Yam-3 Environmental Monitoring Post-Drill Survey Report

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EXECUTIVE SUMMARY

Shemen Oil and Gas Resources Ltd (Shemen) has conducted drilling at the Yam-3 exploration well located in the Shemen License off the Israeli coast. As part of this effort, the Ministry of Environmental Protection (MoEP) and Ministry of Energy and Water Resources (MEWR) required Shemen to develop and implement an environmental monitoring program, which consisted of pre-drill and post-drill environmental surveys. The Yam-3 Environmental Baseline Survey was conducted in September 2012 prior to drilling activities. Drilling of the Yam-3 well was completed on 15 October 2013. Final abandonment of the well was performed between 24 October and 3 November 2013. The Post-Drill survey began on 24 November 2013, 21 days after drilling activities were completed at the Yam-3 wellsite. Video data, hydrographic profiling data, water column samples, and sediment samples were collected during the Post-Drill survey.

The purpose of the Yam-3 environmental monitoring program was to characterize the environmental conditions in the vicinity of the wellsite before and after drilling activities. The physical, chemical, geological, and biological environmental conditions were inspected for temporal and spatial variation within the study area. These data were used to assess potential effects from drilling discharges by comparing deviations from natural background values that were provided in the EBS (Pre-Drill survey). In addition, the data were used to provide information on deviations from internationally and locally accepted environmental standards.

The sampling effort consisted of 1) collection of video data; 2) hydrographic profiling of the water column and collection of water samples at specific depths in the water column; and 3) collection of sediment and infaunal samples. To generally characterize the substrate and associated biological community, video data were collected from eight 250-m transects radiating from the wellsite at 45º intervals and from four 200-m transects radiating at 90º intervals from the center point of two reference locations. Water samples were collected both within 250 m of the wellsite and at 3,000 m from opposite sides of the wellsite as reference locations.

Hydrographic profiling of the water column was performed to acquire measurements of conductivity (salinity), temperature, fluorescence, and dissolved oxygen concentrations from the ocean surface to the seafloor. Seawater samples were collected at three discrete water depths (i.e., near-surface, mid-depth, and near-bottom) at the wellsite and the two reference locations. Sediment sampling was conducted using a stratified random pattern within four strata: wellsite or Center (0- to 250-m wellsite radius); Near-field (250- to 500-m wellsite radius); Mid-field (500- to 1,000-m wellsite radius); Far-field (1,000- to 2,000-m wellsite radius); and reference areas: North Reference (3,000 m north of the wellsite), and South Reference (3,000 m south of the wellsite). Sediment samples were collected at seven randomly located stations within each of the four strata and two reference areas (total 42 samples).

The seafloor observed within the survey area was relatively flat with many small irregularities of the sediment surface, apparently caused by resident burrowing biota. Similar observations were made during the Pre-Drill survey throughout the entire survey area. As anticipated after drilling activities, the wellsite area was covered with large sediment particles and coarse grain sediment, becoming more prevalent closer to the wellhead and slightly raising the topography. Cuttings, identified by coarse unconsolidated fragments lying on the seafloor, were observed within 100 m of the wellhead. Cement pieces were observed within 50 m of the wellhead. Anthropogenic debris was occasionally observed within the wellsite survey area. No hard bottom substrate or chemosynthetic communities were observed within the survey area. Biological activity, including the presence of motile biota and bioturbation, was observed and mapped within the survey area during the Post-Drill survey. The organisms most commonly observed (only a Post-Drill visual survey was conducted) were fishes, seapens, sea urchins, and feather stars. Biological activity was detected at the wellhead itself as it was encrusted by tube worm-snails and inhabited with fishes. Biological activity at the Pre-Drill survey of Yam-3 wellsite was only qualitatively described and observed to be sparse and included organisms similar to those mentioned for the Post-Drill survey.

Seawater analysis indicated that TSS concentrations observed during the Post-Drill survey were in agreement with results obtained in studies from recent years conducted in a similar environment in the northeastern Mediterranean. Post-Drill nutrient concentrations in seawater remained low and stable throughout the water column as expected due to light penetration to all water depths, resulting in primary production activity and high nutrient consumption. All total petroleum hydrocarbon (TPH) and alkane values in seawater were well below the proposed maximum concentrations in the Environmental Quality Standards for the Mediterranean Sea in Israel (also referred to as the Mediterranean Environmental Water Quality Standards [MEQS]). Minute differences between Pre-Drill and Post-Drill metals concentrations in seawater may be due to the change in laboratories between the two surveys following a request by the MoEP. Nonetheless, these results indicated that water quality within the survey area was not impacted by drilling activities.

Sediment samples were analyzed to determine grain size distribution and concentrations of total organic carbon (TOC), total metals, hydrocarbons, and radionuclides. An analysis of sediment parameters suggested that statistically detectable changes occurred in sediment grain size at the Yam-3 survey area; however, these changes were minimal and localized to the vicinity of the drillsite. Percentages of sand changed throughout the survey area, presumably through natural processes (winter storms). Sediment characteristics throughout the survey area did not change substantially from the Pre-Drill and could generally be classified as Clayey Silt.

Post-Drill total organic carbon (TOC) concentrations in sediments were low throughout the survey area, including the reference areas. Similar results were obtained during the Pre-Drill survey, indicating that drilling activities did not influence the organic carbon levels in the sediments.

Metals results for the Post-Drill survey were analyzed in a different laboratory than the one used for the Pre-Drill survey because of a specific requirement by the MoEP. Thus, in many instances, the effects of drilling activities were investigated mainly by the differences between strata in the Post-Drill survey. Statistical analysis of seafloor sediment metals concentrations indicated that a potential drilling effect was found for barium (Ba) and lead (Pb). Both metals were present in high concentrations in the barite used for drilling activities. Silver (Ag), mercury (Hg), and antimony (Sb) had statistically higher concentrations at the Center stratum during Post-Drill survey, but the concentrations were below Effects Range Low (ERL), indicating absence of an environmental effect.

Assessment of alkanes and TPH in sediments revealed some significant differences between the Center and other strata, but effects were inconsistent. Eight alkanes, including total alkanes, did not vary in a way that indicated drilling effects; only four alkanes suggested a potential drilling effect. TPH was found to be significantly higher at the Near-field stratum. These findings suggest a consistent but minor drilling effect. There are no toxicity reference values available for alkanes in sediment. Sediment polyaromatic hydrocarbons (PAHs) also were tested. Although significant differences were detected among strata, there was no coherent sequence to the pattern of differences with distance from the wellsite, indicating a lack of drilling effect. For example, total PAHs were significantly higher at the Center stratum, but not from the Mid-field stratum. We therefore conclude that the PAHs are likely patchily distributed over the seafloor.

Radionuclides were not sampled during the Yam-3 Pre-Drill survey. Statistical analysis (ANOVA) was applied for the Post-Drill survey radionuclides results. Only Pb 210 (lead) was found to be significantly different, being lower at the Center and Near-field stratum than all other strata, suggesting a dilution effect from deposition of new sediments.

The infaunal assemblage in the survey area exhibited high abundances and diversity. For the Pre-Drill survey, 32 infaunal benthic samples yielded 2,285 individual organisms representing 153 taxa; and for the Post-Drill survey, 42 infaunal benthic samples yielded 7,296 individual organisms representing 202 taxa. Polychaetes were the most abundant taxa collected during both surveys. A two-way ANOVA was conducted to determine if there were statistically significant differences in infaunal characteristics between the Pre-Drill and Post-Drill surveys as well as among sampling strata. Significant differences and interaction among survey and strata were observed in three out of five metrics calculated. However, these differences lacked a coherent sequential pattern that would indicate a consistent drill effect. Nonetheless, both species richness and species abundance presented higher values at the Post-Drill than observed at the Pre-Drill. The uniformity of results suggested that differences might more likely be attributed to natural seasonal conditions and biological activity rather than being drilling related. Infauna in both surveys were relatively even, meaning species were well represented. Similarly, a comparison of diversity between the Pre-Drill and Post-Drill surveys showed little change with nonmeaningful differences in the survey by strata interaction.

TABLE OF CONTENTS

Page

Page

List of Tables

List of Figures

Figure **Page**

LIST OF IMAGES

List of Acronyms and Abbreviations

Ac	actinium
ANOVA	analysis of variance
$BaSO_4$	barium sulfate
CCC	Criterion Continuous Concentration
CCD	charge-coupled device
CO_2	carbon dioxide
CoC	chain-of-custody
CSA	CSA Ocean Sciences Inc.
CTD	conductivity, temperature, and depth
DGPS	differential global positioning system
DO	dissolved oxygen
EBS	Environmental Baseline Survey
EDTA	ethylenediaminetetraacetic acid
EMSL/LV	Environmental Monitoring Systems Laboratory, Las Vegas
ERL	Effects Range Low
ERM	Effects Range Median
FTU	formazin turbidity unit
GC-MS	gas chromatography-mass spectrometry
GPS	global positioning system
HCL	hydrochloric acid
HF	hydrofluoric acid
HNO_3	nitric acid
ICP-AES	inductively coupled plasma-atomic emission spectrometry
ICP-MS	inductively coupled plasma-mass spectrometry
ISO	International Organization for Standardization
ITM	Israeli Transverse Mercator
MCL	maximum contaminant level
MDL	method detection limit
MEQS	Mediterranean Environmental Water Quality Standards
MEWR	Ministry of Energy and Water Resources
MoEP	Ministry of Environmental Protection
NH_4	ammonium
NO_2	nitrite
NO_3	nitrate
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
PO_4	phosphate
ppm	parts per million
PSA	particle size analysis
QC	quality control
Ra	radium
Rn	radon
ROV	remotely operated vehicle
SAP	Sampling and Analysis Plan
SBE	Sea-Bird Electronics
Shemen	Shemen Oil and Gas Resources Ltd
SOW	Scope of Work
Th	thorium
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TPH	total petroleum hydrocarbons
TSS	total suspended solids
USEPA	U.S. Environmental Protection Agency
Y	yttrium

1.0 INTRODUCTION

Shemen Oil and Gas Resources Ltd (Shemen) has conducted drilling at the Yam-3 exploration well located in the Shemen License off the Israeli coast. The Yam-3 drillsite is located approximately 15 km off the Israeli coastline (**Figure 1**) in the southeastern portion of the Levantine Basin in a water depth of approximately 90 m. Drilling of the Yam-3 well was completed on 15 October 2013, immediately followed by well testing of the reservoir and concluding that the well was a dry hole. Final abandonment of the well was performed between 24 October and 3 November 2013. Total volumes of discharged waste for the Yam-3 wellsite, including drill cuttings and drilling fluids, is provided in **Table 1**.

Table 1. Total discharge sources and volumes during drilling operations at the Yam-3 wellsite. (All volumes are in m^3 unless otherwise indicated).

Indicator	Contractor	Total Volume
Drilling fluid	MI-Swaco	**7,377**
Drill cuttings (tons)	MI-Swaco	**2,849**
Waste water (oil-water separator)	Atwood Beacon	**367.0**
Sanitary treated water	Atwood Beacon	**1,623**
Gray water	Atwood Beacon	**8,550**
Desalinated water	Atwood Beacon	**641,753**
Cooling system water	Atwood Beacon	**2,667,980**
Shredded organic kitchen waste	Atwood Beacon	**9**
Cement	Schlumberger	**60**

1.1 BACKGROUND

The Ministry of Environmental Protection (MoEP) and Ministry of Energy and Water Resources (MEWR) required Shemen to develop and implement an environmental monitoring program, which consisted of Pre-Drill and Post-Drill environmental surveys. Shemen contracted CSA Ocean Sciences Inc. (CSA)[1] to provide support for the environmental monitoring program. This support included developing a Scope of Work (SOW) and Sampling and Analysis Plan (SAP) as well as conducting the environmental monitoring. CSA, on behalf of Shemen, conducted an Environmental Baseline Survey (Pre-Drill survey) at the Yam-3 wellsite in September 2012 prior to formally implementing environmental monitoring program for offshore exploration activities. To comply with the MoEP environmental monitoring program, a post-drill environmental survey SOW/SAP for the Yam-3 wellsite was submitted to the MoEP in October 2013. The SOW/SAP was based on MoEP and MEWR Appendix A1 “Guidelines for Marine Monitoring for the purpose of Studying the Effects of Oil and Gas Exploration Activities on the Marine Environment in the State of Israel” and incorporated MoEP-specific comments on the pre-drill survey report. The SOW/SAP was the guidance document used for conducting the Yam-3 Post-Drill survey. It described the environment in the vicinity of the wellsite, parameters to be sampled, sampling methods, data processing and laboratory methods, and data analysis and reporting as described in this report. The approved SOW/SAP and the MoEP’s Scope of Work Approval are provided in **Appendices A** and **B**, respectively. **Appendix C** is the MoEPDischarge Permit. The drilling plan for the Yam-3 location, including a description of the drilling rig, a timeline for drilling activities, and a discussion of drilling discharges, is presented in the Yam-3 Exploration Program Environmental Assessment (AdaMa, 2012).

[1] CSA International, Inc. changed its company name to CSA Ocean Sciences Inc. effective 1 January 2013.

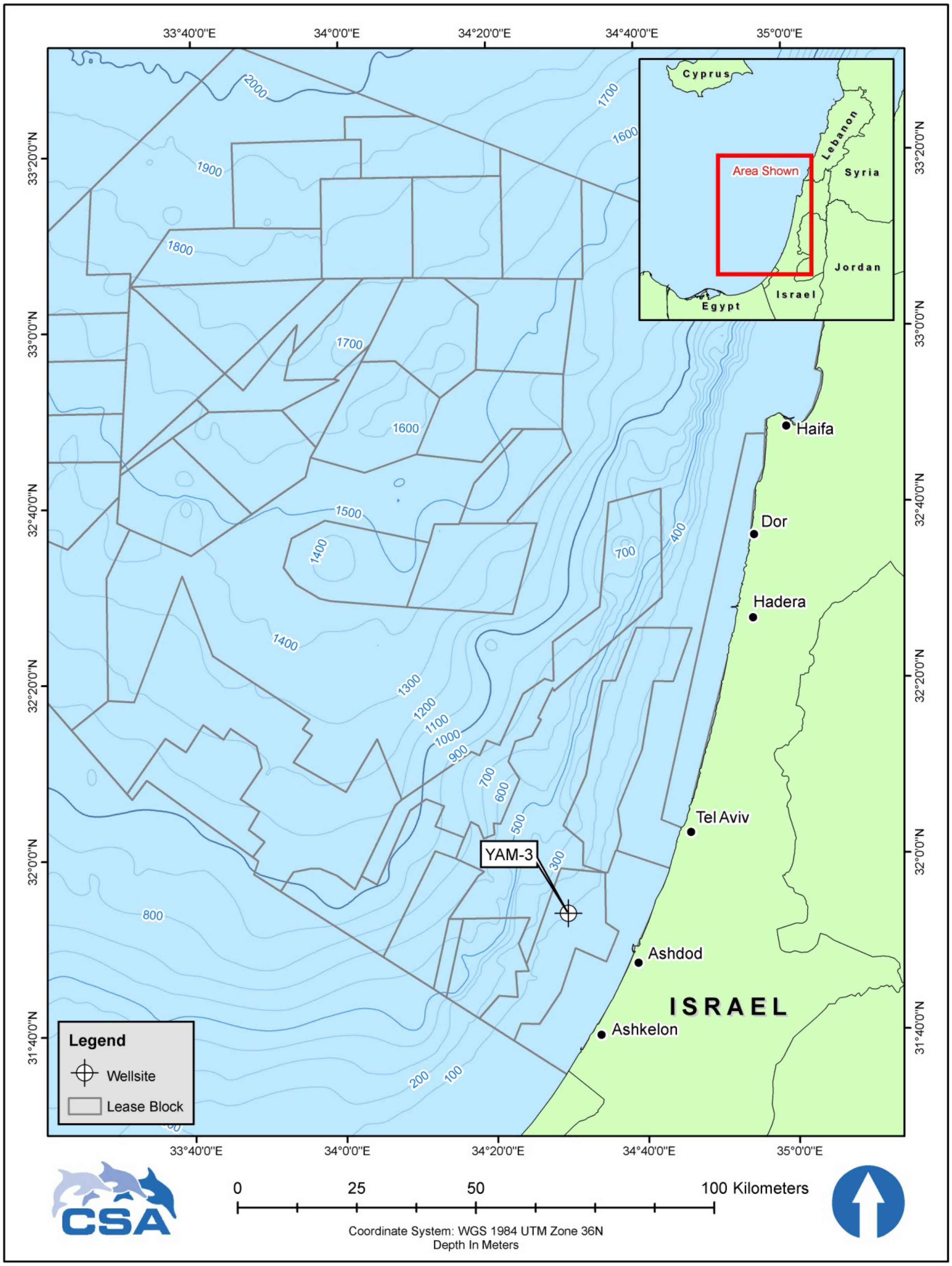


Figure 1. Location of the Yam-3 drillsite relative to the Israeli coastline and boundaries of offshore lease blocks.

The purpose of the Yam-3 environmental monitoring program was to characterize the environmental conditions in the vicinity of the wellsite before and after drilling activities were completed. The main objectives of the monitoring program according to the accepted SOW/SAP were to:

- Determine the temporal and spatial variation of selected environmental components (i.e., chemical, geological, physical, and biological) within the study area; and
- Assess potential effects from drilling discharges on selected environmental components.

In addition to these objectives, the results of the monitoring program (both Pre-Drill and Post-Drill survey data) will be compared to regional baseline data and internationally and locally accepted environmental standards to determine the ecological significance of any deviations from background levels. Monitoring will provide warnings on possible deviations from acceptable environmental standards (World and Israel), including deviations from natural background.

2.0 SURVEY DESIGN

The Post-Drill survey began on 24 November 2013, 21 days after the *Atwood Beacon* jack-up rig was released from the wellsite and the site was abandoned. Sampling efforts for the Pre-Drill and Post-Drill surveys were conducted within 3 km of the Yam-3 wellsite (**Figures 2** and **3**). The WGS84 coordinates for the Yam-3 wellhead are 31°53'41.4716" North and 34°29'42.6930" East. The UTM Zone 36N coordinates are northing 3,529,756 and easting 641,397. The Israel Datum ITM (Israeli Transverse Mercator) coordinates are 152359.59 easting and 644878.67 northing.

2.1 STATION CONFIGURATION

The Post-Drill survey used the same stratified random sampling design as the Pre-Drill survey. All stations were "re-randomized" within the strata for the Post-Drill survey. **Figure 2** shows the locations of the water and sediment sampling locations, including reference areas. Geographic coordinates of the sampling stations are listed in **Appendix D**. The sampling design is a key component of any monitoring study. The stratified random sampling design has proven to be statistically defensible and avoids potential pseudo-replication (sensu Hurlbert, 1984). Pseudo-replication can occur if treatment effects are tested with an error term that is inappropriate to the hypothesis being considered. In contrast, a fixed station approach means that statistical inference can only be made between the individual stations and not for distance, per se. Therefore, a statistical inference cannot be drawn relative to a particular distance from the wellsite, otherwise there is pseudo-replication. The stratified random approach avoids this complication because individual box cores are randomly located within each stratum (distance zone such as 0 to 250 m from the wellsite location), which results in the ability to make statistical inferences concerning the strata (i.e., among distances from the wellsite). Thus results obtained from the stratified random approach are more representative of the conditions within each stratum and among the strata and, consequently, are more informative concerning the extent of impacts.

The stratified random sampling design consisted of seven re-randomized sediment stations within four sampling strata (**Figure 2**) as follows (distances are from the wellsite location):

- Center: 0 to 250 m;
- Near-field: 250 to 500 m;
- Mid-field: 500 to 1,000 m; and
- Far-field: 1,000 to 2,000 m.

The survey design also included two randomly located reference areas located 3,000 m from the wellsite (**Figure 2**) to the northeast and to the southwest. The reference areas established during the Pre-Drill survey were designed as four stations located 500 m apart along the 3,000-m line. For the Post-Drill survey, the strata design was adopted when seven stations defined by a 250-m radius circle were sampled. The reference areas were located in the same general water depth and characterized by a similar sediment texture as the experimental stations and between the two surveys. In accordance with the latest guidelines of MoEP and MEWR (October 2013), two alterations in station layout were made to the Post-Drill SOW/SAP: seven sampling stations were added at the Far-field (2,000-m) stratum (**Figure 2**) and the two 400-m video transects were converted into four 250-m video transects radiating at 90º intervals from the center point of each reference location (**Figure 3**).

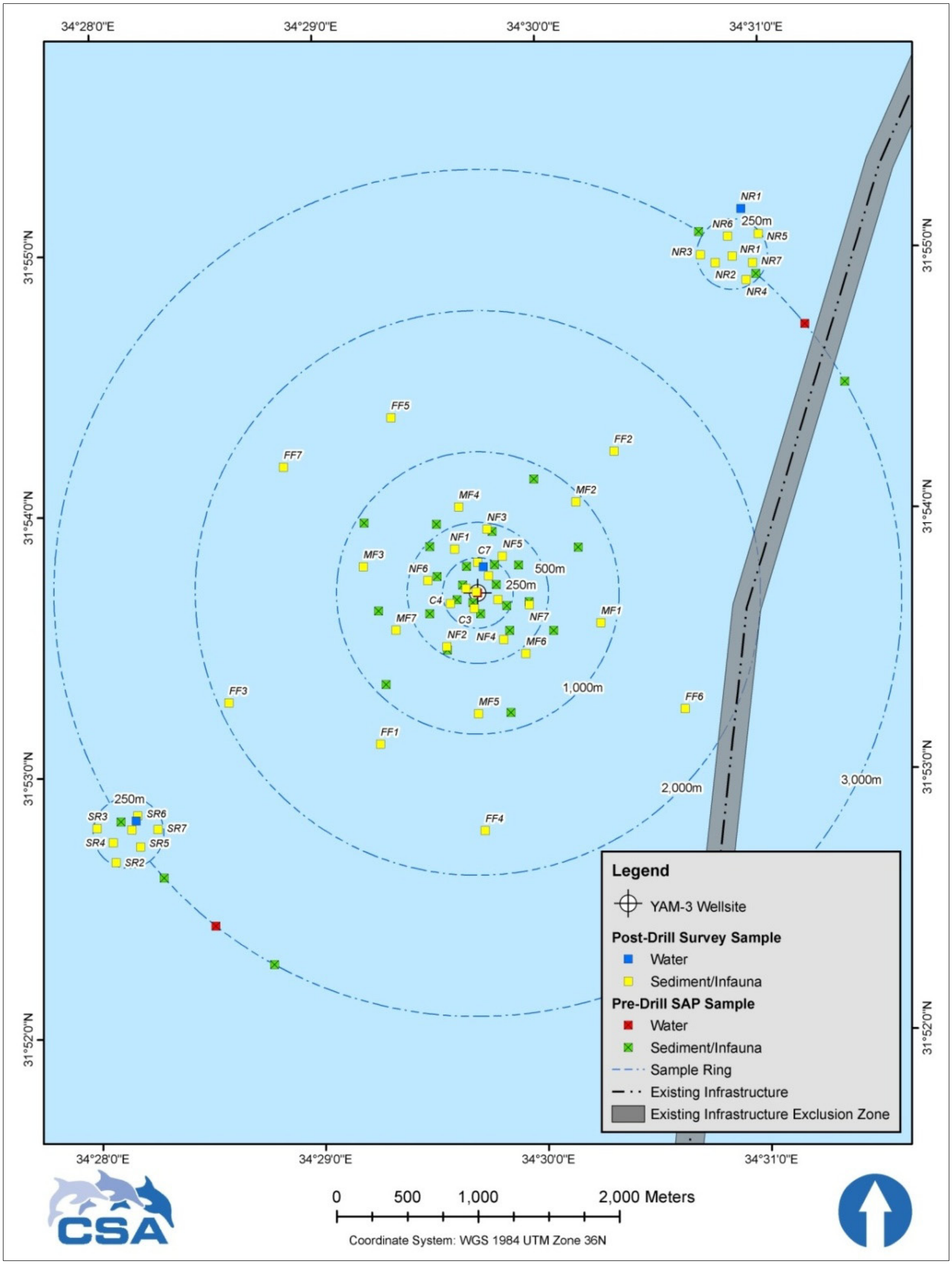


Figure 2. Configuration of Pre- and Post-Drill sediment/infauna and water sampling stations relative to the Yam-3 wellsite. Sample ring indicates distance from wellsite.

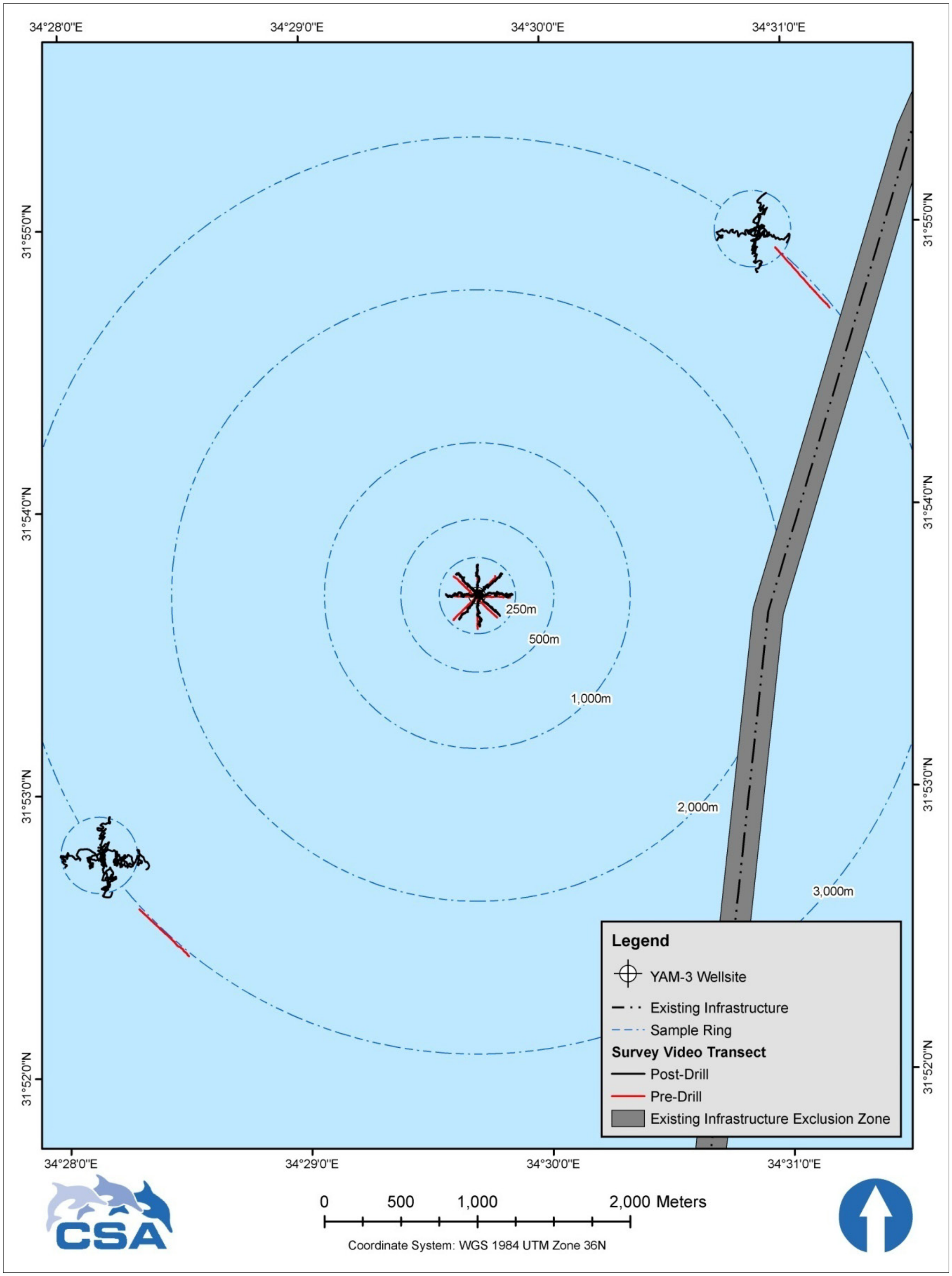


Figure 3. Configuration of Pre- and Post-Drill 250-m video transects relative to the Yam-3 wellsite. Sample ring indicates distance from wellsite.

2.2 SAMPLING PARAMETERS

Field surveys involved biological, water column (*in situ* profiles and seawater), and sediment sampling. Biological aspects of the sampling program involved assessment of the epibiota, demersal fishes, and infaunal communities using videography and box core sampling methods. Differences between Pre-Drill and Post-Drill analytes are due to adding new post-drill requirements established by the MoEP and MEWR.

2.2.1 Seawater Samples

Seawater samples were collected and hydrographic profiles were conducted at the wellsite location. The water column was profiled for temperature, conductivity (salinity), pH, turbidity, fluorescence, and dissolved oxygen (DO). Seawater samples were collected at three water depths (near-surface, mid-depth, and near-bottom). Water samples were analyzed for total suspended solids (TSS), total organic carbon (TOC), nutrients (total nitrogen [TN], total phosphorus [TP], nitrate [NO_3^-], nitrite [NO_2^-], ammonium [NH_4^+], and phosphate [PO_4^{-3}]), total metals, hydrocarbons (alkanes, TPH, and polycyclic aromatic hydrocarbons [PAHs]), and radionuclides (radium [Ra] 226 and Ra 228, lead [Pb] 210, and thorium [Th] 228). Seawater samples were not collected during the Pre-Drill survey for the following analytes: NO_2, NO_3, NH_4, PO_4, TSS, and radionuclides.

2.2.2 Sediment and Infauna Samples

Seafloor sediment samples were collected at 42 stratified random stations, which were organized into six strata based on their distance (and direction, in the case of the two reference locations) from the Yam-3 wellsite (**Figure 2**). Sampling stations established for the Pre-Drill survey were re-randomized for the Post-Drill survey and one sample per station was collected and analyzed for grain size, TOC, metals, hydrocarbons, radionuclides, and infauna. The stratified random design allows for replicate samples within a stratum, thus one box core per station equaled a replicate and the total number of box cores per stratum resulted in an adequate statistical power for data analyses.

2.2.3 Videography

Video data were collected to generally characterize the substrate and associated epibiotic and demersal biological community. Data were collected along 16 video transects: eight 250-m transects radiating from the wellsite at 45° intervals and four 250-m transects radiating at 90° intervals from the center point of each reference location (**Figure 3**).

3.0 FIELD METHODS

The Post-Drill survey was completed in two cruises: the first, from 24 to 28 November 2013, included collection of hydrographic profiling data, water column samples and sediment samples. The second, from 19 to 22 December 2013, concluded the operation with the collection of video data from the survey area. The survey was divided into two cruises because sea conditions during the first cruise precluded collection of all samples in the time allotted for the vessel, requiring a second cruise to complete the survey.

3.1 VESSEL OPERATION, NAVIGATION, AND REQUIRED PERSONNEL

3.1.1 First Cruise – Hydrographic Profiling and Sample Collection

The R/V *Mediterranean Explorer*, owned and operated by EcoOcean nonprofit organization, was contracted for the first leg of field operations. The survey vessel was mobilized with personnel and equipment at the Herzliya Marina in Israel. Vessel specifications are provided in **Appendix E**.

Methods to accurately position the vessel were used during the collection of all survey data. A Furuno global positioning system (GPS) model GP-32 and fathometer model FCV-1100L were interfaced with the onboard HYPACK Survey navigation software (version 13.0.0.6) to provide real-time position and depth data. Prior to the survey, all sampling locations (i.e., seawater and sediment sampling stations) were pre-plotted and submitted to the navigator for entery into the navigation software. The GPS and vessel fathometer were connected to an onboard computer equipped with navigation and data acquisition software. The positions of sediment sampling drops were recorded and stored by the navigation software.

The survey involved 12-hour operations during the field sampling effort. CSA provided four survey personnel (three scientists and an operational technician) to conduct in-country mobilization of survey equipment and supplies, program hydrographic instrumentation, and process collected samples. The CSA Chief Scientist was responsible for preparing sampling equipment and storage containers, directing data collection, overseeing all aspects of sample processing, and coordinating shipment or delivery of samples to respective laboratories.

3.1.2 Second Cruise – Visual Survey

The M/V *SURVEY*, owned and operated by EDT Shipping Company Ltd., was contracted and used for the second leg of the survey field operations. The survey vessel was mobilized with personnel and equipment at the Ashdod Marina in Israel. Vessel specifications are provided in **Appendix E**.

HYPACK Survey navigation software was used to communicate with the differential global positioning system (DGPS) receiver and vessel fathometer and was used for navigating the vessel to the specified points of interest and along the video transects. Prior to embarking, the video transects were preplotted and submitted to the vessel’s navigator for entry into the HYPACK software. An ultrashort baseline transponder was attached to the remotely operated vehicle (ROV) to record its underwater position, using DGPS, relative to the vessel position. The positions of the ROV track and the vessel were recorded and stored by the navigation software.

The survey involved 12-hour operations during the field visual survey effort. CSA provided two scientists to lead the operation, a Chief Scientist and support scientist. The CSA Chief Scientist was responsible for directing and coordinating quality data collection with the ROV and vessel crew and overseeing recording of video observations.

3.2 REMOTELY OPERATED VEHICLE

Video transects were conducted with a *Seaeye Falcon* ROV tethered to a 450-m umbilical and rated for 300m depth (**Image 1**). The ROV was equipped with a high resolution (480 TVL) fixed focus color camera on 180^o tilt platform, two forward facing variable intensity 3,200 - Lumen LED flood lighting, and auto depth and heading system. Four vectored horizontal and a single vertical brushless DC thrusters, magnetically coupled with velocity feedback enabled precise and rapid propulsion of the ROV. The ROV is owned and operated by EDT Shipping Company Ltd. Survey personnel launched the ROV from the M/V *SURVEY* using a crane located at the aft of the vessel.

Image 1. *Seaeye Falcon* ROV used during the Post-Drill survey.

3.3 VIDEOGRAPHY

Video data provide visually based monitoring focused on seafloor features near the wellsite and reference stations. Underwater video were collected along a total of 16 transects: eight 250-m transects radiating from the wellsite at 45˚ intervals and four 250-m transects radiating at 90˚ intervals from the center point of each reference location (North Reference and South Reference). The track followed by the ROV along the designated transects was recorded using the ROV's onboard navigation system, enabling the ROV to sample the same general areas during the Pre-Drill and Post-Drill survey.

Underwater video data were collected using a video camera mounted on the *Seaeye Falcon* ROV system. The ROV-mounted camera was aimed slightly above vertical to provide a field of view that included the bottom substrate in front of the system. The ROV was maneuvered at relatively slow speeds close to the seafloor to ensure video data that allowed enumeration and, to the degree practical, identification of macrofauna, topographic features and biological activity. Video observations were continuously recorded along each transect to provide information to determine the spatial extent of topographic features relative to the wellsite. Additionally, video data were used to determine the presence or absence and relative abundance estimates for epifauna and demersal fishes in the survey area.

3.4 WATER COLUMN SAMPLING

Water column sampling was conducted to evaluate chemical and physical parameters. Hydrographic data, including conductivity (salinity), temperature, dissolved oxygen (DO), fluorescence, turbidity and pH were collected throughout the water column with an SBE-19*plus* V2 conductivity, temperature, and depth (CTD) water quality profiler.

Seawater samples were collected at three discrete depths (near-surface, mid-depth, and near-bottom) at the wellsite and the two reference locations. The water column was sampled to provide seawater for the analysis of TSS, TOC, nutrients, total metals, hydrocarbons, and radionuclides. Seawater samples were collected with clean 8-L Niskin sample bottles mounted on a SBE32C compact carousel water sampler (**Image 2**) and actuated electrohydraulically. The CTD was mounted on the rosette to collect the hydrographic data through the water column during water sample collection.

A seawater sample (≤8 L) was collected to analyze parameters in listed in **Table 2**. All samples were placed in pre-cleaned (as appropriate for specified parameters) labeled sample containers. Seawater sampling and handling protocols are summarized in **Table 2**.

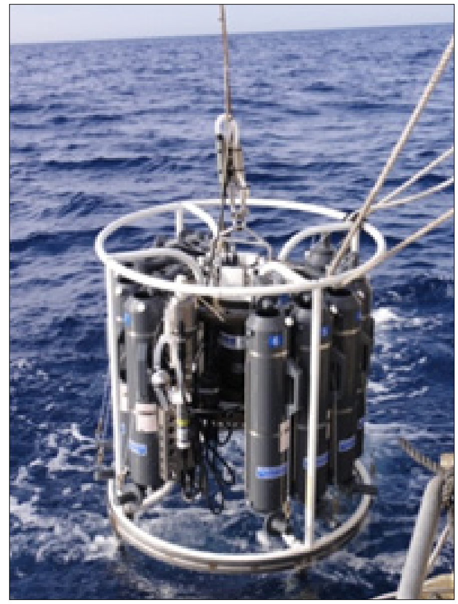


Image 2. Rosette water sampling system.

Table 2. Processing and storage requirements for seawater samples collected for analysis.

Parameter/Analyte(s)	Minimum Sample Volume	Container Type and Size	Handling, Storage Conditions, and/or Preservation Method	Holding Time
Total suspended solids	1 L unfiltered	1-L plastic bottle	Cool to 4°C; filter in the field and store preweighed filter frozen; ship on ice	Indefinite
Nutrients (total organic carbon, total nitrogen, total phosphorous, nitrate, nitrite, ammonium and phosphate)	250 mL	250-mL plastic bottle	Cool to 4°C	28 d
Metals other than mercury	1 L	1-L narrow-mouth plastic bottle	HNO_3 to pH <2; cool to 4°C; ship on ice	6 mo
Mercury	500 mL	500-mL narrow-mouth glass	HNO_3 to pH <2; cool to 4°C; ship on ice	28 d
Hydrocarbons (alkanes , TPH, and PAHs)	1 L	1-L amber glass bottle	Cool to 4°C; ship on ice	7 d
Radionuclides (radium [Ra] 226 and Ra 228)	4 L	4-L narrow-mouth plastic bottle	HNO_3 to pH <2; cool to 4°C; ship on ice	n/a

HNO_3 = nitric acid; PAHs = polycyclic aromatic hydrocarbons; TOC = total organic carbon; TPH = total petroleum hydrocarbons; n/a = not applicable (half-life based).

3.5 SEDIMENT AND INFAUNAL SAMPLING

Sediment and infaunal sampling were conducted with a stainless steel 0.25 x 0.25 m box corer (modified Gray-O'Hara type) (**Image 3**). Three box core samples were collected at each sampling station (**Figure 2**). Each box core sample was evaluated for acceptability on return to deck using standard U.S. Environmental Protection Agency (USEPA) sediment grab sampling criteria (USEPA, 2001):

- No sediment touched the top of the sampler or overflowed from the sampler;
- Clear, overlying water was present in the sampler;
- No sign of channelling or sample washout;
- Proper depth was achieved within the substrate for sample collection; and
- No evidence of sediment loss.

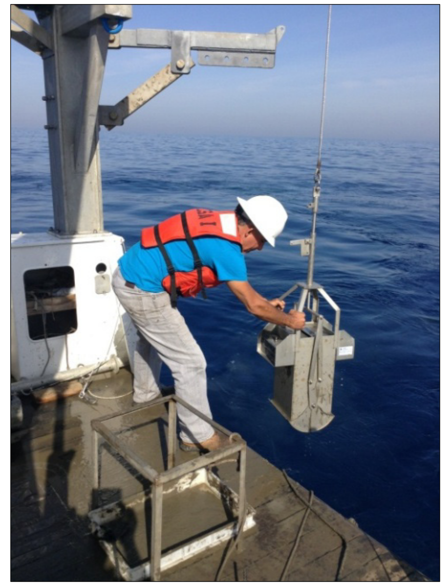


Image 3. Modified Gray-O'Hara box corer used to collect sediment samples.

If the box core sample did not meet the above grab sample criteria, additional samples were immediately collected while on station until sampling criteria were met.

Acceptable box core samples were then sampled for sediment chemical, geological, and infaunal analyses. Two successful box cores per sampling station were used for inafunal sampling and another was used for the chemical and geological sampling.

3.5.1 Chemical and Geological Samples

All chemical and geological subsamples were collected from the top 2 cm of sediment outside of the stainless steel insert. Sediment samples were transferred from the box corer with a stainless steel spoon into pre-cleaned sample containers, frozen, and handled/stored as recommended by USEPA protocols. Sediment sampling protocols are summarized in **Table 3**. Sampled parameters included grain size distribution by particle size analysis, TOC, total metals, hydrocarbons (alkanes, total petroleum hydrocarbons [TPH], and PAHs), and radionuclides (Ra 226, Ra 228, Th 228, and Pb 210). Within each sampling stratum, an additional core for sediment grain size was collected to a depth of approximately 15 cm for correlation with the infaunal data.

Table 3. Processing and storage requirements for sediment sampling parameters.

Parameter/Analyte(s)	Minimum Sample Volume	Container Type and Size	Handling, Storage Conditions, and Preservation Method	Holding Time
Grain size and total organic carbon	200 g (wet)	250-mL wide-mouth plastic jar	Freeze, ship on ice, and store frozen	Indefinite when frozen
Total metals	150 g	250-mL wide-mouth plastic jar	Freeze, ship on ice, and store frozen	Indefinite when frozen
Mercury	150 g	250-mL wide-mouth plastic jar	Freeze, ship on ice, and store frozen	Indefinite when frozen
Hydrocarbons (alkanes, TPH, and PAHs)	150 g	125-mL wide-mouth glass jar	Freeze, ship on ice, and store frozen	28 d
Radionuclides (radium [Ra] 226, Ra 228, thorium 228, and lead 210)	500 g (wet)	500-mL wide-mouth plastic jar	None	Indefinite

PAHs = polycyclic aromatic hydrocarbons; TPH = total petroleum hydrocarbons.

3.5.2 Infaunal Samples

Infaunal samples were collected from the top 15 cm of the two box cores equal to 0.125-m^2 surface area. Samples of infaunal sediment were elutriated and wet-sieved on board through a 0.50-mm mesh sieve with gentle streams of seawater using a flotation technique (barrel technique) that minimizes trauma to the infaunal organisms and facilitates separation from the sediment. The apparatus consisted of a sample mixing barrel fitted with a spillover drain that was positioned above a large spillover barrel. A 12-in. diameter stainless steel 0.50-mm sieve was mounted between the spillover drain and over the lower spillover barrel (**Image 4**). The flow rate from the mixing barrel was monitored to prevent overloading on the sieve screen. The sieved sample (containing infaunal organisms, residual sediment, and debris) was consolidated and transferred to a labeled sample container and preserved with an 8% borax-buffered formalin solution.

Image 4. Macrobenthic infaunal sieving apparatus consisting of an upper mixing barrel and sieve table over a lower spillover barrel.

3.6 QUALITY CONTROL

The typical quality control (QC) measures included preparation of equipment blanks (rinsates) to determine the potential of contamination of samples by the sampling equipment; preparation of field blanks to determine the potential of sample contamination from containers and general sample handling; preparation and completion of sample/data checklists; equipment performance and data checks; use of CoC processes; reference materials for laboratory analyses; and use of qualified/certified equipment, personnel, and laboratories.

For this project, field QC included equipment blanks, field blanks, laboratory splits, sample/data checklists, and data checks. Adequate volume of all blanks was placed in the same sample containers as the primary samples and clearly labeled for each analysis, along with the date and location. Post-survey shipment and sample tracking ensured delivery of samples to designated laboratories within the recommended holding times and condition.

Cleaning Procedures

To ensure that samples represent natural conditions, sample collection equipment must not cause contamination of the samples and sampling methods must not cause unacceptable changes in samples collected (sampling artifacts). Thus, pre-cleaned sample containers were used to collect all samples. Water samplers, sediment samplers, and sample processing equipment were thoroughly cleaned according to accepted procedures prior to use in the field. Pre-cleaned sample containers were processed by the distributor following appropriate USEPA protocols as specified in the Office of Solid Waste and Emergency Response (OSWER) Directive 9240.0-05A “Specifications and Guidance for Contaminant-Free Sample Containers”.

3.6.1 Quality Control Measures

Equipment Blanks

After the sampling equipment was cleaned, an equipment blank was prepared by pouring deionized water through the equipment and collecting the deionized water rinsate in a pre-cleaned and labeled 1-L sample container bottle, which was then shipped to the laboratory in the same fashion as the other samples.

Field Blanks

Field blanks were prepared by pouring analyte-free deionized water into clean sample containers while in the field.

Laboratory Quality Control – Sample Splits

Laboratory quality control measures included the analysis of randomly selected sample splits from the samples provided.

Sea-Bird Profiler Data Check

During or soon after a water column profile cast was completed, the SBE hydrographic data were downloaded and plotted in the field to check that the collected data were within expected ranges for the conditions at the survey area, that equipment was functioning normally, and the configuration and data files were in good order.

Data and Sample Collection Checklists

Prior to the survey, data and sample checklists were prepared by the Chief Scientist and completed in the field as appropriate for QC. Prior to departing each sampling station, the Chief Scientist or designee reviewed the checklist and physically examined and confirmed data files, logbooks, and sample containers to ensure that the data and required samples were properly collected and stored.

Sample Preservation and Holding Times

Samples were preserved as specified by applicable regulations or industry practice and transported to the laboratories for analysis within the prescribed sample holding times under appropriate preservation and handling conditions.

3.6.2 Sample Handling and Transport

After sample collection, proper sample handling protocols were followed to ensure that valid results are obtained from the analysis of each sample.All samples were be transported or shipped under a CoC process. Proper CoC was maintained for all samples, and a CoC record accompanied all samples. Each person involved with the custody of the sample(s) signed the appropriate forms and ensured that the samples were properly handled, stored, transported, and/or analyzed. Each sample has a unique identifier that can be directly tracked to the field logbook or data sheets. Labels were waterproof or covered with clear tape and securely fastened to the container. Labels contained information concerning date of collection, preservation information, and the person responsible for sample collection. Shipping containers were adequate to protect the sample containers and avoid breakage. Containers were secured to be leak proof, avoid cross-contamination, and prevent sample loss during shipment.

Samples were shipped to the appropriate laboratory for analysis as soon as possible after collection. Sample analysis requests/instructions were prepared by the chief scientist to accompany or be sent separately for all samples shipped to the laboratory. Transport and shipping were coordinated to ensure strict compliance with sample-holding times. The chief scientist or his designee needs to ensured and confirmed by telephone, fax, or e-mail that all samples were delivered and logged in good condition at each designated laboratory.

3.6.3 Document and Data Security

Vessel navigation and positioning data, along with field data files from ROV videography and CTD/DO profiles, were saved to a computer file and backed up on an external hard drive. All data collected during field operations (navigation and positioning, CTD, still and video imagery in digital format, acoustic, etc.) were duplicated and stored on two hard drives (primary laptop and an external hard drive). This storage occurred as soon as possible after collection but within the same watch or day, depending on the field deployment. Either the Chief Scientist or Operations Lead ensured that a backup external drive was included in the project mobilization. While on site, backup media were stored separately from the field computer. During return from the field, computer and backup media were transported separately whenever feasible but at least one copy traveled in personal possession. Either the Chief Scientist or the Operations Lead ensured that the data drives are delivered to CSA's Stuart office. Field notebooks and datasheets were then copied and scanned into a file associated with the job's other data and backed up on the data server. The link to these data was shared with the Project Manager to ensure redundant knowledge for future access. The Chief Scientist verified that the data was put into CSA's enterprise class storage system. CSA maintained two copies of the data; one live working copy and one on archival tape for disaster recovery purposes. The link to these data was also shared with the Project Manager.

4.0 LABORATORY METHODS, DATA PROCESSING, AND ANALYSIS

4.1 VIDEOGRAPHY

Video data were reviewed to visually characterize the seafloor substrate and associated biological community (i.e., epibiota and demersal fishes). The presence/absence and relative abundance estimates for epibiota and demersal fishes were used to characterize the biological community.

4.2 HYDROGRAPHIC PROFILES

Digital data files from the SBE19*plus* V2 CTD profiler were processed using SBE data processing software, a proprietary modular family of data processing software specific to SBE oceanographic instruments. The SBE data processing modules were used, as appropriate, to convert the raw data to a text file, extract the desired sections for specific stations, smooth the data, and import the file into a spreadsheet prior to plotting. Further processing prepared the data as diagrammatic vertical hydrographic profiles with SigmaPlot and tabular spreadsheet summaries presented in this report.

4.3 SEAWATER AND SEDIMENT ANALYSIS

Tables 4 and **5** outline the analytical parameters, analysis methods, reporting units, and reporting limits of seawater and sediment samples, respectively. ALS Limited (Kelso, Washington, U.S.) performed the analysis of seawater and sediment metals. TDI Brooks (College Station, Texas, U.S.) performed the analysis of seawater and sediment hydrocarbon samples. Weatherford Laboratories (Shenandoah, Texas, U.S.) performed the analysis of sediment grain size and TOC. Chesapeake Biological Laboratory (CBL; Solomons, Maryland, U.S) performed the analysis of seawater nutrients, TSS and TOC. ALS Limited (Fort Collins, Colorado, U.S.) performed the analysis of sediment and seawater radionuclides. Reporting limits or laboratory method detection limits (MDL) indicate the lowest concentration of a parameter that the laboratory is able to detect under standard conditions. MDLs are dependent upon sample volume and can vary slightly if the sample volume deviates from the standard volume needed to analyze a parameter.

Table 4. Analytical parameters, primary laboratory, analysis methods, reporting units, and reporting limits of quantification for seawater samples.

Parameter/ Analyte	Primary Analytical Laboratory	Digestion/ Extraction Method	Analytical/Detection/ Quantification Method	Quantification Limit [1]	CCC[2]	Israeli Mediterranean Seawater Quality Standards[3]		Unit
						Avg.	Max.	
Arsenic[4]	ALS Environmental Kelso	n/a	ICP-MS	0.5	36	36	69	µg L^{-1}
Antimony[4]		n/a	ICP-MS	1	500[p]	--	--	µg L^{-1}
Barium[4]		n/a	ICP-MS	8	200	--	--	µg L^{-1}
Beryllium[4]		n/a	ICP-MS	0.02	--	--	--	µg L^{-1}
Cadmium[4]		n/a	ICP-MS	0.02	8.8	0.5	2	µg L^{-1}
Chromium III[4]		n/a	ICP-MS	0.2	--[5]	10	20	µg L^{-1}
Copper[4]		n/a	ICP-MS	0.1	3.1	5	10	µg L^{-1}
Lead[4]		n/a	ICP-MS	0.02	8.1	5	20	µg L^{-1}
Mercury[4]		n/a	Based on USEPA 1631E	0.001	0.94	0.16	0.4	µg L^{-1}
Nickel[4]		n/a	ICP-MS	0.2	8.2	10	50	µg L^{-1}
Selenium[4]		n/a	ICP-MS	1	71	60	150	µg L^{-1}

Table 4. (Continued).

Parameter/ Analyte	Primary Analytical Laboratory	Digestion/ Extraction Method	Analytical/Detection/ Quantification Method	Quantification Limit [1]	CCC[2]	Israeli Mediterranean Seawater Quality Standards[3]		Unit
						Avg.	Max.	
Silver[4]	ALS Environmental Kelso (cont'd.)	n/a	ICP-MS	0.02	--	3	7	µg L^{-1}
Thallium[4]		n/a	ICP-MS	0.02	--	--	--	µg L^{-1}
Vanadium[4]		n/a	ICP-MS	8	50	50	100	µg L^{-1}
Zinc[4]		n/a	ICP-MS	0.5	81	40	100	µg L^{-1}
Alkanes	TDI Brooks	Hexane	USEPA 1664/8100/8015 GC-MS	0.069 – 0.277	--	--	--	µg L^{-1}
Total petroleum hydrocarbons (TPH)		Hexane	USEPA/SW-846 Modified 8100/8015C	13	--	--	--	µg L^{-1}
Polycyclic aromatic hydrocarbons (PAHs)		Hexane	USEPA SW-846/8260/ GC-MS	0.74 – 2.91	--	--	--	ng L^{-1}
Total nitrogen (TN)	Chesapeake Biological Laboratory (CBL)	Persulfate digestion	Diazo colorimetric method	0.01	--	1.0		mg L^{-1}
Total phosphorus (TP)		Persulfate digestion	Molybdo-phosphoric colorimetric method	0.0013	--	0.1		mg L^{-1}
Ammonium		Sodium phenoxide, Sodium hypochlorite	Indophenol colorimetric method	0.01	--	0.50	2.4	mg L^{-1}
Nitrite		Sulfanilamide	Diazo colorimetric method	0.0007	--	--		mg L^{-1}
Nitrate		n/a	Diazo colorimetric method	0.002	--	--		mg L^{-1}
Phosphate		Ascorbic acid digestion	Antimony-phospho-molybdate colorimetric method	0.0006	--	--		mg L^{-1}
Total organic carbon (TOC)		n/a	High-temperature combustion	0.24	--	--		mg L^{-1}
Total Suspended Solids (TSS)		n/a	Analytical balance	0.01	--	>10% and 10 mg L^{-1} above average		mg L^{-1}
Radium 226	ALS Environmental, Ft. Collins	n/a	USEPA Method 903.1	1	--	--	--	--
Radium 228		n/a	USEPA Methods 904.0 and SW-846 9320	1	--	--	--	pCi L^{-1}

GC-MS = gas chromatography-mass spectrometry; ICP-MS = inductively coupled plasma-mass spectrometry; n/a = Not applicable; USEPA = U.S. Environmental Protection Agency.
[1] Limits of quantification are the reporting limit for both metals, alkanes and PAHs.
[2] CCC = Criterion Continuous Concentration (Buchman 2008); CCC is an estimate of the highest concentration of a material in ambient water to which an aquatic community can be exposed indefinitely without resulting in unacceptable adverse effect.
[3] Proposed by MoEP Israel.
[4] Infromation applicable for total and dissolved metals.
[5] Chromium III = 27.4 µg L^{-1}; Chromium VI = 50 µg L^{-1}.
[p] = proposed.

Table 5. Analytical parameters, primary laboratory, analysis methods, reporting units, and reporting limits of quantification for sediment samples.

Parameter/ Analyte	Analytical Laboratory	Digestion/ Extraction Method	Analytical/Detection/ Quantification Method	Quantification Limit	ERL	ERM	Unit
Particle size distribution	Weatherford	n/a	Laser diffraction particle size analysis	0.1	--	--	µm
Total organic carbon		n/a	Based on European Standard Norm 1484	5	--	--	%
Aluminum	ALS Environmental - Kelso	HF[1]	Based on ISO 11885	2	--	--	%
Antimony		HF[1]	Based on ISO 11885	1	2	25	ppm
Arsenic		HF[1]	Based on ISO 11885	3	8.2	70	ppm
Barium		HF[1]	Based on ISO 11885	0.5	--	--	ppm
Beryllium		HF[1]	Based on ISO 11885	1	--	--	ppm
Cadmium		HF[1]	Based on ISO 11885	0.032	1.2	9.6	ppm
Chromium		HF[1]	Based on ISO 11885	1	81	370	ppm
Copper		HF[1]	Based on ISO 11885	1	34	270	ppm
Iron		HF[1]	Based on ISO 11885	1	--	--	%
Lead		HF[1]	Based on ISO 11885	5	46.7	218	ppm
Nickel		HF[1]	Based on ISO 11885	1	20.9	51.6	ppm
Selenium		HF[1]	Based on ISO 11885	1.6	--	--	ppm
Silver		HF[1]	Based on ISO 11885	0.07	1	3.7	ppm
Thallium		HF[1]	Based on ISO 11885	1	--	--	ppm
Vanadium		HF[1]	Based on ISO 11885	1	--	--	ppm
Zinc		HF[1]	Based on ISO 11885	1	150	410	ppm
Mercury		HF[1]	Based on USEPA 1631E	0.02	0.15	0.71	ppm
Alkanes	TDI Brooks	Hexane	USEPA 1664/8100/8015/GC-MS	0.004 to 0.019	--	--	µg g^{-1}
Total petroleum hydrocarbons		Hexane	USEPA/SW-846 Modified 8100/8015C	1.4	--	--	µg g^{-1}
Polycyclic aromatic hydrocarbons (PAHs)		Hexane	USEPA SW-846/8260/GC-MS	0.041 to 1.267	550[2] 4,000[3]	3,160[2] 44,792[3]	ng g^{-1}
Radium 226	ALS Environmental - Ft. Collins	n/a	USEPA Method 901.1	1	--	--	pCi g^{-1}
Radium 228		n/a	USEPA Method 901.1	1	--	--	pCi g^{-1}
Thorium 228		n/a	USEPA, EMSL/LV 053917	0.1	--	--	pCi g^{-1}
Lead 210		n/a	Liquid scintillation (PAI 704 Rev 10)	1	--	--	pCi g^{-1}

EMSL/LV = Environmental Monitoring Systems Laboratory, Las Vegas; ERL = Effects Range Low (Buchman, 2008); ERM = Effects Range Median (Buchman, 2008); GC-MS = gas chromatography-mass spectrometry; ISO = International Organization for Standardization; n/a = not applicable; ppm = parts per million; USEPA = U.S. Environmental Protection Agency.

[1] HF = hydrofluoric acid (this digestion procedure results in the release of nearly all the metal content of a sample and it is believed to be a more accurately estimate of the metal concentrations in all sample matrices).

[2] Low molecular weight polycyclic aromatic hydrocarbons.

[3] Total polycyclic aromatic hydrocarbons.

4.3.1 Seawater

Post-Drill survey results were compared with Pre-Drill results. In addition, Pre-Drill and Post-Drill survey results were also compared to the proposed Environmental Quality Standards for the Mediterranean Sea in Israel (also referred to as the Mediterranean Environmental Water Quality Standards [MEQS]) (MoEP, 2002) and USEPA water quality benchmarks to determine if seawater concentrations surrounding the Yam-3 wellsite had the potential to cause adverse ecological effects. The USEPA Criterion Continuous Concentration (CCC) for seawater is an estimate of the highest concentration of a material in water that an aquatic community can be exposed to indefinitely without resulting in unacceptable adverse effects. TSS, TOC, NH4, NO_2, NO_3, PO_4, and radionuclide samples were not collected during the Pre-Drill survey and thus could not be compared over time. Radionuclide results for the Post-Drill survey were compared to the USEPA-established maximum contaminant level (MCL) for combined Ra 226 and Ra 228 (USEPA, 1976). The MCL is a maximum permissible level of a contaminant that ensures the safety of the water over a lifetime of consumption and also takes into consideration feasible treatment technologies and monitoring capabilities.

Total Suspended Solids

Acceptable methods for the laboratory determination of TSS were taken from USEPA Method 160.2 and Standard Methods 2540D. TSS in seawater samples was determined by pouring a known volume of seawater (~1 L) through a preweighed glass fiber filter of a specified pore size and then weighing the filter again to 0.001 mg after rinsing the filter with deionized water to remove salts and drying in an oven to remove residual water.

Total Organic Carbon

TOC was determined in a Shimadzu TOC-5000 analyzer using a high temperature combustion method. Samples were treated with hydrochloric acid and sparged with ultrapure carrier grade air to drive off inorganic carbon. High temperature combustion (680°C) on a catalyst bed of platinum-coated alumina balls breaks down organic carbon into carbon dioxide (CO_2). The CO_2 was carried by ultra-pure air to a nondispersive infrared detector, where CO_2 was detected and quantified.

Nutrients

Seawater nutrient analyses included TN, TP, NO_3, NO_2, PO_4 and NH_4. TN was determined through colorimetric methods in a segmented flow analyzer. TN was determined by the diazo colorimetric method after alkaline persulfate digestion. TP was determined by the molybdo-phosphoric blue colorimetric method after alkaline persulfate digestion. NO_2 was determined by the diazo colorimetric method after reaction under acidic conditions with sulfanilamide. NO_3 was determined after total reduction of NO_3+NO_2 to NO_2 and subtraction of the corresponding NO_2 value from the NO_3+NO_2 concentration. PO_4 was determined by the antimony-phospho-molybdate blue colorimetric method after ascorbic acid digestion. NH_4 was determined through colorimetric method after reaction with sodium phenoxide, followed by sodium hypochlorite.

Total Metals

Total metals (i.e., metals in unfiltered samples) were analyzed principally by inductively coupled plasma-mass spectrometry (ICP-MS) methods. The analysis was by flow injection ICP-MS using an Elan DRC-e Perkin-Elmer without dilution of samples. Analysis of mercury was by atomic fluorescence spectroscopy with a PS Analytical Millennium System.

ALS Environmental's methods for analysis of metals in seawater involved reductive precipitation methods to achieve lower detection limits in a high salt matrix. The seawater samples were treated with iron and palladium carriers, pH adjusted, and then subjected to reducing conditions using sodium tetrahydridoborate (sodium borohydride) then analyzed by ICP-MS. Barium was analyzed by inductively coupled plasma-atomic emission spectrometry (ICP-MS). Antimony was determined in a 1:20 dilution of seawater in a sample and analyzed by ICP-MS. Selenium (Se) in seawater was determined by borohydride reduction and atomic absorption spectrophotometry. Seawater samples analyzed for mercury were prepared for analysis by the addition of bromine monochloride solution and analyzed with a Brooks Rand Model III cold-vapor atomic fluorescence spectrometer.

Hydrocarbons

Hydrocarbon components in seawater were analyzed using solvent extraction and gas chromatographic techniques. The analytical method for alkanes was USEPA Method 1664 (solvent extraction; gas chromatography-mass spectrometry [GC-MS]). The analytical method for TPHs is USEPA/SW-846 Modified 8100/8015C. Analytical methods for PAHs include USEPA SW-846/8260 or 8270 or equivalent using an Agilent Model 6890/5973 gas chromatograph-mass spectrometer.

Radionuclides

Radium 226 in aqueous samples is concentrated and separated by co-precipitation with barium sulfate ($BaSO_4$). Prior to separation, a portion of the sample is removed for inductively coupled plasma-atomic emission spectrometry (ICP-AES) determination of the preparation concentration of Ba in the sample. The $Ba[Ra]SO_4$ precipitate is dissolved in basic ethylenediaminetetraacetic acid (EDTA) solution, placed in a 40 mL volatile organic analysis vial, purged of any existing radon (Rn) 222, and stored to allow quantitative in-growth of Rn 222. After in-growth, the Rn is purged into an alpha scintillation cell. The short-lived Rn 222 progeny are allowed to come to equilibrium with the parent Rn (~4 hours) before the scintillation cell is counted for alpha activity. The 4-hour in-growth period also allows for the decay of other Rn isotopes.

The Ra isotopes in a water sample are collected by co-precipitation of Ba and lead sulfate and purified by re-precipitation out of a basic EDTA solution. This technique is devised so that the beta activity from actinium (Ac) 228, which is produced by decay of Ra 228, can be determined and related to the activity concentration of Ra 228 present in the sample. After a 36-hour period to allow for the in-growth of Ac 228, Pb is removed as lead (II) sulfide, and Ac is carried on yttrium (Y) as the hydroxide and mounted as the oxalate, and quickly beta-counted on a gas flow proportional counter to minimize decay of the short-lived Ac 228 (~6 hours).

4.3.2 Sediment

The following subsections provide a brief summary of the analytical methods used for each sediment sample parameter as summarized in **Table 5**. Post-Drill survey results were compared with Pre-Drill survey results. Statistical comparisons were made using SAS (SAS Institute Inc., 2011) among strata between Pre-Drill and Post-Drill survey; Radionuclides samples were not collected during the Pre-Drill survey; therefore, comparisons were only performed among strata for the Post-Drill.

Results were also interpreted in the context of the actual values (means) relative to benchmark values to evaluate their biological relevance. Hydrocarbon and metals concentrations were compared to the USEPA sediment quality benchmarks to determine if sediment concentrations surrounding the Yam3 wellsite have the potential to cause adverse ecological effects. A benchmark is a chemical concentration in sediment above which there is the possibility of harm to organisms in the environment. The USEPA recommends benchmark values such as the Effects Range Low (ERL) and Effects Range Median (ERM) to assess the potential risk to fish and other marine life (Long et al., 1995). These sediment quality guidelines are based on marine sediment chemistry paired with sediment toxicity bioassay data. The benchmarks represent points on a continuum of chemical concentrations ranked from lowest (least toxic) to highest (more toxic) concentrations defined as follows:

- ERL is indicative of concentrations below which adverse effects rarely occur; and
- ERM is indicative of concentrations above which adverse effects frequently occur.

Grain Size

Sediment grain size was determined by means of laser (diffraction) particle size analysis using a Malvern 2000 Mastersizer. Particle sizes were computed automatically within the instrument using the Mie Model for light scattering and reported as percent distribution according to size classes representing sand, silt, and clay-sized particles.

Total Organic Carbon

TOC was analyzed by the combustion and gravimetric methods based on European Standard Norm 1484 with an Analytik Jena AG Multi N/C 2000 TOC analyzer. Samples were treated with acid to remove carbonates and air-dried prior to analysis. CO_2 generated by the combustion of organic matter in the sample was quantitatively measured with an infrared detector and calibrated against prepared standard solutions. The quantity of organic matter in a sediment sample was expressed in parts per million (ppm).

Total Metals

Analyses were conducted to determine the concentrations of various metals including Ag, Al, As, Ba, Be, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Se, Sb, Tl, V, and Zn. Analysis for all sediment metals except Hg was conducted by acid digestion and with Varian Vista AX inductively coupled plasma-atomic absorption spectrometer and calibrated against prepared standard solutions. Hg analysis of sediments was conducted using cold-vapor atomic absorption spectroscopy and calibrated against prepared standard solutions. The sediment subsample was digested in nitric acid, hydrogen peroxide, and hydrofluoric acid with the release of elemental Hg by the addition of stannous chloride.

Results of metals analysis for the Yam-3 monitoring program were compared to the average total metals concentrations in marine sediments and the continental crust. Average total metals concentrations in marine sediments are described by Salomons and Förstner (1984) and are based upon a diverse compilation of world-wide values aggregated from many peer-reviewed sources within the marine sediment and geochemistry literature. The continental crust values reported in Wedepohl (1995) are also based on a compilation of values obtained from peer-reviewed literature sources, although with a bias toward data described from European crusts.

Hydrocarbons

Hydrocarbon components in sediments were analyzed by solvent extraction and gas chromatographic techniques. The analytical methods for hydrocarbons included USEPA Method 1664/8100/8015 (solvent extraction; GC-MS) for alkanes, USEPA/SW-846 Modified 8100/8015C for TPHs, and USEPA SW-846/8260 or 8270 using an Agilent Model 6890/5973 gas chromatograph-mass spectrometer and calibrated against prepared standard solutions for PAHs.

Radionuclides

For Ra 226, the method involved drying and sieving the sample, sealing the sample in a steel can, and allowing 21 days for the in-growth of the Pb 214 and bismuth (Bi) 214 progeny. The analysis entailed quantification of the Pb 214 and Bi 214 progeny, assuming secular equilibrium, and reporting the abundance weighted average of the Pb and Bi activities as Ra 226. Assuming secular equilibrium, the gamma emissions from Ac 228, which is produced by decay of Ra 228, are determined and related to the activity concentration of Ra 228 present in the sample. Gamma emissions from radionuclides were detected by a semiconductor germanium crystal, which provided a small electronic pulse for each gamma interaction where the pulse height was proportional to the gamma incident energy. These electronic data were converted to digital data by an analog-to-digital converter and stored in a multichannel buffer. The data collected by the multichannel buffer were subsequently interpreted by a complex software program, generating results in units of radioactivity per unit sample volume.

Samples for Th 228 were dried and ground to a fine particle size. For cases in which there is high organic matter, the samples are placed in a muffle furnace so that any organic matter is removed by combustion. Tracers were added and dissolution was accomplished using nitric, hydrochloric, and hydrofluoric acids. When actinides were being determined, a hydroxide co-precipitation was performed to pre-concentrate actinides and remove constituents that did not form insoluble hydroxides. The hydroxide precipitate was then redissolved, and further purification was performed through various chromatography resins. The purified Th 228 was co-precipitated with lanthanum fluoride and mounted on a filter membrane for quantification by alpha spectroscopy.

Pb 210 samples were also dried and ground to a fine particle size. A stable lead carrier was spiked into the samples and the lead was solubilized using nitric acid (HNO_3), hydrofluoric acid (HF), and hydrochloric acid (HCl). A chromatographic resin with a high affinity for lead was used to isolate Pb 210 from potentially interfering radionuclides. In HNO_3, lead is retained on the resin while other unwanted sample constituents are not. Lead was stripped from the resin with HCl. The purified solution containing lead was mixed with a liquid scintillation cocktail and counted in a liquid scintillation counter for Pb 210. Stable lead, added into the samples at the beginning of the procedure to monitor the chemical recovery, was measured in the sample by ICP-AES before and after chemical separation in a filter membrane for quantification by alpha spectroscopy.

4.4 INFAUNA

Samples were transported to EcoAnalysts, Inc. (Moscow, Idaho, U.S.) for sorting and taxonomic identification. Prior to sorting each infaunal sample, the sample was transferred from formalin to ethyl alcohol. Samples were sorted to major taxonomic groups and then distributed to taxonomists for species identification and enumeration. During the taxonomic process, organisms were identified to the lowest practical taxonomic level by EcoAnalysts, Inc. in-house taxonomists. Nematodes were not identified, and oligochaetes and ostracods were only enumerated. Data were recorded on electronic datasheets within the EcoAnalysts, Inc. laboratory information management system and then later output in a Microsoft Excel format.

4.5 STATISTICAL ANALYSIS

A two-way analysis of variance (2ANOVA) was performed on most parameters, where appropriate, to determine statistical differences among sampling strata and survey (Pre-Drill versus Post-Drill). The 2ANOVA tests the main effects of the survey program. These main effects were distance from the wellsite (sampling strata) and survey (Pre-Drill and Post-Drill). In many instances there was a significant interaction of main effects which typically meant there were significant effects of both distance and survey but that those differences were not consistent among surveys. Where interaction was significant, main effects may not be considered in isolation but must always be described in the context of the other main effect(s). When no interaction was detected, the ANOVA was re-run without the interaction term to improve degrees of freedom and test strength; however, no change in significant differences at $p < 0.05$ were detected for any parameter re-run without the interaction term. For nonpercent data, all numeric data were natural-log (+1, when less than 1) transformed to alleviate heteroscedasticity and all percent data were $\log_2$ transformed. No transformation was necessary for fauna and infauna data because these data were normal.

Two important factors were considered in interpreting the 2ANOVA results; first, whether Post-Drill survey values were higher, indicating potential enrichment of that parameter by the drilling activity. Conversely, if Post-Drill survey values were lower, this could indicate a Post-Drill dilution effect arising from the release of formation sand near the wellsite and this too was considered. The other important factor was the sequence or pattern of values with distance (from the wellsite). We have seen in many deep ocean surveys a patchy distribution of many parameters, with occasional isolated peaks and lows, which underscores the importance of randomized sampling to generalize at the scale of the entire distance (from wellsite) strata. Either the 2ANOVA or ANOVA may detect differences by distance, but if those differences did not indicate a logical sequence of either enrichment or dilution with distance from the wellsite, then we considered this not to be a signature of drilling activities (i.e., consistent drill effect).

For the infaunal results a variety of statistical routines were applied to the resulting datasets using PRIMER v.6 (Clarke and Gorley, 2006) software, to calculate several univariate community structure indices, including Shannon's H′ (base 2), Pielou's evenness value (J′), and Fisher's log-series *alpha* (Fisher et al., 1943). Fisher's log-series model of species abundance has been widely used, particularly by entomologists and botanists (Magurran, 1988). Taylor's (1978) studies of the properties of this index found that it was the best index for discriminating among subtly different sites.

5.1 SEA STATE

Weather conditions during survey operations (24 to 27 November; 19 to 22 December 2013) were fairly constant. A low amplitude, long period swell was experienced during both parts of the survey. Light to fresh land and sea breezes were present during the morning and late in the afternoon, respectively. Throughout the day moderate to calm winds dominated from the South, occasionally becoming variable. For the entire duration of the survey sea state was calm to slight with wind waves not exceeding 0.7 m wave height. Apparent water column water mixing due to a recent winter storm made visibility very poor during the visual survey and was limited to between 1-3m ahead of the ROV.

5.2 VIDEOGRAPHY

Seafloor Features

The seafloor of the survey area was observed to have a flat topography with many sediment irregularities of the sediment surface, apparently caused by the resident burrowing biota (**Image 5**). Similar observations were made during the Yam-3 Pre-Drill survey for the entire survey area (**Image 6**). However, during the present survey the seafloor at the wellsite was highly disturbed unlike that observed for the reference areas and the Pre-Drill survey. Starting at 250 m from the wellhead, the seafloor sediment was similar to that of the reference areas as it appeared to be soft and flat. Disturbances in the form of large sediment chunks creating multidimensional structures were first observed within approximately 100 m of the wellhead (**Image 7**), changing the topography and becoming prevalent closer ahead as the ROV approached the wellhead. At approximately 50 m from the wellhead what looked like cement pieces and drill cuttings became evident (**Images 8** and **9**), scattered over the seafloor and visually changing the sediment grain size. The wellhead itself protruded from inside a dug-out pit (**Image 10**). Anthropogenic debris (i.e., plastic bin, pipe fitting, ratchet chain hoist, heavy duty steel rigging hardware, plastic bags and bottles, wire ropes) were occasionally observed within the wellsite survey area (**Image 11**). No hard bottom substrate or chemosynthetic communities were observed within the survey area.

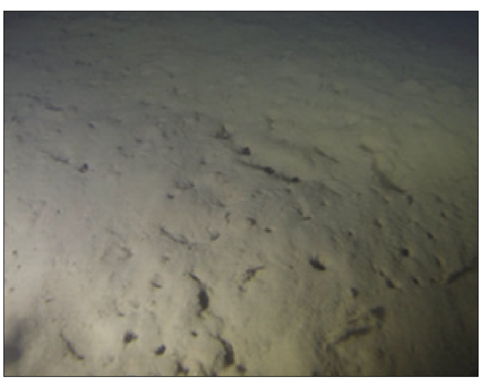


Image 5. Sea bottom observed at the North Reference area during the Yam-3 Post-Drill survey. Bottom sediment, described to be soft clayey silt, was characterized by relatively flat bioturbated seafloor topography.

Image 6. The wellsite survey area observed during the Yam-3 Pre-Drill survey. Much like the Post-Drill survey, the seafloor was observed to be relatively flat with irregularities (bioturbations) in soft bottom substrate.

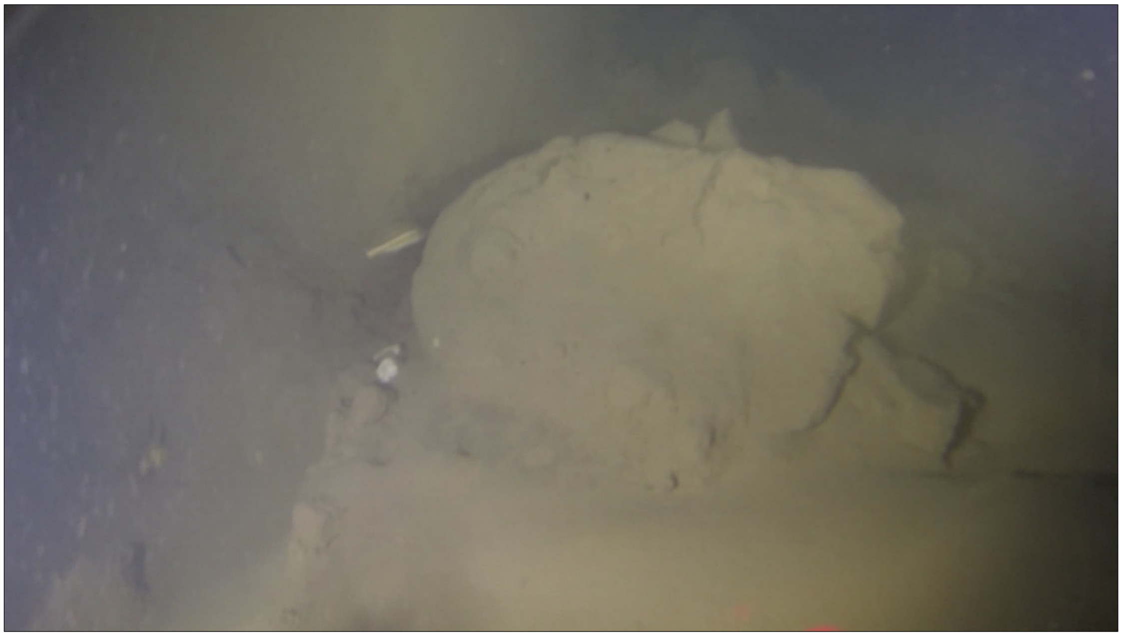


Image 7. Seafloor imagery showing large sediment chunks creating multidimensional structures in the seafloor at transect 225°, 100 m from the wellhead. Behind the observed chunk are a fish and sea urchin seeking shelter. The sediment chunk estimated to be 1 m^3.

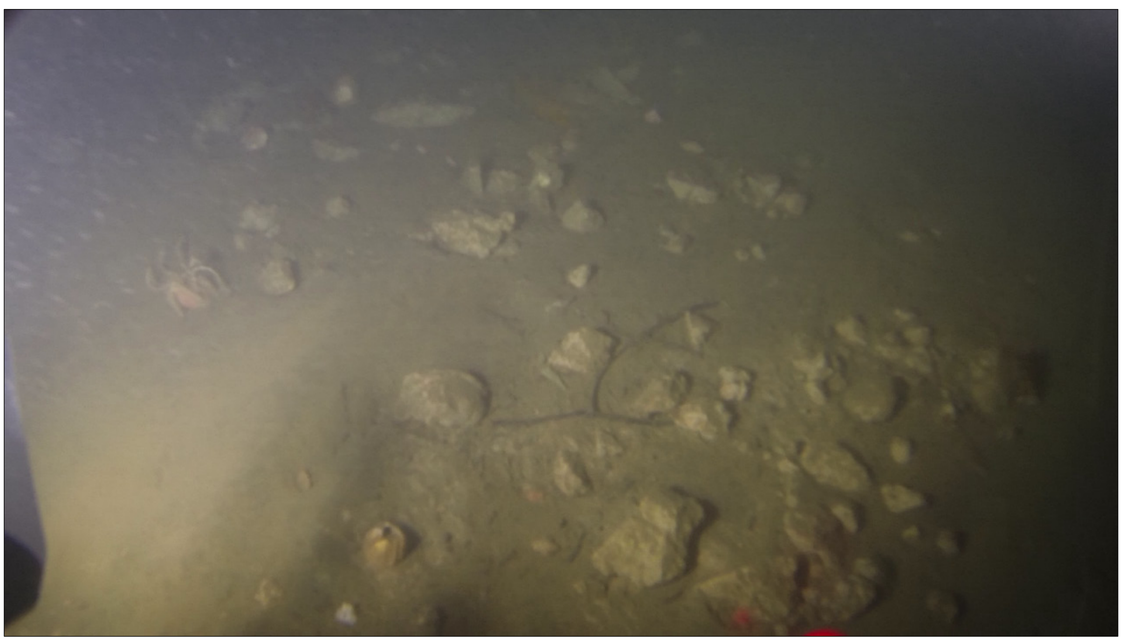


Image 8. Seafloor imagery showing possible cement pieces (a few centimeters in size) buried in the sediment at transect 225°, 50 m from the wellhead.

Image 9. Seafloor imagery taken at transect 315° from the wellhead. At approximately 50 m from the wellhead, drill cuttings overlaying the sediment became conspicuous.

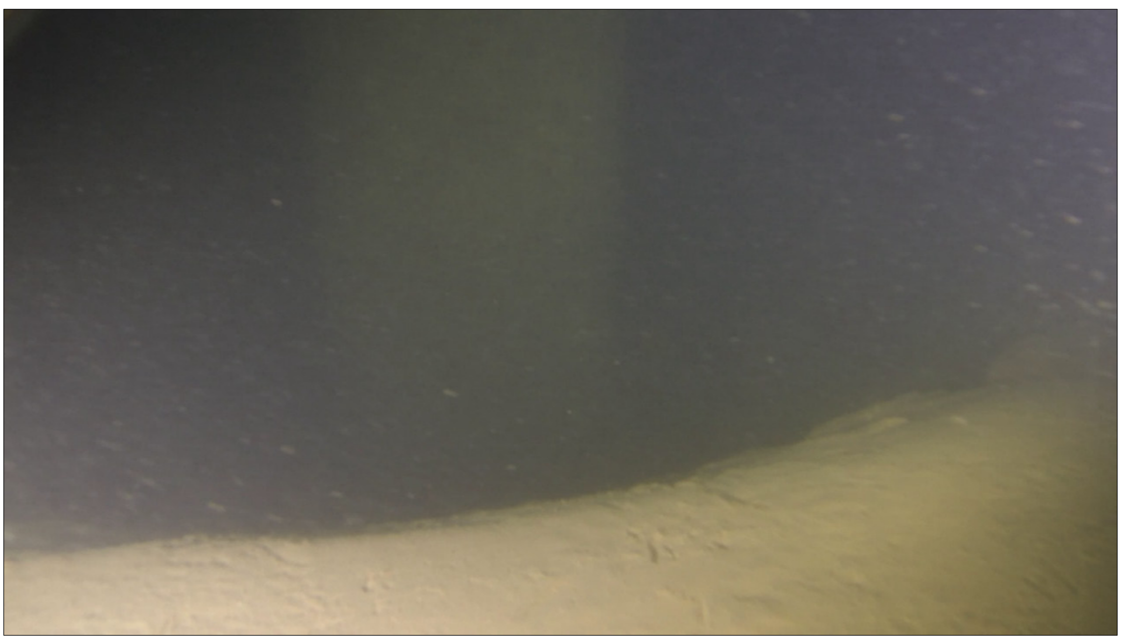


Image 10. Wellhead shown protruding from a dug-out pit, probably created during excavation operations prior to well abandonment.

a)

b)

Image 11. Anthropogenic debris found at different locations along the Yam-3 wellsite survey transects. a) shows a ratchet chain hoist and b) heavy duty steel rigging hardware (wire rope and shackles). Debris mainly consisted of plastics and were occasionally observed at the wellsite survey area as well as at the North and South Reference areas.

Biota

Biological activity, including the presence of motile biota and bioturbation (i.e., biologically maintained burrows and mounds), was observed and mapped within the Post-Drill survey area (video observation log is provided in **Appendix F**). **Figure 4** presents mapping of general biological activity at the wellsite area observed during ROV transects. **Figure 5** shows further details of biological communities by groups of organisms.

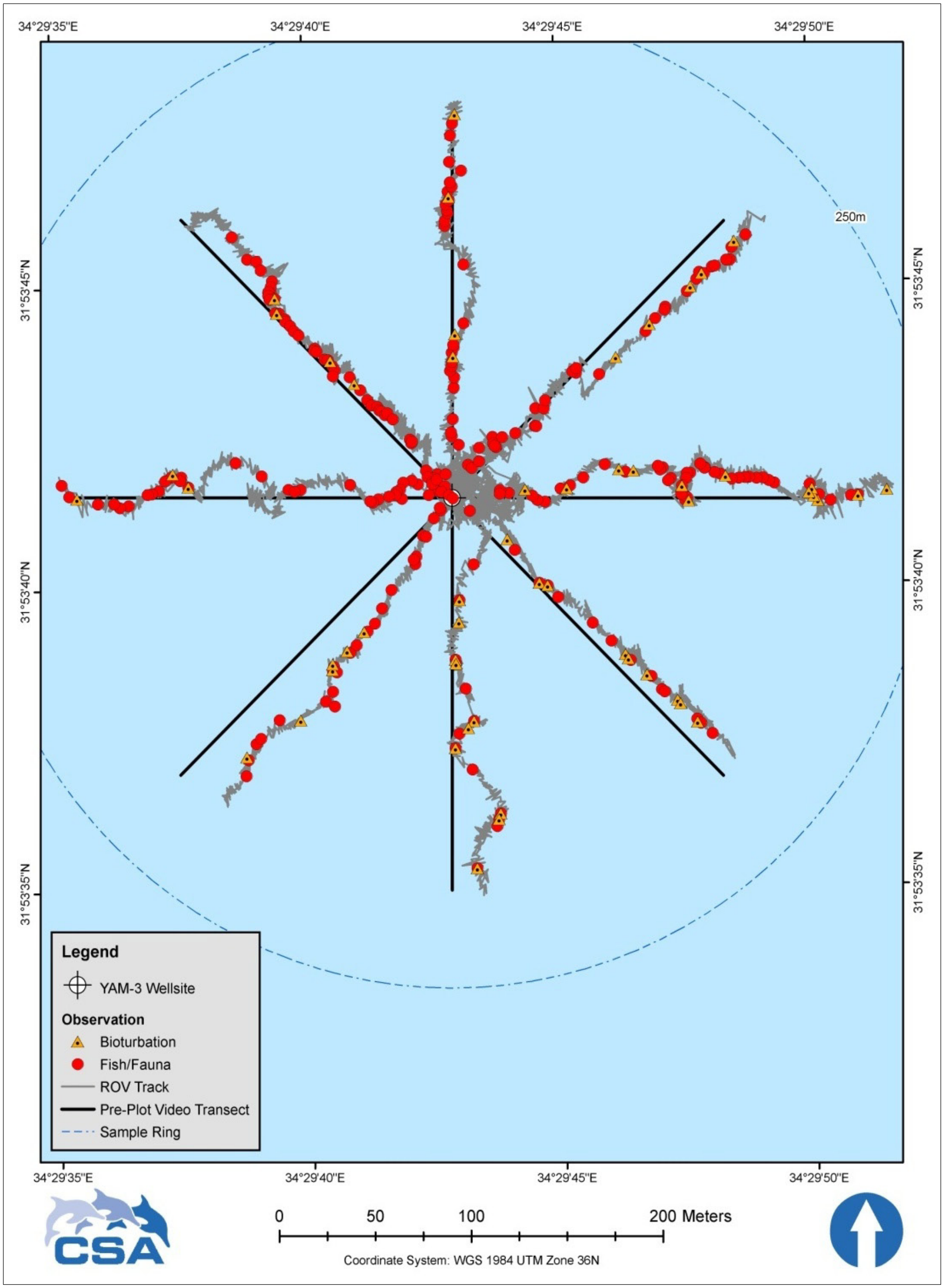


Figure 4. Location of observations of biological activity along the remotely operated vehicle (ROV) track around the Yam-3 wellsite during the Post-Drill survey.

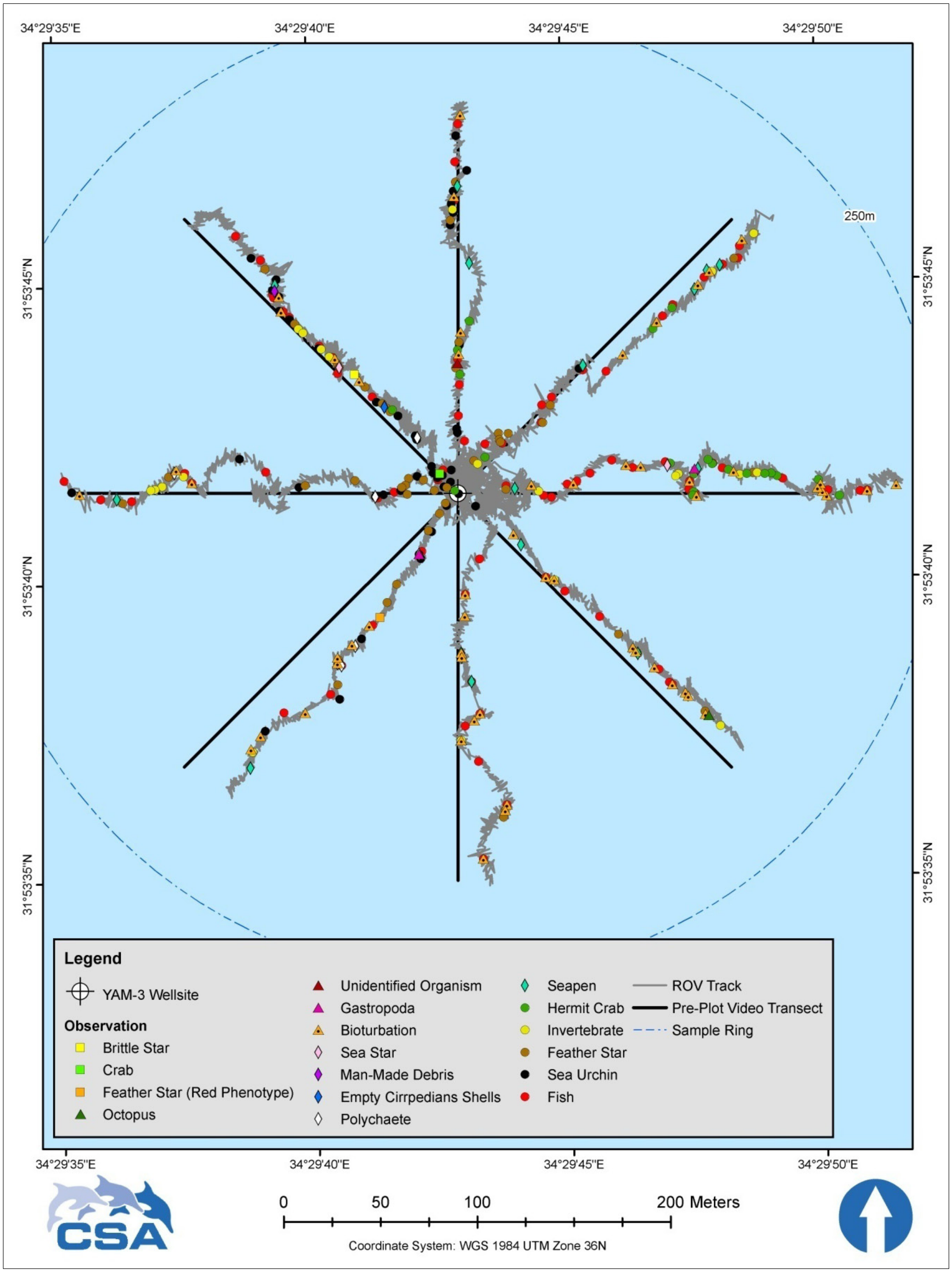


Figure 5. Locations of biological observations by groups of organisms along the remotely operated vehicle (ROV) track around the Yam-3 wellsite during the Post-Drill survey.

Organisms most commonly observed during the Post-Drill visual survey were fishes (i.e., Bothidae, Carangidae, Sparidae) (**Images 12** and **13**), seapens (Pennatulacea) (**Image 14**), sea urchins (*Stylocidaris affinis*) (**Image 15**), and feather stars (*Antedon mediterranea*) (**Image 16**). Many fishes observed during the visual survey could not be identified by video analysis mostly due to poor visibility during the video transects and, in part, because of limitations in video resolution.

Image 12. A sea bream (Sparidae) next to anthropogenic debris observed near the wellhead.

Image 13. A flounder (Bothidae) observed swimming at the South Reference site.

Image 14. Seapen (*Pennatula rubra*) observed within the wellsite survey area.

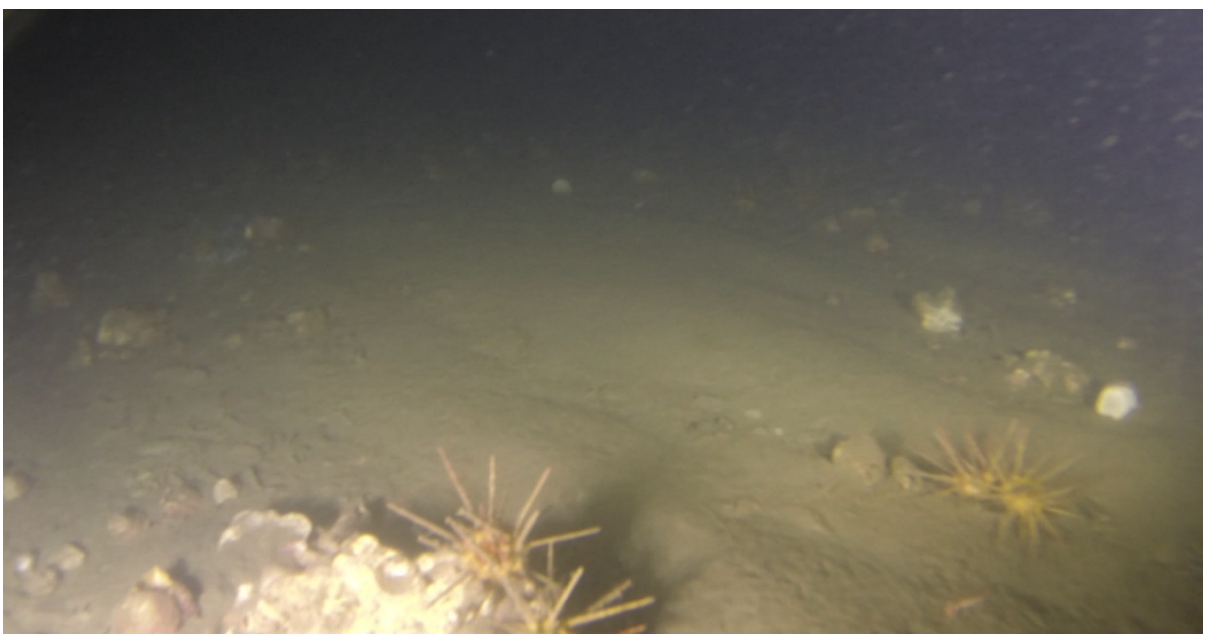


Image 15. Several individuals of the sea urchin *Stylocidaris affinis* found near the wellhead during along a wellsite transect.

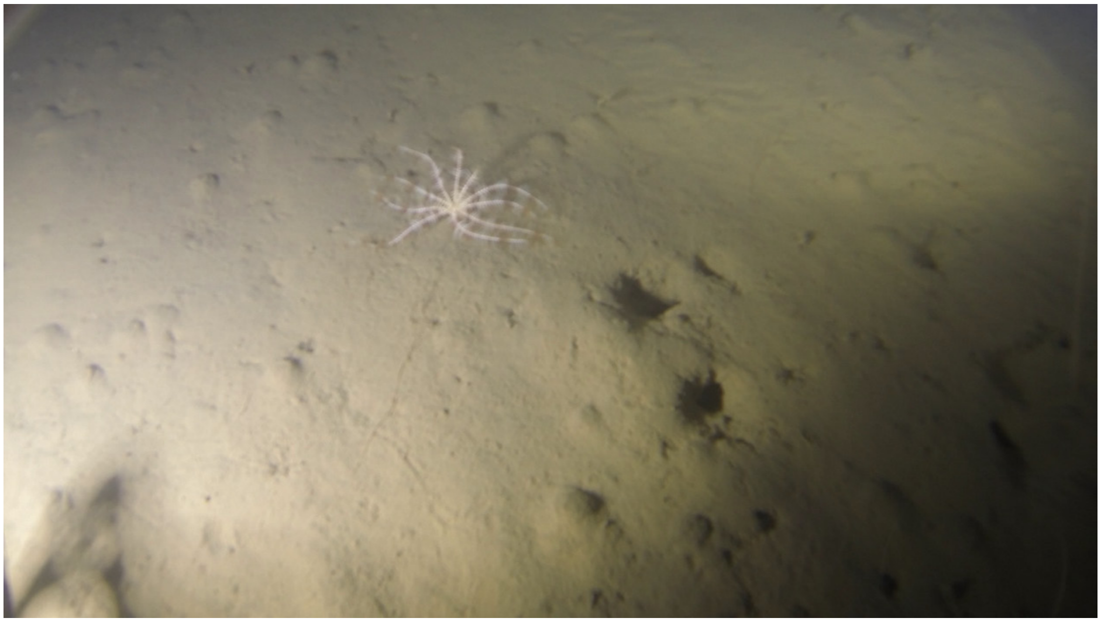


Image 16. The feather star, *Antedon mediterranea*, resting on the soft bottom sediment with its arms facing up.

Bioturbation was commonly observed along all video transects and included patterned burrows (small groupings) and small (approximately 15 to 30 cm) conical mounds likely formed by deposit-feeding worms (Polychaeta). Biological activity was detected at the wellhead itself as it was encrusted by tube worm-snails (Vermetidae) and inhabited by fishes (**Image 17**). Empty Cirripedia shells were seen in the vicinity of the wellsite, approximately 50 m away from the wellhead. The empty shells, although varying in size, were up to 10 cm in diameter (**Image 18**) and originated in the jack-up rig legs.

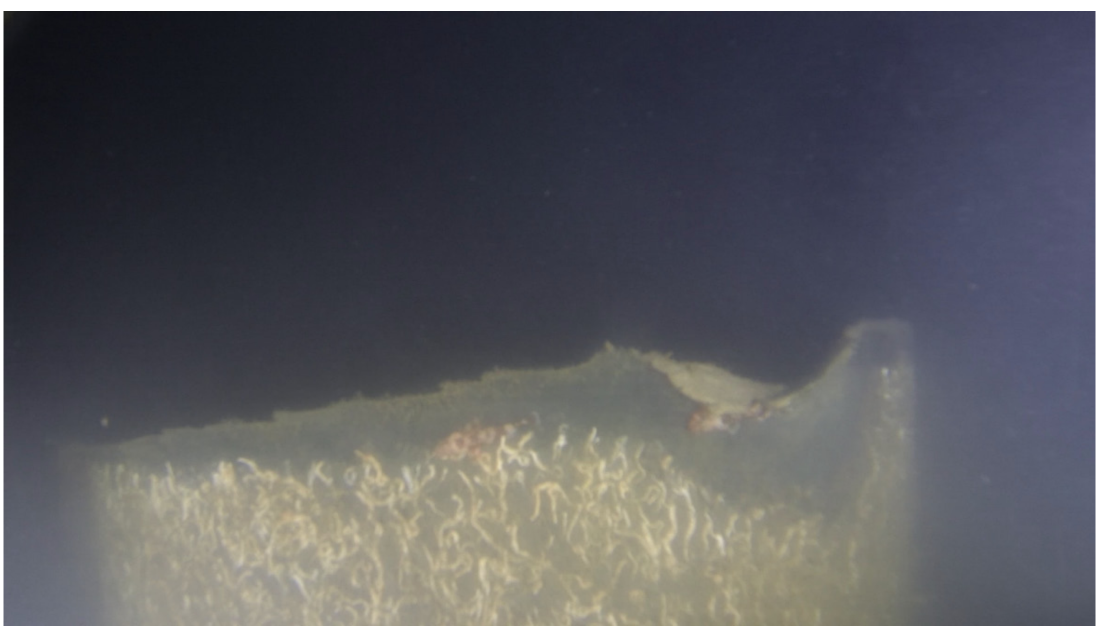


Image 17. Top end of the Yam-3 wellhead covered by vermetids and serving as shelter for several cryptic fish.

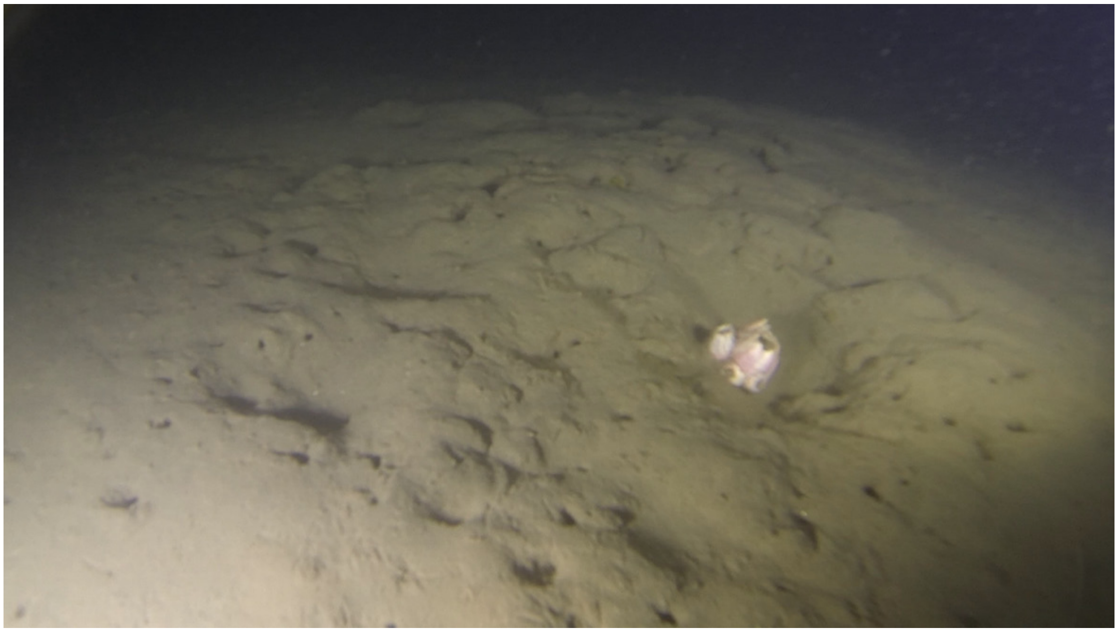


Image 18. Empty Cirripedia shells observed during one of the wellsite transects. These are assumed to be a species of the genus Megabalanus (Family Balanidae).

Biological activity at the Pre-Drill survey of Yam-3 wellsite was only qualitatively described and mentioned to be sparse and included organisms similar to those mentioned for the Post-Drill survey (sea pens, feather stars, sea urchin, and bioturbations).

For the Post-Drill survey, standardized averges and total numbers of major biological observations seen throughout the survey were calculated and summarized (**Table 6**). Dominating the wellsite area were fishes and sea urchins. At the North and South Reference areas, fishes and sea urchins were comparable and also joined by high numbers of seapens (**Table 6**). Bioturbations were seen throughout the entire survey area (**Figure 4**), but were more common at the reference areas than at the wellsite area.

Table 6. Total number and standardized average (± standard deviation) of major biological observations along video transects at the Center stratum and North and South Reference areas during the Post-Drill survey. Standardized average represents the average number of fishes or shrimps observed per 100 m of transect.

Major Biological Observation	Standardized Average (± standard deviation)			Total Number		
	Center	Reference Area		Wellsite	Reference Area	
		North	South		North	South
Fish	5.9 ± 3.2	7.4 ± 7.9	12.5 ± 7.1	118	59	88
Seapens	2.0 ± 0.9	4.5 ± 1.1	6.3 ± 0.8	40	36	40
Sea urchins	6.2 ± 7.2	2.6 ± 1.7	9.7 ± 2.8	124	21	98
Feather stars	3.8 ± 2.5	1.4 ± 1.1	2.8 ± 1.3	75	11	27
Bioturbations	3.0 ± 1.7	9.8 ± 2.3	12.8 ± 1.9	60	78	102

5.3 HYDROGRAPHIC DATA

Surface sea conditions were calm (<1 m) during the entire survey period. All hydrographic data were collected on 24 November at the Yam-3 drilllsite in approximately 90-m water depth.

Hydrographic data acquired during water column profiling were typical of shallow nearshore conditions in the eastern Mediterranean at the beginning of the winter (**Figure 6**). At this time of year, a deepening of the upper mixed layer is expected due to storms and cooling of the water column. Profiling the water column showed consistency among stations and a representative profile from the wellsite is shown in **Figure 6**. Temperature, salinity, oxygen concentration, and oxygen saturation were conservative (23.5°C, 39.5, 6.4 mg L^{-1}, and 94%, respectively) with water column mixing showing stability down to 65 m.

A winter thermocline/halocline was observed at 65 m in which temperature and salinity decreased gradually to reach 20°C and 38.8°C near the seafloor. Past the upper mixed layer, oxygen levels increased with increasing water depth to reach a concentration of 7.3 mg L^{-1} and oversaturation of 101.5%. pH was fairly consistent throughout the water column averaging 8.3. Fluorescence (chlorophyll concentration), within the water column reached maximum values at a water depth of 40 m, indicating a maximum in the abundance of phytoplanktonic communities.

Turbidity followed fluorescence throughout the water column with a peak of <1 formazin turbidity units (FTU) corresponding with 0.58 mg m^{-3} *in situ* fluorescence (as chlorophyll) at 40-m depth. Water profile differences between Pre-Drill and Post-Drill surveys were within the natural variations due seasonal change in water stratification (Gertman and Hecht, 2002; author personal observations).

5.4 SEAWATER AND SEDIMENT ANALYSIS

Detailed results from the Post-Drill survey and averages (± standard deviations) for comparison with Pre-Drill results are provided in the following sections. A stratified random approach was developed to detect trends within set distances from the wellsite to determine any potential effects caused by drilling activities. Temporal statistical analysis of seawater parameters were not appropriate because of the high level of mixing and exchange of water particles within the column. Parameters within a sampling station that are elevated over baseline conditions may be indicative of natural (i.e., seasonal) variation if reported throughout the survey region, or as a point-source disturbance if reported within a single station, and are explained as such. Statistical analysis of sediment parameters and infauna characteristics were conducted using either ANOVA or 2ANOVA tests. The criteria for determining if a significant finding was the result of drilling activities was described in **Section 4.5**.

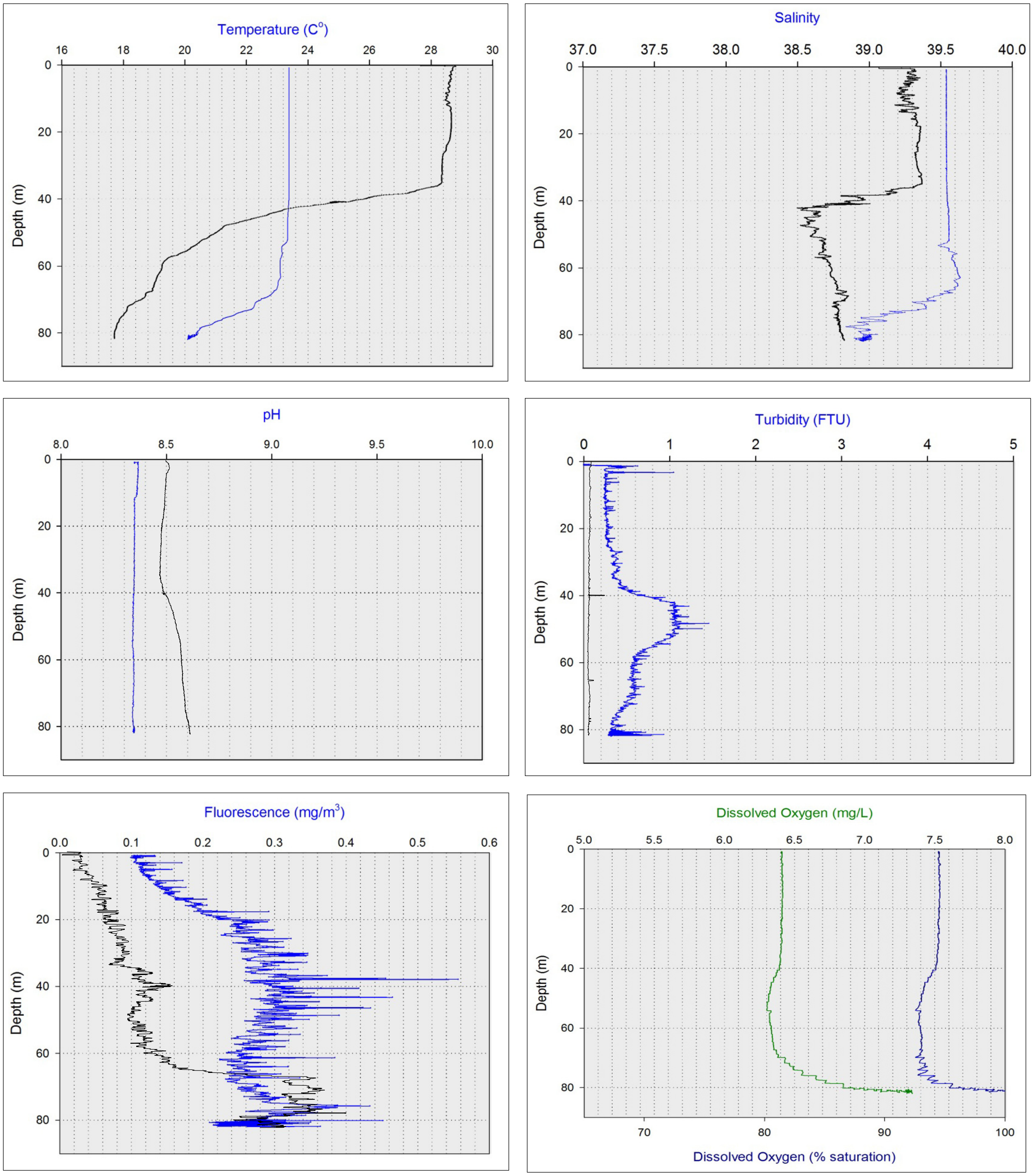


Figure 6. Water column profiles showing comparison of Pre-Drill and Post-Drill data of salinity, temperature, pH, turbidity, fluorescence (as chlorophyll), and dissolved oxygen at the Yam-3 drillsite. Pre-Drill (black) was collected in September 2012 and Post-Drill (blue) was collected in November 2013. Dissolved oxygen was not measured during the Pre-Drill survey.

5.4.1 Seawater

Total Organic Carbon

TOC in the form of carbohydrates, oils, proteins, and amino acids is a natural component of the water column in the marine environment typically resulting from the mineralization of organic matter and biological activity. Pre-Drill TOC levels were below detection limit of the laboratory conducting the analysis, thus providing a problematic base for comparison with Post-Drill results. However, concentrations observed during the Post-Drill were uniform among the sampling stations, including reference areas, and were within the acceptable analytic error from the Proposed MEQS in Israel (**Table 7**). Therefore, the results of the Post-Drill survey indicate that TOC concentrations were not impacted by drilling activities and no ecological impacts are anticipated.

Table 7. Average concentrations (mg L^{-1}) of total suspended solids (TSS), total nitrogen (TN), total phosphorus (TP), and total organic carbon (TOC) in seawater samples collected from the Yam-3 Pre-Drill and Post-Drill surveys.

Stratum	Water Depth	TOC		TP		TN		Nitrate	Nitrite	Ammonium	Phosphate	TSS
		Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Post-Drill*				
		Concentration (mg L^{-1})										
Center	Near-surface	<2.50	1.05	<0.010	0.0056	<0.50	0.09	0.0043	0.0007	0.0100	0.0018	4.4
	Mid-depth	<2.50	0.96	<0.010	0.0055	<0.50	0.13	0.0044	0.0007	0.0120	0.0018	5.6
	Near-bottom	<2.50	0.97	<0.010	0.0065	<0.50	0.11	0.0036	0.0007	0.0100	0.0018	5.6
North Reference	Near-surface	<2.50	1.01	<0.010	0.0057	<0.50	0.10	0.0018	0.0007	0.0100	0.0015	3.1
	Mid-depth	<2.50	1.12	<0.010	0.0062	<0.50	0.11	0.0022	0.0007	0.0100	0.0018	2.5
	Near-bottom	<2.50	0.98	<0.010	0.0056	<0.50	0.09	0.0035	0.0007	0.0100	0.0018	2.4
South Reference	Near-surface	<2.50	1.04	<0.010	0.0045	<0.50	0.09	0.0028	0.0007	0.0100	0.0015	2.4
	Mid-depth	<2.50	1.05	<0.010	0.0040	<0.50	0.11	0.0018	0.0007	0.0100	0.0015	4.5
	Near-bottom	<2.50	0.95	<0.010	0.0044	<0.50	0.09	0.0038	0.0008	0.0100	0.0014	7.1
Proposed MEQS in Israel (MoEP, 2002)		1		0.1		n/a		n/a	n/a	0.5	n/a	n/a

* Nitrogen and phosphorus species and TSS were not collected during the Pre-Drill survey.
MEQS = Mediterranean Environmental Water Quality Standards; MoEP = Ministry of Environmental Protection; n/a = data not available.

Nutrients

The eastern Levantine Basin has extremely low levels of nutrients, and the region is considered "ultra-oligotrophic". Nitrate and phosphate concentrations in surface waters in the eastern Mediterranean are one-half the concentration in the western basin (Bethoux et al., 1992). This severe nutrient deficit is due to the very low net supply of nutrients to the Mediterranean Basin because the Atlantic inflow brings in nutrient-depleted surface waters and there is very little nutrient input from rivers in the eastern Levantine Basin (Krom, 1995, Tanhua et al., 2013). The system is unusual in that it is phosphorus limited, presenting high N:P ratio. Nutrient budget calculations using long-term datasets show that nitrogen and phosphorus loads to the region are substantially different from the Redfield molar ratio of 16:1 (Krom et al., 2004) being mainly responsible for the deficiency in phosphorus, in particular in deep water where nitrate to phosphate ratio is as high as 28:1 (Krom et al., 1991). This ratio is presumably retained by dominant anti-estuarine flow in the region (Krom et al., 2004).

Post-Drill nutrient concentrations remained stable throughout the water column as expected because light penetrates all water depths, resulting in primary production activity and high nutrient consumption (**Table 7**). Results from the Pre-Drill survey for both TP and TN concentrations were below the detection limit of the laboratory conducting the analysis, yet those detection thresholds corresponded with the very low results obtained during the Post-Drill survey. Post-Drill results were well below the available proposed MEQS in Israel (**Table 7**). Nitrogen species, ammonium, nitrate and nitrite, comprised a small fraction of the TN measured (**Table 7**), suggesting most of it was found in the organic form. A similar observation was made with phosphate and TP. Overall, nutrients concentration are consistent with previous studies from the Levantine Basin (Azov, 1986; Herut et al., 1999; Kress et al., 2005), suggesting no impact by the drilling activities.

Total Suspended Solids

The eastern Mediterranean is known as a highly oligotrophic body of water with high water column transparency. The low TSS levels and high underwater transparency expected in the eastern Mediterranean are attributed to low water column productivity and low terrestrial inputs from riverine discharges. TSS concentrations observed during the Post-Drill survey were in agreement with results obtained in studies from recent years conducted in similar environment at the northeastern Mediterranean (Yilmaz et al., 1998; Uysal and Köksalan, 2006; Uysal and Köksalan, 2010). Comparison between past and present conditions was not possible because TSS was not sampled during the Pre-Drill survey. For Post-Drill survey, TSS values among stations ranged from 2.4 to 4.4 mg/L for near-surface samples, 2.5 to 5.6 mg L^{-1} for mid-depth samples, and 2.4 to 7.1 L^{-1} for near-bottom samples. TSS concentrations observed at the wellsite were similar to TSS levels observed at the reference areas (**Table 7**).

Total Metals

Results of total metals analysis in seawater are provided in **Table 8** compared to the proposed MEQS in Israel (MoEP, 2002) and toxicity reference values (marine CCCs from Buchman, 2008). Where the USEPA's National Recommended Water Quality Criteria (Buchman, 2008) are not available for some metals, criteria from other countries (e.g., Canada, and New Zealand) are provided for reference. All seawater total metals concentrations (Pre-Drill and Post-Drill samples) were below Israel's MEQS and CCC reference values. Concentrations of Ag, Be, Cd, Hg, Pb, Se, Tl, V, and Zn were below the analytical laboratory's quantification limits. Other than antimony, concentrations of all other metals were similar or below Pre-Drill survey results. Antimony concentrations were found to be somewhat elevated compared with the Pre-Drill survey, yet the exceptions are consistent among stations and water column depths and are well below both proposed MEQS and CCC reference values. Minute differences between the Pre-Drill and the Post-Drill may be due to the change in laboratories between the two surveys following a request by the MoEP. Analytical results for total metals in seawater samples are provided in **Appendix G**. It was concluded that no ecological impacts are anticipated from seawater total metals concentrations at the Yam-3 wellsite.

Table 8. Metals concentrations ($\mu g\ L^{-1}$) in seawater from the Yam-3 survey area (Pre-Drill and Post-Drill surveys), with comparisons to toxicity reference values (Criterion Continuous Concentration [CCC]) (Buchman, 2008) and the proposed Mediterranean Environmental Water Quality Standards (MEQS) in Israel (Ministry of Environmental Protection, 2002).

Water Depth	Survey	Stratum	Silver (Ag)	Arsenic (As)	Barium (Ba)	Beryllium (Be)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Mercury (Hg)	Nickel (Ni)	Lead (Pb)	Antimony (Sb)	Selenium (Se)	Thallium (Tl)	Vanadium (V)	Zinc (Zn)
Near-surface	Pre-Drill	Center	<0.50	<10.0	8.05	<0.01	0.079	0.597	0.555	<0.02	<0.50	<0.30	0.361	0.188	<0.10	1.84	<2.0
		North Reference	<0.50	<10.0	8.40	<0.01	0.067	3.580	0.523	<0.02	1.88	0.332	0.401	0.175	<0.10	2.19	3.22
		South Reference	<0.50	<10.0	8.21	<0.01	0.081	0.603	<0.50	<0.02	0.572	<0.30	0.399	0.160	<0.10	2.15	<2.0
	Post-Drill	Center	<0.50	1.10	9.00	<0.02	<0.02	0.20	0.20	<0.001	0.20	<0.02	1.29	<1.0	<0.02	<8.0	<0.50
		North Reference	<0.50	1.40	8.40	<0.02	<0.02	0.30	0.30	<0.001	0.40	<0.02	1.86	<1.0	<0.03	<8.0	<0.50
		South Reference	<0.50	1.40	9.00	<0.02	<0.02	0.30	0.30	<0.001	0.30	<0.02	<1.0	<1.0	<0.03	<8.0	<0.50
Mid-depth	Pre-Drill	Center	<0.50	<10.0	8.11	<0.01	<0.05	0.916	0.707	<0.02	0.604	0.455	0.415	0.170	<0.10	1.91	2.29
		North Reference	<0.50	<10.0	8.11	<0.01	0.058	1.03	<0.50	<0.02	0.57	<0.30	0.381	0.172	<0.10	2.03	3.81
		South Reference	<0.50	<10.0	7.79	<0.01	0.063	0.69	<0.50	<0.02	<0.50	<0.30	0.393	0.170	<0.10	1.83	<2.0
	Post-Drill	Center	<0.50	1.0	8.80	<0.02	<0.02	0.20	0.20	<0.001	0.20	<0.02	1.17	<1.0	<0.02	<8.0	<0.50
		North Reference	<0.50	1.4	9.00	<0.02	<0.02	0.30	0.30	<0.001	0.30	<0.02	1.23	<1.0	<0.03	<8.0	<0.50
		South Reference	<0.50	1.3	9.00	<0.02	<0.02	0.30	0.30	<0.001	0.40	<0.02	<1.0	<1.0	<0.03	<8.0	1.0
Near-bottom	Pre-Drill	Center	<0.50	<10.0	9.39	0.02	0.071	0.686	0.544	<0.02	3.67	0.416	0.367	0.162	<0.10	1.96	5.11
		North Reference	<0.50	<10.0	7.56	<0.01	<0.05	0.371	<0.50	<0.02	<0.50	<0.30	0.37	0.176	<0.10	1.92	<2.0
		South Reference	<0.50	<10.0	8.02	<0.01	<0.05	0.598	<0.50	<0.02	<0.50	<0.30	0.372	0.175	<0.10	1.88	<2.0
	Post-Drill	Center	<0.50	1.1	8.20	<0.02	<0.02	0.20	0.20	<0.001	0.20	<0.02	<1.0	<1.0	<0.02	<8.0	<0.50
		North Reference	<0.50	1.5	9.00	<0.02	<0.02	0.30	0.20	<0.001	0.30	<0.02	1.37	<1.0	<0.03	<8.0	<0.50
		South Reference	<0.50	1.6	8.40	<0.02	<0.02	0.30	0.20	<0.001	0.30	<0.02	1.11	<1.0	<0.03	<8.0	<0.50
Proposed MEQS in Israel (MoEP, 2002)	Mean		3	36	--	--	0.5	10	5	0.16	10	5	--	60	--	50	40
	Maximum		7	69	--	--	2	20	10	0.4	50	20	--	150	--	100	100
CCC Value[1]			0.95* (1/2)	36	200 BC	100 BC	8.8	50	3.1	0.94	8.2	8.1	500[p]	71	17 NZ	50 BC	81

[1] Sources of CCC toxicity reference values: primary entry is the U.S. Ambient Water Quality Criteria; BC = British Columbia Water Quality Guidelines; NZ = Australian and New Zealand Environmental Concern Levels and Trigger Values.
-- = concentration not determined; CCC = Criterion Maximum Concentration; MoEP = Ministry of Environmental Protection; ND = not detected; p = proposed; (1/2) = Criterion Maximum Concentration has been halved to be comparable to 1985 guidelines for minimum data requirements and derivation procedures.

Hydrocarbons

Generally, alkanes in seawater from the survey area were either not detected or found to be below the analytical method detection limit (see **Table 9** and **Appendix H**). Throughout all sampling stations, concentrations of hexadecane (C16) and octadecane (C18) were just above the analytic method detection limit and an elevated concentration (2.716 µg L^{-1}) at the South Reference near-bottom sample. Equipment blanks showed consistency with these findings, suggesting that they were not related to the drilling activities. TPH values were slightly elevated in both samples and the equipment and field blanks. No change in smell, seawater sheen, or discoloration were observed during water sampling. Other than the mentioned exceptions, the results correspond with nondetectable concentrations reported from the Yam-3 Pre-Drill survey.

Table 9. Alkanes and total petroleum hydrocarbon (TPH) concentrations (µg L^{-1}) in seawater from the Yam-3 Post-Drill survey.

Alkane (µg L^{-1})	MDL	Near-Surface			Mid-Depth			Near-Bottom			EB	FB
		Center	N-Ref	S-Ref	Center	N-Ref	S-Ref	Center	N-Ref	S-Ref		
Undecane C11	0.251	<0.253	0.048	0.04	<0.251	0.051	0.062	<0.251	0.057	0.047	<0.264	<0.256
Dodecane C12	0.266	0.08	0.094	0.091	0.08	0.133	0.111	0.079	0.135	0.17 J	0.146	<0.272
Tetradecane C14	0.277	0.151	0.167	0.176	0.151	0.242	0.177	0.175	0.23	0.508	0.142	<0.282
Hexadecane C16	0.234	0.32	0.506	0.469	0.32	0.811	0.55	0.456	0.876	2.716	0.379	<0.239
Octadecane C18	0.1	0.117	0.14	0.114	0.117	0.19	0.169	0.167	0.211	0.65	0.14	<0.102
Eicosane C20	0.077	0.041	0.051	0.048	0.041	0.063	0.062	0.058	0.053	0.183	0.063	<0.079
Tetracosane C24	0.069	0.022	0.046	0.072	0.022	0.055	0.066	0.094	0.049	0.124	0.092	<0.07
Octacosane C28	0.077	0.015	0.015	0.036	0.015	0.065	0.135	0.027	0.078	0.148	0.049	<0.079
Dotriacontane C32	0.083	<0.084	<0.077	<0.082	<0.083	0.038	0.078	<0.083	<0.081	0.052	<0.087	<0.084
Hexatriacontane C36	0.113	<0.114	<0.106	<0.112	<0.113	<0.115	<0.109	<0.113	<0.111	<0.117	<0.119	<0.115
Tetracontane C40	0.144	<0.145	<0.142	<0.134	<0.144	<0.138	<0.147	<0.144	<0.141	<0.148	<0.151	<0.147
TPH	13	56	69	50	56	88	76	19	18	36	140	404

EB = equipment blank; FB = field blank.

All TPH and alkanes values were well below the proposed maximum Israeli MEQS concentration of 0.5 mg L^{-1}. Although there are no toxicity reference values available for alkanes in seawater, no ecological impacts are anticipated due to the low concentrations encountered.

PAH seawater concentrations and MDLs for the primary analytical laboratory are reported in **Table 10** and **Appendix H**. PAHs were not detected at a reporting limit of 10 to 30 ng L^{-1} during the Pre-Drill survey. In the Post-Drill survey, PAHs were detected in both reference and wellsite sampling stations with total PAH concentrations ranging from 53.1 to 240 ng L^{-1}. Naphthalene levels were mainly responsible for the indicated PAH values. Although concentrations of some PAHs were found to be above the MDL during the Post-Drill survey, all reported values were much below the lowest marine CCC of 1,400 ng L^{-1} for naphthalene (Buchman, 2008), and total PAH concentrations were below the MEQS indicating that no ecological impacts are anticipated.

Table 10. Polycyclic aromatic hydrocarbon (PAH) concentrations (ng L^{-1}) in seawater collected from the Yam-3 Post-Drill survey area.

PAH Analyte (ng L^{-1})	MDL	CCC[1]	Near-Surface			Mid-Depth			Near-Bottom		
			Center	N-Ref	S-Ref	Center	N-Ref	S-Ref	Center	N-Ref	S-Ref
Naphthalene	2.91	1,400	176	105	17.3	94.1	189	173	112	81.4	169
Acenaphthylene	1.17	--	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Acenaphthene	1.44	--	0.829*	<1.4	<1.4	<1.4	<1.5	<1.4	<1.4	<1.5	<1.4
Fluorene	0.81	--	1.01	1.05	1.00	0.986	1.50	1.18	1.22	3.59	1.33
Anthracene	0.77	40,000	0.566*	0.273*	0.289*	<0.8	<0.8	0.293*	<0.8	<0.8	0.358*
Phenanthrene	2.26	4,600	2.28*	2.73	2.37	2.21*	3.91	2.87	2.79	11.5	3.41
Fluoranthene	1.09	11,000	1.00*	0.939*	1.02*	0.856*	1.13	<1.1	0.898*	1.98	0.920*
Pyrene	1.37	--	1.03*	1.03*	1.00*	1.07*	1.18*	1.14*	1.15*	1.67	0.956*
Benz(a)anthracene	0.74	--	<0.7	<0.7	<0.7	<0.7	<0.8	<0.7	<0.7	<0.8	<0.7
Chrysene /Triphenylene	0.80	--	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
Benzo(b)fluoranthene	2.38	--	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.5	<2.4
Benzo(k,j)fluoranthene	2.51	--	<2.5	<2.5	<2.5	<2.5	<2.6	<2.5	<2.5	<2.6	<2.5
Benzo(a)pyrene	2.69	--	<1.9	<1.9	<1.9	<1.9	<2	<1.9	<1.9	<2	<1.9
Indeno(1,2,3-c,d)pyrene	1.39	--	1.15*	0.377*	0.490*	0.823*	0.304*	0.832*	0.862*	0.378*	0.519*
Dibenz(a,h)anthracene	1.14	--	0.97*	0.234*	0.330*	0.617*	0.194*	0.561*	0.560*	0.191*	0.311*
Benzo(g,h,i)perylene	2.51	--	1.56*	0.650*	0.822*	1.25*	0.458*	1.02*	1.35*	0.558*	0.793*
Total PAHs			**213**	**142**	**53.1**	**129**	**240**	**213**	**151**	**192**	**219**
Proposed MEQS in Israel (MoEP, 2002)	Mean		5,000								

1 Proposed Criterion Continuous concentration (CCC) in marine surface waters (Buchman, 2008).
* Analyte detected below the method detection limit.
MDL = method detection limit of the analytical laboratory; MEQS = Mediterranean Environmental Water Quality Standards; MoEP = Ministry of Environmental Protection.

Radionuclides

Seawater samples for analysis of radionuclides were taken at each water depth at the Center stratum and both reference areas. Radionuclides were not sampled during the Yam-3 Pre-Drill survey. Results of the seawater analysis of radionuclides (Ra 226 and Ra 228) for the Post-Drill survey are provided in **Table 11** and **Appendix I**. Concentrations ranged from 0.03 to 0.29 pCi L^{-1} for Ra 226 and 0 to 0.28 pCi L^{-1} for Ra 228. Combined Ra 226/228 values for seawater ranged from 0 to 2.70 pCi L^{-1}, which are below the USEPA established MCL of 5 pCi L^{-1} for combined Ra 226 and Ra 228 (USEPA, 1976). All samples but one were found to be less than the sample specific MDC. These data indicate that Ra concentrations at Yam-3 wellsite were within the naturally occurring levels and therefore below levels of concern.

Table 11. Mean and combined mean concentrations (pCi L^{-1}) of radionuclides (radium [Ra] 226 and Ra 228) in seawater from the Yam-3 Post-Drill survey area.

Stratum	Water Depth	Radionuclide Concentration (pCi L^{-1})		
		Ra 226	Ra 228	Combined Ra 226 and Ra 228
Center	Near-surface	0.15	0.12	1.25
	Mid-depth	0.29	0.22	1.32
	Near-bottom	0.22	0.28	0.79
North Reference	Near-surface	0.16	0.08	2.00
	Mid-depth	0.27	0.1	2.70
	Near-bottom	0.15	0.1	1.50
South Reference	Near-surface	0.11	-0.02	-5.50
	Mid-depth	0.12	0.19	0.63
	Near-bottom	0.03	0.15	0.20

Negative values indicate values below laboratory blank.

5.4.2 Sediment

Grain Size

Table 12 summarizes the grain size distribution and sediment type (Shepard, 1954) during the Yam-3 Post-Drill survey. Grain size characteristics were generally similar between Pre-Drill grain size averages (September 2012) and Post-Drill grain size results (**Figure 7** and **Table 13**). Laboratory reports for grain size analysis are provided in **Appendix J**. Seafloor sediments at the wellsite were primarily composed of silt, both during the Pre-Drill (69.6%) and Post-Drill survey (60.7%) (**Table 13**). Sediments at all stations during both surveys were primarily composed of silt with a high clay fraction and were classified as Clayey Silt (Shepard, 1954).

Table 12. Grain size distribution and sediment type within the Yam-3 Post-Drill survey area.

Stratum	Station	Clay (%)	Silt (%)	Sand (%)	Sediment Type
Center	1	21.8	57.8	20.4	Clayey Silt
	2	26.5	62.5	11.0	Clayey Silt
	3	26.3	57.8	15.9	Clayey Silt
	4	22.2	63.0	14.7	Clayey Silt
	5	27.7	58.9	13.4	Clayey Silt
	6	18.4	61.7	19.9	Clayey Silt
	7	23.7	63.4	13.0	Clayey Silt
Near-Field	1	28.8	63.4	7.8	Clayey Silt
	2	17.1	51.7	31.2	Clayey Silt
	3	23.3	65.0	11.7	Clayey Silt
	4	21.6	67.6	10.8	Clayey Silt
	5	21.8	63.3	14.9	Clayey Silt
	6	24.3	65.5	10.2	Clayey Silt
	7	26.5	63.1	10.4	Clayey Silt
Mid-Field	1	25.8	65.5	8.7	Clayey Silt
	2	20.1	57.5	22.4	Clayey Silt
	3	27.5	67.7	4.8	Clayey Silt
	4	21.1	63.5	15.4	Clayey Silt
	5	26.2	66.1	7.7	Clayey Silt
	6	22.8	61.7	15.4	Clayey Silt
	7	23.2	66.4	10.4	Clayey Silt
Far-Field	1	29.5	66.4	4.1	Clayey Silt
	2	19.5	56.8	23.7	Clayey Silt
	3	29.7	64.9	5.4	Clayey Silt
	4	31.0	62.0	6.9	Clayey Silt
	5	26.4	67.3	6.3	Clayey Silt
	6	25.4	59.7	14.9	Clayey Silt
	7	27.3	61.2	11.5	Clayey Silt
North Reference	1	28.7	62.4	8.9	Clayey Silt
	2	23.3	68.1	8.6	Clayey Silt
	3	27.9	65.9	6.2	Clayey Silt
	4	25.9	65.7	8.4	Clayey Silt
	5	25.1	64.8	10.1	Clayey Silt
	6	25.3	62.2	12.5	Clayey Silt
	7	27.3	65.2	7.5	Clayey Silt
South Reference	1	31.7	62.3	6.1	Clayey Silt
	2	26.5	66.9	6.7	Clayey Silt
	3	26.5	68.0	5.5	Clayey Silt
	4	26.0	65.6	8.4	Clayey Silt
	5	13.1	47.2	39.7	Clayey Silt
	6	25.1	68.9	6.0	Clayey Silt
	7	27.6	66.3	6.1	Clayey Silt

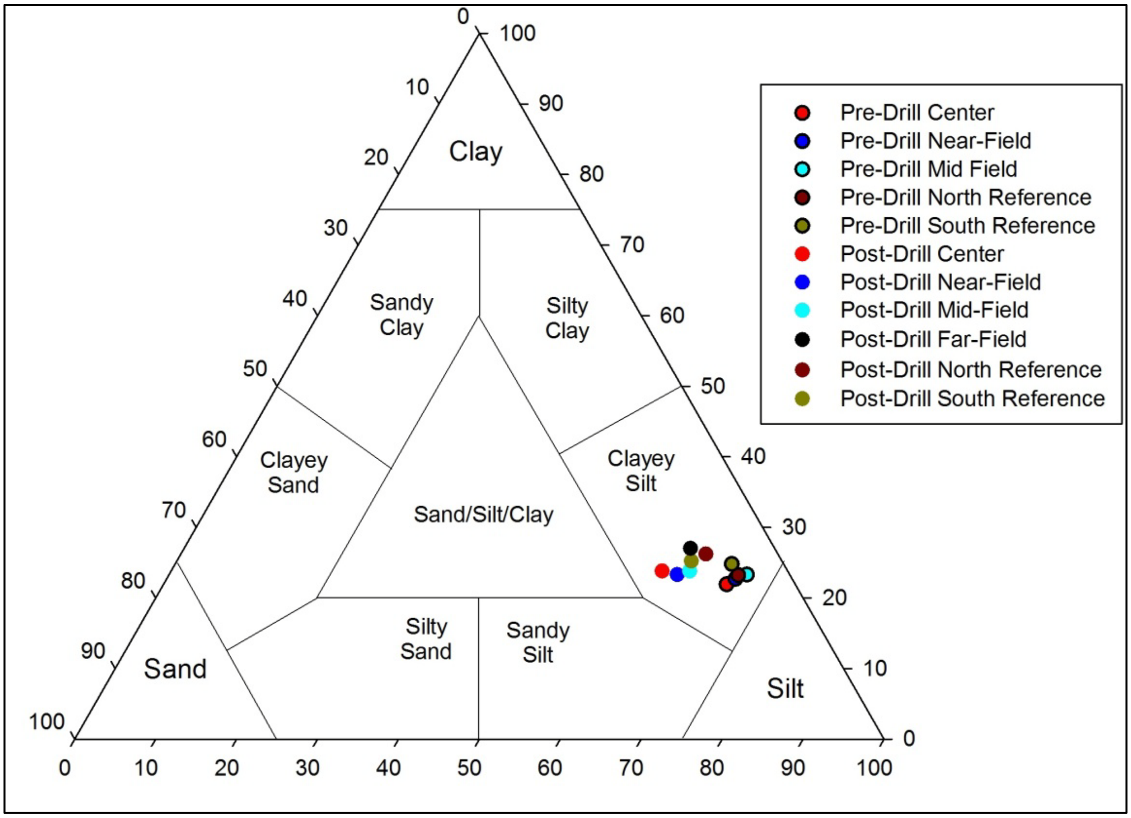


Figure 7. Ternary diagram showing grain size characteristics from sediment samples collected within the Yam-3 Post-Drill survey area.

The most dynamic fraction of sediment observed to change between Pre-Drill and Post-Drill was the sand content. A certain patchiness in sediment composition likely occurs on the continental shelf of Israel. An example of such variability can be seen at the South Reference area where some stations presented higher sand content than other stations in the area (**Table 12**). As observed in **Images 10** and **11**, the seafloor in the vicinity of the wellhead consisted of a high percentage of sand/large grain size compared with Near-field, Mid-field, and Far-field stations (**Table 12**) and compared with the Pre-Drill (**Table 13** and **14**). Examination of the sand component (**Figure 8**) showed the sand fraction to be slightly coarser (approximately 5.5%) at the Center stratum than at strata farther away from the drillsite.

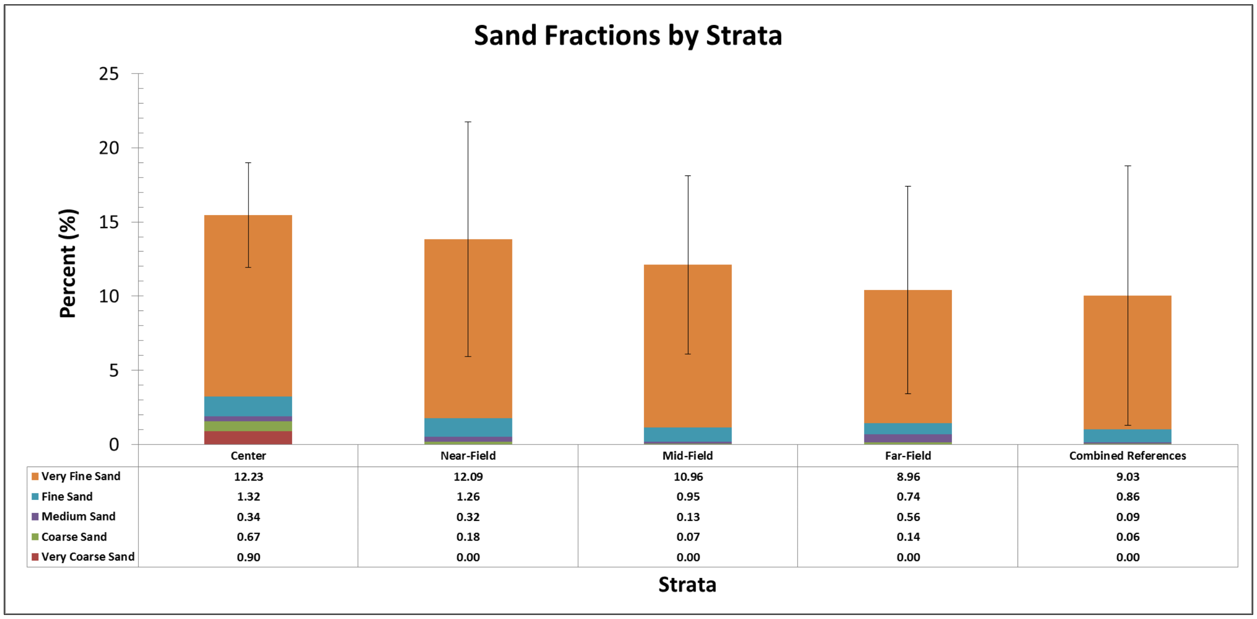
The 2ANOVA statistical analysis showed that a drilling effect took place resulting in a small change in sediment grain size between the Pre-Drill and the Post-Drill survey (**Table 14**). However, it is also possible that winter storms, which occurred before the sampling effort, substantially contributed to resuspending the sediment and shuffling grain size in the survey area. Clay remained relatively consistent between surveys and, despite showing higher results at the Post-Drill, the difference between surveys was not substantial (Pre-Drill: 22.9%, Post-Drill: 24.9%; $p < 0.05$). The percentage of both sand and silt were significantly different between surveys and any increase in sand was accompanied by concomitant decrease in the silt fraction. The percentages of sand varied considerably among strata at the Post-Drill survey (**Table 14** and **Figure 8**). This variability was assumed to be the result of both fine cuttings being transported away from the discharge point (30 m under the surface) by an active longshore current (Zviely, 2007) and by deep water column mixing, during the winter time, suspending fines from the seafloor. Longshore sand transport known to transport sand from the delta of the Nile (Zviely, 2007) may well be another source for sand distribution in the survey area.

Table 13. Average (± standard deviation) grain size distributions and sediment types observed during the Yam-3 Pre-Drill and Post-Drill surveys. (Sediment samples were not collected at the Far-field stratum during the Pre-Drill survey.)

Grain Size Fraction (%)	Center		Near-Field		Mid-Field		Far Field		North Reference		South Reference	
	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill
Clay	21.9 ± 1.4	23.8 ± 3.3	22.7 ± 1.1	23.3 ± 3.8	23.3 ± 0.7	23.8 ± 2.8	-	27.0 ± 3.8	23.2 ± 0.9	26.2 ± 1.9	24.8 ± 2.2	25.2 ± 5.7
Silt	69.6 ± 2.1	60.7 ± 2.5	70.3 ± 1.6	62.8 ± 5.1	71.4 ± 1.4	64.1 ± 3.5	-	62.6 ± 3.8	70.4 ± 1.9	64.9 ± 2.1	68.8 ± 4.6	63.6 ± 7.5
Sand	8.5 ± 3.1	15.5 ± 3.5	7.0 ± 2.2	13.8 ± 7.9	5.3 ± 1.8	12.1 ± 6.0	-	10.4 ± 7.0	6.4 ± 2.3	8.9 ± 2.0	6.3 ± 4.8	11.2 ± 12.6
Sediment Type	Clayey Silt	Clayey Silt	Clayey Silt	Clayey Silt	Clayey Silt	Clayey Silt	-	Clayey Silt	Clayey Silt	Clayey Silt	Clayey Silt	Clayey Silt

Table 14. Results of two-way analysis of variance (2ANOVA) for grain size fraction for the Yam-3 Post-Drill survey. X = significant difference at $p < 0.05$; NS = no significant difference at $p < 0.05$.

Grain Size Fraction (%)	Main Effects		Interaction	Post-Drill Higher?	Consistent Drill Effect?	2ANOVA Assessment
	Strata	Survey				
Sand	X	X	NS	Yes	Unclear	There was statistical difference with the Post-Drill having a higher overall value (Pre-Drill: 6.8%, Post-Drill: 12.0%). In the Post-Drill there was more variability in values among strata, contributing to the effect of distance from the wellsite, but not in a coherent sequence that clearly defined a drilling effect.
Silt	NS	X	NS	No	Unclear	There was statistical difference among surveys with Post-Drill survey being lower than Pre-Drill (Pre-Drill: 70.2%, Post-Drill 63.1%). However, the Post-Drill was consistently lower than the Pre-Drill across all strata.
Clay	NS	X	NS	Yes	No	Although there was statistical difference, the difference among surveys was not meaningful (Pre-Drill: 22.9%, Post-Drill 24.9%).



	Center	Near-Field	Mid-Field	Far-Field	Combined References
Very Fine Sand	12.23	12.09	10.96	8.96	9.03
Fine Sand	1.32	1.26	0.95	0.74	0.86
Medium Sand	0.34	0.32	0.13	0.56	0.09
Coarse Sand	0.67	0.18	0.07	0.14	0.06
Very Coarse Sand	0.90	0.00	0.00	0.00	0.00

Figure 8. Average percent of sand fractions by stratum for the Yam-3 Post-Drill survey. Changes in sand composition are seen among the different strata within Yam-3 survey area. Standard deviation relates to total sand variability among sampling stations at each stratum. Note the very coarse and coarse sand fractions found at the Center stratum, attributed to the drilling operations.

The results suggest that statistically detectable changes occurred in sediment grain size in the survey area; however, these changes were minimal and localized in the vicinity of the drillsite (<250 m). Sand was re-distributed in the survey area, presumably through natural processes. Sediment characteristics did not change substantially from the Pre-Drill survey, classifying it as Clayey Silt.

Total Organic Carbon and Total Metals

Values for TOC and total metals concentrations in sediment samples collected during the Post-Drill survey are provided in **Table 15**. Comparative averages (± standard deviation) of TOC and total metals concentrations in the Pre-Drill and Post-Drill survey are provided in **Table 16**. Sediment quality was compared with National Oceanic and Atmospheric Administration (NOAA) ERL and ERM (**Tables 15** and **16**), and average marine sediments and continental crust values (**Table 16**; Salomons and Förstner, 1984; Wedepohl, 1995). Analytical results for TOC and total metals in sediment samples are provided in **Appendices L** and **L**, respectively.

TOC concentrations were low (0.36% to 0.87%, respectively) throughout the survey area, including the reference areas. Similar results were obtained during the survey (**Table 16**) indicating that drilling activities did not influence organic carbon levels in the sediments.

Metals results for the Post-Drill survey (**Table 16**) were analyzed in a different laboratory than the one used for the Pre-Drill because of a specific requirement by MoEP. Differences in methods, working procedures, and detection limits between the laboratories created difficulties in comparing the Pre-Drill with the Post-Drill survey results results. Pre-Drill versus Post-Drill comparisons could not be made for Al, Cd, Fe, Hg, and Se. The effects of drilling activities were therefore investigated mainly by the differences among strata in the Post-Drill and by comparing with drilling fluids/mud and dry barite contents as provided by the operator per requirements by the MoEP discharge permit.

Concentrations of As and Cu were similar in both the Pre-Drill and Post-Drill surveys. Some metals (Be, V, Cr, and Ni) showed indications of dilution effects (i.e., the Post-Drill Center stratum was slightly lower than the other strata) presumably by deposition of formation sand. Although there was a drilling effect, it was noted only at lower levels, below that of adjacent baseline conditions and thus were not considered to be a negative drilling impact (**Tables 17** and **18**).

Mercury was analyzed in the Post-Drill survey in a different method (according to the proposed new regulations), and differences between Pre-Drill and Post-Drill concentrations were striking. All Pre-Drill Hg values were higher than Post-Drill, but within the Pre-Drill there was a pattern of decline with distance from the wellsite. Except for elevated values at the Center stratum in the Post-Drill survey (which were only half the ERL), no differences were noted among the remaining strata and, given the levels and pattern, Hg concentrations did not present an ecological concern (**Table 18**).

Barium, an alkaline earth element found in natural marine sediments, was also present in high concentration in drilling fluids, as a constituent of the weighing agent Barite, consequently findings its way to the adjacent seafloor. Average marine sediments and continental crust occur naturally at concentrations of 460 and 584 ppm, respectively (**Table 16**), but may vary from 1 to 2,000 ppm depending on the mineralogical properties of the sediment (Robertson and Carpenter, 1976; Siegel et al., 2000; Neff, 2002). As expected, Ba was significantly higher during the Post-Drill survey (**Tables 16** and **18**), specifically peaking at the Center stratum and diminishing rapidly with distance (**Tables 15**, **16**, and **18**). Most of the Ba in sediments was in the form of barite (BaSO4). Barite in drilling muds (**Tables 17** and **18**) and sediments has a low solubility in seawater, because of the high natural concentration of sulfate in the ocean. Because it is insoluble in seawater, it has a low bioavailability and toxicity to marine organisms (Neff, 2005). No ERL or ERM are available for Ba.

Pb concentrations at the Center stratum in the Post-Drill survey ranged from 26 ppm at station C4 to 658 ppm at station C1, averaging at 178.13 ± 221.94 ppm for the entire strata, indicating a highly patchy distribution (**Table 15**). Lead concentration in the sediments decreased rapidly with distance from the drillsite. It should be noted that the elevated lead concentrations were very localized and confined only to the Center stratum (<250 m). Lead, together with barium, chromium and zinc are metals that are frequently present in drilling muds at substantially greater concentrations than soils and sediments (Neff, 2005). Metals analysis (**Table 17**) for drilling muds and dry barite shows that lead was a dominant component of the drilling muds used for the Yam-3 program. Overall, lead concentration for four of six survey strata fell within average marine sediments and continental crust averages. Four samples out of seven at the Center stratum and two samples out of seven at the Near-field stratum had values above the ERL (**Table 15**). The average value of only the Center stratum was found to be above the ERL concentration.

Slight and point specific enrichments in the Post-Drill survey were observed at Center stratum for Ag, Cd, Hg, and Sb as shown in **Tables 16** and **18**. However, none of the metals were above the ERL.

Concentrations of As, Cr, Cu, and Ni were above the ERL in both the Pre-Drill and Post-Drill surveys. These metals were uniform throughout the survey area and are considered to be derived from high natural background concentrations and not related to the drilling operations. At least one metal, Cr, was mentioned in the literature to be naturally enriched at the southern portion of the continental shelf of Israel (Herut, 1993). Concentrations for the mentioned metals per drilling mud samples analyzed (**Table 17**) cannot account for a hypothetical wide spread at the survey area. In addition, Ba, which serves as a tracer for the dispersion of other trace metals, did not coincide with the distribution of these metals.

Table 15. Total organic carbon (TOC) content and total metals concentrations in sediments from the Yam-3 Post-Drill survey area compared with ERL and ERM (Buchman, 2008). Bold entries denote values that exceed ERL values*. Bold and underlined entries denote values that exceed both ERL and ERM. (Concentrations in ppm unless otherwise indicated.)

Stratum	Station	TOC (%)	Ag	Al (%)	As*	Ba	Be	Cd	Cr*	Cu*	Fe (%)	Hg	Ni*	Pb	Sb	Se	Tl	V	Zn
Center	1	0.56	0.80	6.21	13.50	44000	1.27	0.38	67.9	57.50	4.28	0.145	46.80	**<u>658.00</u>**	2.80	ND	0.32	104	120
	2	0.62	0.37	7.62	17.00	14800	1.21	0.23	134	50.30	6.61	0.065	68.9	**67.9**	0.90	ND	0.43	190	111
	3	0.58	0.32	7.79	16.90	7400	1.10	0.21	138	47.70	6.76	0.062	70.50	33.60	0.50	ND	0.30	196	109
	4	0.62	0.32	7.74	14.70	7330	1.23	0.20	145	45.80	6.72	0.030	68.30	26.00	0.42	ND	0.26	197	106
	5	0.74	0.62	6.75	12.70	47400	1.15	0.32	96.5	43.50	4.78	0.142	50.60	**195.00**	1.80	ND	0.30	135	119
	6	0.48	0.47	6.58	14.50	52800	0.95	0.27	125	46.10	5.62	0.135	60.30	**182.00**	1.90	ND	0.21	171	114
	7	0.52	0.36	7.44	15.80	25900	1.55	0.25	130	44.90	6.09	0.024	62.20	**84.40**	1.40	ND	0.28	179	107
Near-Field	1	0.57	0.32	7.88	17.20	10400	1.69	0.23	142	49.80	6.47	0.012	69.30	**51.60**	0.58	ND	0.19	199	110
	2	0.42	0.30	7.80	14.20	6650	1.57	0.22	136	44.50	6.95	0.023	68.80	30.90	0.45	ND	0.17	192	110
	3	0.60	0.29	7.48	16.20	12200	1.61	0.23	153	47.40	6.61	0.028	68.60	36.10	0.43	ND	0.17	205	109
	4	0.57	0.30	7.70	14.20	1800	1.63	0.22	139	45.90	6.50	0.016	69.20	16.40	ND	ND	0.19	193	106
	5	0.45	0.39	7.58	14.60	15500	1.59	0.29	132	43.10	6.25	0.025	64.70	**63.30**	1.50	ND	2.30	181	108
	6	0.55	0.31	8.11	15.30	9530	1.55	0.22	139	46.10	7.61	0.019	67.10	27.40	0.47	ND	0.47	194	105
	7	0.36	0.26	7.68	14.20	5660	1.47	0.19	138	43.80	6.86	0.021	66.70	32.00	ND	ND	0.27	191	103
Mid-Field	1	0.64	0.27	8.20	14.60	709	1.64	0.20	134	45.20	6.97	0.009	66.40	13.20	0.56	ND	0.22	187	101
	2	0.53	0.25	7.74	13.10	1110	1.59	0.21	140	45.70	6.76	0.018	68.90	12.60	ND	ND	0.19	192	103
	3	0.72	0.27	8.49	16.70	1810	1.73	0.19	134	49.40	7.08	0.017	70.30	16.90	ND	ND	0.21	196	107
	4	0.60	0.30	7.83	14.40	4780	1.48	0.19	139	44.70	6.71	0.015	68.30	20.30	ND	ND	0.17	193	104
	5	0.67	0.28	8.20	17.70	1060	1.67	0.22	142	49.20	7.23	0.019	71.50	14.50	ND	ND	0.20	202	110
	6	0.66	0.28	7.91	14.20	660	1.57	0.22	135	37.70	6.75	0.019	69.60	12.60	ND	ND	0.18	194	106
	7	0.62	0.34	7.90	15.20	2520	1.68	0.23	131	45.30	6.69	0.016	66.00	17.10	0.62	ND	0.17	191	102
Far-Field	1	0.75	0.27	8.33	18.4	1670	1.69	0.24	129	50.00	6.97	0.024	70.4	20.3	0.86	ND	1.4	195	107
	2	0.59	0.29	7.84	14.70	1930	1.47	0.19	137	44.30	6.79	0.017	67.10	14.50	ND	ND	0.31	196	103
	3	0.71	0.27	8.35	20.10	587	1.68	0.20	130	50.60	6.97	0.024	70.80	15.70	ND	ND	0.25	198	107
	4	0.64	0.27	7.84	17.50	541	1.56	0.21	139	49.30	6.77	0.021	70.10	14.30	ND	ND	0.21	204	108
	5	0.77	0.27	8.46	16.50	886	1.49	0.18	135	46.60	7.09	0.016	69.10	13.60	ND	ND	0.20	198	105
	6	0.65	0.28	8.05	17.10	445	1.46	0.21	141	45.80	6.70	0.017	68.90	13.30	ND	ND	0.18	203	106
	7	0.77	0.28	7.85	16.80	438	1.54	0.20	130	48.60	6.89	0.022	69.70	14.00	ND	ND	0.19	195	106

Table 15. (Continued).

Stratum	Station	TOC (%)	Ag	Al (%)	As*	Ba	Be	Cd	Cr*	Cu*	Fe (%)	Hg	Ni*	Pb	Sb	Se	Tl	V	Zn
North Reference	1	0.79	0.28	7.31	16.80	865	1.54	0.19	138	48.00	6.66	0.016	70.00	14.10	ND	ND	0.20	203	107
	2	0.76	0.30	7.13	16.80	2010	1.50	0.21	133	46.70	6.43	0.019	69.30	16.70	0.65	ND	0.20	194	106
	3	0.73	0.30	7.10	17.60	2100	1.50	0.22	135	48.40	6.76	0.021	69.50	18.20	ND	ND	0.17	198	108
	4	0.79	0.28	7.51	17.70	1430	1.50	0.20	135	47.10	6.75	0.020	68.60	15.70	ND	ND	0.18	196	106
	5	0.73	0.27	7.32	18.20	1620	1.48	0.18	137	48.00	6.96	0.018	70.80	16.90	ND	ND	0.18	201	108
	6	0.66	0.25	7.44	15.50	1170	1.39	0.18	137	44.40	6.83	0.017	67.10	14.80	ND	ND	0.17	199	102
	7	0.73	0.31	7.60	16.60	561	1.50	0.24	135	48.40	6.72	0.020	71.00	14.00	0.55	ND	1.02	199	108
South Reference	1	0.87	0.27	7.34	17.80	351	1.56	0.22	131	48.50	6.54	0.018	69.10	13.10	0.59	ND	0.19	195	105
	2	0.75	0.29	7.52	16.90	449	1.49	0.21	132	46.60	6.70	0.018	67.50	13.30	ND	ND	0.17	192	106
	3	0.73	0.37	7.63	19.40	479	1.56	0.21	130	49.50	6.81	0.019	69.90	15.20	ND	ND	0.18	194	108
	4	0.69	0.37	7.46	19.10	335	1.60	0.27	136	49.60	6.84	0.016	71.10	14.80	1.20	ND	2.27	203	109
	5	0.66	0.28	6.88	12.40	423	1.35	0.2	132	41.60	6.51	0.012	66.90	11.10	ND	ND	0.38	187	100
	6	0.82	0.25	7.27	16.90	354	1.49	0.19	135	46.80	6.79	0.016	69.00	13.20	ND	ND	0.26	199	105
	7	0.65	0.28	7.32	17.40	349	1.54	0.23	131	49.20	6.56	0.013	69.80	14.30	ND	ND	0.21	198	134
ERL		--	1	--	8.2	--	--	1.2	81	34	--	0.15	20.9	46.7	--	--	--	--	150
ERM		--	3.7	--	70	--	--	9.6	370	270	--	0.71	51.6	218	--	--	--	--	410

Ag = silver; Al = aluminum; As = arsenic; Ba = barium; Be = beryllium; Cd = cadmium; Cr = chromium; Cu = copper; Fe = iron; Hg = mercury; Ni = nickel; Pb = lead; Sb = antimony; Se = selenium; Tl = thallium; V = vanadium; Z = zinc.

* Entries (all stations) for the metals arsenic (As), chromium (Cr), copper (Cu), and nickel (Ni) are found to be above the ERL. The results are consistent with the Pre-Drill survey and are considered to be of background levels. These values are therefore not bolded in the table (see text for details).

Table 16. Total organic carbon (TOC) content and total metals concentrations in sediments from the Yam-3 Pre-Drill and Post-Drill survey areas (average ± standard deviation) compared with average marine sediments (Salomons and Förstner, 1984), continental crust (Wedepohl, 1995), and ERL, and ERM (Buchman 2008). (Concentrations in ppm unless otherwise indicated.)

Stratum	Survey	TOC (%)	Ag	Al (%)	As	Ba	Be	Cd	Cr	Cu	Fe (%)	Hg	Ni	Pb	Sb	Se	Tl	V	Zn
Center	Pre-Drill	0.60 ± 0.07	0.21 ± 0.04	n/a	16.36 ± 1.88	121.63 ± 25.88	1.46 ± 0.04	0.06 ± 0.01	119.63 ± 3.25	45.59 ± 1.54	n/a	0.26 ± 0.13	71.11 ± 2.11	10.18 ± 0.66	0.31 ± 0.03	1.25 ± 0.13	0.17 ± 0.01	172.13 ± 6.17	92.05 ± 2.82
	Post-Drill	0.59 ± 0.08	0.47 ± 0.18	7.16 ± 0.64	15.01 ± 1.64	28518 ± 19475	1.21 ± 0.18	0.27 ± 0.06	119.49 ± 27.49	47.97 ± 4.72	5.84 ± 0.99	0.09 ± 0.05	61.09 ± 9.29	178.13 ± 221.94	1.39 ± 0.86	ND	0.30 ± 0.07	167.43 ± 35.17	112.29 ± 5.59
Near-Field	Pre-Drill	0.58 ± 0.05	0.22 ± 0.06	n/a	17.00 ± 1.10	130.7 ± 31.60	1.46 ± 0.09	0.06 ± 0.03	118.0 ± 3.85	45.35 ± 2.21	n/a	0.16 ± 0.12	72.15 ± 3.55	10.54 ± 0.50	0.30 ± 0.02	1.25 ± 0.22	0.17 ± 0.00	172.88 ± 9.22	93.69 ± 4.46
	Post-Drill	0.50 ± 0.09	0.31 ± 0.04	7.75 ± 0.21	15.13 ± 1.18	8820 ± 4528.10	1.59 ± 0.07	0.23 ± 0.03	139.86 ± 6.57	45.80 ± 2.30	5.91 ± 2.36	0.02 ± 0.01	67.77 ± 1.69	36.81 ± 15.73	0.55 ± 0.44	ND	0.54 ± 0.78	193.57 ± 7.39	107.29 ± 2.69
Mid-Field	Pre-Drill	0.62 ± 0.06	0.20 ± 0.02	n/a	17.86 ± 2.09	118.01 ± 27.42	1.45 ± 0.04	0.05 ± 0.01	118.25 ± 3.49	45.31 ± 1.45	n/a	0.27 ± 0.05	71.63 ± 1.50	11.07 ± 0.97	0.32 ± 0.02	1.21 ± 0.08	0.17 ± 0.01	171.13 ± 5.57	92.63 ± 4.33
	Post-Drill	0.63 ± 0.06	0.28 ± 0.03	8.04 ± 0.27	15.13 ± 1.57	1807 ± 1466.98	1.62 ± 0.08	0.21 ± 0.02	136.43 ± 3.95	46.2 ± 3.88	6.88 ± 0.21	0.02 ± 0.00	68.71 ± 2.00	15.31 ± 2.90	0.31 ± 0.19	ND	0.19 ± 0.02	193.57 ± 4.65	104.71 ± 3.15
Far-Field	Pre-Drill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Post-Drill	0.69 ± 0.07	0.28 ± 0.01	8.10 ± 0.27	17.30 ± 1.67	928.14 ± 618.57	1.56 ± 0.10	0.20 ± 0.02	134.43 ± 4.83	47.89 ± 2.35	6.88 ± 0.14	0.02 ± 0.00	69.44 ± 1.24	15.10 ± 2.42	0.29 ± 0.25	ND	0.39 ± 0.45	198.43 ± 3.69	106.00 ± 1.63
North Reference	Pre-Drill	0.60 ± 0.03	0.20 ± 0.02	n/a	19.53 ± 1.64	115.25 ± 16.38	1.43 ± 0.08	0.05 ± 0.01	124.75 ± 5.56	45.75 ± 2.53	n/a	0.18 ± 0.02	72.50 ± 3.44	11.68 ± 0.64	0.32 ± 0.02	1.13 ± 0.09	0.18 ± 0.01	177.00 ± 7.35	97.60 ± 4.75
	Post-Drill	0.74 ± 0.04	0.28 ± 0.02	7.34 ± 0.19	17.03 ± 0.89	1393.71 ± 570.70	1.49 ± 0.05	0.20 ± 0.02	135.71 ± 1.70	47.29 ± 1.43	6.73 ± 0.16	0.02 ± 0.00	69.47 ± 1.34	15.77 ± 1.58	0.31 ± 0.20	ND	0.30 ± 0.32	198.57 ± 2.99	106.43 ± 2.15
South Reference	Pre-Drill	0.68 ± 0.11	0.19 ± 0.02	n/a	18.30 ± 2.42	95.13 ± 4.80	1.46 ± 0.04	0.05 ± 0.01	117.25 ± 4.43	45.13 ± 1.83	n/a	0.016 ± 0.01	72.73 ± 3.11	10.97 ± 1.27	0.31 ± 0.01	1.25 ± 0.13	0.17 ± 0.00	170.00 ± 5.35	94.43 ± 3.79
	Post-Drill	0.74 ± 0.08	0.30 ± 0.05	7.35 ± 0.05	17.13 ± 2.31	391.43 ± 57.73	1.51 ± 0.08	0.22 ± 0.03	132.43 ± 2.23	47.40 ± 2.84	6.68 ± 0.14	0.02 ± 0.00	69.04 ± 1.44	13.57 ± 1.37	0.40 ± 0.38	ND	0.52 ± 0.77	195.43 ± 5.19	109.54 ± 11.18
Average Marine Sediments		--	0.06	7.20	7.70	460.00	2.00	0.17	72.00	33.00	4.10	0.19	52.00	19.00	--	0.42	--	150.00	95.00
Continental Crust		--	0.07	7.96	1.70	584.00	2.60	0.10	126.00	25.00	4.32	0.04	56.00	14.80	0.30	0.05	0.52	98.00	65.00
ERL		--	1	--	8.2	--	--	1.2	81	34	--	0.15	20.9	46.7	--	--	--	--	150
ERM		--	3.7	--	70	--	--	9.6	370	270	--	0.71	51.6	218	--	--	--	--	410

Ag = silver; Al = aluminum; As = arsenic; Ba = barium; Be = beryllium; Cd = cadmium; Cr = chromium; Cu = copper; Fe = iron; Hg = mercury; Ni = nickel; Pb = lead; S = antimony; Se = selenium; Tl = thallium; V = vanadium; Z = zinc; n/a = data not available; ND = not detected

Table 17. Metals concentrations (mg L^{-1}) per sampled drilling fluids/mud and dry barite for the Yam-3 drilling program. Mud samples were obtained and analyzed by the operator and barite was analyzed by the supplier (ADO Mining), mud engineers (Schlumberger), and laboratories (Aminolab and Bactochem).

Phase	Month/2013	Flow (m^3/mo)	Ag	Al	As	Ba	Be	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Sb	Se	V	Zn
Mud	Dec.	1,608	5	11,501	5	182	2	2	14	10	12,671	2	11	4	--	5	15	21
	Feb.	980	5	6,711	5	2,454	2	2	10	12	7,880	2	7	19	--	5	10	13
	March #1	700	5	15,343	12	510	2	2	20	44	22,748	2	14	305	--	5	22	80
	March #2	784	2	1,184	5	231	0.1	0.3	3	16	16,956	0.2	2	115	--	0.1	4	47
	May	613	3	13,389	22	50	0.3	1	13	64	18,062	0.5	10	1,853	--	0.5	17	75
	June	546	0.5	2,665	10.4	1,885	0.13	1	5.85	28.6	7,970	0.5	5.2	650	3	3	6.5	46.8
	Aug.	557	0.05	1,896	12.6	1,380	0.3	0.8	2.9	34.4	5,888	0.03	4.9	985	0.9	0.05	5.2	72
	Sept.	128	1	4,146	17.2	4,543	0.1	0.72	7.6	50.2	10,355	1	8.75	2,178	3	3	9.8	178
	Oct.	367	1	2,210	11.3	7,890	0.1	2	4.7	42	6,710	1	6.9	18,158	3	3	6	180
Barite	Jan. – April; June – July		--	--	≤1	--	--	<0.1 - 3.5	0.05 - 0.110	0.022 - 8.3	--	<0.1 - 1.5	--	0.130 - 3.3	--	<0.11	--	0.485 - 3

-- Metal concentration not measured or not specified.
1Measured as Cr (VI).

Table 18. Results of two-way analysis of variance (2ANOVA) for metals and total organic carbon (TOC

Metals and TOC	Main Effects		Strata x Survey Interaction	Post-Drill Higher?	Consistent Drill Effect?	2ANOVA Assessment
	Strata	Survey				
Ag	X	X	X	Yes	Yes (below ERL)	**Silver**: Pre-Drill values were all significantly lower and uniform; Post-Drill values were higher, but not meaningfully with a larger value at the Center stratum that contributed to the significant interaction term. Values remained below ERL.
Al (%)	X	n/a	n/a	n/a	No	**Aluminum**: Pre-Drill values were all nondetects (no variance) and could not be tested against Post-Drill (see text for differences between Pre- and Post-Drill laboratories). Post-Drill one-way ANOVA: (equal: ff, mf, nf), (equal: cc, sr, nr). Large nonsequential overlap of strata and equivalency among Center and Reference strata suggested no drilling effect.
As	X	X	--	No	No	**Arsenic**: Pre-Drill values were overall slightly (significantly) higher than Post-Drill. Both Pre- and Post-Drill showed a similar (significant) slight trend of increasing concentration with distance from the wellsite. Overall values were not meaningfully different.
Ba	X	X	X	Yes	Yes	**Barium**: Pre-Drill values were uniformly very low and there was a significant Post-Drill peak at the Center stratum, which diminished rapidly with distance toward Pre-Drill values.
Be	X		X	No	Yes (dilution)	**Beryllium**: Overall there were no differences Pre- versus Post-Drill except for a significant dip at the Center stratum Post-Drill, which contributed to the significant interaction term. The Center dip may be associated with possible dilution by formation sand deposition.
Cd	X	n/a	n/a	n/a	No	**Cadmium**: These values are suspect as the Post-Drill was significantly higher at all strata. Post-Drill one-way ANOVA (equal: cc, nf) (equal: nf, mf, ff, nr, sr). This indicates a significantly higher value at the Center stratum with rapid decline of concentration by the Near-field stratum. However, the differences were not meaningful (Center = 0.266; grand mean of other strata = 0.213).
Cr		X	X	Yes (suspect)	No	**Chromium**: High variability at the Post-Drill Center stratum contributed to the significant interaction term and may have resulted from possible dilution by formation sand deposition. Consistently higher Post-Drill values at all other locations can be explained by the different laboratories (see text for differences between Pre- and Post-Drill laboratories).
Cu	--	--	--	No	No	**Copper**: No significant differences detected. Values were the same by distance from wellsite and among surveys.
Fe (%)	X	n/a	n/a	n/a	No	**Iron**: All Pre-Drill values were nondetects while all Post-Drill values were detectable at all strata (see text for differences between Pre- and Post-Drill laboratories). Post-Drill one-way ANOVA: Center stratum was slightly lower than all other strata, which were not significantly different from each other. Although statistically significant, the difference was not meaningful (Center = 5.8; grand mean of other strata = 6.75).
Hg	X	n/a	n/a	n/a	Yes (below ERL)	**Mercury**: The higher values from all Pre-Drill strata again suggested an analytical issue as explained in the text. Post-Drill one-way ANOVA: Center stratum was significantly higher than all other strata, which were not different from each other. Values remained below ERL.
Ni	X	X	X	No	Yes	**Nickel**: Values were overall slightly (significantly) lower in the Post-Drill (see

Table 18. (Continued).

Metals and TOC	Main Effects		Strata x Survey Interaction	Post-Drill Higher?	Consistent Drill Effect?	2ANOVA Assessment
	Strata	Survey				
					(dilution)	text for differences between Pre- and Post-Drill laboratories). The interaction and other term effects appear to be driven by a significantly lower mean value at the Post-Drill Center stratum, suggesting possible dilution by formation sand deposition.
Pb	X	X	X	Yes	Yes	**Lead**: High values at the Post-Drill Center and Near-field strata drive the results. Pre-Drill values were consistently low and uniform, similar to the Post-Drill values beginning with the Mid-field values and beyond, indicating a limitation of the effect to the vicinity of the wellsite.
Sb	X	X	X	Yes	Yes (below ERL)	**Antimony**: High values at the Post-Drill Center and Near-field strata drive the results. Pre-Drill values were consistently low and uniform, similar to the Post-Drill values beginning with the Mid-field values and beyond, indicating a limitation of the effect to the vicinity of the wellsite.
Se	--	n/a	n/a	Unknown	Unknown	**Selenium**: Post-Drill values were all nondetects (see text for differences between Pre- and Post-Drill laboratories). Pre-Drill one-way ANOVA: no significant difference among strata.
Tl	--	X	--	Yes (suspect)	No (suspicious high variability)	**Thallium**: Very high variability in the Post-Drill (Pre-Drill values were quite uniform) which varied dramatically among strata (see text for differences between Pre- and Post-Drill laboratories). Despite numerically higher Post-Drill means (except for Mid-field stratum) the extreme variability apparently prevented detection of any survey or interaction effects. Differences were likely driven by the low variability of the Post-Drill Mid-field samples, allowing it to stand out among strata.
V	X	X	X	Yes	Yes (dilution)	**Vanadium**: With the exception of the Center stratum (lower mean, high variance) all Post-Drill strata were equivalent, but consistently higher than the Pre-Drill values, which were uniform (see text for differences between Pre- and Post-Drill laboratories). The lower mean and high variability at the Post-Drill Center stratum suggested possible dilution by formation sand deposition.
Zn	--	X	X	Yes	No	**Zinc**: Post-Drill means were all higher than Pre-Drill (see text for differences between Pre- and Post-Drill laboratories). Small differences in the pattern among strata when comparing surveys drove the interaction term. Absence of a clear sequence of values across strata suggested no drilling effect.
TOC (%)	X	--	X	No	No	**TOC**: In both surveys, values increased with distance away from the Center, but in a slightly different pattern (Post-Drill Near-field values were low), driving the interaction term. Overall, no survey effects were noted. Absence of a clear sequence of values across strata suggested no drilling effect.

Strata abbreviations: cc = Center; nf = Near-field; mf = Mid-field; ff = Far-field; sr = South Reference; nr = North Reference. ppm = parts per million. ERL = effects range low. Gray shading and x = significant difference at $p < 0.05$. Blue highlighted cells indicate either Pre-Drill or Post-Drill one-way ANOVA assessment only. Reference to sequential differences refers to an anticipated gradient from Center stratum to Near-field, Mid-field, Far-field, and out to Reference strata.

Given the described metal concentrations and relative to effects range low (ERL) and effects range median (ERM) thresholds we conclude that for the metals only barium and lead have evidence of drilling effect. In both cases, Center stratum values were higher and showed enrichment declining with distance from the wellsite. Deviations in seafloor sediment metals concentrations for other metals in addition to Ba and Pb also are noted in **Table 18**. Statistical analysis of metals concentrations in sediments from from both surveys is summarized in **Table 18**. Each metal was analyzed using either one-way ANOVA or 2ANOVA tests. Interpretations of the results are provided in the table.

Hydrocarbons

Average alkane and total petroleum hydrocarbons (TPH) concentrations per strata and MDLs are reported in **Table 19**. Results from all stations are reported in **Appendix M**. Alkanes and TPH levels in sediments at the Yam-3 Pre-Drill survey were below detection limits of the laboratory for all sampling locations. In the Post-Drill survey, alkanes and TPH were generally detected within sediments at low concentrations throughout the survey area (**Appendix M**). Yet, TPH levels at the Center and Near-field strata were higher than those reported for the reference areas. Of all stations within the Center stratum, C1, C5, and C6 stood out above the rest with TPH levels of 253.9, 103.8 and 126.8 µg g^{-1}, respectively. There are no toxicity reference values available for alkanes in sediment.

Table 19. Average (± standard deviation) alkane and TPH concentrations (µg g^{-1}) by stratum in sediments from the Yam-3 Post-Drill survey area.

Analyte (Alkane or TPH) (µg g^{-1})	MDL	Stratum					
		Center	Near-Field	Mid-Field	Far-Field	North Reference	South Reference
Undecane C11	0.016	0.033 ± 0.019	0.034 ± 0.015	0.046 ± 0.012	0.031 ± 0.015	0.040 ± 0.014	0.021 ± 0.008
Dodecane C12	0.019	0.040 ± 0.032	0.032 ± 0.017	0.044 ± 0.013	0.027 ± 0.013	0.038 ± 0.018	0.020 ± 0.009
Tetradecane C14	0.013	0.066 ± 0.095	0.022 ± 0.011	0.023 ± 0.007	0.016 ± 0.008	0.023 ± 0.011	0.012 ± 0.003
Hexadecane C16	0.004	0.119 ± 0.170	0.014 ± 0.005	0.016 ± 0.003	0.013 ± 0.004	0.013 ± 0.005	0.009 ± 0.002
Octadecane C18	0.004	0.158 ± 0.165	0.053 ± 0.007	0.050 ± 0.005	0.042 ± 0.010	0.043 ± 0.007	0.042 ± 0.005
Eicosane C20	0.012	0.077 ± 0.110	0.005 ± 0.003	0.018 ± 0.027	0.007 ± 0.004	0.007 ± 0.008	0.008 ± 0.013
Tetracosane C24	0.005	0.043 ± 0.047	0.020 ± 0.015	0.010 ± 0.005	0.013 ± 0.002	0.014 ± 0.002	0.014 ± 0.002
Octacosane C28	0.011	0.053 ± 0.034	0.049 ± 0.038	0.043 ± 0.003	0.044 ± 0.003	0.031 ± 0.005	0.029 ± 0.003
Dotriacontane C32	0.012	0.048 ± 0.017	0.059 ± 0.046	0.037 ± 0.015	0.042 ± 0.013	0.048 ± 0.005	0.048 ± 0.010
Hexatriacontane C36	0.016	0.030 ± 0.016	0.022 ± 0.008	0.023 ± 0.011	0.028 ± 0.006	0.018 ± 0.008	0.021 ± 0.008
Tetracontane C40	0.019	0.032 ± 0.006	0.018 ± 0.008	0.020 ± 0.008	0.023 ± 0.007	0.014 ± 0.005	0.016 ± 0.008
Total Alkanes	n/a	3.085 ± 1.956	2.085 ± 0.484	2.357 ± 0.126	2.144 ± 0.213	1.977 ± 0.256	1.764 ± 0.213
TPH	1.4	91.718 ± 80.657	38.146 ± 3.322	15.789 ± 3.191	15.409 ± 3.121	[1]19.748 ± 19.123	11.483 ± 3.661

1 North Reference Station 5 showed an unusually higher value; upon removing the station, TPH decreased to 12.582 ± 2.730.
MDL = method detection limit; n/a = data not available.

Average polycyclic aromatic hydrocarbons (PAH) concentrations per stratum and MDLs are reported in **Table 20**. Results from all stations are reported in **Appendix M**. Total PAH levels in sediments at the Yam-3 Pre-Drill survey were extremely low and generally below detection limits. PAHs were generally detected within sediments at low concentrations throughout the survey area. Total PAH levels at the Center stratum showed a slight increase but with very high standard deviations (**Table 20**). This observation corresponded with results for total alkanes and TPH; stations C1, C5 and C6 again stood out above the rest, presenting total PAH levels of 1,107, 279 and 209 ng g^{-1}, respectively. Despite the aforementioned, total PAH levels from the Yam-3 survey area fall well below ERL value of 4,022 ng g^{-1}

Table 20. Average PAH concentrations (ng/g) by strata in sediments from the Yam-3 Post-Drill survey area.

PAH Analyte (ng g^{-1})	MDL	Stratum					
		Center	Near-Field	Mid-Field	Far-Field	North Reference	South Reference
Naphthalene	0.342	5.056 ± 5.642	3.003 ± 0.806	4.188 ± 0.698	3.265 ± 0.831	3.699 ± 0.456	2.714 ± 0.663
Acenaphthylene	0.041	0.318 ± 0.399	0.143 ± 0.028	0.278 ± 0.064	0.250 ± 0.102	0.246 ± 0.028	0.238 ± 0.054
Acenaphthene	0.103	0.701 ± 1.078	0.148 ± 0.040	0.177 ± 0.016	0.150 ± 0.028	0.161 ± 0.021	0.167 ± 0.073
Fluorene	0.183	1.602 ± 1.894	0.795 ± 0.333	1.084 ± 0.251	0.806 ± 0.204	0.984 ± 0.268	0.616 ± 0.099
Anthracene	0.115	1.257 ± 1.329	0.309 ± 0.129	0.676 ± 0.104	0.484 ± 0.121	0.497 ± 0.048	0.611 ± 0.140
Phenanthrene	0.208	6.275 ± 8.030	3.108 ± 0.979	4.055 ± 0.434	3.419 ± 0.473	3.719 ± 0.429	3.584 ± 0.903
Fluoranthene	0.333	3.260 ± 1.470	2.894 ± 1.109	4.501 ± 0.486	3.803 ± 1.097	3.856 ± 0.549	4.918 ± 1.719
Pyrene	0.136	4.243 ± 2.396	3.073 ± 1.041	3.851 ± 0.371	3.923 ± 1.749	3.527 ± 0.541	4.726 ± 1.547
Benz(a)anthracene	0.192	2.055 ± 0.790	1.897 ± 0.746	2.532 ± 0.307	2.645 ± 1.897	2.295 ± 0.368	2.933 ± 0.977
Chrysene /Triphenylene	0.116	3.182 ± 2.461	2.069 ± 0.709	2.601 ± 0.330	2.843 ± 1.440	2.539 ± 0.321	3.390 ± 1.014
Benzo(b)fluoranthene	0.203	4.369 ± 3.217	3.149 ± 1.001	4.617 ± 0.386	4.359 ± 1.240	4.388 ± 0.556	4.591 ± 1.028
Benzo(k,j)fluoranthene	0.098	1.014 ± 0.216	1.113 ± 0.304	1.153 ± 0.088	1.296 ± 0.467	1.197 ± 0.085	1.845 ± 0.856
Benzo(a)pyrene	0.101	1.719 ± 0.942	1.367 ± 0.569	1.765 ± 0.246	1.824 ± 0.977	1.688 ± 0.269	2.193 ± 0.819
Indeno(1,2,3-c,d)pyrene	0.05	1.276 ± 0.511	1.157 ± 0.437	1.448 ± 0.157	1.983 ± 0.942	1.580 ± 0.159	1.964 ± 0.612
Dibenz(a,h)anthracene	0.064	0.379 ± 0.288	0.281 ± 0.116	0.373 ± 0.035	0.561 ± 0.305	0.414 ± 0.064	0.503 ± 0.166
Benzo(g,h,i)perylene	0.088	4.387 ± 4.846	1.936 ± 0.439	2.583 ± 0.316	2.837 ± 0.969	2.623 ± 0.261	2.745 ± 0.643
Total PAHs	**--**	**287.984 ± 368.297**	**101.495 ± 20.162**	**131.534 ± 11.371**	**116.174 ± 18.739**	**111.836 ± 6.486**	**108.794 ± 19.429**

MDL = method detection limit.

Pre-Drill reports for hydrocarbons were mostly below detection limit and therefore a one way analysis of variance (ANOVA) was conducted for Post-Drill alkanes, TPH and PAH parameters. Assessment of alkanes and TPH (**Table 21**) revealed significant difference between the Center and other strata in TPH and the alkanes hexadecane, octadecane, eicosane, tetracosane. TPH was found to be significantly different also at the Near-field stratum. A consistent drill effect, suggesting a signature of drilling activites was determined for the Center stratum in the parameters mentioned above. TPH was observed to gradually decrease from the Center throughout the Near-field, reaching stable values at the Mid-field where it showed no significant difference from the Reference areas (**Table 19**).

Table 21. Results of Post-Drill one-way analysis of variance (ANOVA) for alkanes and total petroleum hydrocarbons (TPH). Significant difference at $p < 0.05$; NS = no significant difference at $p < 0.05$. Analytes with no drill effects highlighted in blue.

Alkanes and TPH	Significant Differences Detected?	Consistent Drill Effect?
Undecane C11	Yes	No (lack of sequential pattern)
Dodecane C12	Yes	No (lack of sequential pattern)
Tetradecane C14	Yes	No (lack of sequential pattern)
Hexadecane C16	Yes	Yes (Center higher)
Octadecane C18	Yes	Yes (Center higher)
Eicosane C20	Yes	Yes (Center higher)
Tetracosane C24	Yes	Yes (Center higher)
Octacosane C28	No	No significant differences
Dotriacontane C32	No	No significant differences
Hexatriacontane C36	No	No significant differences
Tetracontane C40	Yes	No (lack of sequential pattern)
Total Alkanes	Yes	No (lack of sequential pattern)
TPH	Yes	Yes (Center, then Near-field higher; all others NS)

Assessment of PAH (**Table 22**) showed significant differences in several of the 16 PAH analyzed; however these differenced did not show a sequential pattern that would indicate a drill effect. Total PAH levels at the Center stratum were statistically similar to Mid-field and together different than the rest of the sampled strata (Near-field, Far-field, and References). Altogether the sequence of values with distance from the wellsite was incoherent and did not clearly follow the TPH values. In the absence of comparable values from the baseline survey and based on reference areas results, the indicated statistical differences could potentially be attributed to drilling activities; however, these are confined and localized to the vicinity of the wellsite (<250m). Importantly, despite statistical differences among strata all values are extremely low, and where applicable are found to be well under the proposed ERL and ERM, thus not posing a biological or ecological threat.

Table 22. Results of Post-Drill one-way analysis of variance (ANOVA) for polycyclic aromatic hydrocarbons (PAH). Significant difference at $p < 0.05$; NS = no significant difference at $p < 0.05$. Analytes with no drill effects highlighted in blue.

Polyaromatic Hydrocarbons	Significant Differences Detected?	Consistent Drill Effect?
Naphthalene	No	No significant differences
Acenaphthylene	No	No significant differences
Acenaphthene	No	No significant differences
Fluorene	Yes	No (lack of sequential pattern)
Anthracene	Yes	No (lack of sequential pattern)
Phenanthrene	No	No significant differences
Fluoranthene	Yes	No (lack of sequential pattern)
Pyrene	Yes	No (lack of sequential pattern)
Benz(a)anthracene	No	No significant differences
Chrysene /Triphenylene	Yes	No (lack of sequential pattern)
Benzo(b)fluoranthene	Yes	No (lack of sequential pattern)
Benzo(k,j)fluoranthene	Yes	No (lack of sequential pattern)
Benzo(a)pyrene	Yes	No (lack of sequential pattern)
Indeno(1,2,3-c,d)pyrene	Yes	No (lack of sequential pattern)
Dibenz(a,h)anthracene	Yes	No (lack of sequential pattern)
Benzo(g,h,i)perylene	Yes	No (lack of sequential pattern)
Total PAHs	Yes	Yes (although Center was highest, it was not different from the Mid-field stratum, skipping Near-field, which was not different from all remaining strata)

Radionuclides

Radionuclides were not sampled during the Yam-3 Pre-Drill survey. Results for each individual sampling station are provided in **Appendix N**. Analytical results for Ra 226, Ra 228, Th 228 and Pb 210 were averaged by sampling stratum and are provided in **Table 23**.

Table 23. Average concentrations (pCi g^{-1}) of radionuclides (radium [Ra] 226, Ra 228, thorium [Th] 228, and lead [Pb] 210) in sediments from the Yam-3 Post-Drill survey area.

Analyte	Center	Stratum				
		Near-Field	Mid-Field	Far-Field	North Reference	South Reference
Ra 226	0.259 ± 0.063	0.251 ± 0.058	0.329 ± 0.122	0.276 ± 0.055	0.266 ± 0.067	0.336 ± 0.092
Ra 228	0.544 ± 0.102	0.447 ± 0.125	0.483 ± 0.226	0.461 ± 0.303	0.593 ± 0.254	0.461 ± 0.247
Th 228	0.616 ± 0.101	0.566 ± 0.060	0.573 ± 0.092	0.553 ± 0.045	0.579 ± 0.053	0.604 ± 0.076
Pb 210	2.303 ± 1.022	3.221 ± 0.821	3.657 ± 0.895	4.230 ± 0.451	4.857 ± 0.310	4.320 ± 1.311

Statistical analysis (ANOVA) was applied for the Post-Drill survey radionuclides results. Only Pb 210 (lead) was found to be significantly lower at the Center (2.30 pCi g^{-1}) and Near-field (3.22 pCi g^{-1}) than all other strata, suggesting a dilution effect from deposition of new sediments. All other strata were not statistically different from each other; Mid-field (3.66 pCi g^{-1}), Far-field (4.23 pCi g^{-1}), South Reference (4.32 pCi g^{-1}), and North Reference (4.86 pCi g^{-1}). Ambient Ra concentrations in most natural soils and rocks are approximately 0.5 to 5.0 pCi/g of total radium (U.S. Geological Survey, 1999). Ambient concentrations of Th 228 in sediments range from 0.36 to 1.93 pCi g^{-1} (Agency for Toxic Substances and Disease Registry, 1990). USEPA (1998) established a protective health based level for Ra and Th of 5 pCi g^{-1} at the sediment surface as a threshold for the cleanup of the top 15 cm of soil from contaminated U.S. Superfund sites.

5.5 INFAUNA

Official results of the infaunal analysis from all stations during the Post-Drill survey are provided in **Appendix O**. A compilation of species abundances collected during both the Pre-Drill and Post-Drill surveys is provided in **Appendix P**. Infauna collected from the Pre-Drill survey area included two samples whereas 42 samples were collected for the Post-Drill survey.. Because additional sampling stations were added at the Far-field stratum and Reference areas, a Pre- versus Post-Drill analysis could not be conducted. A 2ANOVA was conducted to determine if there were statistically significant differences in infauna characteristics (e.g., number of species, abundance, evenness, and diversity) between the Pre-Drill and Post-Drill surveys as well as among sampling strata. Significant differences and interaction were observed in three of five metrics calculated (**Table 24**). However, these differences lack a clear sequential pattern that would allow to assume a consistent drill effect and deduce a biological and ecological relevance. **Figure 9** shows average infauna metrics by survey. **Figure 10** shows average infauna metrics by sampling strata for the Yam-3 Post-Drill survey.

Table 24. Results of two-way analysis of variance (2ANOVA) for infauna. (X = significant difference, NS = no significant difference at $p < 0.05$. df = degrees of freedom).

Infauna Parameter	Main Effects		Strata x Survey Interaction	Post-Drill Higher?	Consistent Drill Effect?	2ANOVA Assessment
	Strata	Survey				
Species Richness	X	X	X	Yes	No	Post-Drill values were generally higher across most strata but in slightly different (nonsequential) pattern than Pre-Drill. One reference site (South Reference) was closer to Pre-Drill conditions.
Abundance	X	X	X	Yes	Potential	Post-Drill values were generally higher across all strata. Highest values were seen in the Post-Drill at the Center stratum, but then showed an inconsistent pattern from the Center. Pre-Drill values were equivalent among strata. Two Post-Drill strata (Far-field, South Reference) were closer to Pre-Drill conditions.
Pileou's Evenness (J')	X	X	X	No	No	High numbers of df allowed detection of significance but all means ranged between 0.82 and 0.92 in a generally haphazard fashion. Overall values were lower in the Post-Drill survey. However the lowest evenness was observed in the Post-Drill at the Center but the difference between that and the survey mean was marginal and thus not biologically relevant.
Log Series Fisher's *a*	NS	NS	NS	No	No	No difference among surveys or strata.
Shannon-Weiner Diversity Index (H')	NS	NS	X	No	No	High numbers of df allowed detection of significance but in a haphazard fashion. H' was lower in the Pre-Drill but not meaningfully (3.15 vs. 3.19 Post-Drill). The Post-Drill Center value was only slightly lower than all other observations.

Two metrices, species richness and species abundance, present higher values at the Post-Drill than those observed at the Pre-Drill (**Figure 9**). Species richness (number of different species) results compared among the different strata for the Post-Drill survey uniform (**Figure 10**; **Table 25**) with the exception of the South Reference presenting lower numbers (South Reference 26.71 ± 7.2; other strata average 43.8 ± 3.87). This uniformity suggested that differences might be attributed to natural seasonal and or interannual conditions and biological activity rather than being drilling related. Abundance, generally higher across all strata at the Post-Drill, showed highest average number of individuals at the Center stratum, decreasing with distance (**Figure 10**; **Table 25**). However, the large variability between stations within each stratum, and the high number of individuals observed at the North Reference created an inconsistent pattern that did not indicate a drilling effect.

Species evenness, as determined by Pileou's Evenness, was lower during the Post-Drill survey (**Figure 9**). Infauna in both surveys was relatively even, meaning species are well represented, and range (J') between 0.82 and 0.92. Evenness results at the Post-Drill survey were lower across all strata and lowest at the Center stratum (**Figure 10**; **Table 25**) though these were marginal and do not suggest a meaningful biological effect.

Species diversity, as calculated by the Shannon-Weiner Diversity Index, takes into consideration both the abundance and richness of the identifed species in a given sample. Summarizing the score of each species into a single H' value enabled us to compare unrelated samples and be able to draw conclusions on their population properties. Comparing diversity between the Pre-Drill and Post-Drill surveys (**Figure 9**) showed the metric to be quite similar (3.16 ± 0.1 and 3.19 ± 0.15, respectively) with nonmeaningful differences in survey and strata interaction (**Table 24**). The lower evenness (Pre-Drill 0.91 ± 0.01; Post-Drill 0.87 ± 0.03) and higher richness (Pre-Drill 32.68 ± 2.72; Post-Drill 40.96 ± 7.79) of the Post-Drill survey (**Figure 9**) offset each other to produce the similar diversity metric. Species diversity (3.06 ± 0.30) at the Post-Drill Center stratum was only slightly lower than all other strata (**Figure 10**; **Table 25**). Of the seven stations at the strata, C1 and C5 had the lowest diversity, driven by a different combination of species evenness and richness. Station C1 was the least even (J' = 0.775) and second lowest in richness (34 spp.) while station C5 was the poorest in species (23 spp.) but ranked high in evenness (J' = 0.821) among the Center stratum stations.

Table 25. Average benthic community parameters for the Yam-3 Pre-Drill and Post-Drill surveys.

Stratum	Species Richness		Abundance		Pileou's Evenness (J')		Shannon-Weiner Diversity Index (H')	
	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill
Center	33.63 ± 7.91	44 ± 12.25	75.63 ± 26.85	190 ± 75.71	0.92 ± 0.02	0.82 ± 0.03	3.22 ± 0.30	3.06 ± 0.30
Near-Field	30.63 ± 5.93	44.86 ± 8.01	65 ± 17.64	159.71 ± 45.35	0.92 ± 0.02	0.86 ± 0.03	3.13 ± 0.16	3.26 ± 0.17
Mid-Field	29.88 ± 6.56	42.14 ± 8.91	68 ± 21.23	124.71 ± 30.09	0.90 ± 0.06	0.87 ± 0.02	3.04 ± 0.26	3.24 ± 0.21
Far-Field	--	38.71 ± 10.29	--	97.71 ± 46.35	--	0.89 ± 0.03	--	3.23 ± 0.18
South Reference	36.75 ± 3.30	26.71 ± 7.20	70.25 ± 13.52	56.88 ± 23.83	0.90 ± 0.02	0.92 ± 0.03	3.13 ± 0.22	2.97 ± 0.21
North Reference	32.50 ± 5.97	49.29 ± 7.57	83.75 ± 15.73	170 ± 23.41	0.92 ± 0.02	0.87 ± 0.03	3.30 ± 0.11	3.38 ± 0.17

*Pre-Drill survey included eight stations at the Center, Near-field, and Mid-field strata, and four stations at each reference area. No sampling was conducted at the Far field (1,000 to 2,000 m). Stations were re-randomized between surveys.
"—" = parameter cannot be calculated.

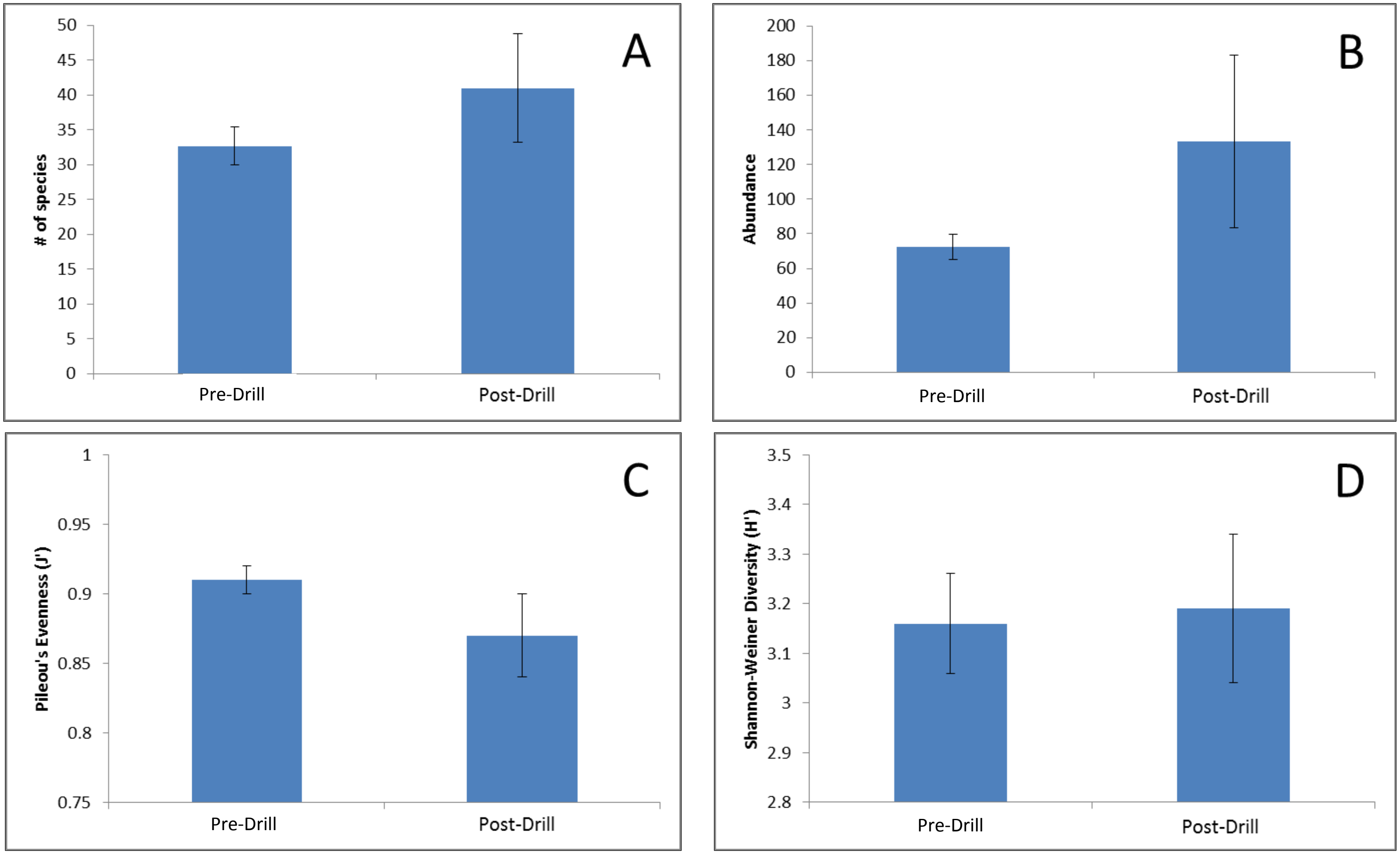


Figure 9. Average (± standard deviation) of infauna metrics during the Pre-Drill and Post-Drill surveys. A = number of species collected, B = abundance (i.e., number of organisms collected), C = Pileou's Evenness, D = Shannon-Weiner Diversity index. Significant difference was observed for A, B, and C.

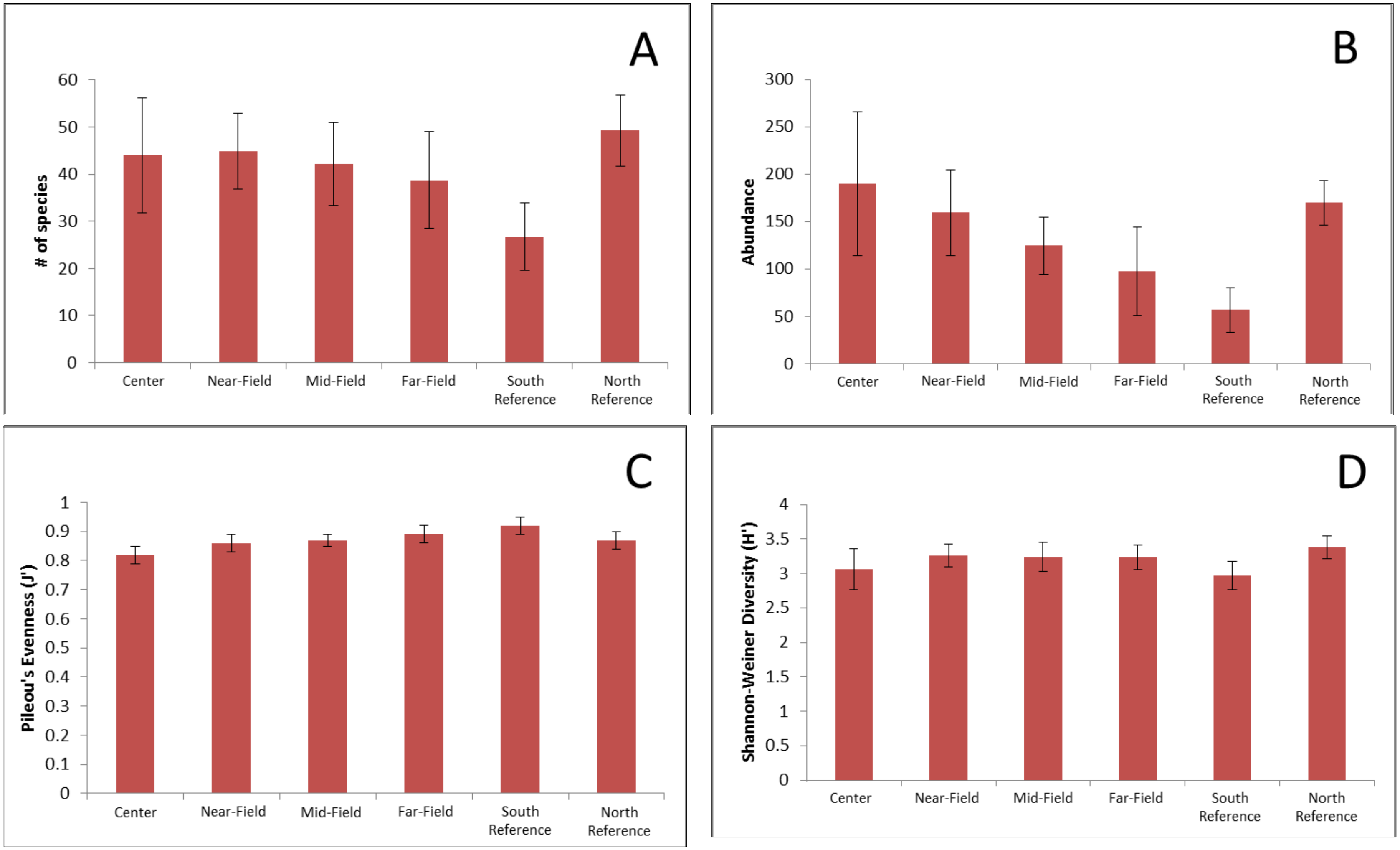


Figure 10. Average (± standard deviation) of infauna metrics by sampling strata for the Post-Drill survey. A = number of species collected, B = abundance (i.e., number of organisms collected), C = Pileou's Evenness, D = Shannon-Weiner Diversity index.

Bentic community parameters at infaunal sampling stations during both surveys are presented in **Table 26**. Distributions of species found in Yam-3 infaunal samples according to major taxonomic groups and subgroups are shown in **Appendix P Table P-1**. For the Pre-Drill survey, 32 infaunal benthic samples yielded 2,285 individual organisms representing 153 taxa, and for the Post-Drill survey, 42 infauna benthic samples yielded 7,296 individual organisms representing 202 taxa. Abundances of individual infaunal taxa ranged from 0.19 to 45.91 individuals/m^2 in the Pre-Drill and 0.19 to 154.29 individuals/m^2 in the Post-Drill survey (**Table P-1**). The increase in abundance per m^2 at the Post-Drill survey was widely distributed between the different individual infaunal taxa which may indicate: a) non specific response to seasonal and or interannual changes resulting in an overall population change and increase; b) increase in identified species resulting in higher counts of individuals or; c) a combination of the previous.

Distribution of the taxa according to major taxonomic groups and subgroups is shown in **Table 27**. Polychaetes were the most abundant taxa collected during both surveys and represented 41.75% and 60.02% of all taxa represented during the Pre-Drill and Post-Drill surveys, respectively. The most abundant organism collected during the Pre-Drill survey was the bivalve *Corbula gibba* accounting for 8.36% of all organisms collected. For the Post-Drill survey, the most abundant organism collected was the polychaete *Prionospio* sp. with 11.10% of the collected infauna (**Table P-1**).

Table 26. Benthic community parameters at infaunal sampling stations during Yam-3 Pre-Drill and Post-Drill surveys. *Stations were re-randomized between surveys. -- = parameter cannot be calculated. Data excludes Meiofauna and multispecies taxa.

Stratum	Sampling Station*	Species Richness		Abundance (Number of Indiv/m^2)		Pileou's Evenness (J')		Log Series Fisher's *alpha*		Shannon-Weiner Diversity Index (H')	
		Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill
Center	1	38	34	892	1272	0.896	0.775	19.684	13.259	3.261	2.732
	2	36	47	677	1720	0.942	0.797	22.742	18.559	3.374	3.069
	3	16	56	208	2448	0.908	0.799	16.514	20.095	2.519	3.216
	4	29	43	392	1064	0.936	0.876	27.891	22.044	3.150	3.294
	5	36	23	569	640	0.932	0.822	27.654	10.804	3.338	2.576
	6	35	47	592	1472	0.911	0.821	24.767	20.391	3.237	3.160
	7	41	58	708	2024	0.918	0.829	28.368	23.544	3.409	3.365
	8	38	--	615	--	0.955	--	28.333	--	3.472	--
Near-Field	1	35	32	531	1048	0.916	0.845	28.398	13.498	3.256	2.928
	2	27	56	392	1832	0.899	0.812	23.258	23.637	2.965	3.269
	3	26	42	415	960	0.924	0.892	19.714	22.971	3.010	3.333
	4	23	50	423	1216	0.936	0.877	14.859	25.985	2.936	3.432
	5	28	39	423	872	0.918	0.860	22.830	21.737	3.059	3.151
	6	39	50	685	1672	0.930	0.861	26.484	20.822	3.407	3.368
	7	38	45	731	1344	0.886	0.884	23.474	20.138	3.223	3.367
	8	29	--	400	--	0.949	--	27.030	--	3.196	--
Mid-Field	1	38	49	746	1344	0.917	0.845	23.005	23.255	3.336	3.287
	2	26	51	446	1128	0.958	0.866	18.109	28.696	3.122	3.405
	3	25	31	446	616	0.898	0.861	16.675	19.273	2.890	2.957
	4	33	39	531	944	0.928	0.893	24.814	20.345	3.246	3.271
	5	38	30	685	784	0.861	0.858	25.091	14.750	3.133	2.919
	6	31	50	438	1112	0.929	0.884	27.790	27.998	3.190	3.457
	7	19	45	246	1056	0.940	0.884	19.679	24.075	2.767	3.365
	8	29	--	646	--	0.772	--	15.679	--	2.598	--

Table 26. (Continued).

Stratum	Sampling Station*	Species Richness		Abundance (Number of Indiv/m^2)		Pileou's Evenness (J')		Log Series Fisher's *alpha*		Shannon-Weiner Diversity Index (H')	
		Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill
Far-Field	1	--	32	--	512	--	0.884	--	25.469	--	3.063
	2	--	45	--	968	--	0.859	--	25.955	--	3.269
	3	--	26	--	488	--	0.914	--	17.136	--	2.979
	4	--	38	--	736	--	0.905	--	24.240	--	3.292
	5	--	37	--	784	--	0.877	--	21.636	--	3.166
	6	--	58	--	1512	--	0.861	--	28.568	--	3.495
	7	--	35	--	472	--	0.941	--	36.193	--	3.346
South Reference	1	41	14	808	152	0.923	0.967	24.744	24.032	3.428	2.552
	2	33	25	631	328	0.911	0.916	20.508	27.191	3.184	2.948
	3	36	29	623	472	0.935	0.942	24.833	22.572	3.349	3.171
	4	37	25	515	472	0.900	0.934	33.958	16.375	3.249	3.006
	5	--	38	--	776	--	0.873	--	23.005	--	3.175
	6	--	26	--	448	--	0.905	--	18.860	--	2.950
	7	--	30	--	536	--	0.883	--	20.868	--	3.003
North Reference	1	35	45	600	1064	0.885	0.913	24.404	23.926	3.146	3.474
	2	31	45	477	1272	0.927	0.882	24.673	20.908	3.184	3.359
	3	25	44	431	1400	0.877	0.824	17.331	18.898	2.824	3.118
	4	39	48	654	1424	0.915	0.866	27.899	21.577	3.352	3.351
	5	--	62	--	1656	--	0.859	--	29.995	--	3.543
	6	--	58	--	1456	--	0.882	--	29.401	--	3.582
	7	--	43	--	1248	--	0.859	--	19.618	--	3.231

Table 27. Distribution of the taxa according to major taxonomic groups and subgroups for the Yam-3 Pre-Drill and Post-Drill surveys.

Taxonomic Group	Abundance (number of Phylum/Class)		Abundance (individuals/m^2)		Total Fauna (%)	
	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill	Pre-Drill	Post-Drill
Cnidaria	1	24	0.24	4.57	0.04	0.33
Chordata-Tunicata	2	0	0.48	0.00	0.09	0.00
Nematoda	1	288	0.24	54.86	0.04	3.95
Nemertea-Anopla	67	158	16.11	30.10	2.93	2.17
Nemertea-Enopla	1	4	0.24	0.76	0.04	0.05
Mollusca-Aplacophora	0	1	0.00	0.19	0.00	0.01
Mollusca-Bivalvia	369	344	88.70	65.52	16.15	4.71
Mollusca-Gastropoda	173	155	41.59	29.52	7.57	2.12
Mollusca-Scaphopoda	2	17	0.48	3.24	0.09	0.23
Arthropoda-Malacostraca	550	918	132.21	174.86	24.07	12.58
Arthropoda-Maxillopoda	14	38	3.37	7.24	0.61	0.52
Arthropoda-Ostracoda	21	56	5.05	10.67	0.92	0.77
Arthropoda-Pycnogonida	57	33	13.70	6.29	2.49	0.45
Annelida-Clitellata	0	4	0.00	0.76	0.00	0.05
Annelida-Polychaeta	954	4379	229.33	834.10	41.75	60.02
Sipuncula	31	1	7.45	0.19	1.36	0.01
Sipuncula-Phascolosomatidea	0	31	0.00	5.90	0.00	0.42
Echinodermata-Asteroidea	0	1	0.00	0.19	0.00	0.01
Echinodermata-Crinoidea	0	1	0.00	0.19	0.00	0.01
Echinodermata-Echinoidea	5	8	1.20	1.52	0.22	0.11
Echinodermata-Ophiuroidea	16	29	3.85	5.52	0.70	0.40
Echinodermata-Holothuroidea	2	0	0.48	0.00	0.09	0.00
Phoronida	1	7	0.24	1.33	0.04	0.10
Hemichordata-Enteropneusta	17	799	4.09	152.19	0.74	10.95
Platyhelminthes	1	0	0.24	0.00	0.04	0.00
Total	**2285**	**7296**	**549.28**	**1389.71**	**100.00**	**100.00**

6.0 Literature Cited

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APPENDICES

APPENDIX A

Scope of Work/Sampling and Analysis Plan – Post-Drill Survey

APPENDIX B

Ministry of Environmental Protection Scope of Work Approval

APPENDIX C

Ministry of Environmental Protection Discharge Permit

APPENDIX D

Sampling Station Coordinates

APPENDIX E

Vessel Specifications

APPENDIX F

Video Observation Log

APPENDIX G

Seawater Total Metals Analytical Data Sheets

APPENDIX H

Seawater Hydrocarbons Analytical Data Sheets

APPENDIX I

Seawater Radionuclide Analytical Data Sheets

APPENDIX J

Sediment Grain Size Analytical Data Sheets

APPENDIX K

Sediment Total Organic Carbon Analytical Data Sheets

APPENDIX L

Sediment Total Metals Analytical Data Sheets

APPENDIX M

Sediment Hydrocarbons Analytical Data Sheets

APPENDIX N

Sediment Radionuclide Analytical Data Sheets

APPENDIX O

Infauna Report

Yam-3 Environmental Monitoring Program Post-Drill Survey
Benthic Infaunal Community Assessment
Final Report

April 2014

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Page

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

Recent hydrocarbon exploration and development activities are currently proceeding off the coast of Israel in nearshore and offshore lease blocks. As a consequence of these activities, and given the relative paucity of site-specific benthic community data within the blocks of interest, baseline studies were performed in September 2014 to determine current benthic infaunal conditions and, for those locations where hydrocarbon exploration and development activity has been limited, to provide a reference point to determine if these activities may have affected the benthic infaunal community.

2.0 METHODS

Samples were collected as detailed in Section 2.0 of the YAM-3 Wellsite Environmental Baseline Report, processed onboard, and transported to EcoAnalysts, Inc. for sorting and taxonomic identification. Samples were sieved using a 0.3-mm mesh screen onboard the ship and within EcoAnalysts' laboratory. Prior to sorting, the samples were transferred from formalin to ethyl alcohol (ETOH). Samples were pre-sorted to major taxonomic groups and then distributed to taxonomists for species identification and enumeration. During the taxonomic process, organisms were identified to the Lowest Practical Taxonomic Level (LPTL) by EcoAnalysts' in-house taxonomists. Oligochaetes were identified to Class level. Ostracods and copepods were enumerated only while nematodes were ignored. All three groups are considered meiofaunal and are not included within benthic infaunal database diversity metrics. Data were recorded on electronic datasheets within the EcoAnalysts' laboratory information management system (LIMS) and then later output in a Microsoft Excel format.

A variety of statistical routines were applied to the resulting datasets using the PRIMER v.6 (Clarke and Gorley, 2006) software, which was used to calculate several univariate diversity indices, including Shannon's H′ (base 2), Pielou's evenness value J′, and Fisher's log-series *alpha*[2].

For comparison, the Bray-Curtis similarity measurement was also used, based on fourth-root transformation of the data; these analyses were carried out in PRIMER v.6 (Clarke and Gorley, 2006). The SIMPROF routine in PRIMER was applied to test for statistically significant differences between samples. Principal component analyses to determine similarity as well as Chao species accumulation estimates were also calculated in PRIMER (Clarke and Gorley, 2006). All similarity matrices were clustered using group average sorting and dendrograms were plotted. Results of these analyses were inspected for patterns among and between the different stations.

3.0 RESULTS

3.1 Numerically Dominant Species

The 42 infaunal benthic samples yielded 7,296 individual and identifiable organisms, which were assigned to 202 taxa (see the **Attachment**). The material was generally well preserved and fine discriminations could be made, even though scientific names could not be applied to some taxa at this point; several of the species were thought to be new to science and further investigation at a later date is warranted. Other species were more difficult to define and would require additional research to define to

[2] Fisher's log-series model of species abundance (Fisher et al., 1943) has been widely used, particularly by entomologists and botanists (Magurran, 1988) and more recently for deep-sea benthic data analysis. Taylor's (1978) studies of the properties of this index found that it was the best index for discriminating among subtly different sites.

lower taxonomic level. **Table 1** provides a list of taxa identified from the 42 sample locations (see Figure 2 of the YAM-3 Wellsite Environmental Baseline Report).

Distribution of the taxa according to major taxonomic groups and subgroups is shown in **Table 2**. The polychaetous annelids were dominant and accounted for over 60% of the faunal abundance. The other two major taxa that typically dominate the benthos, Crustacea (excluding Maxillopoda) and Mollusca, accounted for 13.02% and 7.06%, respectively. Among the crustaceans, Maxillopoda (Ostracoda, Copepoda, and Cirripedia) comprised 1.29% of the total faunal composition. Enteropneusts (Hemicordata: acorn worm) were abundant within the stations sampled with 799 individuals found from the 42 stations with 10.94% of the total fauna. Echinoderms comprised 0.53% of the total fauna. Other groups including Phoronids, oligochaetes, cnidarians, and sipunculids were found to comprise a small percentage of total fauna identified (**Table 1**).

Overall, 27 benthic infaunal taxa contributed more than 50 individuals to the 42 samples (**Table 3**). Seventeen taxa of annelid polychaetes were among the top numerical dominants, with *Prionospio* sp., *Terebellides stroemeri*, Cirratulidae spp., *Magelona* sp., *Levensinia* sp. and Exogone sp. having the greatest abundances among the polychaetes. . Amphipods in the Families Phoxocephalidae (*Harpinia* sp.) and Ampeliscidae (*Ampelisca* sp.) were the dominant crustaceans with 312 and 117 individuals among the 42 stations, respectively. The most abundant mollusks included two species of bivalves Corbula gibba (n=66) and Timoclea ovate (n=114) from the 42 samples. A large number of acorn worms (enteropneusts) were also collected. A total of 799 individual acorn worms were identified from the 42 samples.

3.2 Univariate Community Parameters

Sampling stations for the YAM3 survey are abbreviated as follows: Center (C), Nearfield (NF), Midfield (MF), Farfield (FF), Reference (REF). The REF stations were separated into two subgroups Reference North (NREF) and Reference South (SREF).

For the 42 stations sampled, average species richness ranged from a low of 14 taxa at SREF-1 to a high of 62 taxa at NREF-5 (**Table 4**). **Figure 1** provides a graphic comparison of species diversity (H′) and abundance among each of the 42 stations by replicate sampled within each strata location. To better understand trends within the dataset, NF, MF, FF, NREF, and SREF stations were averaged to and standard errors were compared for total abundance, richness, Shannon-Weiner diversity (H′), Pielou's Evenness (J′), Fisher's log-series α, and maximum diversity (Hmax) (**Figure 2**).

A comparison of mean species richness (number of species) among the strata groups suggests that C, NF, MF, and FF are not significantly different (**Table 5**) although a trend of lower species richness was observed within stations moving further away from the center location, except for NREF. The NREF station did not show significantly higher species richness when compared to the other station locations except the SREF, FF, and MF station locations (**Figure 2**).

While data may not be significantly different for all strata when average abundance was compared, there was a trend observed that stations located further from the center well location had lower abundances except for NREF. By excluding the NREF location, the stations showed abundances were higher closer to the wellsite and progressively diminished as samples were collected further away from the well center location.

No significant differences were observed when average Pileou's evenness, average Shannon-Weiner diversity (H'), average Fisher's log series alpha, and average maximum diversity (Hmax) for different strata sampled. Depths at each station were nearly equivalent and did not have an effect on species distributions.

Chao analysis, which is another form of evaluating species richness through prediction of the species richness accumulation showed that the 42 stations may not have completely sampled all species at these location, however, the project accumulation curve was near asymptote, and therefore species richness was may not have increased significantly if additional stations were sampled within each strata (**Figure 3**).

Table 1. Infaunal species identified in 42 samples from offshore Israel.

CNIDARIA
- *Actinaria* sp.

NEMATODA
- *Nematoda* sp.

NEMERTEA
- *Enopla* sp.

Family Carinomidae
- Carinomidae

Family Lineidae
- Lineidae

Fanuky Tubulanidae
- Tubulanidae

ANNELIDA - CITELLATA
- *Oligochaeta* sp.

ANNELIDA - POLYCHAETA

Family Ampharetidae
- *Amphicteis gunneri*
- *Anobothrus* sp.
- *Lysippe* sp.
- *Melinna* sp.

Family Apistobranchidae
- Apistobranchus sp.

Family Capitellidae
- Capitellidae sp.
- *Barantolla* sp.
- *Leiocapitella* sp.
- *Mediomastus* sp.
- *Neomediomastus* sp.
- *Notomastus* sp.
- *Pseudocapitella incerta*

Family Chaetopteridae
- *Spiochaetopterus* sp.

Family Cirratulidae
- Cirratulidae
- *Aphelochaeta marioni*
- *Chaetozone* sp.
- *Dodecaceria* sp.
- *Monticellina* sp.

Family Cossuridae
- *Cossura* sp.

Family Dorvilleidae
- Dorvilleidae
- *Schistomeringos* sp.

Family Eunicidae
- *Lysidice* sp.

Family Flabelligeridae
- *Diplocirrus glaucus*
- *Flabelliderma* sp. 1 EcoA

Family Glyceridae
- *Glycera lapidium*
- *Glycera unicornis*

Family Hesionidae
- Hesionidae
- *Gyptis* sp.
- *Podarkeopsis* sp.

Family Lumbrineridae
- *Abyssoninoe* sp. 1 EcoA
- *Gallardoneris* sp. 1 EcoA

Family Magelonidae
- *Magelona* sp.

Family Maldanidae
- Maldanidae
- *Asychis biceps*
- *Euclymene* sp.
- *Maldane glebifex*
- *Praxillella gracilis*
- *Rhodine loveni*

Family Nephtyidae
- Nephtyidae
- *Aglaophamus* sp.
- *Nephtys* sp.

Family Nereididae
- *Ceratonereis* sp.

Family Oenonidae
- *Drilonereis filum*

Family Onuphidae
- Onuphidae
- *Onuphis* sp.

Family Opheliidae
- Opheliidae

Family Oweniidae
- *Galathowenia oculata*

Family Paralacydoniidae
- *Paralacydonia paradoxa*

Family Paraonidae
- Paraonidae
- Aricidea *(Acmira) simplex*
- Aricidea *(Allia) antennata*
- Aricidea *(Allia) monicae*
- *Aricidea* sp. 1 EcoA
- *Cirrophorus branchiatus*
- *Cirrophorus furcatus*
- *Levinsenia* sp.

Family Phyllodocidae
- *Eteone* sp.
- *Eulalia* sp.
- *Eumida* sp.

Family Pilargidae
- *Ancistrosyllis groenlandica*
- *Litocorsa stremma*
- *Sigambra tentaculata*

Family Poecilochaetidae
- *Poecilochaetus* sp.

Family Polynoidae
- *Eunoe* sp.

Family Sabellidae
- Fabriciinae
- *Euchone* sp.

Family Serpulidae
- *Hydroides* sp.
- *Josephella* sp.
- *Salmacina* sp.

Family Sigalionidae
- *Sthenelanella* sp.

Family Sphaerodoridae
- *Sphaerodoridium* sp.

Family Spionidae
- Spionidae
- *Dipolydora* sp.
- *Laonice* sp.
- *Prionospio* sp.
- *Scolelepis* sp.
- *Spiophanes* sp.

Family Sternaspidae
- *Sternaspis scutata*

Family Syllidae
- *Exogone* sp.
- *Sphaerosyllis* sp.

Family Terebellidae
- Terebellidae
- Terebellinae
- *Pista* sp.
- *Proclea* sp.
- *Pseudampharete* sp.
- *Thelepus* sp.

Family Trichobranchidae
- *Terebellides stroemii*

SIPUNCULA
- Sipuncula

SIPUNCULA - PHASCOLOSMATIDEA
- *Antedon mediterranea*

MOLLUSCA – BIVALVIA
- Bivalvia

Family Arcidae
- *Anadara* sp.

Family Cardiidae
- *Parvicardium* sp.

Family Corbulidae
- *Corbulidae gibba*

Family Cuspidariidae
- *Cardiomya costellata*
- *Cuspidaria cuspidate*
- *Cuspidaria rostrata*
- *Cuspidaria* sp.

Family Kelliellidae
- *Kelliella* sp.

Family Lucinidae
- *Myrtea spinifera*

Family Mytilidae
- *Musculus* sp.

Family Nuculanidae
- *Nucula* sp.
- *Nucula sulcata*

Family Pandoridae
- *Pandora pinna*

Family Propeamussiidae
- Propeamussiidae sp.

Family Semelidae
- Semelidae
- *Abra prismatica*

Family Thraciidae
- Traciidae

Family Thyasiridae
- Thyasiridae
- *Thyasira biplicata*
- *Thyasira* sp.

Family Veneridae
- Veneridae
- *Timoclea ovata*

MOLLUSCA – GASTROPODA
- Gastropoda

Family Acteonidae
- Acteonidae

Family Borsoniidae
- *Drilliola loprestiana*

Family Cerithiidae
- Cerithiidae sp.

Family Eulimidae
- Eulimidae
- *Eulima glabra*

Family Nassariidae
- *Nassarius elatus*

Family Naticidae
- Naticidae

Family Philinidae
- Philinidae

Family Pyramidellidae
- *Odostomia* sp.
- *Turbonilla* sp.

Family Ringiculidae
- *Ringicula conformis*

Family Rissoidae
- *Alvania* sp.
- Rissoidae

Family Turritellidae
- *Turritella* sp.

MOLLUSCA – SCAPHOPODA
- Scaphopoda sp.

Family Dentaliidae
- *Antalis* sp.

ARTHROPODA – MALACOSTRACA
- Tanaidomorpha sp.

Family Ampeliscidae
- *Ampelisca jaffaensis*

Family Akanthophoreidae
- *Akanthophoreus* sp.

Family Alpheidae
- Alpheidae
- *Alpheus* sp.

Family Ampeliscidae
- *Ampelisca* sp.

Family Anthuridae
- Anthuridae

Family Aoridae
- *Leptocheirus* sp.

Family Apseudidae
- *Apseudopsis elisae*

Family Callianassidae
- *Callianassa subterranea*

Family Carangoliopsidae
- *Carangoliopsis spinulosa*

Family Cirolanidae
- *Natatolana* sp.

Family Corophiidae
- *Apocorophium acutum*
- *Medicorophium* sp.

Family Desmosomatidae
- *Desmosomatidae* sp.

Family Diastylidae
- Diastylidae
- *Diastylis* sp.

Family Eusiridae
- *Eusirus* sp.

Family Gnathiidae
- *Gnathia* sp.

Family Isaeidae
- Isaeidae

Family Isaeidae
- *Photis* sp.

Family Laomediidae
- *Jaxea nocturna*
- *Leptochelia tanykeraia*
- *Leptognathia* sp.

Family Leuconidae
- *Eudorella* sp.
- *Leucon siphonatus*
- Majoidea

Family Leucosiidae
- *Ebalia granulosa*

Family Leucothoidae

Leucothoe oboa
Family Lysianassidae
Lysianassidae
Family Melitidae
Melitidae
Eriopisa elongata
Family Nebaliidae
Nebalia sp.
Family Nototanaidae
Nototanaidae
Family Oedicerotidae
Oedicerotidae
Family Paguridae
Paguridae
Family Pasiphaeidae
Leptochela pugnax
Family Phoxocephalidae
Phoxocephalidae
Harpinia sp.
Family Phtisicidae
Phtisicidae
Family Portunidae
Portunidae
Family Processidae
Processa sp.
Family Pseudotanaidae
Pseudotanais sp.
Pseudotanais stiletto
Family Synopiidae
Synopiidae
Family Tanaellidae
Tanaellidae

ARTHROPODA – MAXILLOPODA
Calanoida spp.
Cyclopoida spp.
Pedunculata sp.

ARTHROPODA – OSTRACODA
Ostracoda spp.

ARTHROPODA – PYCNOGONIDA
Family Phoxichilidiidae
Phoxichilidiidae

ECHINODERMATA – ASTEROIDEA
Asteroidea sp.

ECHINODERMATA – CRINOIDEA
Family Antedonidae
Antedon mediterranea

ECHINODERMATA – ECHINOIDEA
Cidaroida sp.
Spatangoida sp.

ECHINODERMATA – OPHIUROIDEA
Ophiuroidea spp.
Family Amphiuridae
Amphiuridae
Amphiura filiformis
Amphiura incana
Family Ophiuridae
Ophiura sp.

PHORONIDA
Phoronida sp.

HEMICHORDATA - ENTEROPNEUSTA
Enteropneusta sp.

Table 2. Abundance distribution of major taxa and subgroups.

Taxonomic Group	Abundance	Percent Total Fauna
Polychaeta	4383	60.06
Crustacea (excluding Maxillopoda)	918	12.57
Hemichordata	799	10.94
Bivalvia (Mollusca)	344	4.70
Nematoda	288	3.95
Nemertea	162	2.22
Gastropoda (Mollusca)	155	2.12
Ostracoda, Copepods, Cirripedia (Crustacea)	94	1.29
Echinodermata	39	0.53
Pycnogonida	33	0.45
Sipuncula	32	0.44
Cnidaria	24	0.33
Scaphopoda (Mollusca)	17	0.23
Phoronida	7	0.10
Oligochaeta	4	0.05
Aplacophora (Mollusca)	1	0.01
Total	7296	100.00

Table 3. Top dominant benthic infaunal taxa from 42 sampling stations offshore Israel.

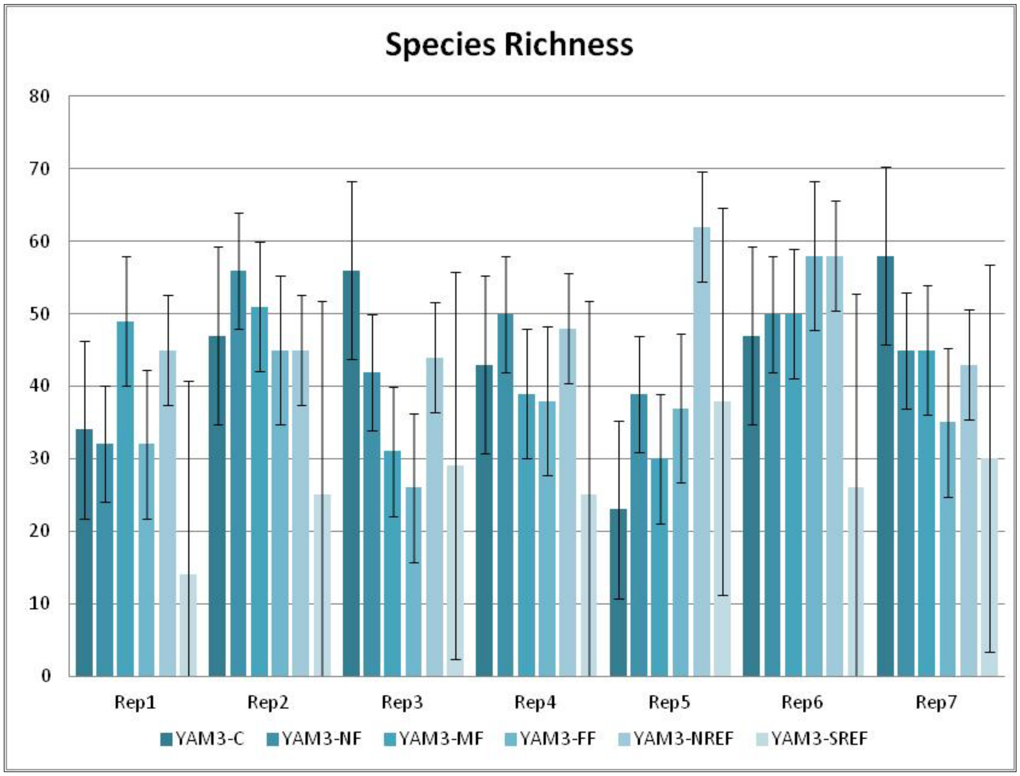
Major Taxonomic Group	Lowest Taxonomic Designation	Abundance
Hemichordata (Enteropneusta)	*Enteropneusta* sp.	799
Polychaeta	Cirratulidae spp.	415
Polychaeta	*Magelona* sp.	407
Polychaeta	*Levinsenia* sp.	357
Polychaeta	*Monticellina* sp.	345
Crustacea (Amphipoda)	*Harpinia* sp.	312
Polychaeta	*Exogone* sp.	190
Polychaeta	*Aricidea* sp. 1 EcoA	156
Polychaeta	*Aphelochaeta marioni*	154
Polychaeta	*Terebellides stroemii*	135
Polychaeta	*Galathowenia oculata*	118
Crustacea (Amphipoda)	*Ampelisca* sp.	117
Mollusca (Bivalvia)	*Timoclea ovata*	114

Table 4. Benthic community parameters, including sediment texture results, at 42 sampling stations offshore Israel.

	Species Richness	Abundance	Pileou's Evenness (J')	Log Series Fisher's alpha	Shannon-Weiner Diversity (H')	Maximum Diversity (Hmax)
YAM3-C1	34	159	0.775	13.259	2.732	3.526
YAM3-C2	47	215	0.797	18.559	3.069	3.850
YAM3-C3	56	306	0.799	20.095	3.216	4.025
YAM3-C4	43	133	0.876	22.044	3.294	3.761
YAM3-C5	23	80	0.822	10.804	2.576	3.135
YAM3-C6	47	184	0.821	20.391	3.160	3.850
YAM3-C7	58	253	0.829	23.544	3.365	4.060
YAM3-NF1	32	131	0.845	13.498	2.928	3.466
YAM3-NF2	56	229	0.812	23.637	3.269	4.025
YAM3-NF3	42	120	0.892	22.971	3.333	3.738
YAM3-NF4	50	152	0.877	25.985	3.432	3.912
YAM3-NF5	39	109	0.860	21.737	3.151	3.664
YAM3-NF6	50	209	0.861	20.822	3.368	3.912
YAM3-NF7	45	168	0.884	20.138	3.367	3.807
YAM3-MF1	49	168	0.845	23.255	3.287	3.892
YAM3-MF2	51	141	0.866	28.696	3.405	3.932
YAM3-MF3	31	77	0.861	19.273	2.957	3.434
YAM3-MF4	39	118	0.893	20.345	3.271	3.664
YAM3-MF5	30	98	0.858	14.750	2.919	3.401
YAM3-MF6	50	139	0.884	27.998	3.457	3.912
YAM3-MF7	45	132	0.884	24.075	3.365	3.807
YAM3-FF1	32	64	0.884	25.469	3.063	3.466
YAM3-FF2	45	121	0.859	25.955	3.269	3.807
YAM3-FF3	26	61	0.914	17.136	2.979	3.258
YAM3-FF4	38	92	0.905	24.240	3.292	3.638
YAM3-FF5	37	98	0.877	21.636	3.166	3.611
YAM3-FF6	58	189	0.861	28.568	3.495	4.060
YAM3-FF7	35	59	0.941	36.193	3.346	3.555
YAM3-N-Ref1	45	133	0.913	23.926	3.474	3.807
YAM3-N-Ref2	45	159	0.882	20.908	3.359	3.807
YAM3-N-Ref3	44	175	0.824	18.898	3.118	3.784
YAM3-N-Ref4	48	178	0.866	21.577	3.351	3.871
YAM3-N-Ref5	62	207	0.859	29.995	3.543	4.127
YAM3-N-Ref6	58	182	0.882	29.401	3.582	4.060
YAM3-N-Ref7	43	156	0.859	19.618	3.231	3.761
YAM3-S-Ref1	14	19	0.967	24.032	2.552	2.639
YAM3-S-Ref2	25	41	0.916	27.191	2.948	3.219
YAM3-S-Ref3	29	59	0.942	22.572	3.171	3.367
YAM3-S-Ref4	25	59	0.934	16.375	3.006	3.219
YAM3-S-Ref5	38	97	0.873	23.005	3.175	3.638
YAM3-S-Ref6	26	56	0.905	18.860	2.950	3.258
YAM3-S-Ref7	30	67	0.883	20.868	3.003	3.401

Table 5. Average data for station location groups with standard deviation (SD) and standard error (SE) for benthic community parameters at 42 sampling stations offshore Israel in 2013.

	Species Richness	Abundance	Pileou's Evenness (J')	Log Series Fisher's alpha	Shannon-Weiner Diversity (H')	Maximum Diversity (Hmax)
YAM3-C Average	44.00	190.00	0.817	18.385	3.059	3.744
YAM3-C Standard Dev.	12.25	75.71	0.03	4.67	0.30	0.32
YAM3-C Standard Error	4.63	28.62	0.01	1.76	0.11	0.12
YAM3-NF Average	44.86	159.71	0.862	21.256	3.264	3.789
YAM3-NF Standard Dev.	8.01	45.33	0.03	3.93	0.17	0.19
YAM3-NF Standard Error	3.03	17.13	0.01	1.49	0.07	0.07
YAM3-MF Average	42.14	124.71	0.870	22.627	3.237	3.720
YAM3-MF Standard Dev.	8.91	30.09	0.02	4.94	0.21	0.23
YAM3-MF Standard Error	3.37	11.37	0.01	1.87	0.08	0.09
YAM3-FF Average	38.71	97.71	0.891	25.600	3.230	3.628
YAM3-FF Standard Dev.	10.29	46.35	0.03	5.92	0.18	0.25
YAM3-FF Standard Error	3.89	17.52	0.01	2.24	0.07	0.10
YAM3-NREF Average	49.29	170.00	0.869	23.475	3.380	3.888
YAM3-NREF Standard Dev.	7.57	23.41	0.03	4.54	0.17	0.15
YAM3-NREF Standard Error	2.86	8.85	0.01	1.72	0.06	0.06
YAM3-SREF Average	26.71	56.86	0.917	21.843	2.972	3.249
YAM3-SREF Standard Dev.	26.71	56.86	0.92	21.84	2.97	3.25
YAM3-SREF Standard Error	10.10	21.49	0.35	8.26	1.12	1.23



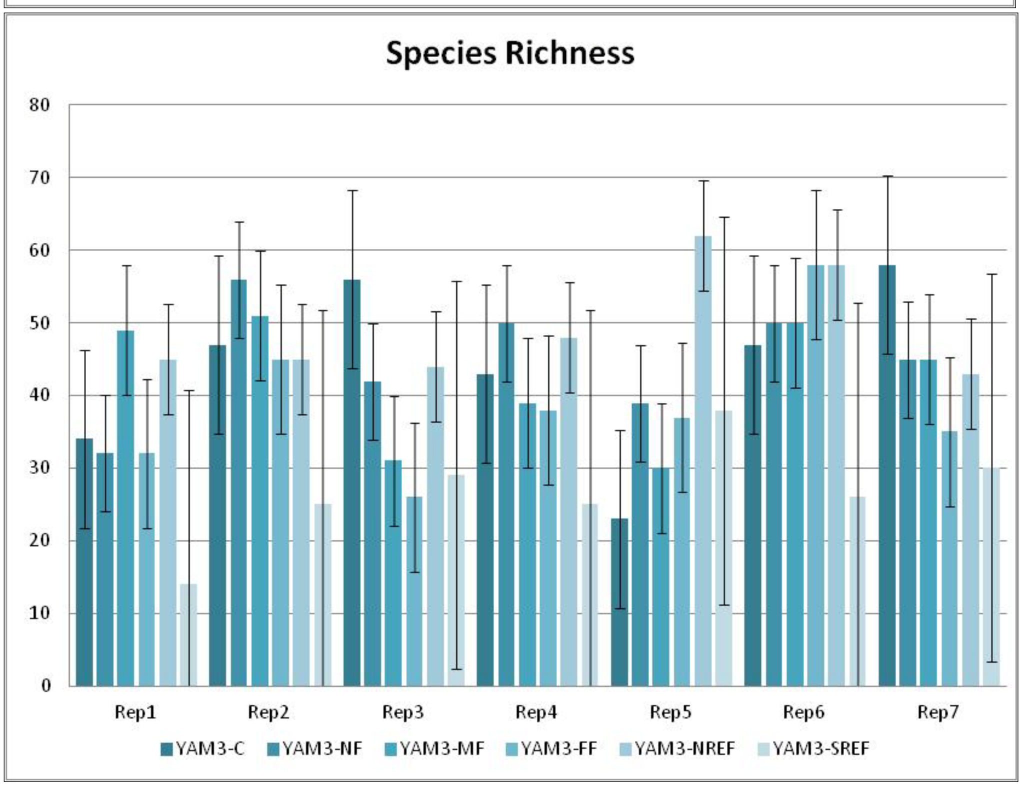


Figure 1. Species richness and total abundance plotted with standard deviations for each sampling station offshore Israel in 2013.

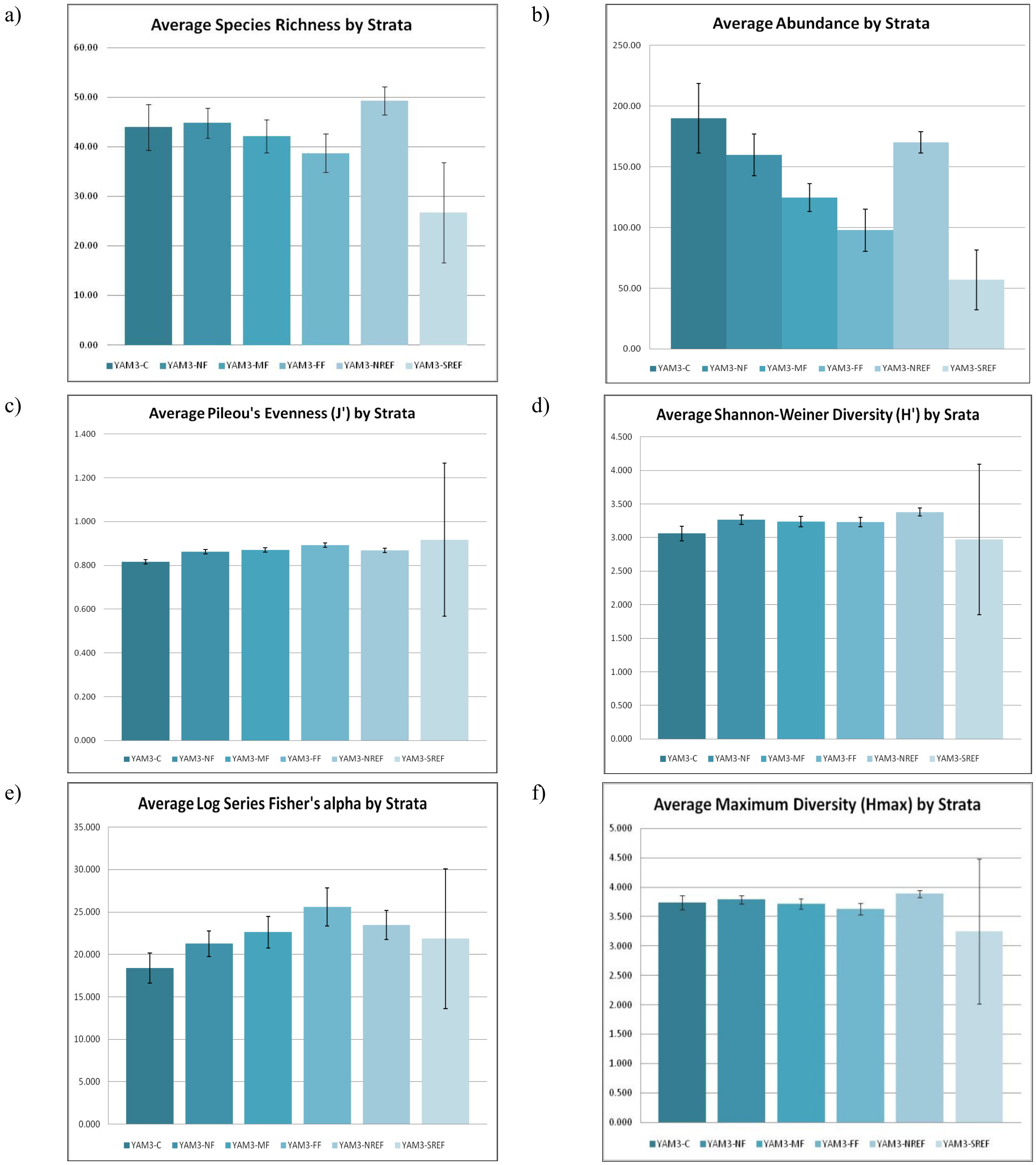


Figure 2. Number of species, total infaunal abundance, evenness, H′ diversity, α-diversity, and Hmax for sampling stations offshore Israel in 2013.

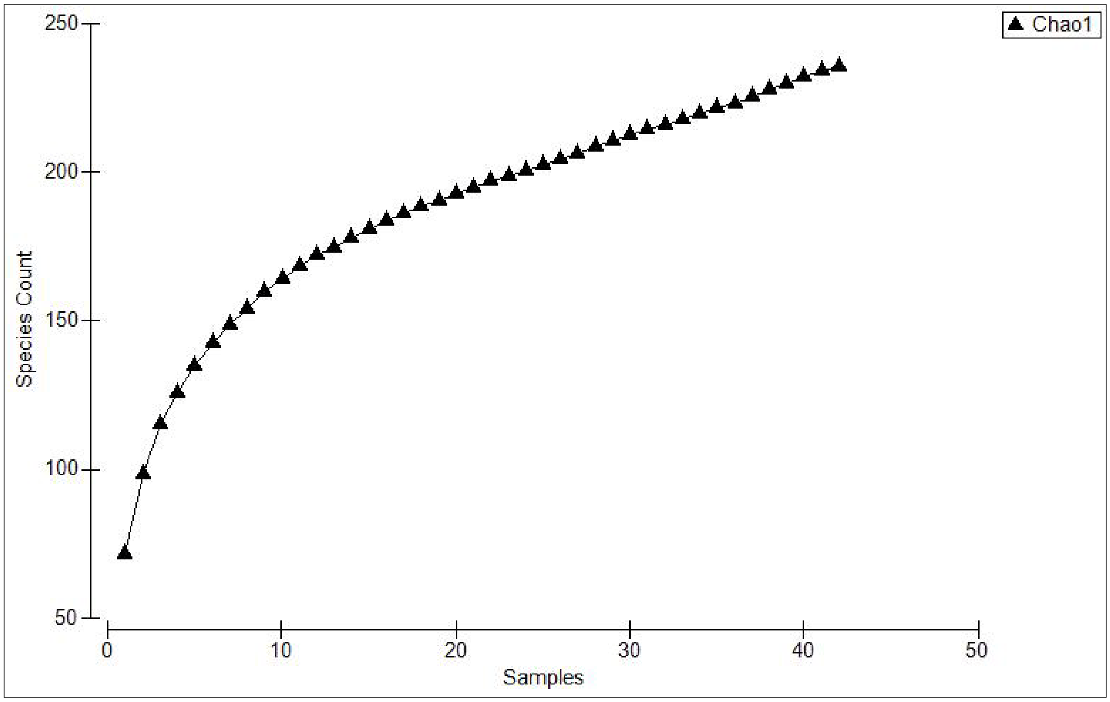


Figure 3. Chao species accumulation curve for 42 sampling stations offshore Israel. The slope and leveling of the curve near the terminal end suggests the number of samples may not have adequately represented the species diversity in the area but that there is a trend toward the asymptote and additional samples may have yielded only slightly higher species richness. Number of taxa identified (n=202) were conservative as some taxa were not identified below Family level.

3.2.1 Multivariate Analysis

Similarity Among Stations

Multivariate similarity analysis based on the Bray-Curtis algorithms of second-root-transformed data, showed no trend when stations are compared individually. The Center, NF, MF, FF and RF stations had between 40% to 70% similarity to each other (**Figure 4**). The small clusters with multiple branching suggested the sampled stations had similarity to each other but there was no clearly defined grouping of Center, NF, MF, and FF stations from Reference sites. Reference stations did not group separately from other strata. Stations REFS1, REFS2 and REFS5 formed an outgroup cluster to all other stations. REFS1 formed an outlier due to low species richness and low abundance, the lowest of all stations sampled. REFS2 and REFS5 had low abundance but had high species richness, although taxa found at these locations was similar to the taxa at other locations.

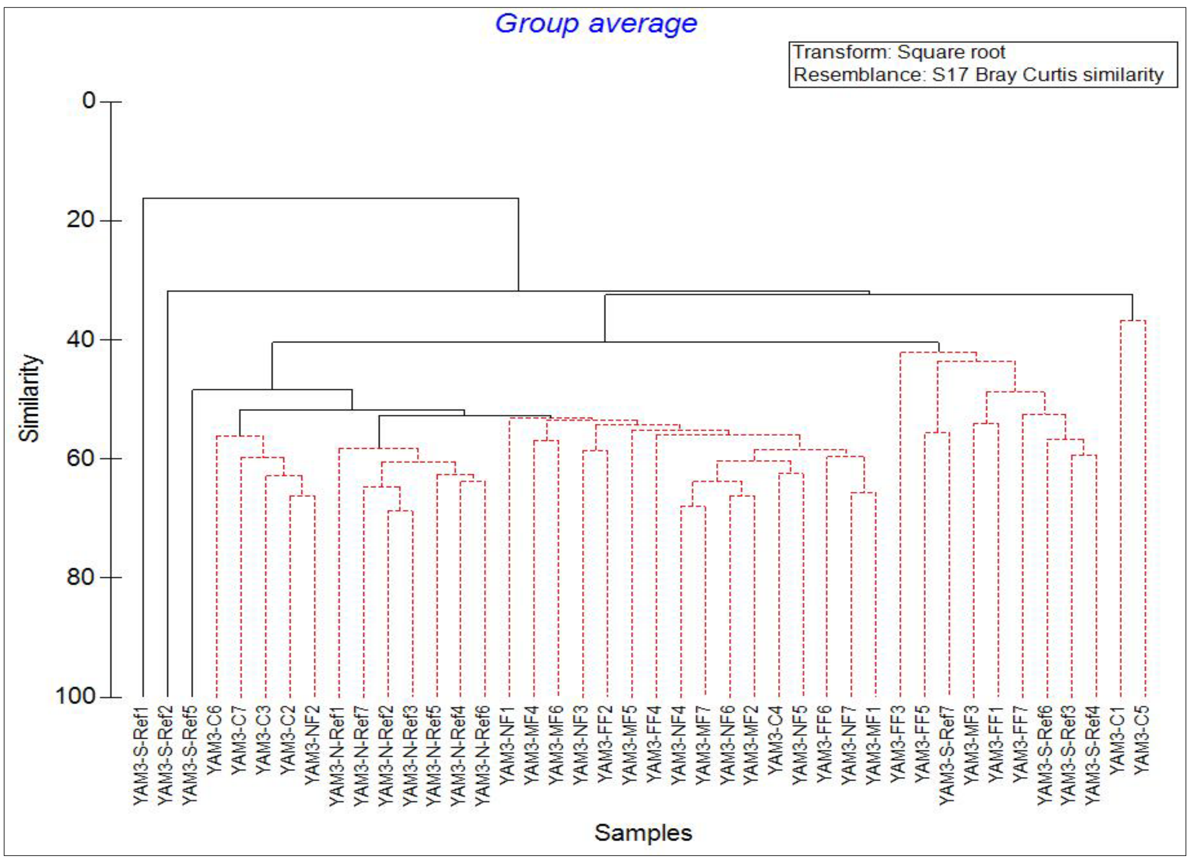


Figure 4. Similarity among the 42 sampling stations offshore Israel as determined by the Bray-Curtis algorithm applied to 4th-root-transformed data with group-average clustering. The vertical black line indicates the percent similarity level.

The average abundance for each species was calculated for the sampling station locations and then compared using Bray-Curtis cluster analysis. By calculating the average taxa abundance at each strata location, similarities among strata were higher with a range between 60-75%. SREF again formed an outlier to all other locations largely due to lower abundances at this location. Only NF and MF grouped together with enough similarity that this subgroup was significant using SIMPEROF testing (red lines, **Figure 5**).

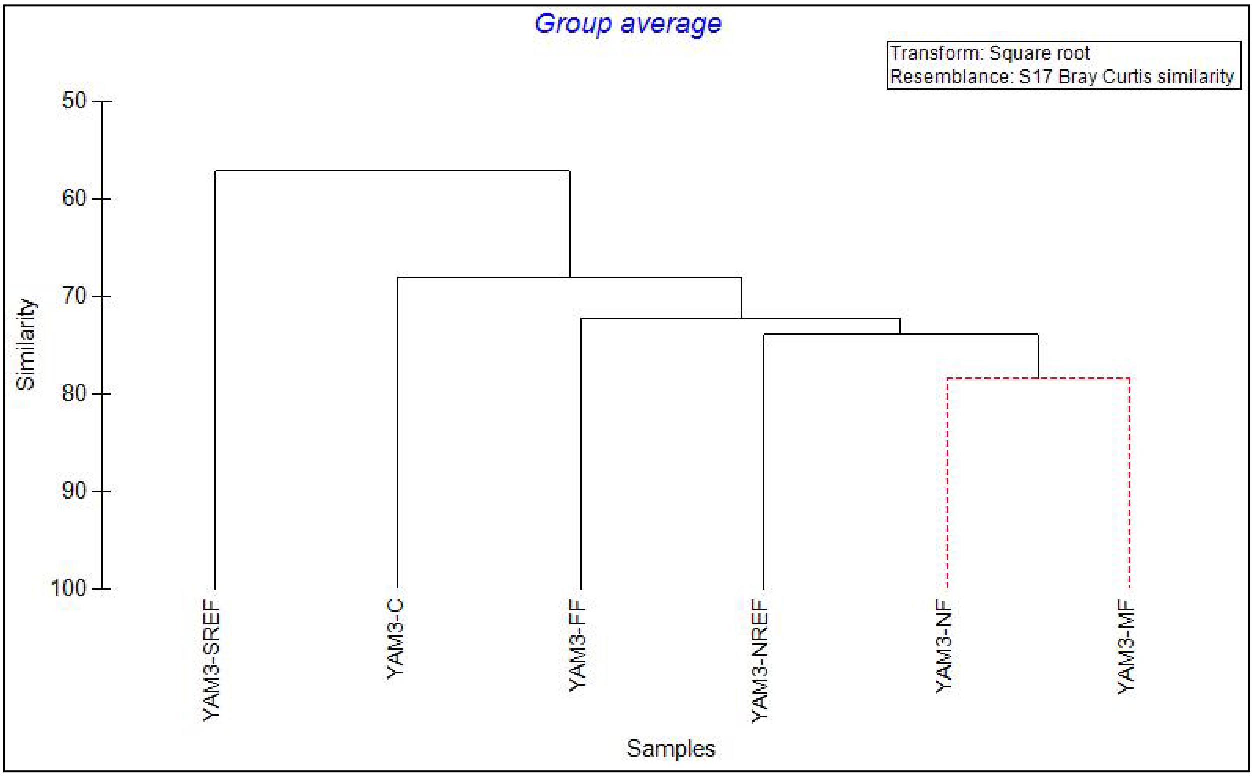


Figure 5. Similarity among the averaged sampling stations compared with reference locations offshore Israel in 2013 as determined by the Bray-Curtis algorithm applied to 2nd-root-transformed data with group-average clustering. Dotted red lines indicate significant clusters of stations as determined by the SIMPROF analysis. Vertical lines indicate percent similarity.

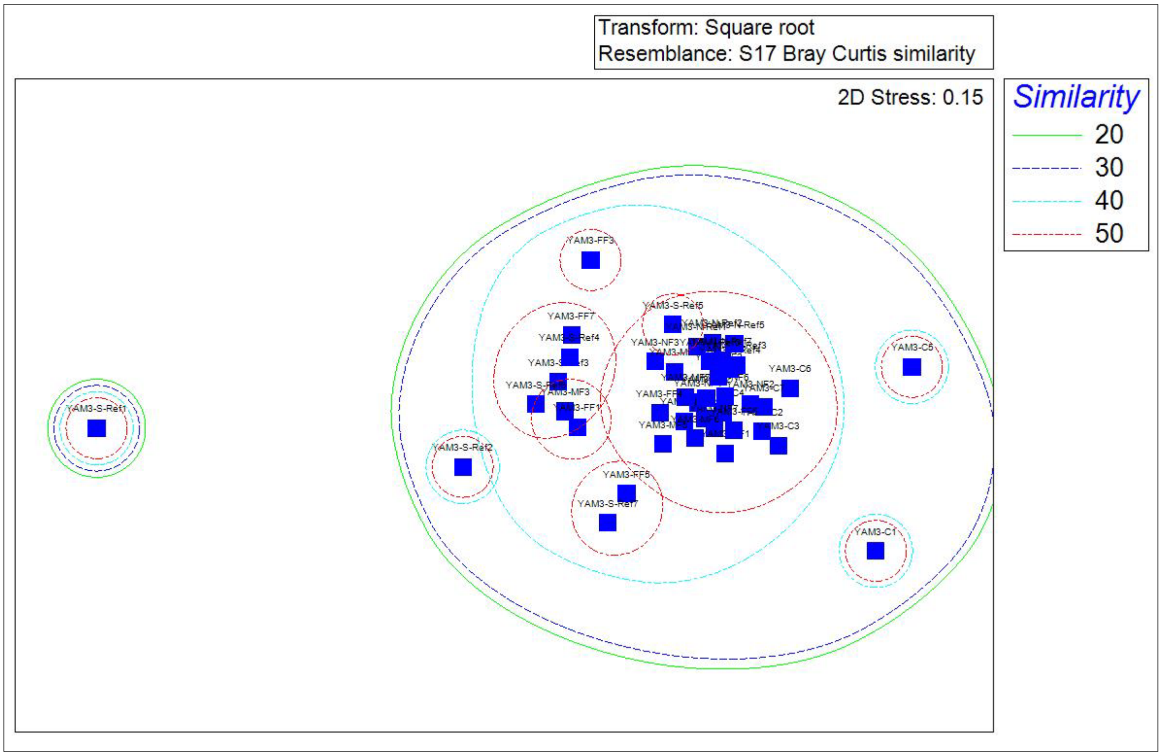
3.2.2 Multidimensional Scaling and Ordination

The multidimensional scaling diagram based on the Bray-Curtis analysis (**Figure 6a**) reflects the station location clustering. The most similar stations were a mix of Center, NF, MF, FF and Ref stations with approximately 60% similarity. When individual stations within each sampled location are treated as replicates and averaged, similarity among MF and NF are much higher but reference sites did not group together. Results from MDS analysis show FF, MF, NF, NREF, and Center locations grouping together with 60% similarity while SREF is an outlier to all other strata locations with only 40% similarity (**Figure 6b**).

PCA analysis suggested no major groups when individual stations are compared. The first two axes accounted for only 32.4% of the total variation; the first three axes accounted for only 39.7% of the variation. Because only 32.4% of the variation is accounted for in the first two axes, three PCA axes were summarized. The contributions of individual species to the metric scaling of the stations are detailed in **Table 6**. The various polychaetes such as Galathowenia oculata, Exogone sp., Aphelochaeta marioni, Prionospio sp., Monticellina sp., and Ceratoneries sp., along with the amphipod Harpinia sp. and the mollusks belonging to Turbonilla sp. and Thyasiridae sp. contributed to the general similarity among all the stations. There is no clear separation of Center, NF, MF, FF or REF groups when stations are compared individually (**Figure 7a**).

When station replicates were averaged by location a distinct groupings of NF, MF, and FF was formed with PCA analysis. The first two axes accounted for 70.8% of the total variation; the first three axes accounted for 85.5% of the variation. Variation of the three PCA axes were summarized for the averaged data and contributions of individual species to the metric scaling of the stations are detailed in **Table 7**. The mollusks Turbonilla sp. and Thyasirdae sp. along with the polychaetes Monticellina sp. and Ceratoneries sp. contributed toward these groups. References stations formed outlier groups and did not group together, likely due to low abundances found at SREF (**Figure 7b**).

a)



b).

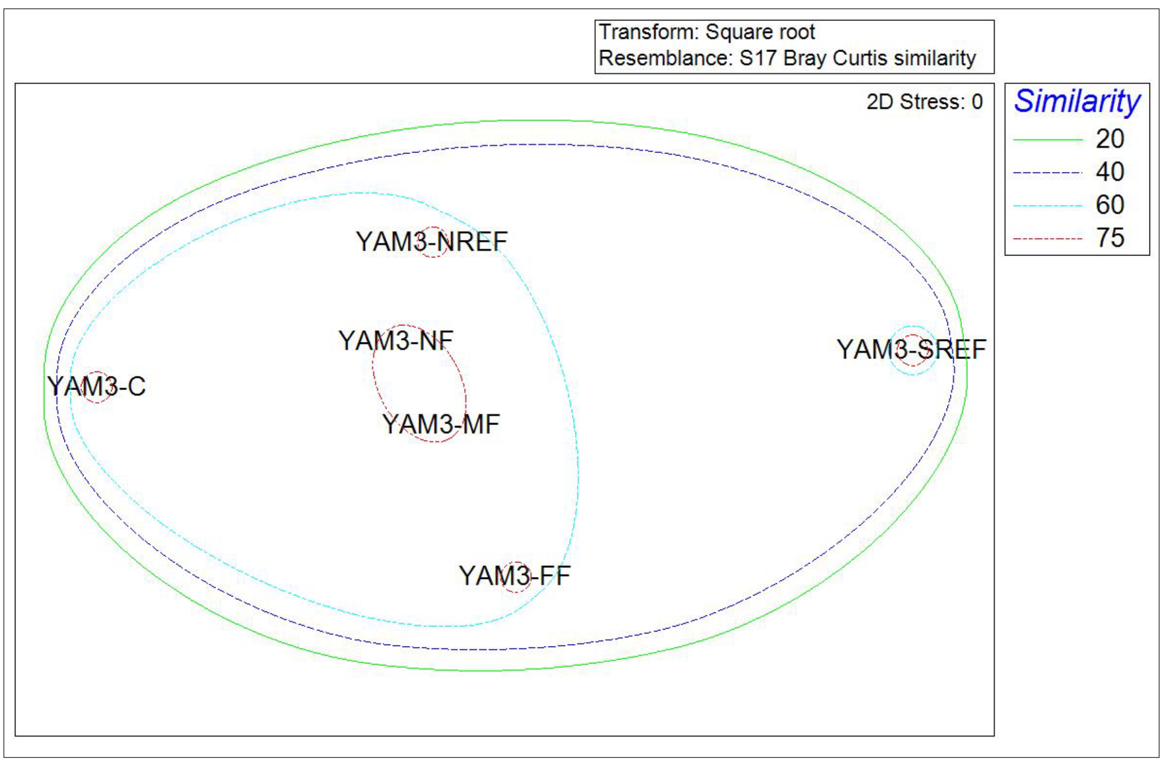


Figure 6. Multidimensional scaling diagram of the 42 sampling stations offshore Israel. Clusters refer to groups elucidated by SIMPROF analysis.

a)

b)

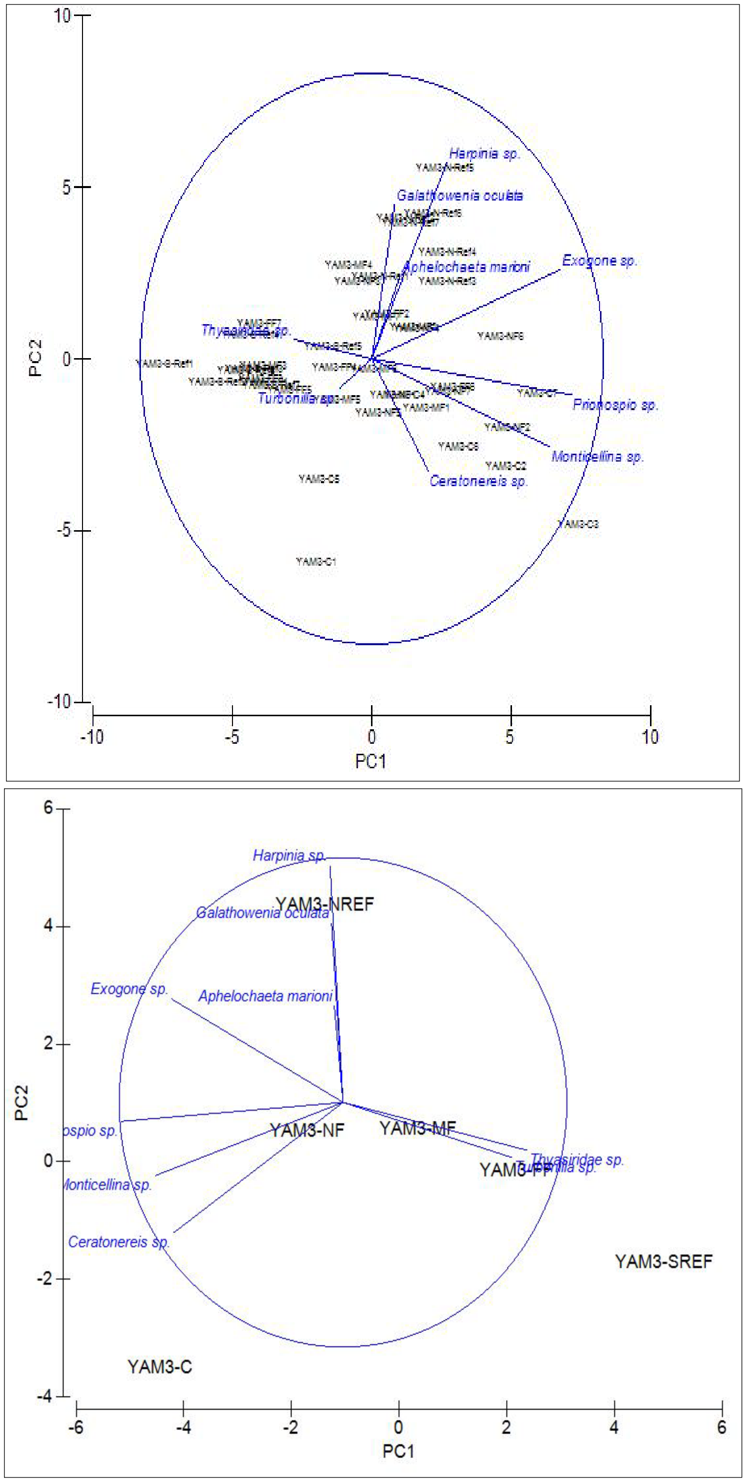


Figure 7. Principal component analysis results of 42 sampling stations offshore Israel. a) Individual stations compared; b) averaged stations by location compared. Length of line indicates relative importance of species to similarity analyses.

Table 6. Species contributions to metric scaling of 42 sampling stations offshore Israel as determined by PCA analysis for individual stations (see **Figure 5**).

Variable	PC1	PC2	PC3
Actiniaria sp.	0.062	0.02	-0.016
Lineidae	0.028	-0.08	0.029
Tubulanidae	0.179	-0.046	-0.099
Carinomidae	0.013	-0.027	0.013
Enopla sp.	0.013	-0.016	-0.057
Neomeniomorpha sp.	0.007	-0.011	0.018
Cardiomya costellata	0.013	0.007	-0.001
Cuspidaria cuspidata	-0.007	0.011	0.024
Cuspidaria rostrata	0.013	0.006	0.025
Cuspidaria sp.	0.004	0.013	-0.005
Pandora pinna	-0.003	-0.004	-0.025
Thraciidae	0.004	0.001	0.02
Anadara sp.	-0.018	0	-0.02
Corbula gibba	0.094	-0.022	-0.206
Musculus sp.	-0.004	-0.026	0.044
Saccella commutata	-0.002	-0.005	-0.068
Saccella sp.	0.018	-0.015	0.04
Ennucula sp.	0.028	-0.005	-0.056
Nucula sp.	0.004	-0.006	-0.013
Nucula sulcata	0.009	0.017	-0.009
Propeamussiidae sp.	-0.011	0.002	-0.001
Parvicardium sp.	0	0.032	-0.027
Kelliella sp.	-0.004	0.028	0.001
Myrtea spinifera	0.007	-0.011	0.018
Semelidae	0.129	0.004	-0.03
Abra prismatica	-0.012	-0.003	-0.001
Thyasiridae	-0.041	0.012	-0.019
Thyasira biplicata	-0.002	0.033	0.016
Thyasira sp.	-0.009	0.004	0.003
Veneridae	0.001	0.006	0
Timoclea ovata	0.064	0.056	-0.077
Gastropoda	-0.006	0	-0.028
Eulimidae	-0.018	-0.007	-0.009
Eulima glabra	0.029	-0.003	-0.048
Ringicula conformis	0.003	-0.021	-0.042
Turritella sp.	0.019	0.082	-0.103
Philinidae	0.065	-0.06	-0.092
Acteonidae	0.007	0.019	0.008
Odostomia sp.	0.007	0.055	-0.076
Turbonilla sp.	-0.014	-0.015	-0.037

Variable	PC1	PC2	PC3
Nassarius elatus	0.046	-0.047	-0.077
Cerithiidae	0.022	0.045	-0.046
Naticidae	0.002	-0.005	-0.005
Rissoidae	-0.01	0.025	0.027
Alvania sp.	0.017	0.034	0.029
Scaphopoda	0.056	0.04	0.058
Antalis sp.	-0.002	0.012	0.003
Ampelisca jaffaensis	0.045	-0.06	-0.018
Ampelisca sp.	0.115	0.117	-0.137
Leptocheirus sp.	0.011	-0.041	-0.081
Carangoliopsis spinulosa	-0.025	0.044	0.04
Apocorophium acutum	0.003	0.011	0.075
Medicorophium sp.	0.033	0.011	0.035
Eusirus sp.	0.01	-0.009	-0.006
Isaeidae	0.001	0.01	0.015
Photis sp.	-0.003	0.001	0
Leucothoe oboa	-0.012	-0.003	-0.001
Lysianassidae	0.014	0.043	0.025
Melitidae	0.008	0.012	0.002
Eriopisa elongata	0.008	0.029	0.004
Oedicerotidae	0.005	-0.021	0.002
Phoxocephalidae	-0.039	0.099	0.059
Harpinia sp.	0.109	0.333	-0.186
Phtisicidae	0.001	-0.003	-0.013
Synopiidae	0.006	-0.004	-0.017
Diastylidae	0.01	0.003	-0.001
Diastylis sp.	0.012	-0.037	-0.057
Eudorella sp.	-0.026	0.02	-0.023
Leucon siphonatus	-0.022	0.026	0.011
Majoidea	0.012	0.021	-0.004
Alpheidae	-0.012	-0.003	-0.001
Alpheus sp.	0.02	-0.014	-0.04
Callianassa subterranea	0.008	0.005	-0.038
Jaxea nocturna	-0.009	-0.003	0.004
Ebalia granulosa	-0.003	0.026	-0.012
Paguridae	-0.016	-0.002	-0.014
Leptochela pugnax	0.021	0.025	-0.042
Portunidae	-0.004	-0.026	0.044
Processa sp.	0.035	0.041	-0.014
Anthuridae	-0.004	-0.01	-0.018

Table 6. (Continued).

Variable	PC1	PC2	PC3
Drilliola loprestiana	-0.013	0.007	-0.015
Desmosomatidae	0.113	0.263	0.153
Gnathia sp.	0.024	0.036	0.054
Nebalia sp.	-0.009	0.003	-0.004
Tanaidomorpha sp.	0.039	-0.004	-0.064
Akanthophoreus sp.	0.028	0.038	0.037
Apseudopsis elisae	0.027	0.043	0.043
Leptochelia tanykeraia	0.055	0.019	0.029
Leptognathia sp.	0.094	0.292	0.208
Nototanaidae	0.146	0.261	-0.049
Pseudotanais sp.	0.037	-0.009	0.091
Pseudotanais stiletto	0.022	-0.031	-0.009
Tanaellidae	-0.008	-0.003	-0.006
Phoxichilidiidae	0.051	0.111	-0.012
Oligochaeta sp.	0.035	-0.066	0.041
Capitellidae	-0.006	-0.004	-0.008
Barantolla sp.	-0.002	-0.044	0.049
Leiocapitella sp.	0.007	0.03	0.062
Mediomastus sp.	-0.005	-0.256	0.416
Neomediomastus sp.	0.004	-0.003	0.005
Notomastus sp.	0.044	-0.015	0.007
Pseudocapitella incerta	-0.009	-0.014	0.023
Cossura sp.	0.087	0	0.099
Maldanidae	0.003	0.004	-0.008
Asychis biceps	-0.068	0.069	-0.053
Euclymene sp.	0.181	-0.087	-0.197
Maldane glebifex	-0.024	0.011	0.009
Praxillella gracilis	0.018	0.026	0.011
Rhodine loveni	0.055	0.012	-0.077
Opheliidae	0.023	-0.033	0.012
Dorvilleidae	-0.003	0.001	0
Schistomeringos sp.	-0.018	-0.112	0.185
Lysidice sp.	-0.004	-0.026	0.044
Glycera lapidium	0.035	-0.071	0.009
Glycera unicornis	-0.004	-0.026	0.044
Hesionidae	0.017	0.042	0.029
Gyptis sp.	0.049	-0.083	0.043
Podarkeopsis sp.	0.032	0.002	0

Variable	PC1	PC2	PC3
Natatolana sp.	0.007	0.007	0.075
Paralacydonia paradoxa	-0.011	-0.009	-0.011
Paralacydonia paradoxa	-0.011	-0.009	-0.011
Eteone sp.	0.006	-0.004	-0.018
Eulalia sp.	-0.001	-0.032	0.005
Eumida sp.	0.055	0.041	0.041
Ancistrosyllis groenlandica	0.057	-0.009	0.014
Litocorsa stremma	0.054	-0.041	0.002
Sigambra tentaculata	0.108	-0.015	0.17
Eunoe sp.	0.066	0.007	-0.045
Sthenelanella sp.	-0.014	-0.008	-0.014
Sphaerodoridium sp.	0.003	0.016	0.002
Exogone sp.	0.318	0.176	0.211
Sphaerosyllis sp.	0.068	0.023	0.003
Amphicteis gunneri	-0.001	0.01	0.04
Anobothrus sp.	0.114	0.068	-0.142
Lysippe sp.	0.004	-0.006	-0.013
Melinna sp.	0.004	-0.006	-0.013
Apistobranchus sp.	0.032	-0.017	0.012
Spiochaetopterus sp.	0.062	-0.047	-0.03
Aphelochaeta marioni	0.031	0.106	-0.163
Chaetozone sp.	0.058	-0.13	0.043
Dodecaceria sp.	0	-0.002	-0.012
Monticellina sp.	0.223	-0.129	-0.099
Diplocirrus glaucus	0.059	-0.061	-0.021
Flabelliderma sp. 1 EcoA	0.01	0.006	0.029
Magelona sp.	0.344	-0.119	-0.063
Galathowenia oculata	0.026	0.207	0.004
Poecilochaetus sp.	0.018	0.014	0.004
Fabriciinae	0.008	0.034	0.084
Euchone sp.	0.036	0.052	-0.007
Hydroides sp.	-0.007	0.007	0.037
Josephella sp.	0.002	-0.005	-0.005
Salmacina sp.	0.08	0.352	0.23
Spionidae	-0.028	-0.001	0.004
Dipolydora sp.	-0.007	0.025	-0.023
Laonice sp.	0.022	0.087	0.003
Prionospio sp.	0.325	-0.068	-0.01

Table 6. (Continued).

Variable	PC1	PC2	PC3
Abyssoninoe sp. 1 EcoA	0.1	0.002	0.028
Gallardoneris sp. 1 EcoA	0.183	-0.047	-0.108
Nephtyidae	0.009	-0.131	0.136
Aglaophamus sp.	0	-0.002	-0.008
Nephtys sp.	0.026	0.01	-0.042
Ceratonereis sp.	0.037	-0.086	0.001
Drilonereis filum	0.054	-0.045	-0.054
Onuphidae	0.013	-0.005	0.01
Onuphis sp.	0.002	0.007	-0.024
Aricidea *(Acmira) simplex*	0.01	0.045	0.002
Aricidea *(Allia) antennata*	0.056	0.075	0.036
Aricidea *(Allia) monicae*	0.014	0.049	0.009
Aricidea sp. 1 EcoA	0.255	-0.043	0.265
Cirrophorus branchiatus	0.073	-0.076	-0.023
Cirrophorus furcatus	0.04	-0.072	-0.095
Levinsenia sp.	0.367	-0.226	0.138

Variable	PC1	PC2	PC3
Scolelepis sp.	0.114	0.055	-0.074
Spiophanes sp.	0.104	-0.031	0.048
Sternaspis scutata	0.118	-0.04	-0.15
Terebellidae	0.036	-0.039	0.012
Terebellinae	-0.009	-0.001	-0.003
Pista sp.	0.057	-0.049	-0.164
Proclea sp.	0.027	-0.023	-0.067
Pseudampharete sp.	-0.008	-0.001	-0.006
Thelepus sp.	-0.008	-0.001	-0.006
Terebellides stroemii	0.159	0.033	-0.062
Sipuncula	0.01	-0.014	-0.006
Apionsoma murinae bilobatae	0.01	0.21	0.077
Asteroidea	-0.004	-0.016	0.026
Antedon mediterranea	0	0.005	-0.011
Cidaroida sp.	-0.012	-0.003	-0.001
Spatangoida sp.	0.013	-0.048	0.001

Table 7. Species contributions to metric scaling of 42 averaged sampling stations based on location offshore Israel as determined by PCA analysis.

Variable	PC1	PC2	PC3
Actiniaria	-0.055	0.016	0.054
Lineidae	-0.047	-0.022	-0.049
Tubulanidae	-0.133	-0.013	0.086
Carinomidae	-0.039	-0.068	-0.033
Enopla sp.	0.012	0.009	0.109
Neomeniomorpha sp.	-0.031	-0.038	-0.028
Cardiomya costellata	-0.004	-0.012	-0.066
Cuspidaria cuspidata	0.014	-0.008	-0.013
Cuspidaria rostrata	-0.041	0.009	-0.072
Cuspidaria sp.	-0.025	0.007	-0.057
Pandora pinna	-0.004	0.057	0.058
Thraciidae	-0.038	0.015	-0.034
Anadara sp.	0.007	0.012	0.119
Corbula gibba	-0.02	-0.027	0.1
Musculus sp.	-0.031	-0.038	-0.028

Variable	PC1	PC2	PC3
Cerithiidae	0.014	0.082	0.017
Naticidae	-0.031	-0.038	-0.028
Rissoidae	0.062	0.033	-0.1
Alvania sp.	-0.029	0.087	-0.028
Scaphopoda sp.	-0.075	0.02	-0.133
Antalis sp.	-0.006	-0.01	-0.103
Ampelisca jaffaensis	-0.083	-0.052	0.071
Ampelisca sp.	-0.014	0.053	-0.042
Leptocheirus sp.	0.007	-0.071	0.153
Carangoliopsis spinulosa	0.025	0.062	-0.013
Apocorophium acutum	-0.028	0.034	-0.036
Medicorophium sp.	-0.034	-0.012	-0.057
Eusirus sp.	-0.012	0.006	0.049
Isaeidae	-0.01	0.047	-0.044
Photis sp.	0.035	-0.019	-0.03

Table 7. (Continued).

Variable	PC1	PC2	PC3
Saccella commutata	0.009	0.014	0.145
Saccella sp.	-0.041	-0.046	0.034
Ennucula sp.	-0.046	0.045	0.064
Nucula sp.	0.003	0.006	0.039
Nucula sulcata	-0.022	0.053	0.004
Propeamussiidae	0.05	-0.021	-0.015
Parvicardium sp.	0.035	0.059	0.032
Kelliella sp.	0.008	0.051	0.009
Myrtea spinifera	-0.031	-0.038	-0.028
Semelidae sp.	-0.117	-0.022	0.027
Abra prismatica	0.035	-0.019	-0.03
Thyasiridae sp.	0.086	-0.025	0.036
Thyasira biplicata	0.045	0.019	-0.131
Thyasira sp.	0.015	-0.002	0.015
Veneridae	0.015	-0.002	0.015
Timoclea ovata	-0.046	0.016	0.094
Gastropoda	0.019	0.006	0.07
Eulimidae	0.05	-0.021	-0.015
Eulima glabra	-0.024	0.017	0.041
Ringicula conformis	0.05	-0.016	0.045
Turritella sp.	0.02	0.04	0.075
Philinidae	-0.053	-0.035	0.043
Acteonidae	0.006	0.045	-0.029
Odostomia sp.	0.052	0.069	0.072
Turbonilla sp.	0.076	-0.03	-0.017
Drilliola loprestiana	0.023	-0.013	0.019
Nassarius elatus	-0.048	-0.026	0.063
Nebalia sp.	0.035	-0.019	-0.03
Tanaidomorpha sp.	-0.035	-0.006	0.037
Akanthophoreus sp.	-0.051	0.056	-0.117
Apseudopsis elisae	-0.037	0.132	0.015
Leptochelia tanykeraia	-0.074	0.029	-0.016
Leptognathia sp.	-0.104	0.267	-0.154
Nototanaidae sp.	-0.136	0.181	0.201
Pseudotanais sp.	-0.095	-0.013	-0.077
Pseudotanais stiletto	-0.044	-0.054	-0.04
Tanaellidae	0.015	-0.002	0.015
Phoxichilidiidae	-0.024	0.053	0.028
Oligochaeta	-0.062	-0.076	-0.056

Variable	PC1	PC2	PC3
Leucothoe oboa	0.035	-0.019	-0.03
Lysianassidae	-0.017	0.082	-0.077
Melitidae	-0.006	0.051	0.02
Eriopisa elongata	0.001	0.049	0.01
Oedicerotidae	-0.009	-0.041	-0.007
Phoxocephalidae	0.095	0.048	-0.168
Harpinia sp.	0.012	0.337	0.095
Phtisicidae	0.01	0.003	0.07
Synopiidae	0.015	-0.002	0.015
Diastylidae	-0.012	0.006	0.049
Diastylis sp.	-0.024	-0.044	0.053
Eudorella sp.	0.049	0.055	0.064
Leucon siphonatus	0.055	0.019	-0.072
Majoidea	0.006	0.045	-0.029
Alpheidae	0.035	-0.019	-0.03
Alpheus sp.	-0.028	-0.034	0.036
Callianassa subterranea	0.01	0.003	0.07
Jaxea nocturna	0.015	-0.002	0.015
Ebalia granulosa	-0.049	0.023	0.031
Paguridae	0.014	-0.061	-0.161
Leptochela pugnax	0.006	0.05	0.09
Portunidae	-0.031	-0.038	-0.028
Processa sp.	-0.064	0.049	0.092
Anthuridae	0.037	-0.013	0.008
Natatolana sp.	-0.054	0.041	0.005
Desmosomatidae	-0.079	0.214	-0.067
Gnathia sp.	-0.055	0.013	-0.072
Eulalia sp.	-0.011	-0.043	0.05
Eumida sp.	-0.045	0.021	-0.119
Ancistrosyllis groenlandica	-0.07	0.03	0.032
Litocorsa stremma	-0.087	0.035	0.081
Sigambra tentaculata	-0.138	0.038	-0.008
Eunoe sp.	-0.044	0.016	0.023
Sthenelanella sp.	0.05	-0.021	-0.015
Sphaerodoridium sp.	-0.007	0.053	-0.006
Exogone sp.	-0.239	0.137	-0.162
Sphaerosyllis sp.	-0.075	0.002	0.004
Amphicteis gunneri	-0.006	-0.01	-0.103
Anobothrus sp.	-0.09	0.086	0.117

Table 7. (Continued).

Variable	PC1	PC2	PC3
Capitellidae	0.015	-0.002	0.015
Barantolla sp.	-0.042	-0.048	-0.001
Leiocapitella sp.	-0.073	0.052	-0.015
Mediomastus sp.	-0.239	-0.289	-0.178
Neomediomastus sp.	-0.031	0.042	0.046
Notomastus sp.	-0.015	-0.005	0.013
Pseudocapitella incerta	0.004	-0.005	-0.036
Cossura sp.	-0.131	0.036	-0.078
Maldanidae	0.003	0.006	0.039
Asychis biceps	0.099	0.06	0.015
Euclymene sp.	-0.119	-0.028	0.17
Maldane glebifex	0.052	0.04	-0.025
Praxillella gracilis	0.006	0.006	-0.106
Rhodine loveni	-0.017	0.008	0.061
Opheliidae	-0.044	-0.054	-0.04
Dorvilleidae	0.035	-0.019	-0.03
Schistomeringos sp.	-0.132	-0.162	-0.119
Lysidice sp.	-0.031	-0.038	-0.028
Glycera lapidium	-0.071	-0.014	0.026
Glycera unicornis	-0.031	-0.038	-0.028
Hesionidae	-0.014	0.088	-0.038
Gyptis sp.	-0.061	-0.095	-0.053
Podarkeopsis sp.	-0.066	-0.001	-0.035
Abyssoninoe sp. 1 EcoA	-0.093	0.04	0.09
Gallardoneris sp. 1 EcoA	-0.086	-0.019	0.163
Nephtyidae	-0.078	-0.156	-0.131
Aglaophamus sp.	0.003	0.006	0.039
Nephtys sp.	-0.013	-0.011	-0.003
Ceratonereis sp.	-0.076	-0.031	0.053
Drilonereis filum	-0.043	-0.009	0.021
Onuphidae	-0.031	-0.038	-0.028
Onuphis sp.	-0.007	0.016	0.116
Paralacydonia paradoxa	0.038	-0.015	0.034
Eteone sp.	-0.012	0.006	0.049
Aricidea *(Allia) monicae*	0	0.101	-0.019
Aricidea sp. 1 EcoA	-0.269	0.033	-0.107

Variable	PC1	PC2	PC3
Lysippe sp.	0.003	0.006	0.039
Melinna sp.	0.003	0.006	0.039
Apistobranchus sp.	-0.066	-0.06	0
Spiochaetopterus sp.	-0.09	-0.013	0.023
Aphelochaeta marioni	-0.004	0.072	0.177
Chaetozone sp.	-0.068	-0.115	-0.042
Dodecaceria sp.	0.004	0.008	0.055
Monticellina sp.	-0.177	-0.065	0.119
Diplocirrus glaucus	-0.06	-0.062	0.083
Flabelliderma sp. 1 EcoA	-0.041	0.009	-0.072
Magelona sp.	-0.265	-0.071	0.104
Galathowenia oculata	-0.002	0.059	-0.067
Poecilochaetus sp.	-0.011	0.053	0.04
Fabriciinae	-0.051	0.056	-0.117
Euchone sp.	-0.047	0.039	0.008
Hydroides sp.	-0.006	-0.01	-0.103
Josephella sp.	-0.031	-0.038	-0.028
Salmacina sp.	-0.044	0.365	-0.217
Spionidae	0.06	-0.032	-0.052
Dipolydora sp.	0.066	0.018	-0.061
Laonice sp.	-0.019	0.066	-0.061
Prionospio sp.	-0.248	0	0.039
Scolelepis sp.	-0.094	0.082	0.078
Spiophanes sp.	-0.031	-0.031	-0.068
Sternaspis scutata	-0.107	-0.06	0.068
Terebellidae	-0.066	-0.082	0.001
Terebellinae	0.035	-0.019	-0.03
Pista sp.	-0.018	-0.07	0.172
Proclea sp.	-0.054	-0.045	0.138
Pseudampharete sp.	0.003	0.006	0.039
Thelepus sp.	0.003	0.006	0.039
Terebellides stroemii	-0.128	0.016	0.012
Aricidea *(Acmira) simplex*	-0.021	0.1	-0.005
Aricidea *(Allia) antennata*	-0.074	0.135	0.005
Cidaroida	0.035	-0.019	-0.03
Spatangoida sp.	-0.023	-0.056	0.054

Table 7. (Continued).

Variable	PC1	PC2	PC3
Cirrophorus branchiatus	-0.069	-0.081	0.05
Cirrophorus furcatus	0.001	-0.055	0.007
Levinsenia sp.	-0.369	-0.024	-0.073
Sipuncula sp.	-0.031	-0.038	-0.028
Apionsoma murinae bilobatae	0.038	0.184	-0.064
Asteroidea	-0.031	-0.038	-0.028
Antedon mediterranea	0.003	0.006	0.039

Variable	PC1	PC2	PC3
Amphiuridae	0.05	-0.021	-0.015
Amphiura filiformis	0.008	0.075	0.055
Amphiura incana	-0.022	0.053	0.004
Ophiura sp.	-0.041	0.009	-0.072
Phoronida	-0.053	0.023	-0.036
Enteropneusta	-0.161	0.249	0.096

4.0 CONCLUSIONS

The 42 samples have similar sediment texture and depth and percentage changes in silt and sand were so minimal that they did not separate stations into subgroups. Univariate analyses suggested that REFS stations had lower abundances when compared to other stations but overall, Center, NF, MF, FF, and REFN locations were not statistically significantly different. When individual stations are compared utilizing Bray-Curtis cluster analysis, MDS, and PCA, there appears to be no definitive grouping among the stations. When stations are averaged, MDS analysis showed grouping of NF and MF and PCA analysis showed a cluster of MF, NF, and FF strata, however, Center, REFN, and REFS formed outliers and did not group with the main cluster or with each other.

The analysis of these 42 stations indicates a benthic environment with moderate to high species diversity, as is typical for continental shelf marine environments. Many widely distributed taxa such as the polychaetes *Prionospio* sp., *Monticellina* sp., *Lumbrineris* sp., and *Levinsenia* sp. are present while taxa specific to the area were also identified e.g. *Turbonilla* sp., high abundances of acorn worms (enteropneusts) and several species of tanaids were specific to this location. For this survey a sieve size of 0.3 mm was utilized and this accounts for the increased abundances and diversity observed at these sampled stations when compared to the pre-drill study. Regardless of the additional taxa and higher abundances similar to the pre-drill study there seems to be no significant differences when stations are compared and there is a trend where stations closer to the well location had higher abundances and species richness. Overall diversity and evenness were similar for all strata compared. These results support the overall patchiness of the benthic community in the area where the 42 samples were collected and that drilling in this region has not impacted benthic community structure.

5.0 REFERENCES CITED

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Attachment

Taxonomic Data

Lab Sample ID	C1	C2	C3	C4	C5	C6	C7	NF1	NF2	NF3	NF4	NF5	NF6	NF7	MF1	MF2	MF3	MF4	MF5	MF6	MF7	FF1	FF2	FF3	FF4	FF5	FF6	FF7	SRef1	SRef2	SRef3	SRef4	SRef5	SRef6	SRef7	NRef1	NRef2	NRef3	NRef4	NRef5	NRef6	NRef7
	6685.01-01	6685.01-02	6685.01-03	6685.01-04	6685.01-05	6685.01-06	6685.01-07	6685.01-08	6685.01-09	6685.01-10	6685.01-11	6685.01-12	6685.01-13	6685.01-14	6685.01-15	6685.01-16	6685.01-17	6685.01-18	6685.01-19	6685.01-20	6685.01-21	6685.01-22	6685.01-23	6685.01-24	6685.01-25	6685.01-26	6685.01-27	6685.01-28	6685.01-29	6685.01-30	6685.01-31	6685.01-32	6685.01-33	6685.01-34	6685.01-35	6685.01-36	6685.01-37	6685.01-38	6685.01-39	6685.01-40	6685.01-41	6685.01-42
TAXON NAME																																										
Actiniaria sp.	0	0	2	0	0	0	3	2	0	0	0	0	2	2	2	1	1	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0	1	0	1	0
Nematoda spp.	0	4	18	5	1	7	32	10	7	13	6	3	0	0	14	11	9	5	10	8	11	5	10	8	25	0	0	11	0	6	5	6	5	0	0	12	21	0	0	0	0	0
Lineidae sp.	5	3	4	1	0	0	0	0	0	0	0	1	1	3	4	1	1	0	1	0	0	1	0	1	1	2	0	0	0	2	1	0	1	0	1	0	2	2	2	1	0	1
Tubulanidae sp.	0	7	9	3	1	5	5	3	9	4	4	2	5	3	3	4	2	4	2	3	0	0	1	0	0	2	6	3	0	2	2	0	0	1	0	1	1	4	4	0	4	2
Carinomidae sp.	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enopla sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neomeniomorpha sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bivalvia spp.	1	0	0	0	1	4	0	0	4	0	0	0	0	1	2	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	1	0	0	1	1
Cardiomya costellata	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0
Cuspidaria cuspidata	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0
Cuspidaria rostrata	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Cuspidaria sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Pandora pinna	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Thraciidae sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Anadara sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corbula gibba	0	2	4	5	0	0	1	1	0	2	3	2	2	3	3	5	0	0	3	0	3	0	2	0	3	0	8	2	2	0	1	0	3	0	0	0	0	2	3	0	1	0
Musculus sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saccella commutata	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saccella sp.	1	0	0	3	0	1	1	0	0	0	0	0	2	0	0	1	0	0	1	0	3	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0

Lab Sample ID	C1 6685.01-01	C2 6685.01-02	C3 6685.01-03	C4 6685.01-04	C5 6685.01-05	C6 6685.01-06	C7 6685.01-07	NF1 6685.01-08	NF2 6685.01-09	NF3 6685.01-10	NF4 6685.01-11	NF5 6685.01-12	NF6 6685.01-13	NF7 6685.01-14	MF1 6685.01-15	MF2 6685.01-16	MF3 6685.01-17	MF4 6685.01-18	MF5 6685.01-19	MF6 6685.01-20	MF7 6685.01-21	FF1 6685.01-22	FF2 6685.01-23	FF3 6685.01-24	FF4 6685.01-25	FF5 6685.01-26	FF6 6685.01-27	FF7 6685.01-28	SRef1 6685.01-29	SRef2 6685.01-30	SRef3 6685.01-31	SRef4 6685.01-32	SRef5 6685.01-33	SRef6 6685.01-34	SRef7 6685.01-35	NRef1 6685.01-36	NRef2 6685.01-37	NRef3 6685.01-38	NRef4 6685.01-39	NRef5 6685.01-40	NRef6 6685.01-41	NRef7 6685.01-42
Ennucula sp.	0	0	1	0	0	0	0	0	0	0	1	0	0	2	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Nucula sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nucula sulcata	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Propeamussiidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Parvicardium sp.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0
Kelliella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Myrtea spinifera	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semelidae sp.	0	0	2	4	0	3	6	2	0	2	1	0	4	2	1	0	0	2	1	1	0	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	2	3	0	1	0	0
Abra prismatica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Thyasiridae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0
Thyasira biplicata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	3	0	0	0	0	0	2	0	2	0
Thyasira sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veneridae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Timoclea ovata	0	0	2	6	1	7	3	0	3	4	7	4	4	3	7	0	2	1	2	12	4	0	3	4	2	0	2	2	1	1	3	3	4	0	0	5	3	1	1	4	3	0
Gastropoda sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eulimidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Eulima glabra	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ringicula conformis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Turritella sp.	0	0	2	0	0	0	1	0	1	5	3	1	2	1	0	1	1	0	1	1	3	4	2	0	0	0	2	0	1	1	3	1	0	1	0	1	1	1	0	2	1	1
Philinidae sp.	0	2	3	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	1	1	3	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Acteonidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Odostomia sp.	0	0	0	0	0	0	0	0	0	0	2	0	1	1	0	0	0	2	0	1	1	0	0	0	0	0	2	1	0	2	0	0	0	0	1	0	0	0	1	0	2	0

Lab Sample ID	C1	C2	C3	C4	C5	C6	C7	NF1	NF2	NF3	NF4	NF5	NF6	NF7	MF1	MF2	MF3	MF4	MF5	MF6	MF7	FF1	FF2	FF3	FF4	FF5	FF6	FF7	SRef1	SRef2	SRef3	SRef4	SRef5	SRef6	SRef7	NRef1	NRef2	NRef3	NRef4	NRef5	NRef6	NRef7
	6685.01-01	6685.01-02	6685.01-03	6685.01-04	6685.01-05	6685.01-06	6685.01-07	6685.01-08	6685.01-09	6685.01-10	6685.01-11	6685.01-12	6685.01-13	6685.01-14	6685.01-15	6685.01-16	6685.01-17	6685.01-18	6685.01-19	6685.01-20	6685.01-21	6685.01-22	6685.01-23	6685.01-24	6685.01-25	6685.01-26	6685.01-27	6685.01-28	6685.01-29	6685.01-30	6685.01-31	6685.01-32	6685.01-33	6685.01-34	6685.01-35	6685.01-36	6685.01-37	6685.01-38	6685.01-39	6685.01-40	6685.01-41	6685.01-42
Turbonilla sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Drilliola loprestiana	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Nassarius elatus	0	2	3	0	0	1	0	2	1	0	1	1	0	1	0	1	2	1	0	2	1	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0
Cerithiidae sp.	0	0	0	0	0	0	0	0	1	1	1	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	2	2	0	0
Naticidae sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rissoidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	2	0	0	0	0	0
Alvania sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1
Scaphopoda sp.	0	1	0	2	0	2	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	1	1	1	0
Antalis sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
Ampelisca jaffaensis	0	0	3	0	0	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ampelisca sp.	0	8	2	3	0	3	2	0	3	3	5	1	3	2	2	4	0	2	3	2	3	2	0	0	7	2	10	2	0	0	2	2	4	2	5	1	5	2	3	6	7	4
Leptocheirus sp.	0	0	1	0	0	0	2	1	2	1	2	1	0	0	0	1	0	0	1	2	0	1	2	2	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Carangoliopsis spinulosa	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	2	0	4	0	0	0	2	0	0	0	0	2	0	0	0	2	1	0	0	0	3
Apocorophium acutum	1	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	2	1	1	0	0	0	0
Medicorophium sp.	0	0	0	0	1	0	2	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0
Eusirus sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isaeidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Photis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Leucothoe oboa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Lysianassidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0
Melitidae	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Lab Sample ID	C1	C2	C3	C4	C5	C6	C7	NF 1	NF 2	NF 3	NF 4	NF 5	NF 6	NF 7	M F1	M F2	M F3	M F4	M F5	M F6	M F7	FF 1	FF 2	FF 3	FF 4	FF 5	FF 6	FF 7	S Re f1	S Re f2	S Re f3	S Re f4	S Re f5	S Re f6	S Re f7	N Re f1	N Re f2	N Re f3	N Re f4	N Re f5	N Re f6	N Re f7
	6685.01-01	6685.01-02	6685.01-03	6685.01-04	6685.01-05	6685.01-06	6685.01-07	6685.01-08	6685.01-09	6685.01-10	6685.01-11	6685.01-12	6685.01-13	6685.01-14	6685.01-15	6685.01-16	6685.01-17	6685.01-18	6685.01-19	6685.01-20	6685.01-21	6685.01-22	6685.01-23	6685.01-24	6685.01-25	6685.01-26	6685.01-27	6685.01-28	6685.01-29	6685.01-30	6685.01-31	6685.01-32	6685.01-33	6685.01-34	6685.01-35	6685.01-36	6685.01-37	6685.01-38	6685.01-39	6685.01-40	6685.01-41	6685.01-42
sp.																																										
Eriopisa elongata	0	0	0	0	0	1	0	0	2	0	1	0	0	0	0	0	0	0	0	0	1	0	0	2	1	2	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	2
Oedicerotidae sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoxocephalidae sp.	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	5	0	3	0	0	2	3	0	6	0	2	4	1	0	2	0	1
Harpinia sp.	0	1	4	4	0	1	1	6	10	12	6	3	9	8	15	13	7	10	10	8	12	4	6	1	7	8	15	2	2	3	2	7	6	1	5	8	12	16	13	24	9	21
Phtisicidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synopiidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diastylidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diastylis sp.	0	1	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eudorella sp.	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	0	0	1	0	0	1	0	0	0	1	0	1	0
Leucon siphonatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0
Majoidea sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Alpheidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Alpheus sp.	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Callianassa subterranea	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jaxea nocturna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ebalia granulosa	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Paguridae sp.	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	1	0	0	0	0	0	0	1	0
Leptochela pugnax	0	0	0	0	0	0	0	0	0	1	1	0	2	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
Portunidae sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Lab Sample ID	C1	C2	C3	C4	C5	C6	C7	NF 1	NF 2	NF 3	NF 4	NF 5	NF 6	NF 7	M F1	M F2	M F3	M F4	M F5	M F6	M F7	FF 1	FF 2	FF 3	FF 4	FF 5	FF 6	FF 7	S Re f1	S Re f2	S Re f3	S Re f4	S Re f5	S Re f6	S Re f7	N Re f1	N Re f2	N Re f3	N Re f4	N Re f5	N Re f6	N Re f7
	6685.01-01	6685.01-02	6685.01-03	6685.01-04	6685.01-05	6685.01-06	6685.01-07	6685.01-08	6685.01-09	6685.01-10	6685.01-11	6685.01-12	6685.01-13	6685.01-14	6685.01-15	6685.01-16	6685.01-17	6685.01-18	6685.01-19	6685.01-20	6685.01-21	6685.01-22	6685.01-23	6685.01-24	6685.01-25	6685.01-26	6685.01-27	6685.01-28	6685.01-29	6685.01-30	6685.01-31	6685.01-32	6685.01-33	6685.01-34	6685.01-35	6685.01-36	6685.01-37	6685.01-38	6685.01-39	6685.01-40	6685.01-41	6685.01-42
Processa sp.	0	0	0	0	0	2	0	0	1	2	0	3	0	0	0	0	1	0	0	0	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
Anthuridae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Natatolana sp.	2	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	2	0	0	1	1	0	0
Desmosomatidae sp.	0	1	0	1	0	1	1	5	1	0	1	0	3	0	0	3	0	4	0	0	3	0	1	0	0	0	0	1	0	0	1	0	1	0	0	4	4	4	2	8	8	6
Gnathia sp.	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	1	0	0	1	0
Nebalia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Tanaidomorpha sp.	0	0	1	0	0	0	1	0	0	1	1	0	0	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Akanthophoreus sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0
Apseudopsis elisae	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	2	0	0	0
Leptochelia tanykeraia	0	0	2	0	1	1	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1
Leptognathia sp.	0	0	0	0	0	0	2	1	0	2	0	1	1	0	0	1	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	5	7	6	3	9	8	4
Nototanaidae sp.	0	1	0	0	0	0	4	0	0	9	10	0	8	7	0	5	0	3	0	1	5	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	2	8	3	2
Pseudotanais sp.	0	0	0	0	2	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Pseudotanais stiletto	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanaellidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calanoida spp.	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	2	1	15	4	0	0	1	0	0	0	0
Cyclopoida spp.	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pedunculata sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Ostracoda spp.	0	0	0	0	2	0	5	0	0	5	2	0	1	1	0	0	0	0	0	0	1	0	3	0	0	1	0	0	2	0	0	0	1	0	2	2	1	1	10	12	0	4
Phoxichilidiidae sp.	0	0	1	0	0	2	1	0	0	3	0	0	2	1	0	1	1	4	0	3	0	0	1	0	0	0	1	1	0	0	0	2	0	1	0	0	0	0	2	2	2	2

Lab Sample ID	C1	C2	C3	C4	C5	C6	C7	NF 1	NF 2	NF 3	NF 4	NF 5	NF 6	NF 7	M F1	M F2	M F3	M F4	M F5	M F6	M F7	FF 1	FF 2	FF 3	FF 4	FF 5	FF 6	FF 7	S Re f1	S Re f2	S Re f3	S Re f4	S Re f5	S Re f6	S Re f7	N Re f1	N Re f2	N Re f3	N Re f4	N Re f5	N Re f6	N Re f7
	6685.01-01	6685.01-02	6685.01-03	6685.01-04	6685.01-05	6685.01-06	6685.01-07	6685.01-08	6685.01-09	6685.01-10	6685.01-11	6685.01-12	6685.01-13	6685.01-14	6685.01-15	6685.01-16	6685.01-17	6685.01-18	6685.01-19	6685.01-20	6685.01-21	6685.01-22	6685.01-23	6685.01-24	6685.01-25	6685.01-26	6685.01-27	6685.01-28	6685.01-29	6685.01-30	6685.01-31	6685.01-32	6685.01-33	6685.01-34	6685.01-35	6685.01-36	6685.01-37	6685.01-38	6685.01-39	6685.01-40	6685.01-41	6685.01-42
Oligochaeta sp.	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Capitellidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barantolla sp.	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leiocapitella sp.	0	0	0	0	0	4	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	5	1	0	0	0	0	0
Mediomastus sp.	41	0	0	0	10	7	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neomediomastus sp.	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
Notomastus sp.	1	0	2	0	0	0	0	0	2	0	0	0	0	0	0	1	0	1	0	0	0	0	2	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0
Pseudocapitella incerta	0	0	0	0	2	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0
Cossura sp.	0	0	4	0	2	2	3	1	0	0	2	3	2	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	4	0	1	0	0	1	5
Maldanidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asychis biceps	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	1	0	1	0	2	0	0	1	1	0	2	1	0	3	2	0	1	0	0	1	0	0	2	1	0
Euclymene sp.	0	6	5	2	0	4	5	3	6	5	1	3	3	9	7	0	0	0	2	6	3	1	0	0	3	2	4	0	0	0	0	0	1	0	2	1	1	0	3	1	2	0
Maldane glebifex	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0	1	0
Praxillella gracilis	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	1	1	1	0
Rhodine loveni	0	0	3	0	0	0	3	3	2	1	1	1	5	0	3	1	0	1	0	0	2	1	0	1	3	0	0	0	0	0	2	2	0	0	2	2	0	0	0	4	0	0
Opheliidae sp.	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dorvilleidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Schistomeringos sp.	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lysidice sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycera lapidium	5	1	8	0	2	0	5	1	4	1	2	3	2	1	0	3	5	2	3	4	1	2	0	0	2	3	2	1	1	1	1	1	0	3	0	5	0	2	0	2	3	1
Glycera	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Lab Sample ID	C1	C2	C3	C4	C5	C6	C7	NF 1	NF 2	NF 3	NF 4	NF 5	NF 6	NF 7	M F1	M F2	M F3	M F4	M F5	M F6	M F7	FF 1	FF 2	FF 3	FF 4	FF 5	FF 6	FF 7	S Re f1	S Re f2	S Re f3	S Re f4	S Re f5	S Re f6	S Re f7	N Re f1	N Re f2	N Re f3	N Re f4	N Re f5	N Re f6	N Re f7
	6685.01-01	6685.01-02	6685.01-03	6685.01-04	6685.01-05	6685.01-06	6685.01-07	6685.01-08	6685.01-09	6685.01-10	6685.01-11	6685.01-12	6685.01-13	6685.01-14	6685.01-15	6685.01-16	6685.01-17	6685.01-18	6685.01-19	6685.01-20	6685.01-21	6685.01-22	6685.01-23	6685.01-24	6685.01-25	6685.01-26	6685.01-27	6685.01-28	6685.01-29	6685.01-30	6685.01-31	6685.01-32	6685.01-33	6685.01-34	6685.01-35	6685.01-36	6685.01-37	6685.01-38	6685.01-39	6685.01-40	6685.01-41	6685.01-42
unicornis																																										
Hesionidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0
Gyptis sp.	1	0	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Podarkeopsis sp.	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Abyssoninoe sp. 1 EcoA	1	1	2	1	0	2	0	0	3	0	1	1	3	0	0	2	0	3	0	0	1	0	2	2	1	0	2	0	0	0	0	0	0	0	0	1	0	2	1	1	0	1
Gallardoneris sp. 1 EcoA	0	2	4	1	1	2	4	2	3	0	2	1	4	5	5	4	0	1	0	1	2	1	3	0	1	0	9	0	0	0	0	0	1	0	0	0	1	1	1	1	0	1
Nephtyidae sp.	9	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Aglaophamus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nephtys sp.	0	1	0	0	0	0	3	0	2	0	2	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	2	1	0	0	1	1	0	0
Ceratonereis sp.	3	0	2	0	0	1	0	1	0	0	1	0	0	1	1	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Drilonereis filum	1	2	3	1	0	0	0	0	0	0	0	2	1	1	1	1	0	1	1	2	1	0	0	0	1	1	1	0	0	0	0	0	1	1	0	2	1	0	0	1	0	0
Onuphidae sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onuphis sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paralacydonia paradoxa	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Eteone sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eulalia sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Eumida sp.	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1	0
Ancistrosyllis groenlandica	1	2	0	0	0	0	0	0	2	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
Litocorsa stremma	2	0	0	1	0	1	1	0	1	0	1	2	1	0	1	1	1	0	1	2	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0
Sigambra tentaculat	4	0	1	1	1	3	1	1	4	0	0	1	1	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	3	2	1	1

Lab Sample ID	C1	C2	C3	C4	C5	C6	C7	NF1	NF2	NF3	NF4	NF5	NF6	NF7	MF1	MF2	MF3	MF4	MF5	MF6	MF7	FF1	FF2	FF3	FF4	FF5	FF6	FF7	SRef1	SRef2	SRef3	SRef4	SRef5	SRef6	SRef7	NRef1	NRef2	NRef3	NRef4	NRef5	NRef6	NRef7
	6685.01-01	6685.01-02	6685.01-03	6685.01-04	6685.01-05	6685.01-06	6685.01-07	6685.01-08	6685.01-09	6685.01-10	6685.01-11	6685.01-12	6685.01-13	6685.01-14	6685.01-15	6685.01-16	6685.01-17	6685.01-18	6685.01-19	6685.01-20	6685.01-21	6685.01-22	6685.01-23	6685.01-24	6685.01-25	6685.01-26	6685.01-27	6685.01-28	6685.01-29	6685.01-30	6685.01-31	6685.01-32	6685.01-33	6685.01-34	6685.01-35	6685.01-36	6685.01-37	6685.01-38	6685.01-39	6685.01-40	6685.01-41	6685.01-42
a																																										
Eunoe sp.	0	1	1	0	0	1	0	0	1	1	1	0	1	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2	0	0
Sthenelanella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Sphaerodoridium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Exogone sp.	2	5	10	3	2	8	23	0	6	3	4	1	13	3	4	4	0	3	0	3	3	0	5	0	4	0	3	1	0	0	0	0	4	0	0	11	12	9	7	17	8	9
Sphaerosyllis sp.	0	1	1	0	0	0	2	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Amphicteis gunneri	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Anobothrus sp.	0	5	0	1	0	0	3	1	3	1	5	5	0	7	3	2	0	0	6	3	1	0	1	0	2	0	2	1	0	0	0	2	0	0	0	3	1	0	3	1	3	4
Lysippe sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melinna sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apistobranchus sp.	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spiochaetopterus sp.	0	1	3	0	0	0	0	0	2	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Cirratulidae spp.	8	21	16	6	13	12	18	9	34	8	6	8	22	8	9	6	8	6	7	5	11	0	3	8	8	6	11	7	1	7	6	2	8	4	7	9	11	19	17	19	11	10
Aphelochaeta marioni	0	5	1	4	0	1	3	9	7	1	6	1	4	6	1	4	10	9	6	4	11	5	2	7	1	4	1	2	0	2	5	3	1	5	0	1	8	2	2	3	3	4
Chaetozone sp.	5	4	3	1	0	0	2	0	0	0	0	1	2	0	0	0	0	0	0	1	0	0	1	0	0	1	2	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0
Dodecaceria sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monticellina sp.	5	20	29	7	4	11	15	7	25	6	9	11	19	15	6	5	9	7	3	9	10	6	5	2	7	9	9	4	0	2	5	3	6	6	5	7	6	11	8	5	4	3
Diplocirrus glaucus	0	1	2	0	0	1	0	0	2	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flabelliderma sp. 1 EcoA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Magelona sp.	3	21	30	14	10	23	24	15	25	9	16	11	21	12	18	11	1	8	6	6	4	1	9	4	8	3	15	1	0	1	1	3	12	1	4	9	4	7	9	4	16	7

Lab Sample ID	C1	C2	C3	C4	C5	C6	C7	NF 1	NF 2	NF 3	NF 4	NF 5	NF 6	NF 7	M F1	M F2	M F3	M F4	M F5	M F6	M F7	FF 1	FF 2	FF 3	FF 4	FF 5	FF 6	FF 7	S Re f1	S Re f2	S Re f3	S Re f4	S Re f5	S Re f6	S Re f7	N Re f1	N Re f2	N Re f3	N Re f4	N Re f5	N Re f6	N Re f7
	6685.01-01	6685.01-02	6685.01-03	6685.01-04	6685.01-05	6685.01-06	6685.01-07	6685.01-08	6685.01-09	6685.01-10	6685.01-11	6685.01-12	6685.01-13	6685.01-14	6685.01-15	6685.01-16	6685.01-17	6685.01-18	6685.01-19	6685.01-20	6685.01-21	6685.01-22	6685.01-23	6685.01-24	6685.01-25	6685.01-26	6685.01-27	6685.01-28	6685.01-29	6685.01-30	6685.01-31	6685.01-32	6685.01-33	6685.01-34	6685.01-35	6685.01-36	6685.01-37	6685.01-38	6685.01-39	6685.01-40	6685.01-41	6685.01-42
Galathowenia oculata	0	0	0	3	0	3	11	3	0	4	3	2	4	0	3	2	1	2	0	8	4	1	3	2	2	2	2	3	0	2	0	6	5	3	4	2	10	1	7	4	3	3
Poecilochaetus sp.	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Fabriciinae sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0
Euchone sp.	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Hydroides sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Josephella sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salmacina sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	8	6	12	6	12	10
Spionidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Dipolydora sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0
Laonice sp.	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	2	3
Prionospio sp.	24	38	44	21	3	38	36	25	30	14	20	19	27	19	27	24	12	13	19	19	18	13	27	10	10	18	27	8	0	9	7	6	16	8	14	11	17	26	26	25	19	23
Scolelepis sp.	0	1	2	0	0	0	1	0	1	1	4	0	1	4	1	2	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	3	2	1	1
Spiophanes sp.	1	3	2	1	2	4	6	1	1	0	0	0	1	2	6	1	0	3	1	2	0	0	1	0	0	5	5	0	0	0	2	3	2	0	2	2	1	1	0	3	4	1
Sternaspis scutata	0	4	6	6	0	0	0	0	2	0	1	1	4	2	0	2	1	1	1	0	2	0	1	0	2	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	1
Terebellidae sp.	0	0	1	0	0	2	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Terebellinae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pista sp.	0	1	1	1	0	0	1	0	1	1	1	1	0	3	1	1	0	1	0	2	1	1	2	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Proclea sp.	0	0	0	2	0	0	1	0	0	0	2	1	0	0	3	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudampharete sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thelepus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Terebellides	2	4	18	5	0	4	3	4	3	3	3	1	5	5	0	1	4	9	4	2	4	1	5	1	1	3	6	0	0	0	2	1	1	1	2	1	2	2	4	6	6	6

Lab Sample ID	C1	C2	C3	C4	C5	C6	C7	NF 1	NF 2	NF 3	NF 4	NF 5	NF 6	NF 7	M F1	M F2	M F3	M F4	M F5	M F6	M F7	FF 1	FF 2	FF 3	FF 4	FF 5	FF 6	FF 7	S Ref1	S Ref2	S Ref3	S Ref4	S Ref5	S Ref6	S Ref7	N Ref1	N Ref2	N Ref3	N Ref4	N Ref5	N Ref6	N Ref7
	6685.01-01	6685.01-02	6685.01-03	6685.01-04	6685.01-05	6685.01-06	6685.01-07	6685.01-08	6685.01-09	6685.01-10	6685.01-11	6685.01-12	6685.01-13	6685.01-14	6685.01-15	6685.01-16	6685.01-17	6685.01-18	6685.01-19	6685.01-20	6685.01-21	6685.01-22	6685.01-23	6685.01-24	6685.01-25	6685.01-26	6685.01-27	6685.01-28	6685.01-29	6685.01-30	6685.01-31	6685.01-32	6685.01-33	6685.01-34	6685.01-35	6685.01-36	6685.01-37	6685.01-38	6685.01-39	6685.01-40	6685.01-41	6685.01-42
stroemii																																										
Paraonidae spp.	0	0	2	0	2	5	1	2	5	2	0	4	0	0	4	1	3	1	0	0	0	0	0	3	1	2	1	0	0	0	1	0	0	1	1	0	0	0	2	1	4	0
Aricidea (Acmira) simplex	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Aricidea (Allia) antennata	0	2	0	0	0	0	0	0	1	0	1	0	4	0	0	0	0	1	0	0	1	0	0	2	2	0	0	0	0	0	0	0	0	0	0	4	0	6	1	0	0	2
Aricidea (Allia) monicae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0
Aricidea sp. 1 EcoA	3	12	5	6	15	8	11	5	9	0	2	4	6	6	6	2	0	0	0	0	2	1	2	3	0	0	2	1	0	0	0	0	2	0	0	6	8	7	6	6	8	2
Cirrophorus branchiatus	0	0	3	0	0	1	2	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirrophorus furcatus	0	2	3	0	1	0	1	0	1	0	1	0	0	1	1	0	0	0	0	2	1	0	1	0	1	5	1	0	0	1	0	0	0	2	1	0	0	0	0	0	1	1
Levinsenia sp.	8	30	47	6	15	11	23	15	27	1	2	8	13	12	10	6	1	0	11	4	4	2	3	2	4	1	7	1	0	0	2	2	1	3	1	3	10	28	17	6	2	8
Sipuncula sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apionsoma murinae bilobatae	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3	0	0	1	0	0	0	0	0	2	2	1	0	0	0	1	0	1	4	1	2	4	3	2	2
Asteroidea sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antedon mediterranea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cidaroida sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Spatangoida sp.	1	0	0	0	0	0	1	0	0	0	0	0	0	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ophiuroidea spp.	0	0	1	2	1	0	1	0	0	1	1	0	0	2	0	0	0	1	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphiuridae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Amphiura filiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0

Lab Sample ID	C1 6685.01-01	C2 6685.01-02	C3 6685.01-03	C4 6685.01-04	C5 6685.01-05	C6 6685.01-06	C7 6685.01-07	NF1 6685.01-08	NF2 6685.01-09	NF3 6685.01-10	NF4 6685.01-11	NF5 6685.01-12	NF6 6685.01-13	NF7 6685.01-14	MF1 6685.01-15	MF2 6685.01-16	MF3 6685.01-17	MF4 6685.01-18	MF5 6685.01-19	MF6 6685.01-20	MF7 6685.01-21	FF1 6685.01-22	FF2 6685.01-23	FF3 6685.01-24	FF4 6685.01-25	FF5 6685.01-26	FF6 6685.01-27	FF7 6685.01-28	SRef1 6685.01-29	SRef2 6685.01-30	SRef3 6685.01-31	SRef4 6685.01-32	SRef5 6685.01-33	SRef6 6685.01-34	SRef7 6685.01-35	NRef1 6685.01-36	NRef2 6685.01-37	NRef3 6685.01-38	NRef4 6685.01-39	NRef5 6685.01-40	NRef6 6685.01-41	NRef7 6685.01-42
Amphiura incana	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ophiura sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Phoronida sp.	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Enteropneusta sp.	1	13	6	23	0	24	46	16	28	19	35	19	17	29	25	20	11	18	17	34	24	6	24	2	26	4	37	14	2	4	4	12	18	17	1	35	24	15	26	24	45	34
	169	254	350	170	101	237	357	169	308	168	203	143	250	210	223	180	111	150	137	186	180	76	162	82	153	112	242	91	24	64	77	82	130	94	82	192	216	215	234	264	243	205

APPENDIX P

Abundance and Distribution of Major Taxa and Subgroups