

# **SARA-1 WELLSITE RE-ENTRY OPERATION BACKGROUND MONITORING SURVEY**

## **OFFSHORE ISRAEL**

### **Scope of Work/Sampling and Analysis Plan**

November 2014

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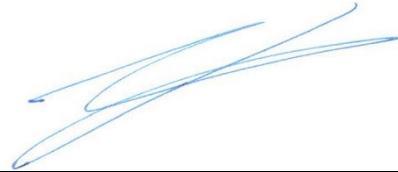
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## List of Acronyms and Abbreviations

3D	three-dimensional
AAC	annual average concentration
ALS	ALS Group Analytical Laboratory
CBL	Chesapeake Biological Laboratory
CCC	Criterion Continuous Concentration
CDC	Climate Diagnostics Center
CIESM	Mediterranean Science Commission
CoC	chain-of-custody
CSA	CSA Ocean Sciences Inc.
CTD	conductivity-temperature-depth
CYCOFOS	Cyprus Coastal Ocean Forecasting and Observing System
DGPS	differential global positioning system
Emanuelle	Emanuelle Energy Ltd
EMP	environmental monitoring program
ERL	effects range low
ERM	effects range median
EUCEQS	European Union Commission on Environmental Quality Standards
GGR	GeoGlobal Resources
IFREMER	French Research Institute for Exploitation of the Sea
IOLR	Israel Oceanographic and Limnological Research
MAC	maximum allowable concentration
IUCN	International Union for Conservation of Nature
MCL	maximum contaminant level
MDL	method detection limit
MEQS	Mediterranean Environmental Water Quality Standards
MNIEWR	Ministry of National Infrastructures, Energy and Water Resources
MoEP	Ministry of Environmental Protection
NCEP	National Center for Environmental Predictions
NOAA – CIRES	U.S. National Oceanic and Atmospheric Administration – Cooperative Institute for Research in Environmental Studies
NTU	nephelometric turbidity unit
PAH	polycyclic aromatic hydrocarbon
QA	quality assurance
QC	quality control
ROV	remotely operated vehicle
SAP	Sampling and Analysis Plan
SBE	Sea-Bird Electronics
SOW	Scope of Work
TDI-Brooks	TDI-Brooks International, Inc.
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TPH	total petroleum hydrocarbons
USEPA	U.S. Environmental Protection Agency
WL	Weatherford Laboratories

### 1.1 BACKGROUND

Emanuelle Energy Ltd (Emanuelle) and partners are planning to re-enter the existing Sara-1 wellsite found within the Sara license. Sara-1 was first drilled in 2012 by GeoGlobal Resources (GGR) in search of hydrocarbons and was abandoned after being declared a dry hole. Previous monitoring efforts in the Sara license were conducted in accordance with the old guidelines provided by the Ministry of Environmental Protection (MoEP) and Ministry of National Infrastructures, Energy and Water Resources (MNIEWR). These previous monitoring efforts included sampling pre-drill, during drilling operations, and post-drill surveys under a Scope of Work (SOW) and Sample and Analysis Plan (SAP) developed for GGR and approved by the Ministries. The Sara Wellsite Environmental Monitoring Program report prepared for GGR is provided in **Appendix A**. The MoEP and MNIEWR now require Emanuelle and partners to develop and implement a new environmental monitoring program (EMP) based on the latest guidelines (December 2013) to allow a more recent assessment of the environmental conditions around the wellsite. The EMP will consist of pre-drill and post-drill environmental surveys. This document describes the pre-drill survey plan. The post-drill survey plan will be developed and presented to the MoEP and MNIEWR at the time of the presentation of the pre-drill survey results.

Emanuelle engaged CSA Ocean Sciences Inc. (CSA) to provide support in developing the SOW/SAP for the environmental monitoring effort. This SOW/SAP document describes the general environment within the Sara license, sampling design, parameters to be sampled, sampling methods, data processing and laboratory methods, and data analysis and reporting.

### 1.2 OBJECTIVES

The purpose of the EMP is to characterize the environmental conditions in the wellsite area before and after drilling. The main objectives of the program include the following:

- Determine the temporal and spatial variation of selected environmental components (i.e., chemical, geological, physical, and biological) within the study area;
- Assess potential effects from drilling discharges on selected environmental components through the comparison of deviations from existing background values; and
- Provide information on possible deviations from internationally and locally accepted standards.

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## 2.0 Description of the Environment

The Sara-1 wellsite, located within the Sara license, is approximately 55 km west of the Israeli coastline in the southeastern portion of the Levantine Basin in a water depth of 1,335 m (**Figure 1**). **Figure 2** shows the location of the Sara-1 wellsite relative to the shipping fairways.

The Levantine Basin is highly oligotrophic (very low in nutrients) and characterized by relatively high species diversity, very low biomass, and a higher degree of endemism (species found only in this area) than other oceans due to its relative isolation. Even within the Mediterranean Sea, the eastern Mediterranean is distinct because of its high salinity, low nutrients, transparency, and the temperature regime of its surface waters, which is higher than other areas of the Mediterranean.

The following section provides an environmental description of the Sara-1 wellsite area, including a summary of peer-reviewed literature for several aspects of the deepwater portion of the Levantine Basin and a synopsis of the findings from the GGR monitoring conducted at the site.

### 2.1 GEOLOGY – ASSESSMENT OF GEOHAZARDS

Regional bathymetry of the eastern Mediterranean Sea was developed by Almagor and Hall (1984), who illustrated the relatively narrow continental shelf bordering the Levantine Basin offshore Israel. An updated version of regional bathymetry is available in Hall et al. (2005). In 2008, the Mediterranean Science Commission (CIESM) and French Research Institute for Exploitation of the Sea (IFREMER) made available a new detailed map of the Mediterranean seafloor morphology at a scale of 1/3,000,000 (Loubrieu and Mascle, 2008). The new image resulted from a re-analysis and extensive consolidation of previous data-gathering efforts in the western and eastern Mediterranean subbasins.

The RPS Group (2011) performed an assessment of geohazards based on three-dimensional (3D) pre-stack depth migration (PDSM) data for the wellsite area provided by the previous operator, GGR. Seafloor features and hazards as well as regional bathymetric contours relative to the Sara-1 wellsite are shown **Figures 3** and **4**. Seafloor morphology indicated a slightly undulated seafloor dissected by two significant fault scarps trending north-northeast to south-southwest and southeast of the location. These fault scarps produce isolated hollows and highs on the seafloor, with increased seafloor dip angles along these features. No obstructions or seafloor hazards were expected at the location. The RPS Group's report did not identify any potential hard substrate or chemosynthetic communities during review of the seismic data. Ground truthing conducted using video observations during the GGR monitoring confirmed this presumption and concluded that no hard bottom or chemosynthetic communities were present within the surveyed area.

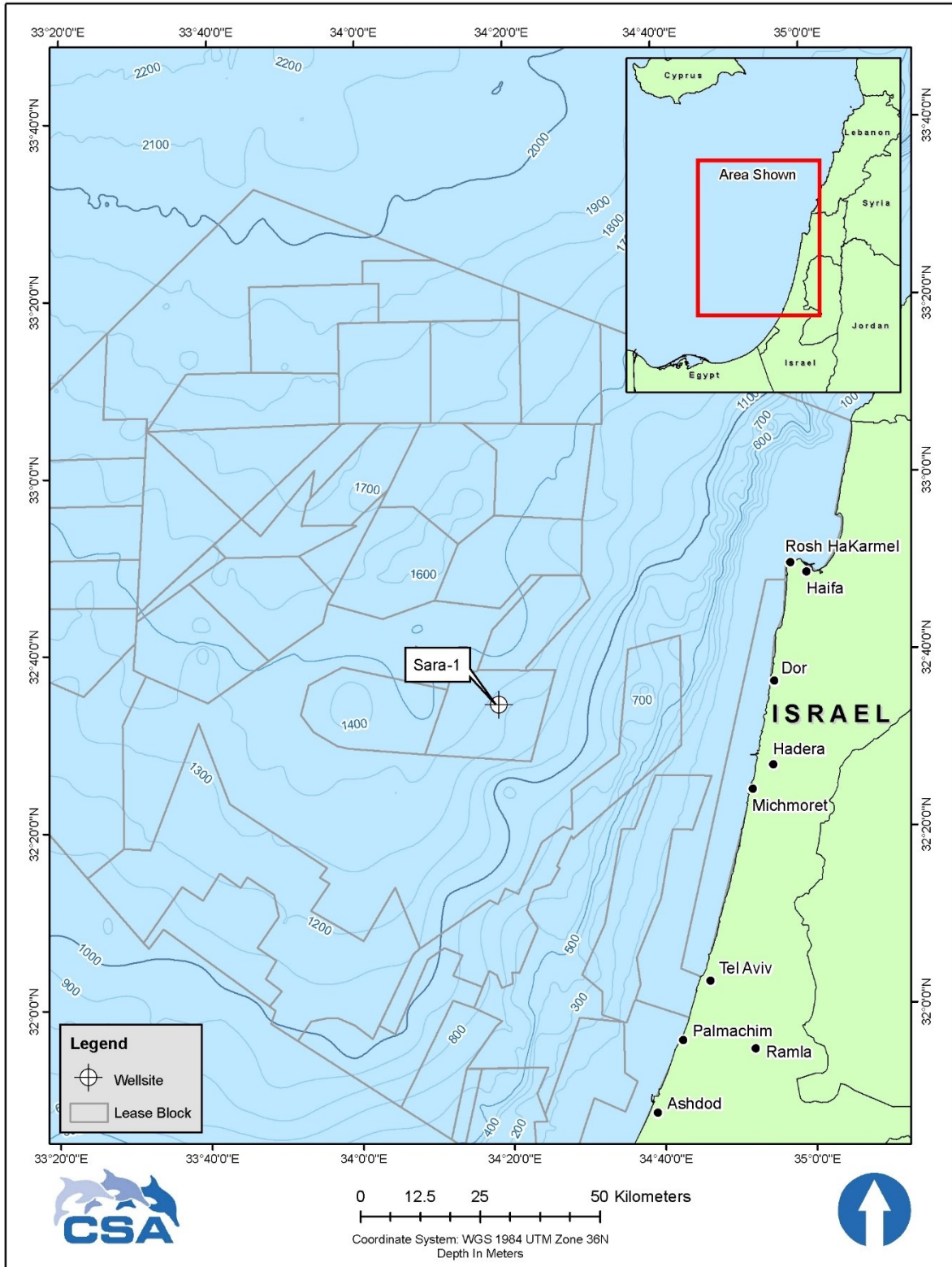


Figure 1. Location of the Sara-1 wellsite relative to the Israeli coastline with regional bathymetric contours. The WGS84 coordinates are 32°34'15.229" N and 34°18'38.086" E. The UTM Zone 36N coordinates are northing 3,604,475.7 and easting 623,022.6. Israel datum ITM coordinates are 135517.899017 (X) and 719979.742429 (Y).

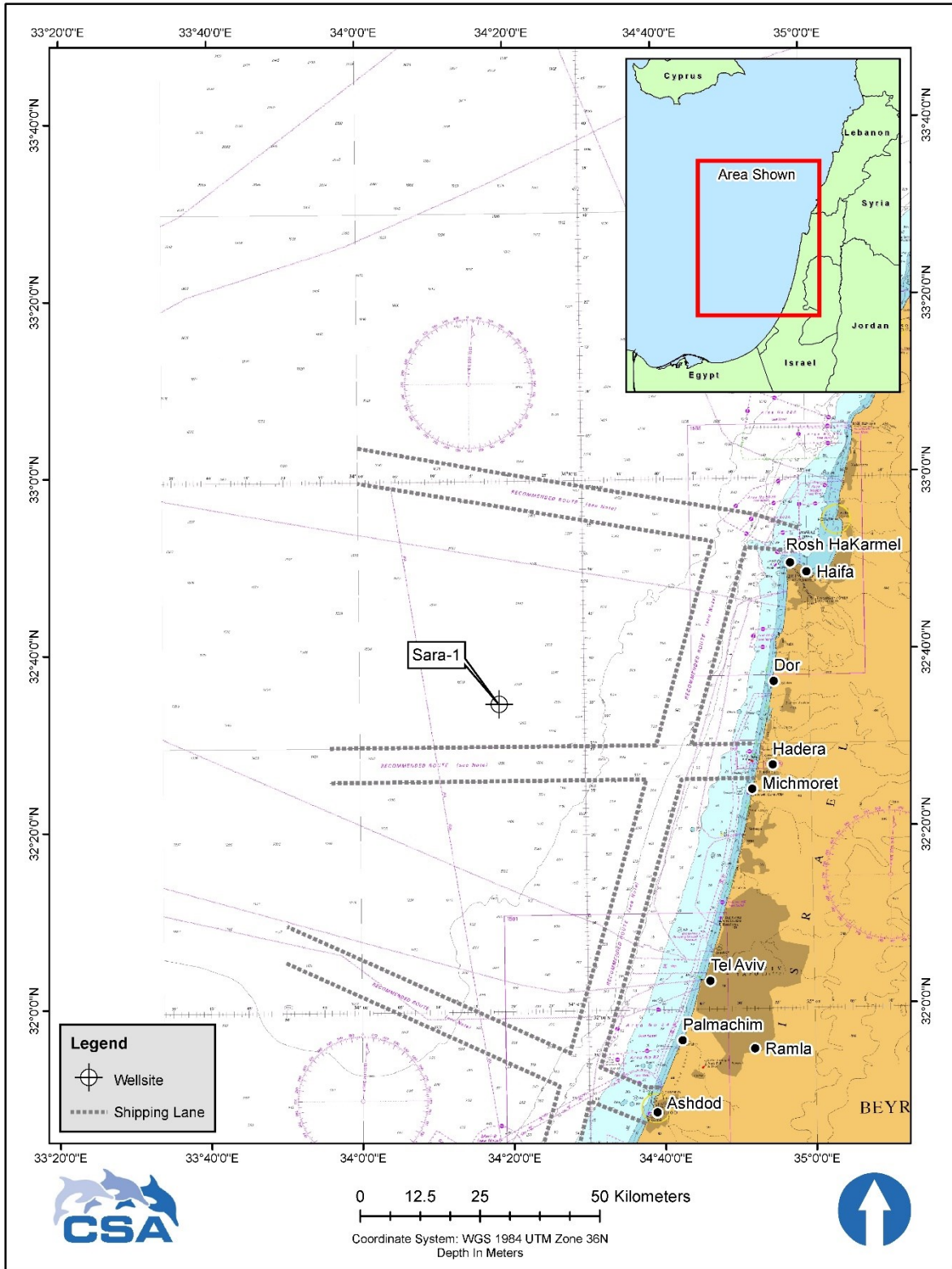


Figure 2. Location of the Sara-1 wellsite relative to shipping fairways off the Israeli coastline.

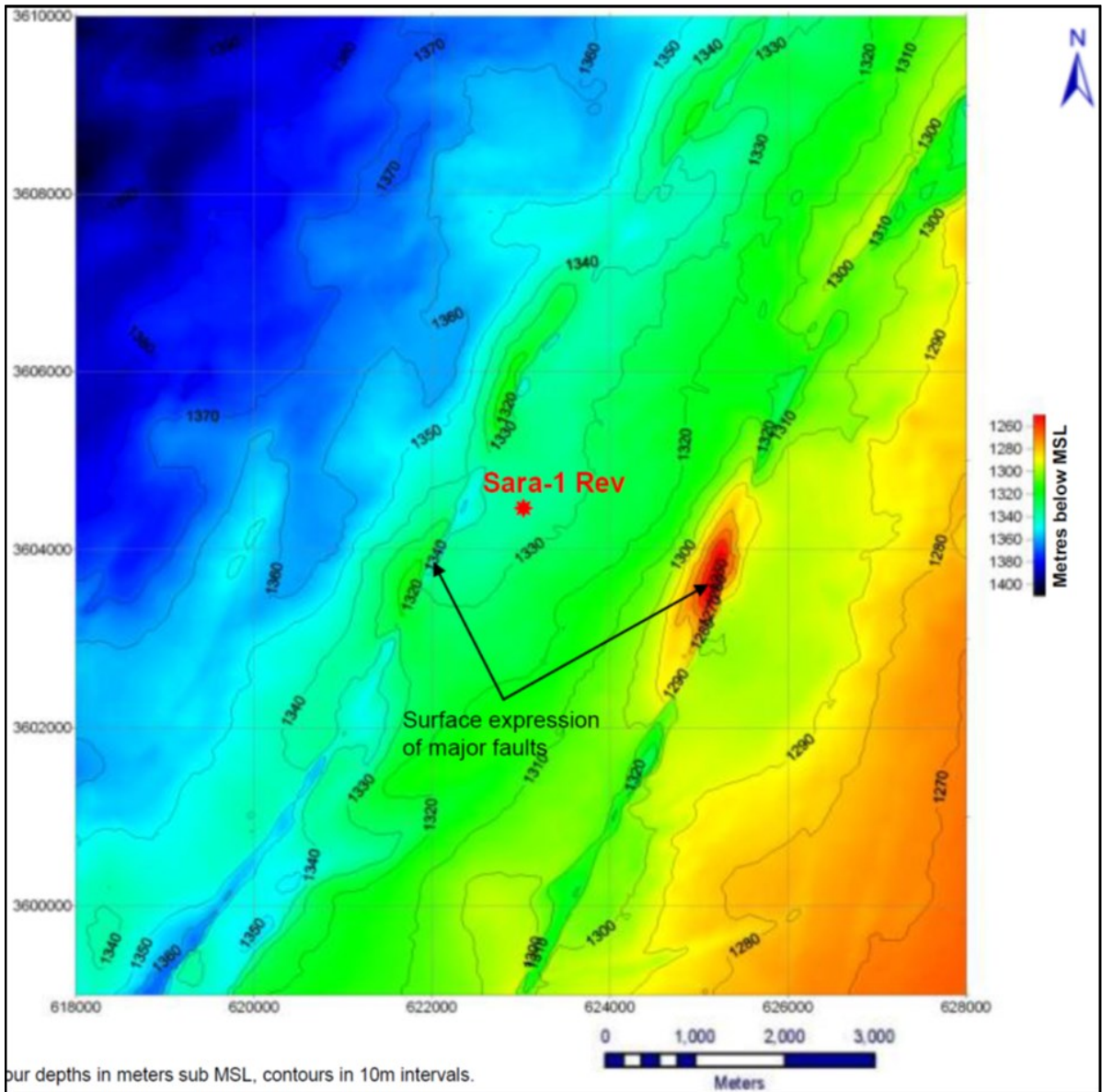


Figure 3. Location of the Sara-1 wellsite relative to the local bathymetry (From: RPS Group, 2011). Surface expression of major fault lines is presented also. Depth contours are in 10-m intervals.

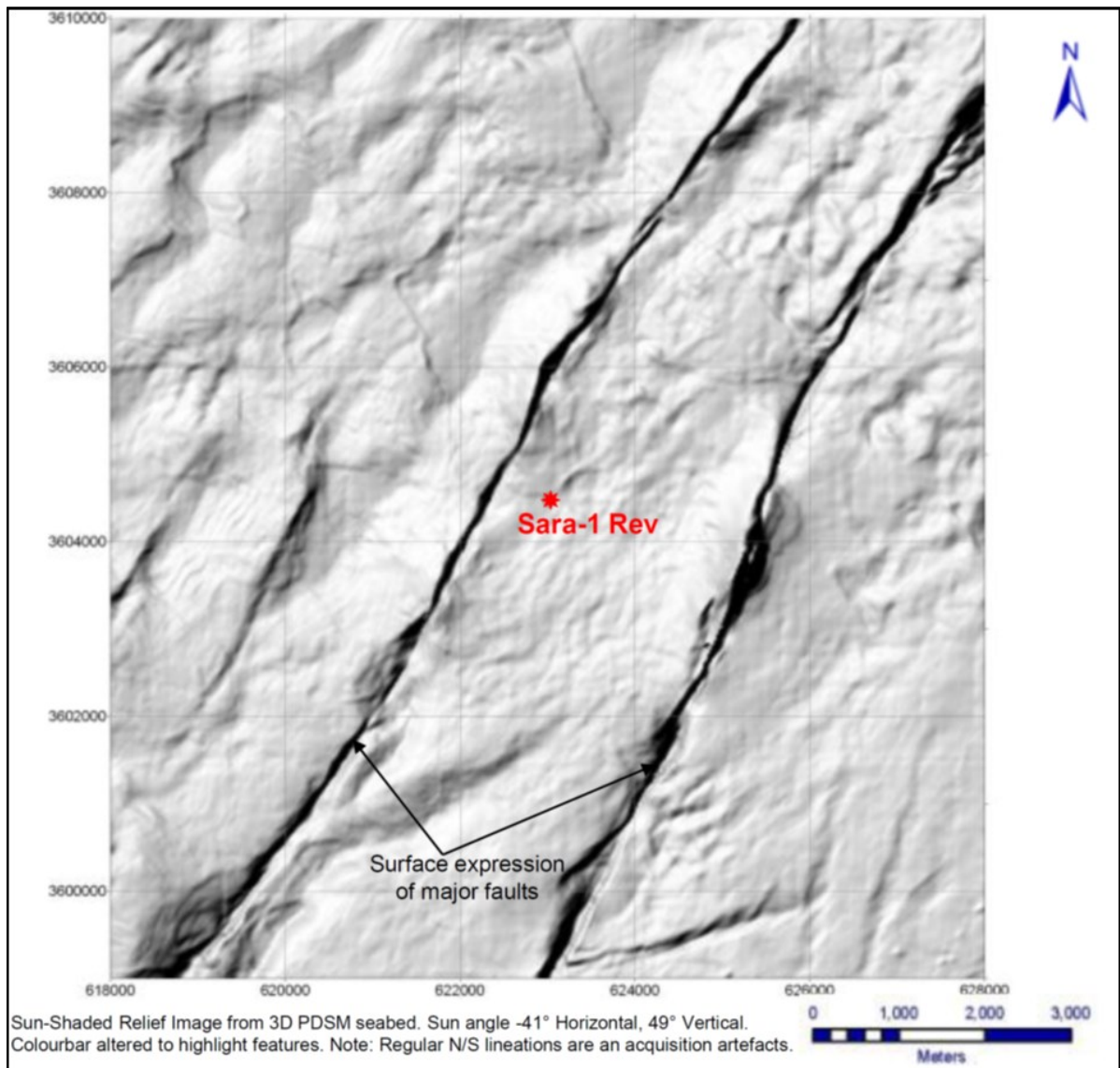


Figure 4. Location of the Sara-1 wellsite relative to the local bathymetry (From: RPS Group, 2011). Surface expression of major fault lines is presented also. Depth contours are in 10-m intervals.

## 2.2 PREVIOUS MONITORING FINDINGS

CSA conducted monitoring surveys at the Sara-1 wellsite for GGR in 2012. The surveys were subject to an early draft version of the environmental guidelines that were still in stages of development and a specific SAP was approved through a correspondence between GGR and the MoEP. Pre-drill sample collection, designed by CSA, was modified by GGR for the during drilling and post-drill surveys and was conducted primarily by GGR. Sampled environmental parameters included total nitrogen (TN) and total phosphorous (TP) in seawater samples and total organic carbon (TOC), total metals, and hydrocarbons content in sediments. This section will provide a brief summary of the findings from the most recent environmental work conducted at the site. For a full description of the results and interpretation, please refer to the Sara Wellsite Environmental Monitoring Program report provided in **Appendix A**.

## 2.2.1 Sediment

### Grain Size

Grain size characteristics within the Sara-1 wellsite area were found to be fairly homogenous and composed primarily of silty clay or clayey silt particles. During drilling, a high proportion of sand particles was found close to the wellsite, likely due to drilling activities depositing sandy sediments in the area immediately adjacent to the wellsite. **Figure 5** illustrates average grain size characteristics of sediment collected at the wellsite area during previous surveys.

### Total Metals and Total Organic Carbon

Ambient sediment metals concentrations generally were low, with the majority of concentrations below established effects range low (ERL) and effects range median (ERM) thresholds (Long and Morgan, 1990). However, ambient concentrations of arsenic (10.20 to 20.50 ppm), copper (37.70 to 61.55 ppm) and nickel (56.73 to 67.90 ppm) during the pre-drill, during drilling, and post-drill surveys exceeded ERL values. Sediment data gathered from other surveys conducted within the deepwater region of the Levantine Basin has shown that ambient concentrations of these three metals are naturally high. Barium concentrations were elevated at stations near the wellsite during the drilling of Sara-1 and remained elevated during the post-drill survey, indicating the potential presence of drilling muds in the vicinity of the wellsite. TOC concentrations generally were low (<200 ppm) around the wellsite except for a sample collected in the during drilling survey that reached 7,049 ppm.

### Hydrocarbons

Ambient total petroleum hydrocarbons (TPH) concentrations in the Sara-1 wellsite area were low or below analytical detection limits (<445 to <1,308  $\mu\text{g kg}^{-1}$ ) during the EMP. However, a few samples collected near the wellsite (within 22 m) during and after drilling activities had elevated TPH concentrations (9,000 to 508,000  $\mu\text{g kg}^{-1}$ ) (**Table 1**). The results indicated that there was no widespread hydrocarbon contamination of the sediments as a consequence of exploratory drilling operations; however, the lack of samples from beyond 41 m from the wellsite due to ROV maneuverability constraints prevented any ability to confirm this.

Table 1. Total petroleum hydrocarbons (TPH) concentrations in sediments from the Sara-1 2012 Environmental Monitoring Program surveys.

Sample Ring Stations	TPH ( $\mu\text{g kg}^{-1}$ dry weight)		
	Pre-Drill Survey	During Drilling Survey	Post-Drill Survey
Wellsite/Well Center	<444	46,000	508,000
22 m	--	<493	9,000
	--	<498	18,000
	--	168,000	<445
	--	<436	9,000
41 m	--	<472	<442
	--	<434	<440
	--	<466	<427
	--	<515	<406
100 m	<445	--	--
	<464	--	--
	<453	--	--
	<450	--	--
200 m	<446	--	--
	<1308	--	--
	<448	--	--
	<440	--	--
References (3,000 m)	<470	--	--
	<454	--	--

-- = station not sampled.

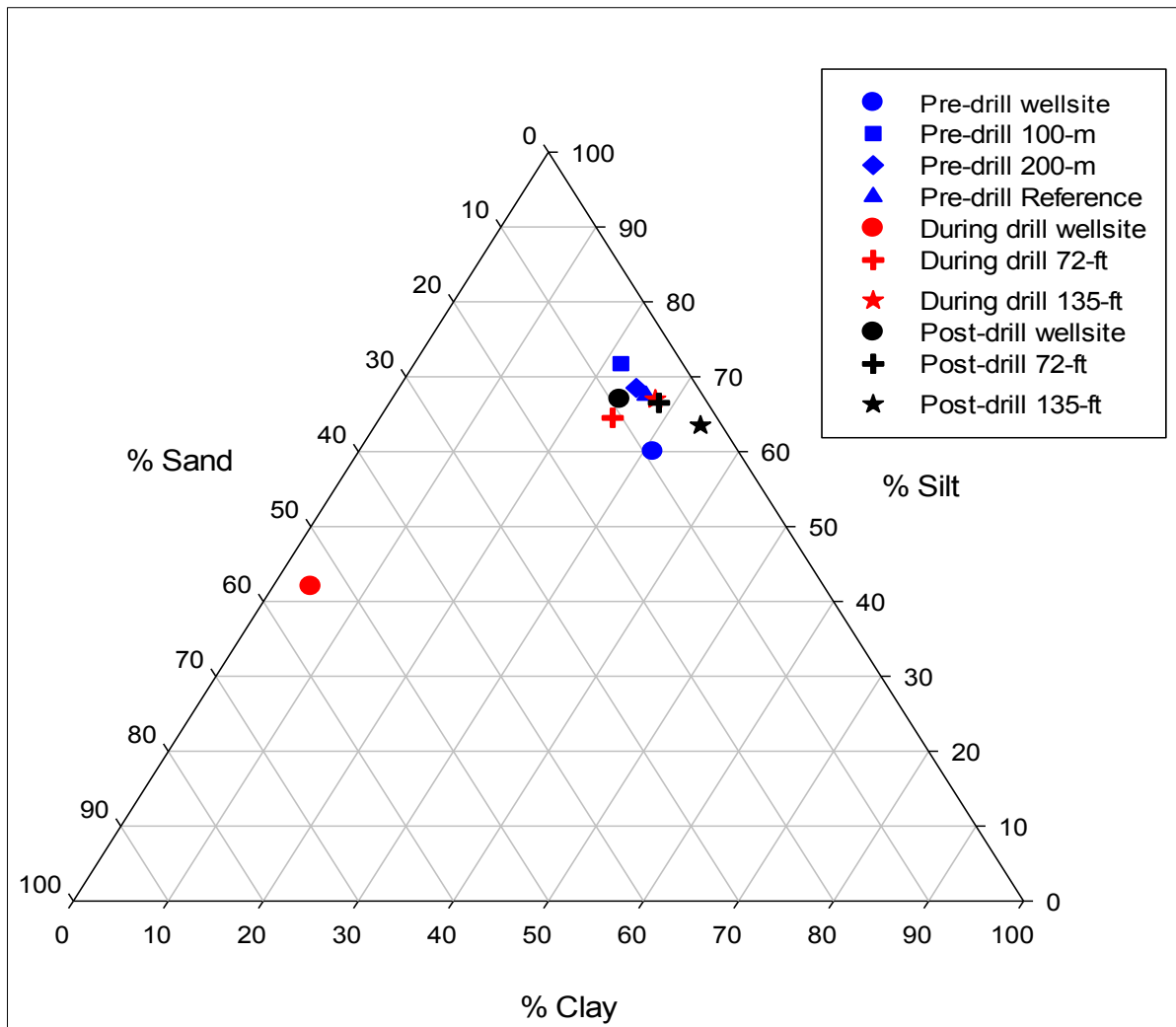


Figure 5. Ternary diagram showing grain size characteristics from sediment samples collected within the Sara-1 wellsite area during the 2012 pre-drill, during drilling, and post-drill monitoring surveys. Except for the during drilling wellsite sample, all sediment samples collected during the Sara-1 Environmental Monitoring Program were as expected for deepwater regions of the Levantine Basin offshore Israel.

### 2.2.2 Seawater

#### *Hydrographic Data*

Hydrographic profiles were taken throughout the water column at the Sara-1 wellsite during the pre-drill survey to show that environmental conditions were typical of summer deepwater subtropical open ocean conditions and considered representative of the water column in the survey area. Surface waters were warm (27.9°C), decreased to 17°C through the thermocline, and gradually stabilized to 13.8°C through the remainder of the water column to the seafloor. A salinity of 39.3 was recorded near the surface, decreased to 38.7 through the halocline (salinity gradient), and gradually stabilized with increasing water depth to 38.8 at the seafloor. Turbidity was low (approximately 0.3 nephelometric turbidity units [NTU]) throughout the water column. The water column was well oxygenated (5.3 mL L<sup>-1</sup>) in the surface layers and decreased gradually through the surface-mixed layer before it stabilized to 4.6 mL L<sup>-1</sup> for the remainder of the water column to the seafloor (Figure 6).

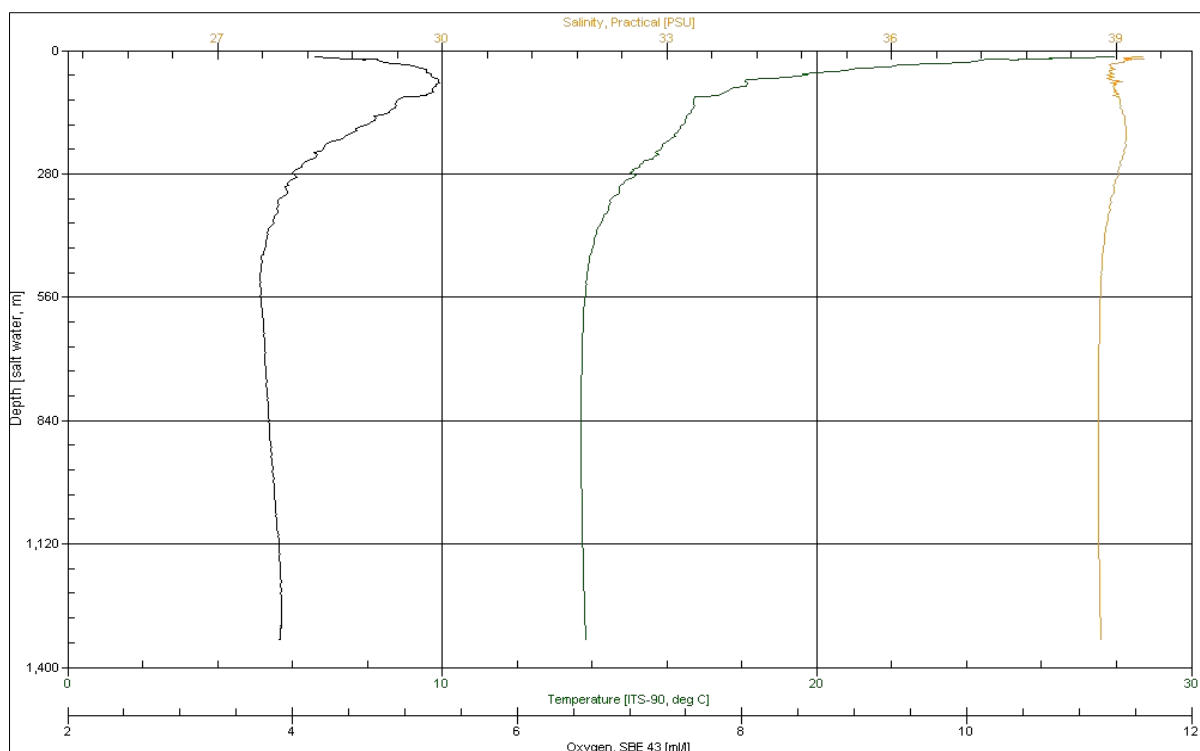


Figure 6. Conductivity-temperature-depth (CTD) and dissolved oxygen water column profiles collected during the pre-drill survey on 8 July 2012 at the Sara-1 wellsite. These profiles are typical hydrographic profiles of summer conditions at the region.

### ***Total Nitrogen and Total Phosphorus***

The Levantine Basin is highly oligotrophic with very low seawater nutrient concentrations. TN and TP concentrations measured in seawater samples collected from near-surface, mid-water, and near-bottom depths at the Sara-1 wellsite during the pre-drill survey were low and relatively consistent within the water column. TN ranged from 0.10 to 0.19 mg L<sup>-1</sup> and TP ranged from 0.0059 to 0.0167 mg L<sup>-1</sup>. During drilling and post-drill concentrations were higher with TN values of 5.0 to 9.0 mg L<sup>-1</sup> and TP values up to 0.5 mg L<sup>-1</sup>. Lack of reference samples from those surveys prevents the ability to confirm data validity and the potential differences in nutrient concentrations between surveys.

## **2.3 PHYSICAL OCEANOGRAPHY**

### **2.3.1 Winds**

There is no known wind dataset representative of the Sara-1 wellsite area. In the absence of an observed dataset, wind data can be obtained from the output of a numerical atmospheric model. Data were assessed from the National Center for Environmental Predictions (NCEP) Environmental Modeling Center Regional Spectral Model provided by the U.S. National Oceanic and Atmospheric Administration – Cooperative Institute for Research in Environmental Studies (NOAA – CIRES) Climate Diagnostics Center (CDC) (<http://www.cdc.noaa.gov>). Wind speed and direction data at a 10-m height from the NCEP model grid location closest to the wellsite (approximately 100 km northwest) were obtained from the NOAA/CDC data server for the 10-year period from January 1999 to January 2009 as representative of the wellsite location.

**Figure 7** shows annual and monthly wind roses developed from the NCEP model grid location. Presentation of recent regional wind history (10-year period from 1999 through 2009) is appropriate for the purpose of the SOW as it provides guidance on the wind conditions (speed and direction)

expected to be encountered during the execution of this survey. Based on the NCEP dataset, the wind regime is characterized by predominant westerly winds throughout most of the year (January through October) and varied winds in November and December. Winds generally are moderate in speed, with mean monthly speeds of approximately  $5 \text{ m s}^{-1}$ . Overall, strong seasonal variability is not evident in the wind data. Winter winds (December through February) have higher maximum speeds than the remainder of the year; however, mean wind speeds are relatively comparable throughout the year. The moderate conditions indicate that relatively efficient survey sampling could be conducted with minimal standby due to weather and sea conditions that would preclude safe vessel operation.

### 2.3.2 Waves

**Table 2** presents significant wave height distribution for a point near the Cyprus Coastal Ocean Forecasting and Observing System (CYCOFOS) MedGoos-3 buoy (33°42' N, 32°08' E) for the period between July 2005 and February 2008. The station is located approximately 238 km west of the Sara-1 wellsite area. Nearly all of the waves are less than 1.5 m in height, and wave direction is nearly always due east at this location (mean of 116°T, standard deviation of 53°) because of the strong westerly winds. While wave height and direction vary daily across the Levantine Basin, the yearly statistics can be regarded as representative values for the entire basin (**Figure 8**).

Table 2. Significant wave heights and their frequency of occurrence in the Levantine Basin during the period from July 2005 to February 2008.

Wave Height Range* (m)	Frequency (Occurrences over Period of Record)	Percentage (%)
0 to 0.2500	91	1.5230
0.5000	1,132	18.9456
0.7500	2,183	36.5356
1.0000	1,388	23.2301
1.2500	565	9.4561
1.5000	261	4.3682
1.7500	140	2.3431
2.0000	69	1.1548
2.2500	52	0.8703
2.5000	21	0.3515
2.7500	14	0.2343
3.0000	10	0.1674
3.2500	11	0.1841
3.5000	4	0.0669
3.7500	7	0.1172
4.0000	11	0.1841
4.2500	9	0.1506
4.5000	6	0.1004
4.7500	1	0.0167
<b>Total</b>	<b>5,975</b>	<b>100</b>

\* Upper limit of bin.

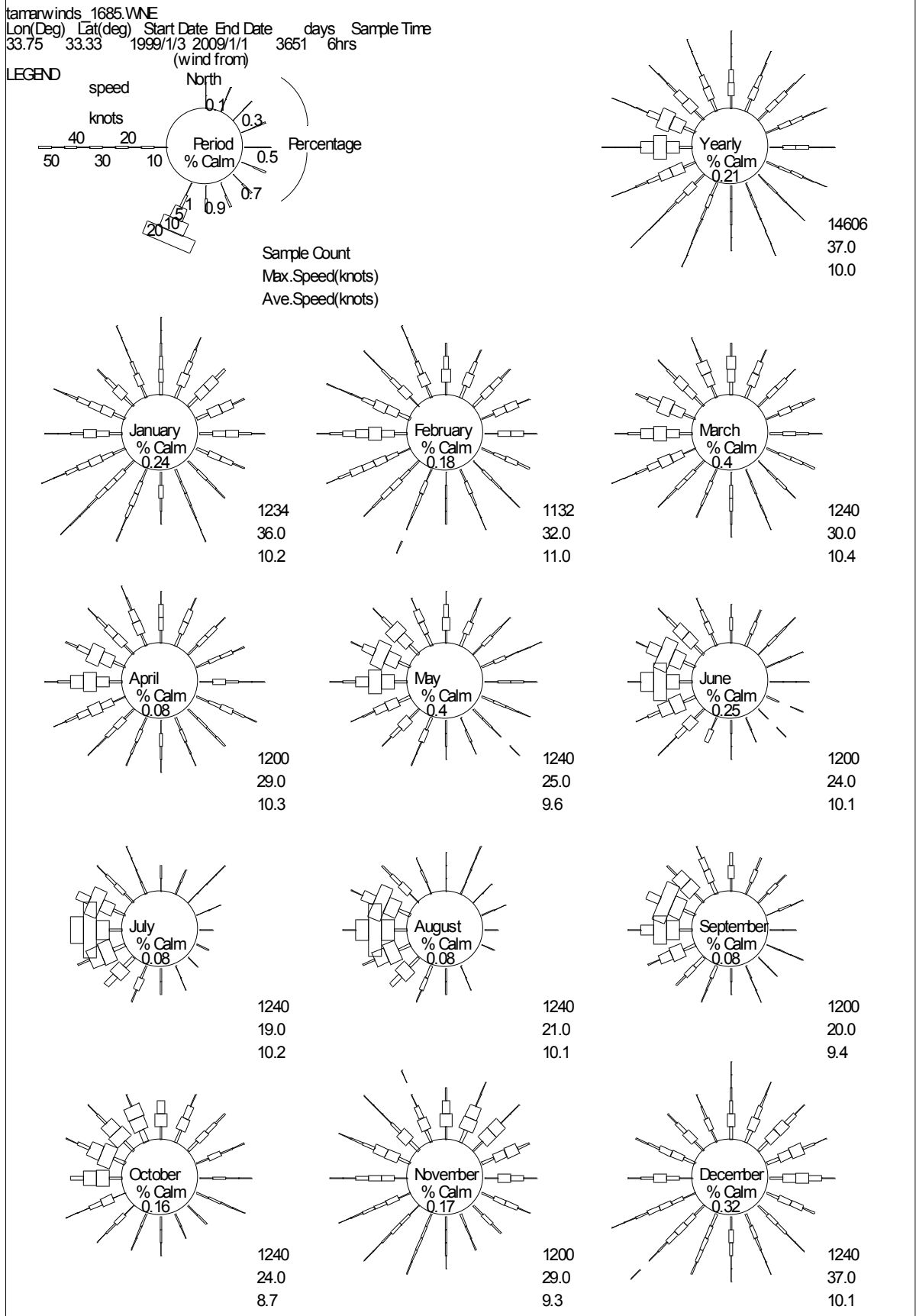


Figure 7. Monthly and yearly wind roses of National Center for Environmental Predictions, Wind Station 1685, January 1999 through January 2009.

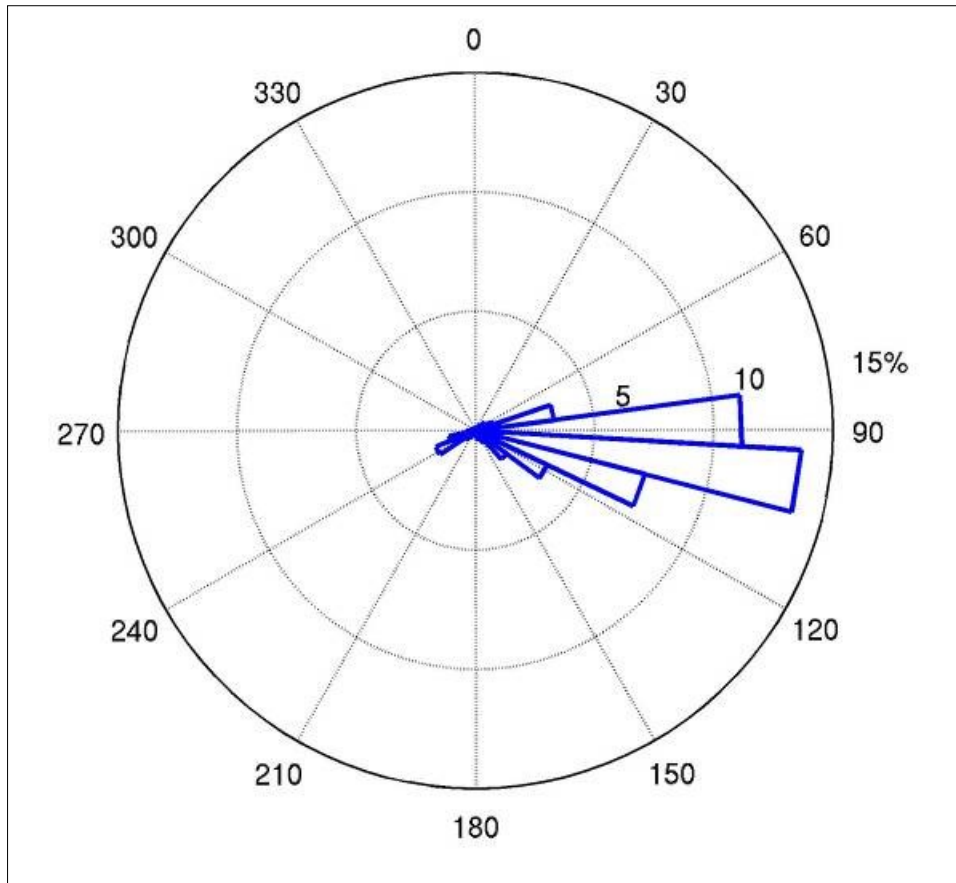


Figure 8. Rose diagram for annual frequency of wave direction per 10° sector. Waves predominantly travel toward the east.

### 2.3.3 Storms

The Eastern Mediterranean region lies between the subtropics and mid-latitudes, and cyclones that develop in the area obtain significant energy from both baroclinicity and surface fluxes (Flocas et al., 2010, 2011). The mean annual cycle of the number of storm tracks that pass through the Eastern Mediterranean region is based on an analysis of storm data from 1962 to 2001. Storm tracks are most frequent during the winter and spring months, from December to April. Storm occurrences decrease during the warm period, with a tendency to increase again in October. The maximum number of cyclonic tracks over the area is observed in January (11.2% of the annual total) and March (10.3%). The minimum number of tracks occurs in July (5.3%).

On a seasonal basis, Mandel et al. (2006) describe winter in the Eastern Mediterranean region as concomitantly/alternatively dominating or dominated by interconnected successions of Red Sea Trough, Winter Lows, Polar Cyclones, and Siberian and Mediterranean subtropical anticyclones. The northward and southward advance and withdrawal of the Red Sea Trough during 5 to 7 months of the year (to the Intertropical Convergence Zone) and Persian Trough affect the large-scale succession of the temporary cyclonic systems (i.e., Winter Lows, Cyprus Lows, and Sharav). The Red Sea Trough conditions dominate during the winter, while Winter Lows and Cyprus Lows are less prevalent.

During the summer, the Persian Trough is the dominant weather type, with subtropical anticyclones dominating at upper levels. At daily intervals, the Persian Trough has the largest persistence, rarely interrupted by other weather types. For example, the Sharav Cyclones, as temporary partners of the Persian or Red Sea Troughs, have a horizontal scale of less than 1,000 km (Alpert and Ziv, 1989) while the trajectory of Cyprus cyclones is greater than 2,500 km, occurring 8 to 13 times per year and lasting for 5 to 7 days (Mandel et al., 2006).

### 2.3.4 Currents

Rohling et al. (2009) provided an update of historical and current characterizations of the local oceanographic processes off Israel. Lawrence et al. (2011) conducted a metocean study offshore Israel near the Sara-1 wellsite. Currents were measured throughout the water column at a single site. The current meter array was located approximately 80 km north of the Sara license in a water depth of 1,688 m.

The upper water column currents at the current meter location were dominated by episodes of strong flows, particularly in the winter. At 25 m depth, the maximum recorded current speed ( $53.6 \text{ cm s}^{-1}$ ) occurred in January 2011. Mean current speeds at this depth were estimated to be as fast as  $25 \text{ cm s}^{-1}$ . At 73 m depth, the maximum current speed ( $49.1 \text{ cm s}^{-1}$ ) was measured in April 2011. Mean current speeds at this depth were estimated to be as fast as  $22 \text{ cm s}^{-1}$ . At 121 m depth, the maximum current speed was  $41.5 \text{ cm s}^{-1}$ . Mean currents were estimated to be as fast as  $17 \text{ cm s}^{-1}$ . At 233 m depth, the maximum current speed ( $25.8 \text{ cm s}^{-1}$ ) occurred in January 2011. The dominant flow direction at the near-surface was toward the south and west. Near-bottom currents do not appear to have a significant seasonal trend, with a maximum speed of only  $8.7 \text{ cm s}^{-1}$ . **Figures 9** through **13** present summaries of the recorded current speeds and directions for 25, 73, 121, 233, and 1,680 m depth.

### 2.3.5 Salinity and Temperature

The yearly range for surface salinity and temperature in the eastern Mediterranean Sea is from approximately 39.0 to 39.5 and from  $17^\circ\text{C}$  to  $28^\circ\text{C}$ , respectively. Salinity remains fairly constant with depth, while temperature decreases with depth from  $17^\circ\text{C}$  to  $14^\circ\text{C}$  (Zodiatis et al., 2001).

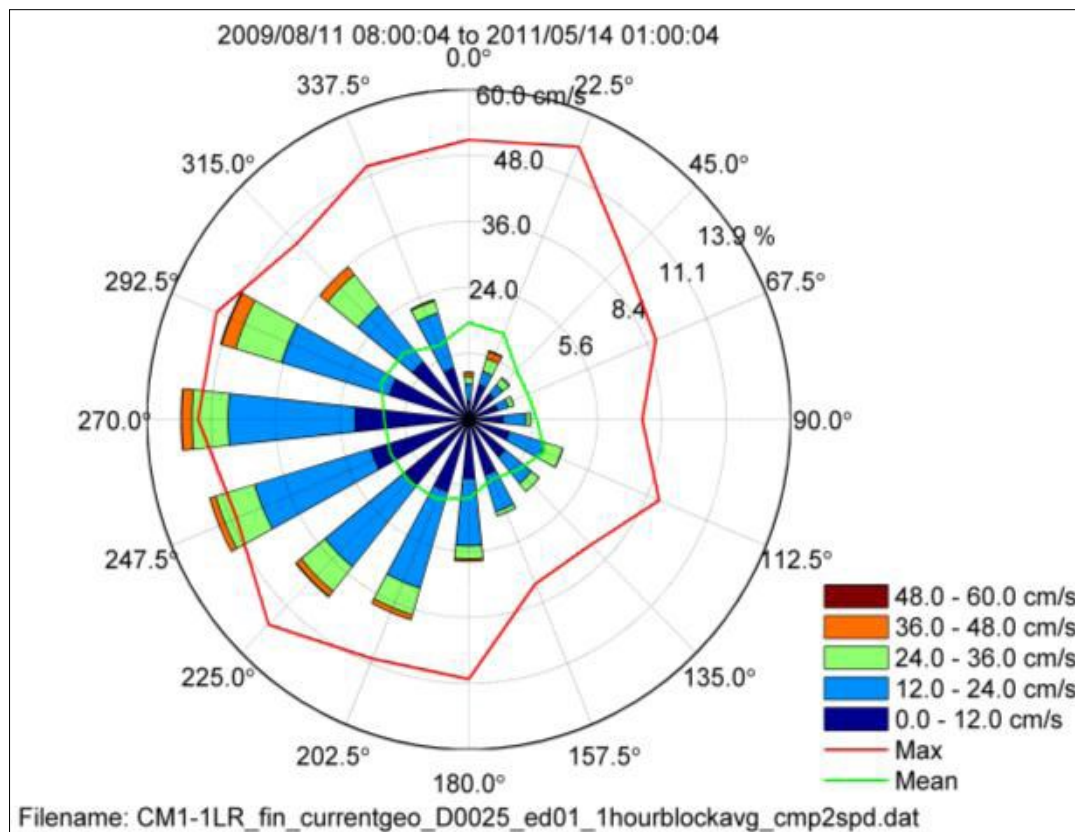


Figure 9. Compass rose plot of the directional distribution of currents recorded at a depth of 25 m near the Sara-1 wellsite.

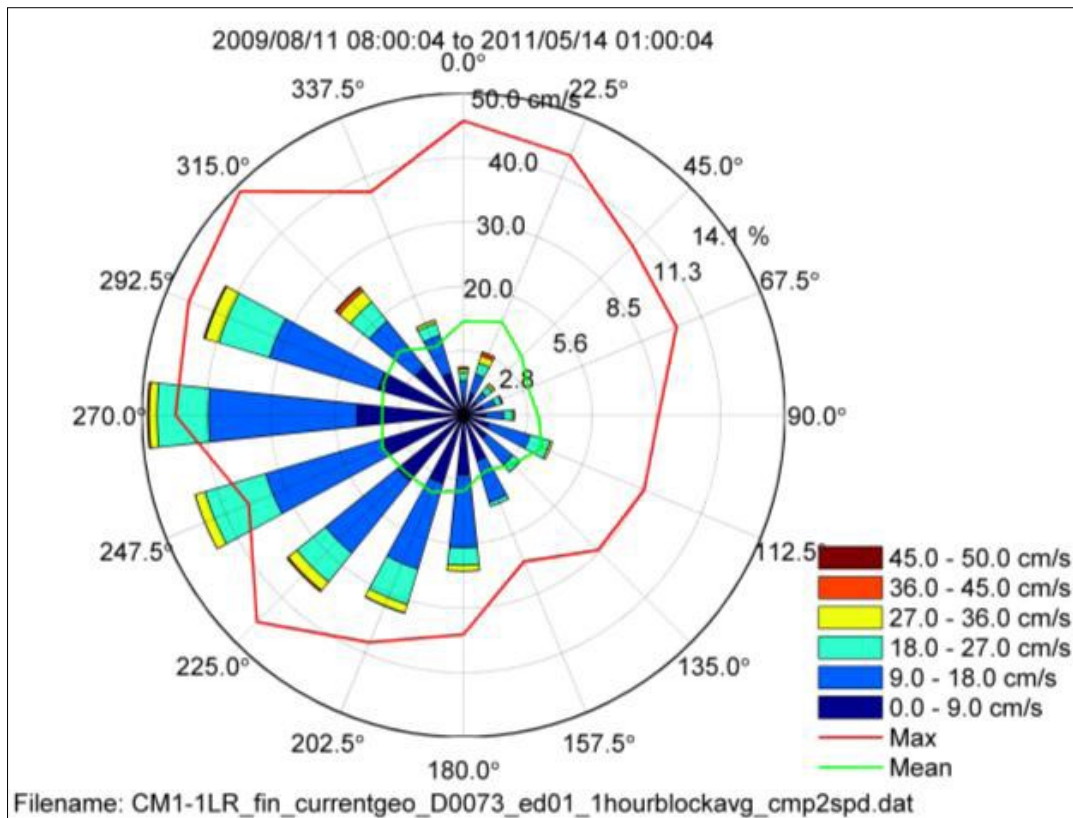


Figure 10. Compass rose plot of the directional distribution of currents recorded at a depth of 73 m near the Sara-1 wellsite.

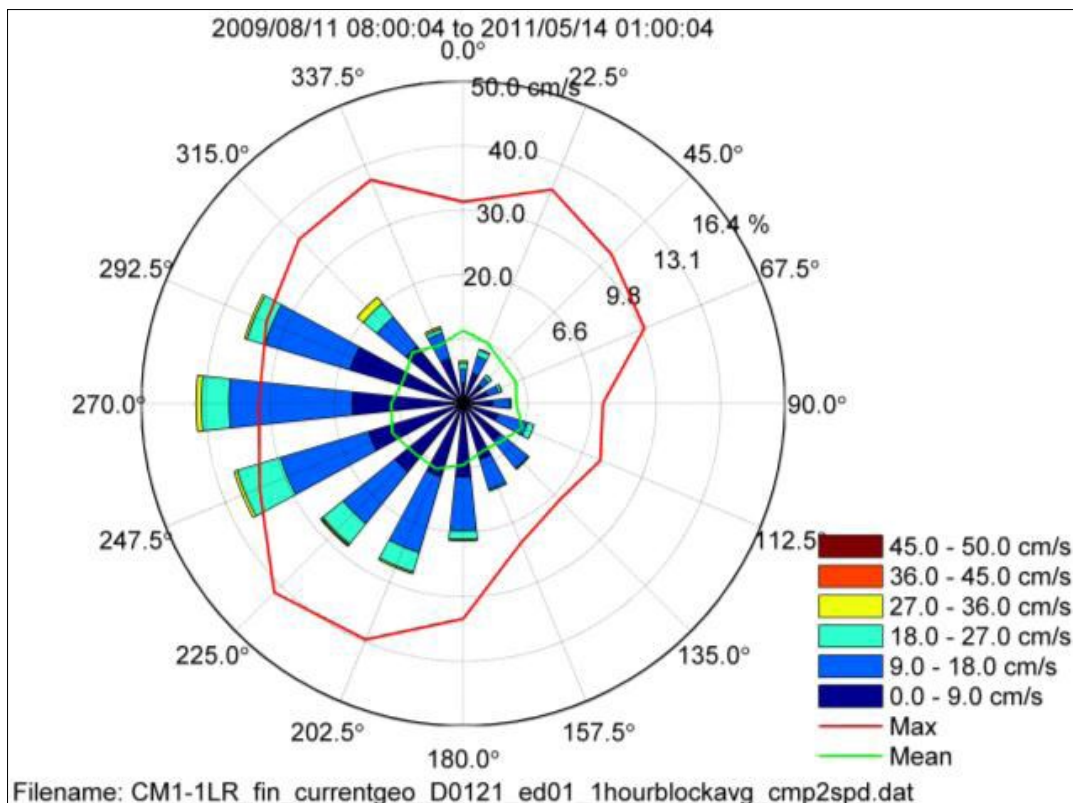


Figure 11. Compass rose plot of the directional distribution of currents recorded at a depth of 121 m near the Sara-1 wellsite.

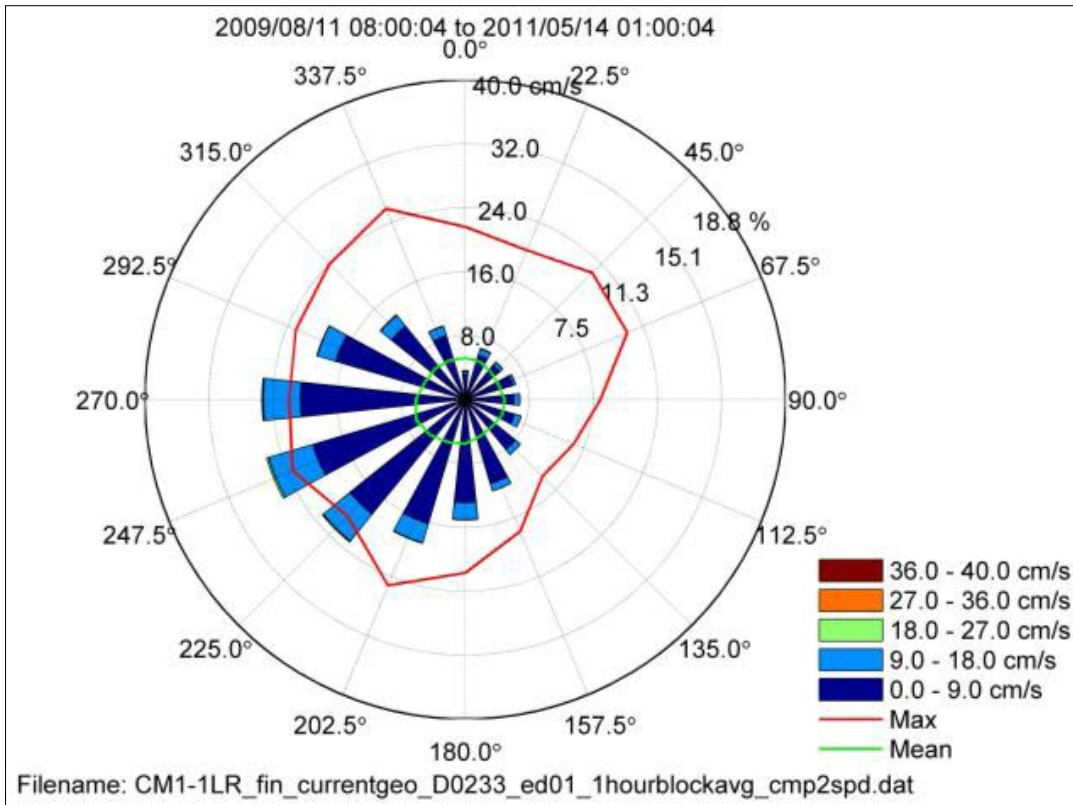


Figure 12. Compass rose plot of the directional distribution of currents recorded at a depth of 233 m near the Sara-1 wellsite.

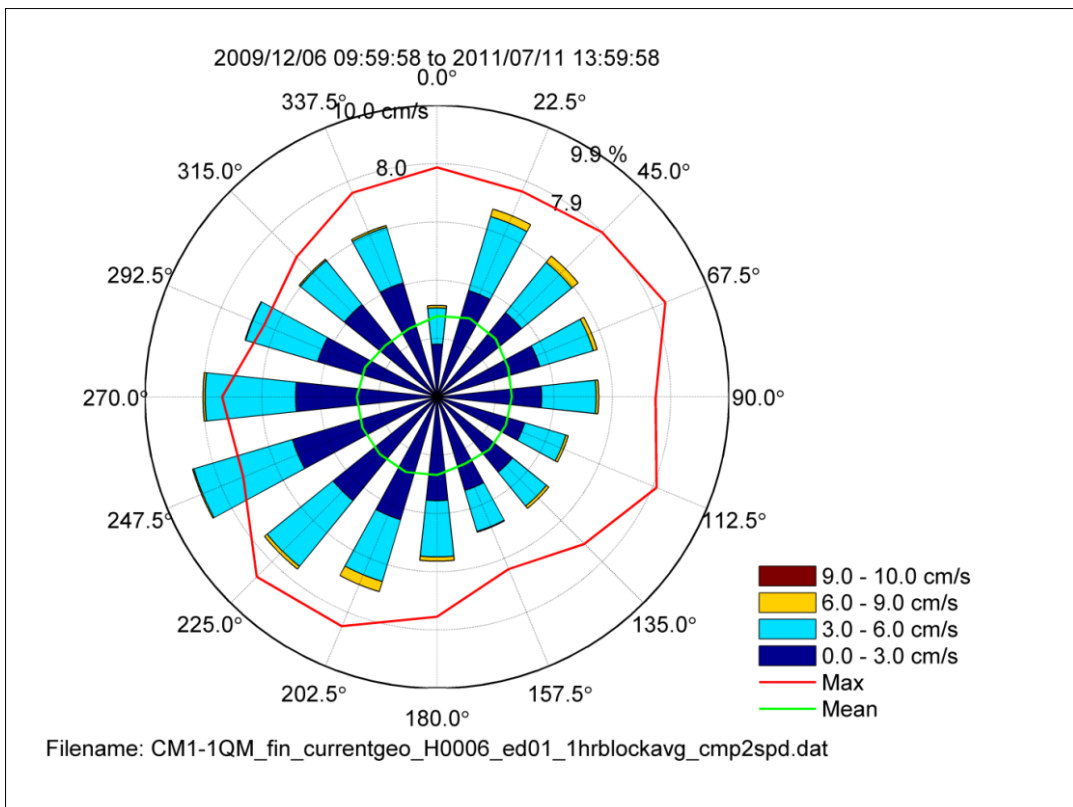


Figure 13. Compass rose plot of the directional distribution of currents recorded at a depth of 1,680 m near the Sara-1 wellsite.

## 2.4 PLANKTON AND WATER QUALITY

Plankton are divided into two groups: phytoplankton (plant) and zooplankton (animal). The composition of both groups is well documented in the eastern Mediterranean Sea. Low nutrient concentrations in the water limit the biomass and production of phytoplankton. Mean chlorophyll concentrations for the euphotic zone (0 to 100 m) off the Israeli coast are 0.06 to 0.12 mg m<sup>-3</sup> (Berman et al., 1986). Moutin and Raimbault (2002) determined that primary productivity values were less than 150 mg C m<sup>-2</sup> d<sup>-1</sup> in the Levantine Basin, which was one-third less than Mediterranean waters farther west offshore Italy. At chlorophyll maximum depths (90 to 120 m), the phytoplankton assemblage is dominated by coccolithophorids and monads (single-celled flagellated protozoa). Phytoplankton biomass increases between November and March due to increased nutrients in the surface waters from storm-related water column mixing. The nutrients are then depleted through use, and the summer biomass decreases by an order of magnitude from the winter biomass peak (Krom et al., 1991).

Copepods (often 80% or greater) are the primary taxonomic group of zooplankton in the Levantine Basin (Mazzocchi et al., 1997). Zooplankton abundance in the eastern Mediterranean Sea is highest in the surface-mixed layer (0 to 50 m) where the phytoplankton assemblage is most productive.

The water quality of the eastern Mediterranean Sea is good with clear water (low turbidity), low nutrients, and high dissolved oxygen. The entire water column in the eastern Mediterranean is well oxygenated; even the deep waters (e.g., 1,000 m depth) have saturation values greater than 70% to 80%. Krom et al. (2005) found that dissolved oxygen concentrations vary from approximately 4.8 mg L<sup>-1</sup> at the surface to 5.4 mg L<sup>-1</sup> through the surface-mixed layer before gradually stabilizing to 4.1 mg L<sup>-1</sup> for the remainder of the water column to the seafloor.

## 2.5 BENTHIC COMMUNITIES

Benthic communities may be classified as biological assemblages associated with either soft or hard bottom substrate. Soft bottom assemblages are composed of biota (typically fauna in depths below the photic zone) living within the sediments (infauna) and on the sediment surface (epifauna). Several studies have documented the composition of these communities in the general area (Kress et al., 1993; Galil and Goren, 1994; Kröncke et al., 2003; Galil, 2004). The studies have shown that the infauna and epifauna generally are in very low abundance (e.g., infaunal density at a deepsea station was approximately 200 individuals m<sup>-2</sup>). The infauna generally is dominated by polychaete worms and the epifauna by crustaceans (crabs and shrimps) and mollusks.

No hard bottom outcroppings or associated communities, including chemosynthetic communities, were observed during the visual survey of the Sara-1 wellsite area conducted in July 2012. Hard bottom offshore Israel is most prevalent in shallower shelf waters at depths of 5 to 30 m and includes naturally occurring sandstone outcrops (Alder, 1985) and artificial structures (Spanier, 2000). However, a deepwater, hard bottom area was discovered in a water depth of approximately 650 m west of Tel Aviv during a cruise by the R/V *Nautilus*.

Specific types of biological communities known as chemosynthetic communities have been documented in the eastern Mediterranean Sea (Dimitrov and Woodside, 2003) and other locations worldwide. Their presence is facilitated by the biological oxidation of sedimentary methane. The presence of these communities can be detected by geophysical surveys as acoustic signatures that appear as small depressions or surficial pockmarks. The biological community associated with the pockmark formations often are dominated by polychaete worms and bivalves. The RPS Group's geohazards assessment report did not indicate the existence of any potential hard substrate or chemosynthetic communities and none were observed within the survey area.

## 2.6 FISH AND FISHERIES

The bottom fish assemblage in the vicinity of the Sara license is much reduced in terms of number of species and individuals compared to similar depths in the western Mediterranean and Atlantic Ocean (Galil, 2004). Galil and Goren (1994) studied the area by conducting a series of cruises between 1988 and 1991 along the approximately 1,500-m depth contour in the vicinity of the Sara license. Observations of macroepifauna and signs of biological activity on the seafloor made during other surveys conducted in the Levantine Basin have revealed a consistently low abundance and diversity of benthic fauna.

## 2.7 MARINE MAMMALS

The Mediterranean Sea supports a diverse marine mammal fauna assemblage, including several species listed by the International Union for Conservation of Nature (IUCN) as critically endangered (e.g., Mediterranean monk seal), endangered (e.g., fin whale and sei whale), or vulnerable (e.g., sperm whale, humpback whale, and common porpoise). Common species that may be present near the wellsite are expected to include the bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, striped dolphin, Cuvier's beaked whale, and several other large whales (minke whale, fin whale, and sperm whale).

The only species of pinniped found in the Mediterranean region is the Mediterranean monk seal (*Monachus monachus*). Belonging to the Phocidae family, the Mediterranean monk seal has fewer than 500 surviving individuals, making it one of the world's most critically endangered mammals. It is very unlikely that monk seals will be in the area of the Sara license because they are extremely rare within waters offshore Israel.

## 2.8 SEA TURTLES

Loggerhead turtles (*Caretta caretta*) and green turtles (*Chelonia mydas*) nest along the Israeli coast; the loggerhead is the most common in the region. Nesting starts at the end of May for loggerhead turtles and in mid-June for green turtles, continuing until the end of July and mid-August, respectively. Another species, the leatherback turtle (*Dermochelys coriacea*), is found throughout the region, although it has no confirmed nesting locations in Israel. Loggerhead turtles are listed by the IUCN as endangered, and leatherback turtles and green turtles are listed as critically endangered. The presence of two other species, the hawksbill turtle (*Eretmochelys imbricata*) and the Kemp's ridley turtle (*Lepidochelys kempii*), are considered rare in the Mediterranean Sea. The occurrence of sea turtles in the area of the Sara license is possible due to transitory activities.

## 2.9 SEABIRDS

The Mediterranean is home to several hundred bird species, a portion of which occur exclusively in this climatic zone. Bird species listed in Annex II of the Barcelona Convention, representing endangered or threatened avifauna of the Mediterranean region, are Cory's Shearwater (*Calonectris diomedea diomedea*), Balearic Shearwater (*Puffinus mauretanicus*) and Levantine Shearwater (*Puffinus yelkouan*), European Storm-Petrel (*Hydrobates pelagicus melitensis*), Mediterranean Shag (*Phalacrocorax aristotelis desmarestii*), Pygmy Cormorant (*Phalacrocorax pygmeus*), Great White Pelican (*Pelecanus onocrotalus*), Dalmatian Pelican (*Pelecanus crispus*), Greater Flamingo (*Phoenicopterus ruber roseus*), Osprey (*Pandion haliaetus*), Eleonora's Falcon (*Falco eleonora*), Slender-billed Curlew (*Numenius tenuirostris*), Audouin's Gull (*Larus audouinii*), Lesser Crested Tern (*Sterna bengalensis*), Sandwich Tern (*Sterna sandvicensis*), and Little Tern (*Sterna albifrons*). Most species occur as rare migrants or vagrants in or near Israeli nearshore or offshore waters. Israel is well known as one of two major migratory pathways in the Mediterranean region, with the other being Gibraltar. Noteworthy seabirds of the region include the presence of a wintering population of Balearic Shearwater along the Levantine coast and the pelagic Mediterranean Gull (*Larus melanocephalus*), which is present year-round in the Nile River system. Both species may occur in the drilling location. A few regional coastal sites have been noted for nesting Sternidae (terns) and Laridae (gulls).

### 3.0 Program Components

The Sara-1 Wellsite Re-Entry Operation Background Monitoring Survey will consist of a field survey focused on the sampling of seafloor sediments and the overlying water column as well as biological sampling using appropriate field techniques, analytical procedures, and quality control (QC). Sampling of the sediments and water column include widely used physical and chemical indicators (**Table 3**). The biological aspects of the sampling program will involve assessment of the infaunal communities using videography and box corer sampling methods.

Table 3. Seawater and sediment sampling parameters/analytes.

Analyte	Recommended Procedure
<b>Seawater</b>	
Conductivity/salinity	<i>In situ</i> measurement (CTD)
Temperature	<i>In situ</i> measurement (CTD)
Dissolved oxygen	<i>In situ</i> measurement (CTD)
Fluorescence	<i>In situ</i> measurement (CTD)
Turbidity	<i>In situ</i> measurement (CTD) and static measurement (Hach turbidimeter)
pH	Static measurement (handheld pH meter)
Nitrate, Nitrite, Ammonium	Filter through a 0.7- $\mu$ m filter; use 250-mL plastic jars; freeze
TOC/TN/TP	Use 250-mL plastic jars; freeze
Total suspended solids	Onboard filtration through pre-weighed 0.7- $\mu$ m glass fiber filters; filter stored frozen
Chlorophyll <i>a</i> (Near-surface water only)	Onboard filtration through a 0.7- $\mu$ m glass fiber filter; filter stored frozen
TPH	Use 1-L amber glass containers with Teflon-lined caps; refrigerate; preserve with dichloromethane
PAHs (only analyzed when TPH is detected)	Use 1-L amber glass containers with Teflon-lined caps; refrigerate; preserve with dichloromethane
Dissolved metals (Ag, As, Ba, Be, Cd, Cr, Cu, Ni, Pb, Sb, Se, Tl, V, and Zn)	Filter through a 0.45- $\mu$ m filter. Use 1-L plastic jars with trace metal grade HNO <sub>3</sub> preservative; refrigerate
Dissolved Hg	Filter through a 0.45- $\mu$ m filter. Use fluorinated 500-mL glass jars with trace metal grade HCl preservative; refrigerate
Ra 226 and Ra 228 (10% of sampling locations)	Use 4-L plastic container with trace metal grade HNO <sub>3</sub> preservative; does not need refrigeration
<b>Sediment</b>	
Grain size distribution by particle size analysis	Box core sample; collect in pre-cleaned plastic jar; freeze
TOC	Box core sample; collect in pre-cleaned plastic jar; freeze
Total metals (Ag, Al, As, Ba, Be, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Sb, Se, Tl, V, and Zn)	Box core sample; collect in pre-cleaned plastic jar; freeze
TPH	Use glass container with Teflon-lined caps; freeze
PAHs (only analyzed when TPH is detected)	Use glass container with Teflon-lined caps; freeze
Ra 226 and Ra 228; Th 228 (10% of sampling locations)	Box core sample; collect in pre-cleaned plastic jar; freeze
Infauna – Taxonomy	Box core; preserve with 8% formalin; identification and enumeration
Epibiota	Underwater video by ROV
<b>Ancillary</b>	
Seafloor observations of substrate and biota	Underwater video; visual analysis
Weather/sea conditions	Observations

Ag = silver; Al = aluminum; As = arsenic; Ba = barium; Be = beryllium; Cd = cadmium; Cr = chromium; CTD = conductivity-temperature-depth; Cu = copper; Fe = iron; HCl = hydrochloric acid; Hg = mercury; HNO<sub>3</sub> = nitric acid; Ni = nickel; Pb = lead; PAH = polycyclic aromatic hydrocarbon; Ra = radium; ROV = remotely operated vehicle; Sb = antimony; Se = selenium; Th = thorium; Tl = thallium; TN = total nitrogen; TOC = total organic carbon; TP = total phosphorous; TPH = total petroleum hydrocarbons; V = vanadium; Zn = zinc.

Field sampling will be conducted utilizing a stratified random sampling design. The design has been approved and used by CSA in many other projects offshore Israel. It comprises several strata at fixed distances from the wellsite in which samples are collected randomly to provide adequate replication for each particular stratum. The sampling design is a key component of any monitoring study; the advantages of this proposed sampling design are as follows:

- It is statistically defensible, avoids potential pseudo-replication (*sensu* Hurlbert, 1984), and is appropriate for this monitoring study. Pseudo-replication occurs if treatment effects are tested with an error term that is inappropriate for the hypothesis being considered; the stratified random approach avoids pseudo-replication because individual stations are randomly located within each stratum (distance zones such as 0 to 100 m from the wellsite location), which results in the ability to make statistical inferences concerning the strata (e.g., differences between near-field and reference). The results obtained from the stratified random approach are representative of the conditions within each stratum and among the strata and, consequently, are more informative concerning the extent of impacts.
- It does not require sampling the same location on successive surveys, which is nearly impossible in 1,335 m water depth; the efficient use of a remotely operated vehicle (ROV) is precluded by the necessity to collect large quantities of sediment for infaunal samples.
- It allows the use of a surface-deployed box corer to collect sediment samples, which is logistically efficient and allows for the collection of adequate sample sizes for infaunal analysis.

Seven randomly positioned sediment stations will be sampled from six strata for a total of 42 stations (**Figure 14**):

- Center: 0 to 100 m from the wellsite;
- Near-field: 100 to 250 m from the wellsite;
- Mid-field 1: 250 to 500 m from the wellsite;
- Mid-field 2: 500 to 1,000 m from the wellsite;
- Far-field: 1,000 to 2,000 m from the wellsite; and
- Reference: 3,000 to 5,000 m from the wellsite.

The reference stratum is designed to be sampled farthest away from the wellsite and will be in the same general water depth and characterized by a similar sediment texture as the experimental stations. Sample collection in the reference stratum will be decided based on collection of a bottom sample; if sediment texture within the reference stratum is obviously different than the experimental strata, an alternative location (3,000 to 5,000 m from the wellsite) will be selected for sampling. During the post-drill survey, all sediment stations will be “re-randomized” within the strata in accordance with the statistical design because the sampling method does not allow for precise sampling of the same locations.

Sediment sampling will be conducted with a large Gray-O’Hara box corer that will accommodate concurrent sampling of chemical, geological, and infaunal parameters. One box core will be obtained per station as the statistical design allows for the “pooling” of samples within a stratum. One box core per station will result in an adequate statistical power for data analyses.

Water column sampling will include water sample collection and hydrographic profiling at the wellsite as well as at an upstream and downstream reference stations from the wellsite (**Figure 14**). Sampling will include analysis of chemical and hydrographic parameters as listed in **Table 3**. Water samples will be collected at three water depths (i.e., near-surface, mid-water, and near-bottom).

Video data will be collected to visually document the types of substrate and associated biological communities around the wellsite (**Figure 15**). Video data will be collected within 250 m of the

wellsite along eight transects spaced at approximately 45° angles. Additionally, video data will be collected along four transects of 250 m length spaced at 90° angles located at each reference station positioned upstream and downstream of the wellsite.

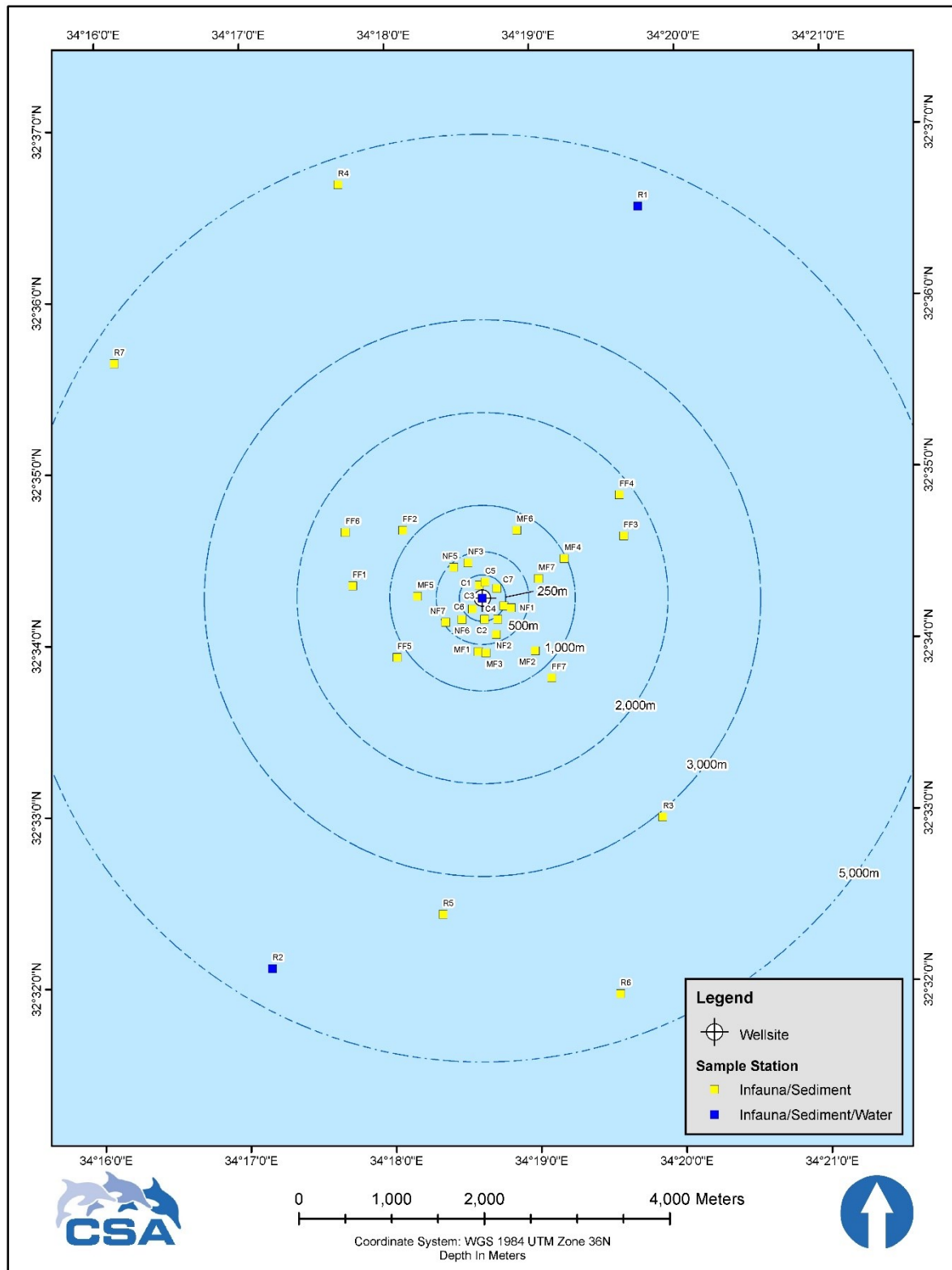


Figure 14. Stratified random sampling design with distance strata superimposed over the Sara-1 wellsite area showing infauna/sediment and water sampling stations.

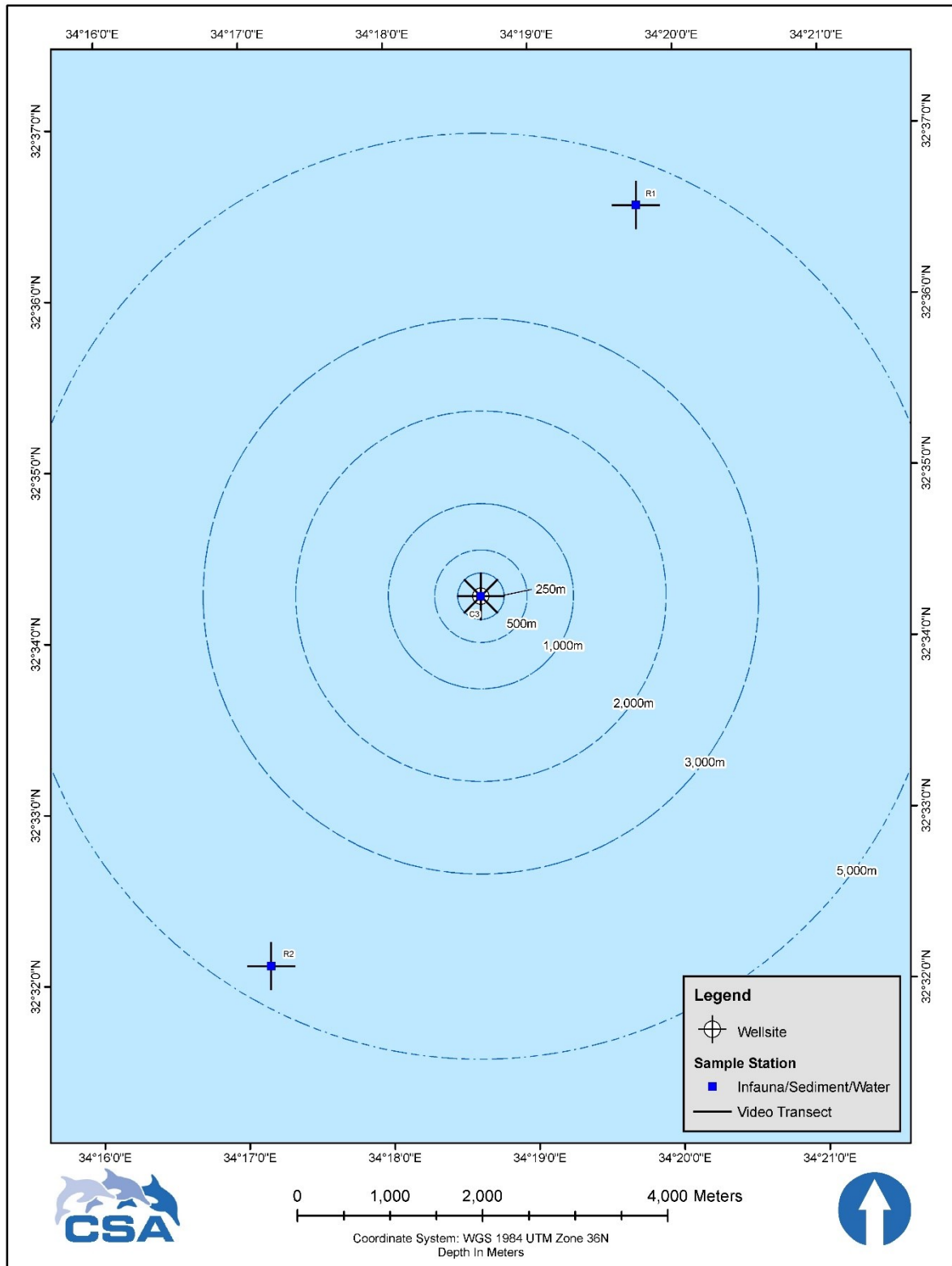


Figure 15. Stratified random sampling design with distance strata superimposed over the Sara-1 wellsite area showing videographic transect locations.

### **5.1 NAVIGATION AND REQUIRED PERSONNEL**

Methods for accurate positioning will be used during the collection of survey data. Dynamic positioning will be used to maintain the vessel on station. A computer software and hardware system will be used to interface various data sources with a differential global positioning system (DGPS) receiver. Prior to survey mobilization, all sampling locations will be plotted and stored in the navigation software program. The DGPS receiver will be used to navigate the survey vessel to all sampling stations. The actual positions of all collected samples will be recorded and stored by the navigational software program.

The survey will involve 24-hour operations. CSA will provide six experienced personnel to conduct the environmental monitoring survey operations. CSA personnel will be augmented with Emanuelle's contractors to provide navigators, deck hands, and supervisors as needed for 24-hour operations. CSA personnel will prepare sampling equipment, direct data collection, conduct all aspects of sample processing, and arrange for shipment and delivery of samples to respective laboratories.

### **5.2 WATER COLUMN SAMPLING**

Water sampling and hydrographic profiling will be conducted at three stations within the project area (**Figure 14**). All water samples will be collected within a singular 24-hour period. Seawater samples will be collected for the analysis of turbidity, pH, nutrients (TN, TP, nitrite, nitrate, ammonium), TOC, total suspended solids, hydrocarbons (TPH), dissolved metals, and radium (Ra) 226 and Ra 228 (**Table 3**) from three water depths (near-surface, mid-water, and near-bottom). Polycyclic aromatic hydrocarbons (PAHs) will be analyzed for only in water samples where TPH is detected; this will provide a better resolution of the hydrocarbon content of the sample. Chlorophyll *a* samples will be collected from the near-surface water samples only, as samples collected from both the mid-water and near-bottom are beneath the photic zone of the water column (>200 m). Combined Ra 226 and Ra 228 samples will be collected at one station, which adheres to the Ministry's recommendation of 10% of all sampling stations. Water samples will be collected with clean Go-Flo water sample bottles mounted on a rosette carousel and actuated electro-hydraulically. Water samples will be transferred into pre-cleaned sample containers, processed on board as necessary, and stored as recommended by the U.S. Environmental Protection Agency (USEPA) protocols (U.S. Geological Survey, 2000). Water sampling protocols are summarized in **Table 4**.

Hydrographic parameters will be measured using a Sea-Bird Electronics (SBE) SBE 19*plus* conductivity-temperature-depth (CTD)/water quality profiler (or equivalent) mounted on the water sampling device. Measured parameters will include conductivity/salinity, temperature, dissolved oxygen (concentration and percent saturation), fluorescence, and turbidity. Date, time, and location of sampling will be included in the raw data. Hydrographic measurements will be profiled from near-surface to near-bottom.

Table 4. Guidelines for water sample collection (From: U.S. Geological Survey, 2000).

Parameter/ Analyte(s)	Minimum Sample Volume	Container Type and Size	Handling, Storage Conditions, and/or Preservation Method	Holding Time
TOC/TN/TP	250 mL	250-mL HDPE plastic bottle	Frozen; ship on ice	28 days
NO <sub>2</sub> , NO <sub>3</sub> , NH <sub>4</sub>	250 mL	250-mL HDPE plastic bottle	Filter through a 0.7- $\mu$ m filter and freeze filtrate; ship on ice	28 days
Total suspended solids	1 L	1-L plastic bottle	Cool to 4°C; filter in the field, rinse with 1 L deionized water, and store pre-weighed filter frozen; ship on ice	Indefinite when filtered and frozen
Chlorophyll a (near-surface water only)	1 L	1-L plastic bottle	Onboard filtration through a 0.7- $\mu$ m glass fiber filter; filter stored frozen	Indefinite when filtered and frozen
TPH*	1 L	1-L amber glass bottle	Dichloromethane; cool to 4°C; ship on ice	7 days
Dissolved Hg	500 mL	500-mL fluorinated plastic bottle	Filtered through a 0.45- $\mu$ m filter; HCl to pH <2; cool to 4°C; ship on ice	28 days
Dissolved Metals other than Hg	1 L	1 L narrow-mouth plastic bottle	Filtered through a 0.45- $\mu$ m filter; HNO <sub>3</sub> to pH <2; cool to 4°C; ship on ice	6 months
Ra 226 and Ra 228	4 L	4-L narrow-mouth plastic bottle	HNO <sub>3</sub> to pH <2; cool to 4°C; ship on ice	N/A

HDPE = high-density polyethylene; Hg = mercury; HCl = hydrochloric acid; HNO<sub>3</sub> = nitric acid; N/A = not applicable (isotope half-life based); NH<sub>4</sub> = ammonium; NO<sub>2</sub> = nitrite; NO<sub>3</sub> = nitrate; Ra = radium; TN = total nitrogen; TOC = total organic carbon; TP = total phosphorus; TPH = total petroleum hydrocarbons.

\*Polycyclic aromatic hydrocarbons will be analyzed for only if TPH is detected within a sample.

## 5.3 SEDIMENT AND INFAUNAL SAMPLING

### 5.3.1 Box Core

A deepwater winch system will be used to deploy a stainless steel 0.5-m  $\times$  0.5-m box corer (modified Gray-O'Hara type) to collect sediment. Each box core sample will be evaluated for acceptability upon return to deck using standard USEPA (2001) sediment grab sampling criteria. These criteria include the following:

- No sediment touching the top of the sampler or overflowing from the sampler;
- Clear, overlying water present in the sampler;
- No sign of channeling or sample washout; and
- No evidence of sediment loss.

Acceptable box core samples will be subsampled for sediment chemical and geological analyses and infauna. The box core sample will be partitioned using a 0.35-m  $\times$  0.35-m stainless steel insert to separate the chemical and geological subsample from the infaunal sample. All chemical and geological subsamples will be collected from the top 2 cm of sediment, while sediment to be sieved for infauna will be collected from within the stainless steel insert down to a depth of 12 to 15 cm. Within each sampling stratum, an additional core for sediment grain size will be collected to a depth of approximately 15 cm for correlation with the infaunal data. Processing for infauna is described in greater detail in **Section 5.3.3**. Pre-cleaned stainless sampling spoons will be used to collect the top 2 cm of the sediment outside of the stainless steel insert for chemical and geological analyses.

### 5.3.2 Sediment

Geological and chemical parameters will include grain size distribution, TOC, metals, hydrocarbons (TPH), and radionuclides (Ra 226, Ra 228, and thorium [Th] 228). Upon consultation with the Ministries on other projects in the region, lead (Pb 210) has been removed from the radionuclides analysis list. PAHs will be analyzed for only in sediment samples where TPH is detected; this will provide a better resolution of the hydrocarbon content of the sample. The metal analytes are listed in **Table 3**. Sediment samples will be transferred into pre-cleaned sample containers, frozen, and handled/stored as recommended by USEPA protocols. Sediment sampling protocols are summarized in **Table 5**.

Table 5. Processing and storage requirements for sediment sampling parameters.

Parameter/ Analyte(s)	Minimum Sample Weight	Container Type and Size	Storage Conditions and/or Preservation Method	Holding Time
Grain size distribution; TOC	200 g (wet)	250-mL wide-mouth plastic jar	Freeze, ship on ice, and store frozen	Indefinite when frozen
Metals	150 g	250-mL wide-mouth plastic jar	Freeze, ship on ice, and store frozen	Indefinite when frozen
TPH*	150 g	125-mL wide-mouth glass jar	Freeze, ship on ice, and store frozen	28 days
Ra 226; Ra 228; Th 228	500 g (wet)	500-mL wide-mouth plastic jar	Freeze, ship on ice, and store frozen	N/A

N/A = not applicable (half-life based); Ra = radium; Th = thorium; TOC = total organic carbon; TPH = total petroleum hydrocarbons.

\*Polycyclic aromatic hydrocarbons will be analyzed for only if TPH is detected within a sample.

### 5.3.3 Infauna

Infauna will be collected at each of the sediment sampling locations. Infaunal samples will be collected from the top 12 to 15 cm of the 0.1225-m<sup>2</sup> surface area of the insert in the box corer. Samples will be elutriated and wet-sieved on board through a 0.25-mm mesh sieve with gentle streams of seawater using a flotation technique that minimizes trauma to the infauna and facilitates separation from the sediment. Infaunal samples will be processed in the field using the overflow barrel technique, which is especially useful for the very fine sediments expected in deepwater sites. The sieved sample (containing infauna, residual sediment, and debris) will be transferred to a sample container(s) and preserved using an 8% borax-buffered formalin solution. Appropriately sized sample jars will be labeled and properly stored aboard the vessel; the lids will be sealed with electrical tape.

## 5.4 VIDEOGRAPHIC TRANSECTS

Video imagery data will be collected to visually document the types of substrate and associated biological communities in the project area. An ROV will be used to collect the bottom video. Video data will be collected along eight 400-m video transects throughout the project area as shown in **Figure 15**.

The track followed by the ROV will be recorded using the ROV's onboard navigation system. Underwater videographic data will be collected using available camera equipment mounted on the ROV system. The ROV-mounted camera will be aimed slightly above vertical to provide a field of view that includes the bottom substrate in front of the system. Video observations will be recorded continuously and used to determine seafloor features and characterize the substrate type(s) and associated biological assemblage(s).

## 6.0 Laboratory Methods, Data Processing, and Analysis

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**Tables 6 and 7** outline the analytical parameters and laboratory, analysis methods, sediment and water quality benchmarks, reporting units, and reporting limits of seawater and sediment samples, respectively. Sediment and water quality benchmarks indicate if concentrations of analytes have the potential to cause adverse ecological effects. Reporting limits or laboratory method detection limits (MDLs) 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.

### 6.1 VIDEOGRAPHY

Videographic data will be reviewed to characterize the background substrate conditions within the Sara-1 wellsite area. Additionally, the data will be analyzed to provide presence/absence and relative abundance estimates for epifauna and demersal fishes within the survey area.

### 6.2 HYDROGRAPHIC PROFILES

Digital data files from hydrographic profiles taken with the SBE 19*plus* CTD profiler will be processed by a CSA scientist or technician using SBE data processing software, a proprietary modular family of data processing software for SBE oceanographic instruments. The SBE Data Conversion, Align, Thermal Cell, Loop Edit, and Bin Average Modules will be used, as appropriate, to convert the data from the raw hexadecimal format to engineering units in a text file, extract the downcast section, remove any loops in the record, smooth the data, and import the file into a spreadsheet. Further data processing may be required to prepare the data for vertical hydrographic profiles and tabular summaries in spreadsheets to be presented in the report. Hydrographic profile graphics and a tabular listing of hydrographic data are generated from the spreadsheet.

### 6.3 SEAWATER AND SEDIMENT SAMPLES

Seawater and sediment samples will be analyzed by the various laboratories following the methods provided in **Tables 6 and 7**.

#### 6.3.1 Seawater

Results of the seawater analyses will be compared to the proposed Environmental Quality Standards for the Mediterranean Sea in Israel (also referred to as the Mediterranean Environmental Water Quality Standards [MEQS]) (Ministry of the Environment, 2002), European Union Commission on Environmental Quality Standards (EUCEQS) for priority substances in the field of water policy (Directive 2008/105/EC) and the proposed amendment (COM(2011)876), and USEPA water quality benchmarks to determine if seawater concentrations in the survey area have the potential to cause adverse ecological effects. Any sampling points with concentrations significantly greater than the MEQS or water quality benchmarks will be depicted on maps in relation to the wellsite area. The MEQS define the maximum and average concentration permitted in the marine environment. The EUCEQS are considered to be the most stringent seawater quality standards in the world, having established concentrations above which chronic impacts (Annual Average Concentration [AAC]) and acute impacts (Maximum Allowable Concentration [MAC]) are expected to occur. The USEPA Criterion Continuous Concentrations (CCCs) for seawater are estimates of the highest concentration of a material in water that an aquatic community can be exposed to indefinitely without resulting in unacceptable adverse effects. Radionuclide results for the pre-drill survey will be compared to the USEPA-established maximum contaminant level (MCL) for combined Ra 226 and Ra 228 (U.S. Environmental Protection Agency, 1976). The MCL is the 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.

Table 6. Analytical parameters, 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 <sup>1</sup>	CCC <sup>2</sup>	EUCEQS <sup>3</sup>		Israeli Mediterranean Seawater Quality Standards <sup>4</sup>		Units
						AAC	MAC	Mean	Max.	
Arsenic <sup>5</sup>	ALS Environmental 1 – Kelso	N/A	ICP-MS	7	36	--	--	36	69	µg L <sup>-1</sup>
Antimony <sup>5</sup>		N/A	ICP-MS	0.2	500 <sup>p</sup>	--	--	--	--	µg L <sup>-1</sup>
Barium <sup>5</sup>		N/A	ICP-MS	0.2	200	--	--	--	--	µg L <sup>-1</sup>
Beryllium <sup>5</sup>		N/A	ICP-MS	0.5	--	--	--	--	--	µg L <sup>-1</sup>
Cadmium <sup>5</sup>		N/A	ICP-MS	0.1	8.8	0.2	1.5	0.5	2	µg L <sup>-1</sup>
Chromium <sup>5</sup>		N/A	ICP-MS	5	-- <sup>6</sup>	--	--	10	20	µg L <sup>-1</sup>
Copper <sup>5</sup>		N/A	ICP-MS	1	3.1	--	--	5	10	µg L <sup>-1</sup>
Lead <sup>5</sup>		N/A	ICP-MS	0.1	8.1	1.3	14	5	20	µg L <sup>-1</sup>
Mercury <sup>5</sup>		N/A	Based on USEPA 1631E	0.01	0.94	--	0.07	0.16	0.4	µg L <sup>-1</sup>
Nickel <sup>5</sup>		N/A	ICP-MS	0.1	8.2	8.6	34	10	50	µg L <sup>-1</sup>
Selenium <sup>5</sup>		N/A	ICP-MS	7	71	--	--	60	150	µg L <sup>-1</sup>
Silver <sup>5</sup>		N/A	ICP-MS	0.5	--	--	--	3	7	µg L <sup>-1</sup>
Thallium <sup>5</sup>		N/A	ICP-MS	0.1	--	--	--	--	--	µg L <sup>-1</sup>
Vanadium <sup>5</sup>		N/A	ICP-MS	2	50	--	--	50	100	µg L <sup>-1</sup>
Zinc <sup>5</sup>	N/A	ICP-MS	2	81	--	--	40	100	µg L <sup>-1</sup>	
Total petroleum hydrocarbons	TDI-Brooks	Hexane	USEPA/SW-846 Modified 8100/8015C	13	--	--	--	--	µg L <sup>-1</sup>	
Polycyclic aromatic hydrocarbons*		Hexane	USEPA SW- 846/8260/ GC-MS	0.74 – 2.91	--	--	--	--	ng L <sup>-1</sup>	
Total nitrogen	Chesapeake Biological Laboratory	Persulfate digestion	Diazo colorimetric method	0.01	--	--	--	1.0		mg L <sup>-1</sup>
Ammonium		N/A	Indophenol colorimetric method	0.01	--	--	--	0.50	2.4	mg L <sup>-1</sup>
Nitrite		N/A	Diazo colorimetric method	0.0007	--	--	--	--		mg L <sup>-1</sup>
Nitrate		Cadmium reduction	Diazo colorimetric method	0.002	--	--	--	--		mg L <sup>-1</sup>
Total phosphorus		Persulfate digestion	Ascorbic acid colorimetric method	0.0013	--	--	--	0.1		mg L <sup>-1</sup>
Chlorophyll <i>a</i>		90% acetone	Fluorometric method	0.68	--	--	--	--		µg L <sup>-1</sup>
Total organic carbon		N/A	High-temperature combustion	0.24	--	--	--	--		mg L <sup>-1</sup>
Total suspended solids		N/A	Analytical balance	0.01	--	--	--	>10% and 10 mg L <sup>-1</sup> above mean		mg L <sup>-1</sup>
Radium 226	ALS	N/A	USEPA Method 903.1	1	--	--	--	--	pCi L <sup>-1</sup>	
Radium 228	Environmental 1 – Ft. Collins	N/A	USEPA Method 904.0 and SW-846 9320	1	--	--	--	--	pCi L <sup>-1</sup>	

AAC = Annual Average Concentration; EUCEQS = European Commission Environmental Quality Standard; GC-MS = gas chromatography-mass spectrometry; ICP-MS = inductively coupled plasma-mass spectrometry; MAC = Maximum Allowable Concentration; N/A = not applicable; USEPA = U.S. Environmental Protection Agency.

<sup>1</sup> Limits of quantification are the detection limits for metals and ions and reporting limit for alkanes and polycyclic aromatic hydrocarbons under ideal conditions; actual quantification limits may be elevated due to sample dilution.

<sup>2</sup> 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.

<sup>3</sup> Directive 2008/105/EC & proposed amendment COM(2011)876

<sup>4</sup> Proposed by the Ministry of Environmental Protection (2002)

<sup>5</sup> Information applicable for dissolved components.

<sup>6</sup> Chromium III = 27.4 µg L<sup>-1</sup>; Chromium VI = 50 µg L<sup>-1</sup>.

<sup>p</sup> = proposed.

\* Polycyclic aromatic hydrocarbons analyzed only if TPH is detected within a sample.

Table 7. Analytical parameters, analysis methods, reporting units, reporting/limits of quantification, and sediment quality guidelines for sediment samples.

Parameter/Analyte	Digestion/Extraction Method	Analytical/Detection/Quantification Method	Quantification Limit	ERL	ERM	Units	Analytical Laboratory
Grain size distribution	N/A	Laser diffraction particle size analysis	0.1	--	--	mm	Weatherford
Total organic carbon	N/A	Based on European Standard Norm 1484	5	--	--	ppm	
Aluminum	HF digestion <sup>a</sup>	Based on ISO 11885	2	--	--	ppm	ALS – Kelso
Antimony	HF digestion	Based on ISO 11885	1	--	--	ppm	
Arsenic	HF digestion	Based on ISO 11885	3	8.2	70	ppm	
Barium	HF digestion	Based on ISO 11885	0.5	--	--	ppm	
Beryllium	HF digestion	Based on ISO 11885	1	--	--	ppm	
Cadmium	HF digestion	Based on ISO 11885	0.5	1.2	9.6	ppm	
Chromium	HF digestion	Based on ISO 11885	1	81	370	ppm	
Copper	HF digestion	Based on ISO 11885	1	34	270	ppm	
Iron	HF digestion	Based on ISO 11885	1	--	--	%	
Lead	HF digestion	Based on ISO 11885	5	46.7	218	ppm	
Nickel	HF digestion	Based on ISO 11885	1	20.9	51.6	ppm	
Selenium	HF digestion	Based on ISO 11885	1	--	--	ppm	
Silver	HF digestion	Based on ISO 11885	1	1	3.7	ppm	
Thallium	HF digestion	Based on ISO 11885	1	--	--	ppm	
Vanadium	HF digestion	Based on ISO 11885	1	--	--	ppm	
Zinc	HF digestion	Based on ISO 11885	1	150	410	ppm	
Mercury	HF digestion	Based on ISO 11885	0.01	0.15	0.71	ppm	
TPH	Hexane	USEPA 1664/8100/8015/ GC-MS	1.4	--	--	ppm	TDI-Brooks
PAHs**	Hexane	USEPA Sw-846/8260/ GC-MS	0.04 – 0.342	552 <sup>b</sup> 4,002 <sup>c</sup>	3160 <sup>b</sup> 44,792 <sup>c</sup>	ppb	
Ra 226 and Ra 228	N/A	USEPA 903.1	1	--	--	pCi L <sup>-1</sup>	ALS – Ft. Collins
Th 226	N/A	High-resolution gamma spectrometry	0.2	--	--	pCi L <sup>-1</sup>	

ERL = effects range low; ERM = effects range median; GC-MS = gas chromatography-mass spectrometry; HF = hydrofluoric acid; PAH = polycyclic aromatic hydrocarbon; Ra = radium; Th = thorium; TPH = total petroleum hydrocarbons; USEPA = U.S. Environmental Protection Agency.

<sup>a</sup> This digestion procedure results in the release of nearly all the metal content of a sample and it is believed to be a more accurate estimate of the metal concentrations in all sample matrices.

<sup>b</sup> PAHs = low molecular weight.

<sup>c</sup> Total PAHs.

\* Quantification limit is the method reporting limit.

\*\* PAHs analyzed only if TPH is detected within a sample.

### 6.3.2 Sediment

Sediment particle sizes will be analyzed for each of the standard Wentworth size classes. Statistical comparisons will be conducted and interpreted in the context of the actual values (means) relative to benchmark values to evaluate their biological relevance. A benchmark is a chemical concentration in sediment above which there is the possibility of harm to organisms in the environment.

Hydrocarbon and metal concentrations will be compared to the USEPA sediment quality benchmarks to determine if sediment concentrations in the survey area have the potential to cause adverse ecological effects. The USEPA recommends benchmark values such as the ERL and ERM to assess the potential risk to fish and other marine life (Long and Morgan, 1990). 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 (most 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.

Any samples with concentrations significantly greater than ERL and ERM values will be depicted on maps in relation to existing infrastructures and wells.

### 6.4 INFAUNA

Infaunal specimens will be sorted, counted, and identified to the lowest practical identification level. As appropriate, specimens will be sent to taxonomic experts for identification. The infauna will be transferred from the formalin preservative to denatured alcohol for archival. Densities of taxonomic categories will be computed based on count data, as appropriate. Various indices will be computed to describe the macrobenthic infaunal assemblage, including Shannon-Weiner diversity ( $H'$ ), Pielou's evenness ( $J$ ), and equitability based on Simpson's diversity index ( $D$ ). Summary statistics, including number of taxa, number of individuals, diversity, evenness, and species richness, will be calculated for each sampling station. The raw data matrix will be converted into a Bray-Curtis similarity matrix. To determine which taxa will be most responsible for driving patterns observed in the samples, similarity percentages will be performed (Clarke and Gorley, 2006). Similarity percentages determine the percentage contribution of each taxon to the mean dissimilarity between sample stations. A species/area curve (rarefaction) will be developed to measure sampling adequacy.

### 6.5 DATA ANALYSIS

A mean and standard deviation will be obtained for each stratum within the survey area. These values will be compared against each other and provide a basis for comparison for the post-drill survey using a set of statistical analysis tools. Additionally, concentrations for chemical tests on the sediment and/or seawater that are determined to be greater than ERL and ERM values will be provided in a map format; however, because certain metals in Levantine Basin sediments are regularly above the ERL (e.g., arsenic) or ERM (e.g., nickel) values, all anomalous values will be taken into an appropriate context regarding the survey area before being called out as anomalous.

A QA program is undertaken to ensure that the project generates scientifically defensible data of known quality that meet the project objectives. In addition to the QC measures described here, QA is furthered by the selection of a qualified analytical laboratory, deployment of an experienced field team, and detailed preparation during mobilization.

### ***Analytical Laboratory***

The selected analytical laboratories have established QA programs and extensive experience in the analysis of seawater and marine sediment samples.

### ***Field Personnel***

The field survey team is staffed with well-qualified and highly experienced CSA personnel. The use of experienced staff who follow appropriate precautions and are attentive to detail when conducting the field surveys minimizes error, enhances quality, and maximizes efficiency in conducting the survey on a 24-hour basis. Field team members will work in 12-hour shifts and provide a briefing and notes to personnel on the next shift to ensure continuity.

### ***Mobilization***

Prior to the survey, the SOW/SAP will be reviewed by the project team to ensure that the field survey will be conducted according to the approved scope. Requirements for containers, chemicals, and other field supplies; field methods and procedures; sample identification labels; checklists; chain-of-custody (CoC); sample disposition and shipping arrangements; and QC measures will be assessed. Responsibilities and action items are assigned to field team members as appropriate. A mobilization item list will be prepared by the Chief Scientist and Mobilization Manager and reviewed by the Project Manager for accuracy and completeness.

## **7.1 QUALITY CONTROL**

The typical QC measures observed by CSA during the conduct of projects include the 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 will include equipment blanks, field blanks, laboratory splits, sample/data checklists, and data checks. Adequate volumes of all blanks will be placed in the same type of sample containers as the primary samples and clearly labeled for each analysis, along with the date and location. Post-survey shipment and sample tracking will ensure delivery of samples to designated laboratories within the recommended holding times and condition.

### ***Equipment Blanks***

After the sampling equipment is cleaned, an equipment blank will be prepared by pouring deionized water through the equipment and collecting the rinsate in a pre-cleaned sample container bottle that will be labeled and shipped to the laboratory in the same fashion as the other samples.

### ***Field Blanks***

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

### ***Laboratory Quality Control – Sample Splits***

Laboratory QC measures include the analysis of randomly selected sample splits from the samples provided.

### ***Sea-Bird Profiler Data Check***

During a water column profile cast, or soon after one is completed, the SBE hydrographic data will be examined by a CSA scientist to check that the collected data are within expected ranges (for the conditions at the study area), the equipment is functioning normally, and the configuration and data files are in good order.

### ***Data and Sample Collection Checklists***

Prior to the survey, data and sample checklists will be prepared by the Chief Scientist and completed in the field as appropriate for QC. Prior to departing each sampling station, the Chief Scientist or his designee will review the checklist and physically examine and confirm data files, log books, and sample containers to ensure the data and samples required from the station were collected and properly stored.

### ***Sample Preservation and Holding Times***

Samples will be preserved as specified by applicable regulations or industry practice and transported to the laboratories for analysis under appropriate preservation and handling conditions.

## **7.2 SAMPLE HANDLING AND TRANSPORT**

After sample collection, proper sample handling protocols will be followed to ensure that valid results are obtained from the analysis of each sample.

All samples will be transported and shipped under a CoC process. Proper CoC will be maintained for all samples, and a CoC record will accompany all samples. Each person involved with the custody of the sample(s) is responsible for signing the appropriate forms and ensuring that the samples are properly handled, stored, transported, and/or analyzed. Each sample will have a unique identifier that can be directly tracked to the field logbook or data sheets. Labels will be waterproof or covered with clear tape and securely fastened to the container. Labels will also contain information concerning date of collection, preservation information, and the person responsible for sample collection. Shipping containers will need to be adequate to protect the sample containers and avoid breakage. Containers will be secured to be leak proof, avoid cross-contamination, and prevent sample loss during shipment.

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

## **7.3 DOCUMENT AND DATA SECURITY**

Navigation and positioning data, along with field data files from the Sea-Bird CTD and underwater video, will be saved to a computer file and backed up on a separate, removable medium (e.g., backup computer, flash memory/data stick, or DVD/CD-R/RW). Backup media will be stored and transported separately from the field computer. Upon return to CSA's corporate headquarters in Stuart, Florida, the Chief Scientist will ensure that all data are properly backed up and/or archived on CSA's local area network file server or other appropriate alternative.

#### **7.4 DATA AND DOCUMENT REVIEW**

Data review and QC procedures will be implemented to ensure that sample and data collections from the field and analytical results from laboratories are accurate and accompanied by required metadata. A CSA scientist with requisite experience and background will review all datasets prior to data analysis and inclusion into the report. The draft report will be subject to in-house technical and editorial review and copy proofing.

The Sara-1 Wellsite Re-Entry Operation Background Monitoring Survey will comply with the updated Guidelines for Monitoring the Marine Environment due to Oil and Natural Gas Exploration Activities in Israel (Appendix B1 of the Environmental Document for Gas and Oil Exploratory Drilling for Monitoring of the Marine Environment). The report will present data to document the physical, chemical, geological, and biological conditions within the survey area. Survey results will be compared to the proposed MEQS (Ministry of the Environment, 2002) and USEPA sediment and water quality benchmarks to determine if concentrations in the survey area have the potential to cause adverse ecological effects.

The report will describe methods and QC procedures utilized during sample collection and laboratory analyses. A written description of the type of area each sampling point represents also will be included, and a table of the sampling locations will be provided as an appendix to the report. Coordinates will be provided in WGS84, UTM Zone 36N, and Israel Datum ITM. The report will include maps, figures, and other illustrations referencing the sample locations as well as the analytical results. Any samples with concentrations significantly greater than the sediment or water quality benchmarks will be depicted in maps in relation to the project area.

The report will be submitted to the MoEP (Marine and Coastal Environmental Division) and MNIWR (Petroleum Commissioner) in five hard copies and electronically as Adobe Acrobat PDF files. In addition, copies of the laboratory reports and the data in the Israel Oceanographic and Limnological Research (IOLR) format for uploading to the National Marine Information Center as per Appendix B1.1 of the IOLR Environmental Guidelines will be provided.

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## 9.0 Project Team and Corporate Qualifications

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CSA and its science and operations personnel have decades of experience conducting environmental surveys in the U.S. and abroad. CSA is very familiar with using scientifically defensible, logistically efficient, and field-proven approaches, methods, and technologies for environmental monitoring of offshore oil and gas facilities. CSA's ability to mobilize and execute field programs, coupled with scientific rigor, is well recognized in the oil and gas industry. The hundreds of projects with sample and data collection components in the U.S. and internationally that CSA has conducted for multiple clients are a testament to CSA's expertise and competence. CSA has or is currently providing environmental services to operators in various geographic areas, including Israel, Cyprus, Nicaragua, and the Gulf of Mexico. Selected examples of CSA's environmental monitoring and related experience are provided in **Appendix B**.

As the prime contractor, CSA will be responsible for coordinating the efforts of all subcontractors and producing the project report for submission to the appropriate Ministries. CSA scientists will be responsible for QC of all collected data and will prepare the final report and deliverables. CSA's extensive corporate and individual staff experience with offshore environmental monitoring survey and management will ensure collection of scientifically defensible samples and data.

### 9.1 KEY PERSONNEL

CSA has assembled a well-qualified team to implement the EMP. The project team was specifically brought together because of their knowledge, expertise, and experience conducting similar projects as well as a wide range of additional projects employing their assigned technical field of expertise. Biosketches for CSA's key personnel are provided in **Appendix C**.

Mr. Elad Mills and Mrs. Deborah Fawcett, experts on environmental impacts, will be the CSA Project Managers. Dr. Yossi Azov and Dr. Alan Hart, CSA's Executive Vice President – Energy, will be responsible for technical execution and oversight of the work. Bruce Graham, a CSA Senior Scientist and marine specialist with extensive experience conducting similar projects, will be the lead benthic ecologist and will assist Mr. Mills and Mrs. Fawcett with program management. Mr. Graham and Mr. Stephen Viada, both benthic ecologists, and Mr. David Snyder, a specialist on fish and other nekton, will provide expertise in their fields and develop the biological sections of the report. Each scientist has at least 25 years of experience in their respective fields. The field survey team will be led by Mr. Graham, Mr. Viada and/or Dr. Christopher Kelly. Mr. Mills together with Dr. Kelly, a marine ecologist, will be primarily responsible for preparing the report, with contributions from other project team members. Mr. Mills, a marine specialist on the Israeli coastal and offshore environment, and Mrs. Fawcett, a marine scientist with more than 10 years of experience in marine survey programs, will contribute to survey operations. Dr. Kelly will also assist with the statistical analysis of acquired data.

### 9.2 SUBCONTRACTORS

The analytical laboratories selected for this program are TDI-Brooks International, Inc. (TDI-Brooks)/B&B Laboratories, ALS Group Analytical Laboratory (ALS), Weatherford Laboratories (WL), Chesapeake Biological Laboratory (CBL), and EcoAnalysts, Inc. As requested by the MoEP, an accredited U.S. laboratory specific to hydrocarbon analyses, TDI-Brooks/B&B Laboratories, will be used for analyses of water and sediment hydrocarbon samples. The ALS laboratory in Kelso, Washington, will be used for analyses of water and sediment metals. The ALS laboratory in Fort Collins, Colorado, will conduct the radioactivity analyses. CBL will determine the nutrient and total suspended solids concentrations. WL will analyze the sediment grain size and TOC samples. EcoAnalysts, Inc. will conduct the infaunal taxonomic identification and analyses.

### **9.2.1 TDI-Brooks International, Inc./B&B Laboratories**

TDI-Brooks owns B&B Laboratories, a laboratory facility in College Station, Texas. B&B Laboratories has state-of-the-art equipment and an accomplished staff with a broad range of published expertise in geochemistry and environmental chemistry. They specialize in the analysis of organics, including petroleum hydrocarbons, and have extensive experience in analysis of seawater and marine sediments. B&B Laboratories operates a Quality Management System that complies with the requirements of ISO 9001:2008 for the analysis of geochemical, geotechnical, and environmental samples. They have certification validating that all analytical processes are fully established, functional, and meet international standards. B&B Laboratories has participated in the highly rigorous U.S. *National Institute of Standards and Technology* intercalibration exercise for trace organics since 1997 and has always ranked in the top group for the exercise.

### **9.2.2 ALS Group Analytical Laboratory**

ALS is one of the world's largest and most diversified testing services providers. ALS provides sophisticated, modern analytical services specific to the minerals (i.e., geochemistry), life sciences (i.e., environmental), and energy (i.e., oil and gas) industries. More than 20 million samples per year are analyzed by ALS's staff of 13,000 people at 350 locations in 55 countries around the world. ALS's major hub facilities are located in Australia, Asia, North America, South America, Europe, the Middle East, and Africa.

#### ***Kelso, Washington, United States***

ALS – Kelso is a National Environmental Laboratory Accreditation Program-accredited contract laboratory with extensive experience in the analysis of seawater and marine sediments. ALS – Kelso has approximately 57,500 sq. ft. of laboratory space with highly trained support staff providing enhanced testing services. Specialized procedures at ALS – Kelso include the ultra-trace determination of analytes in difficult sample matrices, including marine sediments, water samples, and tissue.

#### ***Fort Collins, Colorado, United States***

ALS – Fort Collins is a premier radiochemistry and environmental laboratory that serves the U.S. Department of Energy and U.S. Department of Defense as well as numerous environmental engineering and consulting firms and the private industry. ALS – Fort Collins performs a full range of organic, inorganic, and radiochemical analyses; holds a current Radioactive Materials Handling License in the State of Colorado; and has 18 other U.S. State accreditations.

### **9.2.3 Weatherford Laboratories, Inc.**

WL is a long-established geochemical service laboratory with extensive experience supporting the oil and gas industry, universities, consultants, and consortiums. WL offers laboratory services at 14 locations in North America, 6 locations in Latin America, 6 locations in Asia/Pacific Rim, 6 locations in the Middle East/North Africa, and 5 locations in Europe. WL combines a global team of geoscientists, engineers, technicians, and researchers with the industry's most comprehensive, integrated laboratory services worldwide.

### **9.2.4 Chesapeake Biological Laboratory**

CBL's Nutrient Analytical Services Laboratory provides a wide range of water quality analyses on state-of-the-art instrumentation while following strict quality assurance/quality control (QA/QC) procedures. CBL provides services to several U.S. governmental agencies (Environmental Protection Agency, Geological Survey, and Fish and Wildlife Service), local regulatory agencies (Maryland Department of Natural Resources, Maryland Department of the Environment), and many private

environmental firms. CBL is a national leader in environmental chemistry and toxicology, ecosystem science, and restoration ecology.

#### **9.2.5 EcoAnalysts, Inc.**

The EcoAnalysts team of taxonomists comprises 10 taxonomists with 20 North American Benthological Society certifications and more than 190 years of combined taxonomy experience. Multiple taxonomists working on a project increases accuracy and repeatability of identifications. In addition to their taxonomy capabilities, EcoAnalysts employs 15 full-time professional sorting technicians, including specially trained QC technicians. This allows EcoAnalysts to minimize the potential for introducing sorting error in the bioassessment process. As the largest bioassessment laboratory in North America, EcoAnalysts processes more than 6,000 benthic samples annually and has completed projects throughout North America, as well as in Suriname, Peru, Brazil, Mexico, Dominican Republic, Australia, and India. EcoAnalysts serves federal, state, and municipal government agencies; environmental engineering and consulting firms; environmental law firms; regulated industry clients; volunteer monitoring groups and watershed councils; universities; tribes; and a variety of non-governmental organizations.

- Alder, E. 1985. The submerged kurkar ridges off the northern Carmel Coast. Master's Thesis, Department of Maritime Civilizations, University of Haifa, Israel. 106 pp (Hebrew, English abstract).
- Almagor, G. and J.K. Hall. 1984. Morphology of the Mediterranean Continental Margin of Israel: a Comparative Summary and a Bathymetric Chart. Geological Survey of Israel.
- Alpert, P. and B. Ziv. 1989. The Sharav Cyclone: Observations and some theoretical considerations. *J. Geophys. Research* 94 (D15):18495-18514.
- Berman, T., Y. Azov, Y. Schneller, P. Walline, and D.W. Townsend. 1986. Extent, transparency, and phytoplankton distribution of the neritic waters overlying the Israeli coastal shelf. *Oceanologica Acta* 9:439-447.
- Buchman, M.F. 2008. Screening quick reference tables. NOAA OR&R Report 08-1. NOAA, Office of Response and Restoration, Seattle, WA. 34 pp.
- Clarke, K.R. and R.N. Gorley. 2006. PRIMER version 6 User manual/Tutorial. Primer-E Ltd: Plymouth, U.K. 190 pp.
- Dimitrov, L. and J. Woodside. 2003. Deep sea pockmark environments in the eastern Mediterranean. *Mar. Geol.* 195:263-276.
- European Parliament and Council. 2008. Directive 2008/105/EC on environmental quality standards in the field of water policy. Official Journal of the European Union.
- Flocas, H.A., I. Simmonds, J. Kouroutzoglou, K. Keay, M. Hatzaki, D. Asimakopoulos, and V. Bricolas. 2010. On cyclonic tracks over the eastern Mediterranean. *Journal of Climate* 23:5,243-5,257.
- Flocas, H.A., I. Simmonds, J. Kouroutzoglou, K. Keay, M. Hatzaki, V. Bricolas, and D. Asimakopoulos. 2011. The passage of storms through the eastern Mediterranean. Accessed at: [http://www.wcrp-climate.org/WGNE/BlueBook/2011/individualarticles/02\\_Flocas\\_Helena\\_wgne\\_2011\\_east\\_med\\_cyclone\\_tracks\\_flocas\\_simmonds\\_et\\_al.pdf](http://www.wcrp-climate.org/WGNE/BlueBook/2011/individualarticles/02_Flocas_Helena_wgne_2011_east_med_cyclone_tracks_flocas_simmonds_et_al.pdf).
- Galil, B.S. 2004. The limit of the sea: the bathyal fauna of the Levantine Sea. *Scientia Marina* 68:63-72.
- Galil, B.S. and M. Goren. 1994. The deep sea Levantine fauna. New records and rare occurrences. *Senckenbergiana marit.* 25(1/3):41-52.
- Hall, J.K. and R. Calvo. 2005. Digital shaded relief maps of Israel. Geological Survey of Israel.
- Hurlbert, S.H. 1984. Pseudoreplication and the Design of Ecological Field Experiments. *Ecological Monographs* 54(2):187-211.
- Kress, N., A. Golik, B. Galil, and M.D. Krom. 1993. Monitoring the disposal of coal fly ash at a deep water site in the eastern Mediterranean Sea. *Mar. Poll. Bull.* 26(8):447-456.
- Krom, M.D., N. Kress, S. Brenner, and L.I. Gordon. 1991. Phosphorus limitation of primary productivity in the eastern Mediterranean Sea. *Limnol. Oceanogr.* 36:424-432.
- Krom, M.D., E.M.S. Woodward, B. Herut, N. Kress, P. Carbo, R.F.C. Manoura, G. Spyres, T.F. Thingstad, P. Wassman, C. Wexels-Riser, V. Kitidis, C.S. Law, and G. Zodiatis. 2005.

- Nutrient cycling in the south east Levantine basin of the eastern Mediterranean: Results from a phosphorus starved system. *Deep Sea Res. Part II* 52(2-3):2,879-2,896.
- Kröncke, I., M. Türkay, and D. Fiege. 2003. Macrofauna communities in the eastern Mediterranean deep sea. *Marine Ecology* 24(3):193-216.
- Lawrence, J., T.D. Mudge, D.B. Fissel, K. Borg, and J. Rietsma. 2011. 2009-2011 Ocean Currents at Tamar and the Pipeline Route: Metocean Design Criteria Values. ASL Environmental Sciences, Inc. ASL File: PR-658.
- Long E.R. and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52. National Oceanic and Atmospheric Administration. Seattle, Washington.
- Loubrieu, B. and J. Mascle. 2007. Morpho-Bathymetry of the Mediterranean Sea. Medimap Group. CIESM and IFREMER Special Publications 1:3,000,000.
- Mandel, M., P. Alpert, and I. Osetinsky. 2006. Assessing the eastern Mediterranean mesoscale circulation by clustering the daily weather. The Annual Meeting of Israel Meteorological Society, 23 March 2006, Basel Hotel, Tel Aviv.
- Mazzocchi, M.G., E.D. Christou, N. Fragopoulou, and I. Siokou-Frangou. 1997. Mesozooplankton Distribution from Sicily to Cyprus (eastern Mediterranean): I. General aspects. *Oceanol. Acta* 20:521-524.
- Ministry of the Environment. 2002. Environmental Quality Standards for the Mediterranean Sea in Israel. Marine and Coastal Environment Division. 36 pp.
- Moutin, T. and P. Raimbault. 2002. Primary production, carbon export and nutrients availability in western and eastern Mediterranean Sea in early summer 1996 (MINOS cruise). *J. Mar. Syst.* 33-34:273-288.
- Spanier, E. 2000. Artificial reefs off the Mediterranean coast of Israel, Chapter 1. In: A.C. Jensen, K.J. Collins, and A.P.M. Lockwood (eds.), *Artificial Reefs in European Seas*, 1-9. Kluwer Academic Publishers, Lockwood, Kluwer, Great Britain. 508 pp.
- Rohling, E.J., R.H. Abu-Zied, J.S.L. Casford, A. Hayes, and B.A.A. Hoogakker. 2009. The marine environment: present and past, pp. 33-67. In: J.C. Woodward (ed.), *The Physical Geography of the Mediterranean*. Oxford University Press, Oxford.
- RPS Group. 2011. Proposed Sara-1 (revised) Well Location Drilling Constraints and Geohazard Study for GeoGlobal Resources Inc. Submitted July 2011. 25 pp.
- U.S. Environmental Protection Agency. 1976. Interim primary drinking water regulations – promulgation of regulations on radionuclides: *Federal Register*, v. 41, July 9, 1976, Part II, pp. 28,402-29,409.
- U.S. Environmental Protection Agency. 2001. Methods for collection, storage and manipulation of sediments for chemical and toxicological analysis. EPA-823-B-01-002. Office of Water, Washington, D.C., USA.
- U.S. Geological Survey. 2000. Interagency Field Manual for the Collection of Water-Quality Data. Open-File Report 00-213. Compiled by D.L. Lurry and C.M. Kolbe. U.S. Geological Survey, in cooperation with the U.S. Environmental Protection Agency, Austin, TX.

Zodiatis, G., B. Manca, and E. Balopoulos. 2001. Synoptic, seasonal and interannual variability of the warm core eddy south of Cyprus, SE Levantine Basin. *Rapp. Comm. Int. Mer Medit.* 36:89.

## **Appendices**

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## **Appendix A**

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### **Sara Wellsite Environmental Monitoring Program Report**

## **Appendix B**

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### **Relative CSA Project Experience**

## U.S. PROJECTS

### **U.S. DEPARTMENT OF ENERGY (1992 to 1997)**

CSA conducted a multiyear study of the environmental impacts associated with produced water discharges from oil and gas operations in the Gulf of Mexico and coastal Louisiana. CSA served as the prime contractor for the study, managed a seven-company team of experts, and organized and coordinated a Scientific Review Committee. The primary project goal was to increase the base of scientific knowledge concerning 1) the characteristics of produced water and also produced sand discharges as they pertain to organics, metals, and naturally occurring radioactive materials (NORM) variably found in association with the discharges; 2) the fate of organics, metals, and NORM in water, sediment, and biota near a number of offshore oil and gas production facilities; 3) the recovery of two terminated produced water discharge sites located in open bay areas of coastal Louisiana; and 4) the catch, consumption, and human use patterns of seafood species collected from coastal and offshore waters. A plan of study in the form of a Field Plan (Sampling and Analysis Plan) was prepared. These data were used in an ecological risk assessment for organics and metals that was performed under this contract. The data were also used by Brookhaven National Laboratory for an ecological risk assessment for radionuclides and a human health risk assessment for organics, metals, and radionuclides. The study also examined the economic and energy supply impacts of existing and anticipated Federal and State offshore and coastal discharge regulations.

### **OFFSHORE OPERATORS COMMITTEE (1994 to 1997)**

CSA conducted the Gulf of Mexico Produced Water Bioaccumulation Study for the Offshore Operators Committee (OOC). This industry-wide study was designed to replace many site-specific bioaccumulation monitoring studies by individual operators to satisfy National Pollution Discharge Elimination System (NPDES) Permit requirements by the U.S. Environmental Protection Agency (EPA), Region VI. The program had two components: 1) the Definitive Component; and 2) the Platform Survey Component. The two objectives of the Definitive Component were 1) to determine whether statistically significant bioaccumulation of produced water related organics and inorganics occurs in the edible tissue of resident fish and invertebrates in the immediate vicinity of representative Gulf of Mexico offshore platforms that discharge more than 4,600 bbl/day of produced water; and 2) to evaluate the environmental significance of any statistically significant increases observed due to produced water related bioaccumulation in edible tissue. The Platform Survey Component collected additional data on the bioaccumulation of selected chemical constituents in the edible tissue of marine organisms found in the immediate vicinity of a set of offshore Gulf of Mexico platforms. CSA prepared Sampling and Analysis Plans prior to offshore surveys, which were conducted during Fall 1994, Spring 1995, and Fall 1995. For the Definitive Component, produced water, ambient water, and fish and invertebrate tissue samples were collected and analyzed for volatile and semivolatile organic compounds, metals, and radionuclides. Only tissue samples were collected and analyzed for the Platform Survey Component. Post Survey Reports and Data Reports were submitted after each of the cruises. In addition to a Final Report for each component, a Bioaccumulation Literature Review was prepared as a separate document for the Definitive Component. CSA gave oral presentations of the study design and results to the OOC and EPA.

### **U.S. DEPARTMENT OF THE NAVY, SOUTHERN DIVISION, NAVAL FACILITIES ENGINEERING COMMAND (2002 to 2003)**

CSA provided numerous marine environmental services associated with increased Fleet training, support, and infrastructure improvements at the Naval Air Facility in Key West, Florida. The proposed action involved dredging in Truman Annex Harbor and the associated Turning Basin and Main Ship Channel, along with subsequent dredged material disposal. CSA managed the marine biology, chemistry, bioassay, and bioaccumulation aspects of the project and conducted the marine data analysis, synthesis, and reporting of these aspects. CSA prepared the marine environmental sections of the Environmental Assessment (EA) in accordance with the National Environmental Policy Act (NEPA), regulations on implementing NEPA procedures from the Council on Environmental Quality and Department of the Navy, and other related Acts, Executive Orders, and requirements. In addition to the EA, CSA prepared a Biological Assessment in accordance with

requirements of the Endangered Species Act. CSA also prepared an Essential Fish Habitat Assessment as required by Final Rule provisions of the Magnuson-Stevens Fishery Conservation and Management Act. CSA conducted a Tier I Evaluation according to U.S. Army Corps of Engineer (USACE) Testing Manuals for dredged material management. CSA prepared a Sampling and Analysis Plan and Quality Control Plan for CSA's Bathymetric Survey, Biological Characterization Survey, Sediment and Water Quality Sampling Survey, and subcontractor laboratory analyses. CSA also conducted these surveys. In addition, CSA prepared marine environmental information for other project permits, including the National Marine Sanctuary General Permit, Florida Environmental Resource Permit, Water Quality Certificate, Coastal Zone Consistency Determination and Certificate, etc. CSA attended the Project Kickoff Meeting with the Navy and other meetings with the Florida Department of Environmental Protection, Environmental Protection Agency, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, USACE, etc.

#### **MOBIL EXPLORATION & PRODUCING U.S. INC. (1994 to 1995)**

CSA conducted a tiered monitoring program to satisfy U.S. Environmental Protection Agency requirements in Viosca Knoll Block 202. The monitoring was done to satisfy a National Pollutant Discharge Elimination System permit stipulation for exploratory drilling in the block and to comply with the Section 403(c) requirements of the Clean Water Act. The monitoring plan involved three tiers: Tier 1 – pre-drill and post-drill sediment chemistry surveys; Tier 2 – an infaunal community structure survey; and Tier 3 – a bioaccumulation study. A plan of study in the form of a Sampling and Analysis Plan was prepared. The pre-drill and post-drill Tier 1 sediment chemistry surveys were conducted at four stations. Results of the post-drill survey were used to determine if significant changes in the levels of drill mud components in the sediments had occurred. These elevations were found and the Tier 2 survey was required. If significant changes in the benthic community structure had been detected and shown to correlate with elevations in drill mud component levels during the Tier 2 survey, the Tier 3 bioaccumulation study would have been performed. Since the results of the Tier 2 survey did not show correlated changes, the Tier 3 survey was not required or conducted. (Note: Bioaccumulation study was not conducted for this project because it was determined it was not required.)

#### **AMERICAN PETROLEUM INSTITUTE (1991 to 1993)**

CSA conducted a study of two platforms offshore of Louisiana to determine concentrations of radioactivity in tissue, sediment, and water samples as caused by naturally occurring radioactive materials (NORM). The study included analysis of samples from biofouling community organisms, benthic soft substrate megafaunal community organisms, mid-water fish, produced water discharges, and sediments for radionuclide content. Sediment samples were also analyzed for grain size. Current data as well as water column salinity, temperature, depth, and dissolved oxygen data were also collected. A plan of study in the form of a Sampling and Analysis Plan was prepared.

#### **MID-CONTINENT OIL AND GAS ASSOCIATION (1989 to 1991)**

CSA investigated levels of radium 226/228 in the vicinity of produced waters discharges at three industrial facilities. Levels were measured in water, sediment, and tissues sampled near the discharge canals. Water quality sampling was also conducted.

#### **SOHIO PETROLEUM COMPANY (1985 to 1987)**

CSA conducted an environmental monitoring program during the drilling of an exploratory well in Gainesville Area Block 707 (eastern Gulf of Mexico). The primary purpose of the program was to determine if the drilling operation affects the seagrass *Halophila decipiens* in the vicinity of the drillsite. Program elements included seagrass and live bottom photography; surficial sediment and sediment trap samples for barium, chromium, and iron; current meter and transmissometer data collection; and biota collection to determine bioaccumulation of barium and chromium.

#### **MOBIL PRODUCING TEXAS & NEW MEXICO INC. (1982 to 1986)**

CSA conducted a comprehensive environmental monitoring program during the drilling of eight wells from a production platform near the East Flower Garden Bank in the Gulf of Mexico. The program

included the collection and chemical analyses of surficial sediments, trapped sediments, and discharged drilling muds for trace metals and high molecular weight hydrocarbons. The program also included continuous recording of water current speed and direction at various depths; hydrographic profiles of salinity, temperature, and dissolved oxygen; analyses of bivalves for bioaccumulation; and extensive quantitative analyses of larval settling rates and lateral and vertical growth of hermatypic corals. In addition, a damage assessment survey was performed following the observation of a vessel anchored in the coral reef zone. A reassessment of the surveyed area was performed 2 years later to document recovery.

#### **UNION OIL COMPANY OF CALIFORNIA (1982 to 1983)**

CSA conducted a comprehensive environmental monitoring program during the drilling of one exploratory well near the West Flower Garden Bank in the Gulf of Mexico. The program included video and still camera photographic documentation, collection and chemical analyses of surficial and trapped sediments, analyses of discharged drilling fluids, hydrographic profiles, continuous water current data recording, analyses of bivalves for bioaccumulation, and extensive quantitative analyses of growth of hermatypic corals. Site clearance and anchor placement surveys were conducted using underwater video and still photography.

## INTERNATIONAL PROJECTS

### **SHELL CHEMICAL YABUCOA, INC. (2005 to 2008)**

CSA conducted a 403(c) monitoring program related to a National Pollutant Discharge Elimination System (NPDES) permit for a discharge from the Shell Chemical Yabucoa, Inc. (SCY) refinery into Yabucoa Bay, Puerto Rico. CSA also conducted three additional studies required by the Puerto Rico Environmental Quality Board (EQB) under the NPDES permit. Prior to conducting the studies, a Toxicity Testing Protocol and Metals Translator Study (MTS) Protocol prepared by CSA were reviewed and approved by the EQB. The 403(c) Plan of Study, a Quality Assurance Project Plan required for the 403(c), and additional studies prepared under a previous project by CSA were approved by the Environmental Protection Agency (EPA) and EQB. The 403(c) monitoring program required by the EPA consisted of two major elements: 1) whole effluent evaluation, which consisted of priority pollutant scans and biotoxicity tests, on a quarterly basis; and 2) analysis of sediment quality and the benthic community, which included the macroinfaunal community, coral reefs, and seagrass beds within Yabucoa Bay. Compositing (whole) effluent samples were collected quarterly for toxicity testing and priority pollutant scans. Effluent samples also were to be annually tested for toxicity for a period of 3 years. A field survey was conducted for sampling and analysis of sediment quality and the benthic community in the dry season. Sediment sampling was performed at six stations in the vicinity of the ocean outfall and at three reference stations. The macrobenthic communities, coral reefs, and seagrass beds adjacent to the ocean outfall were surveyed. Quarterly toxicity testing reports were submitted to EPA. Annual reports detailing the results of the quarterly whole effluent sampling and priority pollutant analysis and the benthic field survey were prepared and submitted to the EPA and EQB. The Interim Mixing Zone Validation Study (IMZVS) involved sampling ambient water at the mixing zone and effluent on a monthly basis for 1 year and then yearly for 3 years thereafter. Hourly samples were collected over a 6-hour period, composited, and the time-composited samples analyzed for metals and other parameters specified in the permit. The MTS involved sampling ambient water at the mixing zone and effluent over 10 sampling events in 2005 to 2006 under stringent "Clean Hands" techniques and analyzing the samples for lead and copper with low-level methods. A plan of study in the form of Sampling and Analysis Plan for each study was prepared. Post-cruise field reports and preliminary data reports for the monthly IMZVS and MTS surveys were submitted. Reports were prepared upon completion of the IMZVS and MTS and submitted to EQB. Reports also were prepared for the annual Toxicity Testing and IMZVS surveys and submitted to EPA and EQB, respectively. In addition, CSA assisted SCY in preparing a report addressing Special Condition 23 of the permit and prepared responses to EPA on issues concerning selenium in the effluent. CSA prepared a response to EPA's determination that seagrass toxicity testing was required based on Endangered Species Act consultations with the National Marine Fisheries Service (NMFS) and the Fish and Wildlife Service (FWS). The response was instrumental in dissuading NMFS and FWS from requiring SCY to conduct additional monitoring of seagrass communities in Yabucoa Bay.

### **BHP BILLITON (TRINIDAD 2-C) LIMITED (2009 to 2010)**

CSA conducted a field sampling survey associated with produced water discharge in the nearshore Guayaguayare Bay area off the southeast coast of Trinidad, Trinidad and Tobago, West Indies. Water and sediment samples were collected for analyses of BTEX (benzene, toluene, ethylbenzene, and xylenes), polycyclic aromatic hydrocarbons, and radionuclides. A plan of study in the form of a Sampling and Analysis Plan was prepared. A report was prepared to present the results of the surveys and analyses and, where appropriate, compare those results with findings of other similar studies. This project was conducted as a subcontract to CSA International, Inc, TT Branch.

### **CLIENT AND FACILITY CONFIDENTIAL**

CSA was contracted to develop an ecological sampling program associated with the discharge of produced water from a floating production, storage, and offloading (FPSO) facility in the South China Sea. The sampling program included sampling and analysis of water, sediment, and fish tissues as well as a description of the sampling design, field and laboratory methodologies, and quality assurance/quality control (QA/QC) measures. A plan of study in the form of a Sampling and Analysis

Plan was prepared. CSA also purchased the necessary equipment and provided personnel to participate in the sampling cruise to monitor QA/QC and train facility personnel. CSA prepared a baseline survey report and two quarterly monitoring reports that included an interpretation of the laboratory analyses.

#### **MAXUS SOUTHEAST SUMATRA, INC. (1996 to 1997)**

CSA managed three subcontractors and provided data and consultation for an Effluent Discharge Impact modeling effort of the acute and chronic (bioaccumulation) toxicity of produced water discharges on fish and zooplankton in Indonesia. The data consisted of 96-hour LC<sub>50</sub> toxicity testing on two produced water samples. The tests were performed on non-aged and aged or biodegraded produced water samples with *Mysidopsis bahia* (brine shrimp) and *Menidia beryllina* (silverside fish). Samples of non-aged and aged produced waters were analyzed for an extensive number of organic compounds. Uptake of nonylphenol by *Mysidopsis* was also determined from <sup>14</sup>C. Guidance on the incorporation of these results and other data into the model was provided as well as suggestions on how to model biological uptake of the produced water constituents. This project was conducted as a subcontract to P.T. Environmental Indonesia.

#### **TULLOW GHANA LIMITED (2010 to 2011)**

CSA completed a study to assess the impacts of drill cuttings and associated non-aqueous drilling fluids on benthic and pelagic systems located in the Jubilee Field, Ghana. Two primary tasks were completed, including 1) preparing a literature review summarizing the scientific and grey literature on drill cuttings discharge and related impacts as well as regulatory limits and accepted monitoring practices worldwide; and 2) conducting an OSPAR-compliant field survey to assess the impact of drill cuttings discharges on the marine environment in the Jubilee Project area, verifying modeling undertaken to date and documenting the potential recovery of affected sites. A plan of study in the form of a Field Plan (Sampling and Analysis Plan) was prepared. The field survey involved collecting seawater, sediment, infauna, and sediment profile imaging data in deepwater in close proximity to existing subsea facilities. Seawater and sediment sample analyses were conducted by U.S. laboratories. Infauna were analyzed by a local laboratory. CSA also prepared a Final Report for submission to the Ghana EPA on drill cuttings impacts in the Jubilee Project area. The report placed the observed impacts into context and included recommendations for National Discharge guidelines of oil on cuttings concentrations based on the literature review and field survey results.

## **Appendix C**

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### **Key Personnel Résumés**



**Managing Director – MVI Israel**

**Education**

*Doctor of Science in Environmental & Water Resources Engineering, Technion - Israel Institute of Technology, Haifa, Israel, 1979*

*Master of Human Environmental Sciences, Hebrew University of Jerusalem, Israel, 1975*

*Bachelor in Biology, Hebrew University of Jerusalem, Israel, 1973*

An expert on the environmental impacts of marine pollution associated with eutrophication and effects on marine food chain, Dr. Azov has over 30 years of experience with environmental, ecological, biological, and engineering issues concerning oceanic, coastal, and land problems. He has published over 30 papers in scientific journals in his field. Relevant experience includes Dr. Azov's participation in the environmental impact assessment of proposed marine outfall for the wastes of Industrial plants in Haifa Bay and his role as scientific coordinator for a project concerning the monitoring of sea water during marine works conducted by Noble Energy. In addition, he has evaluated the biological effects of the marine sludge outfall of Greater Tel-Aviv wastewater treatment plant and evaluated the effects of brine from effluent desalination on marine life. He has also evaluated the causes for phytoplankton bloom in artificial marine lagoon in Eilat as well as the effects of heated water on the fauna and flora of the Hertzelia Marina. In addition, he participated in a specialist forum at the Grand Water Research Institute – Technion concerning water desalination plants.

Dr. Azov has served as a scientific advisor for a number of projects throughout the proposed project area. He served as the scientific advisor to the Israel Rivers Remediation Authority concerning remediation of Hadera River; for bi-national research conducted at the Technion concerning CO<sub>2</sub> mitigation by algae; and for numerous plants, including the Greater Haifa wastewater treatment plant, the Arad wastewater treatment plant, the construction of a demonstration plant in Thessaloniki, Greece for wastewater treatment in South Europe sponsored by E.E.C., the construction of a demonstration plant in Sau-Paulo, Brazil for wastewater treatment in small municipalities, the Greater Tel-Aviv wastewater treatment plant concerning the effects of lagoon drying on the surrounding area, and the Bet Jan wastewater treatment plant in case of photosynthetic bacteria bloom.

In addition, Dr. Azov has served as the Coordinator of many monitoring projects, including the Caesarea Industrial Park monitoring program concerning effects on groundwater quality, the Greater Tel-Aviv wastewater reclamation program, and the Haifa Complex wastewater reclamation program

**EXPERIENCE**

**2013 to Present: CSA Ocean Sciences Inc. – Managing Director – Marine Ventures Intl. – Israel**

- Responsible for the general management of the Israel CSA operations and office.

**1997 to Present: Private Consultant**

- Numerous consulting contracts in areas of marine pollutions, water quality, water treatment, groundwater quality, wastewater treatment, algal growth and production, etc.

**1996 to 1997: Environmental and Water Resources Engineering Department, Technion, Haifa – Senior Research Fellow**

- Research involved wastewater treatment and effluent quality. Monitoring of groundwater quality.

**1987 to 1996: Environmental and Water Resources Engineering Department, Technion, Haifa – Senior Research Associate**

- Research involved wastewater treatment and effluent quality.

**1984 to 1987: Environmental and Water Resources Engineering Department, Technion, Haifa, Israel – Research Associate and Project Engineer**

- Research field: "Effluent supply for irrigation in northern Israel."

**1981 to 1984: Israel Oceanographic & Limnological Research Institution, Haifa – Scientist**

- Main research fields: Marine phytoplankton, Marine food chain, Primary production in Eastern Mediterranean. Research conducted both on board ship and in the laboratory.

**1980 to 1981: Woods Hole Oceanographic Institution, U.S.A. – Post-Doctoral Researcher**

- Research field: "Effect of ammonia on marine and fresh water algae."

**1976 to 1980: Environmental and Water Resources Engineering Department, Technion, Haifa – Head of Biological Research Group**

- Research field: "Algal growth and production for animal feed."

**1973 to 1975: Human Environmental Sciences Department, Hebrew University of Jerusalem, Israel – Research Assistant**

- Research field: "Ammonia toxicity to algae."

**1997 to Present: Technion – Israel Institute of Technology, Haifa, Israel – Adjunct Senior Teaching Fellow**

- Graduate course in "Hydrobiology."

**2005 to Present: Haifa University, Haifa, Israel – Adjunct Senior Teaching Fellow**

- Graduate course in "Water and Wastewater Treatment."

**PUBLICATIONS (Corporate)**

Abeliovich, A. and Y. Azov. 1976. Toxicity of ammonia to algae in sewage oxidation ponds. Appl. Environ. Microbiol. 31:801-806.

Oron, G., G. Shelef, A. Levi, A. Meydan, and Y. Azov, Y. 1979. Algae bacteria ratio in high-rate ponds used for waste treatment. Appl. Environ. Microbiol. 38:570-576.

Shelef, G., Y. Azov, R. Moraine, and G. Oron. 1980. Algal mass production as an integral part of a wastewater treatment and reclamation system. In: Algae Biomass, Production and Use (G. Shelef and C.J. Soeder, eds.), Elsevier Biomedical Press, pp. 163-189.

Azov, Y., G. Shelef, R. Moraine, and A. Levi. 1980. Controlling algal genera in high-rate oxidation ponds. In: Algae Biomass, Production and Use (G. Shelef and C.J. Soeder, eds.), Elsevier Biomedical Press, pp. 245-253.

Azov, Y., G. Shelef, R. Moraine, and A. Levi. 1980. Controlling algal genera in high-rate oxidation ponds. In: Algae Biomass, Production and Use (G. Shelef and C.J. Soeder, eds.), Elsevier Biomedical Press, pp. 245-253.

- Azov, Y., G. Shelef, R. Moraine, and G. Oron. 1980. Alternative operating strategies of high-rate sewage oxidation ponds. In: *Algae Biomass, Production and Use* (G. Shelef and C.J. Soeder, eds.), Elsevier Biomedical Press, pp. 523-529.
- Goldman, J.C., Y. Azov, C.B. Riley, and M.R. Dennett. 1982. The effect of pH in intensive algal cultures. *J. Exp. Mar. Biol. Ecol.* 57:1-13.
- Azov, Y., G. Shelef, and N. Narkis. 1982. Effect of hard detergents on algae in a high-rate oxidation pond. *Appl. Environ. Microbiol.* 43:491-492.
- Azov, Y., G. Shelef, and R. Moraine. 1982. Carbon limitation of biomass production in high-rate oxidation ponds. *Biotechnol. Bioengr.* 24:579-594.
- Azov, Y. and G. Shelef. 1982. Operation of high-rate oxidation ponds: theory and experiments. *Water Res.* 16:1,153-1,160.
- Azov, Y. 1982. Effect of pH on inorganic carbon uptake in algal cultures. *Appl. Environ. Microbiol.* 43:1,300-1,306.
- Azov, Y. and J.C. Goldman. 1982. Free ammonia inhibition of algal photosynthesis in intensive algal cultures. *Appl. Environ. Microbiol.* 43:735-739.
- Shelef, G., Y. Azov, and R. Moraine. 1982. Nutrients removal and recovery in a two-stage high-rate algal wastewater treatment system. *Wat. Sci. Tech.* 14:8700.
- Berman, T., D.W. Townsend, S.Z. El-Sayed, C.C. Trees, and Y. Azov. 1984. Optical transparency, chlorophyll and primary productivity in the Eastern Mediterranean near the Israeli coast. *Oceanol. Acta* 7:367-372.
- Berman, T., Y. Azov, and D.W. Townsend. 1984. Understanding oligotrophic oceans: Can Eastern Mediterranean be a useful model? In: *Lecture Notes on Coastal and Estuarine Studies*, 8: *Marine Phytoplankton and Productivity* (O. Holm-Hansen et al., eds.) Springer Verlag Publs., pp. 101-112.
- Azov, Y. 1986. Seasonal patterns of phytoplankton productivity and abundance in near shore oligotrophic waters of the Levant Basin (Mediterranean). *J. Plankton. Res.* 8:41-53.
- Berman, T., Y. Azov, A. Schneller, P. Walline, and D.W. Townsend. 1986. Extent, transparency and phytoplankton distribution of the neritic waters overlying the Israel coast. *Oceanol. Acta* 9:439-447.
- Shelef, G. and Y. Azov. 1987. High-rate oxidation ponds: The Israeli experience. *Wat. Sci. Tech.* 19:249-255.
- Azov, Y. and G. Shelef. 1987. Effect of pH on the performance of high-rate oxidation ponds. *Wat. Sci. Tech.* 19:381-383.
- Azov, Y. 1990. Eastern Mediterranean - a marine desert? *Marine Poll. Bull.* 23:225-232.
- Azov, Y. and G. Shelef. 1991. Effluents quality along a multiple-stage wastewater reclamation system for agricultural reuse. *Wat. Sci. Tech.* 23:2119-2126.
- Azov, Y., M. Juanico, G. Shelef, A. Kanarek, and M. Priel. 1991. Monitoring the quality of secondary effluents reused for unrestricted irrigation after underground storage. *Wat. Sci. Tech.* 24:267-275.
- Teltsch, B., M. Juanico, Y. Azov, I. Ben Harim, and G. Shelef. 1991. The clogging capacity of reclaimed wastewater: a new quality criterion for drip irrigation. *Wat. Sci. Tech.* 24:123-131.

- Teltsch, B., Y. Azov, M. Juanico, and G. Shelef. 1992. Plankton community changes due to effluents addition to a freshwater reservoir used for drip irrigation. *Water Res.* 26:657-666.
- Azov, Y., M. Juanico, and G. Shelef. 1992. Monitoring large scale wastewater reclamation systems - policy and experience. *Wat. Sci. Tech.* 26:1,545-1,553.
- Shelef, G., Y. Azov, A., Kanarek, G. Zac, and A. Shaw. 1994. The Dan Region sewerage wastewater treatment and reclamation scheme. *Wat. Sci. Tech.* 30:229-238
- Armon, R., K. Dozoretz, Y. Azov, and G. Shelef. 1995. Residual contamination of crops irrigated with different effluent quality: A field study. *Wat. Sci. Tech.* 31:239-248.
- Juanico, M., R. Ravid, Y. Azov, and B. Teltsch. 1995. Removal of trace metals from wastewater during long-term storage in seasonal reservoirs. *Water, Air & Soil Pollution.* 82:617-633.
- Azov, Y. and T. Tregubova. 1995. Nitrification processes in stabilization reservoirs. *Wat. Sci. Tech.* 31:313-319.
- Juanico, M., Y. Azov, B. Teltsch, and G. Shelef. 1995. Effect of effluents addition to a freshwater reservoir on the filter clogging capacity of irrigation water. *Water Res.* 29:1,695-1,702.
- Shelef, G. and Y. Azov. 1995. The coming era of wastewater reclamation and reuse in the Mediterranean Basin. Invited paper to the 2nd International Symposium on Wastewater Reclamation and Reuse, Iraklio, Crete. *Wat. Sci. Tech.* 31:313-319.
- Azov, Y., M. Khinich, S. Rabkin, A. Ben Yosef, and G. Shelef. 1996. Control of algae in the reservoirs of the 'Third Line'. In: *Preservation of Our World in the Wake of Change* (Y. Steinberger, ed.), Vol VI A/B, ISEEQS Pub. Israel, pp. 707-710.
- Juanico, M., R. Ravid, Y. Azov, and B. Teltsch. 1999. Trace metals. In: *Reservoirs for Wastewater Storage and Reuse* (I. Dor and M. Juanico, eds.). Springer Publs. pp. 219-232.
- Shelef, G. and Y. Azov. 2000. Meeting stringent environmental and reuse requirements by an integrated pond system at the 21st century. *Wat. Sci. Tech.* 42 (10-11) pp. 299-305.
- Pearson, H.W., D.D. Mara, and Y. Azov. 2000. Waste Stabilization Ponds: Technology and the Environment. *Wat. Sci. Tech.* 42 (10-11).



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**Education**

*Doctor of Philosophy  
in Oceanography,  
Texas A&M  
University, 1981*

*Bachelor of Science in  
Zoology, Texas Tech  
University, 1973*

Dr. Hart has over 30 years of oceanographic and environmental science experience. He has served as Project Manager on numerous oil and gas industry projects. Currently, he is Deputy Project Manager for a major Minerals Management Service (MMS)-sponsored interdisciplinary study of environmental effects from cuttings discharges for synthetic-based drilling muds systems of selected sites on the continental slope of the Gulf of Mexico. He is also the Project Manager and responsible for experimental design, data analysis, data interpretation, and reporting for a major study of the environmental fate and effects of drill cuttings discharged in association with synthetic-based drilling muds systems. This study is jointly sponsored by industry and government (MMS and U.S. Department of Energy [DOE]). He has conducted several studies concerning predicting the environmental consequences of unintentional petroleum hydrocarbon discharges in the vicinity of sensitive biological communities. These projects involved incorporating aspects of toxicity studies from the literature, literature review of the sensitive biological communities, and modeling dispersion and movement of spilled hydrocarbons. He was also the Project Manager for a major water quality study for the Florida Keys National Marine Sanctuary to develop a water quality protection plan for the Environmental Protection Agency. Dr. Hart has also served as Task Leader and Assistant Project Manager on a number of major multidisciplinary projects, including a recently completed multimillion dollar study of offshore platforms for DOE and another major multimillion dollar study of bioaccumulation of produced water discharges into the Gulf of Mexico performed for the Offshore Operators Committee.

Dr. Hart has served as an environmental consultant for numerous industry clients and Federal and State agencies concerning developmental activities in the Gulf of Mexico, Atlantic and Pacific Oceans, Sea of Okhotsk, Caribbean and Caspian Seas, and Alaska waters. He is experienced in assessing environmental impacts as they are related to biological, chemical, geological, and physical oceanography. Dr. Hart has developed sampling designs, performed the statistical analyses of the data, and prepared and edited the manuscripts for numerous biological assessments of offshore and coastal areas, multidisciplinary baseline studies, and ecosystem programs.

Dr. Hart routinely serves as CSA's data manager, data analyst, and ecological statistician for projects including large scale multidisciplinary studies requiring database manipulation and computer analyses. He routinely supervises data entry and data processing, and provides software support and statistical services for principal investigators on large multidisciplinary research projects. He has been responsible for data management and statistical analyses for numerous baseline studies and environmental monitoring programs in connection with outer continental shelf oil and gas activities. Prior to joining CSA, Dr. Hart served as a Data Manager on the Bryan Mound Site Brine Impact Study of the Strategic Petroleum Reserve Project funded by the DOE. He also worked at the Texas Agricultural Experiment Station as a programmer on a National Marine Fisheries Service Grant to provide vessel budget simulations for the Texas shrimping fleet.



## REPRESENTATIVE EXPERIENCE

### February 1982 to Present: CSA International, Inc. – Science Director, Executive Vice President

- Project Manager of a project to characterize northern Gulf of Mexico deepwater hard bottom communities with emphasis on the deepwater coral *Lophelia*. This was a 3-year study sponsored by the MMS. It involved 2 years of field work utilizing the Johnson SeaLink submersible and coordination of multiple subcontractors from University of Oregon, Pennsylvania State University, Dauphin Island Marine Laboratory, Florida State University, and the Smithsonian Institution.
- Project Manager and responsible for experimental design, data analysis, data interpretation, and reporting for a major study of the environmental fate and effects of drill cuttings discharged in association with synthetic-based drilling muds systems. This study is jointly sponsored by industry and government (MMS and DOE).
- Chief Project Scientist and Data Manager for an environmental monitoring program for the Offshore Operators Committee (OOC) titled the Gulf of Mexico Produced Water Bioaccumulation Study. The objectives of the program were to determine whether statistically significant bioaccumulation of produced water related organics and inorganics occurs in the edible tissue of resident fishes and invertebrates in the immediate vicinity of representative Gulf of Mexico offshore platforms that discharge more than 4,600 barrels per day of produced water, and to evaluate the environmental significance of any statistically significant increases observed due to produced water related bioaccumulation in edible tissue. Produced water, ambient water, and fish and invertebrate tissue samples were collected for analyses of volatile and semivolatile organic compounds, metals, and radionuclides. Dr. Hart finalized Post-Survey Reports and Data Reports submitted after each of the three cruises. Final Reports and a Bioaccumulation Literature Review were prepared as separate deliverables. Dr. Hart also presented final results orally at a technical conference and in a paper published in a peer-reviewed scientific journal (Offshore Operators Committee, 1994 to 1997).
- Chief Project Scientist and Data Manager for a 3-year, multimillion dollar study of the potential environmental, economic, and health impacts associated with produced water, produced sand, and other discharges from oil and gas operations in the Gulf of Mexico. Dr. Hart coordinated CSA's role as the prime contractor for the study, managing a seven-company team of experts, and organizing and coordinating a Scientific Review Committee. The primary project goal was to increase the base of scientific knowledge concerning the 1) fate and environmental effects of organics, trace metals, and naturally occurring radioactive materials (NORM) in water, sediment, and biota near several offshore oil and gas facilities; 2) characteristics of produced water and produced sand discharges as they pertain to organics, trace metals, and NORM variably found in association with the discharges; 3) recovery of four terminated produced water discharge sites located in wetland and high-energy open bay sites of coastal Louisiana and Texas; 4) economic and energy supply impacts of existing and anticipated Federal and State offshore and coastal discharge regulations; and 5) catch, consumption, and human use patterns of seafood species collected from coastal and offshore waters (U.S. Department of Energy, 1992 to 1997).



**ALAN D. HART, Ph.D.**

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- Conducted an analysis of the Marine Industry Response Group/S. L. Ross Spill Impact Assessment Model was conducted in two phases. Phase I included training on the model as well as a review process with State and Federal agency representatives. This review process included identifying proper agencies and personnel, preparing appropriate discussion issues with those individuals, and finally conducting those discussions. Phase II included a peer review of the model to the extent of addressing the concerns of the Phase I discussions with the State and Federal agencies (Marine Industry Response Group, 1991 to 1993).
- Data Manager/Biostatistician for CSA's portions of the MMS Southwest Florida Shelf Ecosystems Study, a major multidisciplinary environmental study. Data were from sediment grain size, trace metal, and hydrocarbon samples; macroinfaunal samples; dredge and trawl samples; and bottom photographs (Minerals Management Service, 1982 to 1987).

#### **PUBLICATIONS (Corporate)**

Uhler, A.D., R.M. Uhler, and A.D. Hart. 2004. Chapter 8 - The Organic Chemistry of Synthetic Based Fluid Residues and Total Petroleum Hydrocarbons in Sediments. In: Continental Shelf Associates, Inc., Gulf of Mexico Comprehensive Synthetic Based Muds Monitoring Program. A report prepared for the SBM Research Group.

Continental Shelf Associates, Inc. 1998. Joint EPA/Industry screening survey to assess the deposition of drill cuttings and associated synthetic based mud on the seabed of the Louisiana Continental Shelf, Gulf of Mexico, Data Report. Report for the American Petroleum Institute Health & Environmental Sciences Dept., Washington, D.C.

Hart, A.D., B.D. Graham, and L.L. Lagera, Jr. 1997. Chapter 2 - Study design and overview. In: Continental Shelf Associates, Inc., Radionuclides, Metals, and Hydrocarbons In Oil and Gas Operational Discharges and Environmental Samples Associated with Offshore Production Facilities on the Texas/Louisiana Continental Shelf with an Environmental Assessment of Metals and Hydrocarbons. A report prepared for U.S. Department of Energy, Bartlesville, Oklahoma.

#### **PUBLICATIONS (Individual)**

Hart, A.D., D.B. Snyder, K.D. Spring, and R.M. Hammer. 2006. Application of Scientific Experimental Design in Monitoring Hard Bottom Habitats Associated with Areas of Beach Nourishment. Proceedings of the 19<sup>th</sup> Annual National Conference on Beach Preservation Technology February 1-3, 2006, Sarasota, Florida.

Neff, J.M., A.D. Hart, J.P. Ray, J.M. Limia, and T.W. Purcell. 2005. An Assessment of Seabed Impacts of Synthetic-Based-Drilling-Mud Cuttings in the Gulf of Mexico, SPE 94086. SPE/EPA/DOE Exploration and Production Environmental Conference, 7-9 March 2005, Galveston, Texas

Gettleson, D.A., A.D. Hart, S.T. Viada, and N.W. Phillips. 2004. Effects of Oil and Gas Exploration and Development at Selected Continental Slope Sites in the Gulf of Mexico, SPE 86773. SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production, 29-31 March 2004, Calgary, Alberta, Canada

- Hart, A.D. 2003. Effects of oil and gas exploration and development at selected continental slope sites in the Gulf of Mexico. In: McKay, M. and J. Nides (eds.), Proceedings: Twenty-First Annual Gulf of Mexico Information Transfer Meeting, January 2002. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-005. 748 pp.
- Hart, A.D. 2003. Joint industry project, Gulf of Mexico Comprehensive Synthetic Based Muds Monitoring Program: An overview. In: McKay, M. and J. Nides (eds.), Proceedings: Twenty-First Annual Gulf of Mexico Information Transfer Meeting, January 2002. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-005. 748 pp.
- Neff, J.M., T.C. Sauer, and A.Hart. 2000. Monitoring Polycyclic Aromatic Hydrocarbon (PAH) Bioavailability Near Offshore Produced Water Discharge. Environmental Toxicology and Risk Assessment: Science, Policy and Standardization – Implications for Environmental Decisions (Tenth Volume), ASTM STP 1403. In: B.M. Greenberg, R.N. Hull, M.H. Roberts, Jr., and R.W. Gensemer (eds.), American Society for Testing and Materials, West Conshohocken, Pennsylvania.
- Hart, A.D., B.D. Graham, D.A. Gettleson, D.L. Demorest, and B.W. Smith. 1996. Naturally Occurring Radioactive Materials Associated with Offshore Produced Water Discharges in the Gulf of Mexico. In: Mark Reed and Ståle Johnsen (eds.), Produced Water 2, Environmental Science Research, Volume 52, Plenum Press, New York NY.
- Hart, A.D., B.D. Graham, D.A. Gettleson, D.L. Demorest, and B.W. Smith. 1995. Naturally Occurring Radioactive Materials Associated with Offshore Produced Water Discharges in the Gulf of Mexico. A presentation at the 1995 International Produced Water Seminar sponsored by STATOIL Research and Development, 25-28 September 1995, Trondheim, Norway.
- Hart, A.D., B.D. Graham, and D.A. Gettleson. 1995. NORM Associated with Produced Water Discharges, SPE 29727. SPE/EPA Exploration and Production Environmental Conference, 27-29 March, Houston, Texas
- Sturges, W., A.J. Clarke, S. Van Gorder, X. Liu, and A.D. Hart. 1994. Current-meter observations south of Pensacola: Comparison of wind-forced currents with the Clarke-Van Gorder Model. A presentation at the Northeastern Gulf of Mexico Physical Oceanography Workshop sponsored by the Minerals Management Service, New Orleans OCS Office. Florida State University, Tallahassee, FL.
- Hart, A.D., B. Graham, and D.A. Gettleson. 1993. Concentrations of naturally occurring radioactive materials associated with produced water discharges from production platforms in the northwestern Gulf of Mexico. Presentation at the 14<sup>th</sup> Meeting of the Society of Environmental Toxicology and Chemistry, Houston, TX.
- Randolph, T.M., R.C. Ayers, Jr., R.A. Shaul, A.D. Hart, W.T. Shebs, J.P. Ray, S.A. Savant-Malhiet, and R.V. Rivera. 1992. Radium fate and oil removal for discharged produced sand. In: J.P. Ray and F.R. Engelhart (eds.), Produced Water. Plenum Press, New York, NY.
- Deis, D.R.; Spring, K.D., and Hart, A.D. 1992. Captiva Beach restoration project - biological monitoring program. In: New Directions in Beach Management, Proceedings of the 5<sup>th</sup> Annual National Conference on Beach Preservation Technology; St. Petersburg, FL. Florida Shore and Beach Preservation Association; 227-241.



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- Brooks, J.M., M.C. Kennicutt, T.L. Wade, A.D. Hart, G.J. Denoux, and T.J. McDonald. 1990. Hydrocarbon distributions around a shallow water multiwell platform. *Environ. Sci. Technol.* 24(7):1,079-1,085.
- Hart, A.D., P.N. Boothe, and B.J. Presley. 1990. Fate and effects of routine discharges: Implications for South Florida communities and resources, pp. 505-535. In: N.W. Phillips and K.S. Larson (eds.), *Synthesis of Available Biological, Geological, Chemical, Socioeconomic, and Cultural Resource Information for the South Florida Area*. OCS Study MMS 90-0019. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, Herndon, VA.
- Thompson, M.J., A.D. Hart, and C.W. Kerlin. 1989. Exposure of deep seagrass beds off the west coast of Florida to discharged drilling effluents, pp. 137-156. In: F.R. Engelhardt, J.P. Ray, and A.H. Gillam (eds.), *Drilling Wastes*. Elsevier Applied Science, New York, NY.
- Hart, A.D. 1985. The Offshore Operators' Committee drilling muds discharge model as a management tool. Presentation at Information Transfer Meeting, Minerals Management Service, New Orleans, LA.
- Cummings, J.A. and A.D. Hart. 1982. Data management, Chapter 8. In: R.W. Hann, Jr. and R.E. Randall (eds.), *Evaluation of Brine Disposal From the Bryan Mound Site of the Strategic Petroleum Reserve Program*. A final report submitted to the Department of Energy.
- Hart, A.D. and J.H. Wormuth. 1982. Pelagic amphipods of the Gulf Stream cyclonic cold core rings. Presented at Winter Meetings, AGU/ASLO.
- Hart, A.D. and J.H. Wormuth. 1982. Pelagic amphipods - Gulf Stream cyclonic rings, data report. Department of Oceanography, Texas A&M University, College Station, TX. Ref. 82-3-T. 163 pp.



**Project Scientist, Marine Specialist – MVI Israel**

**Education**

*Master of Science in Environmental Studies, Tel-Aviv University, 2012*

*Bachelor of Science in Marine Sciences & Biotechnology, Ruppin Academic Center, 2009*

Mr. Mills has been working in the oil and gas industry for over 4 years during which time he gained valuable experience and knowledge in exploration and production (upstream) of crude oil and natural gas, including drilling of exploratory wells, well completion operations, well testing, production, and export of petroleum. Since joining CSA Ocean Sciences Inc. (CSA) in 2013, he has been focused on multiple monitoring surveys in the eastern Mediterranean Sea.

Mr. Mills had the unique opportunity to get hands-on experience in field engineering work, practicing the principles of fluids dynamics, hydraulics, and three-phase separation. Through his training as a marine biologist and his studies in environmental sciences, he successfully implemented this knowledge and expertise into his work. When working as an environmental superintendent, Mr. Mills coordinated the onshore production operations with environmental regulations and promoted environmental awareness among his colleagues. Upon turning to offshore operations, he acquired expertise in the fields of Health, Safety, and Environment (HSE) and permitting while working actively under the Halliburton Project team for the Gabriella drilling project. There, Mr. Mills played an important role in promoting the environmental monitoring, discharge permit, and the oil spill contingency plan.

During his years at university, he gained experience in environmental, ecological, biological, physical, and chemical issues concerning coastal and oceanic problems. He participated in numerous projects testing water properties in the eastern Levant and characterizing seasonality in the planktonic community.

In his thesis dissertation, Mr. Mills investigated the role of microorganisms in bleaching of the Mediterranean coral *Oculina patagonica*. The purpose of this project was to elucidate the reason for seasonal bleaching in the coral and provide evidence for temperature-regulated infection by a *Vibrio* species. The research supported the bacterial bleaching hypothesis and included the utilization of advanced molecular techniques, classic microbiological tools, and frequent SCUBA diving under rough sea conditions.

**EXPERIENCE**

**2013 to Present: CSA Ocean Sciences Inc. – Deputy Branch Director, Marine Ventures International, Inc., Israel**

- Project Manager for the preparation of Environmental Impact Assessment (EIA) for offshore Israel O & G drilling. Responsibilities included coordinating the completion the EIA among the client, EIA author, technical review, editing, and document production staff as well as budget management.
- Field scientist in multiple monitoring surveys for oil and gas operators within the eastern Mediterranean Sea to assess deep-sea benthic habitat prior to and after anthropogenic disturbances. Surveys include the collection of seawater and sediment samples from a vessel using common methodology and a remotely operated vehicle (ROV).
- Contributing author of Environmental Analysis Statement, including editing and in-depth preparation of the section related to air pollution regulation, process-derived air emissions impact, and waste management and resource exhaustion in Israel.
- Contributing author of Oil Contingency Spill Program, assisting in the preparation of coastal and nearshore habitat characterization.

- Regional and local lead for CSA business development. The goal was to develop and implement growth opportunities for the company in local industries and create a long term value from customers and markets. Focus was put into areas of expertise such as the O & G industry and ports development. Emphasis was also given to partnerships and collaborations with complementary services providers.

**2012 to 2013: Gabriella Offshore Drilling Project, Adira Energy Israel Ltd, Ramat-Gan – HSEQ Representative**

- Assisted in the development, monitoring, and management of Health, Safety, Environment and Quality (HSEQ) Management Systems.
- Ensured compliance with the statutory requirements and promoting permits approval.
- Liaised with all contractors and sub-contractors to ensure that company requirements were followed.
- Assisted in HSEQ internal and external audits.

**2010 to 2012: Meged-5 Crude Oil Production Site, Givot Olam Oil Ltd, Shoham – Environmental Superintendent**

- Promoted an environmental agenda to reduce externalities.
- Implemented environmental regulatory requirements at the production site.
- Liaised with foreign well services companies and personnel to bridge environmental standards.
- Responsible for the proper maintenance of chemicals on site and assuring safe handling.
- Edited and reviewed standard operating procedures.

**2012 to Present: The School of Marine Sciences & Oceanic Environment, Ruppin Academic Center, Michmoret – Student Instructor**

- Assisted in the coordination of planning and logistics of short courses dealing with the marine and coastal environment, including lecturing and frontal presentation of relevant topics in the fields of oceanography, zoology, botany, and geomorphology.

**2010 to 2011: Marine Ecosystems Laboratory, Israel Oceanographic & Limnological Research Institution, Haifa, Israel – Ecological Research Assistant and Lab Technician**

- Research Field: Abrasion Platforms habitat and benthic-pelagic coupling.
- Established experimental designs and setups specializing in coastal benthos ecology.
- Initiated and promoted advanced research ideas (i.e., ocean acidification effect on abrasion platforms and the imposed implications on coastal abrasion).

**2008 to 2009: Ramat Hanadiv Forest Park, Binyamina, Israel – Ecological Research Assistant**

- Devised and prepared ecological surveys of terrestrial vegetation in research on innovative environmental management programs and provided scientific data for educational activities. The research focused on the dispersion of pine trees in the southern end of Mount Carmel and their interactions with the Mediterranean shrubland.

**PUBLICATIONS (Peer Reviewed)**

Mills, E., K. Shechtman, Y. Loya, and E. Rosenberg. 2013. Bacteria appear to play important roles in both causing and preventing the bleaching of the coral *Oculina patagonica*. Marine Ecology Progress Series. Prepress – doi: 10.3354/meps10391.



### **PROFESSIONAL CERTIFICATIONS**

Dive Master – World Underwater Federation (CMAS) and the Israeli Diving Federation  
Licensed Skipper for coastal and international waters (level 60) – State of Israel, Ministry of  
Transport (MOT)  
First Aid and CPR certified

### **PROFESSIONAL AFFILIATIONS**

Israeli Society of Microbiology, 2012  
Israeli Diving Federation, 2013  
Israeli Association for Aquatic Sciences, 2010



**BRUCE D. GRAHAM**

**Senior Scientist, Marine Specialist**

**Education**

*Master of Science in  
Biological Sciences,  
Florida Institute of  
Technology, 1983*

*Bachelor of Science in  
Biological Sciences,  
University of New  
Hampshire at Durham,  
1979*

*Exchange program,  
California State  
University at Chico,  
1977 to 1978*

Mr. Graham is a marine biologist with nearly 30 years experience in field studies of benthic communities. He has served as Project Manager and/or Chief Scientist on numerous marine programs, including habitat assessment and restoration, multidisciplinary baseline studies, and environmental monitoring programs. He has prepared survey plans; supervised and conducted sample collection, processing, and analysis; and has been responsible for the interpretation and synthesis of data in conjunction with document preparation. He has been responsible for the analyses of more than 10,000 photographs of hard and soft bottom benthic communities collected in areas that include the Atlantic Ocean, Gulf of Mexico, Antigua, Sea of Okhotsk (Russia), Federated States of Micronesia, U.S. Virgin Islands, and Taiwan.

Mr. Graham is the Resource Restoration and Damage Assessment Business Line Manager for CSA Ocean Sciences Inc. (CSA). He is responsible for directing overall project management and has provided marine biological technical expertise, environmental impact assessment capabilities, and management oversight on numerous multidisciplinary damage assessments of activities in U.S. domestic (i.e., Federal and State) and international waters. He has been Chief Scientist on habitat restoration and damage assessments at sites off the east coast of Florida including Biscayne National Park (BISC) and the Florida Keys National Marine Sanctuary (FKNMS), Dry Tortugas, Mississippi Sound, Hawaii, Antigua, Colombia, Federated States of Micronesia, Mexico, Puerto Rico, the U.S. Virgin Islands, the Bahamas, and the Turks and Caicos.

Mr. Graham has extensive experience conducting environmental studies as a scientific diver. His diving experience includes benthic still and video photography, in-situ identification of epibiota, and in-field sample collection (e.g., biological and sediment chemistry). Mr. Graham is a certified SCUBA and Nitrox specialty diver and is trained in Red Cross cardiopulmonary resuscitation (CPR) and first aid. He has conducted studies worldwide and participated as Senior Field Scientist in the environmental monitoring of the Exxon Valdez remediation and the Macondo well blowout monitoring programs. He has developed and field-tested new methods for biological reattachment and transplantation and substrate stabilization and augmentation as a means of accelerating habitat recovery.

Mr. Graham has authored several technical publications concerning zoogeography, various restoration techniques including hard coral reattachment to accelerate marine habitat recovery, oil and gas environmental monitoring, vessel grounding case studies, and crustacean natural history. He co-authored and produced an interactive CD-ROM version of the "Ecology of Live Bottom Habitats of the Northeastern Gulf of Mexico: A Community Profile" for the U.S. Department of the Interior, Minerals Management Service (MMS). Mr. Graham has co-authored grant proposals for successful procurement of funding from the South Florida Water Management District and the Florida Fish and Wildlife Conservation Commission to develop and deploy artificial reefs in Martin County, Florida.

Mr. Graham has also conducted Habitat Equivalency Analyses (HEA) associated with resource damage from natural gas pipeline installations and vessel groundings. Tasks associated with HEA include selection and scaling of appropriate restoration/mitigation options.



**BRUCE D. GRAHAM**

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Mr. Graham has been qualified by the State of Florida to act as an expert witness in cases relating to marine environmental science. Mr. Graham participated as an expert panel member for the Southeast Florida Coral Reef Initiative workshop “Maritime Industry & Coastal Construction Impacts” to develop guidelines for rapid response to and restoration of coral reef injuries in southeast Florida. He was part of the BISC interdisciplinary team for developing a Restoration Plan and Programmatic Environmental Impact Statement to address ecological restoration of coral reef and seagrass in BISC that have sustained injury from vessel groundings.

## **EXPERIENCE**

**2006 to Present: CSA Ocean Sciences Inc.**

**2000 to 2005: Marine Resources Inc.**

**1983 to 2000: Continental Shelf Associates, Inc.**

- Project Manager/Chief Scientist during damage assessment, restoration planning, and compensatory scaling of the M/Y *WHITE CLOUD* anchor damage site offshore Providenciales of the Turks and Caicos Islands. Responsible for directing and conducting natural resource damage process including assessments of injury footprint and primary restoration options. (American International Group, 2013 to present).
- Project Manager/Chief Scientist during damage assessment, restoration, and monitoring of the M/T *MARGARA* grounding site offshore southwest Puerto Rico. Responsible for directing and conducting natural resource damage process, including assessment, restoration, monitoring, and compensatory scaling. Restoration included substrate stabilization and reattachment of over 11,000 corals. Program included the development of a reattachment strategy to propagate staghorn coral (*Acropora cervicornis*) (Independent Maritime Consulting Ltd., 2006 to present).
- Project Manager/Chief Scientist during injury assessment, habitat restoration, and settlement considerations for the grounding event of the *SPAR ORION*, offshore Port Everglades, Florida. Restoration included substrate stabilization and biological reattachment of 278 hard corals, 73 soft corals, and 21 large sponges. Program included a Habitat Equivalency Analysis and presentation of programmatic finding during the settlement mediation (Independent Maritime Consulting Ltd., 2006 to 2010).
- Project Manager/Chief Scientist during injury assessment, resource triage, and habitat restoration for the *SUEZ MATTHEWS* grounding event off the south coast of Puerto Rico. Restoration included substrate stabilization and biological reattachment of over 4,300 hard corals, 3,200 soft corals, and 40 barrel sponges. Structural restoration included the use of approximately 100 tons of cement to stabilize approximately 300 tons of loose substrate. Over 180 restoration structures of variable sizes, which adhered to specifics outlined in restoration plan, were created using cement, large boulders, and rubble in the impact area. (Independent Maritime Consulting Ltd., 2009 to 2010).



- Project Manager/Chief Scientist to assess the settlement claim submitted by the U.S. National Park Service (NPS) for injuries incurred by the grounding of the *VOYAGER EAGLE* within the Virgin Islands National Park, St. John, U.S. Virgin Islands. Tasks included an on-site inspection, damage assessment, a synopsis of the NPS settlement claim based on technical review of grounding-associated documents and evaluation of NPS settlement claim components, and a response to the NPS settlement claim considering information obtained from the on-site inspection of the Voyager Eagle grounding site and current environmental industry data (Global Claims & Co., 2006 to 2008).
- Chief Scientist during multi-task monitoring program for the Texas Reef, in support of the Martin County Artificial Reef Program. Objectives of the monitoring program are to provide qualitative and quantitative information on the geographic and vertical dimensions of the reef structure and document the temporal and spatial changes of the associated epibenthic and ichthyofaunal assemblages (Ecological Associates, Inc., 2003 to 2007).
- Chief Scientist during damage assessment, restoration, and monitoring of the MSC *DIEGO* anchor damage site in the Dry Tortugas Ecological Reserve in the Florida Keys National Marine Sanctuary. Responsible for collecting photographic data, developing restoration plan to reattach displaced deep-water hard corals, and conducting restoration. Restoration included substrate stabilization and reattachment of 1,111 hard corals comprising 15 taxa. Cooperatively developed and implemented 5-year monitoring of attachment status and relative health of reattached hard corals (Houck, Hamilton & Anderson, P.A., 2003 to 2005).
- Chief Scientist during nearshore survey of marine benthic habitats along the Ocean Express Natural Gas Pipeline that extends from Freeport, Bahamas to Port Everglades, Florida. Survey objective was to qualitatively and quantitatively characterize various benthic habitats to provide guidance in identifying a preferred pipeline route that would minimize impact to benthic communities. Data obtained during the survey define pre-construction baseline conditions of existing benthic habitats and will be utilized for post-construction monitoring (Kimley-Horn and Associates, Inc., 2002 to 2003).
- Chief Scientist during assessment and restoration of the *CONNECTED* grounding on Western Sambo Reef in the Florida Keys National Marine Sanctuary. Responsible for the collection of photographic data, developing restoration plan to reattach broken fragments of *Acropora palmata*, and conducting restoration. Restoration included substrate stabilization, reattachment of 370 coral fragments within artificial reef replacement modules, and collection of baseline monitoring data (Fowler, White, Burnett, Hurley, Banick & Strickroot, 2001).
- Natural resource damage assessment (NRDA) for the *GILBERT TAYLOR* barge grounding and salvage incident on the north shore of Petit Bois Island in Mississippi Sound. Program objectives were to quantify the extent and volume of the bathymetric anomalies (i.e., seafloor disturbances), assess biological impacts, and identify options to restore the habitat to its pre-existing condition. Field operations included collection of bathymetric data, ground-truthing detected anomalies, and determining presence/absence of seagrasses within the impact site (U.S. National Park Service, 2001).



- Chief Scientist during assessment, habitat restoration, and monitoring of the *FIRAT* grounding on nearshore hard bottom reef at Fort Lauderdale, Florida. Responsible for the collection of video and still photographic data and in-situ identification of predominant fauna impacted during the grounding. Delineated the spatial extent of impact and conducted hard coral reattachment as a compensatory action. Monitored hard coral reattachment status, relative health, and recruitment for 5 years following habitat restoration. Responsibilities also included document preparation and project management (Taylor, Mosely, & Joyner, 1994 to 2000).
- Project Manager and/or Chief Scientist on over 70 photodocumentation surveys in the Gulf of Mexico, northwest Atlantic, and Russia. Supervised collection and analysis of samples and data, document preparation, and report presentation (Various clients, 1983 to 2000).
- Chief Scientist and Scientific Diver during survey to investigate potential bioaccumulation of chemical components of produced water in biota near offshore oil and gas facilities in the northwest Gulf of Mexico. Responsible for sample collection of water, and biota that included fish, macroinvertebrates, and bivalves. Other responsibilities included sample processing, data analysis, project management, and document preparation (Offshore Operators Committee, 1994 to 1997).
- Monitoring impact and recovery of seagrass (primarily *Halophila decipiens*) during exploratory gas drilling operation in the Big Bend region offshore of northwest Florida. Collected and analyzed video and photographic data to determine and map spatial and temporal extent of impact recovery (Sohio, 1988).

## PUBLICATIONS

Graham, B.D., E. Hodel, and A. McCarthy. 2008. Coral Community Restoration following Vessel Groundings in Broward County, Florida: A Review of Efforts and Future Needs. The 11th International Coral Reef Symposium (Abstract). Mini-Symposium 24: Reef Restoration, Fort Lauderdale, FL.

Kilbane, D.A., B.D. Graham, R.D. Mulcahy, A. Onder, and M. Pratt. 2008. Coral Relocation for Impact Mitigation in Northern Qatar. The 11th International Coral Reef Symposium (Abstract). Mini-Symposium 24: Reef Restoration, Fort Lauderdale, FL.

Moore, T., B.D. Graham, S. Griffin, K. Kirsch, C. Lilyestrom, and M. Nemeth. 2008. Restoration of *Acropora cervicornis* at the site of the M/T MARGARA Grounding. The 11th International Coral Reef Symposium (Abstract). Mini-Symposium 24: Reef Restoration, Fort Lauderdale, FL.

Graham, B.D. and R.D. Mulcahy. 2003. Coral Reef Injuries and Relevant Case Studies: Management Tool for Directing Restoration. MarCuba 6th Congress on Marine Sciences (Abstract). Havana, Cuba.

Tilmant, J., L. Canzanelli, R. Clark, R. Curry, B.D. Graham, M. Mayr, A. Moulding, R.D. Mulcahy, S. Viehman, and T. Whittington. 2003. Restoration of Coral Reef Habitats within the National Park System. 2003 Biennial Conference of the George Wright Society. San Diego, CA.

Turner, R.L. and B.D. Graham. 2000. New Records of Echinoderms from the Gulf of Mexico. The 64th Annual Meeting of the Florida Academy of Sciences (Abstract). Melbourne, FL.

Graham, B.D. and P. Fitzgerald. 1999. New Technique for Hard Coral Reattachment - Field Tested Following Two Recent Ship Groundings. International Conference on Scientific Aspects of Coral Reef Assessment, Monitoring, and Restoration (Abstract). Fort Lauderdale, FL.



Thompson, M.J., W.W. Schroeder, N.W. Phillips, and B.D. Graham. 1999. Ecology of Live Bottom Habitats of the Northeastern Gulf of Mexico: A Community Profile. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0001 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study MMS 99-0004.

Gettleson, D.G., A.D. Hart, K.D. Spring, and B.D. Graham. 1998. Baseline Environmental Surveys of the Piltun-Astokhskoye Field, Offshore Sakhalin Island, Russia. 1998 American Association of Petroleum Geologists Annual Convention (Abstract).

Graham, B.D. and M. Schroeder. 1996. M/V *FIRAT* Removal, Grounding Assessment, Hard Coral Reattachment, and Monitoring - A Case Study, pp. 1,451-1,455. In: Oceans 96 MTS/IEEE Conference Proceedings. The Coastal Ocean - Prospects for the 21st Century. 23-26 September 1996, Fort Lauderdale, FL.

Jaap, W., B.D. Graham, and G. Mauseth. 1996. Reattaching Corals Using Epoxy Cement. 8<sup>th</sup> International Coral Reef Symposium (Abstract).

Jaap, W., B.D. Graham, and G. Mauseth. 1995. *FIRAT* Grounding Assessment and Coral Reattachment Project. International Estuarine Research Federation (Abstract).

Hart, A.D., B.D. Graham, D.A. Gettleson, D.L. Demorest, and B.W. Smith. Naturally Occurring Radioactive Materials Associated with Offshore Produced Water Discharges in the Gulf of Mexico. A presentation at the 1995 International Produced Water Seminar sponsored by STATOIL Research and Development, 25-28 September 1995, Trondheim, Norway.

Hart, A.D., B.D. Graham, and D.A. Gettleson. 1995. NORM Associated with Produced Water Discharges. Society of Petroleum Engineers Publication 29727. Annual Meeting of the Society of Petroleum Engineers. Society of Petroleum Engineers, Richardson, TX.

Gettleson, D.A., A.D. Hart, and B.D. Graham. 1994. Environmental and Economic Assessment of Discharges from Gulf of Mexico Region Oil and Gas Operations. U.S. Department of Energy (Abstract).

Hart, A.D., B.D. Graham, and D.A. Gettleson. 1993. Concentrations of Naturally Occurring Radioactive Materials Associated with Produced Water Discharges from Production Platforms in the Northwestern Gulf of Mexico. Presentation at the 14th Meeting of the Society of Environmental Toxicology and Chemistry, Houston, TX.

Graham, B.D. and R.L. Turner. 1984. Nutrition of Ghost Crabs Fed Prey of Different Organic Composition. Fla. Sci. 47:17-18 (Abstract).

Graham, B.D. 1983. The Effect of Diet on the Biochemical Composition of the Hepatopancreas of Male *Ocypode quadrata*. M.S. thesis, Florida Institute of Technology. 50 pp.

## PROFESSIONAL CERTIFICATIONS

Open Water SCUBA Diver – National Association of Underwater Instructors (NAUI)

CPR – American Red Cross

Multi-media Standard First Aid – American Red Cross

Nitrox Specialty Diver – Professional Association of Diving Instructors (PADI)



**BRUCE D. GRAHAM**

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### **PROFESSIONAL AFFILIATIONS**

Florida Academy of Sciences  
Phi Beta Kappa - University of New Hampshire  
Beta Beta Beta - Florida Institute of Technology  
Sigma Xi - Florida Institute of Technology

### **EXPERT WITNESS TESTIMONY**

Healy & Baillie, 2007. Mr. Graham provided expert witness testimony concerning the structural and biological impact from the *EASTWIND* vessel grounding offshore Broward County, Florida.

U.S. Department of the Interior, National Park Service, 2002. Mr. Graham provided expert witness testimony concerning the structural and biological impact from a vessel grounding within Biscayne National Park. The case was settled prior to litigation.

Coastal Petroleum, 1996. Mr. Graham was Chief Scientist during a photodocumentation survey conducted in Bob Sikes Cut Oil and Gas Lease Block Site A. This survey was required by the State of Florida Department of Environmental Protection and MMS prior to oil and gas activities. Mr. Graham gave expert witness testimony concerning the results of the photodocumentation survey and potential biological resources present within the survey area.

Sunrise Marina, 1989. Mr. Graham was Chief Scientist during a seagrass survey conducted in St. Lucie County, Florida. The survey was sponsored by a concerned citizen opposed to a proposed marina adjacent to his property. Mr. Graham presented factual testimony concerning results of the survey in St. Lucie County Court.



**Senior Staff Scientist, Marine Biologist**

**Education**

*Master of Science in  
Biological  
Oceanography, Texas  
A&M University, 1980*

*Bachelor of Science in  
Zoology, Texas A&M  
University, 1978*

Mr. Viada specializes in the evaluation of impacts of offshore oil and gas operations on the marine environment. He has served as program manager and principal investigator for projects in both U.S. and international offshore areas, including the Gulf of Mexico, Florida, California, Alaska, Russia, United Arab Emirates, Qatar, Azerbaijan, Malaysia, Indonesia, Africa, the Bahamas, and Trinidad. These projects include environmental baseline surveys, monitoring programs, Phase I environmental assessments, and environmental impact assessments (reports and statements) for offshore seismic activities, and oil and gas exploration and production. Offshore surveys include benthic as well as marine mammal and turtle surveys involving the collection of quantitative and qualitative video and still photographic data, fish and invertebrate samples, water quality and water column productivity samples, and sediment chemistry and geology samples.

Mr. Viada is experienced with field studies and resource management and conservation issues pertaining to protected and listed marine mammal, bird, and turtle species. He has conducted several systematic surveys of these resources within the Gulf of Mexico, Atlantic Ocean, Alaska, Australia, Africa, and Russia. He has been a primary author for the National Environmental Policy Act (NEPA) environmental impact analysis reports, including Environmental Assessment (EA), Environmental Impact Analysis (EIA), and Environmental Impact Statement (EIS) reports that address concerns of these resources, including protected and listed species. As staff biologist with the U.S. Department of the Interior, Minerals Management Service (MMS), he was directly responsible for all issues that involved the effects of Outer Continental Shelf (OCS) production and activities upon marine mammal and marine bird resources within the Gulf of Mexico and for addressing these issues within the MMS Environmental Impact Statement for the Gulf of Mexico Central and Western Planning Areas Lease Sales.

Mr. Viada is an experienced marine ecologist/oceanographer who has specialized in benthic community characterization, mapping, and ecology. He has had over 29 years experience in the management and execution of studies that utilize photographic techniques for the qualitative and quantitative analyses of benthic communities, primarily both shallow water and deepwater coral reef and coral-dominated hard bottom communities. He also has over 29 years of experience as a specialist in taxonomic identification of scleractinian corals and octocorals.

**REPRESENTATIVE EXPERIENCE**

**1993 to Present: CSA Ocean Sciences Inc. – Senior Staff Scientist, Marine Biologist**

- Principal investigator and lead scientist for an environmental survey off southwestern Ecuador for Noble Energy, Inc. (2010).
- Project manager and contributing author of an Environmental Impact Assessment document pertaining to proposed nearshore seismic survey operations and exploration drilling off northeast Mozambique for Anadarko Moçambique Área 1, Lda (2008).
- Project manager and lead scientist of a characterization study of the deepwater coral *Lophelia pertusa* and other deepwater hard bottom biological communities in the north-central Gulf of Mexico for the MMS (2003 to 2007).

- Principal author of an Environmental Assessment (Integrated AMDAL) for the gas exploitation, gas transmission, liquefied natural gas (LNG) plant, sea port, airfield, and resettlement associated with the Tangguh LNG Project (Manokwari, Sorong, and Fak-Fak Regencies, Papua Province–Irian Jaya [Western Papua]) for Pertamina and British Petroleum (2003).
- Lead scientist of a study to determine the effects of offshore drilling activities within deepwater (continental slope) environments within the Gulf of Mexico for the MMS (2002 to 2003).
- Project manager and contributing author of a literature review and data synthesis report pertaining to marine mammals and fisheries off Sakhalin Island (Russia) for British Petroleum (2002).
- Project manager for a review of a proposed Scope of Work to conduct a study of the feeding ecology of the western Pacific gray whale off Sakhalin Island (Russia) for LGL Ltd. (2002).
- Lead scientist of a study to determine the effects of synthetic-based drilling fluids within continental shelf and continental slope environments of the Gulf of Mexico for the American Petroleum Institute (API) (2001).
- Program manager and principal investigator of aerial survey program for the assessment of marine mammals and sea turtles offshore of Mayport, Florida, for the U.S. Navy *WINSTON CHURCHILL* (DDG 81) shipshock trial program (1997).
- Awarded Visiting Scientist Grants at the Smithsonian Institute’s National Museum of Natural History (Washington, D.C.) to study deep water octocorals of the North Atlantic (1998 and 2009).
- Program manager and principal investigator of aerial survey program for the assessment of the North Atlantic right whale and other endangered marine mammal and sea turtle species offshore of Georgia and Florida for the U.S. Navy (1996 to 1999).
- Principal investigator and lead scientist of the long-term monitoring study of the Flower Garden Banks (northwest Gulf of Mexico) for the MMS (1995 to 1996).
- Program manager and principal investigator of an aerial survey program for the assessment of marine mammals and sea turtles offshore of Norfolk, Virginia, and Mayport, Florida, for the U.S. Navy *SEAWOLF* submarine shipshock trial program (1995).
- Program manager and lead scientist of the North Sakhalinsk Shelf (Russia) marine mammal and seabird surveys and pre-drilling biological and chemical surveys for Exxon Petroleum Company and Marathon Petroleum Company (1994 to 1995).

**1991 to 1993: U.S. Department of the Interior, Minerals Management Service, New Orleans, Louisiana – Biologist**

- Contributing author of lease sale Environmental Impact Statements, including editing, production of graphics, and in-depth preparation of sections of each impact statement directly related to the marine mammal, marine bird/waterfowl, and hardbottom community resources in the northern Gulf of Mexico.
- Contract inspector for Contract 14-35-0001-30619: The Distribution and Abundance of Marine Mammals in the North-Central and Western Gulf of Mexico (GULFCET). Participant on shipboard and aerial surveys of marine mammals within the central and western Gulf of Mexico.
- Private consultant for taxonomic identifications of collected and photographed scleractinian corals and octocorals.



STEPHEN T. VIADA

1983 to 1984: National Oceanic and Atmospheric Administration (NOAA) – NOAA Corps, Seattle, Washington

#### PEER-REVIEWED PUBLICATIONS

Viada, S.T. In preparation. A new species of *Anthothela* (Anthozoa: Octocorallia) from the northeast Gulf of Mexico.

Viada S.T., R.M. Hammer, R. Racca, D. Hannay, M.J. Thompson, B.J. Balcom, and N.W. Phillips. 2008. Review of potential impacts to sea turtles from underwater explosive removal of offshore structures. Environmental Impact Assessment Review 28(4-5):267-285.

Viada, S.T. and S.D. Cairns. 2007. A new species of *Nicella* (Anthozoa: Octocorallia) from the northeast Gulf of Mexico. Proc. Biol. Soc. Wash. 120(2):227-231.

Viada, S.T. and S.D. Cairns. 1988. Range extensions of ahermatypic Scleractinia in the Gulf of Mexico. Northeast Gulf Science 9(2):131-134.

Cordes, E., M. McGinley, E. Podowski, E. Becker, S. Lessard-Pilon, S.V iada, and C. Fisher. 2008. Coral communities of the deep Gulf of Mexico. Deep-Sea Research Part I, 55(6):777-787.

Bright, T. J., G.P. Kraemer, G.A. Minnery, and S.T. Viada. 1984. Hermatypes of the Flower Garden Banks, Northwestern Gulf of Mexico: A comparison to other western Atlantic reefs. Bulletin of Marine Science 34(3):461-476.

#### PROFESSIONAL CERTIFICATIONS

Marine Mammal Observer (Joint Nature Conservation Committee) (2007)

Protected Species Observer (Minerals Management Service) (2007)

U.S. Coast Guard Merchant Marine Officer License: Master of steam or motor vessels up to 200 gross tons

Oxygen Enriched Air (Nitrox) Dive Gas Blender – IANTD (2002)

Nitrox Diver – IANTD/NURP (1994)

Divemaster – NOAA (1984)

Limited Diver – NOAA (1982)

Variable Volume Diving Suit – NOAA (1982)

SCUBA Cylinder Inspection – NAUI (1984)

Advanced SCUBA Diver – PADI (1984)

Rescue Diver – PADI (1984)

Senior Diver – NASDS (1972)

Basic Diver – NASDS (1969)

Advanced Multimedia Standard First Aid – American Red Cross (2008)

Cardiopulmonary Resuscitation (CPR) – American Red Cross (2008)



DAVID B. SNYDER

**Senior Scientist, Marine Biologist**

**Education**

*Master of Science in  
Marine*

*Biology/Ichthyology,  
Florida Atlantic  
University, 1984*

*Bachelor of Science in  
Zoology, University of  
Florida, 1978*

Mr. Snyder is an experienced marine ecologist and fish biologist. He has more than 25 years of experience in the ecology and taxonomy of western Atlantic and Gulf of Mexico shelf and shore fishes (particularly seagrass and reef-associated species). He has managed and participated in ichthyofaunal surveys of freshwater, estuarine, shelf, and coral reef habitats. He has sampled fish from a variety of habitats ranging from the continental slope to freshwater streams for various environmental assessments and monitoring studies. Mr. Snyder has visually censused fish assemblages off southeast and southwest Florida, the Federated States of Micronesia, Grand Cayman Island, and the Bahamas using quantitative and qualitative methods. He surveyed fishes associated with hard bottom areas subject to impact from dredge and fill projects off the eastern and western Florida coasts. He has monitored reef fish assemblages on nearshore natural and artificial reefs for the town of Palm Beach and Palm Beach County Florida. He has characterized fish assemblages on a deep reef trend in the northern Gulf of Mexico from videotapes taken by a remotely operated vehicle. He is currently working with colleagues at the Florida Museum of Natural History to assemble a comprehensive listing and assessment of marine fishes of southwest Florida and the Florida Keys. He recently studied the response of fish assemblages to water flows and levels in the Loxahatchee River, Florida, using electrofishing gear for the South Florida Water Management District. He is currently investigating habitat utilization by newly settled fishes on nearshore hard bottom habitats in Palm Beach County, Florida for the Florida Department of Environmental Protection. Mr. Snyder is also managing an independent monitoring program for seagrass-associated fishes in the vicinity of Jupiter Inlet, Florida. He has participated in coral reef damage assessment and restoration projects in south Florida, the Florida Keys, and the Federated States of Micronesia.

Mr. Snyder is experienced with coral re-attachment techniques used in rehabilitation of damaged coral reefs. He has worked with commercial fishermen assessing the impacts of shrimp trawling on inshore fish populations in Florida. He also has investigated the life history of the bigeye scad, an important baitfish in southern Florida. He has participated as a Chief Field Scientist on numerous photodocumentation surveys in the Gulf of Mexico and off the Atlantic coast. Mr. Snyder managed field efforts that included trawling, sediment profile imaging, and grab sampling for assessments of sand deposits proposed as borrow sites for beach nourishment offshore of Alabama, Florida, New Jersey, New York, and North Carolina. He also managed a project that investigated the potential conflict between deepwater fisheries and oil and gas operations in the Gulf of Mexico. He currently manages a project that investigates the ecological functions of nearshore hard bottom along the east coast of Florida for the Florida Department of Environmental Protection.

Mr. Snyder has prepared the fish and fisheries sections of several environmental reports. He summarized commercial and recreational fisheries data for Florida, southern California, and the southeastern United States. He has prepared Essential Fish Habitat (EFH) assessments for several environmental impact statements and environmental assessments. Mr. Snyder has extensive experience in the identification, collection, and annotation of marine environmental literature and data.



Prior to joining CSA, Mr. Snyder participated in an ecological study of the fish fauna associated with the discharge canals at Florida Power and Light's nuclear power plant at Crystal River, Florida. He also served as Research Assistant on a U.S. Fish and Wildlife Service (USFWS) project investigating the biology and impacts of introduced fishes in Florida. Mr. Snyder's thesis work entailed monthly collections of seagrass fishes from two estuarine sites near Jupiter Inlet, Florida. He was also Chief Field Scientist and vessel operator during an ichthyoplankton survey of the Loxahatchee River Estuary, Florida. In addition, he worked as a commercial fisherman in Jupiter, Florida for 13 years. Mr. Snyder is an accomplished underwater photographer; his underwater fish photographs have appeared in regional field guides as well as technical and popular publications. His diving experience includes more than 1,200 dives; he is experienced in benthic photography and videotaping, *in-situ* identification of coral reef fishes, reattachment and transplanting both hard corals and octocorals, and the collection of various types of sediment samples.

## REPRESENTATIVE EXPERIENCE

### 1984 to Present: CSA Ocean Sciences Inc. – Senior Scientist

- Chief scientist and project manager for an evaluation of ecological function and mitigation of nearshore hard bottom in southeast Florida (Florida Department of Environmental Protection, 2007 to present).
- Chief scientist and project manager for an assessment of relationships between fish assemblages and dry season flow and stage levels on the riverine reach of the northwest fork of the Loxahatchee River, Florida (South Florida Water Management District, 2008).
- Chief scientist and project manager for monitoring of hard bottom adjacent to fill and borrow areas for a beach nourishment project offshore Venice, Florida (Coastal Technology Corporation, 2005 to present).
- Monitored fish assemblages associated with artificial mitigation reefs and natural hard bottom in conjunction with a beach nourishment project offshore Phipps Park in Palm Beach, Florida (Coastal Planning and Engineering, 2005 to present).
- Managed a fish and epibiotic monitoring program designed to assess the efficacy of artificial reefs as a means of mitigating the effects of beach nourishment projects on nearshore hard bottom habitat off Palm Beach County, Florida. Quantitative data on fish and invertebrate assemblages associated with artificial reefs and natural reefs were collected during summer months. Preliminary analyses indicated that fish assemblages on artificial reefs differed from those on natural reefs (Palm Beach County Department of Environmental Resources Management, 2001 to present).
- Managed field surveys for three projects designed to characterize the biota associated with sand deposits proposed as borrow sites for beach nourishment projects offshore of New York and New Jersey. Data collected included temperature, salinity, dissolved oxygen, sediment grain size, sediment profile imagery infauna, epifauna, and demersal fishes (Minerals Management Service, 2000 to present).

- Analyzed potential interactions between bluewater fishing and deepwater oil and gas operations in the Gulf of Mexico. Fisheries and energy industry information was gathered to assess the potential for problems in the rapidly expanding deepwater oil and gas effort. Current and past conflicts reported in domestic and international waters were examined as well. Areas of potential future conflict were predicted using Geographic Information Systems analyses (Minerals Management Service, 1998 to present).
- Prepared a characterization and trends of recreational and commercial fisheries from the Florida panhandle. This project summarized available recreational and commercial fisheries data from Florida's panhandle for the 1983 to 1993 period. The results will assist federal managers in preventing conflicts between fisheries and oil and gas exploration and development proposed for the panhandle outer continental shelf (National Biological Service, 1995 to 1998).

## PUBLICATIONS)

- Snyder, D.B. and G.H. Burgess. 2006. The Indo-Pacific red lionfish, *Pterois volitans* (Pisces: Scorpaenidae), new to Bahamian ichthyofauna. Coral Reefs.
- Byrnes, M.R., R.M. Hammer, T.D. Thibaut, and D.B. Snyder. 2004. Physical and biological effects of sand mining offshore Alabama, U.S.A. *Journal of Coastal Research*, 20(1):6-24.
- Byrnes, M.R., R.M. Hammer, T.D. Thibaut, and D.B. Snyder. 2004. Effects of sand mining on physical processes and biological communities offshore New Jersey, U.S.A. *Journal of Coastal Research*, 20(1):25-43.
- Snyder, D.B., J.E. Randall, and S.W. Michael. 2001. Aggressive mimicry by the redmouth grouper (*Aetheloperca rogaea*). *Cybium*, 25(3):227-232.
- Snyder, D.B., K.D. Spring, B.D. Graham, S.T. Viada, and D. Hardin. 2000. Northeastern Gulf of Mexico Coastal and Marine Ecosystem Program: Ecosystem monitoring, Mississippi/Alabama shelf; hard bottom communities, pp. 341-346. In: McKay, M. and J. Nides (eds.), Proceedings eighteenth annual Gulf of Mexico Information Transfer Meeting, December 1998. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-030. 538 pp.
- Snyder, D.B. 1999. Mimicry of initial-phase bluehead wrasse, *Thalassoma bifasciatum* (Labridae) by juvenile tiger grouper, *Mycteroperca tigris* (Serranidae). *Revue Francaise d'Aquariologie* 26(1-2):17-20.
- Lindeman, K.C. and D.B. Snyder. 1999. Nearshore hard bottom fishes of southeast Florida and effects of habitat burial by dredging. *Fishery Bulletin* 3:508-525.
- Taylor, J.N., D.B. Snyder, and W.R. Courtenay, Jr. 1986. Hybridization between two substrate spawning tilapias in southern Florida. *Copeia* 4:903-909.
- Snyder, D.B. 1984. Species richness, abundance, and occurrence of grassbed fishes from Jupiter Inlet, Florida. Masters thesis, Florida Atlantic University. 75 pp.



**DAVID B. SNYDER**

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### **PROFESSIONAL CERTIFICATIONS**

U.S. Coast Guard Ocean Operator  
Open Water SCUBA Diver – Professional Association of Diving Instructors (PADI)  
Nitrox Certified – PADI  
Multimedia Standard First Aid – American Red Cross  
Cardiopulmonary Resuscitation (CPR) – American Red Cross

### **PROFESSIONAL AFFILIATIONS**

American Fisheries Society  
American Society of Ichthyologists and Herpetologists  
International Society for Reef Studies  
Gulf and Caribbean Fisheries Institute



**DEBORAH K. FAWCETT**

### **Project Scientist III, Benthic Ecologist**

#### **Education**

*Master of Science in  
Marine Science,  
University of South  
Alabama, 2003*

*Bachelor of Arts in  
Biology, Wittenberg  
University, 2000*

Ms. Fawcett is a marine biologist with over 12 years experience in marine and freshwater biology. She has served as Project Manager, Project Scientist, and/or Lead Field Scientist on several environmental baseline surveys; oil and gas exploration monitoring programs; habitat assessments; coral relocation programs; and restoration and monitoring programs in coral reefs, seagrass beds, hard bottom, and estuarine habitats. She has served as Project Manager, Project Scientist, and/or Lead Author on numerous environmental impact assessments (EIAs), monitoring and implementation plans, field survey reports, and decommissioning projects; supervised field staff in data collection; and provided assistance in the collection and analysis of samples and data for numerous environmental field studies, including both multidisciplinary baseline studies and environmental monitoring programs in the coastal areas of Florida, New Jersey, Puerto Rico, Qatar, and the United Arab Emirates and deep water habitats in the Gulf of Mexico and the Mediterranean Ocean.

Prior to environmental consulting, Ms. Fawcett was a Senior Scientific Associate with the South Florida Water Management District–Everglades Division. She was responsible for logistical and field support, field sampling, and project management of a mandated bimonthly monitoring program. Other responsibilities included Hydrolab and YSI maintenance, data collection, quality assurance/quality control (QA/QC), data analysis, permit renewal, and preparing and editing grant proposals and annual reports. Ms. Fawcett contributed to the preparation of Everglades National Park Comprehensive Annual Reports.

Ms. Fawcett is a certified National Association of Underwater Instructors Advanced Open Water SCUBA diver and is trained in Red Cross cardiopulmonary resuscitation (CPR) and first aid. She has been active in the Palm Beach County, Florida Artificial Reef Program by conducting biological monitoring and co-authoring grant proposals for successful procurement of funding from the Florida Fish and Wildlife Conservation Commission. She is skilled in small boat operations and has completed the U.S. Coast Guard Auxiliary Boating Skills and Seamanship Course.

#### **EXPERIENCE**

##### **2013 to Present: CSA Ocean Sciences Inc. – Project Scientist III, Benthic Ecologist**

- Project Manager for the preparation of multiple Environmental Impact Analyses for Shell Exploration and Production and ConocoPhillips prospects in the Gulf of Mexico. Responsibilities included preparing the EIA and coordinating the completion the EIA among the client, technical review, editing, and document production staff as well as budget management.
- Project Manager on multiple environmental monitoring programs for oil and gas exploration and development in the Levantine Basin and continental slope, offshore Israel. Responsibilities included survey planning, preparation, and coordination, budget management, and project schedule oversight.

- Project Manager for a multi-year environmental monitoring program in Bohai Bay, China. The potential environmental impacts of an accidental release of crude oil and MOBMs were evaluated through a comprehensive Environmental Assessment Program consisting of four Phases beginning in August 2011 and ending in August 2013. Responsibilities included coordination and oversight of subcontractors, assisting client and subcontractor with survey planning and preparation, budget management, project schedule oversight, and deliverable preparation.
- Chief Field Scientist and author on multiple deepwater monitoring surveys for oil and gas development in the Levantine Basin and continental slope, offshore Israel. Responsibilities included assisting in sample collection, preservation, and shipping; in-situ video data analysis; and report preparation.

**2006 to 2013: CSA Ocean Sciences Inc. – Project Scientist II, Benthic Ecologist**

- Project Manager for the preparation of multiple Environmental Impact Analyses for ConocoPhillips prospects in the Gulf of Mexico. Responsibilities included preparing the EIA and coordinating the completion the EIA among the client, technical review, editing, and document production staff as well as budget management.
- Co-Project Manager and contributing author on an analysis of decommissioning options associated with a deepwater platform in the Gulf of Mexico, with an emphasis on the current regulatory environment and platform disposal options.
- Field Scientist and author on multiple deepwater monitoring surveys for oil and gas development in the Levantine Basin and continental slope, offshore Israel. Responsibilities included assisting in sample collection, preservation, and shipping; in-situ video data analysis; and report preparation.
- Project Manager and Lead Author on an Environmental and Social Impact Assessment for an oil and gas development offshore of Cameroon. Responsibilities included preparing the ESIA and coordinating the completion the ESIA among the client, subcontractors, in-country representative, technical review, editing, and document production staff as well as budget management.
- Project Manager for the preparation of Environmental Impact Assessment (EIA) for a Hess prospect in the Gulf of Mexico. Responsibilities included coordinating the completion the EIA among the client, EIA author, technical review, editing, and document production staff as well as budget management.
- Project Manager for the preparation of 25 Environmental Impact Analyses for Shell Exploration & Production Company prospects in the Gulf of Mexico. The EIAs were prepared in accordance with the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) requirements in effect as of 14 December 2010. Responsibilities included coordinating the completion the EIAs, with up to four written concurrently, among the client, EIA authors, technical editing, and document production staff as well as budget management.
- Field Manager and Lead Field Scientist for the RasGas Coral Relocation and Monitoring Project.
- Lead Field Scientist for Bahia Icaos Environmental Survey and Habitat Mapping Project.
- Field Scientist for environmental surveys off Indian River County, Florida, to assess nearshore hard bottom habitat prior to and after construction of three beach nourishment projects. Establish permanent transects and collect close-up video and repetitive *in situ* quadrat data to characterize and monitor hard bottom communities.



- Field Scientist for Hillsboro/Deerfield Beach Renourishment Monitoring Project. Pre-, during, and post-construction nearshore hard bottom and reef characterization and monitoring surveys were conducted in association with the beach renourishment project. Assisted in establishing permanent transects, measuring sediment accumulation, assessing permanent quadrats, and collecting data on sand-hard bottom intercept positions and coral stress observations.
- Lead Field Scientist for Puerto Rico Aqueduct and Sewer Authority (PRASA) wet season coral community monitoring surveys near the Arecibo and Aquadilla Regional Waste Water Treatment Plant outfalls offshore Puerto Rico. Surveys were conducted in compliance with 301(h) waiver demonstration. Responsibilities included video and digital photographic data collection of pre-established transects, data analysis, and report preparation.
- Project Manager/Lead Field Scientist for Biscayne National Park (BISC) Seagrass Restoration Project at No Name Shoal. Restoration activities conducted at two orphan seagrass injuries on No Name Shoal included: a) the placement of approximately 350 yd<sup>3</sup> of loose fill and b) the installation 80 bird roosting stakes. Approximately 272 m<sup>2</sup> of seagrass habitat was returned to grade to improve the likelihood of natural seagrass colonization. Responsibilities included participation in a planning meeting and site assessment survey, seagrass injury mapping, preparation and implementation of a seagrass restoration plan, field oversight of restoration activities, on-sight coordination with BISC staff and sub-contractors, turbidity monitoring, and report preparation.
- Project Manager/Lead Field Scientist for BISC 2010 Derelict Trap and Debris Removal Project. Over a 16-day period, approximately 697 trap equivalents were removed from 1.9 km<sup>2</sup> of shallow patch reef areas east of Elliot Key. Responsibilities included the preparation and implementation of a debris removal plan, field survey oversight, on-sight coordination with BISC staff oversight, and report preparation.
- Supporting Scientist and Field Scientist during emergency coral reef restoration efforts associated with the grounding of the naval destroyer *USS PORT ROYAL* approximately 0.5 mi offshore of Honolulu International Airport's Reef Runway. Member of field team responsible for damage assessment and reattachment of over 5,300 coral colonies.
- Lead Field Scientist for the Village of Key Biscayne Seagrass Restoration and Mitigation Project. Responsibilities included preparation of a restoration and mitigation plan, field implementation of baseline and biannual monitoring surveys, data collection and analysis, and report preparation.
- Lead Field Scientist for a confidential client for a deep water port and preferred route survey offshore northeastern USA. Survey tasks included collection of towed video and digital photographic data, habitat characterization within the survey area, and QA/QC of data.
- Project Scientist for the Shell Pearl GTL Proposed Pipelines Coral Relocation Project. Responsible for scientific oversight and support for the removal, transportation, reattachment, installation and preparation of monitoring sites, and baseline monitoring of approximately 600 corals as mitigation for pipeline installation activities offshore the State of Qatar.
- Project Manager/Field Scientist for the Qatargas Coral Relocation Project. Responsibilities included supervising and conducting the removal, transportation, and reattachment of 4,500 hard corals as mitigation for pipeline installation activities offshore the State of Qatar and the selection, installation, and monitoring of six reattachment sites at 6 and 12 months post-reattachment. Compiled and prepared a coral management plan, project report, monitoring survey reports, documentary video, and several presentations.

- Field Scientist for the Dolphin Energy Limited Mitigation and Coral Recruitment Study. Responsibilities included installation of monitoring stations at the EcoReef, concrete-coated pipeline, rock pile, and control habitats and conduction of baseline monitoring.
- Field Scientist for the Biscayne National Park Seagrass Restoration Project. Responsibilities included oversight and photographic documentation of turbidity screen installation and removal, sediment bag placement, and installation of bird stakes in selected orphan grounding sites on Middle Featherbeds in Biscayne National Park.
- Lead Scientist for Leif Hoegh Re-route Survey in Tampa Bay. Survey tasks included collection of towed video data and habitat characterization within the survey area and delineation of seagrass habitat. Responsible for towed video data collection, QA/QC of data, and seagrass assessment.
- Field Scientist for the Texas Reef Year 4 Monitoring Survey to document temporal and spatial changes of the epibenthic and ichthyofaunal assemblages associated with the artificial reef offshore Hutchinson Island, Martin County, Florida. Responsibilities included conducting qualitative and quantitative diver video transects.
- Field Scientist/Diver for monitoring coral and seagrass health and levels of sedimentation in association with the maintenance dredging of Truman Harbor, the turning basin, and the Key West Ship Channel (U.S. Department of the Navy, 2002 to 2007).
- Project Manager/Field Scientist for Shell Pearl GTL Proposed Pipelines Coral and Seagrass Survey. Survey tasks included collection of towed video data providing complete coverage of the survey area, habitat delineation from review of the towed video data, and quantitative characterization of coral and seagrass habitats encountered within the survey area. Responsibilities included project oversight, scheduling of field survey, data collection, and preparation of Dive Plan, Health, Safety, and Environment (HSE) Plan, Survey Methodologies Plan, survey report, Power Point presentation, and Coral Mitigation Plan,
- Field Scientist for M/V *MARGARA* Restoration Project. Assisted in *in-situ* baseline data collection of hard and soft corals in emergency restoration and control areas for identification, reattachment status, coral size, and coral health.
- Chief Field Scientist/Diver for a field sample and data collection effort for a 301(h) waiver demonstration and Mixing Zone Validation Study at the Aguadilla, Arecibo, and Ponce Regional Wastewater Treatment Plant outfalls off the coast of Puerto Rico. Tasks included collection of sediment and fish samples, oversight of water sample collection, and collection of permanent coral transect diver video data. Survey reports and the results of video and still photograph analyses are being submitted to CH2M Hill (Puerto Rico Aqueduct and Sewer Authority, 2005 to present).
- Project Manager for the New Doha International Airport Mitigation project. Project oversight of harvest and transplant of hard corals and pearl oysters conducted as mitigation for the New Doha International Airport, State of Qatar.
- Project Manager for the North Field Bravo Environmental Baseline Survey offshore the State of Qatar. Responsibilities included project oversight, data analysis, and report preparation.
- Project Manager/Author of the Environmental Assessment of Exploration Drilling, West Cape Three Points Block, offshore Ghana.
- Project Manager/Co-author of environmental impact assessments (EIAs) for the Gumusut-Kakap Field Development Project and Export Pipeline Project offshore Sabah, Malaysia. Responsibilities included project oversight, preparation of two EIAs and preparation and presentation of impact analysis to the client.



- Field Scientist for the M/V *EASTWIND* Restoration Project offshore Broward County, Florida. Assisted in impact assessment, restoration, report preparation, and data assembly.
- Project Manager for the M/V *DEBBET* Restoration and Monitoring Project in Biscayne National Park, Florida. Supervised and conducted restoration and monitoring activities, data analysis, and report preparation.
- Field Scientist for the Texas Reef Year 2 Monitoring Survey to document temporal and spatial changes of the epibenthic and ichthyofaunal assemblages associated with the artificial reef offshore Hutchinson Island, Martin County, Florida. Responsibilities included conducting qualitative and quantitative diver video transects, roving diver fish counts, data analysis, and report preparation.
- Field Scientist for the Florida Power & Light Broward County Subbottom Survey and Sediment Grain Size Analysis projects. Responsibilities included preparation of report and Sediment Sampling Plan.

**2005 to 2006: Marine Resources, Inc. – Staff Scientist**

- Project Manager of the *HEIDI BABY* Seagrass Restoration Project. Project consisted of filling a 98.3 m<sup>3</sup> blowhole and inbound trench created by a 44-ft Sportfisher that ran aground on a *Thalassia testudinum* shoal outside of Whale Harbor Channel in Islamorada, Florida. Responsibilities included oversight of material placement within the injury area, photo and video documentation of restoration activities, and document preparation.
- Field Scientist during the benthic survey to generally characterize the substrate and associated macro-benthic community for the Fort Pierce Marina project.
- Staff Scientist/National Environmental Policy Act (NEPA) Specialist for the *ALLIE B* Grounding Site Restoration Plan and Environmental Assessment and the *IGLOO MOON* Grounding Site Restoration Plan and Environmental Assessment. Responsibilities included documentation and quantification of current site conditions of the injuries, compilation of a visual time-series presentation of temporal changes in the condition of the injury site, and document preparation.
- Staff Scientist/NEPA Specialist for the Habitat Suitability Analysis: Compensation for Injured Reef in Support of Restoration Planning for the Berman Oil Spill (San Juan, Puerto Rico) conducted to identify marine habitats that could be utilized as compensation for lost ecological services provided by the hard bottom reef injured by the vessel grounding. Responsible for conducting a literature search, data compilation, and document preparation.
- Field Scientist for the Texas Reef Year 1 Monitoring Survey to document temporal and spatial changes of the epibenthic and ichthyofaunal assemblages associated with the artificial reef offshore Hutchinson Island, Martin County, Florida. Responsibilities included conducting qualitative and quantitative dive transects, video transects, and report preparation.

**2003 to 2004: South Florida Water Management District – Senior Scientific Associate**

- Project Manager of bimonthly transect monitoring of dissolved oxygen (DO), temperature, specific conductivity, and pH in the Everglades. Responsibilities included deployment and retrieval of Hydrolabs and YSIs by helicopter, Hydrolab and YSI maintenance, data acquisition, QA/QC, data analysis, permit renewal, and end-of-year report preparation.
- Senior Scientific Associate involved in the Periphyton Project to better understand the primary production of various systems within the Everglades ecosystem. Responsibilities included determining the primary production of periphyton mats using a DO micro-profiling system, completing trend analyses of multiple long term databases, and logistical and field support for a short term stable isotope pulse-chase experiment within the Everglades.



### 2000 to 2003: University of South Alabama – Graduate Research Assistant

- Project Manager of the Harmful Algal Bloom Monitoring Program in Mobile Bay, Alabama. Responsibilities included scheduling monthly sampling cruises; collecting water samples from 10 offshore sites; chlorophyll *a* analysis; creating a database and inputting nutrient, chlorophyll *a*, and harmful algal bloom counts from sampling cruises; and coordinating efforts with the Alabama Department of Public Health.
- Research Assistant for benthic field studies sampling in natural and artificial seagrass beds of various sizes, processing of samples, and species identification.
- Research Assistant for Alabama Center for Estuarine Studies: Top Down Trophic Cascade Project. Responsibilities included collection of benthic macrofauna and seagrass samples, sample processing, and species identification.

### PRESENTATIONS

Kilbane-Fawcett, D.A., B.D. Graham, R.D. Mulcahy, A. Onder, and M. Pratt. 2008. Coral Relocation for Impact Mitigation in Northern Qatar. The 11<sup>th</sup> International Coral Reef Symposium (Abstract). Mini-Symposium 24: Reef Restoration, Fort Lauderdale, FL.

Gottlieb, A., S. Hagerthey, R. Shuford, D. Kilbane-Fawcett, and S. Newman. 2004. The effects of varying conductivity on Everglades periphyton community structure. Society of Wetland Scientists. Seattle, WA. July 19 to 23. Poster presentation.

Kilbane-Fawcett, D. 2004. Monitoring artificial reefs in Palm Beach County: October 1, 2000 to September 30, 2002. Florida Artificial Reef Summit. Sarasota, FL. April 27 to 28. Poster presentation.

Kilbane-Fawcett, D. 2004. The status of artificial reefs in Palm Beach County: October 1, 2000 to September 30, 2002. Benthic Ecology Meeting. Mobile, AL. March 25 to 28. Oral presentation.

### PROFESSIONAL CERTIFICATIONS

NAUI Advanced SCUBA Diver  
PADI open water SCUBA Diver  
AAUS Certification  
First Aid/CPR/DAN Oxygen Administration  
Nitrox Certified  
Certified USCG Safe Boating and Seamanship Skills



**CHRISTOPHER J. KELLY, Ph.D.**

**Senior Scientist, Marine Ecologist**

**Education**

*Doctor of Philosophy,  
Ecology, University of  
Maryland, 2011*

*Bachelor of Science,  
Biology (Marine  
Biology and Ecology  
Options), Florida  
Institute of  
Technology, 2001*

Dr. Kelly is a marine ecologist with over 10 years of experience in marine environmental science. He has a strong background in linking the ecological processes of benthic and pelagic systems, investigating the importance of habitat complexity on predator-prey interactions, and examining how anthropogenic pressures affect benthic invertebrate and fish predator communities.

As a Senior Scientist at CSA International, Inc. (CSA), he has served as a Chief Scientist on several research cruises evaluating the impact of anthropogenic disturbance on deep-sea benthic systems. He has been responsible for field collection, management, and analysis of seawater, sediment, and infaunal samples. He has experience in designing and implementing statistically rigorous observational and manipulative research studies. He regularly coordinates fieldwork, supervises field staff in data collection, and prepares field survey reports.

Prior to consulting, Dr. Kelly was a principal investigator as a Ph.D. graduate student in a study researching the suitability of introducing the non-native suminoe (*Crassostrea ariakensis*) oyster into Chesapeake Bay to help alleviate the problems associated with the loss of native eastern (*Crassostrea virginica*) oyster biomass. This project was a collaboration among several universities and local, State, and Federal government agencies. His dissertation also included research on determining how complex aquatic habitats alter predator-prey relationships within a tri-trophic food web.

**REPRESENTATIVE EXPERIENCE**

**September 2011 to Present: CSA International**

- Chief Scientist for three environmental surveys within the eastern Mediterranean Sea to assess deep-sea benthic habitat prior to and after anthropogenic disturbances. Established permanent transects for observation, sediment, and seawater collection using a remotely operated vehicle (ROV). Statistically analyzed environmental data and collaborated on the writing of technical reports.

**2004 to 2011: University of Maryland – Graduate Research Assistant**

- Investigated the importance of essential fish habitat (i.e., oyster reefs, corals, mangroves), and how these structurally complex habitats affect both invertebrate prey and fish predator species through attraction, enhanced secondary production, and the interactions between them.
- Researched the suitability of the exotic suminoe oyster (*Crassostrea ariakensis*) for introduction into Chesapeake Bay to help alleviate the loss of native eastern (*Crassostrea virginica*) oyster biomass.
- Examined seasonal physiological differences of the suminoe and eastern oyster under temperate mesohaline and sub-tropical polyhaline regions.



**2001 to 2003: U.S. Peace Corps, Zambia – Rural Aquaculture / Fisheries Extension Agent**

- Developed a sustainable fishery in Northwestern Province, Zambia. Trained rural farmers how to construct and maintain Tilapia (*Oreochromis niloticus*) ponds using only locally available materials.
- Collaborated with fish farmer associations within Northwestern Province, Zambia to develop market strategies to optimize selling price for fishery products.

**PUBLICATIONS (Peer-Reviewed)**

Kelly, C.J., S.E. Laramore, J. Scarpa, and R.I.E. Newell. 2011. Seasonal comparison of physiological adaptation and growth of Suminoe (*Crassostrea ariakensis*) and eastern (*Crassostrea virginica*) oysters. *Journal of Shellfish Research*. 30: 737-749.

Kelly, C.J. and R.L. Turner. 2011. Distribution of the Hermit Crab *Clibanarius vittatus* and *Pagurus maclaughlinae* in the northern Indian River Lagoon, Florida: A reassessment after 30 years. *Journal of Crustacean Biology*. 31: 296-303.

**PUBLICATIONS (Peer-Reviewed Technical Paper)**

Stryjewski, E., G.G. Goins, and C.J. Kelly. 2001. Quantitative morphological analysis of spinach leaves grown under light-emitting diodes or sulfur-microwave lamps. *SAE Technical Paper* 2001-01-2272.

**Ph.D. DISSERTATION**

Kelly, C.J. 2011. Growth and physiology of eastern and suminoe oysters and the implications of increased habitat complexity for associated oyster reef fauna. Ph.D. Dissertation. University of Maryland. College Park, MD. 230 pp.

**ORAL PRESENTATIONS**

Kelly, C.J., and R.I.E. Newell. 2011. The behavior of fish predators and their interaction with prey species are influenced by the level of structural complexity within their habitat. Benthic Ecology Meeting, Mobile AL, 16 – 21 March

Kelly, C.J., and R.I.E. Newell. 2010. The importance of habitat complexity, refuge, and prey availability on the attraction of grass shrimp, white perch, and striped bass to structure. American Fisheries Society, Pittsburgh PA, 14 September.

Kelly, C.J., and R.I.E. Newell. 2009. Seasonal scope for growth of diploid *Crassostrea ariakensis* and *Crassostrea virginica* under ambient conditions simulating the mesohaline and polyhaline regions of Chesapeake Bay. Coastal and Estuarine research Federation, Portland OR, 3 November.

Kelly, C.J., R.I.E. Newell, J. Scarpa, S.E. Laramore, and R.B. Carnegie. 2008. Diploid *Crassostrea virginica* and *Crassostrea ariakensis* studies in mesocosms simulating Chesapeake Bay and Florida estuaries. National Shellfisheries Association, Providence RI, 8 April.



**CHRISTOPHER J. KELLY, Ph.D.**

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Kelly, C.J., and R.L. Turner. 2001. The influence of altered hydrology on the population distribution of two species of hermit crab (*Clibanarius vittatus* and *Pagurus maclaughlinae*) in the Indian River Lagoon System. Florida Academy of Sciences, Saint Leo University, Saint Leo FL 9 March.  
[Outstanding Student Paper Award for an undergraduate; Florida Institute of Technology Sigma Xi Chapter award for best undergraduate paper.]

## **CERTIFICATIONS**

CPR/First Aid, Emergency First Response, 2012  
Scientific Diver, AAUS, 2012 to present  
Open Water SCUBA Diver, PADI, 1996