	0			0	0			0	0		
	Luidia foliolata	0	0			0	0			0	0		
	Mediaster sp.	0	0			1	0.005			4	0.017		
	Ophiurida	0	0			0	0			0	0		
	Paelopadites confundus	0	0			0	0			0	0		
	Pannychia moseleyi	0	0			0	0			0	0		
	Parastichopus californicus	0	0			0	0			0	0		
	Pisaster sp.	0	0			0	0			0	0		
	Psolus sp.	143	0.794			75	0.357			233	0.971		
	Rathbunaster californicus	0	0			0	0			0	0		
	Solaster sp.	0	0			0	0			0	0		
	Strongylocentrotus purpuratus	0	0			0	0			0	0		
	Tromikosoma	0	0			0	0			0	0		
Elasmobranchs	Rajiformes	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000
	Squalus acanthias	0	0			0	0			0	0		
Mollusc	Bivalve Siphon	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000
	Cirripedia	0	0			0	0			0	0		
	Gastropod	0	0			0	0			0	0		
	Graneledone sp.	0	0			0	0			0	0		
	Neptunea sp.	0	0			0	0			0	0		
	Octopus	0	0			0	0			0	0		
	Pleurobranchaea californica	0	0			0	0			0	0		
Ostheichthyes	Agonidae	0	0	10	0.056	0	0	10	0.048	0	0	24	0.100
	Anoplopoma fimbria	0	0			0	0			0	0		
	Antimora microlepis	2	0.011			1	0.005			2	0.008		
	Citharichthys sp.	0	0			0	0			0	0		
	Careproctus melanurus	0	0			0	0			0	0		
	Cottidae	0	0			0	0			0	0		
	Glyptocephalus zachirus	0	0			0	0			0	0		
	Gobiidae	0	0			0	0			0	0		
	Liparidae	0	0			0	0			0	0		
	Lycenchelys sp.	0	0			0	0			0	0		
	Lycodes sp.	0	0			0	0			0	0		
	Macrourid	0	0			2	0.010			4	0.017		
	Merluccius productus	0	0			0	0			0	0		
	Microstomus pacificus	0	0			1	0.005			1	0.004		
	Ophiodon elongatus	0	0			0	0			0	0		
	Perciformes	0	0			0	0			0	0		
	Pleuronectiformes	0	0			0	0			0	0		
	Salmon	0	0			0	0			0	0		
	Scorpaenid	0	0			0	0			0	0		
	Sebastes spp.	0	0			0	0			0	0		
	Sebastolobus sp.	8	0.044			6	0.029			17	0.071		
	Teleost	0	0			0	0			0	0		
	Zoarcidae	0	0			0	0			0	0		
Other	Bryozoa	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000
	Echiura	0	0			0	0			0	0		
	Polychaeta	0	0			0	0			0	0		
Porifera	Porifera	248	1.378	330	1.833	51	0.243	123	0.586	649	2.704	985	4.104
	White Goiter sponge	3	0.017			0	0			0	0		
	White Ruffled sponge	31	0.172			28	0.133			119	0.496		
	White Trumpet sponge	47	0.261			39	0.186			160	0.667		
	Yellow Goiter sponge	1	0.006			3	0.014			55	0.229		
	Yellow Picasso sponge	0	0			2	0.010			2	0.008		

Seamount 900 m station, cable	Seamount 900 m station, control	Seamount 800-900 m station, cable
Transect Abundance: 948 (5.3 per m)	**Transect Abundance: 625 (3.0 per m)**	**Transect Abundance: 2558 (10.7 per m)**
Number of Lowest Taxa: 20	**Number of Lowest Taxa: 21**	**No. of Lowest Taxa: 23**
Number of Taxon Groups: 5	**Number of Taxon Groups: 5**	**No. of Taxon Groups: 5**

APPENDIX E - Video Data Taxonomic Group Mean Abundance

Taxanomic Group	20 m	43 m		67 m		75 m		140 m		240 m		950 m		1940 m		Seamount 1700 m		Seamount 900 m	
	cable (n=39)	cable (n=12)	control (n=7)	cable (n=12)	control (n=7)	cable (n=8)	control (n=13)	cable (n=23)	control (n=22)	cable (n=11)	control (n=20)	cable (n=14)	control (n=7)	cable (n=1)	control (n=3)	cable (n=29)	control (n=6)	cable (n=5)	control (n=7)
Algae and eel grass	0.3±0.7	--	--	0.1±0.3	0±0	0±0	0.1±0.3	0.3±0.6 p=0.040	0±0.2	--	--	0.7±0.8 p=0.021	0.1±0.3	0±N/A	0.3±0.6	0±0.2	0.3±0.8	--	--
Agnatha	--	--	--	--	--	1.0±1.4	0.2±0.4	--	--	0.1±0.3	0.2±0.4	0.2±0.4	0.2±0.6	0±N/A	0.3±0.6	0±0.2	0±0	--	--
Cnidarians	0.2±0.4	--	--	1.9±1.2	3.4±2.8	13.5±14.3 p<0.001	0.6±1.0	130.2±65.2 p=0.040	94.7±47.5	4.5±3.1 p=0.01	1.4±1.6	46.5±22.8 p=0.004	24.7±11	52±N/A	33.7±16.6	1±1.8	1.2±1.6	67.8±19.1	46.5±30.8
Crustaceans	0.3±1.6	0.5±0.8	0.7±0.5	0.5±0.9	0±0	0.6±1.1	0.2±0.4	0.1±0.3	0.1±0.4	0.3±0.5	0.1±0.2	3.4±3.4 p=0.029	1.2±1	2±N/A	1.3±1.2	1±1	1±1.3	1.6±0.5	1.3±1.3
Echinoderms	11.4±8.4	0.3±0.5	0.3±0.5	242.1±116.4 p<0.001	715.3±219.5	652.2±273.5 p=0.030	347.5±182.0	2.8±1.5	3.5±2.4	34.7±33.4	36±22.7	1.9±1.1 p=0.012	0.9±1	22±N/A	51.7±35.1	1.2±1.6	3.7±3.1	32.8±32.0	17.1±16.1
Ectoprocta	--	--	--	--	--	--	--	0±0.2	0±0	--	--	--	--	--	--	--	--	--	--
Molluscs	0±0.2	--	--	0±0	0.1±0.4	0.1±0.3	0±0	0.3±0.6	0.1±0.3	0.4±0.5	0±0	--	--	--	--	0.4±0.8	1±1.5	--	--
Osteichthyes	0.4±0.6	2.6±2.5 p<0.001	0.1±0.3	6.2±6.4	6.7±4.4	43.1±35.3 p=0.002	8.7±5.5	2.3±2.3	1.8±3.1	4.1±2.5 p=0.026	2±1.9	8.9±5.5	7.6±4	0±N/A	0.3±0.6	1±1.2	1.7±1.6	1.2±2.2	0.7±1.0
Polychaeta	--	--	--	--	--	--	--	1.4±0	0.6±0	--	--	--	--	--	--	--	--	--	--
Porifera	0.5±1.1	0.1±0.3	0±0	--	--	--	--	--	--	--	--	--	--	--	--	0.1±0.4	0±0	57.0±54.8	17.3±28.0

Data are reported as mean abundance ± 1 standard deviation.
n= number of 30 m bins.
Standard deviation is N/A because n=1.
P values are given only for statistically significant results (p<0.05).

APPENDIX F - Infaunal Abundance

reported as mean abundance ± 1 standard deviation

Taxonomic Group	Lowest Taxon	43 m Cable (n=9)	43 m Control (n=10)	67 m Cable (n=10)	67 m Control (n=10)	75 m Cable (n=9)	75 m Control (n=11)	140 m Cable (n=10)	140 m Control (n=10)	240 m Cable (n=5)	240 m Control (n=5)	950 m Cable (n=10)	950 m Control (n=10)	1940 m Cable (n=4)	1940 m Control (n=5)	Seamount 1700 m Cable (n=5)	Seamount 1700 m Control (n=5)	Seamount 900 m Cable (n=5)	Seamount 900 m Control (n=5)
Annelida	Oligochaete	0.1 ± 0.3	1.2 ± 2.3	0.1 ± 0.3	0.0 ± 0.0	0.2 ± 0.4	0.4 ± 0.5	--	--	0.0 ± 0.0	0.2 ± 0.4	--	--	--	--	--	--	--	--
Cnidaria	Anthozoa	0.1 ± 0.3	0.0 ± 0.0	0.8 ± 0.9	1.3 ± 1.2	0.9 ± 0.3	0.6 ± 0.5	0.0 ± 0.0	1.5 ± 4.7	--	--	--	--	--	--	--	--	2.2 ± 3.3	2.0 ± 2.9
	Hydroid	0.0 ± 0.0	0.1 ± 0.3	0.1 ± 0.3	0.0 ± 0.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Pennatulacea	--	--	--	--	--	--	--	--	0.2 ± 0.4	0.2 ± 0.4	--	--	--	--	--	--	--	--
Crustacea	Amphipod	0.8 ± 1.4	0.5 ± 1.0	1.2 ± 1.1	1.5 ± 1.2	0.7 ± 0.9	1.3 ± 1.1	24.9 ± 12.0	26.1 ± 13.2	5.6 ± 2.9	4.6 ± 1.1	0.7 ± 0.6	0.3 ± 0.5	15.0 ± 8.4	14.2 ± 13.7	0.4 ± 0.9	1.2 ± 1.3	0.4 ± 0.5	1.0 ± 0.7
	Brachyura	0.1 ± 0.3	0.0 ± 0.0	0.2 ± 0.4	0.1 ± 0.3	0.2 ± 0.4	0.2 ± 0.4	--	--	--	--	--	--	--	--	--	--	--	--
	Cumacean	0.3 ± 0.7	0.0 ± 0.0	1.2 ± 1.1	1.9 ± 2.1	0.9 ± 0.3	0.5 ± 0.8	0.6 ± 0.7	0.3 ± 0.5	0.6 ± 0.9	0.8 ± 1.3	0.0 ± 0.0	0.1 ± 0.3	3.0 ± 2.9	1.2 ± 1.3	0.2 ± 0.4	0.6 ± 0.9	0.4 ± 0	0.4 ± 0.5
	Harpacticoid	0.9 ± 1.8	0.6 ± 1.0	0.1 ± 0.3	0.3 ± 0.7	0.7 ± 0.7	0.5 ± 0.5	1.9 ± 1.4	2.8 ± 5.4	0.0 ± 0.0	0.2 ± 0.4	0.2 ± 0.4	0.2 ± 0.4	0.5 ± 0.6 p=0.052, df=6.4	1.4 ± 0.5	0.0 ± 0.0	0.4 ± 0.5	--	--
	Isopod	0.1 ± 0.3	0.0 ± 0.0	0.3 ± 0.7	0.4 ± 0.7	0.1 ± 0.3	0.0 ± 0.0	0.5 ± 0.7	1.1 ± 1.5	--	--	--	--	1.3 ± 1.0	2.2 ± 1.8	0.6 ± 0.5 p=0.032, df=6.9	1.8 ± 0.8	0.4 ± 0.5	0.2 ± 0.4
	Ostracod	0.4 ± 1.0	0.5 ± 1.6	2.7 ± 2.6	5.3 ± 5.6	1.4 ± 0.5	1.2 ± 0.4	0.5 ± 0.8	0.6 ± 0.7	0.4 ± 0.5	0.4 ± 0.5	0.0 ± 0.0	0.1 ± 0.3	--	--	0.2 ± 0.4	0.0 ± 0.0	0.2 ± 0.4	0.0 ± 0.0
	Pagurid	4.0 ± 0.0	0.0 ± 0.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.2 ± 0.4
	Tanaid	--	--	--	--	--	--	0.6 ± 0.8	0.5 ± 0.7	0.2 ± 0.4	0.4 ± 0.9	0.1 ± 0.3	0.0 ± 0.0	1.5 ± 1.3	2.8 ± 1.5	0.8 ± 0.8	3.2 ± 2.9	0.2 ± 0.4	0.4 ± 0.5
Echinodermata	Holothurian	0.0 ± 0.0	0.1 ± 0.3	0.3 ± 0.9	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.3	0.0 ± 0.0	0.1 ± 0.3	--	--	--	--	0.3 ± 0.5	0.0 ± 0.0	--	--	0.2 ± 0.4	0.0 ± 0.0
	Ophuroid	0.1 ± 0.3	0.0 ± 0.0	1.0 ± 1.2	0.9 ± 0.9	0.4 ± 0.7	0.6 ± 0.7	0.8 ± 1.0	0.9 ± 0.7	0.4 ± 0.5	1.0 ± 0.7	0.5 ± 0.5	0.8 ± 0.9	--	--	0.8 ± 0.8	0.6 ± 0.5	2.6 ± 2.1	3.2 ± 2.6
Echiuran	Echiuran	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0 ± 0.0	0.2 ± 0.4
Mollusca	Aplacophoran	0.7 ± 2.0	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.3	--	--	--	--	--	--	0.6 ± 0.7	0.0 ± 0.0	0.0 ± 0.0	1.0 ± 0.7.0	0.2 ± 0.4	0.4 ± 0.5	0.4 ± 0.8	0.2 ± 0.4
	Bivalve	1.9 ± 3.9	0.5 ± 1.3	18.1 ± 11.5	10.4 ± 5.9	2.0 ± 0.7	2.7 ± 1.3	5.4 ± 3.2	5.0 ± 2.7	1.4 ± 1.1	2.4 ± 2.9	0.6 ± 0.7	1.0 ± 1.1	1.5 ± 1.3	1.0 ± 0.7	2.2 ± 1.5	2.0 ± 0.7	0.2 ± 0.4	0.0 ± 0.0
	Chiton	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.0 ± 0.2	0.2 ± 0.4
	Gastropod	0.9 ± 1.2	0.1 ± 0.3	5.6 ± 4.0	5.5 ± 3.9	1.1 ± 0.6	1.1 ± 1.1	1.4 ± 0.8	0.6 ± 1.1	0.6 ± 0.9	1.0 ± 0.7	0.1 ± 0.3	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.4	0.6 ± 0.9	0.4 ± 0.5	0.6 ± 0.5	1.6 ± 2.1
	Scaphopod	0.1 ± 0.3	0.0 ± 0.0	1.1 ± 1.6	0.1 ± 0.3	0.2 ± 0.4	0.4 ± 0.5	1.5 ± 0.8	1.9 ± 1.7	--	--	0.3 ± 0.4	0.4 ± 0.7	0.3 ± 0.5	0.2 ± 0.4	0.2 ± 0.4	0.6 ± 0.5	--	--
Nematoda	Nematode	43.6 ± 45.2	67.1 ± 55.8	7.6 ± 6.4	11.3 ± 8.5	0.9 ± 0.3	1.0 ± 0.0	5.6 ± 2.2	5.8 ± 3.4	7.6 ± 5.2	12.0 ± 6.4	5.1 ± 6.2	4.4 ± 5.5	11.3 ± 2.5	16.4 ± 10.8	10.6 ± 11.3	10.4 ± 6.3	12.8 ± 12.2	10.0 ± 14.2
Nemertea	Nemertea	2.1 ± 2.4	0.8 ± 1.1	1.6 ± 1.9	3.4 ± 2.0	0.7 ± 0.7	1.4 ± 1.0	2.1 ± 2.0	1.5 ± 1.2	0.4 ± 0.5	0.6 ± 0.5	0.8 ± 0.9	0.7 ± 0.8	1.0 ± 0.8	0.8 ± 0.8	0.2 ± 0.4	2.0 ± 2.8	0.4 ± 0.5	0.6 ± 1.3
Phoronida	Phoronid	0.1 ± 0.3	0.1 ± 0.3	1.7 ± 2.9	2.9 ± 2.1	0.6 ± 0.5	1.0 ± 0.0	2.2 ± 3.2	1.2 ± 1.9	--	--	--	--	--	--	--	--	--	--
Polychaeta	Polychaete	18.9 ± 17.9	17.1 ± 11.5	24.4 ± 8.8	27.4 ± 13.4	13.6 ± 4.9	11.9 ± 5.2	35.1 ± 8.2	34.1 ± 12.9	21.0 ± 7.3	25.0 ± 7.7	14.2 ± 3.2 p=0.002, df=14.5	9.8 ± 1.9	11.8 ± 4.8	13.8 ± 5.6	17.6 ± 7.2	15.8 ± 4.7	10.8 ± 4.1	7.2 ± 3.0
Pycnogonida	Pycnogonid	--	--	--	--	0.0 ± 0.0	0.1 ± 0.3	--	--	--	--	--	--	--	--	--	--	--	--
Sipunculid	Sipunculid	--	--	0.5 ± 0.5	0.0 ± 0.0	--	--	--	--	--	--	0.1 ± 0.0	0.0 ± 0.3	--	--	--	--	--	--

APPENDIX F - Estimated Number of Infaunal Taxa

reported as mean number of taxa ± 1 standard deviation

Taxonomic Group	Lowest Taxon	43 m		67 m		75 m		140 m		240 m		950 m		1940 m		Seamount 1700 m		Seamount 900 m	
		Cable (n=9)	Control (n=10)	Cable (n=10)	Control (n=10)	Cable (n=9)	Control (n=11)	A Cable (n=10)	A Control (n=10)	Cable (n=5)	Control (n=5)	E Cable (n=10)	E Control (n=10)	F Cable (n=4)	F Control (n=5)	D Cable (n=5)	D Control (n=5)	C Cable (n=5)	C Control (n=5)
Annelida	Oligochaete	0.1 ± 0.4	0.3 ± 0.5	0.1 ± 0.3	0.0 ± 0.0	0.2 ± 0.4	0.4 ± 0.5	--	--	0.0 ± 0.0	0.2 ± 0.4	--	--	--	--	--	--	--	--
Cnidaria	Anthozoa	0.1 ± 0.4	0.0 ± 0.0	0.6 ± 0.5	0.7 ± 0.5	0.9 ± 0.3	0.9 ± 0.8	0.0 ± 0.0	0.1 ± 0.3	--	--	--	--	--	--	--	--	0.8 ± 0.8	0.8 ± 0.8
	Hydroid	0.0 ± 0.0	0.1 ± 0.3	0.1 ± 0.3	0.0 ± 0.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Pennatulacea	--	--	--	--	--	--	--	--	0.2 ± 0.4	0.2 ± 0.4	--	--	--	--	--	--	--	--
Crustacea	Amphipod	0.6 ± 0.8	0.4 ± 0.7	1.1 ± 1	1.4 ± 1.0	0.8 ± 1.1	1.2 ± 1.0	3.7 ± 0.8	4.0 ± 2.1	3.2 ± 0.8	3.4 ± 1.1	0.7 ± 0.5	0.3 ± 0.5	2.5 ± 1.3	2.6 ± 0.9	0.4 ± 0.9	0.8 ± 0.8	0.4 ± 0.5	1.0 ± 0.7
	Brachyura	0.1 ± 0.4	0.0 ± 0.0	0.2 ± 0.4	0.1 ± 0.3	0.2 ± 0.4	0.3 ± 0.5	--	--	--	--	--	--	--	--	--	--	--	--
	Cumacean	0.3 ± 0.5	0.0 ± 0.0	0.9 ± 0.7	0.9 ± 0.7	0.8 ± 0.4	0.6 ± 0.8	0.6 ± 0.7	0.3 ± 0.5	0.4 ± 0.5	0.4 ± 0.5	0.0 ± 0.0	0.1 ± 0.3	1.5 ± 1.3	0.8 ± 0.8	0.2 ± 0.4	0.6 ± 0.9	0.0 ± 0.0	0.4 ± 0.5
	Harpacticoid	0.3 ± 0.5	0.4 ± 0.5	0.1 ± 0.3	0.2 ± 0.4	0.6 ± 0.7	0.7 ± 0.5	0.7 ± 0.5	0.7 ± 0.5	0.0 ± 0.0	0.2 ± 0.4	0.2 ± 0.4	0.2 ± 0.4	0.5 ± 0.6	1.0 ± 0.0	0.0 ± 0.0	0.4 ± 0.5	--	--
	Isopod	0.1 ± 0.4	0.0 ± 0.0	0.2 ± 0.4	0.4 ± 0.7	0.1 ± 0.3	0.0 ± 0.0	0.5 ± 0.7	0.6 ± 0.5	--	--	--	--	0.8 ± 0.5	1.4 ± 1.1	0.6 ± 0.5 p=0.050, df=8.0	1.4 ± 0.5	0.4 ± 0.5	0.2 ± 0.4
	Ostracod	0.3 ± 0.5	0.1 ± 0.3	0.9 ± 0.6	0.8 ± 0.4	1.3 ± 0.5	1.3 ± 0.5	0.4 ± 0.7	0.5 ± 0.5	0.4 ± 0.5	0.4 ± 0.5	0.0 ± 0.0	0.1 ± 0.3	--	--	0.2 ± 0.4	0.0 ± 0.0	0.2 ± 0.4	0.0 ± 0.0
	Pagurid	1.0 ± 0.0	0.0 ± 0.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0 ± 0.0	0.2 ± 0.4
	Tanaid	--	--	--	--	--	--	0.6 ± 0.8	0.5 ± 0.7	0.2 ± 0.4	0.2 ± 0.4	0.1 ± 0.3	0.0 ± 0.0	1.3 ± 1.0	2.4 ± 1.1	0.8 ± 0.8	2.2 ± 1.8	0.2 ± 0.4	0.4 ± 0.5
Echinodermata	Holothurian	0.0 ± 0.0	0.1 ± 0.3	0.1 ± 0.3	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.4	0.0 ± 0.0	0.1 ± 0.3	--	--	--	--	0.3 ± 0.5	0.0 ± 0.0	--	--	0.2 ± 0.4	0.0 ± 0.0
	Ophuroid	0.1 ± 0.4	0.0 ± 0.0	0.9 ± 1.0	0.6 ± 0.5	0.3 ± 0.5	0.7 ± 0.8	0.6 ± 0.7	0.7 ± 0.5	0.4 ± 0.5	1.0 ± 0.7	0.4 ± 0.5	0.5 ± 0.5	--	--	0.8 ± 0.8	0.6 ± 0.5	1.0 ± 0.7	0.8 ± 0.8
Echiuran	Echiuran	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0 ± 0.0	0.2 ± 0.4
Mollusca	Aplacophoran	0.1 ± 0.4	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.3	--	--	--	--	--	--	0.7 ± 0.8	0.0 ± 0.0	0.0 ± 0.0	0.8 ± 0.4	0.2 ± 0.4	0.4 ± 0.5	0.2 ± 0.4	0.2 ± 0.4
	Bivalve	0.6 ± 0.7	0.2 ± 0.4	2.6 ± 1.1	2.4 ± 1.0	2.0 ± 0.7	2.7 ± 1.3	2.5 ± 1.5	2.2 ± 1.2	1.0 ± 0.7	1.4 ± 1.5	0.4 ± 0.5	0.9 ± 1	1.3 ± 1	1 ± 0.7	1.8 ± 1.1	1.8 ± 0.8	0.2 ± 0.4	0.0 ± 0.0
	Chiton	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.2 ± 0.4	0.2 ± 0.4
	Gastropod	0.6 ± 0.7	0.1 ± 0.3	2.5 ± 1.4	2.0 ± 0.9	0.9 ± 0.6	1.3 ± 1.1	1.4 ± 0.8	0.6 ± 1.1	0.4 ± 0.5	1.0 ± 0.7	0.1 ± 0.3	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.4	0.6 ± 0.9	0.4 ± 0.5	0.6 ± 0.5	0.8 ± 0.8
	Scaphopod	0.1 ± 0.4	0.0 ± 0.0	0.5 ± 0.5	0.1 ± 0.3	0.3 ± 0.5	0.3 ± 0.5	0.9 ± 0.3	0.8 ± 0.4	--	--	0.4 ± 0.5	0.3 ± 0.5	0.3 ± 0.5	0.2 ± 0.4	0.2 ± 0.4	0.6 ± 0.5	--	--
Nematoda	Nematode	0.9 ± 0.4	0.9 ± 0.3	0.8 ± 0.4	0.9 ± 0.3	0.9 ± 0.3	1.0 ± 0.0	0.9 ± 0.3	0.9 ± 0.3	1.2 ± 0.4	1.0 ± 0.0	0.6 ± 0.5	0.5 ± 0.5	1.0 ± 0.0	1.0 ± 0.7	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	0.8 ± 0.4
Nemertea	Nemertea	0.9 ± 0.7	0.4 ± 0.5	0.6 ± 0.7	1.2 ± 0.8	0.7 ± 0.7 p=0.028, df=17.9	1.5 ± 0.9	1.0 ± 0.7	0.7 ± 0.5	0.4 ± 0.5	0.6 ± 0.5	0.5 ± 0.5	0.6 ± 0.7	0.8 ± 0.5	0.6 ± 0.5	0.2 ± 0.4	1.0 ± 0.7	0.4 ± 0.5	0.0 ± 0.0
Phoronida	Phoronid	0.1 ± 0.4	0.1 ± 0.3	0.4 ± 0.5	0.8 ± 0.4	0.6 ± 0.5	1.0 ± 0.0	0.5 ± 0.5	0.4 ± 0.5	--	--	--	--	--	--	--	--	--	--
Polychaeta	Polychaete	5.9 ± 2.7	4.5 ± 3.0	10.7 ± 3.2	12.8 ± 4.2	12.7 ± 4.3	12.6 ± 5.7	--	--	10.0 ± 2.4 p=0.010, df=12.1	14.8 ± 8.9	--	--	--	--	--	--	--	--
Pycnogonida	Pychnogonid	--	--	--	--	0.0 ± 0.0	0.1 ± 0.3	21 ± 5.6	17.2 ± 4.6	--	--	11.2 ± 2.6	8.5 ± 1.1	9.0 ± 3.2	11 ± 5.4	14.8 ± 6.2	11.4 ± 3.8	8.6 ± 4.2	5.8 ± 4.1
Sipunculid	Sipunculid	--	--	0.5 ± 0.5	0.0 ± 0.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--

APPENDIX G - Percent Cover Data

each station reported as mean percentage ± 1 standard deviation

Taxonomic Group	Lowest Taxon	20 m Cable (n=20)	43 m Cable (n=20)	43 m Control (n=20)	67 m Cable (n=20)	67 m Control (n=20)	75 m Cable (n=20)	75 m Control (n=20)	140 m Cable (n=19)	140 m Control (n=20)
Algae and eel grass	Coralline algae (encrusting)	2.0 ± 3.8	--	--	--	--	--	--	--	--
	Rhodophycota	0.5 ± 1.6	--	--	--	--	--	--	--	--
Agnatha	*Eptatretus stoutii*	--	--	--	--	--	--	--	--	--
Cnidarian	Actiniaria	0.2 ± 0.6	0.2 ± 0.9	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.9	--	--	--	--
	Actiniaria on cable	--	--	--	--	--	--	--	0.2 ± 0.9	0.0 ± 0.0
	Anthomastus ritteri	--	--	--	--	--	--	--	--	--
	Halipteris sp .	--	--	--	--	--	--	--	2.9 ± 3.0	4.1 ± 3.5
	Hormathiidae	--	--	--	--	--	--	--	--	--
	Metridium farcimen	--	0.2 ± 0.9	0.0 ± 0.0	--	--	0.9 ± 2.6	0.0 ± 0.0	--	--
	Metridium farcimen on cable	--	--	--	--	--	--	--	3.1 ± 9.3	0.0 ± 0.0
	Pennatulacea	--	--	--	0.1 ± 0.4	0.0 ± 0.0	0.3 ± 0.7	0.0 ± 0.0	--	--
	Stomphia spp.	--	--	--	--	--	--	--	--	--
	Stomphia spp. on cable	--	--	--	--	--	--	--	--	--
Crustacean	Paguridae	--	--	--	--	--	--	--	--	--
	Pandalidae	--	--	--	--	--	--	--	--	--
	Paralomis spp.	--	--	--	--	--	--	--	--	--
Echinoderm	*Allocentrotus fragilis*	--	--	--	--	--	--	--	--	--
	Asteroidea	1.3 ± 2.1	--	--	0.1 ± 0.4	0.0 ± 0.0	0.3 ± 1.0	0.1 ± 0.4	--	--
	Florometra serratissima on cable	--	--	--	--	--	--	--	--	--
	Gorgonocephalus	--	--	--	--	--	--	--	--	--
	Holothurian	--	--	--	--	--	--	--	--	--
	Mediaster sp.	--	--	--	--	--	--	--	--	--
	Ophiurida	--	--	--	6.1 ± 2.0	6.2 ± 4.0	6.6 ± 5.5	7.5 ± 4.5	--	--
	Psolus sp.	--	--	--	--	--	--	--	--	--
	Rathbunaster californicus	--	--	--	--	--	--	--	--	--
Mollusc	Gastropod	0.2 ± 0.6	--	--	--	--	--	--	--	--
	Pleurobranchaea californica	--	--	--	--	--	--	--	0.8 ± 3.7	0.0 ± 0.0
Ostheichthyes	*Lycodes sp.*	--	--	--	--	--	--	--	--	--
	Pleuronectiformes	--	--	--	--	--	0.4 ± 1.0	0.0 ± 0.0	0.2 ± 0.9	0.0 ± 0.0
	Sebastolobus sp.	--	--	--	--	--	--	--	--	--
Porifera	Porifera	0.7 ± 2.4	--	--	--	--	--	--	--	--
	Porifera/Tunicate	0.1 ± 0.4	--	--	--	--	--	--	--	--
	White Ruffled sponge	--	--	--	--	--	--	--	--	--
	White Trumpet sponge	--	--	--	--	--	--	--	--	--
	Yellow Goiter sponge	--	--	--	--	--	--	--	--	--
Physical Features	Cable	6.0 ± 0.0	2.3 ± 2.5	0.0 ± 0.0	--	--	--	--	0.5 ± 1.3	0.0 ± 0.0
	Fray/Kelp	10.6 ± 19.6	3.4 ± 6.7	0.0 ± 0.0	--	--	--	--	--	--
	Incised rock	2.2 ± 6.8	--	--	--	--	--	--	--	--
	Rock	67.5 ± 24.3	--	--	--	--	--	--	--	--
	Sediment	4.4 ± 19.7	62.0 ± 42.0	39.6 ± 49.8	65.4 ± 44.0	0.0 ± 0.0	67.5 ± 40.2	22.4 ± 39.9	92.2 ± 10.7	95.9 ± 3.5
					p<0.001, df=1*		p=0.001, df=38			
	Sediment, ripple marks	--	0.0 ± 0.0	14.9 ± 36.4	28.3 ± 44.4	93.6 ± 3.8	24 ± 42.7	70 ± 41.6	--	--
					p<0.001, df=1*		p=0.001, df=38			
	Sediment, sand waves	--	28.3 ± 44.5	44.4 ± 50.4	--	--	--	--	--	--
	Shell hash	0.9 ± 1.8	3.6 ± 3.5	1.1 ± 1.2	--	--	--	--	--	--
			p=0.038, df=38							
	Suspended cable	2.8 ± 8.4	--	--	--	--	--	--	--	--
	Urchin bore hole	0.6 ± 1.8	--	--	--	--	--	--	--	--
	*Mann-Whitney U test									

APPENDIX G - Percent Cover Data

each station reported as mean percentage ± 1 standard deviation

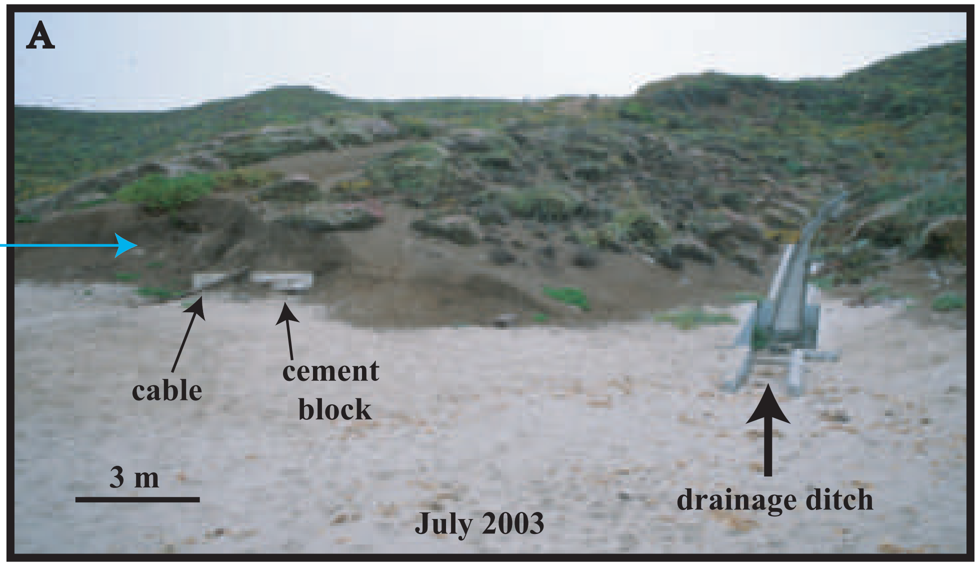
Taxonomic Group	Lowest Taxon	240 m		950 m		1940 m		Seamount 1700 m		Seamount 900 m	
		Cable (n=20)	Control (n=20)	Cable (n=20)	Control (n=20)	Cable (n=4)	Control (n=16)	Cable (n=20)	Control (n=20)	Cable (n=20)	Control (n=20)
Algae and eel grass	Coralline algae (encrusting)	--	--	--	--	--	--	--	--	--	--
	Rhodophycota	--	--	--	--	--	--	--	--	--	--
Agnatha	*Eptatretus stoutii*	--	--	0.3 ± 1.3	0.0 ± 0.0	--	--	--	--	--	--
Cnidarian	Actiniaria	--	--	--	--	0.5 ± 1.0	0.3 ± 0.7	--	--	0.4 ± 0.8	0.1 ± 0.4
	Actiniaria on cable	--	--	--	--	--	--	--	--	--	--
	Anthomastus ritteri	--	--	--	--	--	--	--	--	0.2 ± 0.6	0.1 ± 0.4
	Halipteris sp .	--	--	0.2 ± 0.6	0.2 ± 0.6	--	--	--	--	--	--
	Hormathiidae	--	--	--	--	0.5 ± 1.4	0.0 ± 0.0	--	--	--	--
	Metridium farcimen	0.4 ± 1.2	0.0 ± 0.0	--	--	--	--	--	--	--	--
	Metridium farcimen on cable	--	--	--	--	--	--	--	--	--	--
	Pennatulacea	0.0 ± 0.0	0.2 ± 0.6	--	--	--	--	--	--	--	--
	Stomphia spp.	--	--	0.2 ± 0.6	0.0 ± 0.0	--	--	--	--	0.0 ± 0.0	0.1 ± 0.4
	Stomphia spp. on cable	--	--	1.1 ± 1.5	0.0 ± 0.0	--	--	--	--	--	--
Crustacean	Paguridae	0.1 ± 0.4	0.0 ± 0.0	--	--	--	--	--	--	--	--
	Pandalidae	--	--	--	--	--	--	0.0 ± 0.0	0.1 ± 0.4	--	--
	Paralomis spp.	--	--	--	--	--	--	0.0 ± 0.0	0.3 ± 1.3	0.0 ± 0.0	0.1 ± 0.4
Echinoderm	*Allocentrotus fragilis*	1.9 ± 3.3	0.6 ± 1.3	--	--	--	--	--	--	--	--
	Asteroidea	0.1 ± 0.4	0.1 ± 0.4	--	--	--	--	--	--	--	--
	Florometra serratissima on cable	--	--	--	--	--	--	--	--	0.2 ± 0.6	0.0 ± 0.0
	Gorgonocephalus	0.2 ± 0.9	0.0 ± 0.0	--	--	--	--	--	--	--	--
	Holothurian	--	--	--	--	0.5 ± 1.0	2.0 ± 3.0	0.0 ± 0.0	0.1 ± 0.4	--	--
	Mediaster sp.	--	--	--	--	--	--	--	--	0.2 ± 0.6	0.1 ± 0.4
	Ophiurida	--	--	0.0 ± 0.0	0.1 ± 0.4	3.5 ± 1.9	1.8 ± 2.0	6.9 ± 4.1	7.1 ± 4.3	--	--
	Psolus sp.	--	--	--	--	--	--	--	--	0.0 ± 0.0	0.2 ± 0.6
	Rathbunaster californicus	0.3 ± 1.0	0.0 ± 0.0	--	--	--	--	--	--	--	--
Mollusc	Gastropod	--	--	--	--	--	--	--	--	--	--
	Pleurobranchaea californica	--	--	--	--	--	--	--	--	--	--
Ostheichthyes	*Lycodes sp.*	0.2 ± 0.9	0.0 ± 0.0	--	--	--	--	--	--	--	--
	Pleuronectiformes	--	--	--	--	--	--	--	--	--	--
	Sebastolobus sp.	0.1 ± 0.4	0.1 ± 0.4	--	--	--	--	--	--	--	--
Porifera	Porifera	--	--	--	--	--	--	--	--	--	--
	Porifera/Tunicate	--	--	--	--	--	--	--	--	--	--
	White Ruffled sponge	--	--	--	--	--	--	--	--	0.6 ± 2.0	0.3 ± 1.0
	White Trumpet sponge	--	--	--	--	--	--	--	--	0.2 ± 0.9	0.4 ± 1.8
	Yellow Goiter sponge	--	--	--	--	--	--	--	--	0.6 ± 1.8	0.2 ± 0.9
Physical Features	Cable	3.3 ± 2.6	0.0 ± 0.0	4.4 ± 2.3	0.0 ± 0.0	6.5 ± 1.9	0.0 ± 0.0	4.3 ± 1.0	0.0 ± 0.0	4.7 ± 1.2	0.0 ± 0.0
	Fray/Kelp	--	--	--	--	--	--	--	--	--	--
	Incised rock	--	--	--	--	--	--	--	--	--	--
	Rock	0.4 ± 1.8	0.0 ± 0.0	--	--	--	--	--	--	--	--
	Sediment	91.2 ± 5.2	98.4 ± 2.0	93.8 ± 2.9	99.7 ± 0.7	88.0 ± 5.2	96.0 ± 2.9	88.8 ± 3.9	92.4 ± 4.6	92.9 ± 4.5	98.4 ± 3.6
		p<0.001, df=37.2		p<0.001, df=21.4		p=0.048, df=3.5		p=0.011, df=37.1		p<0.001, df=36.2	
	Sediment, ripple marks	--	--	--	--	--	--	--	--	--	--
	Sediment, sand waves	--	--	--	--	--	--	--	--	--	--
	Shell hash	1.8 ± 3.1	0.6 ± 1.1	--	--	--	--	--	--	--	--
	Suspended cable	--	--	--	--	--	--	--	--	--	--
	Urchin bore hole	--	--	--	--	--	--	--	--	--	--

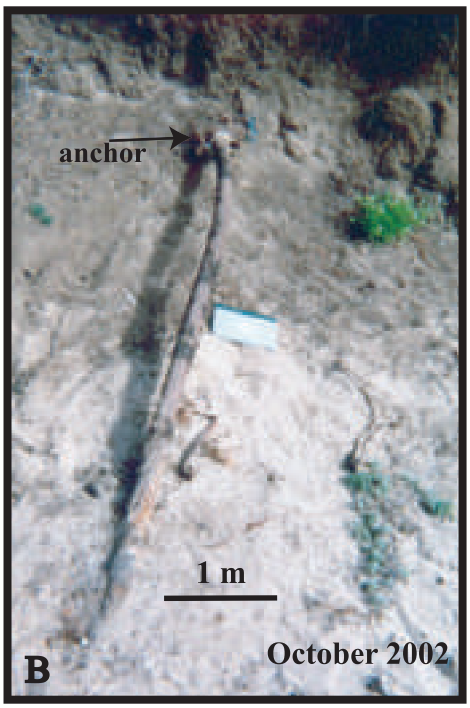
*Mann-Whitney U test

APPENDIX H – Exposure of a cable on the beach near Pillar Point

A submarine cable is currently exposed on the beach near Pillar Point within 9 m of a prominent drainage ditch (Figure 22). Whether the exposed cable is the ATOC/Pioneer Seamount cable is unclear. The beach is next to an Air Force facility where other cables may have been installed. A minimum of two cables exist in this area because of the cable crossing seen at the 20 m station and the cable videotaped during the ATOC pre-installation nearshore diver survey (SSI 1993). However, the exposed cable is of similar dimensions and is anchored using the same method as was employed during ATOC/Pioneer Seamount cable installation (University of Washington 1995). The exposed cable is located to the north of the drainage ditch similar to the diagrammatic location of the ATOC/Pioneer Seamount cable (University of Washington 1995; Figure 22). Hand drawn sketches included in the ATOC/Pioneer Seamount cable installation materials sent to MBARI from UW-APL indicate that cable installation was planned 2.5 to 3 m north of the drainage ditch, considerably closer to the ditch than the location of the cable currently exposed on the beach.

The cliff face behind the beach in this location is eroding (Figure 22). Even if the exposed cable is not the ATOC/Pioneer Seamount cable, any cable installed into the cliff face will become exposed with time producing an aesthetic impact. If the ATOC/Pioneer Seamount cable is not currently exposed on the beach, it may be years before it becomes exposed. The implied concern regarding exposure is due to environmental impacts associated with reburial activities (e.g. public access, recreation, water quality, and marine resource impacts) (CCC 2002). The Marine Reserve status of the beach where the ATOC/Pioneer Seamount cable comes on shore (http://www.eparks.net/Parks/Fitzgerald/) should also be considered in an impact evaluation.





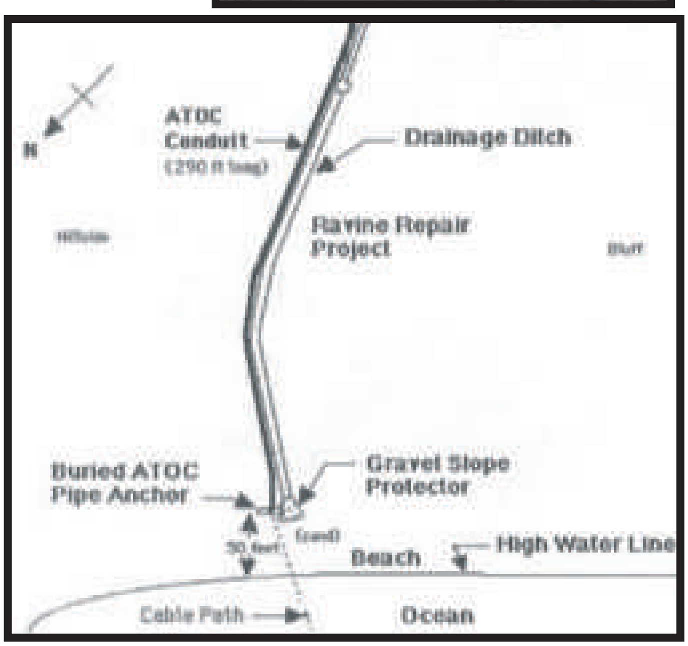


Figure 22: Photographs and diagram of the beach near Pillar Point where the ATOC/Pioneer Seamount cable comes on shore. North is to the left in all photographs. **A:** Photograph showing the relative positions of the drainage ditch and the submarine cable exposed on the beach taken in July 2003. **B:** Photograph showing a close-up of the cable taken in October 2002. **C:** Photograph showing a close-up of the cable taken in July 2003. Note that a cement block is seen in the more recent photograph. Also note that more of the cable is exposed behind the deadman anchor in the more recent photo and that the cliff face has retreated. **D:** Diagram showing the location of the ATOC/Pioneer Seamount cable buried anchor relative to the drainage ditch (University of Washington 1995).

APPENDIX I – Cost of the ATOC/Pioneer Seamount Cable Survey

The ATOC/Pioneer Seamount cable has had an economic impact on NOAA and MBARI resources. The costs of conducting this survey included 15 days of shiptime, supplies, equipment rental, 2 people years of effort for planning and data analysis, and considerable time from MBARI shore-based support staff. We estimate that the entire effort involved $500,000. NOAA contributed $145,000 toward shiptime, Irina Kogan's salary, and infaunal characterization. Some of Erica Burton's time was also dedicated to the project. NOAA's contribution to these studies is ~30% of the real costs. MBARI absorbed the rest. While the scientific efforts invested in conducting this survey may have exceeded the minimum effort required to fulfill the conditions of NOAA-OAR's permit, the entire cable route was not surveyed as preferred in the permit. The cost of carrying out the study as stated in the permit would be considerably more expensive. One has to consider the benefits of such surveys and what may have been done if these resources were not committed. This is especially relevant where the cable is installed, surveyed, and removed using public monies.