EDR

Memorandum

To:	Maria Hartnett, Principal
From:	Caitlin Pfeil, Environmental Scientist Jeff Nield, Senior Project Manager & New England Practice Leader
Date:	May 11, 2022; revised September 15, 2022; revised February 9, 2023
Reference:	Take Estimates from High-Resolution Geophysical Surveys for the Letter of Authorization
EDR Project No:	20043

Updates

The following items have been updated since the initial submittal of this report in May 2022:

- Table 1 – The INNOMAR has been placed in its own category rather than under the category of the CHIRP equipment.
- Table 3 – Footnote 'a' was added to explain that the level of effort presented will occur on an annual basis.
- Table 4 – The title has been updated to indicate that take numbers were calculated on an annual basis. Densities and takes were updated based on current marine mammal density modeling published by Roberts et al. (2022). Footnote 'a' was added to explain what the Survey Area encompasses. Clarifications to footnote 'e' (formerly footnote 'd') address adjusted take for Sei whales, and Footnote 'f' (formerly footnote 'e') provides context on adjusted take for short-finned pilot whales.
- Density Calculations for Pilot Whales and Seals – The method for calculating the density of short-finned pilot whales, long-finned pilot whales, grey seals, and harbor seal has been updated. A description of this methodology is included in text preceding Table 4.
- Attachment C – all densities have been updated to account for updated marine mammal density modeling published by Roberts et al. (2022).

Introduction

This memorandum serves to provide Jasco with estimated takes of marine mammals from high-resolution geophysical surveys that will be conducted for the development of Atlantic Shores Offshore Wind, LLC's (Atlantic Shores') offshore wind energy generation project (the Project). Atlantic Shores proposes to conduct high-resolution geophysical (HRG) and geotechnical surveys within the approximately 589,511-acre survey area. The Survey Area extends from the coastline out to a maximum distance of approximately 24 nautical miles (nm). As depicted in Figure 1, the Survey Area spans from Wall Township, New Jersey to Atlantic City, New Jersey.

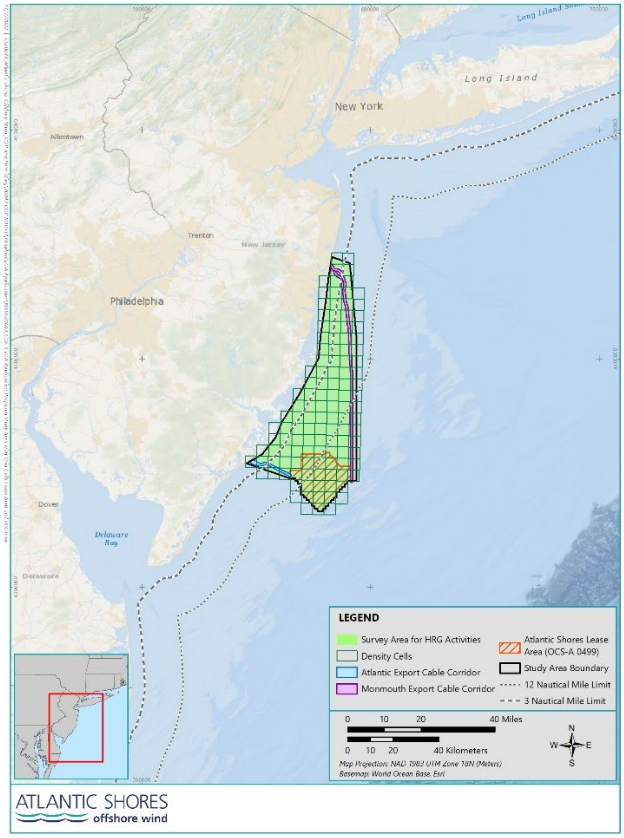


Figure 1. Proposed Survey Area

The purposes of the HRG and geotechnical surveys are as follows:

- Support the site characterization, siting, and engineering design of offshore Project facilities including wind turbine generators, offshore substation(s), and submarine cables within the Survey Area.
- Collect the data necessary to support Project review requirements associated with 30 C.F.R. § 585 and the National Environmental Policy Act.

National Oceanic and Atmospheric Administration (NOAA) Fisheries Greater Atlantic Regional Office (GARFO) programmatic consultation regarding geophysical and geotechnical surveys along the U.S. Atlantic coast in the three Atlantic Renewable Energy Regions (i.e., 2021 NOAA GARFO Biological Assessment) states that noise form geotechnical surveys are not expected to result in physiological or behavioral responses from Endangered Species Act-listed whales. Based on this opinion and other agency-published incidental harassment authorizations (IHAs), it is unlikely that the geotechnical surveys to be conducted by Atlantic Shores (e.g., sample boreholes, deep cone penetration tests [CPTs], and shallow CPTs) will result in Level A or B harassment of marine mammals. Therefore, geotechnical survey activities are not discussed in further detail.

The following sections of this memorandum focus on the type of proposed HRG survey activities, representative examples of equipment, and calculated Level B take of marine mammals.

HRG Survey Activities

The HRG survey activities that have been proposed in the Survey Area will include the following:

- Depth sounding (multibeam depth sounder and single beam echosounder) to determine water depths and general bottom topography (currently estimated to range from approximately 16 feet (ft) (5 meters [m]) to 131 ft [40 m] in depth)
- Magnetic intensity measurements (gradiometer) for detecting local variations in regional magnetic field from geological strata and potential ferrous objects on and below the bottom
- Seafloor imaging (side scan sonar survey) for seabed sediment classification purposes, to identify natural and man-made acoustic targets resting on the bottom as well as any anomalous features
- Shallow penetration sub-bottom profiler (pinger/chirp) to map the near surface stratigraphy (top 0 ft to 16 ft [0 m to 5 m] soils below seabed)
- Medium penetration sub-bottom profiler (chirps/parametric profilers/sparkers) to map deeper subsurface stratigraphy as needed (soils down to 246 ft [75 m] to 328 ft [100 m] below seabed)
- Grab sampling to validate seabed classification using typical sample sizes between 0.1 square meter (m^2) and 0.2 m^2.

The HRG survey equipment to be used in each of the identified Survey Areas will be similar to the HRG survey equipment used to support Atlantic Shores in 2020, 2021 and 2022 surveys and other offshore wind development projects along the Atlantic Coast that have been previously approved by both NOAA Fisheries and Bureau of Ocean Energy Management (BOEM). Geophysical surveys are expected to last for 60 days.

Atlantic Shores has evaluated a range of possible HRG survey equipment that would be necessary to support seabed assessments across the Survey Area during the specified timeframe associated with the proposed activities. This evaluation has been based on both the technical and regulatory requirements for project development as well as the type of survey equipment that has been recently deployed in support of offshore wind projects along the Atlantic Coast. The categories of representative HRG survey equipment with operating frequencies <180 kilohertz (kHz) that are anticipated for use are presented in Table 1. This equipment will either be mounted to or towed behind the survey vessel at a typical survey speed of approximately 3.5 knots (6.5 kilometers [km]) per hour.

Operational parameters presented in Table 1 were obtained from the following sources: Crocker and Fratantonio (2016); manufacturer specifications; personal communication with manufacturers; agency correspondence; and Atlantic Shores. The operational source level, frequency, and beamwidth were used in the NOAA Fisheries Level B spreadsheet tool for calculating the distance to the Level B threshold. Manufacturer specifications are included in Attachment A.

Table 1. Representative Equipment Specification with operating Frequencies Below 180 kHz

HRG Survey Equipment (Sub-Bottom Profiler)	Representative Equipment Type	Operating Frequencies Ranges (kHz)	Operational Source Level Ranges (dB_{RMS})	Beamwidth Ranges (degree)	Typical Pulse Durations RMS_{90} (millisec)	Pulse Repetition Rate (Hz)
Sparker	Applied Acoustics Dura-Spark 240	0.01 to 1.9[a]	203[a]	180	3.4[a]	2
	Geo Marine Geo-Source	0.2 to 5[b]	195[b]	180	7.2[b]	0.41
Chirp	Edgetech 2000-DSS	2 to 16[b]	195[c]	24[d]	6.3	10
	Edgetech 216	2 to 16	179[e]	17, 20, or 24	10	10
	Edgetech 424	4 to 24[f]	180[f]	71[f]	4	2
	Edgetech 512i	0.7 to 12[f]	179[f]	80[f]	9	8
	Pangeosubsea Sub-Bottom Imager™	4 to 12.5[d]	190[d,g]	120[d]	4.5	44
INNOMAR	INNOMAR SES-2000 Medium-100 Parametric [h]	85 to 115[d]	241[i]	2[d]	2	40
	INNOMAR deep -36 Parametric [h]	30 to 42	245	1.5	0.15 to 5	40

Notes:

a) The operational source level for the Dura-Spark 240 is assigned based on the value closest to the field operational history of the Dura-Spark 240 [operating between 500 – 600 J] found in Table 10 in Crocker and Fratantonio (2016), which reports a 203 dB_{RMS} for 500 J source setting and 400 tips. Because Crocker and Fratantonio (2016) did not provide other source levels for the Dura-Spark 240 near the known operational range, the SIG ELC 820 @750 J at 5m depth assuming an omnidirectional beam width was considered as a proxy or comparison to the Dura-Spark 240. The corresponding 203 dB_{RMS} level is considered a realistic and conservative value that aligns with the history of operations of the Dura-Spark 240 over three years of survey by Atlantic Shores. Operational information provided by Atlantic Shores. Geo Marine Survey System operating at 400J.

b) Gene Andella (Edgetech), personal conversation with JASCO Applied Sciences, 2019-07-29.

c) Manufacturer specifications and/or correspondence with manufacturer.

d) Considered EdgeTech Chirp as a proxy source for levels as the Chirp512i has similar operation settings as the Chirp 2000-DSS tow vehicle. See Table 18 in Crocker and Fratantonio (2016) for source levels for 100% power and 2-12 kHz.

e) Values from Crocker and Fratantonio (2016) for 100% power and comparable bandwidth.

f) For frequency of 4 kHz.

g) Based on personal communication with Benjamin Laws, NOAA Fisheries (2022b), NOAA Fisheries does not expect take from these parametric sub-bottom profilers due to their lower frequencies and extremely narrow beamwidth. Therefore, these sources were not considered in calculating the maximum r value for the ZOI calculation.

h) The specification sheet indicates a peak source level of 247 dB re 1 µPa m (Jens Wunderlich, Innomar, personal communication, 7-18-2019). The average difference between the peak SPL source levels for sub-bottom profilers measured by Crocker and Fratantonio (2016) was 6 dB. Therefore, the estimated SPL source level is 241 dB re 1 µPa m.

Previous Atlantic Shores survey experience with the Applied Acoustics Dura-Spark indicates that the necessary electrical input of this sparker is approximately 500–600 joules (J). Only in seafloor areas where very dense substrates are encountered would a higher level of electrical input be used, which has not been the case thus far. For the purposes of estimating Level B Harassment takes from sparker operation, Atlantic Shores consulted NOAA Fisheries staff, published IHAs, NOAA GARFO (2021) and Crocker and Fratantonio (2016) to identify a source level value that considers the use of the Applied Acoustics Dura-Spark that is not overly conservative. Crocker and Fratantonio (2016) reports for the Applied Acoustics Dura-Spark, a source level of 203 dB_{RMS} for 500 J electrical input using 400 tips. The SIG ELC 820 was selected as a comparison to the Applied Acoustics Dura-Spark. As indicated in Table 1, the maximum reported [RMS] source level of 203 dB re 1µPa@1m for the SIG ELC 820 operating at 750 J at a depth of 5 meters provides another point of reference from the Crocker and Fratantonio (2016) report.

Some of the equipment expected to be operated during certain survey activities are not considered impactful to marine mammals and were not included in Table 1. These include single beam depth echosounders which are not believed to result in take of marine mammals; gradiometers which generate no acoustic output and do not pose risk of take to marine mammals; and side scan sonar and multibeam echosounders operated at frequencies above 180 kHz which are outside the general hearing range of most marine mammals (pers comm. Benjamin Laws, NOAA Fisheries, 2021a; CSA Ocean Sciences Inc 2021; NOAA Fisheries 2018). Of the HRG survey equipment expected to be operated during the survey campaign, only the sparkers and non-impulsive, nonparametric sub-bottom profilers generate the sound with characteristics that have the potential to result in the non-lethal take of exposed marine mammals.

Due to implementation of mitigation and monitoring measures, in combination with the behavior of marine mammal species (i.e., their transient nature and their ability to move away from the source of potential harassment), it is unlikely that these pieces of equipment will result in Level A harassment of marine mammals. This conclusion has been supported by both BOEM and NOAA Fisheries through published literature and agency communications from past Atlantic Shores IHA applications. Given the discrete frequency bands and small area of sound propagation emitted from HRG equipment, BOEM has concluded that injury to marine mammals (i.e., Level A harassment) is not expected as sound diminishes rapidly from the equipment (BOEM, 2018). Therefore, Level A take calculations have not been performed and Level A take has not been requested for any marine mammal species. Atlantic Shores is only requesting authorization for the incidental take of small numbers of marine mammals within each of the Survey Areas by Level B harassment. Estimates of Level B take are provided in the following section.

Take Estimates for Marine Mammals

To determine the type of take that could result from the operation of the HRG survey equipment operating below 180 kHz throughout the survey period, Atlantic Shores followed the interim recommendations provided by NOAA Fisheries (2020a) and the NOAA Fisheries HRG Level B Impact Distance Calculation spreadsheet (pers comm. Benjamin Laws, NOAA Fisheries, 2022b) to estimate the maximum horizontal distance to the Level B marine mammal acoustic harassment threshold for impulsive noise (160 $dB_{RMS90\%}$ re 1 µPa) based on equipment source specifications. Results of this assessment are provided in Table 2 and Attachment B.

Table 2. Maximum Distances to Level B 160 $dB_{RMS90\%}$ Threshold by Equipment Type Operating Below 180 kHz

HRG Survey Equipment (Sub-Bottom Profiler)	Representative Equipment Type	Operating Frequencies Ranges (kHz)	Operational Source Level Ranges (dB_{RMS})	Beamwidth Ranges (degree)	Distance to Level B Threshold (m)
Sparker	Applied Acoustics Dura-Spark 240	0.01 to 1.9	203	180	141
	Geo Marine Geo-Source	0.2 to 5	195	180	56
Chirp	Edgetech 2000-DSS	2 to 16	195	24	56
	Edgetech 216	2 to 16	179	17, 20, or 24	9
	Edgetech 424	4 to 24	180	71	10
	Edgetech 512i	0.7 to 12	179	80	9
	Pangeosubsea Sub-Bottom Imager™	4 to 12.5	190	120	32

As evidenced in Table 2, the maximum distance to the Level B harassment threshold is 463 ft (141 m) and results from use of the Applied Acoustics Dura-Spark sparker equipment. This distance was used as the "*r*" input in calculating the zone of influence (ZOI), which in turn is used to calculate estimated takes of marine mammals. It is unlikely that the sound source (sparker) resulting in the maximum possible impact as presented in Table 2 will be used over the entire duration of the 60-day survey period in the Survey Area. As such, the assessment included herein is based on conservative assumptions and provides a cautious approach to predicting active survey operations and their potential impact on marine mammal species.

Atlantic Shores proposes the potential take of small numbers of marine mammals by Level B harassment in the specified areas where the proposed activities will occur (Figure 1). Anticipated impacts to marine mammals from the proposed survey activities will be associated with noise propagation from the use of specific HRG survey equipment deployed to meet the goals of the survey campaigns conducted over the 60-day period. The following sections present the basis for estimating take and associated request for take related to planned HRG surveys.

<u>Basis for Estimating Numbers of Marine Mammals that Might be Taken by Harassment</u>

To provide flexibility in the design, selection, and execution of the survey campaign (including choice of equipment) and to maximize protection of marine mammals from survey activities, the following conservative (i.e., maximum or upper end) parameters to estimate the potential for take:

- Maximum number of days of survey that could occur over a 60-day period in each of the identified Survey Areas

- Maximum distance each vessel could travel per 24-hour period in each of the identified Survey Areas
- Maximum ensonified area (ZOI) from the equipment listed in Table 2
- Maximum average marine mammal densities for any given season that a survey could occur.

The following sections provide additional details on how each of these parameters have been applied to calculate the maximum ZOI associated with the planned survey activities in each survey area, along with estimates and associated requests for take.

Calculation of Maximum ZOI

The ZOI is the maximum ensonified area around the sound source over a 24-hour period. The following formula for a mobile source was used to calculate the ZOI:

$$\textit{Mobile Source ZOI} = (\textit{Distance/day} \times 2r) + \pi r2$$

Where:

Distance/day = the maximum distance a survey vessel could travel in a 24-hour period;
r = the maximum radial distance from a given sound source to the NOAA Level A or Level B harassment thresholds.

For the purpose of the Atlantic Shores HRG surveys, the total distance/day has been estimated to be approximately 34.2 miles (55.0 km) in the Survey Area (see Table 3). This estimated distance per day has taken into consideration not only the line-kilometers per day achieved during Atlantic Shores' surveys to date, but also data inputs from previous offshore wind and oil and gas surveys performed by members of the Atlantic Shores Geoscience Team.

To calculate a conservative ZOI, Atlantic Shores applied the maximum radial distance ("*r*") for any category and type of HRG survey equipment considered in its assessment to the mobile source ZOI calculation. Following the methods in the interim recommendations provided by NOAA Fisheries (2020a) and the results from the NOAA Fisheries HRG Level B Impact Distance Calculation spreadsheet, the maximum calculated distance to the Level B harassment threshold for any category and type of HRG survey equipment that could be operated is the sparker at 462.6 ft (141 m; Table 3 and Attachment B). As such, the ZOI for the sparker was applied as the maximum assumption. Results of the maximum mobile source ZOI calculations are provided in Table 3

Table 3. HRG Survey Area Distances and ZOI[a]

Survey Area	Number of Active Survey Days	Survey distances per day (km)	Maximum Radial Distance (r) (m)	Calculated ZOI per day (km^2)
Survey Area	60	55	141	15.57

Notes:
a) The survey distance and level of effort presented in this table will occur annually.

It should be noted that the maximum ZOI calculation for mobile sources results in a conservative ZOI for the following reasons:

- It uses the sparker, which produces the largest Level B ZOI, as the basis for the take estimates and assumes it is operational for 100% of the survey effort.[1]
- This ZOI is a representation of the maximum extent of the ensonified area around a sound source over a 24-hour period.

Estimate of Numbers of Potential Marine Mammal Takes by Harassment

Estimates of take are computed according to the following formula:

Estimated Take = D x ZOI x (d).

Where:

D = average highest marine mammal species density (number per km2)
ZOI = maximum ensonified area (as summarized in Table 3)
d = number of survey days (as summarized in 3)

The data used as the basis for estimating species density "*D*" for the Survey Areas were derived from data provided by Duke University's Marine Geospatial Ecology Lab and the Marine-life Data and Analysis Team. This dataset is a compilation of the best available marine mammal data (1992-2022) and was prepared in a collaboration between Duke University, Northeast Regional Planning Body, University of North Carolina Wilmington, the Virginia Aquarium and Marine Science Center, and NOAA (Roberts et al. 2016; Roberts et al. 2022; Curtice et al. 2018). To determine seasonal densities of marine mammal species in each of the survey areas, density data from Roberts et al. (2022) were mapped within the boundary of each survey area using geographic information systems (GIS). For each survey area, the densities as reported by Roberts et al. (2022), were averaged by season (spring [March–May], summer [June–August], fall [September–November], and winter [December–February]). To support the most conservative estimates of take over a 12-month period, Atlantic Shores applied the maximum average seasonal density values for each marine mammal to the calculation. The seasonal densities for the Survey Area are provided in Attachment C. Maximum average densities used to support the calculations of take are presented in bold. Table 4 provides a summary of total take for the Survey Area. It should be noted that calculations do not consider whether a single animal is exposed multiple times or whether each exposure is a different animal. Therefore, the numbers summarized in Table 4 are the maximum estimates for animals that may be harassed during the HRG surveys (i.e., Atlantic Shores assumes that each exposure event is a different animal).

For pilot whales and seals, densities in the Roberts et al. (2022) data are provided for the entire guild or group rather than separated by species. To calculate the density of a specific species, the density estimates

[1] Though take estimates account for operation of the sparker during all survey campaigns, Atlantic Shores and their contractor report that it is more likely that the sparker will only be used during 80% of survey campaigns. Thus, using the sparker to calculate take estimates for the entirety of surveying provides conservative take values.

provided by Roberts et al. (2022) were scaled by relative stock size which was derived from abundance estimates provided in NOAA Fisheries' U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2021 report (Hayes et al. 2022). Equation 1 shows the method in which the species-specific densities were calculated, using short-finned pilot whale as the example. This method was used to calculate densities for short-finned pilot whales, long-finned pilot whales, gray seals, and harbor seals.

Equation 1. Example Density Equation Using Short-finned Pilot Whales

$$d_{short-finned} = d_{both}\left(\frac{a_{short-finned}}{a_{short-finned} + a_{long-finned}}\right)$$

For bottlenose dolphin densities, Roberts et al. (2022) does not differentiate by individual stock. Given the northern migratory coastal stock propensity to be found shallower than the 65.6 ft (20 m) depth isobath between Assateague, Virginia, and Long Island, New York (Reeves et al. 2002; Hayes et al. 2018), the Survey Area was roughly divided along the 65.6 ft (20 m) depth isobath, which roughly corresponds to the 10-fathom contour on NOAA navigation charts. Roughly 33% of Survey Area is 65.6 ft (20 m) or less in depth. Therefore, to account for the potential for mixed stocks within Survey Area, 33% of the estimated take calculation for bottlenose dolphins was applied to the northern migratory coastal stock and the remaining was applied to the western North Atlantic offshore stock.

Some take estimates have been adjusted based on species behavior and typical pod size. For the short-beaked common dolphin, estimated takes were adjusted to reflect field observations collected by PSOs during the 2020 survey season. According to an RPS report (2021) which examined Level B exposure from 2020 survey activities of short-beaked common dolphin, PSOs observed voluntary approach behavior to operating survey vessels and strong seasonal abundance trends, which resulted in larger exposure accumulation than calculated take results which depended on density data. Using the total number of authorized takes and survey days from previous NMFS-issued IHA applications for Atlantic Shores (NOAA Fisheries 2021b, 2022c), an average take rate of 1.55 [common dolphin] individuals per day was used to calculate the total take for HRG surveys. Based on guidance from NMFS (email correspondence with Kelsey Potluck on October 29, 2021), the daily take rate of 1.55 individuals was multiplied by the number of survey days (i.e., 60 days), which resulted in 93 common dolphin takes.

Requested take estimates were also adjusted to account for typical group size of long-finned pilot whale, Atlantic spotted dolphin, and Risso's dolphin. While Level B harassment take is unlikely due to the required mitigation measures (e.g., shutdown/power-down if an animal enters the Level B harassment isopleths), a total of 20 takes of long-finned pilot whales, 100 takes of Atlantic spotted dolphin, and 30 takes of Risso's dolphin. These take numbers are based on the 2020, 2021, and 2022 NMFS IHAs issued for Atlantic Shores Offshore Wind (NOAA Fisheries 2020b, 2021b, 2022c). The proposed Survey Area presented in Figure 1 overlaps with the survey areas presented in previous NMFS-issued IHAs for Atlantic Shores, therefore the same group size assumptions were used in the analysis of takes presented in Table 4. Take estimates were also adjusted for short-finned pilot whales; however, since short-finned pilot whales were not included in past NMFS-issued IHAs for Atlantic Shores, take was adjusted based on group size data reported by the OBIS data repository (OBIS 2022). Data obtained from OBIS, which relies on NMFS sighting data, showed an average group size of 6 individuals for short-finned pilot whales. Adding these additional takes ensures the number of takes authorized is at least equal to the average group size.

While Table 4 provides annual estimates of take throughout the Survey Area, not all HRG equipment will be in operation for the entire duration. Yet, to provide maximum operational flexibility, this analysis assumes that the sound source that could result in the largest Level B ZOI (sparker) would be used for the entire duration and in all locations. However, it should be noted that, based on past experience by Atlantic Shores, the sparker is estimated to be used only 80% of the time during the surveys. The remaining 20% of survey time will use other equipment that result in a smaller Level B ZOI. Because the equipment resulting in the maximum-case ZOI would not be used during all survey campaigns in each survey area, the calculated take represents a conservative number. In addition, for delphinoid cetaceans, HRG survey equipment can continue operating if the individuals voluntarily approach the vessel (e.g., to bow ride) when the sound sources are at full operating power. Therefore, the determination of “voluntary” approach will effectively reduce the numbers and percent population affected for delphinoid cetaceans, below estimated values.

Table 4. Total Maximum Average Seasonal Density of Marine Mammals and Total Annual Estimated Level B Harassment Numbers

Species		Survey Area[a]		Total Takes	
		Max. Seasonal Density (No./100 km^2)[b]	Calculated Take (No.)	Adjusted Take Authorization (No.)	Percent of Population
North Atlantic right whale		0.056	1	1	0.27%
Humpback whale		0.090	1	1	0.07%
Fin whale		0.114	2	2	0.03%
Sei whale		0.031	1	2[e]	0.03%
Minke whale		0.401	4	4	0.02%
Sperm whale		0.005	1	1	0.02%
Short-finned pilot whale [c]		0.003	1	6[f]	0.02%
Long-finned pilot whale [c]		0.004	1	20[f]	0.05%
Bottlenose dolphin	N. Coastal Migratory	36.269	113	113	1.70%
	Offshore	36.269	225	225	0.36%
Short beaked common dolphin		1.473	14	93[g]	0.05%
Atlantic white-sided dolphin		0.278	3	3	<0.01%
Atlantic spotted dolphin		0.033	1	100[f]	0.25%
Risso's dolphin		0.017	1	30[f]	0.09%
Harbor porpoise		2.506	24	24	0.03%
Harbor seal [d]		9.704	91	91	0.148%
Gray seal [d]		4.319	41	41	0.150%

Notes:

a) The Survey Area includes waters within and in proximity to the WTA and ECCs. The Survey Area is depicted in Figure 1 of the memo.

b) Cetacean and pinniped density values from Duke University (Roberts et al. 2022).

c) Pilot whale density values from Duke University (Roberts et al. 2022) were reported as "pilot whales" and not species-specific. Density for short-finned and long-finned pilot whales were scaled based on abundance estimates provided in NOAA Fisheries' U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2021 report (Hayes et al. 2022).

d) Pinniped density values from Duke University (Roberts et al. 2022) reported as "seals" and not species-specific. Density for gray and harbor seals were scaled based on abundance estimates provided in NOAA Fisheries' U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2021 report (Hayes et al. 2022).

e) Atlantic Shores is requesting one additional sei whale take for a total of two animals based on average group size (NOAA 2022a) and an encounter during 2020 survey operations where a single sei whale surfaced inside the Level B exposure zone resulting in a take.

f) The number of authorized takes (Level B harassment only) for these species has been increased from the calculated take to consider that more than one individual is normally detected during each detection event and mean species group size. These take numbers are based on past NMFS IHAs issued for Atlantic Shores Offshore Wind (NOAA Fisheries 2020b, 2021b, 2022c). The proposed Survey Area presented in Figure 1 overlaps with the survey areas presented in previous NMFS-issued IHAs for Atlantic Shores, therefore the same group size assumptions were used for this analysis. Short-finned pilot whale group size was determined from historical NMFS sighting data (e.g., Atlantic Marine Assessment Program for Protected Species 2010–2019 aerial and shipboard surveys, NARW aerial surveys, and others) made available through the OBIS data repository (OBIS 2022).

g) Based on guidance from NMFS (email correspondence with Kelsey Potluck, 10/29/2021) and authorized take numbers from previous NMFS-issued IHA applications, an average take of 1.55 individuals per day was multiplied by the number of survey days (i.e., 60 days).

References

Atlantic Shores Offshore Wind. 2021. Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf, OCS-A 0499 – Incidental Harassment Authorization Renewal. Submitted March 2, 2021.

BOEM. 2018. Geological and Geophysical Surveys. Available at: https://www.boem.gov/sites/default/files/about-boem/BOEM-Regions/Atlantic-Region/GandG-Overview.pdf.

Crocker, S.E., and F.D. Fratantonio. 2016. Characteristics of Sounds Emitted During High-Resolution Marine Geophysical Surveys. Naval Undersea Warfare Center Division (Sponsored by BOEM & USGS).

CSA Ocean Sciences Inc. 2021. Application for incidental harassment authorization for the non-lethal taking of marine mammals: site characterization surveys Lease OCS-A 0498. Submitted November 2020. Updated March 2021.

Curtice C., J. Cleary, E. Shumchenia, and P.N. Halpin. 2018. Marine-life Data and Analysis Team (MDAT) technical report on the methods and development of marine-life data to support regional ocean planning and management. Prepared on behalf of the Marine-life Data and Analysis Team (MDAT). Accessed at: http://seamap.env.duke.edu/models/MDAT/MDAT-Technical-Report.pdf.

Hayes, S.A., E. Josephson, K. Maze-Foley, and P.E. Rosel (eds.). 2018. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2017. NOAA Technical Memorandum. Available at: https://repository.library.noaa.gov/view/noaa/22730.

Hayes S.A., E. Josephson, K. Maze-Foley, P.E. Rosel, and J. Wallace (eds.). 2022. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2021. Available at: https://repository.library.noaa.gov/view/noaa/45014.

NOAA Fisheries. 2018. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0) – Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. Office of Protected Resources. NOAA Technical Memorandum NMFS – OPR – 59.

NOAA Fisheries. 2020a. Interim Recommendation for Sound Source Level and Propagation Analysis for High Resolution Geophysical (HRG) Sources. Version 4.0. Available at: https://www.researchgate.net/publication/341822965_INTERIM_RECOMMENDATION_FOR_SOUND_SOURCE_LEVEL_AND_PROPAGATION_ANALYSIS_FOR_HIGH_RESOLUTION_GEOPHYSICAL_HRG_SOURCES. Access April 2022.

NOAA Fisheries. 2020b. Incidental Harassment Authorization for Atlantic Shores Offshore Wind. Available at: https://media.fisheries.noaa.gov/dam-migration/atlantic_shores_final_iha_iha.pdf. Accessed May 2022.

NOAA Fisheries. 2021a. Data Collection and Site Survey Activities Programmatic Informal consultation-NMFS-2021. Available at: https://www.boem.gov/sites/default/files/documents/renewable-energy/OSW-surveys-NLAA-programmatic.pdf.

NOAA Fisheries 2021b. Incidental Harassment Authorization for Atlantic Shores Offshore Wind. Available at: https://media.fisheries.noaa.gov/2021-04/AtlanticShores_2021IHA_Issued508_OPR1.pdf?null=. Accessed May 2022.

NOAA Fisheries. 2022a. Species Directory. Available at: https://www.fisheries.noaa.gov/species-directory. Accessed July 2021.

NOAA Fisheries. 2022b. Marine Mammal Acoustic Technical Guidance. Available at: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance. Accessed April 2022.

NOAA Fisheries. 2022c. Incidental Harassment Authorization for Atlantic Shores Offshore Wind. Available at: https://media.fisheries.noaa.gov/2022-04/AtlanticShoresHRG_2022_IssuedIHA_OPR1.pdf. Accessed May 2022.

OBIS. 2022. Ocean Biodiversity Information System. Intergovernmental Oceanographic Commission of UNESCO. https://www.obis.org. (Accessed 26 April 2022).

Reeves, R.R., B.S. Stewart, P.J. Clapham, and J.A. Powell. 2002. Guide to Marine Mammals of the World. National Audubon Society.

Roberts, J.J., B.D. Best, L. Mannocci, E. Fujioka, P.N. Halpin, D.L. Palka, L.P. Garrison, K.D. Mullin, T.V.N. Cole, C.B. Khan, W.M. McLellan, D.A. Pabst, and G.G. Lockhart. 2016. Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico. Scientific Reports 6: 22615. doi: 10.1038/srep22615.

Roberts J.J., T.M. Yack, PN Halpin. 2022. Density Model for the U.S. East Coast, Version 9, 2022-06-20. Prepared for Naval Facilities Engineering Command, Atlantic by the Duke University Marine Geospatial Ecology Lab, Durham, NC.

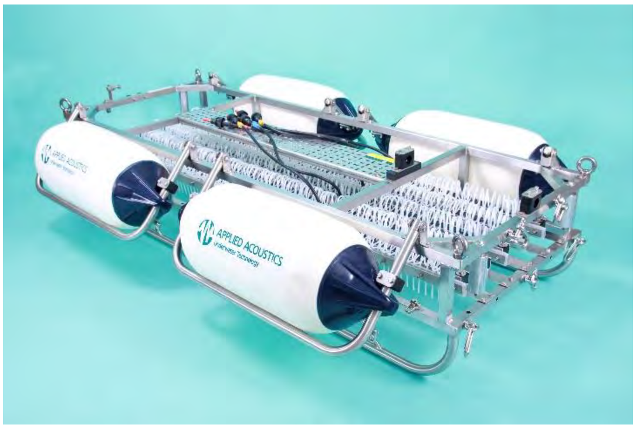
RPS. 2021. Atlantic Shores OCS-A 0499: Common Dolphin Level B Exposure Report. Published by RPS for Atlantic Shores. February 2021.

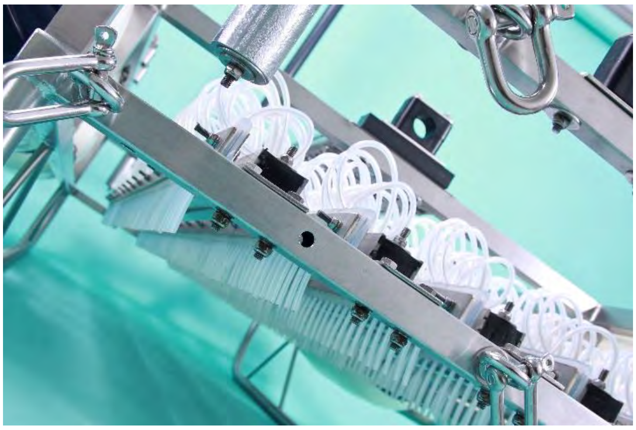
Attachment A

Manufacturer Specifications

Applied Acoustic Engineering Ltd
Marine House, Marine Park, Gapton Hall Road
Great Yarmouth, NR31 0NB
United Kingdom

Dura-Spark UHD, Seismic Sound Source





Key Features

- Long life, durable electrodes
- Pulse stability
- High resolution sub-bottom data, up to 25cms
- Tip array selection from on board junction box
- Flip-flop capability
- GNSS receiver option (101G MiniPod)

Applications

- High and Ultra-High Resolution geophysical surveys
- Single and multi-channel acquisition
- Water depths of 5 to >1000m

The Dura-Spark UHD has been designed to provide a stable, repeatable sound source for sub-bottom geophysical surveys. The long life, durable electrodes produce a consistent pulse signature and keep operational maintenance to a minimum. This provides increased survey efficiency and equipment reliability as the sparker tips rarely need replacement.

The Dura-Spark UHD consists of either 5 or 3 arrays of 80 tips that allow the operator to tune the source from the vessel to its application. This flexibility, together with selectable source depth, allows the sound source to be used in both shallow and deep waters.

The typical operational bandwidth of the Dura-Spark UHD is 300Hz to 1.2kHz. When coupled with the CSP-Nv Seismic Power Supply the system offers 2000J/s peak discharge rate, as well as industry leading design and safety standards.

Dura Spark UHD Technical Specification

PHYSICAL

Dimensions	Length 1893mm Height 372mm frame, 622mm including floatation Width 650mm frame, 1280mm including floatation
Weight	130kg (max)
Connector	RMK 1/0 complete with locking collar

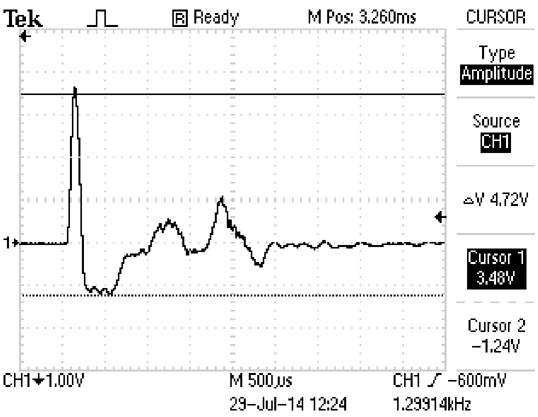
ELECTRICAL

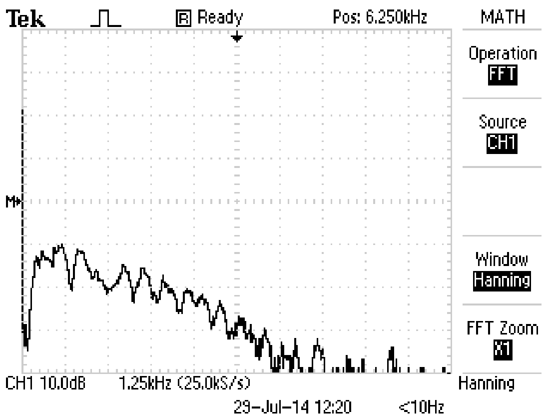
400 tip	2000J, 5J per tip to minimise bubble collapse component, 2400J maximum
240 tip	1000J, 5J per tip to minimise bubble collapse component, 1250J Maximum
Operating voltage	3000-4000V
Maximum number of tips	400 (5 x 80), 240 (3 x 80)
Power supply	CSP-Nv1200, CSP-Nv2400, CSP-SNv1250

SOUND OUTPUT

Source level	226dB re 1µPa at 1m (typical)
Pulse length	0.5 to 1.5ms Dependent on power applied

TYPICAL PULSE SIGNATURES AT 2000J





APPLIED ACOUSTICS
Underwater Technology
An AAE Technologies Group Company

Registration No. QU160081a
ISO9001:2015

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Marine House, Marine Park
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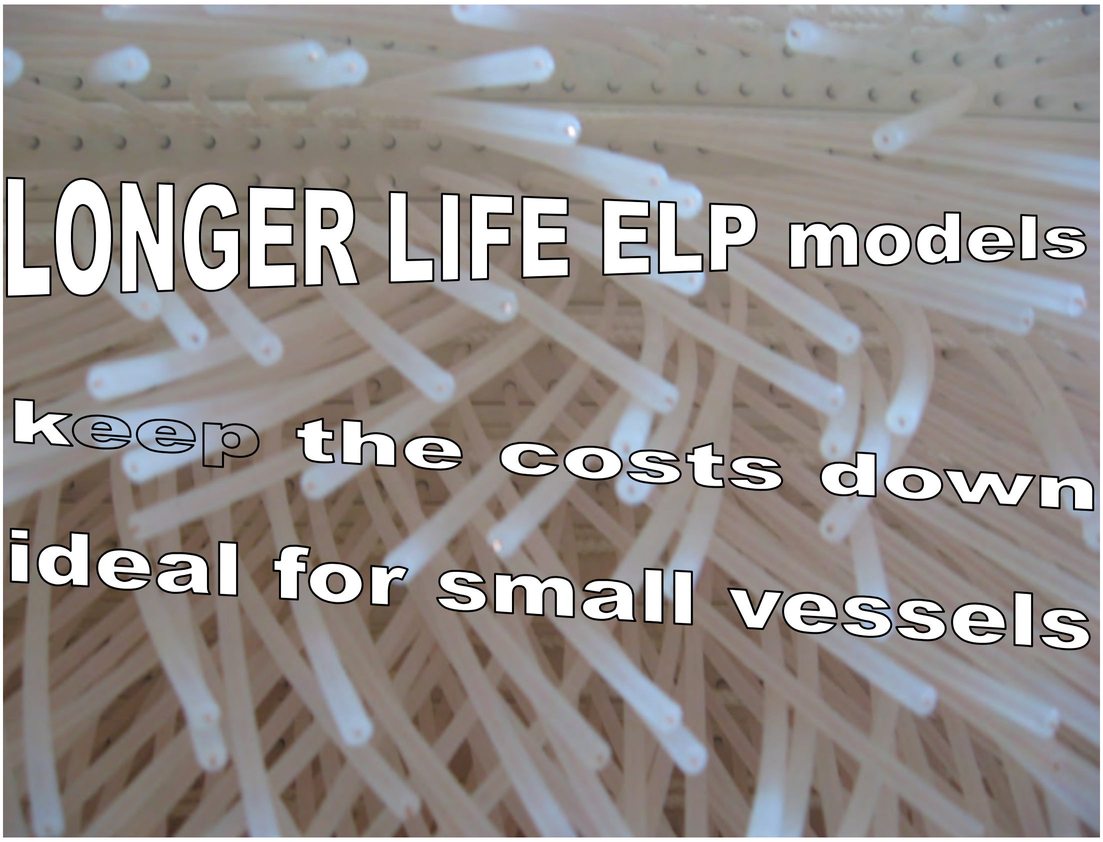
T +44(0)1493 440355
F +44(0)1493 440720
E general@appliedacoustics.com
W www.appliedacoustics.com

SIG sparker-electrodes

SIG

www.marine-seismic-equipments.com

- Longer life ELP models,
- Floating spark-arrays,
- no catamaran necessary,
- Easily replaceable,
- Interchangeable on the same high voltage tow cable



SIG sparker electrodes

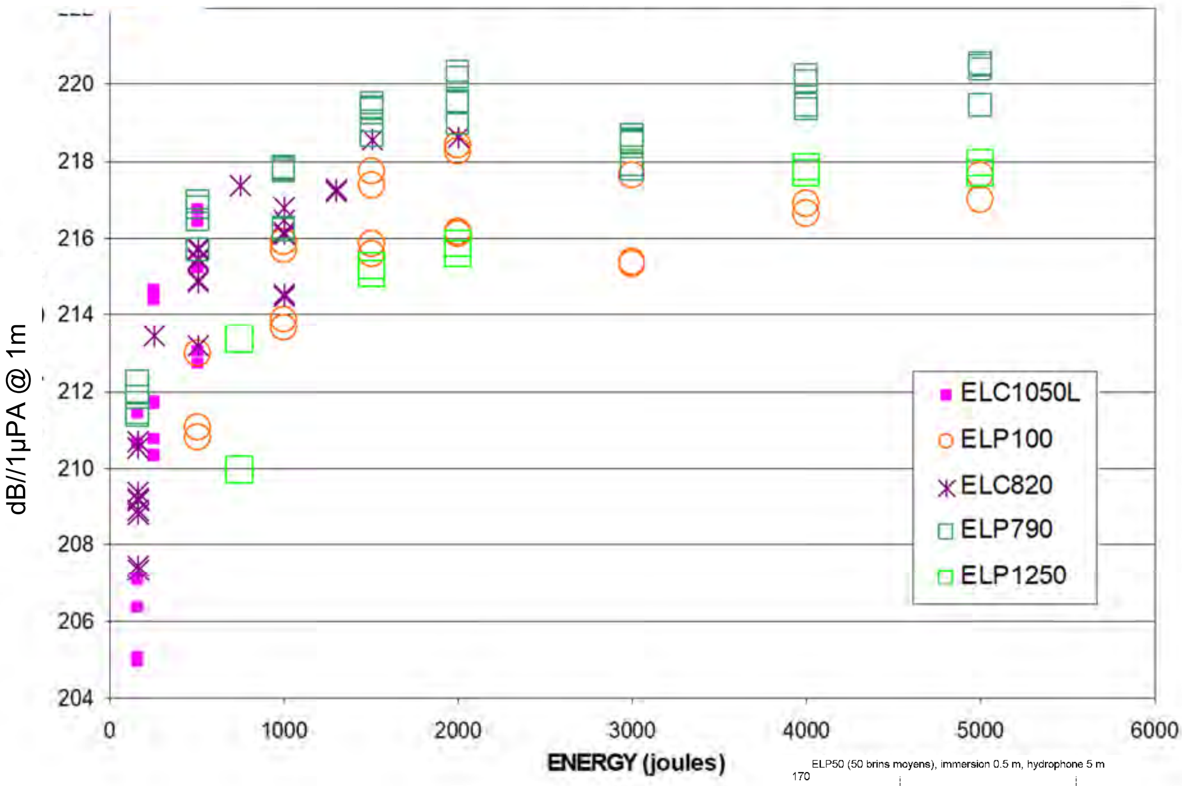
S.I.G.
ZA Route de Campbon
44130 BOUVRON
FRANCE

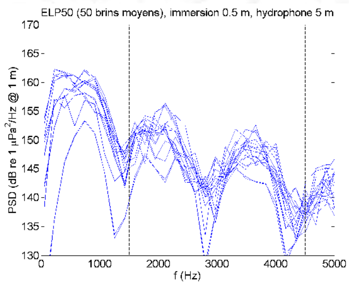
Tel : +33 (0)240 56 31 16
Fax : +33 (0)240 56 20 55
www.marine-seismic-equipments.com
info@sigfrance.com

SIG SPARKER-ELECTRODES MODELS

- ELC 1050L
- ELC1200L
- ELC820
- EDL1020
- ELP 790
- ELP1250

Higher frequency	**ELC1050L & ELC1200L**	**ELC820**	**EDL1020**
Operating energy level :	100 to 500 joules	500 to 1000 joules	400 to 2000 joules
Frequency spectrum :	1000—1400 Hz	900—1400 Hz	900—1400 Hz
Acoustic power level :	217 dB re 1µPa @ 1 m	219 dB re 1µPa @ 1 m	220 dB re 1µPa @ 1 m
Pulse duration :	0.8 ms @ 250 J Immersed 20 cm	0.8 ms @ 750 J Immersed @ 20 cm	1.1 ms @ 1500 J, Immersed @ 40 cm
Dimensions :	0.50 m x 0.60 m x 0.04 m	1 m x 0.60 m x 0.04 m	1 m x 0.60 m x 0.06 m
Weight :	1.0 kg	1.8 kg	3.5 kg





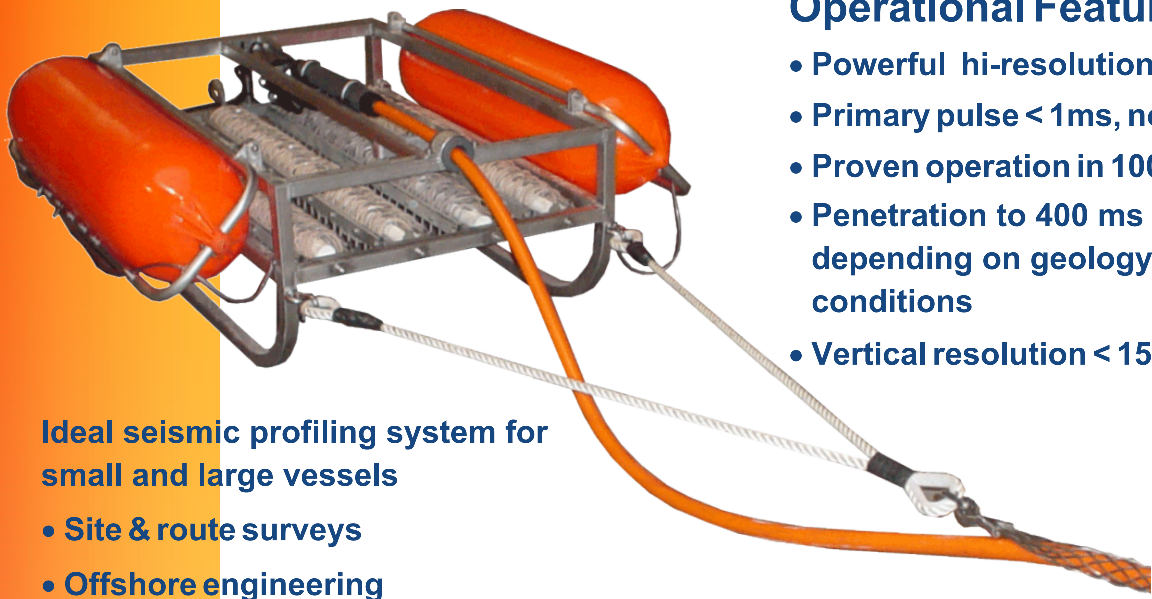
ELP SERIES

COMPROMISE BETWEEN THE LOW COST AND THE NECESSARY TRIMMING THE ELP SERIES IS LONGER LIFE

Lower frequency	**ELP790**	**ELP1250**
Operating energy level :	100 to 3000 joules Optimal 400-1200 joules	1000 to 6000 joules Optimal 1600 joules
Frequency spectrum :	< 800 Hz after 1000 J @ 50cm	Centered 1200 Hz @ 30cm
Acoustic power level :	220 dB re 1µPa @ 1 m	216-218 dB re 1µPa @ 1 m
Pulse duration (immersed @ 30 cm)	Primary 1.18 ms @ 500 J Delta T secondary 2.9 ms @ 1000 J	Primary 1.27 ms @ 2000 J Delta T secondary 2.8 ms @ 4000 J
Dimensions :	1 m x 0.60 m x 0.06 m	1 m x 0.60 m x 0.06 m
Weight :	2 kg	5.2 kg

Geo-Source 200 - 400

Marine Multi-Tip Sparker System



Operational Features

- Powerful hi-resolution seismic source
- Primary pulse < 1ms, no ringing
- Proven operation in 1000 m water depth
- Penetration to 400 ms below seabed, depending on geology and survey conditions
- Vertical resolution < 15 cm

Ideal seismic profiling system for small and large vessels

- Site & route surveys
- Offshore engineering
- Mineral exploration
- Oceanographic research

INNOVATIVE Preserving Electrode Mode

The innovative Geo-Source 200 has been designed for operation with the Geo-Spark 1000 pulsed power supply (PPS) using the patented **Preserving Electrode Mode.** This mode uses a NEGATIVE electric discharge pulse instead of a positive pulse.

(Please note that this negative pulse is NOT the same as the simple reversal of the positive polarity of a 'standard' power supply.)

Maintenance free electrodes 5 year guarantee

The Preserving Electrode Mode **reduces the tip wear to practically zero**. You can shoot day after day, week after week, month after month with practically **NO tip maintenance.**

Always a stable acoustic pulse

Zero tip wear is essential for the **acoustic repeatability** of the pulse, which depends largely on a constant, unaltered electrode surface and tip insulation.

Efficient & Cost Effective

With the Geo-Spark HV power supplies you will save a lot of time and money, since the electrodes do NOT burn off like in all other systems.

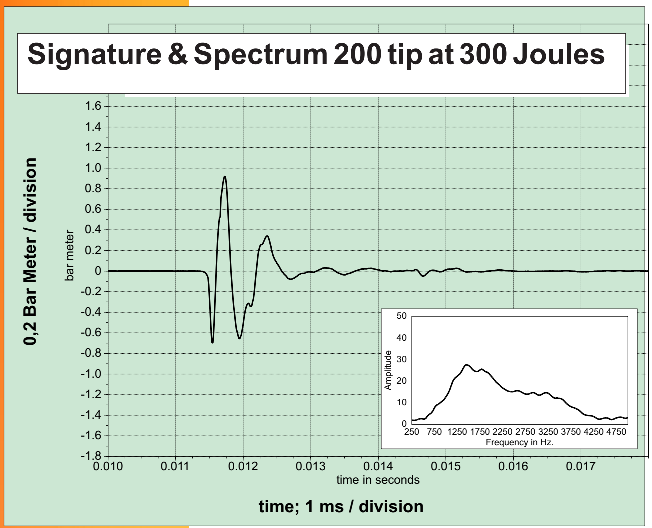
You don't need to trim tips during the survey. There is no need to have any stock of consumables.

Examples of Records

To see examples of our sparker records, please visit the 'Downloads' page on our website: ***www.geo-spark.com***

Geo-Source 200-400

Technical Specifications



Electrodes Geometry

The electrode modules are evenly spaced in a planar array of 0.75 m x 1.00 m. This geometry not only enhances the downward projection of the acoustic energy, it also reduces the primary pulse length, since all tips are perfectly in phase.

Control of Source Parameters 200 - 400 tips

The advanced Geo-Source 200-400 design gives you total control of the source depth and the energy (Joules) per tip

Source depth

Two floats provide a stable towing configuration and insure the proper depth of the electrode tips. This is critical to achieve constructive interference between the primary pulse and its own sea-surface reflection (surface ghost)

Number of tips in use and Energy per tip

Four individually powered electrode modules of 50 or 100 tips each allow you to distribute the energy from the Geo-Spark power supply over 50, 100......, up to 400 tips. (Each tip has an exposed surface area of 1.4 mm^2.)

200 tips, the classic 200 tip configuration is normally used with the Geo-Spark 1000 PPS and consists of four 50-tip electrode modules. This configuration gives an excellent hi-res pulse over the 100 to 500 J power range.

400 tips, for higher energies above 1000 J, and in particular with the Geo-Spark 2000X, we recommend a 400 tip configuration with 4 x 100-tip electrode modules

Coaxial High Voltage (HV) Power/Tow Cable

The Geo-Source 200 is towed by a very high quality, Kevlar-reinforced, coaxial power/tow cable with stainless steel kellum grip. This dedicated high voltage (HV) cable contains **4 x 10 mm^2** inner cores (negative) plus a **40 mm^2** braiding (ground-referenced). It is designed to have a very low self-inductance to preserve the high dI/dt pulse output of the Geo-Spark 1000 PPS.

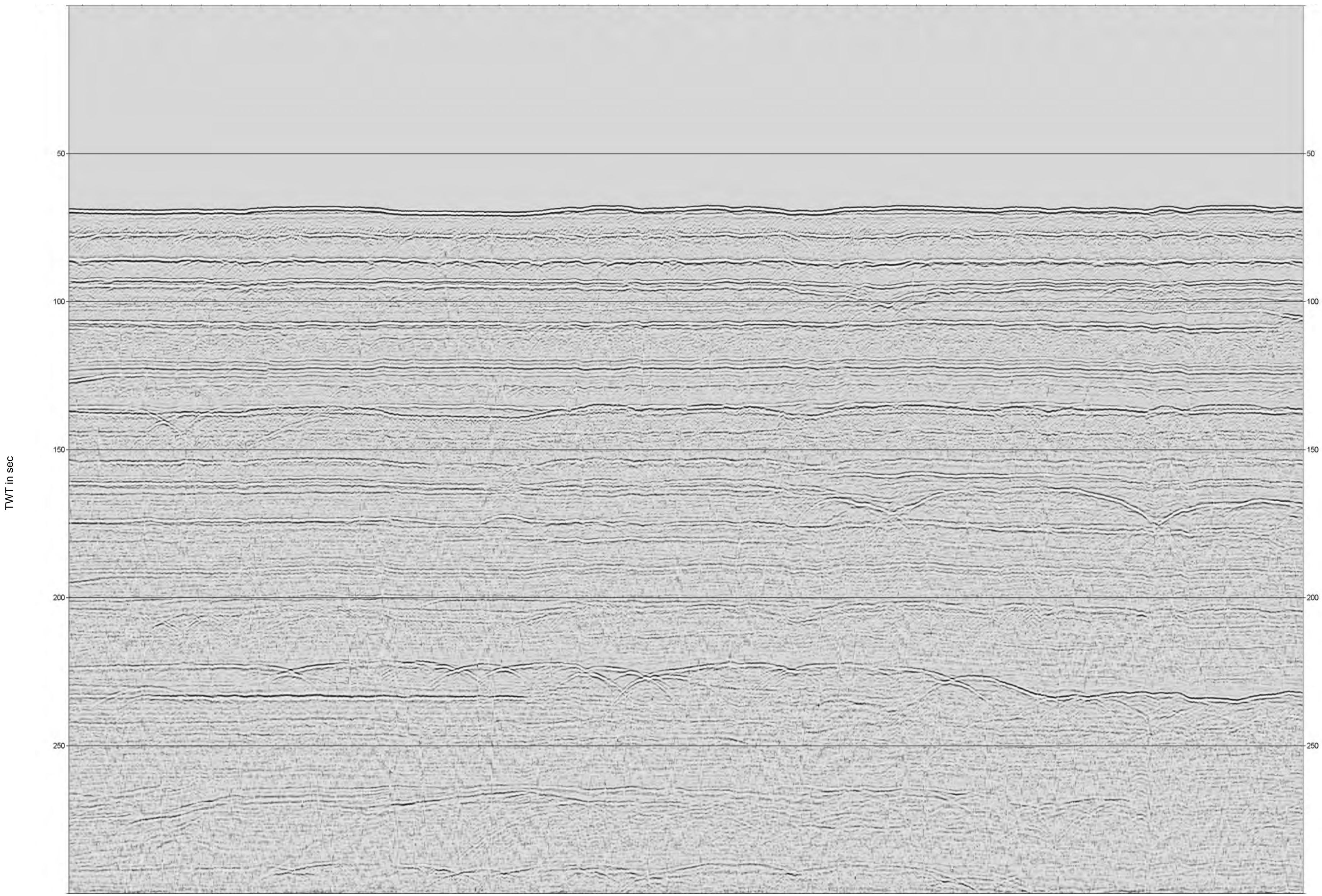
The coaxial structure of the HV cable reduces the electromagnetic interference to the absolute minimum.

The wet end of the cable is terminated with four special HV connectors to the electrode modules and a ground connector to the frame. Connecting or disconnecting the cable to the Geo-Source 200 takes only 10 minutes; so you can handle the sparker sled and the HV cable as independent units.

The dry end of the cable is terminated at the Geo-Source 200 patch panel, which allows you to select the number of electrode arrays in use

Maintenance free electrodes, no trimming, stable signature

GEO Marine Survey Systems b.v.
Sheffieldstraat 8, 3047 AP Rotterdam
The Netherlands
Phone: + 31 10 41 55 755
Fax: +31 10 41 55 351
info@geomarinesurveysystems.com
Website: www.geo-spark.com



Location: Thailand

Date: August 2008

Client: MVM Surveys

Water Depth: 50 - 300 m

Acquisition

Source: Geo-Spark 200
Power Supply: Geo-Spark 1 kJ
Power: 300 J
Streamer: Geo sense
Recording System: Geo-Trace 2
Shot interval: 0.5 s
Record length: 300 ms
Sample Rate: 8000 Hz

Processing

Frequency filtering
Gain
Swell filter
Muting

Display

Horizontal scale 1:4000
Vertical scale 1 cm = 8 ms
One timeline every 50 ms

Geo-Resources BV
Heemraadssingel 235
3023 CD Rotterdam
Netherlands

Phone: +31 10 425 83 70
Fax: +31 10 244 01 04

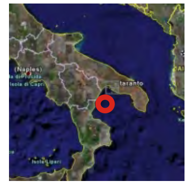
info@geo-resources.com
www.geo-resources.com

Geo-Spark 200 Thailand- August 2008

Alternating sand and clay layers.
Strong reflector at the base of layer turbiditic sequence
represents the top of Messinian evaporites.

Taranto Italy - May 2005

GEO RESOURCES



Location: Taranto Italy

Date: May 2005

Client: Nautilus

Water Depth: 450 - 650 m

Acquisition

Source: Geo-Spark 200
Power Supply: Geo-Spark 1 kJ
Power: 700 J
Streamer: Geo-sense 8 elements
Recording System: Geo-Trace 2
Shot interval: 3 s
Record length: 1500 ms
Sample Rate: 8000 Hz

Processing

Frequency filtering
Gain
Swell filter
Muting

Display

Horizontal scale 1:12000
Vertical scale 1 cm = 15 ms
One timeline every 50 ms

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Phone: +31 10 425 83 70
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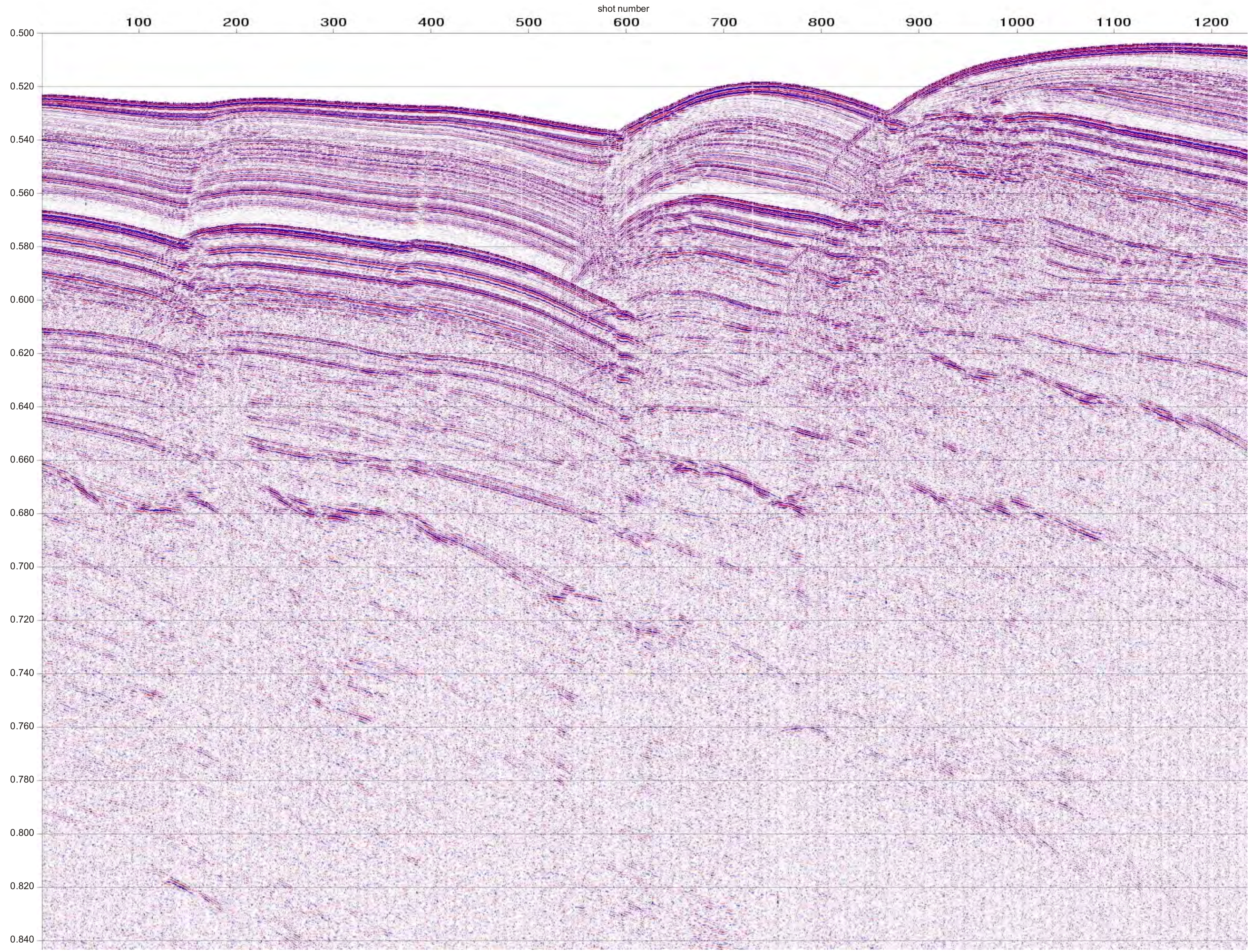
info@geo-resources.com
www.geo-resources.com

Approximately 500m

M09



Mediterranean Sea Egypt , October 2005

RESOURCES

Location: Mediterranean Sea, Egypte

Date: October 2005

Client : Impresub

Water Depth: 350 - 400 m

Acquisition

Source: Geo-Spark 200
Power Supply: Geo-Spark 1 KJ
Streamer: Geo sense 8 elements
Recording System: Geo-Trace 2
Shot interval: 2 s
Record length: 1000 ms
Sample Rate: 10000 Hz

Display

Horizontal scale 1:9000
Vertical scale 1 cm = 10 ms
One timeline every 20 ms

Geo-Resources BV
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3023 CD Rotterdam
Netherlands

Phone: +31 10 425 83 70
Fax: +31 10 244 01 04

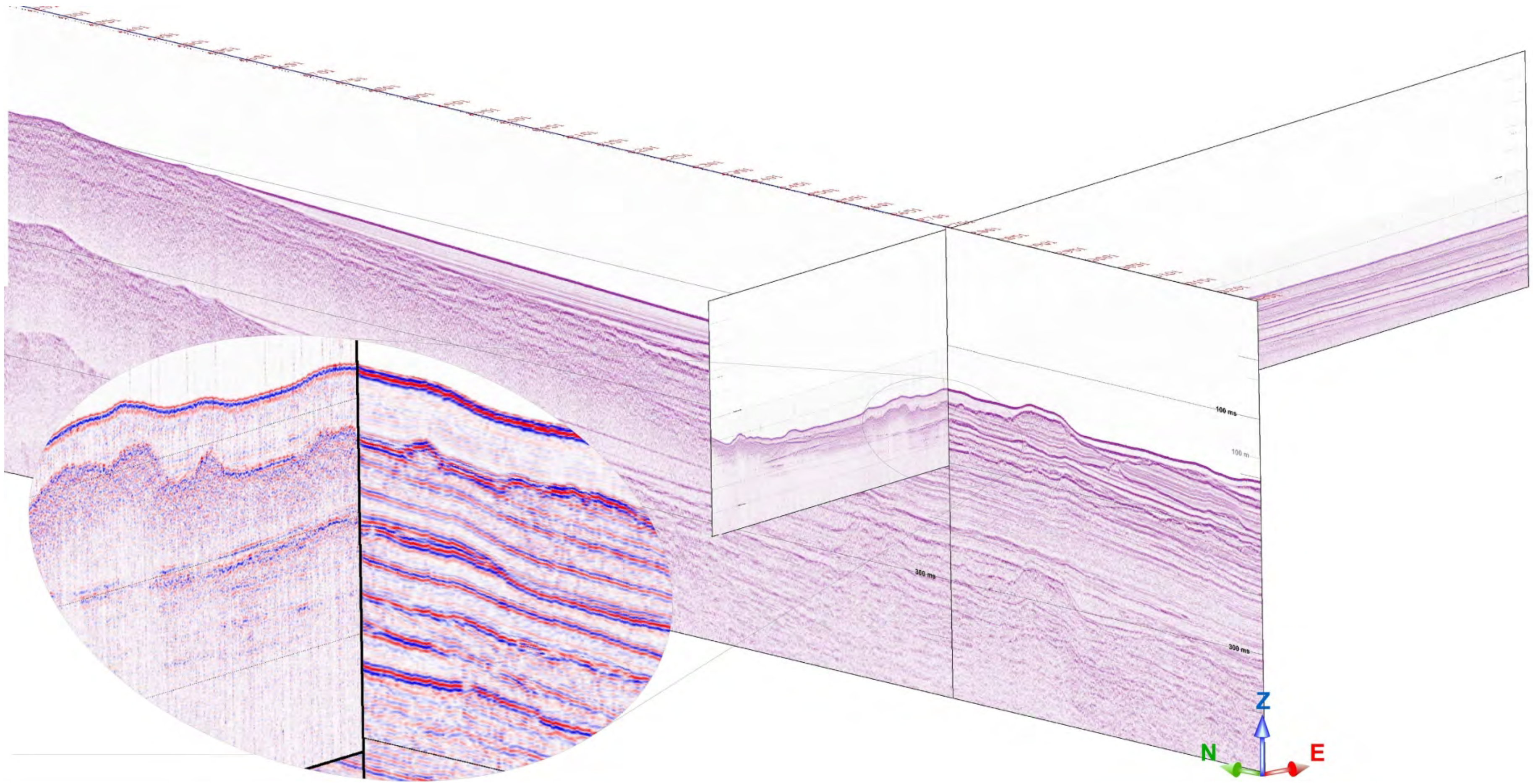
info@geo-resources.com
www.geo-resources.com

Approximately 500m

M10

Comparison between the Sparker Geo-Spark 800 and a Chirp system.

Appreciate the difference of resolution and penetration.



Elba Italy - November 2004

Location: Elba Italy

Date: November 2004

Water Depth: 75 - 115 m

Courtesy of Danillo Morelli, Trieste University

Acquisition

Source: Geo-Spark 800
Power Supply: Geo-Spark 6 kJ
Recording System: Geo-Trace 2
Shot interval: 2 s
Record length: 1000 ms
Sample Rate: 6000 Hz

Sparker Processing

Frequency filtering
Gain
Swell filter
Muting

Display

Horizontal scale 1:5000
Vertical scale 1 cm = 25 ms
One scale line every 100 ms
Data displayed in 3D with OpendTect

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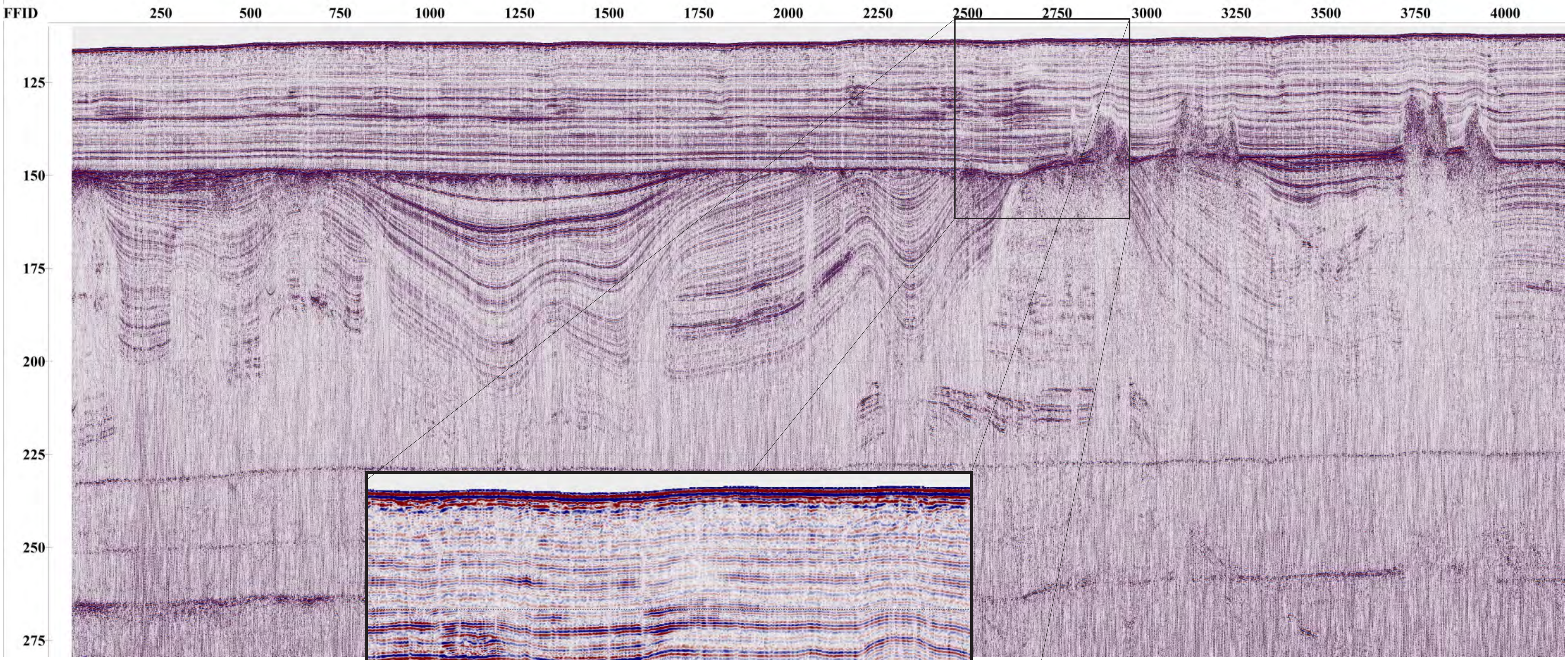
Heemraadssingel 235
3023 CD Rotterdam
Netherlands

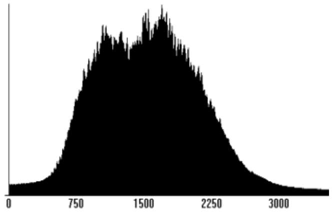
Phone: +31 10 425 83 70
Fax: +31 10 244 01 04

info@geo-resources.com
www.geo-resources.com

Approximately 200m

M03





Appreciate the frequency content up to 3000 Hz and the decimeter scale resolution

Sparker profile shot with the Geo-Source 200 LW using the Geo-Spark 1000 pulsed power supply

Energy: 300 J, Negative Discharge Technology

Vertical Scale in meters, Aspect ratio 1 :20

Location: Sicily, Gellasabbia
Date: May 2012
Geophysicist: Dr. Henrique Duarte

Geo-Source 400 Light Weight

Dimensions (cm) & Weight	110 (L) x 120 (W) x 60 (H) for 80 kg
Tips Number	400
Operation Depth (m)	0 - 2,500
Dominant Frequencies	1000-1500 Hz (at 800 Joules)
Compatible Power Supply	Geo-Spark 1000 Geo-Spark 2000 XF Geo-Spark 7000 XF

2.1.2 Processor Unit Specs

The specifications for the Processing Unit within the rack mount topside are shown in TABLE 2-2.

SPECIFICATION	VALUE
Mother Board	Intel I7 6700 Quad Core 3.4GHz. 8 MB Cache
Sonar Interface	Sonar Interface board (Tiger board) composed of carrier board, Acquisition board, and Sonar board
Memory	8 GB DDR4 RAM
Hard Drives	500 GB minimum (operating system) 1 TB minimum (Removable Drive [Hot Swappable])
DVD-R/W drive	10x4x32 minimum speed
Operating system	Windows 7 64 Bit
Application software	DISCOVER Sub-Bottom
Display	High resolution 23-inch flat panel LCD monitor
Keyboard	High impact industrial
Trackball	High impact industrial
I/O ports	(4) RS-232 Front: (2) Ethernet Ports (2) USB2 Rear: (2) USB2 (2) USB3 (2) USB3.1
Analog input	16-bit resolution, 200 kHz max sampling rate
Analog Output	16-bit resolution, 200 kHz max sampling rate
Pulse type	Full Spectrum CHIRP FM
Pulse length	5-100 ms, depending on tow vehicle and application
Bandwidth	0.5-15 kHz, depending on tow vehicle and application
Trigger in	TTL negative edge triggered
Trigger out	TTL negative edge triggered, 5ms ling pulse minimum
Sampling rate	20, 25, 40, or 50 kHz, depending on the transmit upper frequency
Acoustic power	212 dB re1 NPa @ 1 meter peak (approx.) at center frequency
Input voltage	120-220 VAC, 50/60 Hz, auto sense

Table 2-2: 3200-XS Topside Processor Specs

2.1.3 Power Amplifier

The specifications for the Power Amplifier are show in TABLE 2-5, TABLE 2-4, and TABLE 2-5.

2.1.3.1 Power Output

SPECIFICATION	VALUE
2-ohm Dual (*per channel*)	20 mS BURST: 4,700 W 20 Hz – 20 kHz: 2,800 W 1 kHz: 2,800 W
4-ohm Dual (*per channel*)	3,500 W
8-ohm Dual (*per channel*)	1,500 W
4-ohm Bridge	5,600 W
8-ohm Bridge	6,000 W

Table 2-3: Power Amplifier Specs: Power Output

EdgeTech

2000 SERIES

COMBINED SIDE SCAN SONAR & SUB-BOTTOM PROFILING SYSTEM

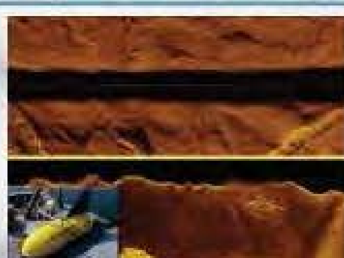
KEY SPECIFICATIONS

SIDE SCAN SONAR		
Frequency (dual simultaneous CHIRP)	100/400 kHz	300/600 kHz
Operating Range	100 kHz: 500 meters/side 400 kHz: 150 meters/side	300 kHz: 230 meters/side 600 kHz: 120 meters/side
Beam Width (2-way) & Along Track Resolution	100 kHz: 1.08 deg or 1.90 m @ 100 m 400 kHz: 0.56 deg or 0.96 m @100 m	300 kHz: 0.6 deg or 1.0 m @ 100 m 600 kHz: 0.26 deg 0.45 m @ 100 m
Across Track Resolution	100 kHz: 6.3 cm 400 kHz: 1.8 cm	300 kHz: 2.8 cm 600 kHz: 1.4 cm

SUB-BOTTOM PROFILER	2000-CSS	2000-DSS	2000-TVD
Frequency Band	500 Hz – 12 kHz	2-16 kHz	1-10 kHz
Resolution	8-20 cm	6-10 cm	9-25 cm
Penetration in coarse sand	20m	6m	20m
Penetration in clay	200m	80m	200m

TOWFISH	2000-CSS	2000-DSS	2000-TVD
Length	160 cm (63")	145 cm (57")	226 cm (89")
Width	124 cm (49")	74 cm (30")	81 cm (32")
Height	47 cm (18.5")	84 cm (33")	55 cm (22")
Weight in Air	232 kg (510 lbs.)	145 kg (320 lbs.)	250 kg (550 lbs.)
Maximum Water Depth	300m	2,000m	3000m

TOPSIDE PROCESSOR	
Hardware	Standard 19" rack
Operating System	Windows XP
Display	Dual 22" high resolution flat panel monitors
Archive	DVD-R/W and/or LAN connection
File Format	Native JSF or XTF for side scan, SEG-Y for sub-bottom
Output	Ethernet
Power Input	90 to 132 VAC and 180 to 260 VAC, Auto voltage detect and switching, 47-63 Hz



For more information please visit EdgeTech.com

info@EdgeTech.com | USA 1.508.291.0057



SPECIFICATION	SB-424 VALUE	SB-216S VALUE	SB-512i VALUE
Frequency range	4-24 kHz	2-16 kHz	0.5-12 kHz
Pulse type	FM	FM	FM & WB (wide band)
Pulse bandwidth/pulse length	4-24 kHz/10 ms 4-20 kHz/10 ms 4-16 kHz/10 ms	2-15 kHz/20 ms 2-12 kHz/20 ms 2-10 kHz/20 ms	0.5-8.0 kHz/5 ms FM 0.5-2.7 kHz/40 ms WB 0.5-6.0 kHz/20 ms WB 0.5-4.5 kHz/50 ms FM 0.5–6.0 kHz/9 ms FM 0.5–6.0 kHz/18 ms FM 0.5–7.2 kHz/30 ms FM 0.7–12.0 kHz/20 ms FM 2.0–12.0 kHz/20 ms FM
Calibration:	Gaussian-shaped pulse spectrum	Gaussian-shaped pulse spectrum	Gaussian- and rectangular-shaped pulse spectrum
Vertical resolution[a]	4 cm (4–24 kHz) 6 cm (4–20 kHz) 8 cm (4–16 kHz)	6 cm (2–15 kHz) 8 cm (2–12 kHz) 10 cm (2–10 kHz)	19 cm (1–5.0 kHz) 12 cm (1.5–7.5 kHz) 8 cm (2–12 kHz)
Penetration in course and calcareous sand[b]	2 m (typ)	6 m (typ)	30 m (typ)
Penetration in soft clay[b]	40 m	80 m	250 m
Beam width	16°, 4–24 kHz 19°, 4–20 kHz 23°, 4–16 kHz	17°, 2–15 kHz 20°, 2–12 kHz 24°, 2–10 kHz	41°, 0.5–5 kHz 32°, 1–6 kHz 24°, 1.5–7.5 kHz 16°, 2–12 kHz
Optimum tow vehicle pitch/roll[c]	<7°, 4–24 kHz <8°, 4–20 kHz <10°, 4–16 kHz	<7°, 2–15 kHz <8°, 2–12 kHz <10°, 2–10 kHz	<16°, 0.5–5 kHz <13°, 1–6 kHz <10°, 2–8 kHz <8°, 2–10 kHz <7°, 2–12 kHz
Optimum tow height	3-5m above sea floor	3-5 m above sea floor	3-5 m above sea floor
Transmitters	1	1	2
Receive arrays	2	2	4
Output power	2000 W	2000W	2000 W
Tow vehicle size	77 cm (30 in.) L 50 cm (20 in.) W 34 cm (13 in.) H	105 cm (41 in.) 67 cm (26 in.) W 46 cm (18 in.) H	158 cm (62 in.) L 134 cm (53 in.) W 46 cm (18 in.) H
Shipping container size	91 cm (36 in.) L 66 cm (26 in.) W 64 cm (25 in.) H	117 cm (46 in.) L 79 cm (31 in.) W 61 cm (24 in.) H	173 cm (68 in.) L 137 cm (54 in.) W 71 cm (28 in.) H
Weight in air	35 kg (78 lb)	72 kg (160 lb)	186 kg (410 lb)
Shipping weight	110 kg (243 lb)	162 kg (357 lb)	356 kg (783 lb)
Tow cable requirements	3 shield-twisted wire pairs	3 shield-twisted wire pairs	3 shield-twisted wire pairs
Depth rating	300 m (984 ft) max	300 m (984 ft) max	300 m (984 ft) max

Table 2-6: Tow Vehicle Specifications

Sub-Bottom Imager™ Sound Source Analysis

for

Information

January 5, 2015

RPT-04563-1

Table of Contents

1 PURPOSE OF DOCUMENT

The purpose of this document is to summarize sound level information pertaining to the Sub-Bottom Imager™ (SBI) high frequency (HF) acoustic projectors, which are operated from a moving platform such as an ROV or vessel. This document will serve as a basis for sound source verification as may be requested by clients.

2 MEASUREMENT APPROACH

In this document, distances to Sound Pressure Level (SPL) and Sound Exposure Level (SEL) isopleths were estimated assuming spherical and cylindrical spreading, where appropriate. This approach does not consider variations in sound propagation due to the geoacoustic properties of the seabed as well as hybrid models.

The Sub-Bottom Imager™ is operated at a nominal elevation of 3.5m (±0.5m) above the seafloor from a moving platform such as an ROV or an over-the-side mounting on a vessel for shallow water applications (i.e. <10m water depth). In this analysis, the acoustic sources are assumed to be omni-directional point sources; the beam pattern of each acoustic projector was not taken into consideration. As such, this analysis is therefore a worst-case approach given that the source does have directionality. All Source Levels (SL) from transducers are assumed to be levels that would occur directly under the transducers in the direction of the seabed (peak of main lobe). The transducer face is assumed to be at the normal elevation of 3.5 m above the seabed.

3 SUB-BOTTOM IMAGER™ SYSTEM AND ACQUISTION PRINCIPLES

The Sub-Bottom Imager™ (SBI) uses multi-aspect acoustic intensity imaging to delineate sub-seabed stratigraphy and buried objects. These buried objects can be infrastructure such as cables and pipelines or can be geohazards such as boulders, hard-ground, man-made debris, abandoned seabed infrastructure and unexploded ordnance. SBI surveys reduce risk and offers subsequent cost reductions during the installation and burial of offshore infrastructure such as pipelines, power cables and umbilicals.

The SBI is an ROV/Vessel deployed unit with a 3.8m folding boom containing sonar projectors and receivers and associated electronics in bottles (Figure 1). The SBI utilizes high frequency (HF) chirp projectors to deliver a continuous 5m x 5m swath below the sub-seabed in real time (Figure 3). The high-resolution volumetric images provide 3D imaging of offshore infrastructure and geohazards to penetration depths of 5m or more depending on soil complexity (Figure 3).

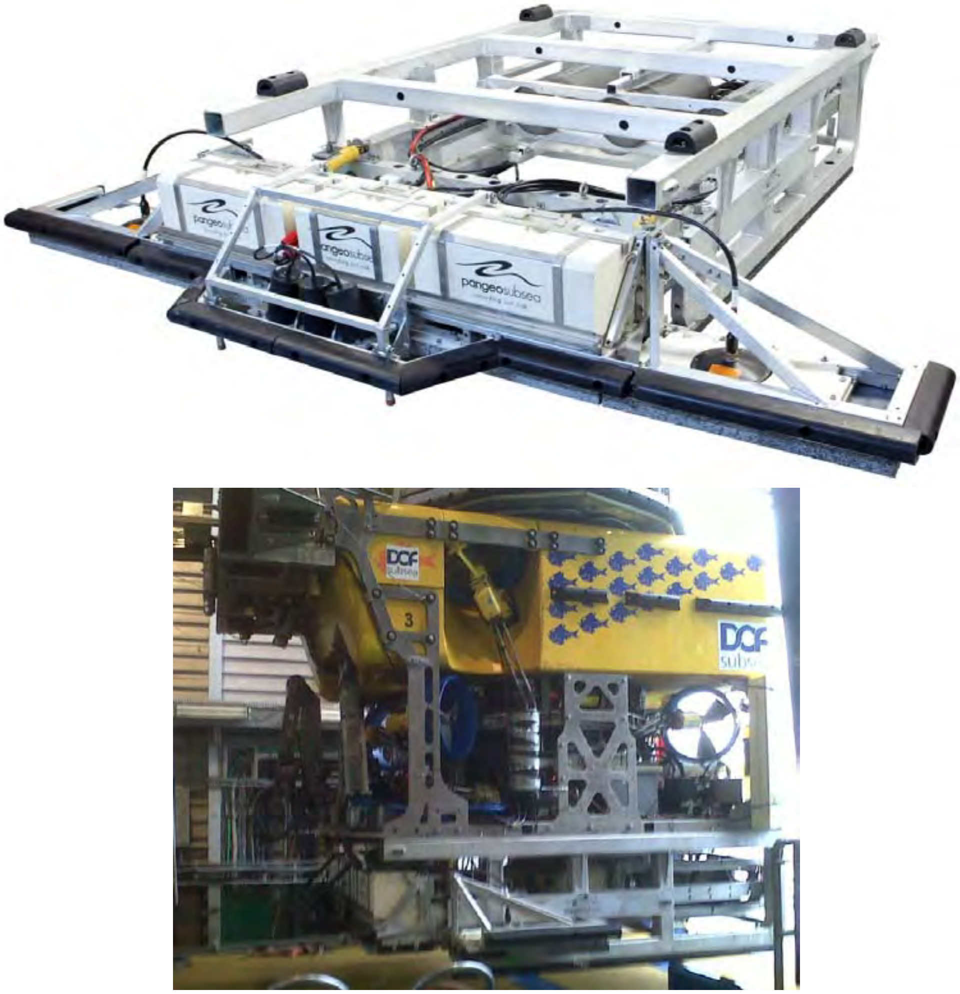


Figure 1: Sub-Bottom Imager™ (complete SBI equipment on an ROV skid (top panel) and SBI on a WROV bottom skid with multibeam also onboard (bottom panel)

3.1 Volumetric Imaging

During acquisition, the Sub-Bottom Imager™ repetitively ensonifies the volume of seabed under the hydrophone array and continuously receives the resulting acoustic reflections from within the seabed, as the array moves forward on the platform. This “raw” sonar data is digitized and transmitted via Ethernet over the vehicles fibre optic umbilical to the surface support vessel.

The high-volume, continuous flow of data is “rendered” on board by computers employing parallel processing architectures to produce a 3D volumetric data set of the seabed (Figure 3). The acoustic data is processed using a combination of beam forming algorithms and synthetic aperture algorithms to render a 3D data volume representing the acoustic reflectivity of the sub-bottom (Figure 2). The seabed under the array can be thought of as a three dimensional cube, encompassing an array of voxels, each comprising x, y, z position, signal intensity, and contribution count. The data is referenced to INS position and each cell contains the average signal intensity of the number of times that voxel was contributed to as the array traversed over top.

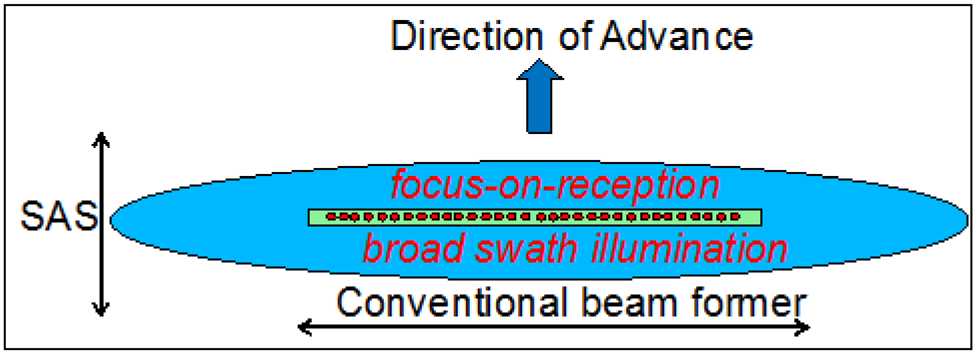


Figure 2: Schematic of SBI Method of Operation

Figure 3 shows the ensonified seabed volume after rendering limits are applied, visualized in the 3D survey software environment (in this case NaviModel). Signal intensity is represented by color with blue representing quieter areas and red higher intensity reflections. The upper blue layer is the water column below the transducer array with the adjacent red layer the seabed interface. The acoustic beam spreads out as the signal penetrates into the seabed, giving a volume width of 3.5m at the transducer, increasing to approximately 5m at the lower extent of the vertical penetration into the seabed of about 5m. The SBI rendered image is used to identify acoustic stratigraphy and acoustic anomalies, consistent with buried objects and geohazards, with a depth-dependent spatial resolution that is a function of the type of seabed (Figure 4).

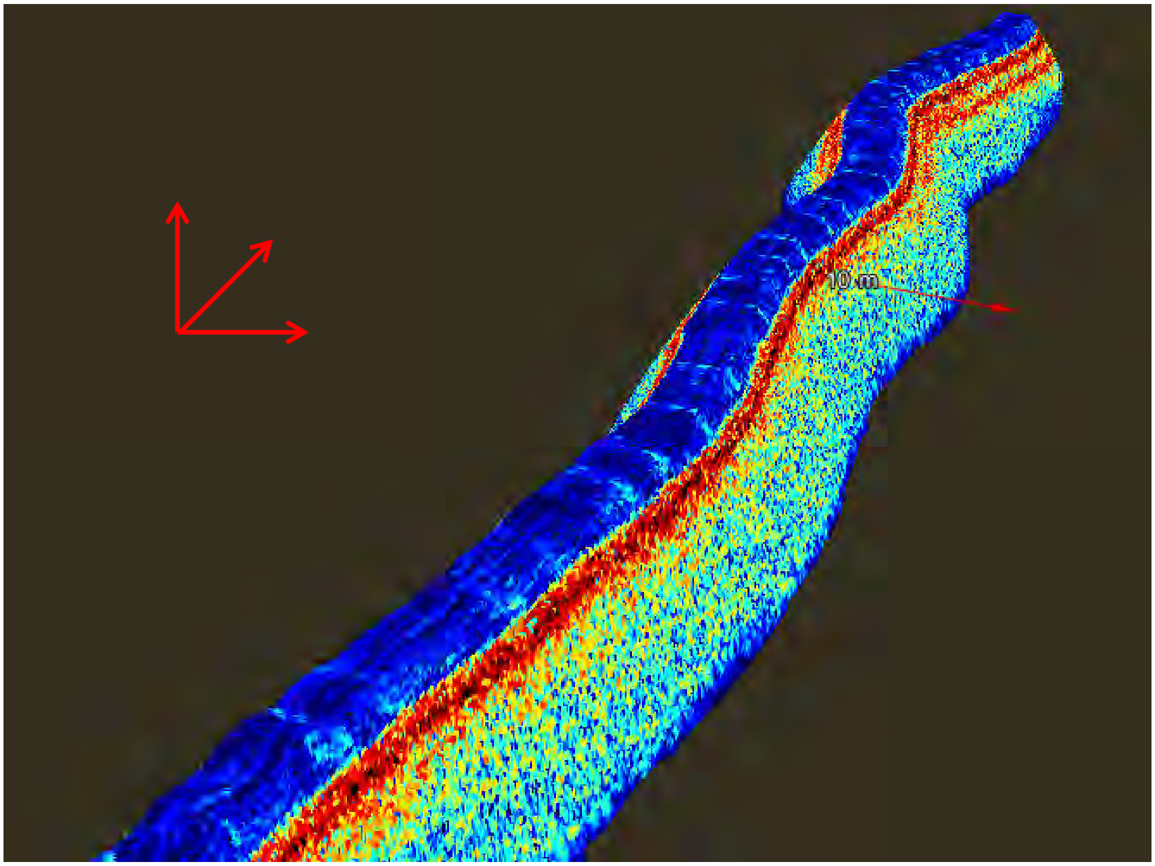


Figure 3: SBI rendered data volume along ROV flight path. This data volume is sectioned and sliced to reveal details of stratigraphy and buried.

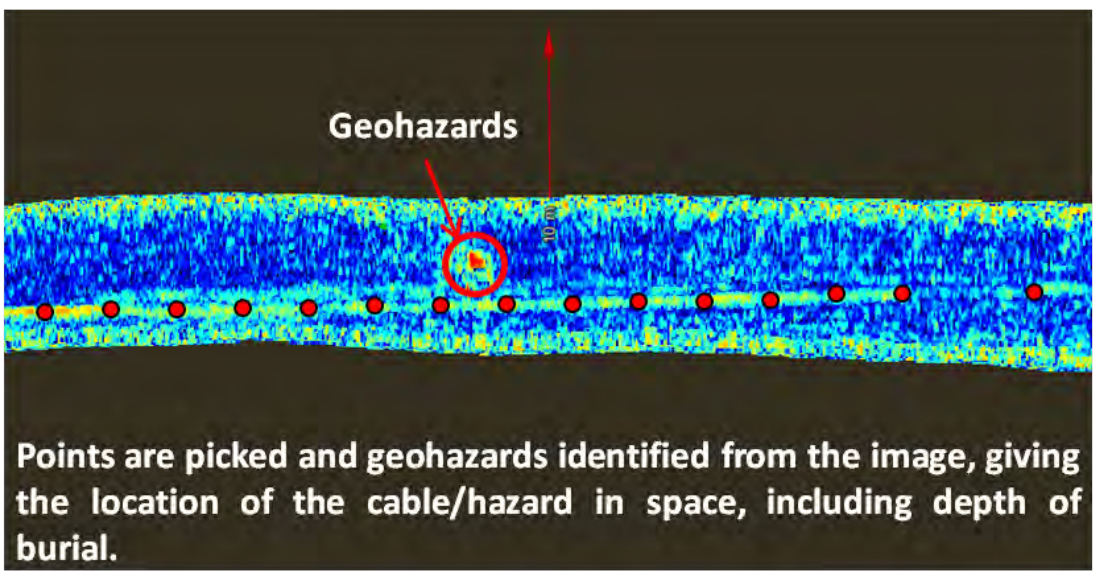


Figure 4: The SBI rendered image is used to provide x-y-z position of surveyed infrastructure and identified geohazards

4 RECEIVED SOUND LEVEL ANALYSIS

4.1 Acoustic Metrics

Sound pressure levels metrics are used to evaluate the levels of the Sub-Bottom Imager HF chirp sound sources and their effects on marine life. The acoustic metrics used are:

- rms sound pressure level (SPL, dB re 1μPa) in a stated frequency band over a time window of T seconds and containing the pulse is defined as:

$$SPL = 10\log_{10}\left(\frac{1}{Tp_0^2}\int_T \ p^2\,(t)dt\right) \quad (1)$$

- sound exposure level (SEL, dB re 1μPa^2.s) is the time integral of the squared pressure in a stated frequency band over a stated time interval or event. In this case SEL_{sweep} represents 100% of the acoustic energy inone sweep:

$$SEL = 10\log_{10}\left(\frac{1}{T_0p_0^2}\int_T \ p^2\,(t)dt\right) \quad (2)$$

where $T_0$is a reference time interval of 1 s and T is the duration of the transmitted signal and in marine settings the reference sound pressure, p_0, equals 1 μPa.

The SPL and SEL are related by the following expression (where $T_0= 1s)$, which depends only on the duration of the time window T:

$$SEL = SPL + \ 10\log_{10}(T) \quad (3)$$

- cumulative sound exposure level ($cSEL$, dB re 1μPa^2.s) represents the total energy received over a defined operational period (in this case 24 hours). For the Acoustic Corer™ case:

$$cSEL = \ SPL + \ 10\log_{10}(T_{sweep}) + \ 10\log_{10}(N_{sweep}) \quad (4)$$

where $N_{sweep}$is the number of sweeps transmitted in 24 hours.

The distances to isopleths of 180 and 160 dB re 1μPa for SPL and180 and 160 dB re 1μPa^2.s for SEL, as well as 198 and 186 dB re 1μPa^2.s for $cSEL$ are shown respectively in Table 2, Table 4, and Table 5 and are calculated as recommended in Southall et al. (2007), NMFS (2005) and MMPA (2007). In order to calculate the above levels the following transmission loss (TL) models are used:

- up to a distance of 3.5m a spherical spreading loss is assumed,

$$TL_{spherical} = 20\ \log_{10} R \quad (5)$$

- at distances greater than 3.5m is estimated assuming cylindrical spreading loss:

$$TL_{cylindrical} = 10\ \log_{10} R \quad (6)$$

IMPORTANT: It is crucial to recognize that this model represents the worse case scenario. That is, the transmission loss model is a substantial under-estimate of actual transmission losses as:

- directivity of the transmit signal is not taken into account and the values used are those of the rms pressure on the peak of the main lobe,

- transmission into sediments and absorption are not taken into consideration,
- the main lobe of the transducer points orthogonally to the seafloor and therefore substantial amount of the transmitted energy of the main lobe is transmitted into the subsurface
- in most applications of the SBI the water depth is greater than 20 metres and therefore the cylindrical transmission loss model beyond the 3.5 metre radius is substantially under-estimating the actual transmission loss.

Hence, the distance to the SPL_{iso} isopleth, $R(SPL_{iso})$, is calculated as in [5]:

$$R(SPL_{iso}) = \begin{cases} 10^{\frac{SPL(1) - SPL_{iso}}{20}} if SPL(1) \geq \ SPL_{iso} \ \geq SPL(3.5) \\ 10^{\frac{SPL(3.5) - SPLiso + 10\log_{10}(3.5)}{10}} if SPL_{iso} \ \leq \ SPL(3.5) \end{cases} \quad (7)$$

Where $SPL(x)$ the rms sound pressure level at x meters away from the transmitter (note that by definition $SPL(1) = SPL$) and,

$$SPL(3.5) = \ SPL(1) - 20\log_{10}(3.5)$$

The distance to the SEL_{iso} isopleths is calculated as in [5]:

$$R(SEL_{iso}) = \begin{cases} 10^{\frac{SEL(1) - SEL_{iso}}{20}} if SEL(1) \geq \ SEL_{iso} \ \geq SEL(3.5) \\ 10^{\frac{SEL(3.5) - SEL_{iso} + 10\log_{10}(3.5)}{10}} if SEL_{iso} \ \leq \ SEL(3.5) \end{cases} \quad (8)$$

Where $SEL(x)$ the rms sound pressure level at x meters away from the transmitter (note that by definition $SEL(1) = SEL$) and,

$$SEL(3.5) = \ SEL(1) - 20\log_{10}(3.5)$$

For the purpose of these calculations the source is considered stationary, which provides a substantial over-estimate of distances to sound level isopleths. The sound pressure levels of the cumulative sound pressure level, *cSEL,* are calculated as in the case of *SEL*, however all instances of *SEL* in Equation (8) are replaced with *cSEL.*

5 SOUND SOURCE INFORMATION AND CALCULATIONS

5.1 Volumetric Data Acquisition (HF Chirp Transducers)

5.1.1 High Frequency Chirp Transducer Background Information

The SBI is equipped with a Neptune 4108 C/D transducer as its HF chirp source. The transducer is generally operated in the 4.5 to 12.5 kHz frequency band. The continuous wave (CW) source level associated with these frequencies is shown in Table 1and Figure 5. From this figure the continuous sweep source level ($SL_{p\text{-}continuous}$) is determined to be 190 dB re 1μPa•m. In Table 1, the CW source level were determined using a calibrated S-range transducer and a calibrated hydrophone to illustrate the Neptune 4108 A/B transmit voltage sensitivities at each tested frequency.

Table 1: HF transducer continuous wave source level with frequency

Frequency (Hz)	CW Source Level (dB re: 1µPa·m)
4000	179.7
4500	180.0
5000	191.6
5500	189.8
6000	191.4
6500	189.0
7000	188.3
7500	189.4
8000	189.3
8500	187.3
9000	186.5
9500	186.7
10000	185.9
10500	186.1
11000	185.7
11500	187.1
12000	187.0
12500	187.9
13000	188.8
13500	184.9
14000	181.8

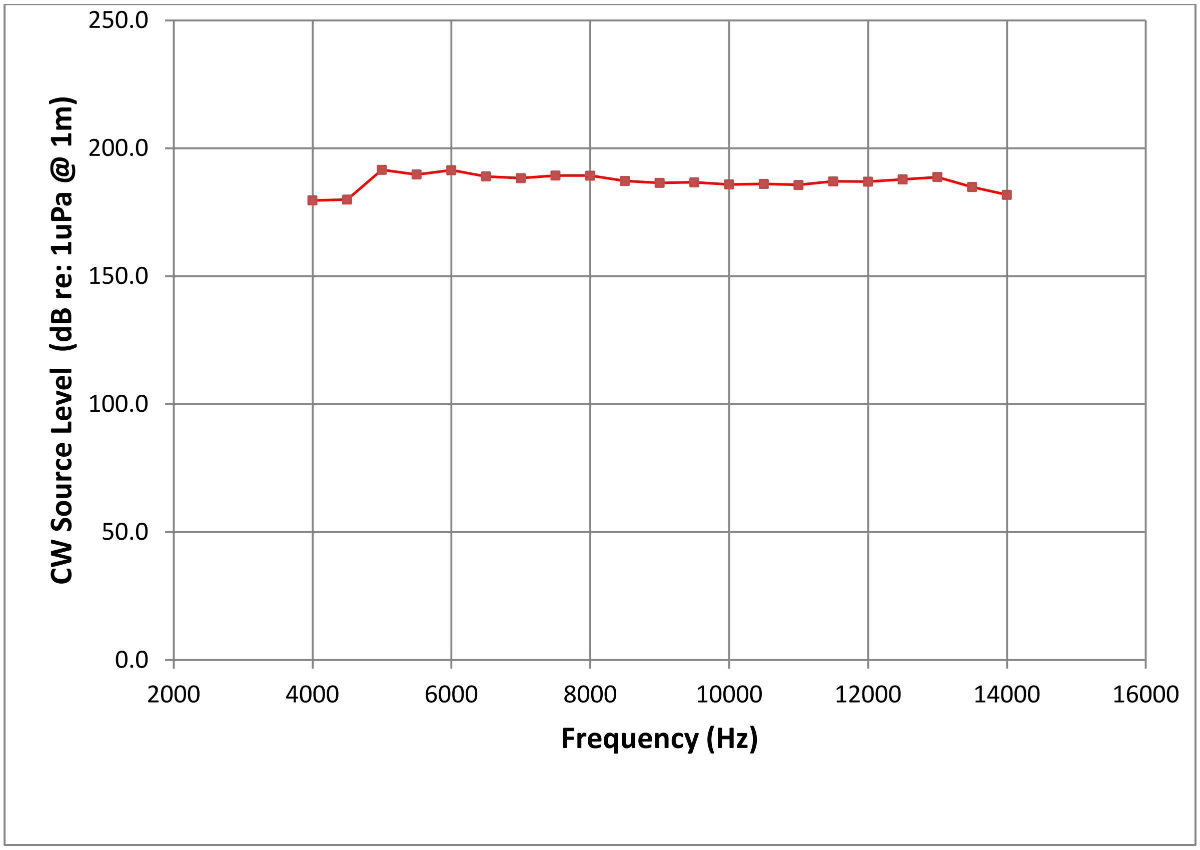


Figure 5: High Frequency transducer continuous wave sound level versus frequency

5.1.2 HF Chirp Transducer Acoustic Metrics

For a continuous SBI sweep:

$SL_{p\text{-}continuous}$= 190 dB re 1µPa•m

where at 1m from the source,

$$SPL_{chirplet} = SL_{p-continuous}$$

Therefore, for a sweep with a triangular wave-shape modulation:

$$SPL = SPL_{sweep} + 20 \log_{10} M$$

where,

M = triangular wave-shape modulation and rms to peak factor = $\sqrt{2/3}$

Provided that the SPL values are relatively flat across the total sweep bandwidth (as shown in Figure 5), the SPL value for the entire sweep is calculated as:

$SPL = 190 - 1.8 = 188.2$ dB re 1μPa @1m

and the sound exposure level associated with a single sweep is:

$$SEL = SPL + 10 \log_{10} T_{sweep}$$

where T_{sweep} is the total time between start of the sweep to the beginning of the next sweep,

$$T_{sweep} = 0.0769 \text{ sec}$$

which results in,

$$SEL = 188.2 + 10 \log_{10}(0.0769) = 177.1 \text{ dB re } 1\mu Pa^2.s \text{ @ 1m}$$

The cumulative SEL ($cSEL$) is calculated by adding the SEL values (in dB scale) from all the sweeps received in 1 hour given a ping rate of 7 Hz. The calculation also assumes the worst-case scenario that the receiver does not move away from the source as the source moves in the water column:

$$cSEL = SEL + 10 \log_{10}(N_{sweep})$$

where N_{sweep} (= 25200) is the total number of sweeps received in 1 hour resulting in,

$$cSEL = 177.1 + 10 \log_{10}(25200) = 221.1 \text{ dB re } 1\mu Pa^2.s \text{ @ 1m}$$

The distance to the SPL_{iso} isopleths is calculated using Equation 7 and the distances to the SEL_{iso} and $cSEL_{iso}$ isopleths is calculated using Equation 8.

The results of the isopleth calculations are shown in the table below.

Table 2: Source levels and maximally over-estimated distance to sound level isopleths for the high frequency (HF) chirp source

Source	SPL dB re: 1μPa	SEL dB re: 1μPa^2.s	Range (m) to SPL_{iso}		Range (m) to SEL_{iso}		Range (m) to $cSEL_{iso}$	
			180 dB re: 1μPa	160 dB re: 1μPa	180 dB re: 1μPa^2.s	160 dB re: 1μPa^2.s	198 dB re: 1μPa^2.s	186 dB re: 1μPa^2.s
SBI HF Chirp	188.2	177.1	2.6	188.8	N/A	14.7	58.3	924.6

6 CONCLUSION

The results of sound level analysis are summarized in Table 3 and Table 4. The distances to *SPL* isopleths of 180 and 160 dB re1µPa, LF and HF Chirp *SEL* isopleths of 180 and 160 dB re: 1µPa^2.s, as well as LF and HF Chirp *cSEL* isopleths of 198 and 186 dB re: 1µPa^2.s are calculated as recommended Southall et al. (2007), NMFS (2005), MMPA (2007).

The calculation assumes the worst-case scenario and does not take into account the directivity of the transmit signal. There are risks associated with acoustic sounding where mammals may be present, but these are minimal due to the SBI operating height of 3.5m above the seafloor. This risk can be reduced further by implementing mitigation procedures that would involve beginning the survey, as part of set-up procedures, using low acoustic power settings and gradually increasing to full power levels to carry out the survey proper. By so doing, marine mammals within the vicinity of the survey area are made aware of the survey activity without harm and can move away from the area prior to the commencement of the survey using full acoustic power.

Table 3: Mean Received Levels at RUNES

Transducer (Frequency)	Pulse Width	Mean Received Level	Variance	Signal-to-Noise Ratio
HF Chirp (4.5 kHz – 12.5 kHz)	4.5 ms	134 dB	12	49 dB

Table 4: Summary of sound level results

Source	*SPL* dB re: 1µPa	*SEL* dB re: 1µPa^2.s	Range (m) $SPL_{isopleth}$		Range (m) to$SEL_{isopleth}$		Range (m) to$cSEL_{isopleth}$	
			180 dB re: 1µPa	160 dB re: 1µPa	180 dB re: 1µPa^2.s	160 dB re: 1µPa^2.s	198 dB re: 1µPa^2.s	186 dB re: 1µPa^2.s
SBI HF Chirp	188.2	177.1	2.6	188.8	N/A	14.7	58.3	924.6

7 REFERENCES

[1] B.L. Southall, AE.. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack, 2007. Marine Mammal Noise Exposure Criteria: Initial Recommendations. Aquatic Mammals, Volume 33, Number 4.

[2] Marine Mammal Protection Act (MMPA) amendment, 2007. Marine Mammal Commission with amendments by NOAA's National Marine Fisheries Service.

[3] National Marine Fisheries Service (NMFS), 2005. Assessment of acoustic exposures on marine mammals in conjunction with USS Shoup active sonar transmissions in Haro Strait, Washington, 5 May 2003.(NMFS Office of Protected Resources report).

[4] Analytical review of the Acoustic Corer™ sound source analysis report by PanGeo Subsea, 2013. Prepared for PanGeo Subsea by Jasco Applied Sciences.

Innomar Sub-bottom Profiler

SES-2000 medium-100

Parametric Sub-bottom Profiler

▶ Performance
- water depth range: 2 – 2,000 m
- penetration: up to 70 m, depending on sediments
- layer resolution: up to 5 cm
- motion compensation: heave, roll
- beam width @ 3 dB: ±1 ° / footprint < 3.5 % of water depth for all frequencies

▶ Transmitter
- primary frequencies: approx. 100 kHz (band 85 – 115 kHz)
- secondary low frequencies: 4, 5, 6, 8, 10, 12, 15 kHz (band 2 – 22 kHz)
- primary source level: > 247 dB//µPa re 1 m
- pulse width: 0.07 – 2 ms
- pulse rate: up to 40/s
- multi-ping mode
- pulse type: CW, Ricker, LFM (chirp)

▶ Acquisition
- primary frequency (echo sounder, bottom track)
- secondary low frequency (sub-bottom data, multi-frequency mode)
- sample rate 96 kHz @ 24 bit

▶ System Components
- transceiver unit 19 inch / 12 U (WHD: 0.52 m x 0.58 m x 0.40 m; 56 kg)
- transducer incl. 30 m cable (WHD: 0.50 m x 0.12 m x 0.50 m; 60 kg)
- system control: internal PC
- KVM remote control

▶ Software
- SESWIN data acquisition software
- SES Convert SEG-Y/XTF data export
- SES NetView remote display
- ISE post-processing software

▶ Power Supply Requirements
- 100 – 240 V AC / 50 – 60 Hz
- power consumption: < 700 W

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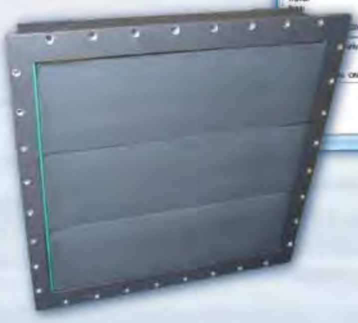
Transducer ▼



▲
Screenshot of the operating software

Top-side unit ▶

INNOMAR deep-36

Parametric Sub-bottom Profiler

▶ Performance

- water depth range: 5 – 6,000 m (option 10,000 m)
- penetration: up to 150 m, depending on sediments
- layer resolution: up to 12 cm
- motion compensation: heave, roll, pitch (option)
- beam width @ 3 dB: ± 1.5° / footprint < 5.5 % of water depth for all frequencies

▶ Transmitter

- primary frequencies: approx. 36 kHz (band 30 – 42 kHz)
- secondary low frequencies: 2, 3, 4, 5, 6, 7 kHz (band 1 – 10 kHz)
- primary source level: > 245 dB//µPa re 1 m
- pulse width: 0.15 – 5 ms
- pulse rate: up to 40/s
- multi-ping mode
- pulse type: CW, Ricker, LFM (chirp)

▶ Acquisition

- primary frequency (echo sounder, bottom track)
- secondary low frequency (sub-bottom data, multi-frequency mode)
- sample rate 48 kHz @ 24 bit

▶ System Components

- transceiver unit 19 inch / 16 U (WHD: 0.52 m x 0.74 m x 0.50 m; 95 kg)
- transducer with frame excl. cable (WHD: 0.90 m x 0.30 m x 0.90 m; 335 kg)
- system control: internal PC
- KVM remote control

▶ Software

- SESWIN data acquisition software
- SES Convert SEG-Y/XTF data export
- SES NetView remote display
- ISE post-processing software

▶ Power Supply Requirements

- 100 – 240 V AC / 50 – 60 Hz
- power consumption < 900 W

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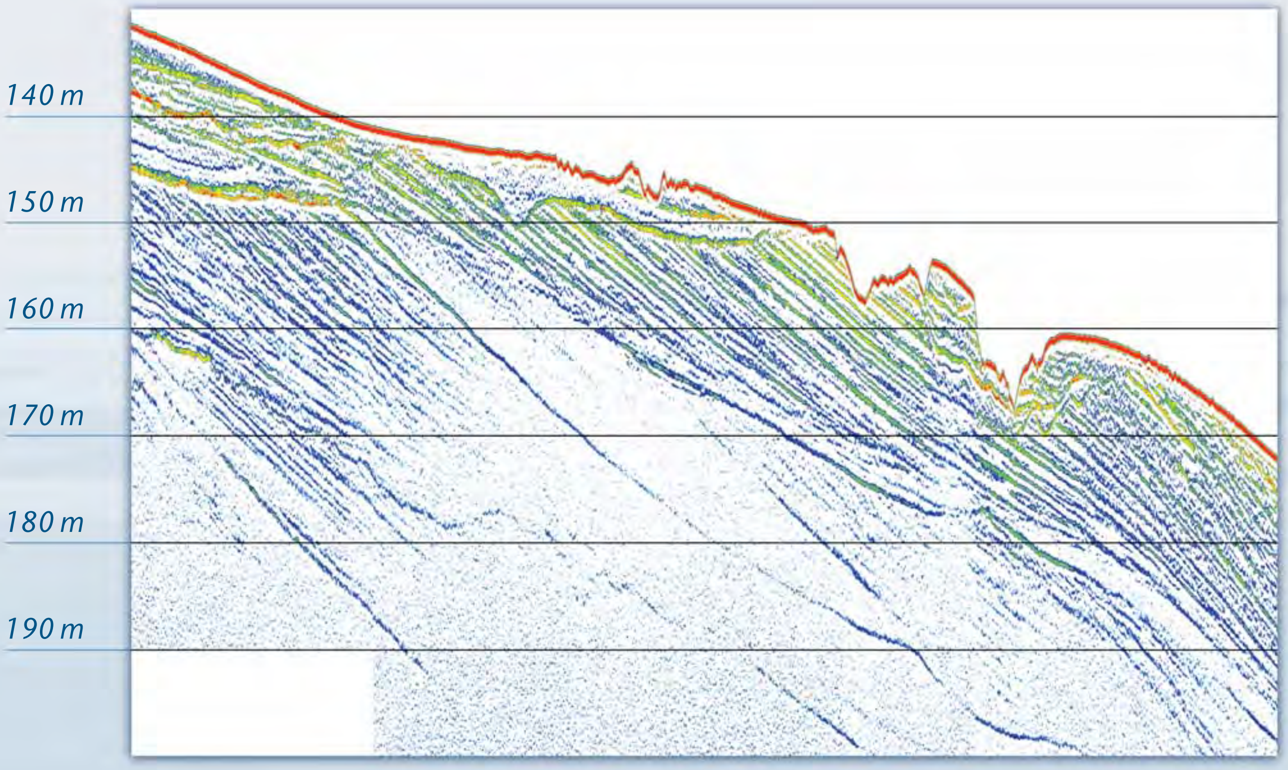
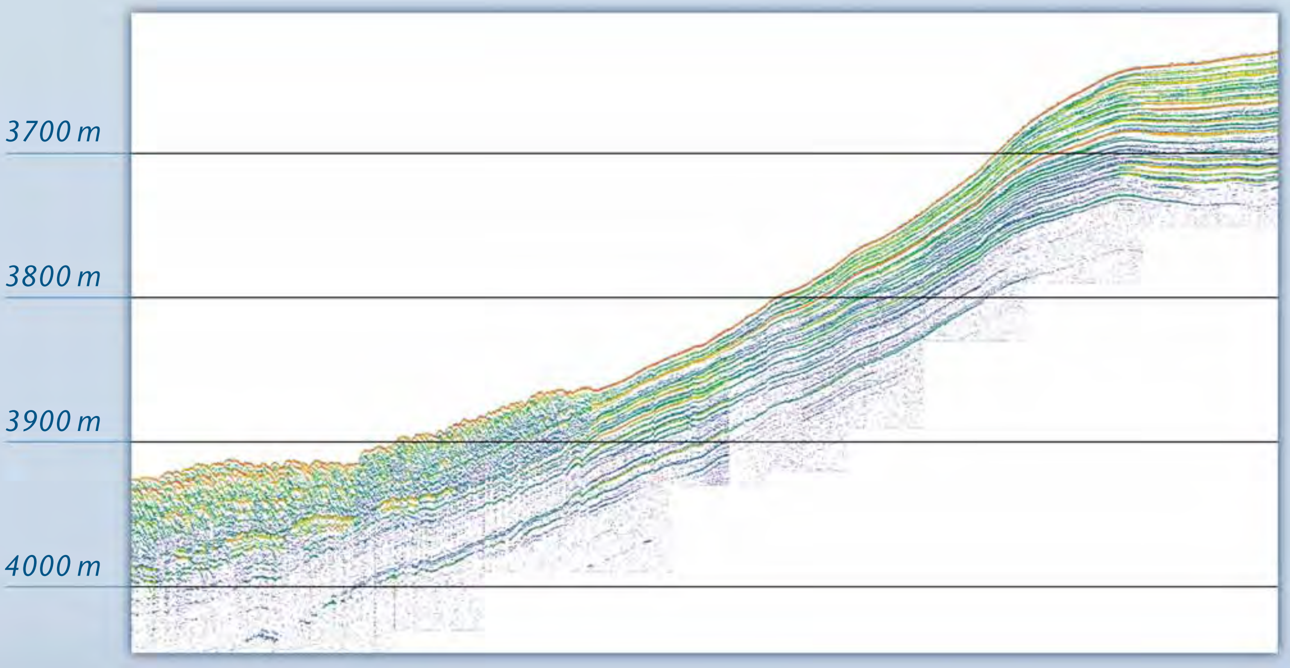
Survey examples of SES-2000 deep-36



South Korean Coast echo plot example
Frequency 4 kHz, pulse length 750 µs, profile length 11 km, survey speed 13 knots



***Atlantic Ocean (Argentina) echo plot example** – Frequency 4 kHz, pulse length 1500 µs, profile length 65 km*

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Attachment B

Level B Threshold Calculations

Source Name: SIG ELC 820 Sparker at 750J

INPUT VALUES (LEVEL B)	
Threshold Level	*160*
Source Level (dBrms)	*203*
Frequency (kH)	*0.01*
Beamwidth (degree)	*180*
Water depth (m)	*5*

COMPUTED VALUES (LEVEL B)	DO NOT CHANGE
alpha (dB/km)	8.8249E-07
TL coefficient	20
Slant distance of threshold (m)	**141**
Vertical depth of threshold (m)	8.6373E-15
Horizontal Threshold Range (m)	**141**

Source Name: Geo Marine Survey System 2D SUHRS at 400J

INPUT VALUES (LEVEL B)	
Threshold Level	*160*
Source Level (dBrms)	*195*
Frequency (kH)	*0.2*
Beamwidth (degree)	*180*
Water depth (m)	*5*

COMPUTED VALUES (LEVEL B)	DO NOT CHANGE
alpha (dB/km)	0.000352994
TL coefficient	20
Slant distance of threshold (m)	**56**
Vertical depth of threshold (m)	3.43042E-15
Horizontal Threshold Range (m)	**56**

Source Name: Edgetech 2000-DSS

INPUT VALUES (LEVEL B)	
Threshold Level	*160*
Source Level (dBrms)	*195*
Frequency (kH)	*2*
Beamwidth (degree)	*24*
Water depth (m)*	*5*

COMPUTED VALUES (LEVEL B)	DO NOT CHANGE
alpha (dB/km)	0.035275879
TL coefficient	20
Slant distance of threshold (m)	**56**
Vertical depth of threshold (m)	54.77626564
Horizontal Threshold Range (m)	**1.062782808**

Source Name: Edgetech 216

INPUT VALUES (LEVEL B)	
Threshold Level	*160*
Source Level (dBrms)	*179*
Frequency (kH)	*2*
Beamwidth (degree)	*24*
Water depth (m)*	*5*

COMPUTED VALUES (LEVEL B)	DO NOT CHANGE
alpha (dB/km)	0.035275879
TL coefficient	20
Slant distance of threshold (m)	**9**
Vertical depth of threshold (m)	8.803328407
Horizontal Threshold Range (m)	**1.062782808**

Source Name: Edgetech 424

INPUT VALUES (LEVEL B)	
Threshold Level	*160*
Source Level (dBrms)	*180*
Frequency (kH)	*4*
Beamwidth (degree)	*71*
Water depth (m)*	*10*

COMPUTED VALUES (LEVEL B)	DO NOT CHANGE
alpha (dB/km)	0.140819438
TL coefficient	20
Slant distance of threshold (m)	**10**
Vertical depth of threshold (m)	8.141155184
Horizontal Threshold Range (m)	**5.807029557**

Source Name: Edgetech 512i

INPUT VALUES (LEVEL B)	
Threshold Level	*160*
Source Level (dBrms)	*179*
Frequency (kH)	*0.7*
Beamwidth (degree)	*80*
Water depth (m)*	*10*

COMPUTED VALUES (LEVEL B)	DO NOT CHANGE
alpha (dB/km)	0.004323847
TL coefficient	20
Slant distance of threshold (m)	**9**
Vertical depth of threshold (m)	6.894399988
Horizontal Threshold Range (m)	**5.785088487**

Source Name: Pangeosubsea Sub-Bottom Imager™

INPUT VALUES (LEVEL B)	
Threshold Level	*160*
Source Level (dBrms)	*190*
Frequency (kH)	*4*
Beamwidth (degree)	*120*
Water depth (m)	*5*

COMPUTED VALUES (LEVEL B)	DO NOT CHANGE
alpha (dB/km)	0.140819438
TL coefficient	20
Slant distance of threshold (m)	**32**
Vertical depth of threshold (m)	16
Horizontal Threshold Range (m)	**8.660254038**

Attachment C

Marine Mammal Seasonal Densities

Species	Density (animals per 100 km^2)			
	Winter	Fall	Spring	Summer
Atlantic Spotted Dolphin	<0.001	0.033	<0.001	0.029
Atlantic White sided Dolphin	0.210	0.214	0.278	0.085
Bottlenose Dolphin	7.965	36.269	12.230	32.783
Fin Whale	0.114	0.027	0.070	0.032
Harbor Porpoise	2.506	0.015	2.104	0.018
Humpback Whale	0.090	0.059	0.079	0.021
Minke Whale	0.031	0.024	0.401	0.048
North Atlantic Right Whale	0.056	0.005	0.029	0.001
Pilot Whale	0.008	0.008	0.008	0.008
Risso's Dolphin	0.017	0.012	0.007	0.002
Seals	14.022	7.237	12.378	3.550
Sei Whale	0.026	0.010	0.031	0.002
Short Beaked Common Dolphin	1.473	1.204	1.162	0.278
Sperm Whale	0.003	0.002	0.005	<0.001