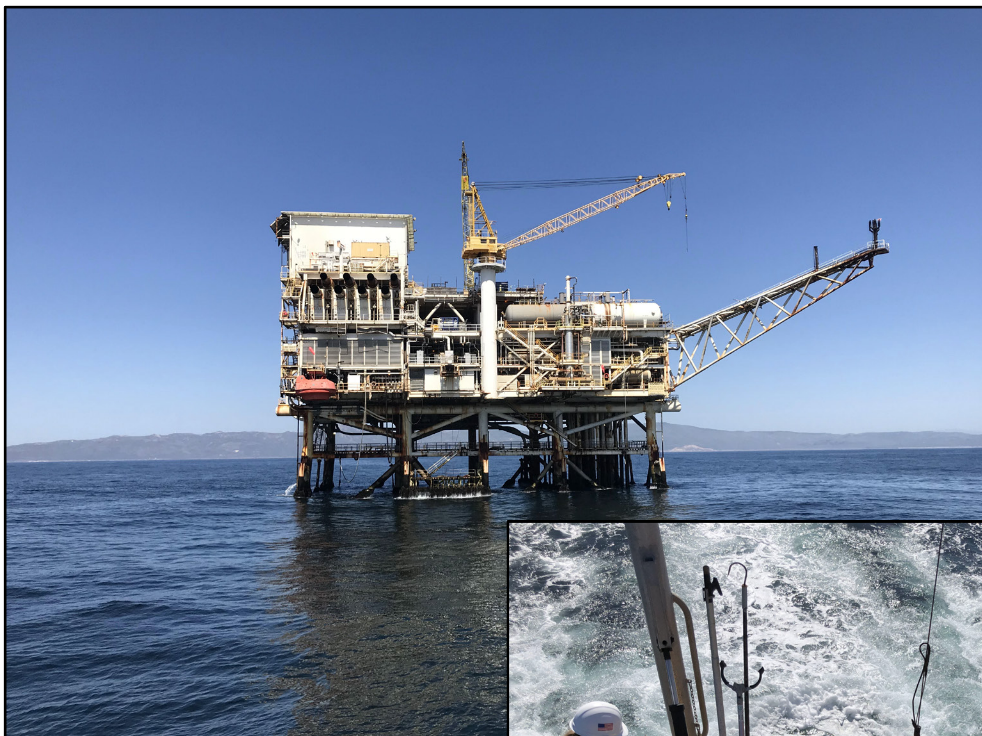
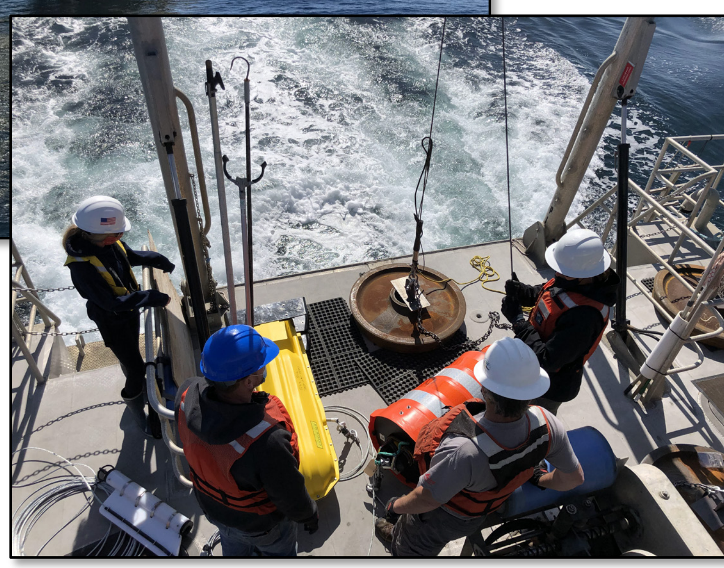
OCS Study
BOEM 2022-029

Characteristics and Contributions of Noise Generated by Mechanical Cutting During Conductor Removal Operations

Volume 2: Appendix A





U.S. Department of the Interior
Bureau of Ocean Energy Management
Pacific OCS Region, Camarillo, CA

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BOEM
Bureau of Ocean Energy Management

DISCLAIMER

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REPORT AVAILABILITY

To download a PDF file of this report, go to the U.S. Department of the Interior, Bureau of Ocean Energy Management Data and Information Systems webpage (http://www.boem.gov/Environmental-Studies-EnvData/), click on the link for the Environmental Studies Program Information System (ESPIS), and search on 2022-029.

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ABOUT THE COVER

Left photo: Photo of Platform Hermosa was taken by Kevin Fowler, Tetra Tech, Inc., during the deployment of the monitoring equipment on March 21, 2021. Right photo: Photo was taken by Kaus Raghukumar, Integral Consulting Inc., of the field team preparing to deploy the hydrophone moorings on March 21, 2021.

REPORT ORGANIZATION

Report OCS Study BOEM 2022-029 consists of three volumes:

Volume 1: Final Report
Volume 2: Appendix A: Final Field Plan
Volume 3: Appendices B – F
- Appendix B: Supplementary Acoustic Data
- Appendix C: Acoustic Analysis: Study Report A, Determination of Periods of Vocally Active Marine Mammals and Evaluation of Acoustic Indices
- Appendix D: Marine Mammal Acoustic Analysis: Study Report B, Development of a Deep Neural Network for Humpback Whales and Delphinids
- Appendix E: Noise Study Photo Log
- Appendix F: Hydrophone - Ocean Instruments Calibration Data

Volume 2: Appendix A: Final Field Plan

Contents

List of Figures

List of Tables

List of Abbreviations and Acronyms

AHr	ampere-hour
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
cm	centimeter
CSV	comma separated value.
CTD	Conductivity, Temperature, and Depth
dB	decibel
Freeport	Freeport-McMoRan Oil & Gas LLC
Harvey Challenger	Freeport vessel
Hidalgo, Harvest and Hermosa	Three Point Arguello Unit Platforms
Hz	hertz
kHz	kilohertz
km	kilometer
lb.	pound
LTSA	long-term spectral averages
μPa	micropascal
NOAA	National Oceanic and Atmospheric Administration
NoiseSpotter™	particle motion monitoring mooring system
PE	parabolic equation
Project	Characteristics and Contributions of Noise Generated by Abrasive Cutting During Conductor-removal Operations Project
QA/QC	quality assurance / quality control
ROV	remotely operated vehicle
Tetra Tech	Tetra Tech, Inc.
TB	terabyte
V	volt

A.1 Introduction

A.1.1 Project Description

The Bureau of Ocean Energy Management (BOEM) has identified 23 oil platforms planned for decommissioning within federal waters offshore of southern California. Freeport-McMoRan Oil & Gas LLC (Freeport) submitted Applications for Permits to Modify (30 Code of Federal Regulations Part 250.1704) to remove well conductors and casings on three Point Arguello Unit Platforms (Hidalgo, Harvest, and Hermosa). The Bureau of Safety and Environmental Enforcement (BSEE) and BOEM have contracted Tetra Tech, Inc. (Tetra Tech) to characterize noise generated by abrasive cutting during conductor removal operations for the Characteristics and Contributions of Noise Generated by Abrasive Cutting During Conductor-removal Operations Project (Project). The scope of this Project is to collect empirical data documenting the characteristics of sound pressure level and particle motion generated by the high-pressure conductor cutting at one of the three Point Arguello Unit Platforms, along with the measurement of temperature, salinity, and pressure to characterize the sound speed profile during the cutting operations. The collected data will be used to understand sound pressure and particle motion levels generated during cutting activities, and aid in the estimation of the beam pattern for future sound propagation modeling.

Conductor cutting involves pumping high-pressure fluids containing seawater and abrasive materials to cut through the conductor piping and other casing strings that are present. Per BSEE requirements, initial cuts will be made approximately 5 meters below the mudline. The wells that the conductors tap will be plugged before the conductors are cut, and the remainder of the platform will be appropriately decommissioned.

Freeport is proposing to remove 62 total conductor casings (14 at Hidalgo, 19 at Harvest, and 29 at Hermosa), over a period of approximately 3 months. One conductor cutting event (i.e., one cut) is expected to last 90 minutes at each location. However, the total time for one full conductor cutting including cutting equipment setup and removal operations is approximately 15 hours.

A.1.2 Purpose and Objectives

The purpose of this Project is to document the characteristics of sound pressure level and particle motion generated by the high-pressure conductor cutting. The objectives of this Project are bulleted below:

- Quantify sound pressure and particle velocity levels for high-pressure abrasive cutting during conductor removal, including amplitude and directionality in three spatial directions and with time.
- Determine the distances, and at what levels, sound from high-pressure abrasive cutting propagates.
- Describe, and to the extent possible, quantify the ambient soundscape prior to, during, and after high pressure abrasive cutting.
- Determine whether high-pressure abrasive cutting contributes to the ambient soundscape, and if so, provide a quantification of that contribution.

A.1.3 Project Location

The three Point Arguello Unit Platforms (Hidalgo, Harvest, and Hermosa) are located approximately 9 kilometers (km) offshore of the coast of Santa Barbara County, California. The water depths in the Project area range from 140 meters to 225 meters (Figures A-1 and A-2).

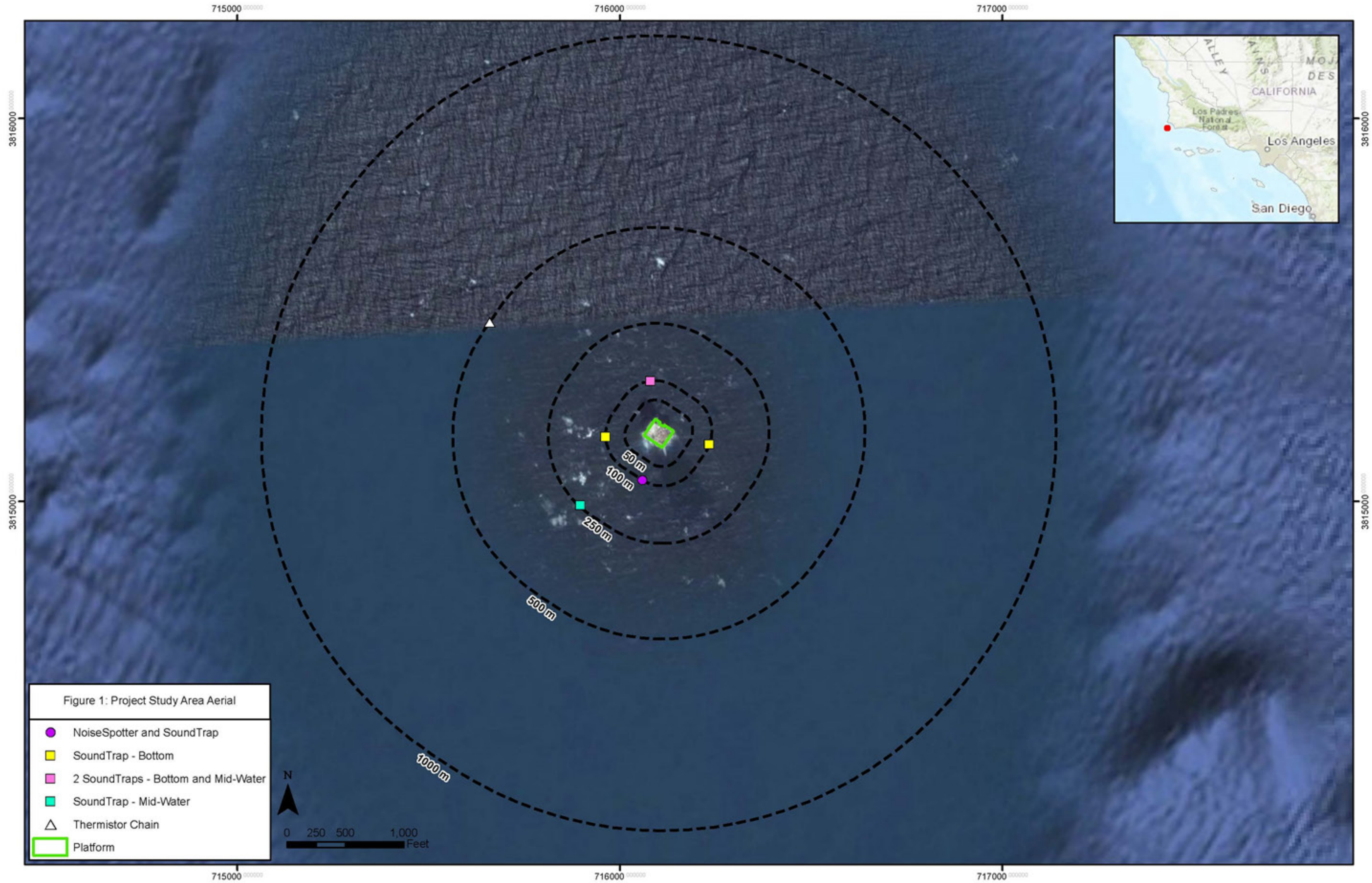


Figure A-1. Project Study Area Aerial View and Locations of SoundTraps, Thermistor Chain, and NoiseSpotter

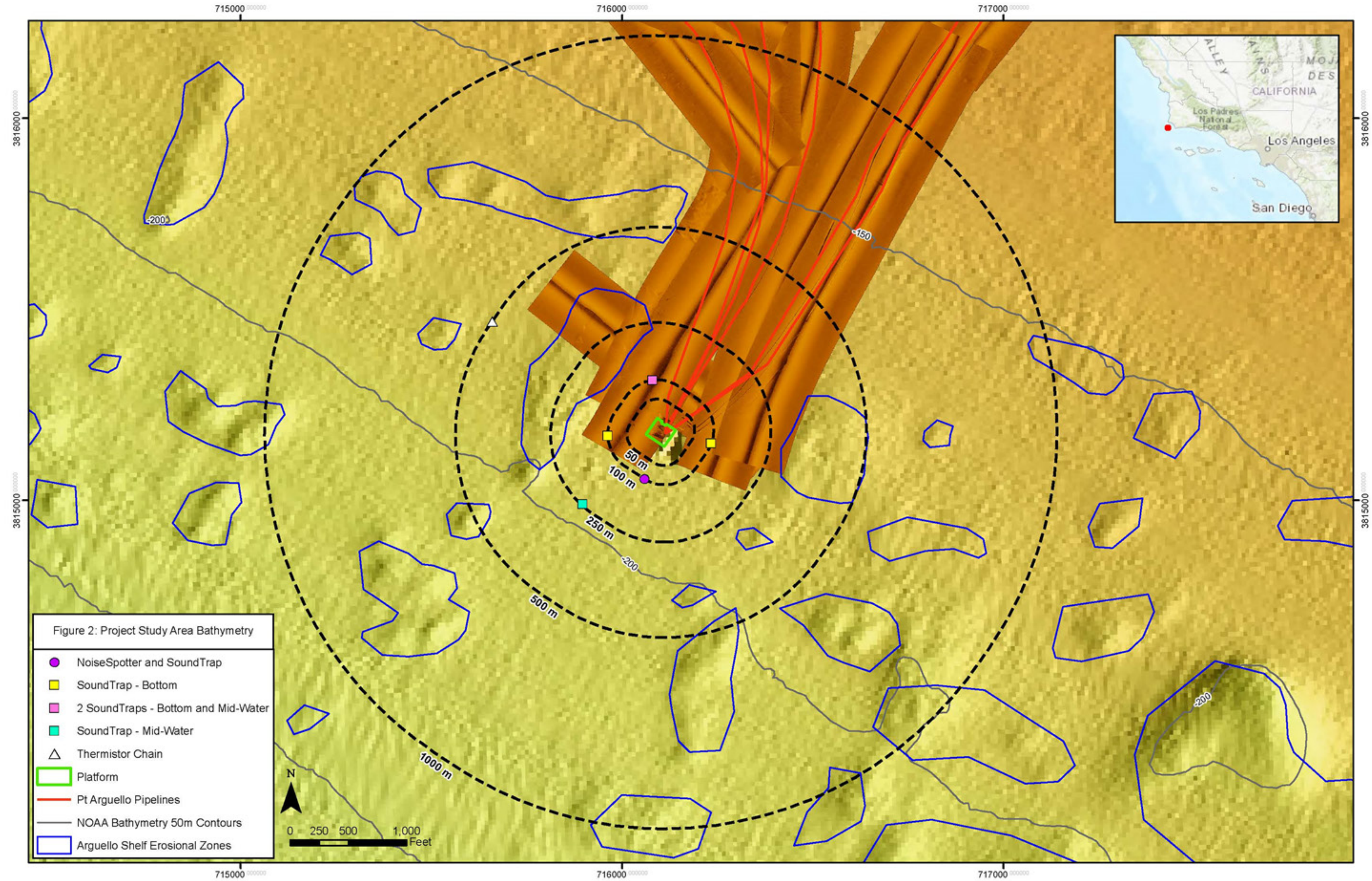


Figure A-2. Project Study Area Bathymetry and Locations of SoundTraps, Thermistor Chain, and NoiseSpotter

A.1.4 Project Schedule

Freeport's schedule for conductor cutting at each platform is bulleted below:

- Hidalgo – Commenced January 22 but operations were halted in early February; operations will commence as soon as possible, but a 4-6-week delay in anticipated;
- Hermosa – Originally planned for March 12 through April 17, 2021;
- Harvest – Originally planned for April 22 through May 16, 2021.

Freeport started cutting at the Hidalgo platform on January 22, 2021. The delay in conductor cutting activities at Hidalgo is expected to affect the schedule for cutting at the Hermosa and Harvest platforms. The acoustic pressure and particle motion monitoring effort will focus on the Hermosa platform, however, due to the unpredictability of the schedule, any necessary modifications will be described in detail in the final report. Instrument deployment is planned for approximately one week after the start of conductor cutting activities. This will allow for more efficient schedule planning and will minimize costs of any other potential delays should they occur for the start of conductor cutting activities. The monitoring equipment will be deployed for a maximum 35-day period (see Figure A-3).

BOEM Contract No. 140M0120C0011

BOEM Conductor Cutting Project

ID	Task Name	Start	Finish
1	**Field Plan**	**Mon 11/30/20**	**Fri 2/26/21**
2	Draft Field Plan	Mon 11/30/20	Thu 2/4/21
3	***Draft Field Plan Submitted to BOEM***	Fri 2/5/21	Fri 2/5/21
4	BOEM Review of Draft Field Plan	Fri 2/5/21	Fri 2/12/21
5	Final Field Plan	Mon 2/15/21	Thu 2/25/21
6	***Final Plan Review Submitted to BOEM***	Fri 2/26/21	Fri 2/26/21
7	**In-Water Monitoring**	**Sun 3/14/21**	**Sat 4/24/21**
8	Team On-site for Mobilization	Sun 3/14/21	Sun 3/14/21
9	Mobilization Day / Load Equipment on Shearwater	Mon 3/15/21	Mon 3/15/21
10	Equipment Testing and Final Preparation on Shearwater	Tue 3/16/21	Tue 3/16/21
11	Equipment Deployment	Wed 3/17/21	Thu 3/18/21
12	Data Collection Period	Fri 3/19/21	Tue 4/20/21
13	Equiqment Retrieval	Wed 4/21/21	Thu 4/22/21
14	Unload Equipment from Shearwater	Fri 4/23/21	Fri 4/23/21
15	Team Demobilization	Sat 4/24/21	Sat 4/24/21

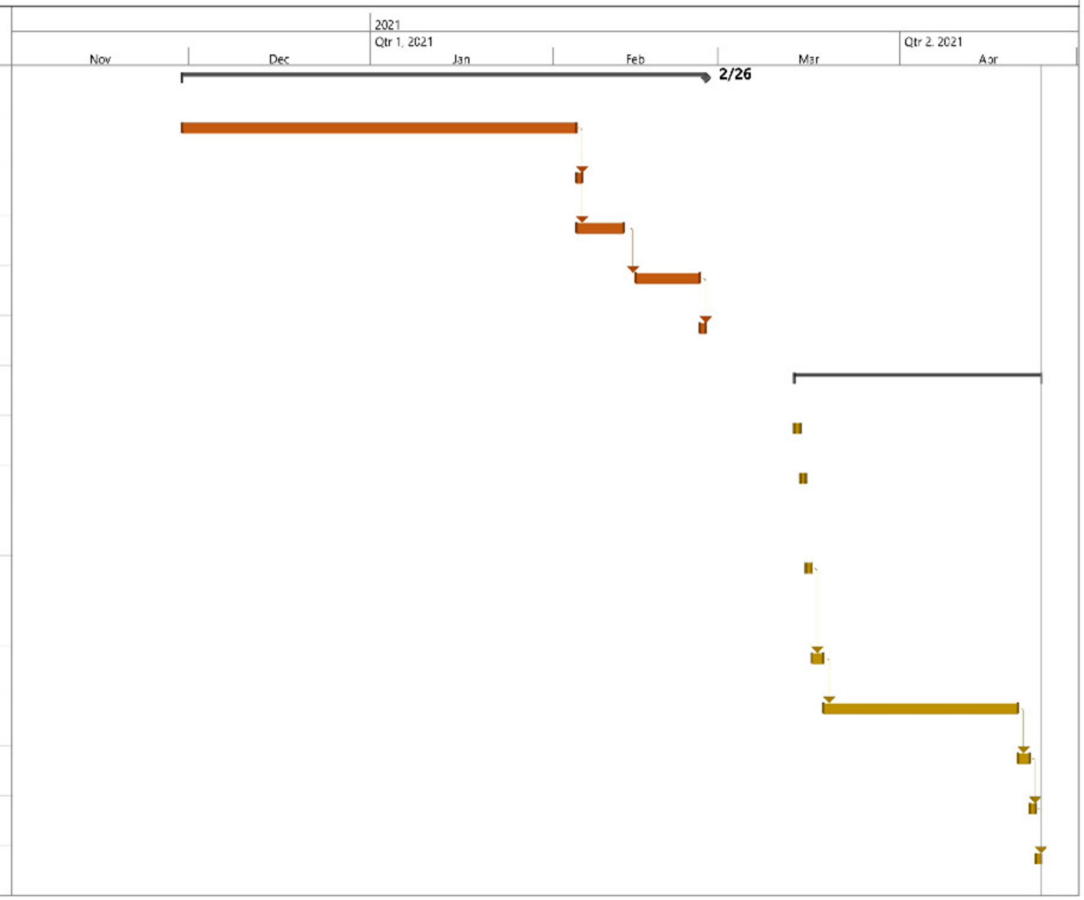


Figure A-3. Example Project Gantt Chart (Sample Field Schedule shown)

A.2 Survey Methodology

A.2.1 Project Personnel

To support Project work, including the field survey efforts, Tetra Tech has complemented its in-house expertise with those of three experienced and knowledgeable subcontractors; Integral Consulting Inc., and Delphis Technical Support and Solutions, LLC. Roles of key Project personnel are the following:

- **Project Manager – Ann Zoidis:** As Project Manager, Ms. Zoidis has full authority for completion and delivery of all deliverables, as well as overall management direction, conducting of the work, and budget and schedule control.
- **Deputy Project Manager / Principal Scientist Underwater Sound Monitoring – Tricia Pellerin:** Ms. Pellerin is a Senior Acoustical Engineer who will oversee the underwater sound monitoring and data processing. Ms. Pellerin works with Ms. Zoidis to provide a parallel management structure for the Project to ensure seamless project execution and success.
- **Principle Scientist Particle Motion Monitoring – Dr. Kaustubha Raghukumar,** Subcontractor Integral: Dr. Raghukumar will oversee the particle motion monitoring and data processing.
- **Data Manager / Senior Scientist Underwater Sound Monitoring – Kevin Fowler**: Mr. Fowler be responsible for executing the field plan as Field Manager as well as processing the underwater sound monitoring data. Mr. Fowler will act as the Data Manager for the Project and is responsible to ensure that data are efficiently obtained, created, managed, shared, and achieved in accordance with the methodologies in this Field Plan.
- **Particle Motion Monitoring Field Manager – Frank Spada, Subcontractor Integral**: Mr. Spada is responsible for the mooring design and field deployment for the particle motion monitoring equipment. Mr. Spada’s role will ensure success of the particle motion data collection while maintaining safe working conditions.
- **Underwater Sound Monitoring Field Manager – Kevin Smith, Subcontractor Delphis**: Mr. Smith is responsible for the mooring design and field deployment for the underwater sound monitoring equipment. Mr. Smith’s role will ensure success of the underwater sound data collection while maintaining safe working conditions.

A.2.2 Vessel Support

The vessel for deployment and recovery operations must be stable and able to transport the fully assembled particle motion monitoring system (the NoiseSpotter™), four underwater sound monitoring mooring systems, and the thermistor-chain mooring. The deployment and recovery vessels will require an aft deck with a minimum working space of 20 square meters. A stern-mounted A-frame or crane with minimum lifting capacity of 2,000 pounds (lb.) is necessary. The vertical lift must be greater than 2 meters to allow sufficient clearance and for removing any threat of mooring line entanglement in the vessel’s propeller. The size of the vessel must be appropriate for the deployment of monitoring equipment offshore of Point Conception. The same vessel may be used for deployment and recovery operations of the monitoring equipment if it meets the requirements for both deployment and retrieval.

It has been determined that the R/V Shearwater will be used for both the deployment and recovery of the equipment. The R/V Shearwater is the National Oceanic and Atmospheric Administration’s (NOAA) first custom designed scientific research vessel, and the first of four built by All American Marine, and operates out of Santa Barbara, California. The R/V Shearwater is a 62-foot high-speed Teknicraft catamaran and is primarily used as a research platform, conducting biotic and abiotic oceanographic research in the waters of the Santa Barbara Channel in Southern California. In addition to this role, the vessel also serves as a host for educational field trips and emergency response in and around the Channel Islands National Marine Sanctuary.

The vessel's A-frame and Markey Com7 scientific winch configuration is used for a variety of projects including trawls; conductivity, temperature, and depth (CTD) casts; sediment sampling; and towing equipment such as sidescan sonar and remotely operated vehicles. The A-frame has a 1,300-lb. maximum working load while the hydraulic winch has a safe working load of 850 lb. with approximately 800 meters of data cable. The vessel is also equipped with a Morgan Model 300 knuckle boom crane, with a safe working load capacity 4,510 lb. and a safe working load capacity of 1,320 lb. at full extension. The R/V Shearwater is also equipped with advanced navigational equipment coupled with a 28-port onboard computer network with remote access to the mainland via a cellular.

During sea trials the boat reached 24.7 knots (over 28 miles per hour) at 100 percent power. The vessel has a cruise speed of 20 knots at 80 percent power. With its 1,200-gallon fuel capacity, cruising range at average load is over 600 nautical miles. The vessel can support operations at a sea state of up to Beaufort 5 depending on the type of operations and swell period; however, operations are also always dictated according to the captain. Two 600-horsepower Detroit Series 60 14-liter diesel engines and Osborne 5 blade propellers power the boat. A Kohler 20-kilowatt diesel generator serves the vessel's 110-volt electrical requirements. Safety considerations include a fixed engine room fire system, portable extinguishers, central fire detection system, SOLAS B coastal life rafts, Search and Rescue Transponder, Emergency Position Indicating Radio Beacons, immersion suits, portable oxygen, automated external defibrillator, and first-aid kits. Additional vessel information is given in Attachment A-1.

A.2.3 Monitoring Locations

All sound pressure level and particle monitoring equipment will be deployed for a maximum 35-day period at one of the three platforms, most likely the Hermosa platform. The NoiseSpotter will be deployed at a distance of approximately 100 meters from the Hermosa platform. There will be a total of six SoundTrap 300HFs deployed. There will be one SoundTrap positioned at a distance of 100 meters from each of the four sides of the Hermosa Platform at approximately 9 meters above the seabed for a total of 4 SoundTraps; there will be one SoundTrap positioned at mid-water column depth; and there will be a single SoundTrap positioned at a distance of 250 meters from the Hermosa Platform (Figures A-1 and A-2). The 11-element thermistor chain located 500 meters from the Hermosa platform will provide measurements of temperature throughout the water column, which, along with conductivity measurements on the NoiseSpotter platform, will provide sound speed profiles for sound propagation modeling. The location of the equipment will be positioned as accurately as possible during the deployment, which is critical for quantification of the spatial anisotropy of sound. A list of monitoring equipment planned for deployment is provided in Table A-1. The approximate coordinates and water depth at each location is provided in Table A-2.

Table A-1. List of Monitoring Equipment

Equipment	Purpose	Notes
NoiseSpotter	Vector sensor array that measures acoustic pressure and particle motion	3 vector sensors, 50 Hz–3 kHz bandwidth
SoundTrap 300HF	Broadband hydrophone to measure acoustic pressure	6 units at 5 locations, 10 Hz–48 kHz bandwidth
SBE 16plus V2	Conductivity, temperature, and depth	Located on NoiseSpotter platform
Thermistor chain	Water column temperature	11 thermistors on a mooring

Table A-2. Approximate Monitoring Equipment Locations

Location ID	Equipment	Equipment Mount Location	Coordinates (UTM Zone 10 S)		Location Depth (m)
			Easting (m)	Northing (m)	
1 – NS	NoiseSpotter / SoundTrap / CTD	Bottom	716058.16	3815056.75	190
2 – ST	Two SoundTraps	Bottom / Mid-Water Column	716079.26	3815314.44	180
3 – ST	SoundTrap	Bottom	715962.40	3815169.96	190
4 – ST	SoundTrap	Bottom	716232.99	3815149.10	183
5 – ST	SoundTrap	Bottom	715896.85	3814990.21	198
6 – TC	11 thermistors	Full Water Column	715464.70	3815600.28	183

A.2.4 Equipment and Mooring Design

The NoiseSpotter and SoundTraps 300HF will be deployed on bottom platforms or moorings with no surface expression. The use of subsurface platforms, particularly close to the oil platform, will avoid any interference with cutting activities. The location of the deployed positions of the moorings will be ascertained by triangulation using the topside deck unit and acoustic releases. The multiple monitoring locations are important for quantification of the spatial anisotropy of sound. The subsurface platforms will feature a pop-up buoy and acoustic release system to enable efficient, safe, and reliable recovery at the end of the study.

A.2.4.1 Acoustic Pressure Monitoring

A.2.4.1.1 Equipment

Broadband hydrophone recordings will be made using the SoundTrap 300HF logging hydrophone. Six SoundTrap 300HF sound recorders will be deployed around the platform. These recorders are ideal instruments for passive acoustic monitoring of sound pressure due to their low self-noise, power efficiency, and ability to collect continuous raw data (i.e., WAV files) at a relatively broad bandwidth of 20 hertz (Hz) to 48 kilohertz (kHz). These calibrated recorders will be configured to record continuously for up to 4 weeks, at a sampling rate of up to 96 kHz. The available frequency range allows for the capability of monitoring for a wide range of sounds from fish, mysticete (baleen), and odontocete (toothed) marine mammals over different bandwidths. The SoundTraps have a low noise floor, making them suitable for the detection of low intensity sounds such as those expected from subsea conductor cutting. Each SoundTrap has a current calibration certificate from the manufacturer. To verify the calibration, an in-field calibration will be conducted using a pistonphone calibrator.

A.2.4.1.2 Hydrophone Mooring Design

Five of the SoundTrap 300HF sound recorders (excluding the sixth SoundTrap attached to the NoiseSpotter frame) will be deployed using a sub-surface mooring with a total height of approximately 15 meters above the sea floor. The five SoundTraps will be attached to a mooring line using a custom clamp-on design (Figure A-4) and will be suspended in the water column along a wire with three 14-inch buoys to maintain an upright configuration during strong currents and provide sufficient buoyancy to carry a recovery line from the anchor to the surface. One of these moorings will have a SoundTrap 300HF also placed near the mid-water column. This design will be possible by adding additional mooring line between the bottom SoundTrap and a SUBS-B style flotation buoy as the primary flotation at the top of the mooring with 60 kg buoyancy. The anchor for all the moorings will consist of an approximately 400 kilogram 36-inch railroad wheel. A dual acoustic release system will be utilized to provide redundancy if one release fails. During retrieval, the acoustic releases will be triggered allowing the monitoring equipment to float to the surface along with a retrieval line for the railroad wheel and rope cannister. The mooring design is illustrated in Figures A-5 and A-6 as well as detailed in Attachment A-1.

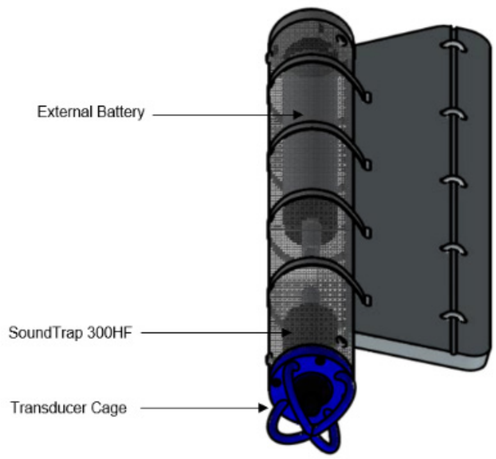


Figure A-4. SoundTrap Clamp-On

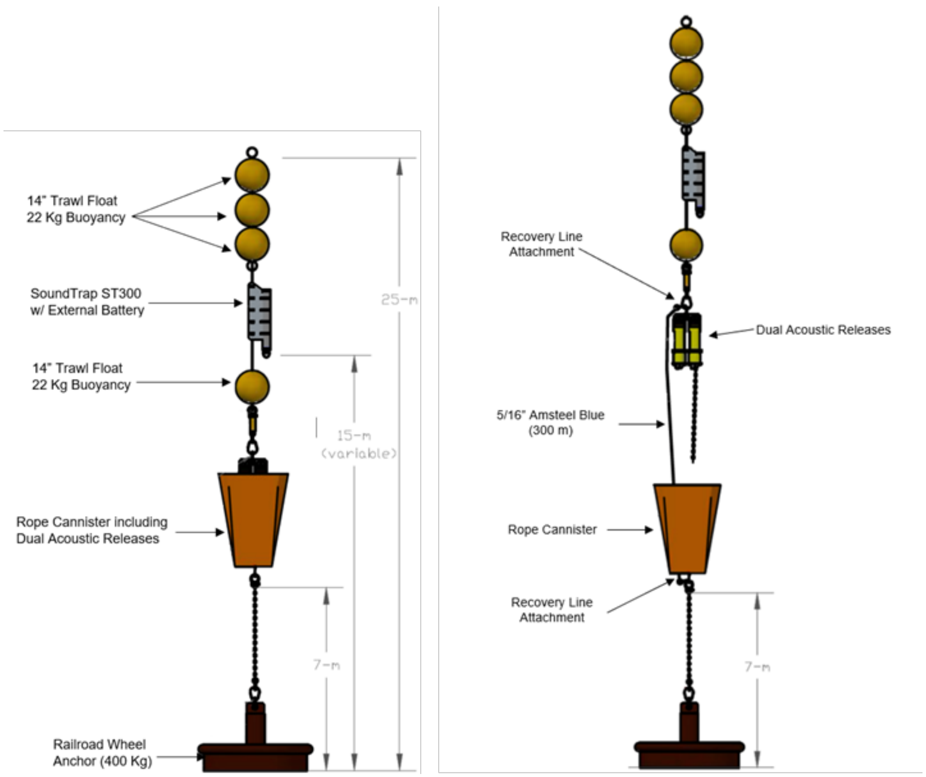


Figure A-5. Left: Acoustic Monitoring Mooring Design. Right: Illustration of the pop-up buoy mechanism for recovery.

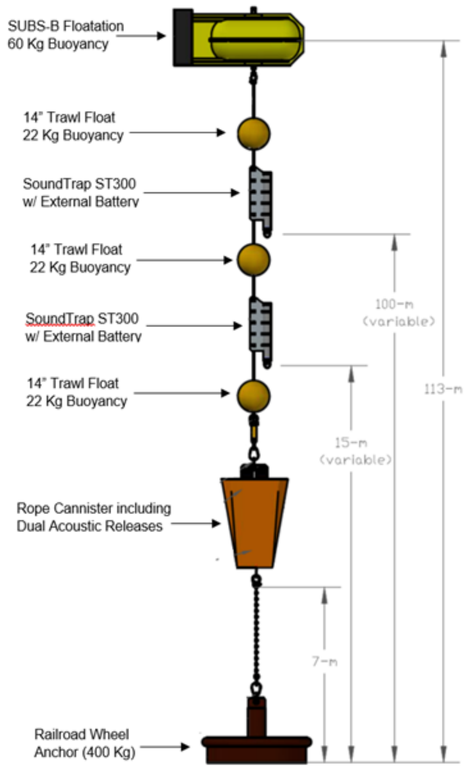


Figure A-6. Acoustic Monitoring Mooring Design with Mid-Water Column Hydrophone

A.2.4.2 Particle Motion Monitoring

A.2.4.2.1 Equipment

To monitor particle motion, a compact, bottom-mounted (1.5 x 1.5 meter footprint) array of three acoustic vector sensors will be deployed. The acoustic vector sensor array, called the NoiseSpotter™ (Raghukumar et al. 2020), measures sound pressure and the three-dimensional particle velocity vector associated with the propagation of an acoustic wave (Figure A-7). The three vector sensors are arranged as a three-dimensional array on an acoustically transparent high-density polyethylene frame. Particle motion measurements are composed of three-dimensional particle velocity vectors (u, v, w) that are translated into a true earth-referenced frame using auxiliary measurements from an integrated inertial motion unit. The sensors are manufactured by GeoSpectrum Technologies Ltd. and consist of two M20-40s and one M20-100. The M20-40 measures acoustic pressure and three-axial particle velocity, while the M20-100 measures the same quantities in addition to measuring the pitch, roll and yaw of the sensor. Sensors are horizontally separated by approximately 1 meter and are at heights of 42 centimeters (cm), 56 cm, and 86 cm above the seabed. Power to the vector sensors is supplied via an amplifier circuit board connected to two submersible rechargeable battery packs (258 ampere-hour [AHr] and 32 AHr), capable of powering the system for approximately 4 weeks. Analog sensor data are sampled at 20 kHz and are stored on board a solid-state 2 terabyte (TB) hard drive.

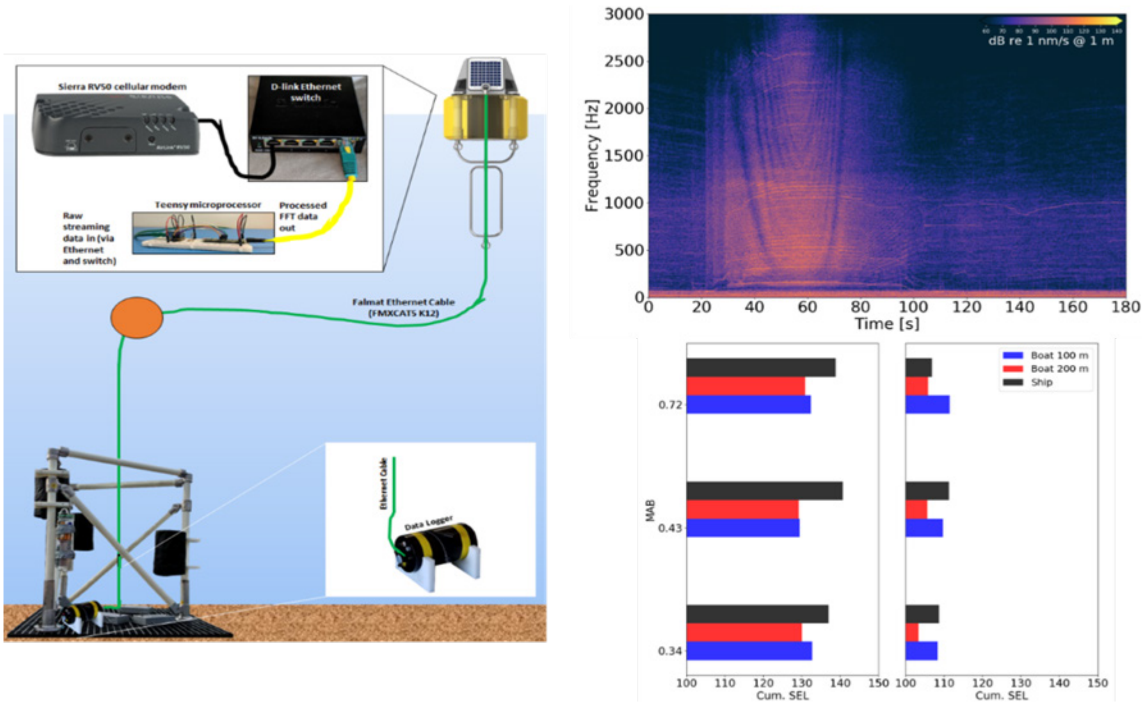


Figure A-7. Left: NoiseSpotter acoustic monitoring platform consisting of three vector sensors, data logger and optional real-time data telemetry unit; telemetry is not proposed for use here. Right top: Example spectrogram of particle velocity measured on one sensor. Right bottom: Sound pressure and particle velocity cumulative sound exposure level profiles at three NoiseSpotter sensor depths, for three source types.

The acoustic vector sensors are sensitive to acoustic frequencies in the 50 Hz to 3 kHz range, with a flat frequency response on the pressure channel, and a peak in the response at 1 kHz on the particle velocity channels (Figure A-8). This frequency range is particularly suited to measurement of sounds from fishes, invertebrates, and baleen whales whose hearing sensitivities fall within this frequency range (50 Hz–3 kHz) (Nedwell et al. 2004). The nominal pressure sensitivity of the pressure channel at 1 kHz is -179 decibels (dB) relative to volts (V) per micropascal (dB re V/µPa), which, along with the saturation level of the sensors, allows for measurement of sound pressure levels up to 240 dB re 1 µPa at a distance of 100 meters from the sensor.

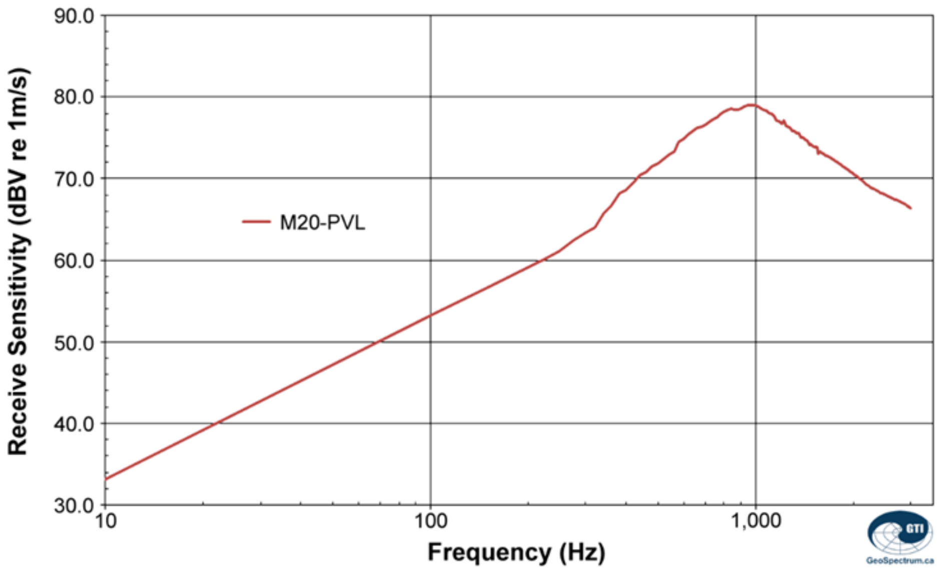


Figure A-8. Frequency Response of M20 Vector Sensor

To facilitate deployments in energetic environments, the NoiseSpotter includes flow noise suppression shields around each vector sensor. Strong hydrodynamic flow from waves and currents can induce non-acoustic pressure fluctuations that lead to contamination of acoustic signals. Flow noise contamination can be particularly acute with vector sensors due to saturation of the built-in accelerometer signal by energetic flows. The flow noise suppression shields have been demonstrated to be effective in reducing flow noise effects (Raghukumar et al. 2019), thereby improving data quality and signal detectability. The M20-40 and M20-100 vector sensors are shipped by Geospectrum Technologies, Ltd with a calibration certificate, which can be provided upon request. No significant drift in sensor response is anticipated for the duration of the project, but occasional (every 5 years) recalibration is recommended. The Project subcontractor Integral has owned and utilized these sensors on Projects since 2017.

A.2.4.2.2 Particle Motion Monitoring Mooring Design

The NoiseSpotter will consist of the three-element vector sensor array, two battery packs, and a data logger. Additionally, one SoundTrap 300HF will be deployed on the NoiseSpotter platform. The NoiseSpotter system will consist of a bottom platform (Figure A-9) and a pop-up buoy mechanism for recovery (Figure A-10). The bottom platform has footprint of 1.5 meters x 1.5 meters x 1.2 meters (Length x Width x Height) and is weighted with approximately 200 kg of lead. The platform is connected to the bottom of a pop-up buoy, located 10 meters above the platform, using ¼-inch spectra rigging line (load strength 8,600 lb.). The pop-up buoy consists of a line-holding bucket, a flotation assembly, trawl float, and acoustic release. The line-holding bucket contains 200 meters of coiled spectra line, which is connected separately to the bottom of the pop-up buoy. The flotation assembly and trawl float provide a total of 38 lb. of buoyancy. Activation of an acoustic release separates the flotation assembly from the line-holding bucket, causing the coiled line to float up to the surface for recovery.

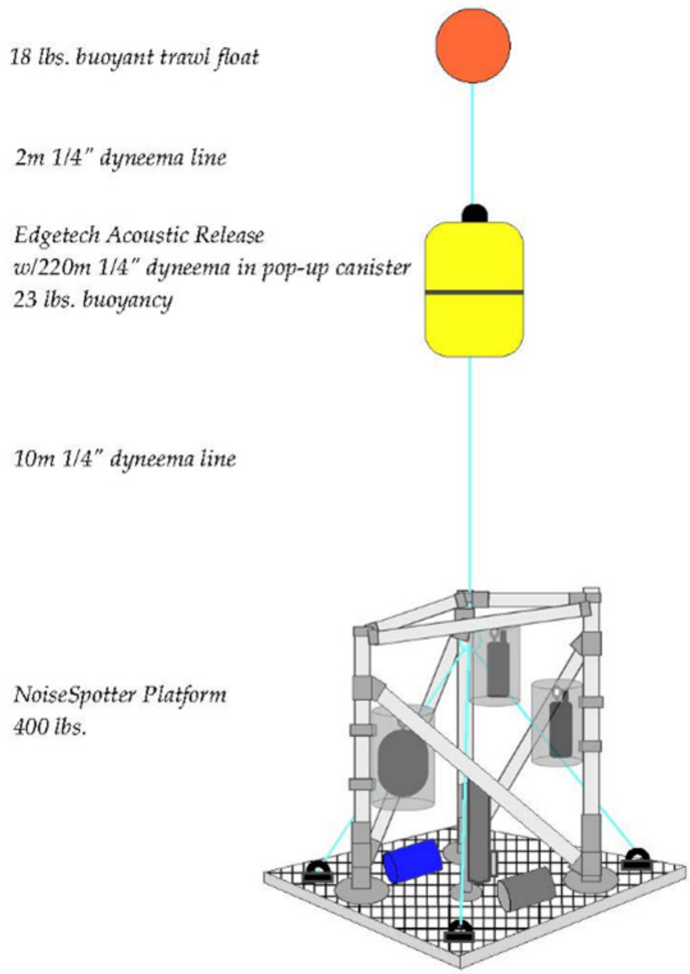


Figure A-9. Schematic of NoiseSpotter vector sensor array with SoundTrap 300HF

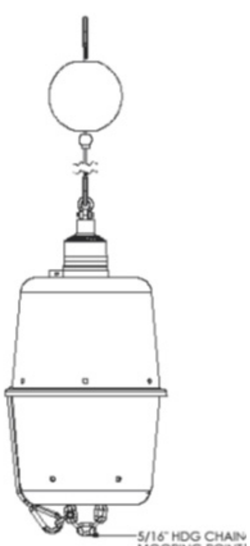


Figure A-10. Pop-up Buoy to be Connected above NoiseSpotter Platform for Recovery

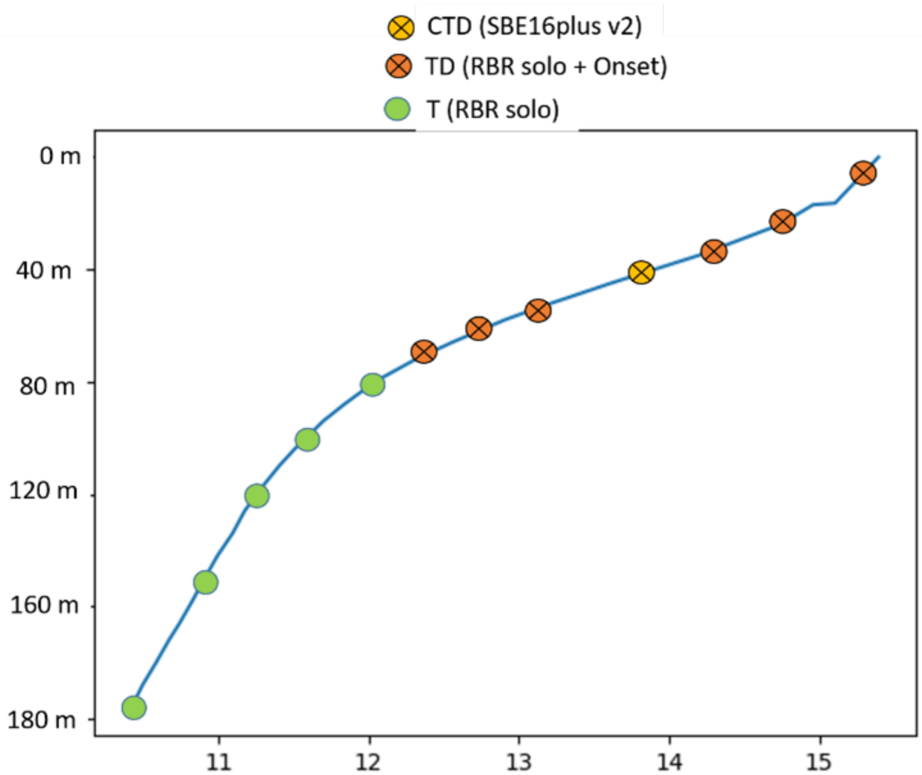
A.2.4.3 Thermistor Monitoring

A.2.4.3.1 Equipment

The thermistor chain mooring will consist of 11 RBR SoloT temperature sensors, 6 Onset Computer Corp. Hobo pressure sensors, and one Sea-Bird Scientific, Inc. SBE16plus v2 CTD (Figure A-11). The RBR SoloTs, Onset Computer Corp. Titanium Hobos, and SBE16plus v2 CTD have been factory-calibrated for this field effort.

Figure A-11. Thermistor (RBR Solo) Pressure Sensor (Onset Titanium HOBO), and CTD (SBE16plus v2)

The locations and depths of the thermistor elements, pressure sensors, and CTD are shown in Figure A-12. The CTD will be mounted at a mid-water column location (approximately 40 meters from the surface). Thermistor chain sensors will be programmed to record continuous data with sampling intervals of 15 minutes, thereby providing sound speed profiles over the duration of the field effort. The thermistor chain mooring will be deployed with a sub-surface buoy with an acoustic release system. The mooring will be anchored with approximately 400 lb. of weight.



Depth	Sensor
10 m	TD
20 m	TD
30 m	TD
40 m	CTD
50 m	TD
60 m	TD
70 m	TD
80 m	T
100 m	T
120 m	T
150 m	T
180 m	T

Figure A-12. Locations of Thermistors, Pressure Sensors and CTD on a canonical Temperature Profile at Platform Hermosa

A.2.4.3.2 Thermistor Chain Mooring Design

The thermistor chain mooring will consist of mooring components designed specifically to the environmental requirements of the deployment location. Integral will engineer the moorings following the standard mooring design, as shown in Figure A-13. The mooring materials will be torsion-free to avoid twisting and kinking of the line or spinning of the buoy. The buoy hull will be connected to stainless steel cage to provide stability (ballast). The cage will terminate at a swivel. The remainder of the mooring will consist of polypropylene line, which will terminate at a shackle connected to 5 meters of chain and bottom anchor weight. A 3 lb. weight will be added to the mooring line 10 meters above the bottom to keep tension on the entire mooring line. The serial number of each thermistor and pressure sensor on the mooring line will be noted following mooring assembly to ensure that the depth and location of each sensor on the mooring line is recorded.

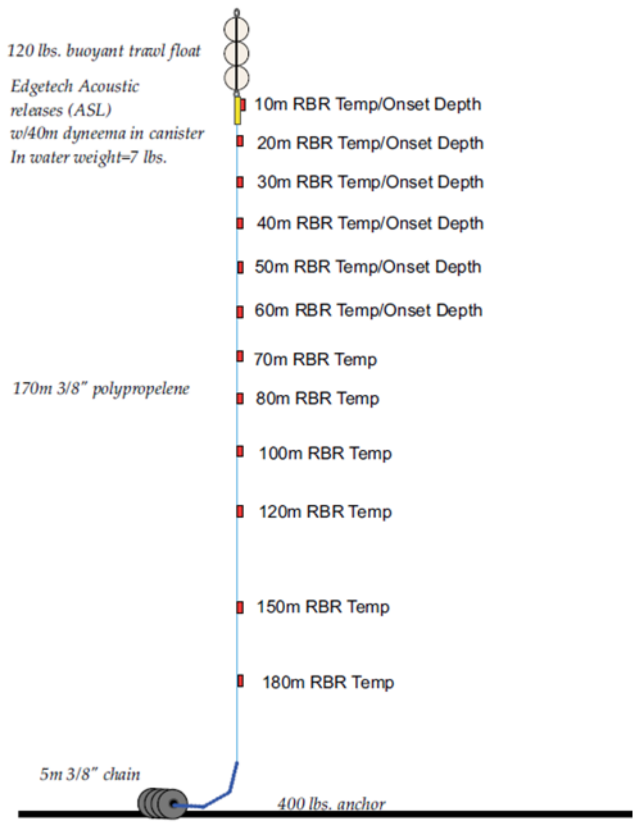


Figure A-13. Thermistor Chain Mooring with CTD
The thermistor chain mooring will be deployed at a range of 500 meters from the platform (Figures A-1 and A-2).

A.2.5 Field Operations

The field operations incorporate the mobilization, deployment, recovery, and demobilization of the acoustic and particle motion monitoring equipment. The deployment and recovery are expected to occur over a single day each. However, an additional day has been planned for each the deployment and recovery as contingency. These field operations are further described in the sections below.

A.2.5.1 Weather Windows/Conditions

Mooring deployment and recovery operations will be subject to weather windows. Wave heights during bottom mount deployment and recovery operations should not be in excess of 1 to 2 meters over a 10-second period and wind speeds should be less than 15 knots, which corresponds to a classification of 4 on the Beaufort scale. Weather windows will be of sufficient time to mobilize crew and boat to base and then to site and return. Vessel captains will have final say on site weather conditions and determining whether those conditions are acceptable to proceed with field work.

A.2.5.2 Field Staff Contact Information

Table A-3 provides contact information for the field staff on this project.

Table A-3. Tetra Tech Team Field Staff Contact Information

Project Role	Name	Email	Phone
Project Manager (offsite)	Ann Zoidis	Ann.zoidis@tetratech.com	510-393-5906
Deputy Project Manager / Principal Scientist (offsite)	Tricia Pellerin	Tricia.pellerin@tetratech.com	617-697-1638
Data Manager /Tetra Tech Team Field Manager Lead	Kevin Fowler	Kevin.fowler@tetratech.com	760-331-3880
Underwater Sound Monitoring Field Manager	Kevin Smith	KevinSmith@Delphis-TSS.com	425-773-0722
Particle Motion Monitoring Lead	Kaustubha Raghukumar, PhD	kraghukumar@integral-corp.com	858-752-0705
Particle Motion Monitoring Field Manager	Frank Spada	fspada@integral-corp.com	805-637-5514

A.2.5.3 Mobilization

In consideration of all Project logistics, pre-field mobilization activities will commence following BOEM’s approval of this Field Plan. Pre-field mobilization activities include:

- Ensuring all field personnel obtain safety gear for field operations and review the project Health and Safety Plan in advance;
- Securing necessary rigging material (e.g., load lifters, release hook, deck cleats);
- Procurement of depth-specific mooring gear including lines, subsurface floats, shackles and pins, swivels, acoustic releases, etc.;
- Mooring assembly dry run at the Integral oceanographic laboratory for the NoiseSpotter and thermistor chain;
- Mooring assembly dry run at the Tetra Tech warehouse for the acoustic monitoring moorings;
- Configure, test, and calibrate all monitoring equipment; and
- Shipping of mooring and rigging materials to the on-site field facility, if necessary.

Once all gear has arrived at the field site, on-site field mobilization activities will begin. Typical on-site mobilization activities for NoiseSpotter platform and thermistor chain mooring system deployment require two days. The on-site mobilization activities for the acoustic monitoring mooring systems will require a single day. These on-site mobilization activities are summarized below:

The NoiseSpotter system will be assembled and the acoustic release system will be tested. While fully assembled, Integral will ensure that the data acquisition systems for all sensors are engaged for at least a six-hour (preferably overnight) burn-in test period to confirm instrumentation operational status. Data will be offloaded and verified following the burn-in period, internal memory cleared, and sensors restarted.

The SoundTraps will be field calibrated using a pistonphone calibrator. They will then be activated prior to being inserted into their respective clamp-on and secured to the mooring and prepared for deployment.

A.2.5.4 Deployment

Once the mobilization is completed, the rigging gear will be organized and loaded onto the vessel. The field personnel including the vessel’s crew will engage in an operations meeting and safety briefing. A deployment exercise will be walked through and discussed in detail as part of required Job Safety Analysis specific to the operation and the vessel. Deployment procedures and weather conditions are reviewed.

The captain of the deployment vessel is in command of the vessel and responsible for the safe operation of the vessel, vessel's company, including technical staff. The following personnel will be needed for deck operations (as a minimum): four field engineers and one deck hand/equipment operator. Integral will oversee the NoiseSpotter and thermistor chain mooring deployment operations. Tetra Tech will oversee the acoustic monitoring mooring deployments. Both teams will train and work with the crew during deployment procedures, and ensure the successful deployment of the NoiseSpotter, thermistor chain mooring, and acoustic monitoring moorings in a safe manner to prevent damages incurred to the ship, personnel, or instrumentation.

Deployment of the acoustic monitoring moorings involve the following procedures:

A.2.5.4.1 Sub-Surface Mooring (Hydrophone)

Deployment of the subsurface moorings will follow the procedures below (example shown in Figure A-14).

1. The SUBs-B buoy is lowered by hand over the side (or behind) the boat and the mooring line and elements are paid out as the vessel slowly moves forward to the deployment location to keep the mooring relatively straight,
2. The anchor is hung over side of the vessel attached to the crane using a quick release. The mooring should be running unobstructed behind the anchor with the anchor slightly submerged or above the water surface to reduce load swing.
3. The vessel then moves into position to the monitoring location.
4. When signaled and given clearance from the bridge that the vessel is over the deployment target location, the quick release is triggered to release the anchor to the seafloor with the mooring trailing.

Figure A-14. Typical Subsurface-Mooring System Deployment

A.2.5.4.2 Sub-Surface Mooring (Thermistor Chain)

Deployment of the sub-surface moorings will follow the procedures below:

1. The system is reassembled on board the vessel with the line laid out in large figure-8 loops to avoid entanglement. The anchor weight is located at the vessel's stern, under the A-frame, with a quick-release hook attached.

2. The sub-surface buoy is lifted over the stern of the vessel as the vessel motors toward the target deployment location.
3. The vessel steams toward the deployment location slowly as the line is payed-out.
4. The anchor is lifted with the A-frame. Once on site, the quick-release hook is released and the anchor is allowed to free-fall to the bottom.

A.2.5.4.3 Bottom Platform (NoiseSpotter)

Deployment of the NoiseSpotter platform will follow the procedures below (example shown in Figure A-15).

1. The bottom-lander will be rigged to the ship's winch and A-frame systems with a slip-line attached to a pelican hook.
2. The platform will be lifted and slowly repositioned using the vessel's A-frame such that it will hover over the water surface.
3. The winch will be used to lower the platform to the seabed.
4. Once on the bottom, the pelican hook will disengage when slip line goes slack, allowing for the slip line to be detached and recovered. A slip-line system guarantees upright deployment of a bottom-lander.
5. Using the acoustic release and deck box transponder, the orientation and exact location of the bottom-lander will be confirmed. If it is not within 45 degrees of vertical, e.g., if deployed on an uneven surface, the system will be recovered and redeployed.

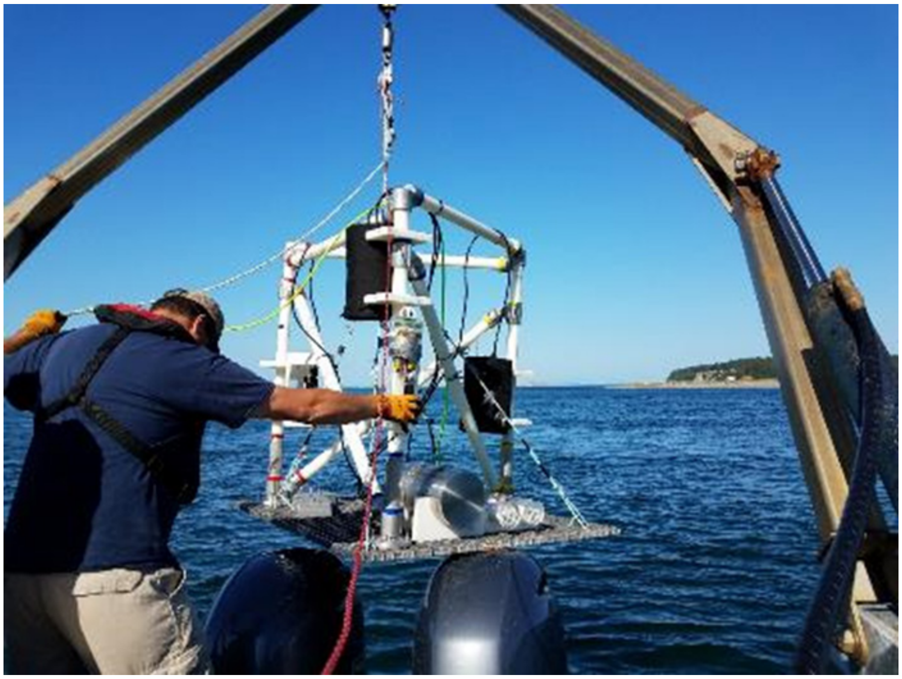


Figure A-15. Example NoiseSpotter Deployment Using a Vessel's A-frame and Slip Line

The following practices, conditions, and restrictions must be observed during equipment deployment:

- The crew must be fully briefed on the operation prior to the deployment. Video footage of past deployments should be reviewed.
- Operations will occur only during daylight hours.

Again, operational safety considerations and adverse weather conditions may delay system deployment and/or recovery; therefore, contingency deployment schedules will be available.

A.2.5.5 Recovery

A.2.5.5.1 Sub-Surface Mooring (Hydrophone and Thermistor Chain Moorings)

When activated from the topside deck unit, the respective release will unlock its release link, freeing the mooring from the anchor and allowing the entire mooring along with the anchor retrieval line to ascend to the surface for recovery. Once visually identified, the vessel will move in for recovery when all components appear on the surface. The mooring line will be hooked or grappled and pulled into the vessel. Surface recovery of components can be accomplished by hand. Once the SoundTraps are recovered, the anchor retrieval line will be attached to the winch and A-frame and will be lifted aboard. If conditions are not favorable for immediate recovery of the anchors, a surface marker buoy may be attached directly to the retrieval line prior to disconnecting the mooring line and released from the vessel once the mooring components are recovered. The SoundTrap will be removed once the mooring line is fully on the vessel and secured for transport back to the port or marina.

For the thermistor chain recovery, the acoustic releases will be triggered to release the subsurface buoy to the surface. A canister of Dyneema line will allow the subsurface floats to rise to the surface while the mooring line is still attached. The floats will be recovered with hook and brought on board. Once on board, the floats will be disconnected, and the line will be attached to the A-Frame and spooled on the winch. Thermistor and pressure sensors will be cut from the line as they come up to the A-frame, allowing for the line to be spooled on the winch. The serial number of each thermistor and pressure sensor will be recorded as they are removed, to verify that each individual sensor was deployed at the correct depth on the mooring line.

A.2.5.6 Bottom Platform (NoiseSpotter Frame and Hydrophones)

Recovery of the NoiseSpotter platform and acoustical monitoring moorings will be facilitated by the acoustic release system and an acoustic deck box transponder. For both recoveries the vessel will be positioned within 100 meters of the bottom-lander triangulated position determined during deployment. From the vessel, the pre-programmed release codes will be sent to the NoiseSpotter platform and acoustic moorings release system. For the NoiseSpotter platform a pop-up buoy will be released, and a recovery line will be discharged to the surface. Once visually identified, the vessel will be repositioned such that the pop-up buoy is aft of the vessel's stern. The buoy will be hooked or grappled, attached to the winch and A-frame system, and lifted onboard. The recovery line will be spooled slowly until the bottom-lander is safely secured to the vessel back deck.

Although generally reliable, acoustic release systems may malfunction. This may be due to:

- Out-of-range acoustic communications
- Electronic failure, e.g., loss of battery power
- Flooding
- Fouling due to marine growth or sedimentation
- Receiver in acoustic shadow of floatation
- Pop-up system line entanglement

In the event of acoustic release failure, the vessel will be repositioned, and the release code resent to improve acoustic communication range. If the release on the target mooring or pop-up buoy does not provide a reply that is indicative of its status or ascent position after 10 minutes, the team will continue sending release codes for another 30 minutes. In the event of continued non-response from the acoustic release, the team will establish that the release is non-responsive and the system recovered by use of a grapple hook and line.

After the mooring and NoiseSpotter platform are recovered, all components will be secured to the back deck of the vessel for transport back to the port or marina. There, gear will be offloaded, and instrumentation will be transferred to Integral technicians for data offload.

A.2.5.7 Demobilization

After the equipment is recovered and the vessel returns to the marina or port the following demobilization activities will occur:

- Offload all equipment from vessel.
- Detach all sensors for data download.
- Back up all downloaded data to external hard drive(s).
- Disassemble moorings for shipping.
- Transport the NoiseSpotter, Thermistor chain mooring, and equipment to Integral.
- Ship the acoustic monitoring mooring to the Tetra Tech warehouse for storage.
- Send the SoundTraps and external hard drive to Tetra Tech's Data Manager.

Data analysis and processing will start once all field work is completed.

A.3 Data

A.3.1 Data Handling and Storage

All acoustic monitoring data will be logged on internal memory of the SoundTraps. The data from the SoundTraps will be WAV file format and once downloaded will be backed up on to an external hard drive in the field. The particle motion data will be stored on a 2 TB miniSATA SSD. The data will be downloaded onto an external hard drive during the return to port, while on the vessel, and will continue until all data are backed up (downloads can take 2 hours or more). Once downloaded onto the first external hard drive, it will be backed up on a second hard drive for protection and redundancy. Upon return to port the SoundTrap data will also be backed up on Tetra Tech in-house servers. Multiple copies of the NoiseSpotter data (raw binary and calibrated MATLAB files) will be made and stored onto four hard drives. Integral will operate on data from one hard drive for further processing and analysis, keeping one hard drive as a backup. Integral will deliver two hard drives to Tetra Tech to be backed up on in-house servers.

A.3.2 Data Processing and Analysis

Acoustic pressure and particle motion data gathered over the 4-week measurement period will be processed and reported with the following goals in mind: characterization of soundscape during and after the cutting, characterization of sound levels (pressure and particle motion) during cutting activities, characterization of the beam pattern for conductor cutting, and bioacoustics analysis of underwater sound data to assess marine mammal vocalizations and occurrence. The team will consult with Freeport in advance to ensure detailed accounts of specific activities are logged so the Tetra Tech team can obtain a configuration of the conductor pipes (spacing, number, cutting order), an accurate log of cutting activities that include start and stop times for cutting of specific conductors, locations of the jack-up rig and storage barge, any other vessel activity, or noise-generating activities on the platform deck. In addition, available ancillary metadata such as vessel traffic, wind, wave and precipitation measurements will be collated.

Prior to any analysis, data will be reviewed and quality controlled. Standard quality control procedures, such as those outlined by NOAA's Integrated Ocean Observing System, will be followed to ensure correct timing, file sizes, identification of data gaps, turnaround periods, spikes, flatlines, and any other anomalies. Appropriate calibration steps will be taken, and all further analysis will be applied to quality-controlled, calibrated data. Given the significantly different frequency bands over which data will be collected, the data analysis methods will be customized to the bandwidth of each measurement system. A low-frequency band (50 Hz to 3 kHz) will be defined across datasets to ensure consistency across sensor platforms. Additional frequency bands will then be defined that span roughly 3 kHz to 48 kHz for the SoundTrap 300HF data. Analysis will span both these identified frequency bands, with overlap as necessary (e.g., for marine mammal species whose vocalization frequencies span one or more bands).

The team will then implement "first-order" standard analysis products such as third-octave band spectral analysis, long-term spectral averages (LTSAs), peak and root mean square sound pressure levels, cumulative exposure levels, and spectral probability densities. These analyses will be implemented across all vector sensor and hydrophone data. The result of these analyses will be a characterization of the soundscape in terms of pressure and particle motion before, during and after cutting, or any other logged activities during the conductor cutting operation. The decay in computed metrics with distance from the platform will be quantified. The analysis of the above metrics over multiple conductor cuttings will provide a statistically robust characterization of sound generation from cutting operations as well as any alterations to the soundscape as the result of cutting operations.

Broadband hydrophone data will be reviewed for the occurrence of cetacean vocalization "events." Two frequency bands will be reviewed, one for baleen whale calls and songs (20 Hz to 10 kHz) and one for toothed whale whistles and clicks (10 kHz to 24 kHz). The LTSAs described above will be manually reviewed and annotated to document the presence of whale calls, song, or clicks. This effort will provide information regarding the biotic contribution of marine mammal sound to the soundscape at the recording site which is a value-added analysis to inform future upcoming impact assessments.

The analysis of data gathered at the 100 m distance from the Hermosa platform will allow for the spectral characterization of low-frequency pressure and particle motion (from NoiseSpotter data) beam pattern, and low- and high-frequency acoustic pressure (from SoundTrap data) beam pattern. Additionally, the temporal and spectral depth-variation in pressure and particle motion will be characterized, and beam patterns inferred at the two additional depths as well. The result of this analysis will be beam pattern estimates at three depths above the seabed at a distance of 100 meters from the platform. Here again, the availability of data from multiple conductor cutting events will yield a statistically robust spectral characterization of the beam pattern from conductor cutting, that can then be used as the source function in future propagation modeling (Jensen et al. 2011).

Finally, the thermistor-chain data will be analyzed, and time-varying sound speed profiles computed for use in propagation modeling. The team has considerable experience in the use of state-of-the-art three-dimensional parabolic equation (PE) propagation models and intimately understands model needs and propriate data formats. For example, many PE models require the specification of sound speed profiles and frequency domain source beam patterns as appropriately annotated Network Common Data Form (or netCDF) or comma separated value (CSV) files. The team will therefore work with BOEM to identify potential modeling programs/platforms and provide the measured data in a format suitable for incorporation into the identified acoustic propagation models.

A.3.3 Data Quality Assurance / Quality Control (QA/QC)

The Tetra Tech data manager will QA/QC and review the data to identify boundary conditions and outliers. As appropriate, descriptive statistics will be used to describe underlying distribution characteristics and appropriate transformations will be applied prior to additional data analysis. Data analysis may take many forms, ranging from simple mathematical calculations to more complex statistical techniques and programmatic manipulation. Tetra Tech analysts routinely use Microsoft Excel and the R Statistical Software and Computing Environment for data analysis. Other software programs can be used as necessary. Tetra Tech will maintain documentation describing the analyses performed on each dataset. This documentation will include the steps taken during the analysis, as well as any assumptions made, and may take the form of a formal document, versioned files, or comments within project-specific software programs.

A.4 Risk Mitigation

With the Project Team's extensive experience in designing and executing underwater acoustic and particle motion monitoring programs, there is an understanding that risk mitigation is an important consideration to maximize the possibility of a successful outcome. In our original equipment layout design, we placed moorings approximately 50 meters from the center point of the Hermosa platform. However, given the possibility for entanglement into the oil platform, and based on consultation with the Freeport cutting contractor, the monitoring locations have been moved to a minimum of 100 meters from the edge of the oil platform. This distance is considered a tradeoff between safety, the goal of not hindering conductor-cutting operations, and being close enough to the cutting activities to allow for a representative measurement of near-field generated sound.

The original design was based on leaving the anchors for the sub-surface moorings on the sea floor; however, since the equipment will be located within the ¼-mile site clearance area for Freeport we will now be recovering the anchors for the SoundTraps, particle motion equipment, and thermistor chain. Given the weight (approximately 200-400 kg each) and size (36-inch diameter) of the anchors and the fact that there will be five anchors to retrieve, safety is a significant concern during the required recovery operations. The Tetra Tech team will target coordinating the recovery efforts during weather conditions optimal for the anchor recovery. However, it is imperative to note that if weather conditions change (e.g., the sea states increase or wind picks up during the recovery) to conditions that risk the safety of the boat and personnel, Tetra Tech will notify BOEM and an additional recovery trip may be needed.

Tetra Tech will attempt to schedule the deployment and retrieval operations during days that the Freeport vessel is not on-site. The contact information for the Freeport team is provided in Table A-4. Coordination with Freeport includes the following communication plan:

- Communicate with Freeport regarding the target deployment and retrieval dates.
- 16 days prior to target deployment and retrieval dates, contact Freeport, and specifically Ronnu Griffin, who is the shorebase manager for the Harvey Challenger to discuss:
    - Freeport vessel plans and schedule.
    - Weather window for the deployment and retrieval dates.

If there is insufficient weather clearance to avoid same-day presence, additional alertness, precautions, and communication would be required. This would include the following:

- Contact Ronnu Griffin to provide departure dates and times.
- Communication to the platform lead operator three times including:
    1. Upon departure from the port, contact platform lead operator at Hermosa at 805-733-5634.
    2. Upon arrival to the Hermosa Platform area, hail the platform lead operator using the marine radio channel 16 and switch to an agreed channel to discuss transit information
    3. Upon departure, hail the platform lead operator on marine radio channel 16 and let them know we are leaving the area

If the Tetra Tech vessel and Freeport vessel are near the platform during the same time, the Tetra Tech vessel captain will hail the Freeport vessel (Harvey Challenger) captain and switch to an agreed channel to discuss operations to avoid being in close proximity to each other.

For further communication needs, the Tetra Tech vessel will also be equipped with an Iridium 9555 satellite phone, which has the number (8816) 524 35829. It should be noted that, when making outgoing calls, dial "00" prior to the phone number being dialed.

Table A-4. Freeport Team Field Staff Contact Information

Project Role	Name	Email	Phone
Director, Environmental Health and Safety	David Rose	drose@fmi.com	805-637-7952
Crevalle Field Lead	Chris Auer	cauer@crevalleusa.com	713-203-8360
DCOR Shorebase Manager	Ronnu Griffin	Rgriffin@dcorlic.com	760-331-3880
Harvey Challenger Captain	Capt. Billy Toon	Challenger@harveygulf.com	931-624-8494
Harvey Challenger Captain	Capt. Steve	Challenger@harveygulf.com	337-351-2322
Harvey Challenger General Contact	Harvey Challenger	Challenger@harveygulf.com	505-985-7012

A.5 References

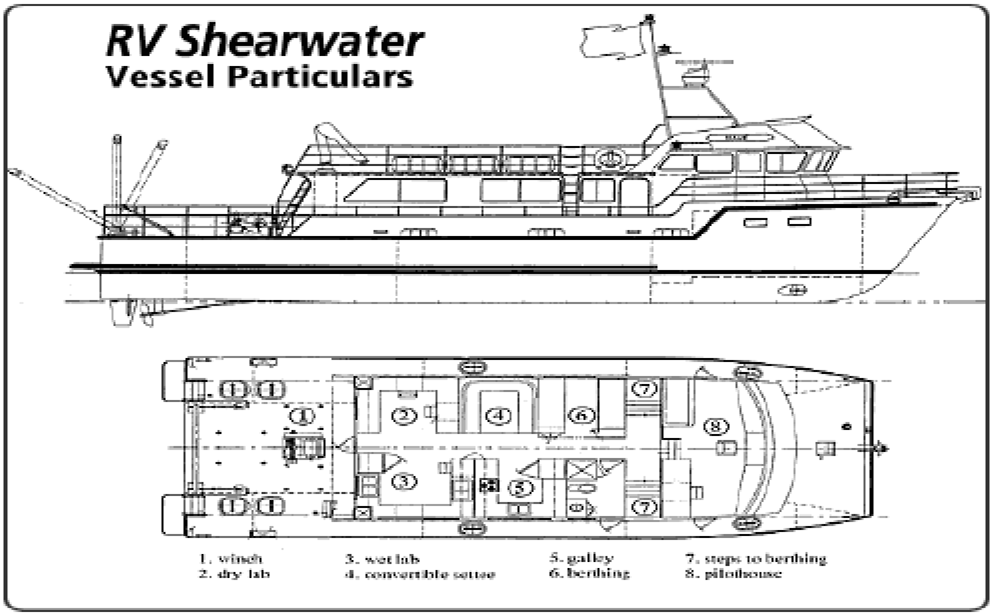
Jensen FB, Kuperman WA, Porter MB, Schmidt H. 2011. Computational ocean acoustics. Springer Science & Business Media.

Nedwell JR, et al. 2004. Fish and Marine Mammal Audiograms: Subacoustech Report ref: 534R0214.

Raghukumar K., Chang G, Spada F, Jones C, Spence J, Griffin S, Roberts J. 2019. Performance characteristics of a vector sensor array in an energetic tidal channel. Proceedings of Underwater Acoustics Conference and Exhibition, Crete. 2019. Paper ID: 757.

Raghukumar K, Chang G, Spada F, Jones CA. 2020. Vector sensor-based acoustic characterization system for marine renewable energy. J. Mar. Sci. Eng. 8:187.

Attachment A-1: Vessel Information



<u>Leading Particulars for the NOAA Research Vessel *Shearwater*</u>
Home Port: Santa Barbara, CA
Builder: All American Marine
Year built: 2002
Vessel type: Research, public education and outreach platform
Hull type: Aluminum Teknicraft hydrofoil-supported catamaran
Call Sign: WDB2424
LOA: 61' 7" **Beam:** 24' **Max. draft:** 6' **Height above water:** 35'
Hull depth (keel to main deck at mid-length): ~10'
Net tonnage: 41.3 tons
Gross tonnage: 76 tons
Displacement fully loaded: 41.3 metric tonnes
Engines: (2) Detroit Series 60 (600Hp each), Twin Disc gears and DDEC controls, shafted to 5 blade propellers
Total Horsepower: 1200Hp at 1200rpm
Fuel storage: 1200 gallons (diesel)
Cruising range: 450NM
Cruising speed: 19 knots
Endurance: 5 days, 4 consecutive nights
Capacity: 32 POB (Day trips - 28 passengers, 4 crew/CINMS staff), 9 POB (Overnight trips -6 passengers, 3 crew; can accommodate more by using cots/tents; consult VOC if you plan on more than 9 POB), 5, 290lbs (MAX load: people and gear)

<u>Identification</u>
NOAA Hull #: R6201
Hull ID #: AA TD62-10 or PP026224-0086

MMSI # 366875820
Visual identification: Grey, aluminum-hulled catamaran with blue longitudinal stripes, NOAA logo, "Shearwater" decal across transom

Operator
Channel Islands National Marine Sanctuary (CINMS), U.S. Department of Commerce/National Oceanic and Atmospheric Administration (NOAA).

Sea Keeping
Operations: Sea state up to Beaufort 5, depending on the type of operations and swell period
Transits: Sea state up to Beaufort 6, depending on heading and swell period

Area of Operations
Channel Islands National Marine Sanctuary - Point Purisima, CA to San Diego, CA out to 60NM, including Santa Barbara Island.

Typical Types of Missions
Oceanographic research including CTD deployments, plankton tows, mooring deployment and recovery, ROV and camera sled operations, dive operations, marine mammal observations, outreach and education, emergency response.

Amenities
Berthing: Bunks for 6 scientists and 3 crew plus cots (9 total + space available for cots - see above comment)
Galley: Range with small oven, fridge/freezer, microwave, coffee maker, toaster, panini press, propane BBQ grill on upper deck Dedicated scientific mini fridge/freezer (in the works)
250 gallons fresh water storage
125 gallons optional fresh water storage on top deck
Head with hot water shower
400 gallon capacity MSD holding tank (Type III), gravity-driven pump

Unique Features
Bridge, Flying Bridge and aft steering control stations (Large flying bridge, well suited for marine mammal observations)
Segregated dry lab space for computers and equipment, wet lab space with saltwater sink and carriage return.
Large swim step and dive ladder
Tie down points on stern and upper decks.
Excellent slow speed maneuvering capability
NOAA Scientific Computer System (SCS) to collect numerous data parameters autonomously
Deck equipment:
Science Winch (Markey COM 7H):
Markey Compact Hydraulic CTD Winch
(S/N 18487)
850lbs SWL approx 800 meters of data (EM) cable; ability to add 700-750m of Spectre cable on top. Wire Diameter: 0.322". Speed:126'/min or 38m/min (can increase to 197'/min or 60m/min after 2,500')
A-Frame:
1,300 lbs max working load

156" to bottom of block from deck

163.5" to bottom of cross-arm from deck

124" between vertical arms

96" clearance of cross-arm from back deck when fully extended over water

Crane (knuckle boom; Morgan Model 300.3 Marine Crane with Rotzler):
4,510 lbs safe working load (SWL) & 1,320 lbs SWL at full extension (14')

Hydraulic Winch on crane (Winch S/N 355662): 2,850 lbs max working load for winch

Anchor (Bruce Anchor, chain, wire wrap, and stopper):
50kg with 140' 3/8" hot dipped stainless steel chain; 300' wire-wrapped on foredeck Kolstrand hydraulic winch drum

Launches Carried Aboard
13'9" Zodiac MKII GR, 15hp outboard, 6 person capacity

Communications and Navigation Equipment (many of these items are being upgraded in February 2021)
Simrad ES80 Sounder
(2) Furuno X-Band Radars
Furuno FA150 AIS
Furuno SC30 satellite compass/heading sensor
Furuno GPS
ComNav 2001 Autopilot
Time Zero Primary navigation software
VHF/DSC Radio; National Park Service Radio
Iridium Satellite Phone (2)
External CCTV camera system for operations monitoring
Wireless Broadband amplifier when operating in wireless range

Electrical Systems
12 and 24V DC primary power,
Northern Lights 20kW (20EOZ), single phase, 60Hz, 120/240 VAC
Generator, Northern Lights 8kW (M753K), single phase, 60Hz
120/240 VAC Generator Best Power UPS, clean power supply
220/110V 30/40 Amp shore power

Power Available for Scientific Equipment

220V	50	Amp,	single phase
220V	30	Amp,	single phase
110V	50	Amp,	single phase 1
10V	30	Amp,	single phase 1
10V	15	Amp,	clean three phase

SCUBA Air Compressor (2)
8.4CFM Electric Bauer Mariner II
Gas powered Bauer Mariner II as backup

Safety
Fixed engine room fire system, portable extinguishers, central fire detection system, SOLAS B coastal life rafts, SART, EPIRB, immersion suits, portable O2, AED, first-aid kits, backboard

Principal contact
Vessel Operations Coordinator, LTJG Nicolas DeProspero
UCSB Ocean Science Education Building 514, MC 6155
Santa Barbara, CA 93106-6155
Phone: 805-893-6426 (office) or 805-450-1504 (work cell)
Email: voc.cinms@noaa.gov

Channel Islands National Marine Sanctuary

NOAA RV *Shearwater* Crane and Winch Info:

Science Winch:
Markey Compact Hydraulic CTD Winch
(S/N 18487)
850lbs SWL approx 800 meters of data (EM) cable

Wire Diameter: 0.322"

Speed: 126'/min or 38m/min (can increase to 197'/ min or 60m/min after 2,500')

A-Frame:
1,300 lbs max working load

156" to bottom of block from deck

163.5" to bottom of cross-arm from deck

124" between vertical arms

96" clearance of cross-arm from back deck when fully extended over water

Crane (knuckle boom):
Morgan Model 300 Marine Crane with Rotzler
4,510 lbs safe working load (SWL)
1,320 lbs SWL at full extension (14')

Hydraulic Winch (Winch S/N 355662)
2,850 lbs max working load for winch

Attachment A-2: Equipment Specifications

A-2.1 OceanInstrumentsNZ SoundTrap ST300 Digital Sound Recorders Specifications

OceanInstruments NZ

SoundTrap ST300 Digital Sound Recorders

STD & HF models

Key features:

- Industry leading audio fidelity
- Very low self-noise
- 60 kHz and 150 kHz bandwidth models
- Up to 13 days continuous recording on internal battery
- Up to 70 days continuous with optional external battery (3 x D cell)
- Simple operation with optional IR remote control
- Sealed, low maintenance, flood proof housing
- Fast USB offload
- Toothed whale Click detection (HF only)

The SoundTrap 300 series are compact self-contained underwater sound recorders for ocean acoustic research. The STD model is intended for general purpose use with a working frequency range of 20 Hz to 60 kHz. While the HF model offers 20 Hz to 150 kHz bandwidth for higher frequency bioacoustic research. Both feature very low self-noise, ensuring beautiful recordings in even the quietest places.

An internal battery enables continuous recording for up to 13 days, or 56 days on a 10 minute per hour duty cycle. For longer deployments plug in the optional external battery pack for up to 70 days continuous recording. Up to 256 GB of internal memory coupled with lossless audio compression provides storage for up to 65 days continuous recording at 72 kHz.

Data offload and battery recharge are done via a high quality wet plug. The housing therefore never needs opening, eliminating the usual worries about o'ring maintenance and moisture ingress. Weighing less than 500 g in air, hydrophone deployment has never been so easy.

Output files are in the industry standard WAV format. Ancillary sensors are included for logging temperature and tri-axial acceleration. The included software offers flexible deployment options for sample rate, gain control, filtering, delayed start and duty cycle. Plus the optional water proof IR remote control makes for convenient in-the-field ad hoc measurements. Each instrument is supplied with a calibration certificate and features self-calibration checks for confirmation of performance in the field.

Detailed Specifications

Bandwidth	
STD model	20 Hz - 60 kHz ± 3dB
HF model	20 Hz - 150 kHz ± 3dB
Self-noise	Better than sea-state 0 (100 Hz - 2 kHz)
STD model	Less than 34 dB re 1 µPa above 2 kHz
HF model	Less than 37 dB re 1 µPa above 2 kHz
Gain	Two gain settings - Low noise and high dynamic range.
	Maximum level before clipping approx. 186 dB re 1 µPa
High Pass Filter	400 Hz selectable high pass for high energy sites
Sample rates	
STD model	288, 144, 96, 48, 36 & 24 kHz
HF model	576, 288, 192, 96, 72 & 48 kHz
ADC	16-bit SAR
Calibration	Factory OCR calibration certificate
	Self-calibration check
	Pistonphone coupler available
Control	Optional Waterproof IR remote control for manual record start/stop.
Ancillary sensors	Temperature - 0.1°C precision, 1°C uncalibrated accuracy in water
	Acceleration – For detecting orientation, or cable strum / platform vibration.
	Tri-axial accelerometer, +/- 8g, Sampling up to 1 Hz

Click Detection

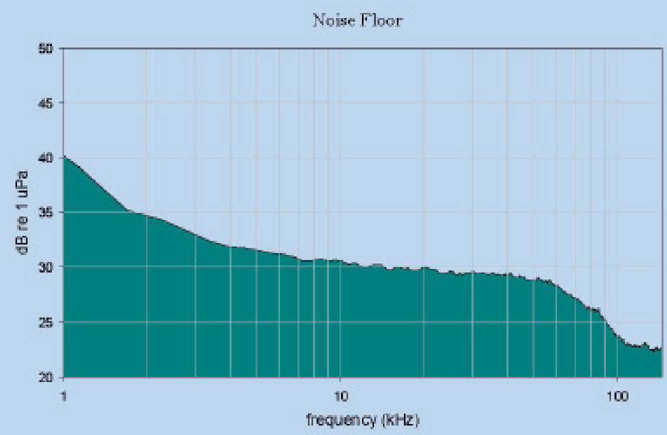
HF model only. Allows detection and journaling of high frequency marine mammal sonar clicks. Detector runs in parallel with normal recording process. Conserves memory by simultaneously using a low sample rate for WAV recording and high sample rate for click detection. See user manual for more information.

Memory	128 or 256 GB Note - loss-less audio compression provides 3-4 times compression, thereby allowing for up to 1TB of wav file storage.
Internal battery	An internal rechargeable battery provides power for up to 13 days continuous operation
External battery	The optional external battery housing takes 3 x D cell batteries, and provides up to 70 days continuous operation.
Connectivity	Wet pluggable connector for connection to GPS or radio telemetry.
Maximum depth	500m (Extended depth version available on request)
Dimensions:	200mm L x 60mm D (excluding connector dummy)
Weight	Approx. 500g in air

Recording Endurance Table (128GB memory)

Sample Rate(kHz)	Duty Cycle	Endurance (days)	With external battery (days)
36	Continuous	13	64
36	10 minutes per hour	56	278
48	Continuous	13	51
48	10 minutes per hour	56	278
96	Continuous	13	25
96	10 minutes per hour	56	153
144	Continuous	13	17
144	10 minutes per hour	56	102
288	Continuous	8	8
288	10 minutes per hour	51	51
576	Continuous	4	4
576	10 minutes per hour	25	25

Table values assume atypical X3 compression rate of 3x and water temp above 20 degrees Celsius.



A-2.2 NoiseSpotterTM and Pressure Sensor Specifications

NoiseSpotter

Frequency range	**50 Hz to 3 kHz**
Sampling frequency	20 kHz/channel
Sensor Sensitivity	-179 dB re V/µPa
Acoustic fields	Pressure, 3D particle motion
Number of sensors	3
Vertical spacing	Customizable. Typically 42 cm, 56 cm and 86 cm above seabed
Horizontal spacing	1.25 m
Intended applications	Soundscape characterization, marine mammal monitoring, particle motion measurements, source localization and tracking.
Operating duration	33 days continuous recording
Telemetry options	Customizable. Currently SPLs and 10 s spectra every minute.
Depth rating	200 m

Pressure Sensor: HOBO Water Level Titanium

Operation range	**0 to 76.5 m water depth**
Factory Calibrated Range	69 to 850 kPa (10 to 123.3 psia)
Burst Pressure	1200 kPa (174 psia) or 112 m (368 ft) depth
Water Level Accuracy	Typical error: ±0.05% FS, 3.8 cm (0.125 ft) water Maximum error: ±0.1% FS, 7.6 cm (0.25 ft) water
Raw Pressure Accuracy	±0.3% FS, 2.55 kPa (0.37 psi) maximum error
Resolution	<0.085 kPa (0.012 psi), 0.87 cm (0.028 ft) water
Pressure Response Time (90%)	<1 second

A-2.3 RBR Solo3 Small Temperature Recorder Specifications

RBR

MEASURE THE BLUE PLANET

rbr-global.com

RBR*solo*^{3} T

SMALL TEMPERATURE RECORDER

30M READINGS ON A SINGLE AA BATTERY

The RBR*solo*^{3} T is one of RBR's most compact, lightweight, and versatile single channel recorders. The logger offers flexible measurement schedules, standard sampling up to 2Hz (optionally up to 32Hz), large memory, extra power for extended deployments, USB-C download for large data files, and temperature accuracy of ±0.002°C.

FEATURES

- Compact and lightweight
- Any AA battery
- 30M measurements
- Up to 32Hz sampling
- USB-C download
- Cabled RBR*coda*^{3} variant available

The RBR*solo*^{3} T is available in the following configurations:

RBR*solo*^{3} T	up to 2Hz continuous sampling
RBR*solo*^{3} T|fast16	up to 16Hz continuous sampling
RBR*solo*^{3} T|fast32	up to 32Hz continuous sampling

The RBR*solo*^{3} T makes it easy to configure the optimum sampling regime for your measurements whether it is moored, towed, or profiling. The large data storage capacity and fast download ability facilitate long deployments with higher sampling rates. A dedicated desiccant holder makes it simple to replace desiccant before each deployment.

The RBR*solo*^{3} T is one of the most flexible single channel recorders available from RBR and like all RBR instruments, the calibration coefficients are stored with the logger. Dataset export to Matlab, Excel, OceanDataView®, or text files makes post processing with your own algorithms effortless.

RBR
MEASURE THE BLUE PLANET

SMALL TEMPERATURE RECORDER

COMPACT, ACCURATE, DEPENDABLE

- Compact and lightweight
- Any AA battery
- 30M measurements
- Up to 32Hz sampling
- USB-C download
- Cabled RBR*coda*³ variant available

RBR Ltd

95 Hines Road
Ottawa, Ontario
Canada K2K 2M5

+1 613 599 8900
info@rbr-global.com
rbr-global.com

Specifications

Physical

Power:	Any AA cell
Communication:	USB-C
Clock drift:	±60 seconds/year
Diameter:	25.4mm
Length:	240mm
Weight (air):	126g
Weight (water):	20g
Depth Rating:	1700m

Temperature

Range:	-5°C to 35°C (optionally 50°C)
Accuracy:	±0.002°C
Resolution:	<0.00005°C
Time constant:	<1s
Typical stability:	0.002°C/year

Sampling rates and Autonomy

RBR*solo*³ T

Sampling rate: 24hr to 1s, and 2Hz

Autonomy:

Rate	Duration	# samples
5s	6 years	40M
2Hz	150 days	25M

RBR*solo*³ T|fast16

Sampling rate: 24hr to 1s, and 2Hz, 4, 8, and 16Hz

Autonomy:

Rate	Duration	# samples
16Hz	100 days	130M

RBR*solo*³ T|fast32

Sampling rate: 24hr to 1s, and 2Hz, 4, 8, 16, 24, and 32Hz

Autonomy:

Rate	Duration	# samples
32Hz	50 days	130M

Realtime variant

Cabled realtime variant available as the RBR*coda*³.

Deep variant

Explore up to 10km deep with the RBR*solo*³ T|deep. Details available on the RBR*solo*³ and RBR*duet*³|deep datasheet.

RBR#0005583revE 10/2019

A-2.4 SEA-BIRD SBE 16plusV2 SeaCAT CT(D) Specifications

SEA·BIRD SCIENTIFIC

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SBE 16plus V2
SeaCAT CT(D)

The SBE 16plus V2 SeaCAT is a high-accuracy conductivity and temperature (pressure optional) recorder designed for moorings or other long-duration, fixed-site deployments. It supports numerous auxiliary sensors (dissolved oxygen, pH, turbidity, fluorescence, oil, PAR, etc.) with six A/D channels and one RS-232 data channel. The 16plus V2 communicates via an RS-232 serial interface, and has internal batteries and memory. It is well suited to networked sensor arrays where its operation can be triggered by satellite, radio, or hardwire telemetry equipment.

Data is recorded in memory and can also be output in real-time in engineering units or raw HEX. Battery endurance varies, depending on the sampling scheme; nine alkaline D-cells provide power for 355,000 samples of C and T.

Features

- Moored Conductivity, Temperature, Pressure (optional), and up to seven auxiliary sensors, at user-programmable intervals (10 seconds to 4 hours).
- RS-232 interface, internal memory, and internal alkaline batteries (can be powered externally).
- Expendable anti-foulant devices and optional pump for bio-fouling protection.
- Depths to 600, 7000, or 10,500 m.
- Seasoft© V2 Windows software package (setup, data upload, real-time data acquisition, and data processing).
- Next generation of the SeaCAT family, field-proven since 1987.
- Five-year limited warranty.

Components

- Unique internal-field conductivity cell permits use of expendable anti-foulant devices, for long-term bio-fouling protection.
- Aged and pressure-protected thermistor has a long history of exceptional accuracy and stability.
- Optional pressure sensor with temperature compensation is available in eight strain-gauge ranges (to 7000 m) and eleven Digiquartz® ranges (to 10,500 m).
- Optional pump runs for each sample, providing improved conductivity and plumbed auxiliary sensor response, bio-fouling protection, and correlation of CTD and auxiliary sensor measurements.

www.seabird.com sales@seabird.com +1 425-643-9866

SBE Sea-Bird Electronics

Options

- Plastic (600 m) or titanium (7000 or 10,500 m) housing.
- XSG/AG or wet-pluggable MCBH connectors.
- No pressure, or strain-gauge or Digiquartz® pressure sensor.
- SBE 5M pump for pumped conductivity; or SBE 5P or 5T pump for pumped conductivity and auxiliary sensor(s).
- Sea-Bird Scientific auxiliary sensors — dissolved oxygen, pH, fluorescence, oil, radiance (PAR), light transmission, turbidity, etc.
- Auxiliary sensors from other manufacturers.
- Battery pack kit for lithium batteries (batteries not supplied by Sea-Bird).

Measurement Range

Conductivity	0 to 9 S/m
Temperature	-5 to +35 °C
Optional Pressure	Strain-gauge 0 to 20/100/350/600/1000/2000/3500/7000 m; Quartz 20/60/130/200/270/680/1400/2000/4200/7000/10,500 m

Initial Accuracy

Conductivity	± 0.0005 S/m
Temperature	± 0.005 °C
Optional Pressure	Strain-gauge ± 0.1% of full scale range; Quartz ± 0.02% of full scale range

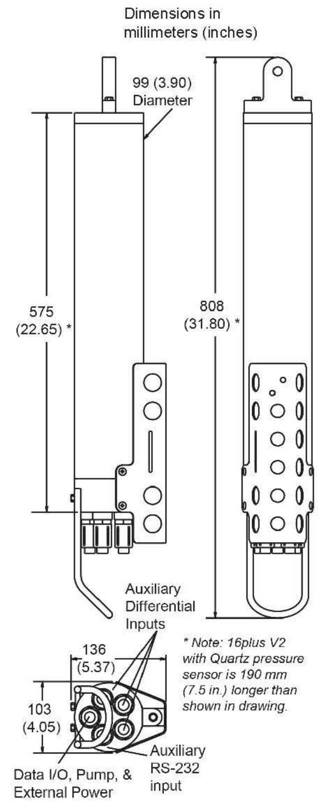
Typical Stability

Conductivity	0.0003 S/m per month
Temperature	0.0002 °C per month
Optional Pressure	Strain-gauge ± 0.1% of full scale range per year; Quartz ± 0.02% of full scale range per year

Resolution

Conductivity	0.00005 S/m typical
Temperature	0.0001 °C
Optional Pressure	Strain-gauge 0.002% of full scale range; Quartz 0.0006% of full scale range for 1-sec integration

Memory & Data Storage	64 Mbyte non-volatile FLASH. Bytes/sample: 6 T&C; 5 pressure; 2 each external voltage; 4 date & time (RS-232 sensor is sensor dependent)
Power Supply & Consumption	9 alkaline D-cell batteries provide 355,000 samples CT; 240,000 samples CTD; 140,000 samples CTD & SBE 5M pump (see manual)
Optional External Power	9 - 28 VDC; consult factory for required current
Auxiliary Sensors	Power out up to 500 mA at 10.5 - 11 VDC; Voltage sensor A/D resolution 14 bits and input range 0-5 VDC
Housing, Depth Rating, & Weight	Acetal Copolymer Plastic, 600 m, in air 7.3 kg, in water 2.3 kg 3AL-2.5V Titanium, 7000 m, in air 13.7 kg, in water 8.6 kg 6AL-4V Titanium, 10,500 m



** Note: 16plus V2 with Quartz pressure sensor is 190 mm (7.5 in.) longer than shown in drawing.*

SEA·BIRD SCIENTIFIC

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U.S. Department of the Interior (DOI)
DOI protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

Bureau of Ocean Energy Management (BOEM)
BOEM's mission is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.

BOEM Environmental Studies Program
The mission of the Environmental Studies Program is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments. The proposal, selection, research, review, collaboration, production, and dissemination of each of BOEM's Environmental Studies follows the DOI Code of Scientific and Scholarly Conduct, in support of a culture of scientific and professional integrity, as set out in the DOI Departmental Manual (305 DM 3).