ENVIRONMENTAL IMPACT ASSESSMENT "3D" OFFSHORE SEISMIC RECORD CAN_100, CAN_108 AND CAN_114 AREAS, ARGENTINA

CHAPTER 4 – PROJECT DESCRIPTION

MARCH 2021

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CHAPTER 4 - PROJECT DESCRIPTION

This chapter describes the key aspects of the project. It is aimed at providing enough information about the project that later serves as input for the description and characterization of the receiving environment, as well as for the environmental assessment that is subsequently carried out.

1 PROJECT LOCATION

The project involves a 3D Offshore Seismic Record in the Argentine Republic, more specifically in CAN_100, CAN_108 and CAN_114 blocks, located in the North Argentine Basin of the Argentine Continental Shelf.

The seismic acquisition shall cover 6,245 km^2 embracing the CAN_100-108 Area, which is located more than 300 km offshore from the nearest coastal town, Mar del Plata, in the Province of Buenos Aires. On the other hand, the surface to be explored in the CAN_114 Area comprises approximately 3,443 km^2, and is located more than 400 km from the City of Necochea, in the Province of Buenos Aires. The CAN_100-108 seismic data acquisition area is situated 162 km from the CAN_114 acquisition area in a straight line.

The following figure shows the seismic data acquisition areas under study, and their distance from the Argentine coast.

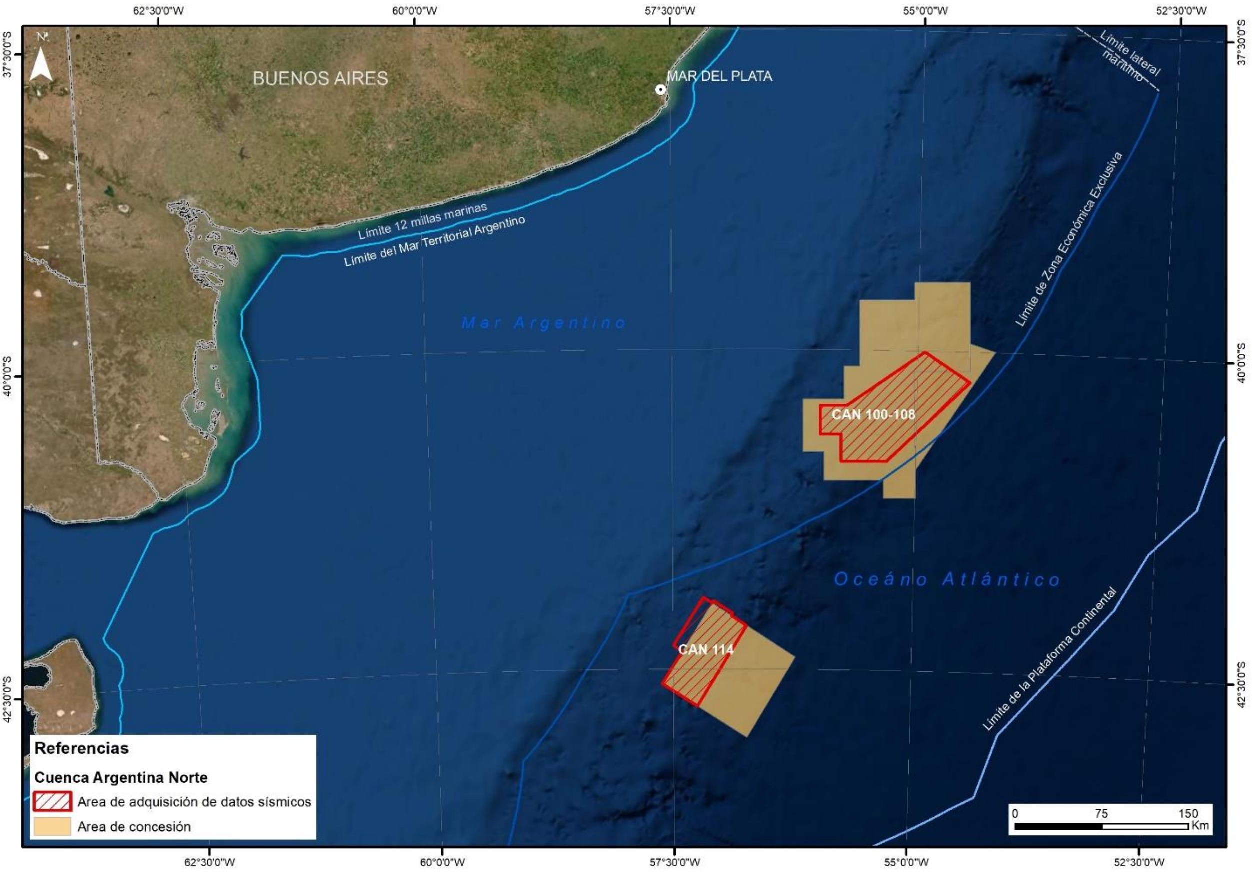
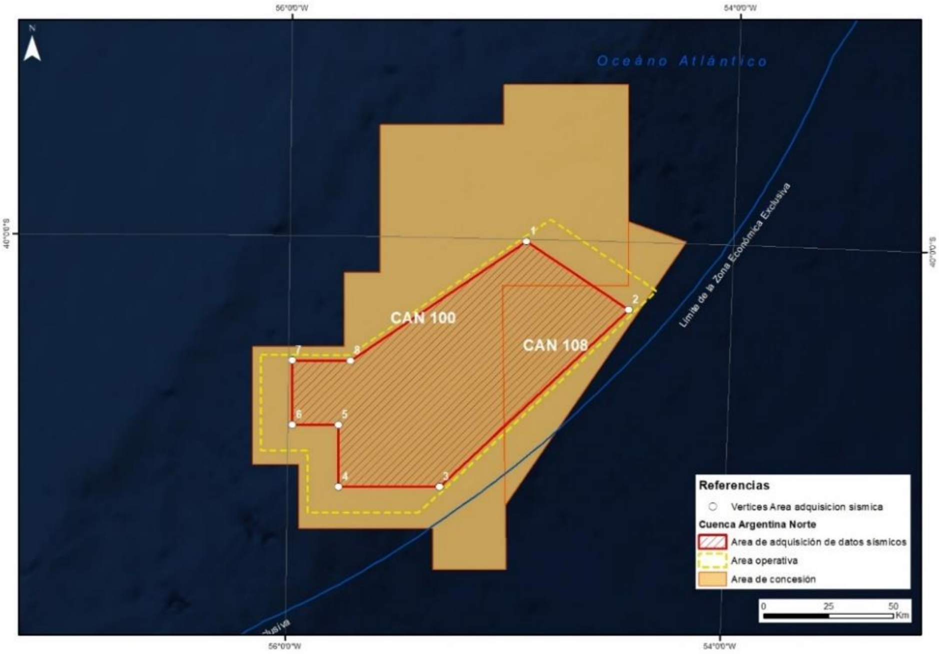


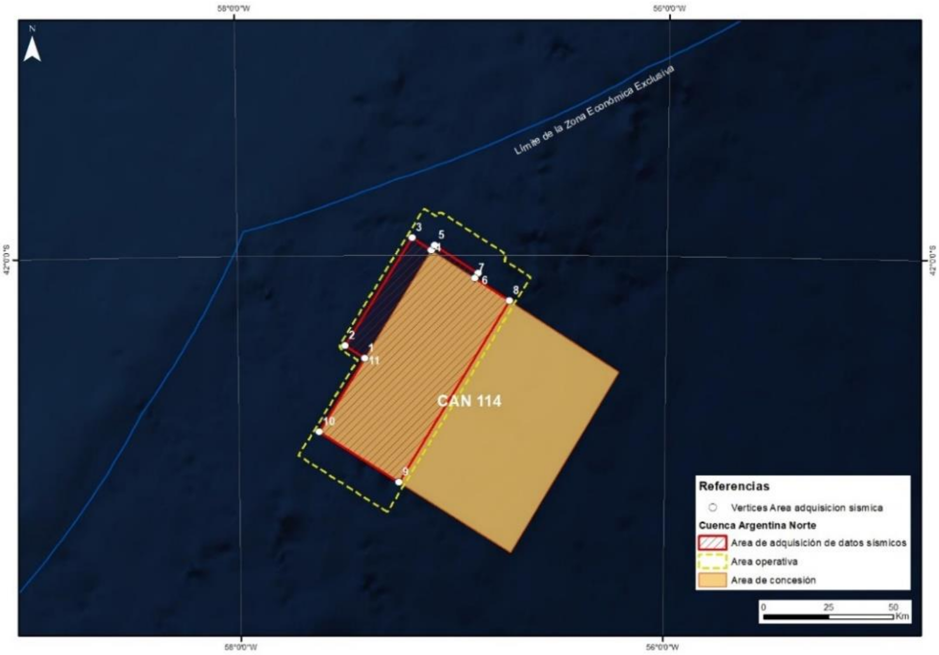
Figure 1. Location of the CAN_100, CAN_108 and CAN_114 seismic data acquisition areas.

There is a map below for each area where exploration is planned.



This map shows the seismic data acquisition area and expected operation of the seismic vessel during normal operations, including turning zones (operational area)[1].

Figure 2. Detailed view of the CAN_100 / CAN_108 seismic data acquisition area.



This map shows the seismic data acquisition area and expected operation of the seismic vessel during normal operations, including turning zones (operational area).

Figure 3. Detailed view of the CAN_100 / CAN_108 seismic data acquisition area.

[1] The criterion used to set up the operational area was to consider about 12 km beyond the limits of the seismic acquisition area within the acquisition lines (prime lines), so as to easily include the turns that the seismic vessel shall make to perform the line changes, which shall not exceed 10 km of radius (see Chapter 5: STUDY AREA AND AREA OF INFLUENCE).

The coordinates that define the License Areas (Table 1) and the Seismic Data Acquisition Areas (Table 2) are hereinbelow detailed:

Table 1. Coordinates of the License areas

Area	Corner	License Areas* World Geodetic System 1984	
		Latitude	Length
CAN_100 Approx. Surface Area. 15.012,52 km^2	1	-39,4653	-55,0484
	2	-39,4534	-54,4904
	3	-40,1526	-54,4648
	4	-40,1637	-55,0375
	5	-41,1513	-54,9905
	6	-41,1563	-55,3249
	7	-41,0139	-55,3285
	8	-41,0209	-55,9421
	9	-40,7970	-55,9456
	10	-40,7987	-56,1575
	11	-40,3890	-56,1626
	12	-40,3852	-55,7449
	13	-40,1279	-55,7497
	14	-40,1260	-55,5883
	15	-39,6115	-55,5988
	16	-39,6035	-55,0445
CAN_108 Approx. Surface Area. 2882,22 km^2	1	-39,9940	-54,2111
	2	-40,9272	-55,0011
	3	-40,1637	-55,0375
	4	-40,1526	-54,4648
	5	-39,9314	-54,4777
CAN_114 Approx. Surface Area. 7079,29 km^2	1	-42,4048	-56,2186
	2	-43,0338	-56,7228
	3	-42,6125	-57,6217
	4	-41,9828	-57,0949

* The exact coordinates and area shall be confirmed in the block´s measurement process.

Table 2. Coordinates of the seismic data acquisition areas

Area	Corner	Seismic data acquisition areas World Geodetic System 1984 Latitude	 Length
CAN_100 and CAN_108	1	-40,2369	-54,4626
	2	-40,8670	-55,3033
	3	-40,8739	-55,7645
	4	-40,6585	-55,7693
	5	-40,6600	-55,9787
	6	-40,4358	-55,9826
	7	-40,4343	-55,7173
	8	-40,0077	-54,9314
CAN_114	1	-42,358526	-57,407713
	2	-42,314952	-57,497793
	3	-41,939576	-57,184723
	4	-41,982785	-57,094858
	5	-41,965735	-57,080388
	6	-42,064030	-56,878549
	7	-42,080943	-56,893342
	8	-42,159382	-56,731330
	9	-42,789179	-57,248111
	10	-42,612514	-57,621748
	11	-42,358526	-57,407713

As shown by Figure 3, the area of seismic data acquisition marginally exceeds the limit of the CAN_114 block licensed to Equinor. Indeed, it can be seen in Figure 4 that the seismic acquisition would be partially developed on the CAN_113 area. This block was tendered as part of the Offshore International Public Bid No. 1 and was granted to TOTAL AUSTRAL SA and British Petroleum (who hold an exploration permit issued by Resolution No. 597/2019 in October 2019).

This is common in seismic surveys for several reasons:

1 – Due to how the subsurface is visualized: when seismic data is acquired, the visualized subsurface is located halfway between the source and the receiver (reflection point). This means that, in order to get a complete picture of the boundaries of the block licensed to Equinor, the seismic source or receiver must be located outside the block to ensure that the midpoint is within the block. This distance increases with the depth of the target (because longer streamers are required) and the geological spatial configuration of the formation to be recorded, which means that the vessel has to be a few kilometers outside the license to be able to correctly register the target within (or at the boundary) of the block.

2 - The exploration of the subsoil mapped from the existing 2D data and that served as the basis for Equinor's decision to tender the licenses is not interrupted at the limits of the license, but extends to both sides of said limits. It is necessary to completely cover the area of interest with as many 3D seismic lines as possible in order to properly assess the potential of the subsurface and allow an optimal decision base to define whether to drill or not in the future.

The CAN_114 operational area (defined by a yellow line), in addition to covering part of the CAN_113 block previously mentioned, involves a sector of the CAN_111 boundary block where vessels shall operate to make turns, maneuvers, etc. without operating seismic sources. According to Resolution 276/2019 of the Ministry of Energy, the CAN_111 area was granted to TOTAL AUSTRAL SA and British Petroleum (who hold an exploration permit issued by Resolution 600/2019 in October 2019).

Equinor has entered into dialogue with the neighboring license operator (TOTAL AUSTRAL SA) and has obtained its authorization to acquire data in a small part of the CAN 113 area and carry out operations (ship turns, etc.) in the CAN_111 area. A copy of the authorization signed by TOTAL AUSTRAL SA is included in Annex I.

The CAN_100-108 operative area is entirely inserted within the respective CAN_100 and 108 blocks; with the exception of the northeastern vertex that minimally exceeds said blocks. However, it does not involve any area of hydrocarbon exploitation. Annex II contains a copy signed by EQUINOR ARGENTINA BV (ARGENTINE BRANCH) who acts as operator on behalf of the Transitory Union of Companies for THE CAN_100 Block, whereby EQUINOR ARGENTINA SA (ARGENTINE BRANCH) which holds the exploration license to explore the CAN_108 Block, is authorized to record data on the CAN_100-108 area. This license was granted by Resolution 691/2019.

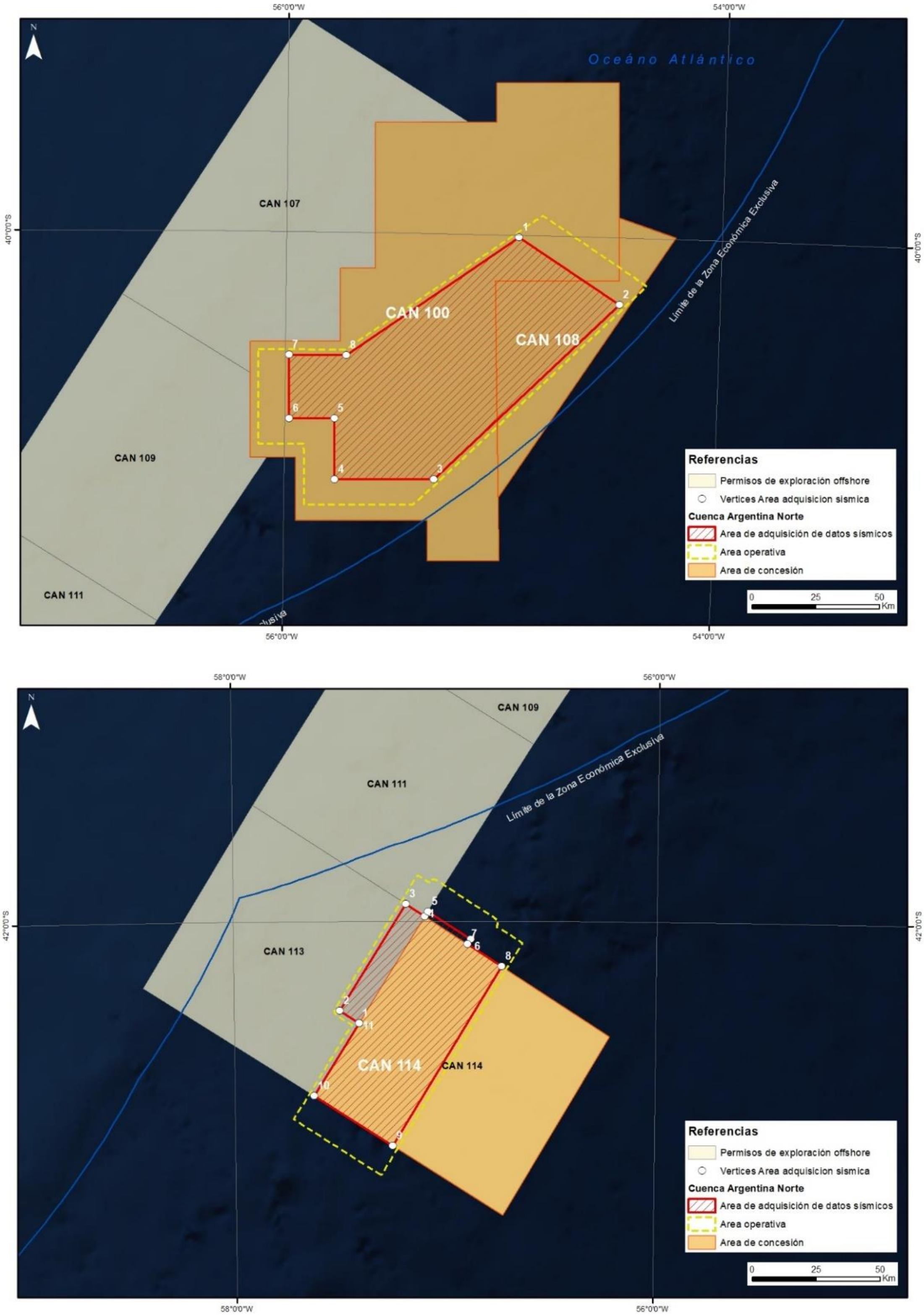


Figure 4. Exploitation licenses bordering the CAN_100-108 and CAN_114 blocks. Source: Carried out by the Ministry of Energy based on SIG [2].

[2] https://www.argentina.gob.ar/produccion/energia/hidrocarburos/mapas-del-sector-de-hidrocarburos

2 DESCRIPTIVE MEMORY

2.1 SEISMIC TECHNOLOGY

Those aspects of the technique that could generate interactions with the environment and potentially lead to environmental impacts are herein defined.

Seismic source

A **seismic source is defined** as any **device** which releases **energy into** the earth in the **form of seismic waves**. The compressed air power source is the most commonly used in marine exploration, which has been the most widely used system in the industry since the 70's.

The compressed air power source is a chamber of compressed air that is rapidly discharged into the water to create an acoustic pulse. It is the most widely used sound source since the pulses are predictable, repeatable and controllable, and use compressed air which is inexpensive and readily available, as well as having only a low impact upon marine life.

The volume of air in the compressed air power source is normally measured in cubic inches (cu. In), and typically ranges between 20 and 800 cu.in - 0.33 to 13.1 liters (Landrø M. and Amundsen L, 2010).

Sending and receiving arrays

An array is a geometric configuration of transducers (sources or receivers) used to generate or to record a physical field, which, in this case, is an acoustic field. A geometric array of seismic sources is a group of sound emission sources, each one activated in a certain sequence fixed in time or from receivers (a group of hydrophones in a seismic cable or “streamer”).

An emitting array consists of 3 to 6 sub-arrays, each of which usually contains 6 to 8 compressed air power sources, then typically involving between 18 and 48 compressed air power sources, although they may have more in special cases.

Compressed air power sources float in the sea between 3 m and 10 m deep (usually around 6 to 7 meters). It is common to place 2 to 4 sources of compressed air energy in a "cluster" or group, placing them close to each other to obtain a more efficient source of equivalent compressed air energy of greater size, improving the characteristics of the signals since the movement of air bubbles is reduced as the air bubbles of the various compressed air energy sources interact. The maximum pressure is emitted vertically, while the levels emitted horizontally are much lower, as shall be seen later.

For aquatic seismic recording, the air power sources are towed by a vessel along the projected survey lines.

In order to calculate precisely where the characteristics of the substrate are located, GPS positioners are used which provide the position of the source and of each group of hydrophones that record the reflected signal.

As shown in Figure 5, the white lines indicate possible paths of the acoustic waves leaving the emitting array, reaching the marine substrate and reflecting until reaching the sensors or hydrophones located in the seismic cable[3]. The tail buoy helps the crew identify the end of the cable.

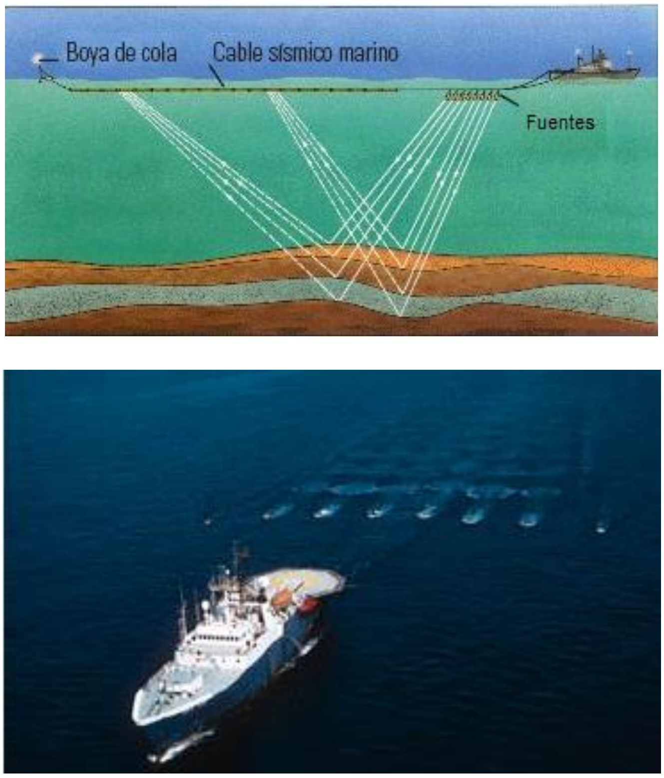


Figure 5. Scheme and photograph of a seismic vessel, the emission sources, the seismic cable (streamers) and the tail buoy.

Next, the most significant aspects related to technology that could generate impacts on the environment are analyzed, based on the characterization of the most critical environmental factors in the study area.

P Waves

The seismic method to be used in the aquatic environment consists of studying the trajectory of compressional waves, called P waves, which when propagating into the interior of the earth and finding changes in physical properties (different geological strata, gas, oil, etc.) are refracted and reflected towards the surface where they are captured by electrical sensors. These waves are measured by the time it takes them to reach the surface, from which depth position and geometry are inferred. The final product is a 3-dimensional "image" of the subsoil after being amplified, filtered, digitized, and registered.

In geophysics, the term "acoustics" refers specifically to the study of P waves.

[3] Source: https://www.glossary.oilfield.slb.com/Terms/s/seismic_acquisition.aspx

S Waves

S waves, on the other hand, are elastic volumetric waves in which the particles oscillate in a direction perpendicular to the direction in which the wave propagates. S waves are generated by most terrestrial seismic sources, but not by compressed air sources.

P waves that collide with an interface with a non-normal angle of incidence can produce S waves, which in this case are called converted waves. Similarly, S waves can be converted to P waves. S waves, or shear waves, propagate more slowly than P waves and cannot propagate through fluids because fluids do not support shear stress.

Pulse duration and emission sequence during seismic acquisition

During seismic acquisition, acoustic pressure waves that penetrate the inner layers of the earth are generated. These are acoustic pulses of very short duration, of a few thousandths of a second and are never in the same position: they move along with navigation.

The rise time of the pulse near the source (from zero to maximum pressure) varies between 5 and 10 ms (milliseconds), and most of the total energy is emitted in no more than 30 ms.

The energy emission moves at constant intervals of distance as the ship proceeds at a normal speed between 4 and 5 knots (about 2 to 2.5 m / s).

During a typical subsea seismic operation, compressed air power sources are typically run at 3 to 15 second-intervals, with emissions of a few tens of milliseconds (ms) (with an operating cycle of approximately 0.3% weather). Although the maximum energy levels can be high, the short duration indicated implies that the total energy transmitted is relatively low.

Compressed air power source

A compressed air power source consists of equipment that discharges pressurized air into the water, made up of a hollow metal chamber that contains compressed air, generated by compressors on board the seismic vessel, and forced from it to the source through a flexible hollow tube.

When shooting, the high-pressure air quickly leaks into the water producing a bubble. Two or more compressed air power sources with different volumes are used to optimize the frequency and amplitude characteristics of the signal emitted by the source and to minimize other effects that obscure the signal.

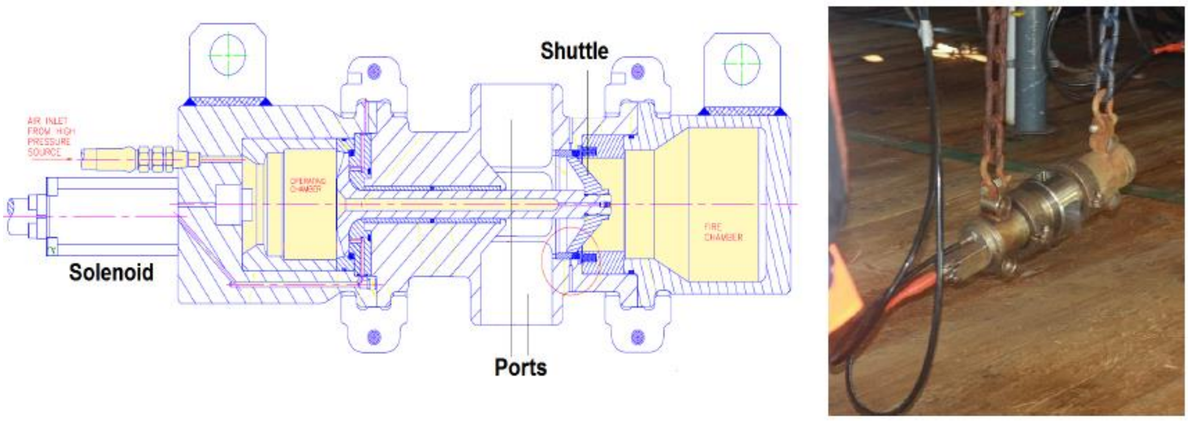


Figure 6. Typical diagram of a compressed air power source.

The possible brands of the sources to be used are indicated in paragraph **Error! Reference source not found.**. It is necessary to bear in mind that all manufacturers use the same type of technology and that the explanations given in this paragraph adequately represent the operation of any of the brands that could eventually be used in prospecting.

Reception of reflected energy

The reception of seismic signals is carried out with a drag system called streamers. It is made of a surface marine seismic cable, which is a floating array of electrical cables that connects the hydrophones and transmits the seismic data to the seismic recording vessel.

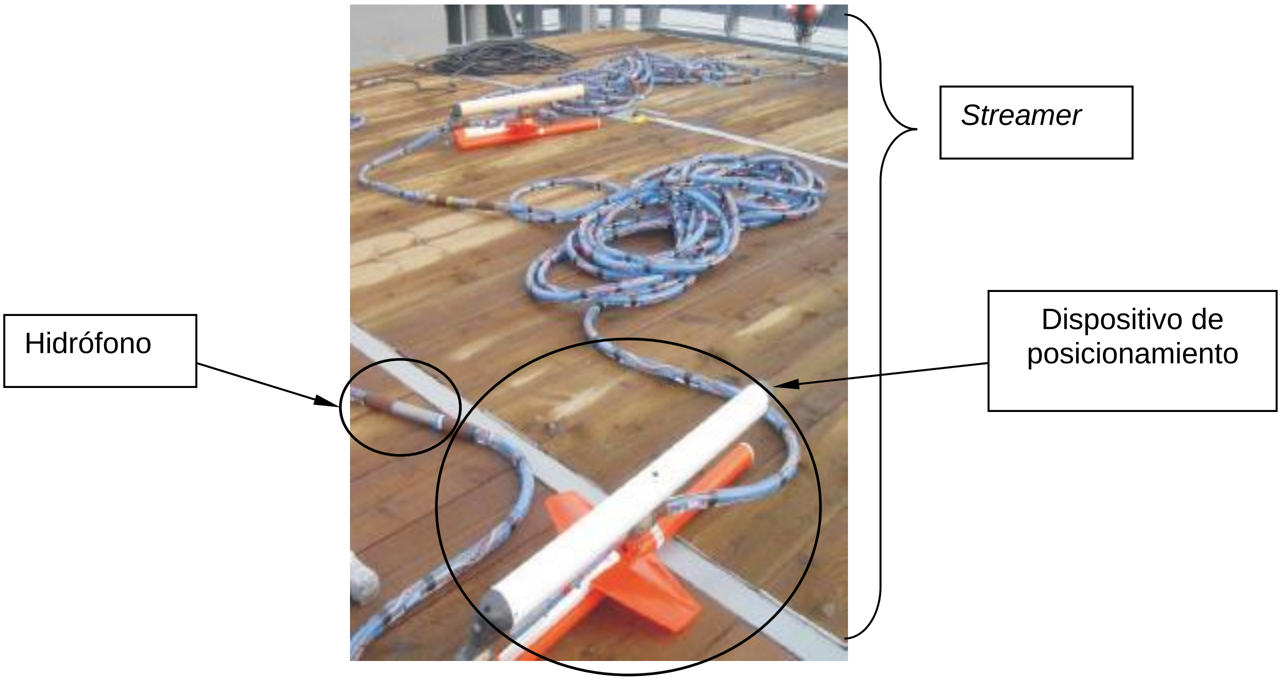


Figure 7. *Streamer*.

The acquisition of seismic information is obtained along lines that make up a 3D registration grid.

The reception of seismic signals of this type is carried out through the use of hydrophones. These are located inside the streamers which are made up of sections of solid cable.

The streamers have neutral buoyancy and devices to regulate their orientation and depth. These factors that are monitored with special sensors located between the hydrophone groups, so that their spatial position is known at all times.

An illustrative diagram of the set is presented in Figure 8. Figure 9 shows the array of the seismic energy sources and the streamers dragged by the seismic vessel.

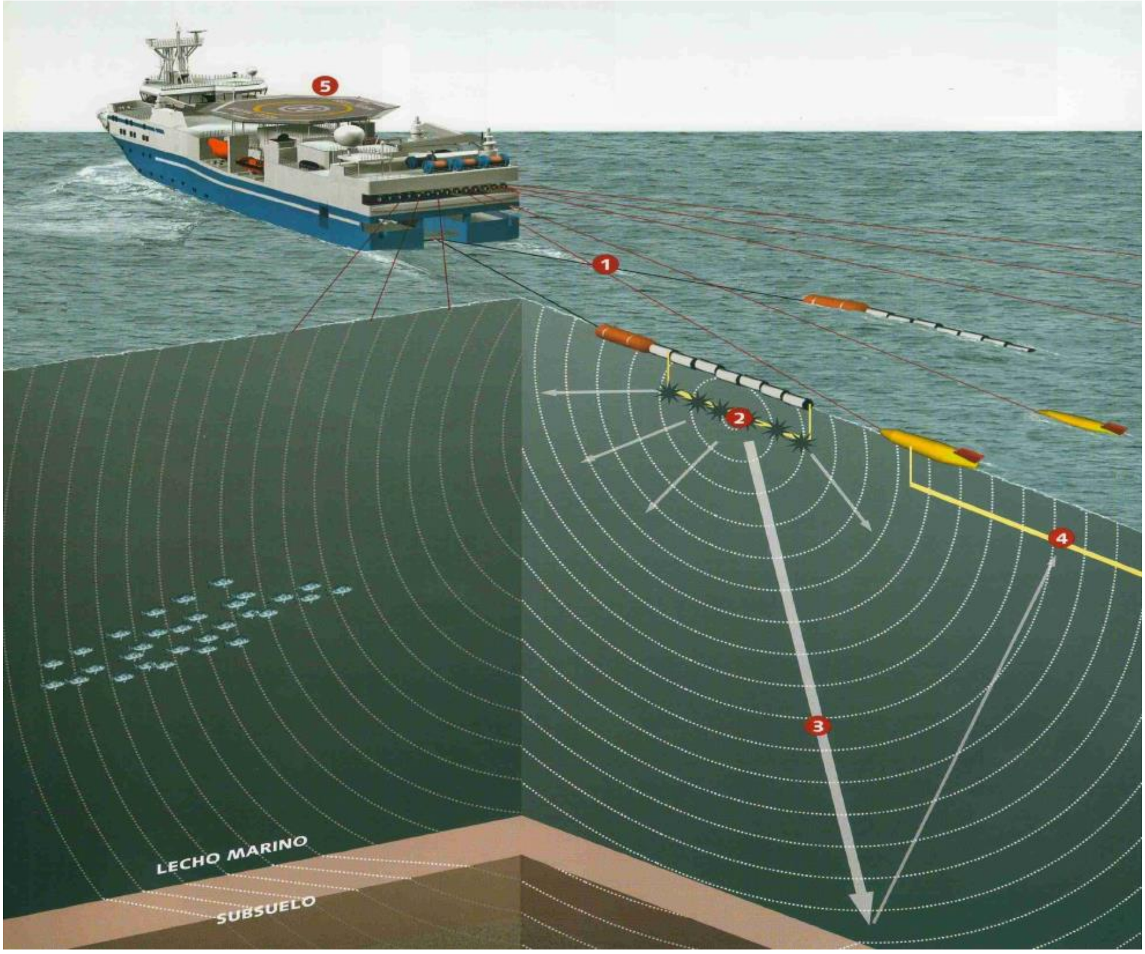


Figure 8. Display of a 3D seismic survey.

References: 1- Deployment of compressed air energy sources and streamers, 2- Generation of pressure wave, 3- Transmission of energy, 4- Recording of reflected waves with hydrophones, 5- Digitalization of ship data.

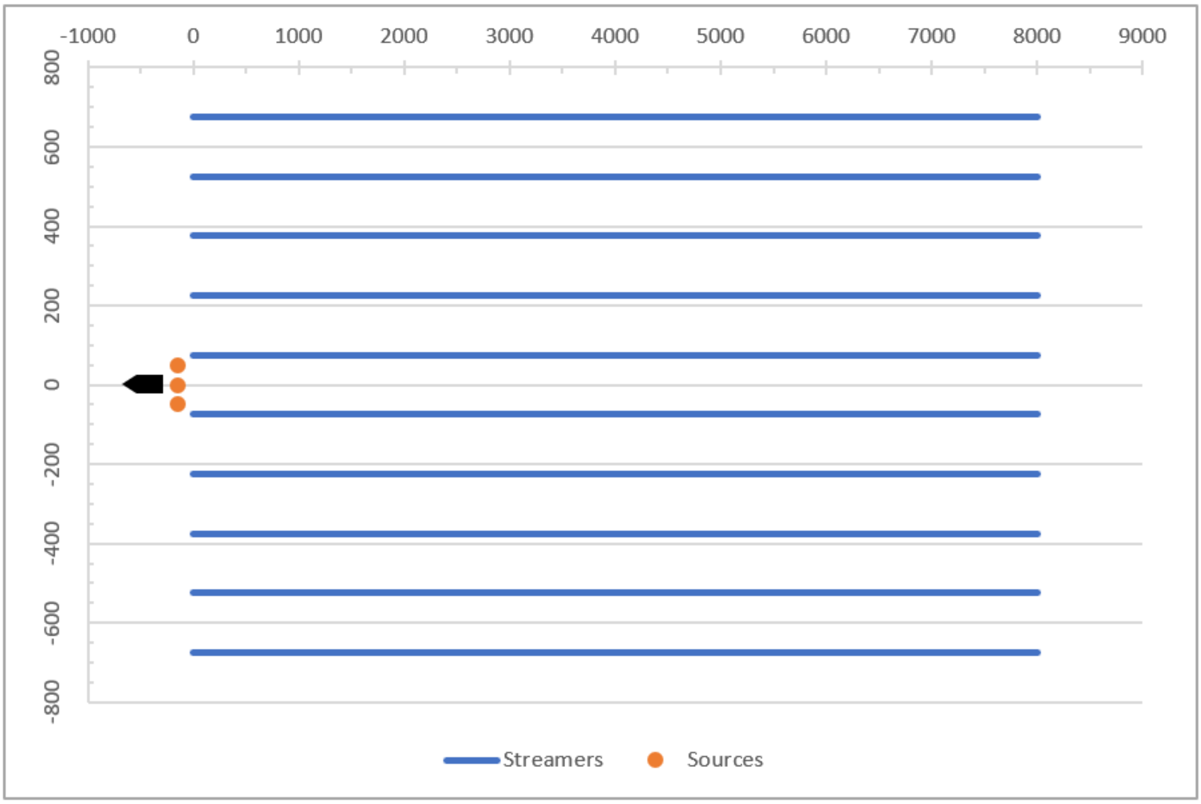


Figure 9. Layout diagram of compressed air energy sources (sources) and streamers.

2.2 SOUND EMISSION EQUIPMENT TO BE USED

Next, the specifications of the sound emission equipment provided for the development of seismic recording by means of streamers are presented. Bottom detectors that use technologies such as OBN (Ocean Bottom Nodes) or OBC (Ocean Bottom Cables) shall not be used).

A concentrated array called "Triple Source" shall carry out the seismic process as it is made up of 6 sub-arrays, which emit alternately in groups of 2 (system called 2-2-2). Each emission source is composed of 2 sub-arrays separated 10 meters from each other, occupying a 10 meter-wide by 14 meters long (140m2) area, with a total volume equal to 3,280 cubic inches (cu.in), 53.75 liters.

Table 3. Equipment conditions. Concentrate array: Triple Source.

Number of Streamers	10	
Streamers Length	8.000	meters (solid streamer)
Interval between receivers	150	meters
Offset Close trace	150	meters
Streamer depth	Between 12 and 18	meters
Number of Sources per sub-array	20 + 2 spare	
Source working pressure	2.000	Psi[4]
Source Volume Total	3.280 / 53,75	cu.in. / liters
Power Sources: 0 to peak	57,5	bar.meter[5]
Depth of the Sources	6	meters

Marine seismic air source configurations are currently limited by a maximum of six source arrays carried by vessels. The Triple source setup uses two sub-arrays on each source.

The position of one of the sources of the anticipated Triple array is presented in Figure 10.

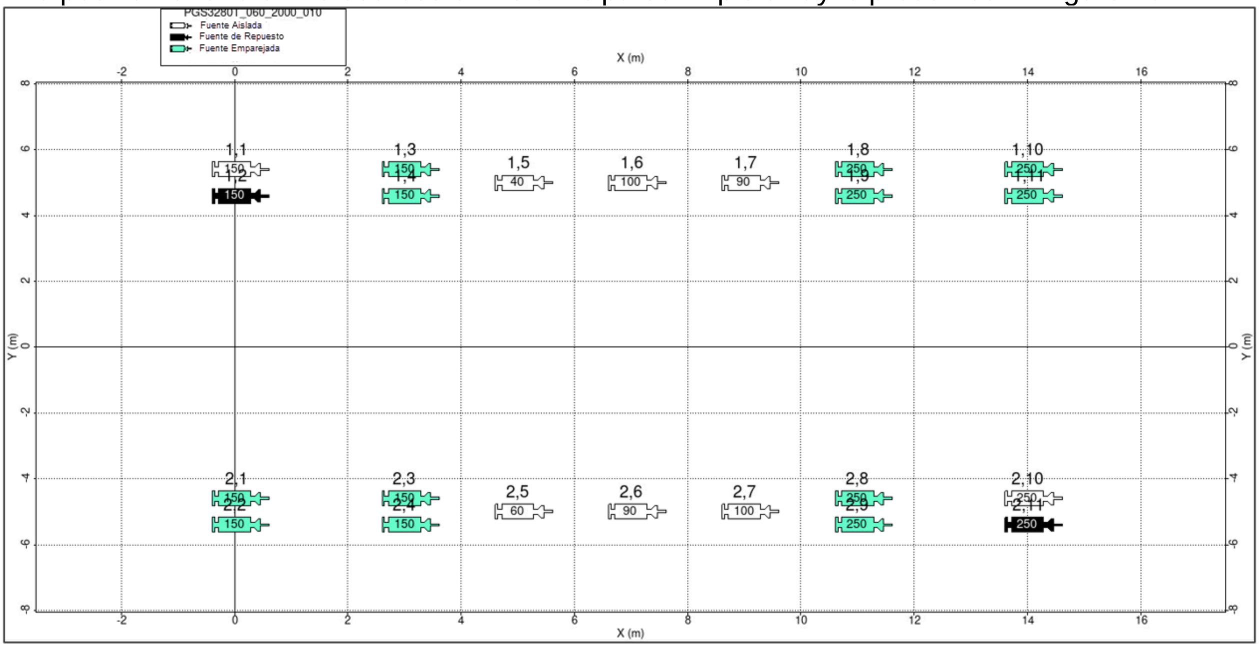


Figure 10. Emitting sub-array of the Triple array of compressed air power sources. 3,280 cu.in Volume.

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[4] Pounds-force per square inch (lbf/in2 abbreviated psi) is an Anglo-Saxon pressure unit. 1 psi = 0,6894757 Newton/cm² approximately.

[5] A Bar is a pressure unit which relates to the most common units as follows:

1 bar = 100.000 Pascal = 1,01972 kgf/cm²

1 atmosphere = 101.325 Pascal = 1,01325 bar

The Triple source is designed in such a way that each of the three 3,280 cubic inch (53.75 liter) sources sequentially emits in "flip-flop-flap" mode. The sequential emission interval for the Triple source is ~ Δ 15 m / Δ 6.5 s considering an average vessel speed of ~ 4.5 knots. The separation of each subset within a source is 10 m, while the individual sources are separated by 50 m, the distance between the two extreme sources being 100 m.

Section **Error! Reference source not found.** of this Chapter shall describe the emission of the array, and Chapter 6 shall analyze the propagation of the emitted sound.

There are only 2 source technologies on the market: Bolt made by Teledyne and G-Gun made by Sercel. The sources expected to be used are Type Bolt 1900 LLXT. Whichever geophysical contractor is selected, only one of these two emission technologies shall be used. Technical information on these sources is presented in the Annex to this chapter.

The array, whose output characteristics were superior to those corresponding to the Triple array provided, would not be used if the array used was modified.

The impulsive signal from these types of sources is approximately symmetrical. On the other hand, the source type has very little influence on the overall output of the matrix, and the 2 types that can be used are very similar.

The parameters that have the greatest impact on the output of the array are:

- Number of sources
- Volume of sources
- Operating pressure
- Geometric distribution of sources within the matrix

The influence of these parameters is as follows:

- Number of sources: There is a linear proportional relationship between the number of sources in a matrix and the strength (intensity) of the matrix, assuming all other variables are held constant. This implies that an array of 20 sources shall generate twice the output of a 10 source-array, assuming all other variables are equal.
- Volume - The output is quite proportional to the cube root of the total volume of the matrix (V1/ 3), that is, an 8000 cubic inch matrix shall only have twice the output of a 1000 cubic inch matrix.
- Operating pressure: there is an almost linear relationship between the intensity of the matrix and the pressure emitted. For example, a 3000 Psi matrix shall bear a pressure amplitude 1.5 times greater than that of a 2000 Psi matrix.
- In terms of the relative influence of these variables, the number of sources displayed in a matrix exerts the greatest influence on the source output (intensity), compared to the total volume and pressure of the sources.

The geophysical contractor shall gradually increase compressed air power sources ("soft start" or " ramp up") at the beginning of each line. This procedure allows a continuing increase in the sound levels generated by the compressed air devices until reaching the operational level before the survey for a 20/40 minute-period, to provide adequate time for the marine fauna to leave the area. The procedure to be applied is described in detail by Chapter 8 (see 2.1 ONBOARD MARINE WATCHER PROGRAM).

2.3 SEISMIC AND SUPPORT VESSELS

The use of a seismic vessel is foreseen for the acquisition. This seismic vessel shall be escorted by two support vessels, whose missions are different. One is the guard or follow-up vessel which shall guarantee the seismic vessel (and its array) a safe navigation, without interference with other vessels.

The other support vessel is a supply one. It shall be used to supply groceries, supplies and carry out crew changes. When this ship does not have to go to the port for groceries and / or crew, it shall also be supporting the seismic vessel or towing it upon emergency in its propulsion system.

Both support vessels are also very specific and special by design.

All hired vessels shall adhere to the four key conventions of the international regulatory framework applicable to the quality and safety of maritime transport, as revised by the International Maritime Organization (IMO):

- The International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS);
- The International Convention on Standards of Training, Certification and Watchkeeping, 1978, as amended (STCW);
- The International Convention for the Prevention of Pollution from Ships, 73/78 (MARPOL); and
- the Maritime Labor Convention (MCL2006), adopted by the International Labor Conference (ILC) of the International Labor Organization (ILO), to establish the rights of seafarers to decent working conditions and help create conditions of fair competition for shipowners.

Each vessel hired by Equinor shall undergo an environmental risk assessment covering pollution prevention, waste management and record keeping, in accordance with MARPOL standards and local legislation.

Equinor is committed to reducing waste and minimizing the impact of its operations on the environment and has historically associated with its contractors to comply with legal requirements and industry guidelines.

2.3.1 Seismic vessel

BGP Prospector

The BGP Prospector is a clean designed, high-capacity seismic vessel capable of towing up to 12 streamers. The vessel is a powerful seismic vessel with a towing capacity of 100 tons at 4.0 ~ 5.0 knots, with up to twelve streamers, ideal for acquiring 3D, 4D, broadband and wide azimuth large projects allowing a variety of acquisition geometries. Classification and HSE meet all DNV, SOLAS, IAGC and OGP requirements. All systems are designed and integrated to meet safe working requirements.

Key Features:

BGP PROSPECTOR	
General	
Ship owner	Prospector Pte Ltd
Flag	Bahamas
Port of Registry	Nassau
Year of built	2011
Class	DNV
ID N°	29868
IMO	9545986
Call sign	C6YF5
Length	100,1 m
Breadth	24 m
Draft	7,3 m (full load), 6,4 m (in the water)
Gross Tonnage	10732
Net Tonnage	3220
Maximum Speed	15 knots
Cruising Speed	13 knots
Fuel Capacity	3400 m^3 (see Anexo III for tank details)
Diesel Consumption	25-40 m^3
Autonomy	90 days
Fresh water	300 m^3
Production of drinking water	Yes
Engine	2 x RRM Bergen B32:40L8P CD
Total Propulsion	2x 4000kW
Propellers	2 x RRM Kamewa Ulstein
Bow Thruster	1 x One DNP power 883 kw
Power Generators	2 x 2880kw ABB
Emergency generator	NT855DM340, 175KW
UPS	MGE, 2x120KVA
Towing capacity	64 t
Minimum security crew certificate	14 crew members
Navigation and communication	
Radar	Kongsberg, S-Band 30 kw Kongsberg, X-Band 25 kw
Communications	Inmarsat C, F and VSAT
Crew Accomodation	
Total	66
Cabin types	28 simple cabins 19 double cabins
Life rafts	6 x 35 people, davit life rafts
Lifeboat	Norsafe 2 x 35 people

Figure 11. Seismic Vessel - BGP Prospector.

For more information on the BGP Prospector Vessel, see Annex III.

2.3.2 Support vessels

Tugboat (escort)

Candela S

Key Features:

Candela S	
Type	Tugboat
Call Sign	LW 3128
Flag	Argentina
Port of Registry	Buenos Aires
N° IMO/MAT	7509495
N° MMSI	701006646
Owner	Zapor SA
Building Year	1975
Gross Tonnage	543 T
Net Tonnage	101 T
a) L.O.A	44,71 M
b) Breadth Moulded	10,66 M
c) Depth Moulded	5,7 M
a x b x c/ 800	4
Freeboard	0.66 M
Height keel-top mast	29,17 M
Summer Deadweight	403 T
Draft for summer D.W	5,50 M
Summer Displacement	1286,81 T
Light Ship Displacement	1060 T
Main Engine	EMD / DIESEL
MCR	4288 KW/ 5800 HP
Propellers	4 blades / Fixed pitch 3070
Service Speed	10 Ns
Slop Tank Capacity	8,857 m3
Cargo tank Capacity	569,76 m3
Bollard Pull	60 T
Crane	26 T
Salvage tools	4 jumbo fenders/ others

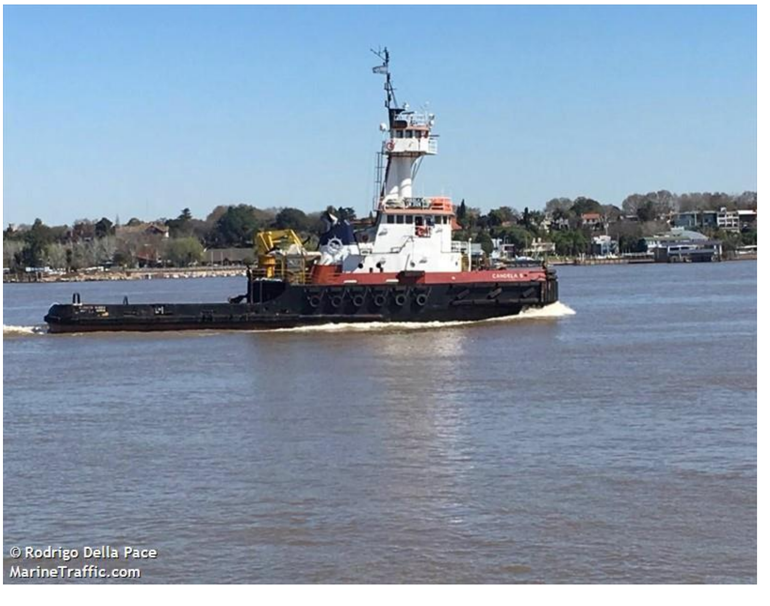


Figure 12. Tugboat – Candela S. Source:
https://www.marinetraffic.com/es/photos/picture/ships/2613216/7509495/shipid:12083

Para más información del Buque Candela S ver Anexo IV.

Supply Boat (*supply*)

Geo Service I

Key features:

Geo Service I	
Ship Owner	Longzhu Oilfield Services (S) Pte. Ltd.
Type	ABS +A1 (E) Offshore Support Vessel, +AMS, +DPS- 1
Port of Registry	Singapore
IMO	9621546
Official N°	397009
Call sign	9V9391
Length overall	59,25 m
Breadth Moulded	14,95 m
Depth Moulded	6,10 m
Fuel Oil	990 m^3
Fresh Water	230 m^3
Deadweight	~1335 t
Gross Tonnage	1736
Net Tonnage	520
Main Engine	2 x 2575 HP at 1600 RPM
Propulsion	2 x CPP, 2650 mm diameter in kort nozzle
Propeller Speed	212.60 RPM
Main Diesel Generator	2 x 245 kWe, 415V/3P/50Hz 0.8 PF
Fuel Oil Transfer equipment	For inter-ship with 90m hose
Crew accomodation (N° of bunks)	48

Figure 13. Supply Boat - Geo Service I.

For more information about the Ship Geo Service I, see Annex V.

2.4 SURVEY CHARACTERISTICS

The navigation orientation that makes it possible to cover the entire area in the shortest time is chosen, that is, the direction that allows longer acquisition lines, and reduces the time lost in leaving one navigation line and entering the next, with the consequent reduction of environmental and operational risks.

The CAN_100-108 area shall bear 75 acquisition lines with an average length of 110 km. The average time required to complete a production line shall be 15 hours. The CAN_114 area shall bear 60 acquisition lines with an average length of 77 km. The average time required to complete a production line shall be 11 hours. In both cases, the change of lines takes about 3.5 to 4 hours.

The search shall start from the extreme south of both areas. Preliminarily, operations are planned to begin in the easternmost sector of the CAN_100-108 area in order to keep operations as far away as possible from the CAN-107 border block, since the exploration of the SHELL operator would coincide temporarily in the fourth quarter. This shall be thoroughly defined in a coordinated manner between both companies closer to the start date as described in the Environmental Management Plan included in this study (see Chapter 8 /2.3.3.6 Coordination with neighboring explorations).

Figure 14 and Figure 15 show the navigation pattern or planned trajectory for data acquisition (for visualization at an adequate scale, see maps in Annex IX). Although the software used does not allow georeferencing of line changes, the information provided demonstrates that all line changes and turns shall be made within the "Operational Area".

In both cases, the distance between 2 adjacent survey lines on the grid is 750 m (Figure 14 and Figure 15). However, the boat turns in a semicircle with a diameter of 10 km or more after completing a line (due to the cables being towed behind the boat) (Figure 16). This means that the distance between 2 consecutive lines shall be 10 km or more, mostly.

The scope of work (number of vessel lines, line spacing, line length, duration of work, etc.) is independent of the geophysical contractor or selected vessel, so it shall not be affected by the definition of one or the other contractor.

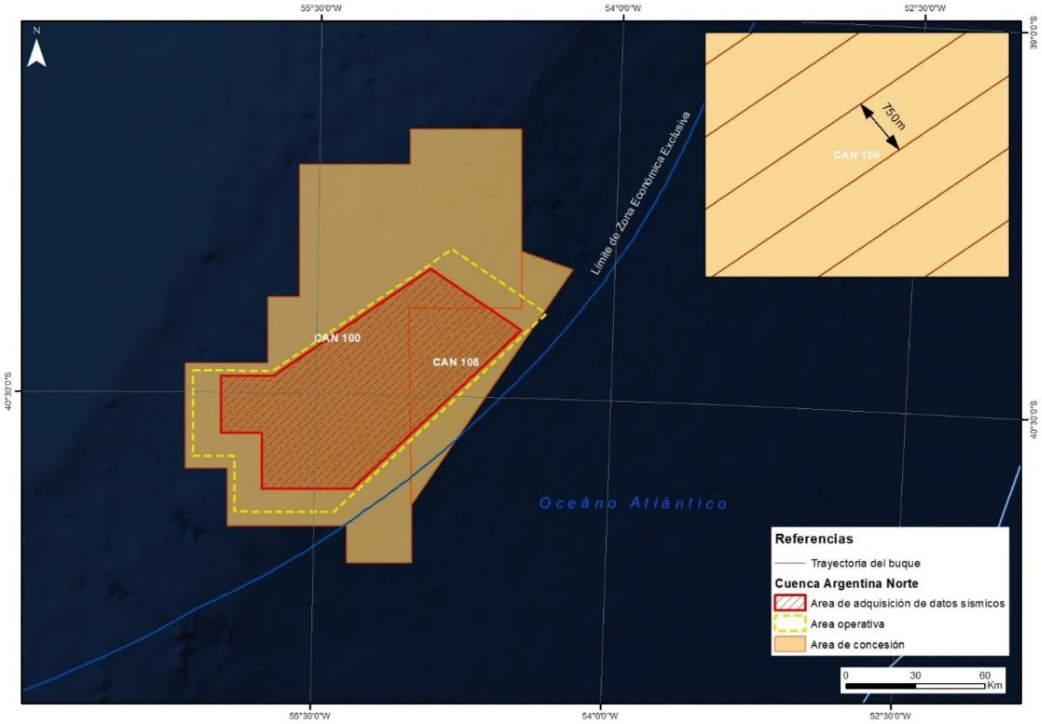


Figure 14. Navigation path for the CAN_100-108 seismic data acquisition area.

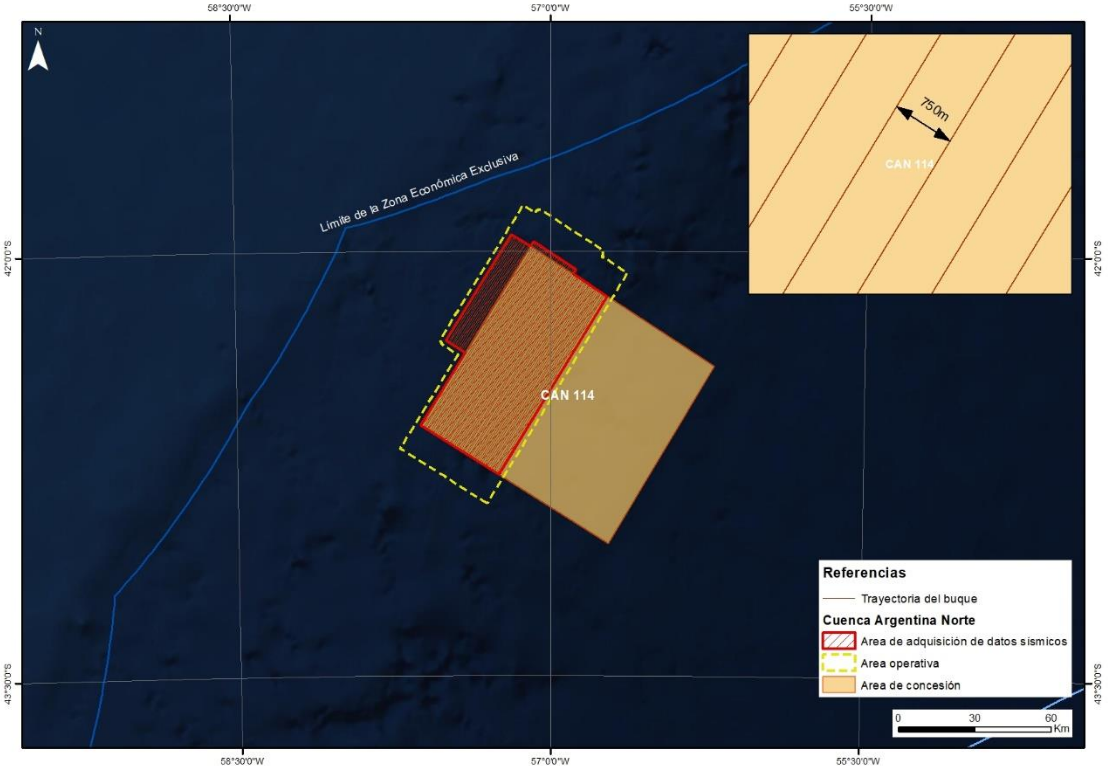


Figure 15. Navigation path for the CAN_114 seismic data acquisition area.

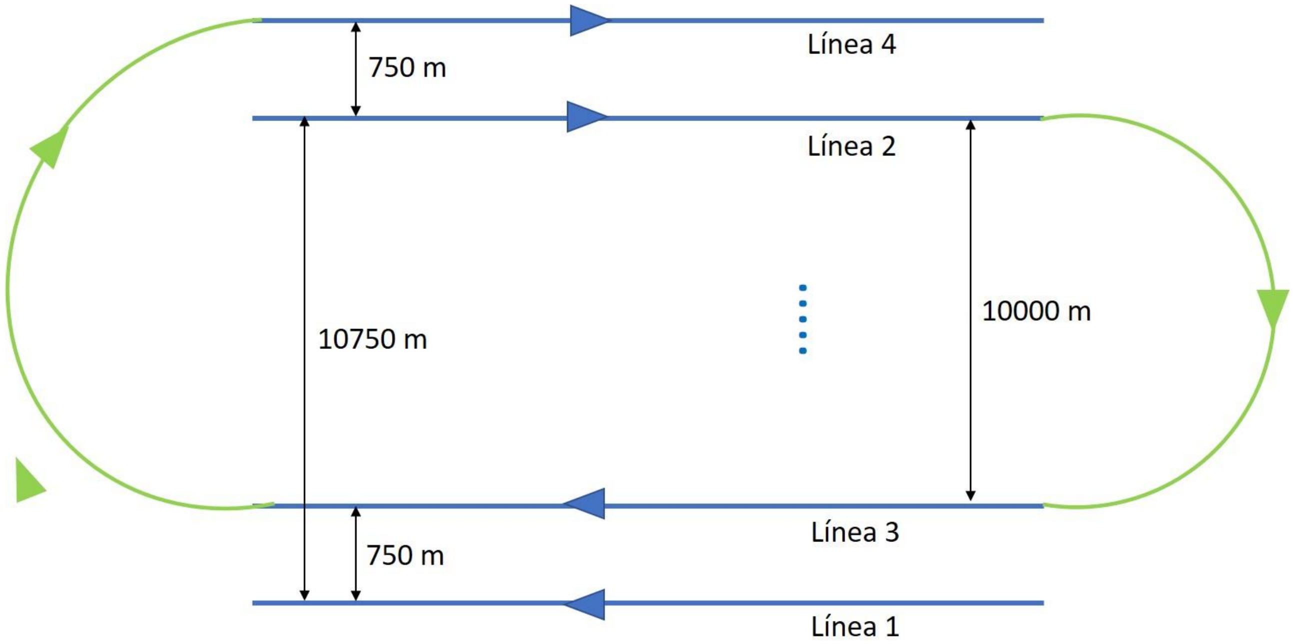


Figure 16. Distance between successive lines

The average speed of the seismic vessel is between 4 and 5 knots.

The operation shall take place 24 hours a day, every day of operation.

Safe operation of the seismic vessel requires a navigation exclusion zone of up to 4 km in front of the vessel and on each side, and up to 12 km behind, depending on the seismic equipment.

2.5 MOBILIZATION AND LOGISTICS

The seismic vessel shall be mobilized to the seismic acquisition area from the Port of Buenos Aires.

Once in the survey area, the seismic vessel shall receive fuel from the supply vessel approximately every 2 or 3 weeks, and shall also receive fresh food, supplies and newly acquired spare parts and equipment from the logistics vessel.

Mar del Plata shall be the port used for logistics services during the execution of the project, when fuel, fresh food and supplies are required. The waste generated on board shall be discharged in said Port and shall also be used for crew changes.

Crew changes shall be made through the logistics vessel at the port. The logistics vessel shall pick up the incoming crew to take them to the seismic vessel and carry the outgoing crew from the seismic vessel back to shore.

The project does not require the construction / development of logistics facilities on land, but uses those in existing ports with enough capacity to receive operations of this type. In these ports, the operations of the vessels associated with the project do not differ from those of any other vessel docking there.

The port of Buenos Aires shall only be used for mobilization (entry of the seismic vessel into the country) and demobilization purposes (departure from the country of the seismic vessel).

The seismic vessel shall be exclusively engaged in CAN_100-118 and CAN_114 areas during the campaign, so it is not expected to carry out activities other than those related to this project.

The following two figures show the routes used from the port to the study area:

- Buenos Aires Port Route (Figure 17): it is the "mobilization" and "demobilization" transit, which shall be carried out once at the beginning of the project and once at the end of it. This journey involves around 740 km (400 nautical miles) and 1.5 days of transit.

- Mar del Plata Port Route (Figure 18): "logistics" route of the support vessel. The support vessel shall move to the Port of Mar del Plata every 2 or 3 weeks on average. The journey between the port and the CAN_100-108 area involves around 330 km (180 nautical miles), 0.75 days of transit (18 hours) and 460 km (250 nautical miles) and 1 day of transit in the case of the CAN_114 Area.

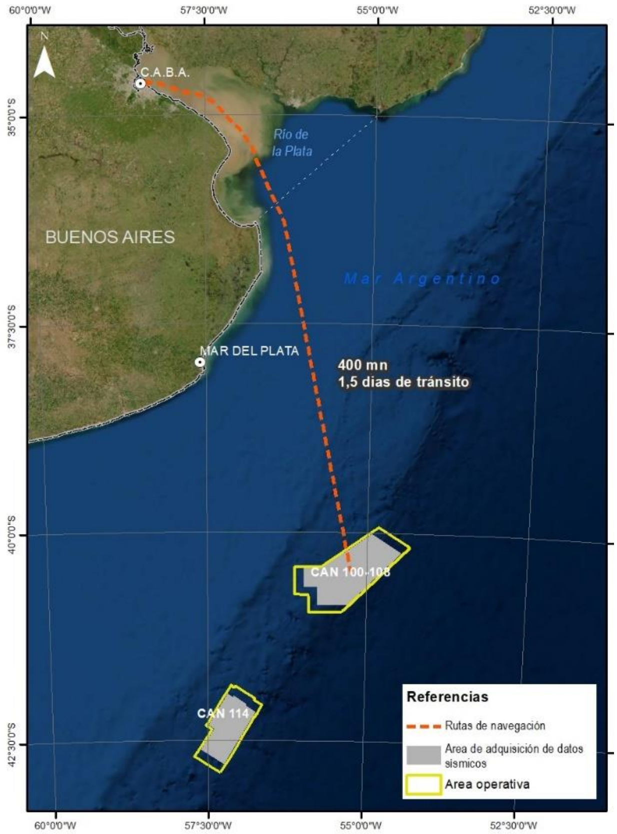


Figure 17. Port of Buenos Aires route, mobilization and demobilization route.

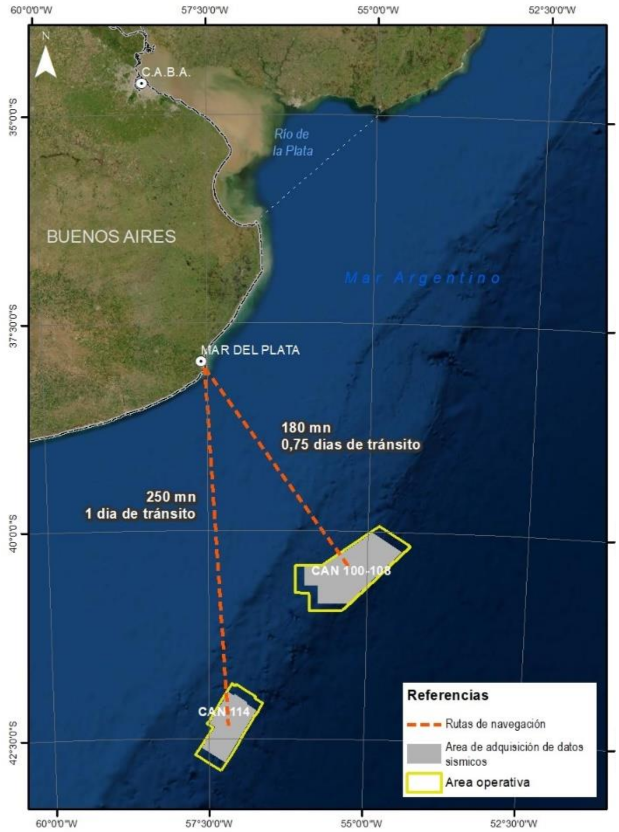


Figure 18. Port of Mar del Plata route, "logistics" route.

2.6 CREW

The crew of the seismic vessel shall be as follows:

- Approximately 33 members of the maritime staff, led by the Captain of the ship. The Captain shall be held liable for the entire seismic vessel and its crew.
- Approximately 26 seismic staff members, led by the "Group Leader" (offshore project manager).
- 1 Physician.
- 3 Equinor representatives, led by the "Lead Customer Representative".
- 3 MFO (Marine Fauna Observers)
- 1 PAM (Passive Acoustic Monitoring) operator

Thus, there shall be approximately a total of 67 crew members on board, but this number could slightly vary depending on operational needs and other limitations (for example, additional personnel could be mobilized in case someone is prevented from flying due to Covid-19 restrictions).

The monitoring vessel shall normally have about 6-8 crew on board, all of whom are maritime personnel, while the logistics ship in charge of resupply shall normally have around 12 maritime crew members.

It should be noted that the personnel involved in the project shall be highly qualified and experienced. Several Argentine Equinor representatives shall be on board the seismic vessel to supervise the work and ensure that everything is carried out according to Equinor standards.

2.7 CONDITIONS AND WORKING ENVIRONMENT

Working conditions are associated with offshore activities. The main risks are related to exposure to noise in engine rooms, low temperatures, wind, on deck radiation, falling overboard and potential drowning. All risks shall be permanently controlled through staff training, use of personal protection elements and compliance with procedures and instructions, in addition to the OLAS and IAGC standards on safety at sea.

2.8 EFFLUENTS, WASTE, EMISSIONS

The technical specifications of the tender require the use of solid-type seismic cables (streamers) and power supply from the ship. This avoids the possible oil and kerosene spills that non-solid streamers contain as fillers.

Due to their typical long periods of work, seismic vessels have the basic implements and the standards required by the IAGC, IMO and MARPOL 73/78 as to effluents and waste management generated by this type of operations.

2.8.1 Effluents

The main effluents generated in the vessels shall be the following:

- Treated greywater from sanitary effluents, for example, washing water, and laundry discharges;
- Treated waste water (blackwaters[6]);
- Treated bilge water [7] used to clean engine rooms and other potentially contaminated sources;
- Deck drains and storm water runoff; and
- Ballast water.

Greywater, wastewater and bilge water shall be treated and discharged in accordance with the applicable annexes to the MARPOL Convention. Greywater and wastewater (blackwater) shall be treated on board before being discharged into the sea.

The ships have an approved wastewater treatment plant which complies with IMO resolution MEPC 159 (55) on wastewater treatment plants and Annex IV of MARPOL. They also hold the International Prevention Certificate of Pollution by Dirty Waters (Table 4).

Table 4. Information on wastewater treatment plants.

Vessel	Type
BGP Prospector	Model: Evac MBR 24; IMO-No. 340.266; Serial No: 9142
Candela S	FAST M-1 8901
Geo Services 1	ST-50U / Manufacturer: Hansun (Shanghai) Marine Technology Co. LTD

All deck fuel fillers have a fixed drip collection tray. All drips accumulate in the bilge. These fluids (including engine wash water) are then processed by the bilge water separator. All separators must comply with MARPOL rules, an agreement to which Argentina is a signatory as a Nation, and in turn must be authorized by the Argentine Coast Guard (PNA), a National Maritime Police.

The maximum oil concentration in the sea is 15 ppm pursuant to Regulation No. 15/98 of the Argentine Coast Guard, Volume 6, Environmental protection regime, Prevention of water pollution, etc. Article 2, Section 2.1.

The minimum flow is 2.5 m3 /hour up to a gross tonnage of 6000 T according to Regulation No. 4/97 of the Argentine Coast Guard, Volume 6, Environmental protection regime, Regulations for the determination of the minimum discharge flow of the engine room through the separating and / or filtering equipment.

[6] Blackwater is used to describe wastewater containing faeces, urine and toilet discharge water along with toilet paper.

[7] Bilge water is water collected in the lower section of the vessel. One of the main contributions to bilge water is the cleaning of a ship's engine rooms. Therefore, this water may be contaminated by oils and other substances.

The sewage effluents must comply with the Argentine Coast Guard Regulation No. 03-14 (DPAM), Volume 6, Regime for environmental protection, Standards to prevent contamination by dirty water from ships.

2.8.2 Waste

The crew's food waste shall be reduced to less than 25 mm to be subsequently discharged 12 nautical miles away, as stated by MARPOL 73/78 Regulation.

Non-hazardous solid waste includes: plastic packaging, glass, paper, wood, kitchen waste (not food), and miscellaneous household waste. Most of this waste shall be incinerated at the ship's facilities or, failing that, shall be compressed and packed to be transported to port. The required management shall be carried out with a licensed contractor at the Port.

Hazardous waste includes: used oils and lubricants, fluorescent light tubes, oil filters, plastic or metal containers that have contained hazardous substances. All these hazardous waste or garbage must be classified by type, compacted when possible, and stored on board before being transferred to a qualified and duly authorized contractor for final disposal on land.

The table below shows an estimate of the volume of waste that each ship generates per day.

Table 5. Estimation of waste per ship / day.

Waste stream	Classification		Estimated volume per day in m^3		
			BGP PROSPECTOR	Candela S	Geo Services 1
Non-hazardous waste	Food Leftovers		0,02	0,02	0,01
	Plastic		0,005	0,02	0,01
	Household waste	Paper	0,02	0,001	0,001
		Glass	0,0001	0,001	0,001
		Wood	0,05	0,05	0,03
	Ashes		N/A	NA	NA
	Cooking oil		N/A	0,0005	0,0005
Hazardous waste	Operating waste	Oily Waste (Rags / Filters)	0,01	0,02	0,01
		Fluorescent tubes	0,007	0,007	0,007
		Medical waste	0,0005	0,0005	0,0005
		Spray cans	0,0005	0,0005	0,0005
		Hazardous waste (oily waste, etc.)	0,01	0,005	0,005
		Oily waste / sludge	0,2	0,17	0,01
	Electronic Waste		0,00001	0,0001	0,0001

All ships have adequate storage areas that prevent the involuntary discharge of waste and avoid cross-contamination of hazardous waste with non-hazardous waste.

Waste is stored in Flexible Intermediate Bulk Containers (FIBC) before being transferred to shore. The FIBCs are secured in a safe place on deck.

The Geophysical Contractor, as responsible for the seismic operation, shall keep a log on board the ship of all the classified and produced garbage during the seismic campaign for each shipment that is delivered to land. Afterwards, the authorized contractor must keep a receipt log and the certification of said delivery from the local authority.

2.8.3 Gaseous emissions

Engines / Fuel

The main source of atmospheric emissions during the seismic acquisition program shall be the burning of fuel (MGO) from Marine Gas Oil to power the electric motors, compressors and generators on board the seismic and support vessels.

The gases emitted by the fuel combustion processes include:

- Carbon Dioxide (CO_2)
- Volatile organic compounds (COV)
- Nitrogen oxides (NOx)
- Carbon monoxide (CO)
- Sulphur Oxides (SOx)
- Suspended Particulates
- Methane (CH4)

Incinerators

Certified incinerators shall be used during the project.

Vessel	Type
BGP Prospector	TeamTec Incinerator Type: OGS200C
Candela S	None
Geo Services 1	None

All emissions from ships shall comply with the MARPOL 73/78 standard for the prevention of atmospheric pollution from ships (Annex VI), in order to reduce global emissions of SOx, NOx and particles.

All engines and generators shall be used in accordance with the Ship´s Energy Efficiency Management Plan and ships must also submit their International Certificates for the Prevention of Atmospheric Pollution.

All fuel supplies shall be strictly controlled to reduce emissions and all ships 'engines, diesel generators and compressors shall be maintained in accordance with the manufacturer's guidance and the ships Preventive Maintenance Systems.

Engines and equipment shall shut down when not in use.

Low sulfur MGO shall be used according to MARPOL.

2.9 NOISE

The noises generated by the project can be classified into those noises that are generally emitted by any ship in operation, and those generated by the submarine emission of compressed air energy sources for seismic surveys.

2.9.1 Aerial sound emission

The human ear has a dynamic range, from hearing threshold to pain threshold, of approximately 130/140 dB (decibels). Range is determined by physical limitations; the lower limit is restricted by natural background noise, and the upper limit, by displacements of sensory structures associated with hearing to a degree that causes traumatic damage.

As a reference, ambient noise inside a typical machine room is around 80 dB noise level equivalent to the human ear, using cup-type hearing protectors, measured in octaves from 125 Hz to 8000 Hz. Without hearing protectors and integrating the entire frequency band (audible and non-audible) for 1 minute, a maximum of 108 dB scale A results, once being 1 meter away from a typical motor-generator.

Since people can talk quietly on deck (60 dB represents normal conversation) and can hear each other clearly, no noise measurement or air sound propagation calculation is required.

2.9.2 Underwater sound emission from the compressed air sources of a seismic vessel

2.9.2.1 Glossary of terms and metrics used

Source Force

The source force is the maximum acoustic pressure radiated by a marine seismic source measured in MPa-m (megapascals 1 m from the source), or in Bar-m, either in a given frequency band or in the totality of significant frequencies.

The conversion is 1Mpa = 10 Bar.

The Bar unit is named after the American inventor Alexander Graham Bell (1847-1922).

Sound Pressure Level (SPL) in dB (decibel)

Since human and animal hearing aids perceive a very wide range of pressures, sound is measured on a scale based on the logarithm of the ratios between measured pressures and a reference pressure. Although it is possible to measure sound intensities directly, it is easier to measure pressures and then convert them to intensities, which are proportional to the squared pressure.

The decibel scale (dB) is used so that the sound pressure level (Sound Pressure Level - SPL) of a sound pressure p can derive in the following formula

$$SPL(dB) = 10\log\left(\frac{{p^2}_{rms}}{{p^2}_{ref}}\right) = 20\log\left(\frac{p_{rms}}{p_{ref}}\right) \quad [1]$$

where p_{ref} is a reference pressure and prms is the root mean square value of the pressure, which is an average value over the duration of the pulse.

The concept of decibel (dB) has no physical meaning unless the reference quantity is indicated. The technical and scientific literature normally measures sound in water in decibels (dB) relative to 1 microPascal (1 μPa). It should be mentioned that an effective sound pressure of 20 μPa is used as a reference in air, which is approximately the threshold of human hearing at 1 kHz, so the value for the same pressure is approximately 26 dB lower in air than in water.

Sound levels expressed in decibels have several advantages:

- the quotients between pressures or intensities simplify the treatment of quantities with large ranges of variation,
- logarithms simplify calculations since multiplication and division are transformed into addition and subtraction and
- the mechanism by which the ear processes relative sounds can reach the logarithmic scale.

In underwater acoustics, the emitted sound level is specified 1 m away from the source. Therefore, the appropriate reference for sound levels should include the number of decibels, the reference level and the distance to the source, although different ways of indicating this are usually used, for example:

SPL = 200 dB re 1μPa @1m o 200 dB re 1μPa a 1m o 200 dB re 1μPa-1m o 200 dB re 1μPa-m

which means 200 dB, relative to 1μPa, 1 m from the source.

Peak-to-Peak Acoustic Pressure (p-p)

The acoustic pressure generated by a seismic array can be expressed by means of different units.

The numerous publications on the effects of noise on biota are sometimes confusing when it comes to making comparisons between results, since the selection of units is not clearly indicated.

The peak-to-peak pressure (pp) is frequently used in geophysics, which is expressed in MPa-m (or Bar-m) and means the difference between the positive peak and the negative peak of the acoustic pulse generated by the array.

This naming applied to a seismic array expresses the acoustic pressure generated by all sources in the array, as if it were concentrated at a point (nominal), and therefore, it is indicated as acoustic pressure in Bar @ 1 m from the source (array).

The value of pp in Bar-m can be converted to the sound level of the SPL source in dB re 1 Pa-m as follows:

SPL (dB re 1μPa-m) = 20 log (p-p) + 220 [2]

The indicated value of 220 dB re 1μPa-m is the lowest value of SPL (sound pressure level) emitted by a typical small source with a pressure of 1 Bar-m, due to the change of Bar-m units regarding the reference value of 1μPa-m.

Indeed, if the pressure emitted by an individual source is equal to 1 bar-m, the SPL is 20log (1 bar-m / 1μPa-m) = 20log (1011 μPa-m / 1 μPa-m) = 20log (1011) = 220 dB re 1μPa-m.

Normally, the emission from a single source can reach even higher values, for example, if the pressure were 2 Bar-m, a value of SPL (pp) = 226 dB re 1μPa-m would apply.

A typical pressure of an emission of 100 bar corresponds to 260 dB re 1 μPa. The SPL value for a complete source arrangement usually ranges from 250 to 263 dB re 1μPa-m.

Zero to Peak Acoustic Pressure (0-p) (SPLpeak or SPL pK)

The zero-peak (0-p) acoustic pressure represents the amplitude measured between zero and the positive peak.

Typically, the SPL values calculated from the acoustic pressure pp are approximately 6 dB higher than those calculated from the acoustic pressure 0-p, this value being exact in case both peaks have the same intensity (Greene 1998; McCauley and others 1998, 2000).

Given that the thresholds of affectation to the biota are expressed according to zero to peak acoustic pressure, all the analysis shall be carried out using this metric.

Acoustic Pressure (root mean square) rms

As previously indicated, the acoustic pressure (rms) represents the average of the acoustic pressure over the duration of the pulse.

Mathematically, it is the square root of the integral in squared pressure time:

$$SPL(rms) = \sqrt{(\frac{1}{T}\int_0^T |p(t)|^2 dt)} \quad [3]$$

Where T is the duration of the signal and p (t) represent its pressure values.

Comparison between acoustic pressure values measured at the same point and generated by the same array show SPL values (rms) typically 10 to 12 dB lower than those 0-p - SPLpeak (Greene, 1998; McCauley et al., 1998, 2000).

Since the rms values depend on the duration of the pulse and this depends on the distance to the source and the propagation conditions of the environment, the calculation of the rms values requires specifying all the variables to make adequate comparisons between units.

Sound Exposure Level SEL (Sound Exposure Level)

SEL is a measure of the energy of an acoustic signal, so it depends on both its amplitude and its duration. It is calculated as the integral of the squared instantaneous pressure values, restored to a squared reference pressure for 1 second. Thus, for underwater sound measurements the SEL is referenced to 1 μPa² s. The formula is as follows:

$$SEL = 10\, log(\int_0^T |p(t)|^2 dt) \quad [4]$$

Where T is the duration of the signal and p (t) are its pressure values.

The SEL units are dB re 1 μ Pa^2 s.

It is a useful metric for evaluating cumulative exposure, as it allows sounds of different duration to be compared in terms of total energy, sometimes with multiple exposures. There are methods to add the energy in multiple exposures to generate a single "equivalent exposure" value, which generally does not involve hearing recovery between repeated exposures.

Both SEL and SPL (rms) are calculated through the squared pressure integral, so they are related by a simple expression that depends only on the T duration of the energy pulse (in seconds):

SPL (rms) = SEL – 10 log10(T) [5]

Although the units of SEL and SPL are different, the numerical value of SEL is typically 20 to 25 dB lower than SPL peak, and 10 to 15 dB lower than SPL pressure (rms) for T duration signals between 30 -100 ms (= integration time).

In this case, and considering a pulse duration of less than 30 ms, 15 dB would be the difference between SPL (rms) and SEL. However, the conservative criterion normally used in the bibliography, a pulse of about 100 ms in duration, corresponds to a difference between SPL (rms) and SEL equal to 10 dB, resulting in a 20 dB difference between the SPL peak and the SEL. In general, this difference could reach up to 25 dB, at the most.

The SEL and SPL (rms) values concur for those signals that last 1 s, as it emerges from the Log10 (1) = 0 equation (Ministry of Agriculture, Food and Environment of Spain, 2012). This may be the case of more than 10 km-distances from the source, since the individual components of the waveform do not differ, and the overall waveform can last one second together with multiple reflections.

2.9.2.2 Emission characteristics from seismic prospecting arrays

Energy spectrum

Most of the sound energy produced by a series of shots amounts to 10-300 Hertz (Hz), with the highest levels at frequencies below 100 Hz (Turnpenny and Nedwell 1994). The calculated source level depends on the frequency range over which the acoustic pulse is measured. Arrays of compressed air power sources are frequently measured between 0 and 125 Hz or between 0 and 250 Hz. There may be a slight underestimation of the total energy for these bandwidths, but the error is small because while the signal from compressed air power sources extends above 250 Hz, reaching frequencies within the kHz band, it has a very low-pressure level in that range.

Oscillating bubbles turn up when compressed air is suddenly discharged into the water. Initially, the pressure inside the bubble exceeds the value of the outer hydrostatic pressure. The bubble therefore expands beyond the point at which the internal and hydrostatic pressures are equal, whereby, when the expansion stops, the internal pressure is less than the hydrostatic pressure, and the bubble begins to collapse.

The collapse again generates a pressure higher than the hydrostatic, and the cycle begins again, the bubble continuing to oscillate within the range of tens to hundreds of microseconds.

Oscillation stops due to frictional forces, and the buoyancy of the bubble causes it to break at the surface of the water. If this cyclical movement could be stopped immediately after the first bubble expansion, an ideal signal with a single peak would be generated, but this does not happen in reality.

The time series of pressures emitted by a compressed air power source in a vertical direction is called the “signature” of pressures. However, another pulse is simultaneously directed upward from the source, reflected off the sea surface, and combined with the original pulse traveling downward.

This time-delayed pulse, reflected off the surface, is known as the "phantom" source. From an information processing point of view, this pulse is considered an intrinsic property of the source wave field, and is included in the definition of the pressure signature.

As previously stated, the total volume of compressed air power sources, and their operating pressure, determines the amplitude of the acoustic signal, measured as the Sound Pressure Level (SPL).

The figure below displays the pressure signature of a 40 cu.in. (0.66 liters) compressed air power source, which shows the measurement of the pressure shock generated by the discharge of air, followed by several oscillations resulting from the repeated collapse and expansion of the air bubble. The amplitude of the signal corresponding to the initial forward wave and the first bubble are P and B, respectively. The near-field relationship between the initial peak and the bubble is PBR = P / B.

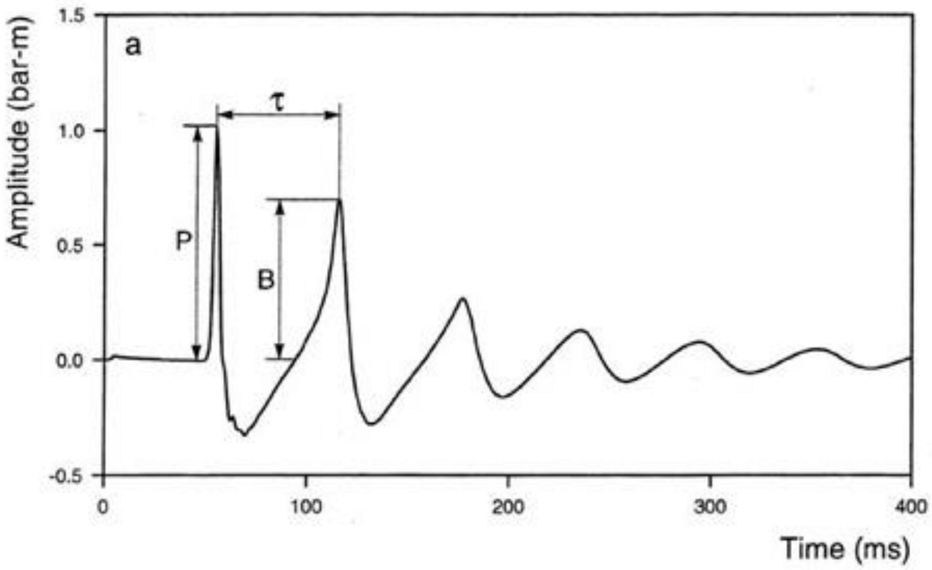


Figure 19. Pressure signature of a compressed air power source in the near field.

The far-field pressure signature illustrated in the figure below, showing the effect of the phantom source. The pp amplitude (the distance between the positive peak of the primary signal and the negative peak of the phantom signal) is 2.3 bar-m.

The peak-to-bubble ratio in the far field is PBR = pp / BB = 1.9. The PBR should be as high as possible so that the matrix signature of compressed air power sources is close to an ideal pulse. The bubble period in this case is*T*=60 ms (Langhammer, 1994).

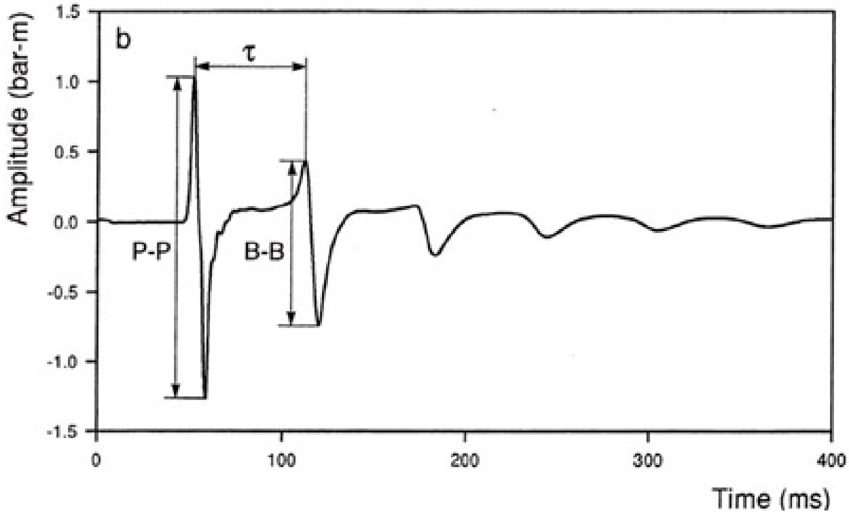


Figure 20. Pressures signature of a compressed air power source in the far field.

Compressed air power supply series typically have a combined volume of 2,000 to 5,000 cubic inches and operate at approximately 2,000 pounds per square inch (PSI). The sound produced by these elements is a function of the volume, size and shape of the "ports" through which the air escapes, and due to the air pressure.

An example of pressures typically generated by compressed air energy, measured 10 m deep and 3,000 m from the source, is presented in the following figure:

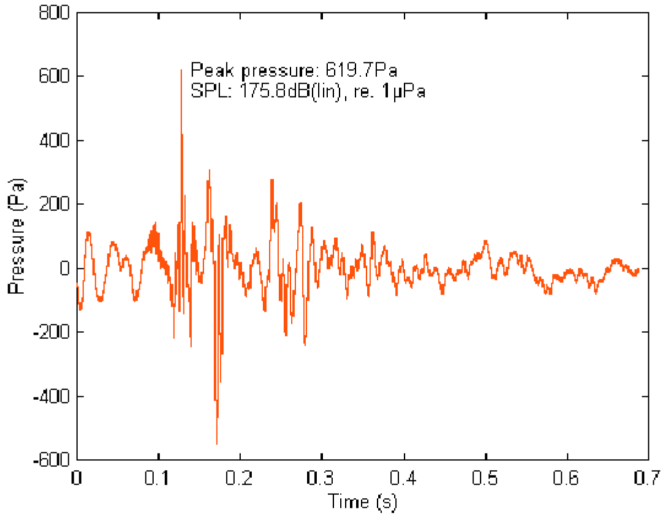


Figure 21. Typical sequence of compressed air energy pressures (Nedwell J. et al., 1999).

The design of the display of compressed air energy sources and the succession of energy released is carefully done to optimize the reception of data.

There are several reasons for deploying compressed air power sources in arrays. The first is to increase the power of the source. The basic idea is that a source matrix of n unique sources produces n times the power of the single source.

The second is to minimize the PBR by tuning the matrix: compressed air power sources with different volumes will have different bubble periods, resulting in a constructive sum of the first (main) peak and the destructive sum of the bubble amplitudes, as can be seen in Figure 22, where the pressures of the different elements of the array are illustrated in color, and the result of their destructive cancellation in white.

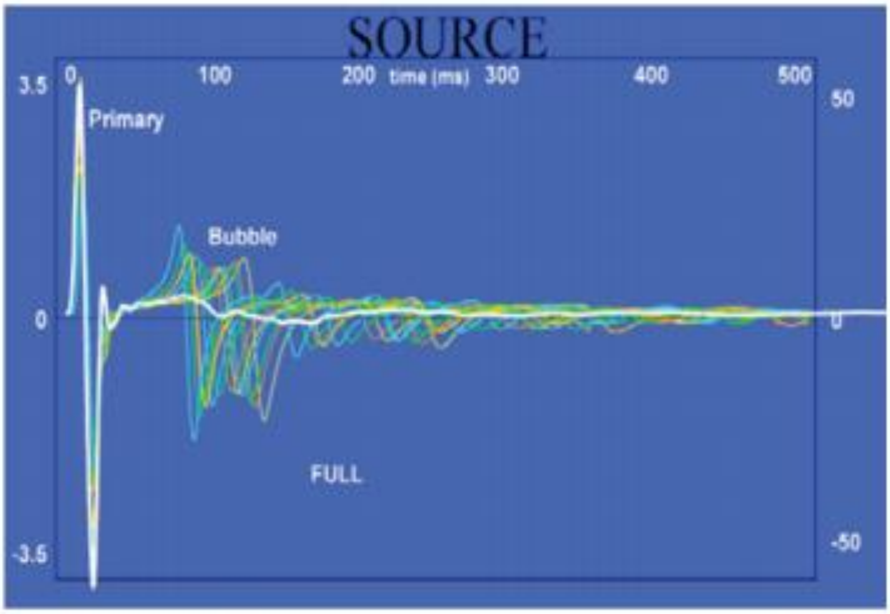


Figure 22. Destructive interference of phantom pressures in an array (Gisiner, 2016).

The energy spectrum describes how it is distributed in frequency. The general steps to generate the energy spectrum are based on the time series of the signal [μPa] in a T [s] time frame. Then the Fourier Transform [μPa / Hz] is computed, the amplitudes [μPa2 / Hz2] are squared and divided by T [resulting in μPa2/Hz]. If T = 1 second, the energy is computed in 1 Hz wide uniform bands. The units of the SEL energy spectrum at 1 m from the source are dB re 1μPa^2 /Hz re 1 m.

Far Field

The array's Far Field Signature (FFS) is the observed theoretical signal output from a recorded source in an infinite body of water.

The FFS of both source arrays presented in this study are based on earlier studies by Ziolkowski et al (1982) and have been implemented in the commercial package Nucleus + Marine Source Modeling (Masomo) version 2.8.0.

All sources typically have Near Field Hydrophones (NFHs) located 1 m above. The waveform recorded by the NFH is used to calculate the theoretical signature of each air source, which takes into account the phantom source, and the interaction between neighboring sources.

The theoretical signatures of the sources are then propagated at an arbitrary distance of 9,000 m below the source matrix and are added up to represent a specific source at that far-field position, where the output signals of individual compressed air power sources constructively interfere. This is then propagated backwards to obtain the theoretical waveform 1 m from the source, taking into account the drop rate in sound pressure according to the distance.

Consequently, the far-field signature of a compressed air power source array, measured vertically below, is used to define the nominal source level. This is the sound pressure 1 m away from a hypothetical equivalent source point that would radiate the same amount of sound in the far field as the actual source Units are in Bar at 1 m, abbreviated as Bar-m.

This nominal point source level is a theoretical sound pressure level. Due to partial destructive interference between signals from individual compressed air power sources, the actual level at this point actually tends to be 10 times (20 dB) lower than the nominal level. The difference is illustrated at a 10 meter-distance by Figure 23 (Long, 2019).[8]

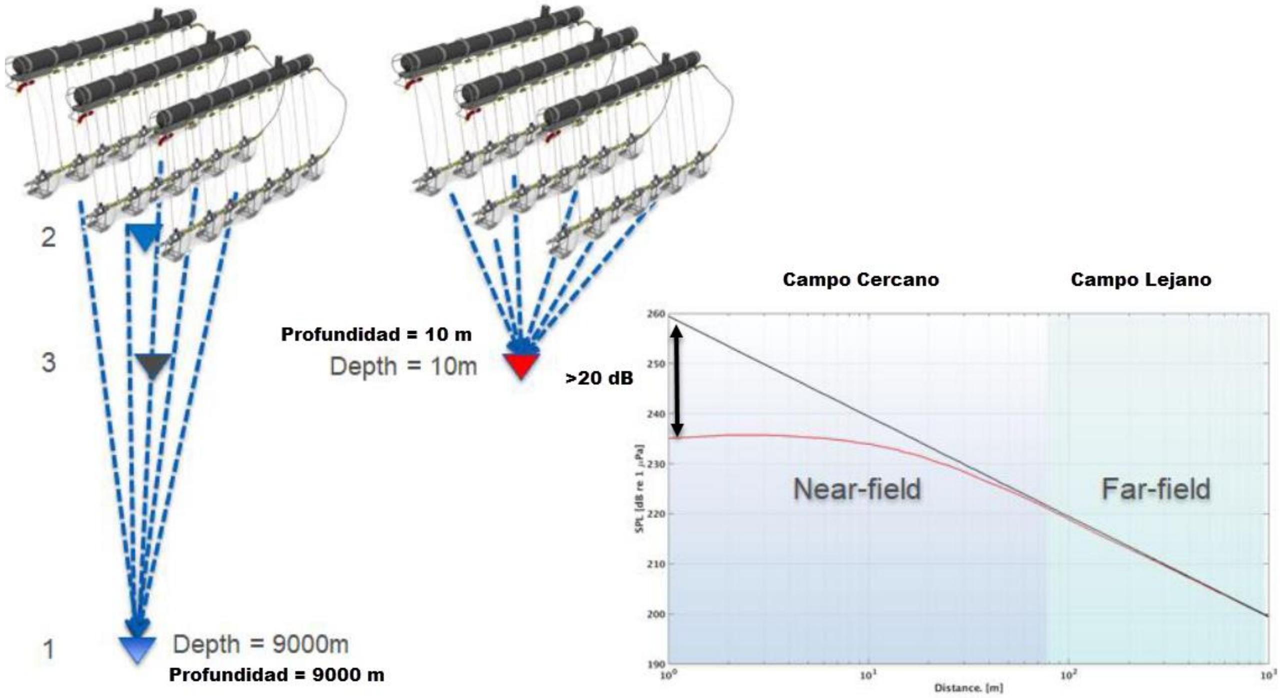


Figure 23. Comparison of how the received sound levels from a source matrix located 10 m below the matrix could be calculated using the definition of the far-field signature (left- black line) versus what would actually be recorded (right - Red line). Adapted from Long (2019)

The p-p intensity (related to this nominal source level) is defined as the difference in absolute amplitude between the peaks of the primary and phantom signals.

Level near the source

Source Level (SL) is a convenient way to normalize sound pressure measurements and is useful as a unique number to characterize the combined acoustic output of the array. However, since the array is not a specific source, but rather an array of sources spaced apart, the actual sound pressure that can be measured within the array (in the near field) is always considerably less than the combined sound level. Even for the largest arrays used in the industry, with nominal sound levels above 260 dB re 1 µPa-m, the pressures within the array do not exceed 240 dB re 1 µPa pp (Caldwell & Dragoset, 2000). This aspect is of particular importance when analyzing the potential of sounds to inflict damage on marine mammals as they approach the array (Boertmann et al, 2010).

[8] https://www.pgs.com/globalassets/technical-library/tech-lib-pdfs/industry_insights2019_04_air-gun-fundamentals.pdf

The acoustic pressure is measured at a certain range (distance) for large sources such as seismic arrays, and a sound propagation model is applied to calculate what the sound pressure would be at 1 m from the source if it behaved like a specific source. This methodology applies to both SPL and SEL values.

Directional dispersion of energy

Air source arrays for seismic exploration are designed so that most of the energy is directed vertically towards the seabed (desired effect), although some of it is horizontally directed (undesired effect). Sound levels emitted vertically are at least 15-24 dB higher than those horizontally directed (Caldwell and others, 2000).

The following figure illustrates typical sound pressures transmitted in different directions:

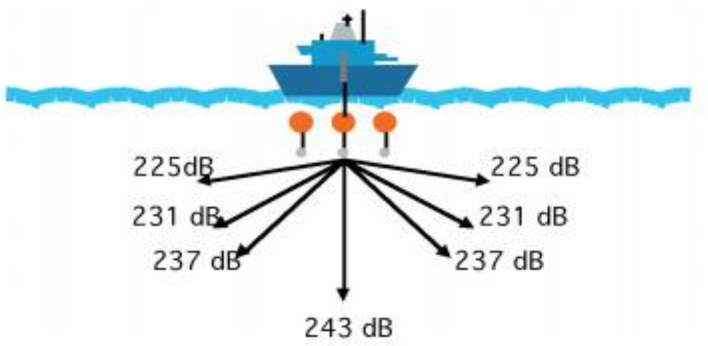


Figure 24. Sound pressures transmitted by an SPLpeak = 260 dB re 1 µPa-m array (Gisiner, 2016).

The Technical Document on impacts and mitigation of marine noise pollution (Ministry of Agriculture, Food and Environment of Spain - 2012), indicates that the nominal vertical emission level, on the vertical axis, for seismic cannon systems can reach values up to about 260 to 262 dB (pp) re 1 µPa @ 1 m. This level decreases as the direction of propagation veers from vertical (towards the bottom) to horizontal (towards the sides of the array), mainly for low frequencies, where it is reduced by around 20-60 dB (depending on the dimensions and spatial placement of the sources). In contrast, mid-high frequencies are best transmitted in the horizontal level. (Parkes y Hatton 1986, Caldwell and Dragoset, 2000).

Octaves and thirds of Octaves

The octave term is taken from a musical scale, corresponding to the interval of frequencies between a given frequency and twice that. The octave can be divided into smaller intervals such as the half octave or the third octave, obtained by dividing by 2 or 3, respectively, the segment that represents an octave on a logarithmic scale.

Then the third of an octave is the frequency interval between the given frequency and the one calculated by multiplying it by $2^{1/3}$. Analysis in thirds of an octave is common because it approximates the spectral processing of the human ear, so it is the best hint we have as to the functioning of other mammals´ ears.

On a logarithmic scale, all octaves are the same length. The relationship between the geometric intervals corresponding to an octave and a third of an octave is (log2) / (log21 /3), which is exactly equal to 3, and hence its name.

The position of any of these intervals is usually indicated by giving the central frequency (fc) of the interval on the logarithmic scale, which corresponds to the geometric average between its initial (fini) and final (ffin) frequencies). Therefore, the relationships between these frequencies for each type of interval are as follows:

Octave: $f_c = f_{ini} \sqrt{2} = f_{fin} / \sqrt{2}$ [6]

Third of Octave: $f_c = f_{ini}\ 2^{1/6} = f_{fin} / 2^{1/6}$ [7]

The standard list of central frequencies of the contiguous thirds of an octave is obtained starting from 1 kHz center frequency, dividing or multiplying by the 2 1/3 factor as many times as necessary to cover the entire spectrum of the signal and rounding the resulting values.

The series of thirds octave frequencies between 100 and 1,000 Hz is as follows: 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000 Hz.

Comparison of sound levels in air and water

Given that the acoustic impedance of the environment (z), which is the resistance it opposes to propagating sound waves, is different in the sea (1.5106 Rayls or Pascal.s / m) than in the air (415 Rayls), and that the relationship between intensity and pressure in free field is given by the expression I = p2/ z, the same pressure exerted in the sea causes a 36 d- intensity greater than in the air (10 log (1, 5106/415) ≈ 36 dB).

Therefore, there are two main reasons why sound levels cannot be directly transformed in the sea and in the air.

The first is due to the fact that variations in the density and speed of sound in each environment cause changes in the transmission of acoustic pressure. In order to correct these effects, 36 dB must be added to the level measured in air.

The second reason is given by the different reference levels used to calculate the level of signals in water (re. 1 μPa) and in air (re. 20 μPa), which translates into 26 dB.

Therefore, as a consequence of changes in the reference pressure and in the impedance of the environment, a p pressure shall cause a I (dB) intensity in the air and I + 62 dB intensity in the sea. A short exposure to 140 dB in air is considered the approximate threshold for permanent damage to humans.

However, given that the adaptations of the acoustic physiology of marine fauna to receive sound are not known, the best practice is not to extrapolate the impacts that the same sound levels could have on sea and air. For this reason, specific studies have been carried out on the impacts on marine biota that are discussed in the following chapters.

Background noise level at sea

The sound sources in the sea are many and varied, for example:

- Wave-shoaling;
- nonlinear interactions between gravity waves passing through each other (known as "microseisms");
- Precipitations (rain, snow or hail);
- violent geological or meteorological activity, such as lightning, hurricanes, earthquakes, or volcanic eruptions;
- other physical processes associated with the behavior of ice on the sea surface;
- marine mammals and other organisms;
- anthropogenic sources, such as sonars, boats or industrial activity.

A graphic of typical levels of the ambient noise spectrum is shown in Figure 25 (Ainslie, 2010) illustrating the varied nature of underwater noise sources. Different parts of the spectrum tend to be dominated by different but specific noise sources. For example, between 300 Hz and 100 kHz, the dominant noise source is often wind-related, while at a slightly lower frequency (30-300 Hz) the strongest component is often due to distant boat traffic. The noise of rain, when present, tends to peak at a few kilohertz.

Biological noise can be broadband, but it can also contain strong spectral peaks (eg around 20 Hz due to blue whales and fin back whales (rorquals).

There is growing evidence that low-frequency sound levels at sea (around 40 Hz) have increased on average up to 3 dB per decade between 1965 and 2003 (McDonald et al., 2006).

This increase is due to a doubling in the number of commercial vessels during that period (from 41,900 to 89,900 vessels) and a nearly four-fold increase in their gross tonnage (from 160 to 605 million tons).

A similar increase in peak levels in whales has been observed (McDonald et al., 2006). The peak frequency of observed blue whale vocalizations decreased from 22 Hz to 16 Hz during the same period.

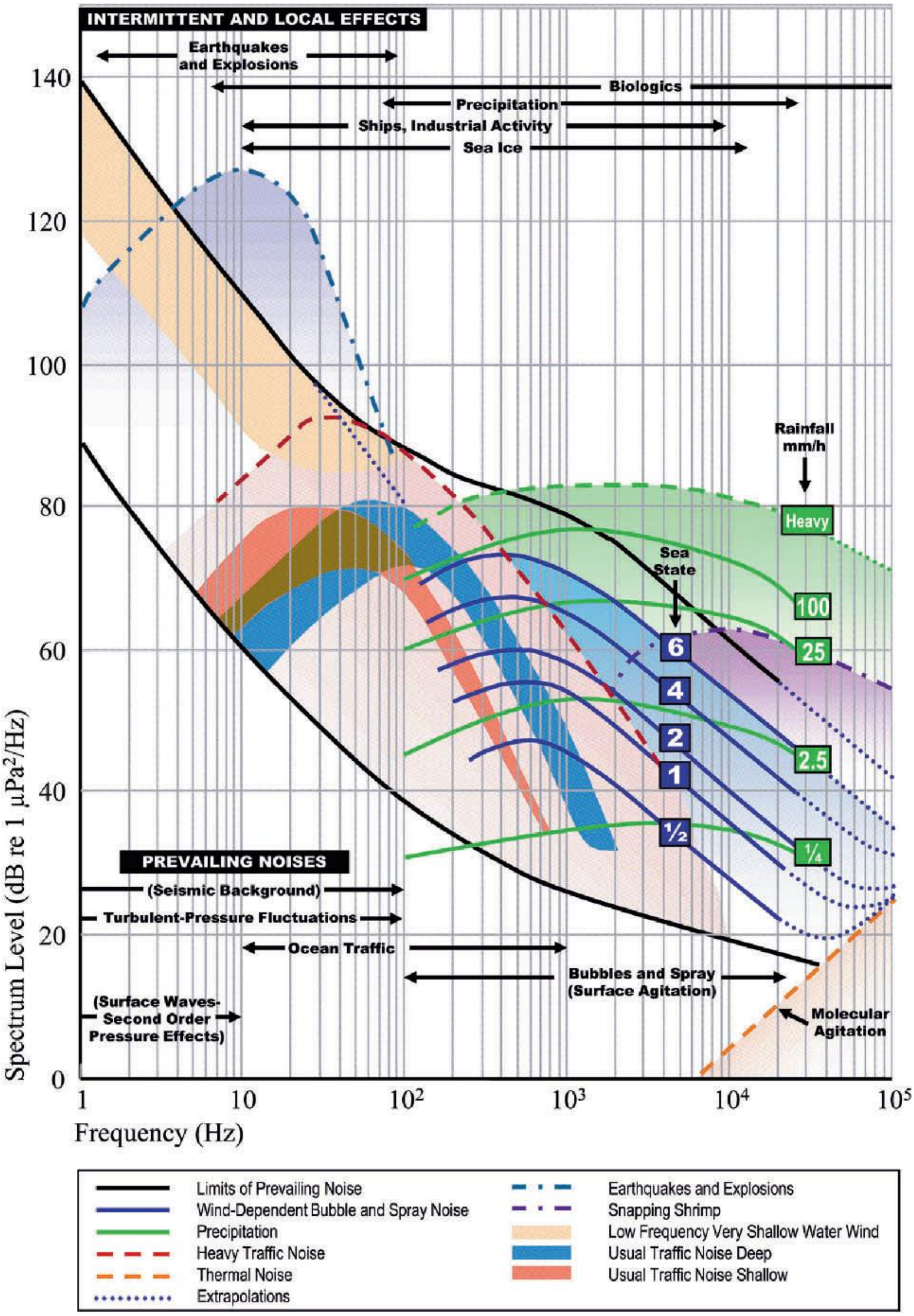


Figure 25. Typical spectrum of marine ambient noise (Ainslie, 2010).

2.9.3 Underwater sound emission from compressed air power sources

The typical concentrated type array of “Triple” compressed air energy sources envisaged and considered for the preparation of this study presents the following emission characteristics.

Table 6. Features of Triple Compressed Air Power Source Array.

Number of subarrays	3	
Number of Sources per sub-array	20 + 2 de spare	
Source working pressure	2.000	Psi
Source Volume Total	3.280 / 53,75	cu.in. / liters
Distance between emission points	15	metres
Interval between emission points	6,5	seconds
Vessel speed during emission	4,5	knots
Energy Sources: 0 to peak	57,5	bar meter
Depth of the Sources	6	Meters
Primary to Bubble Ratio	19,2	No frequency filter application

The near-field relationship between the initial peak and the bubble is high, which means that there is very good reduction of the secondary signal.

The total sound energy emitted by the Triple source array equals the following:

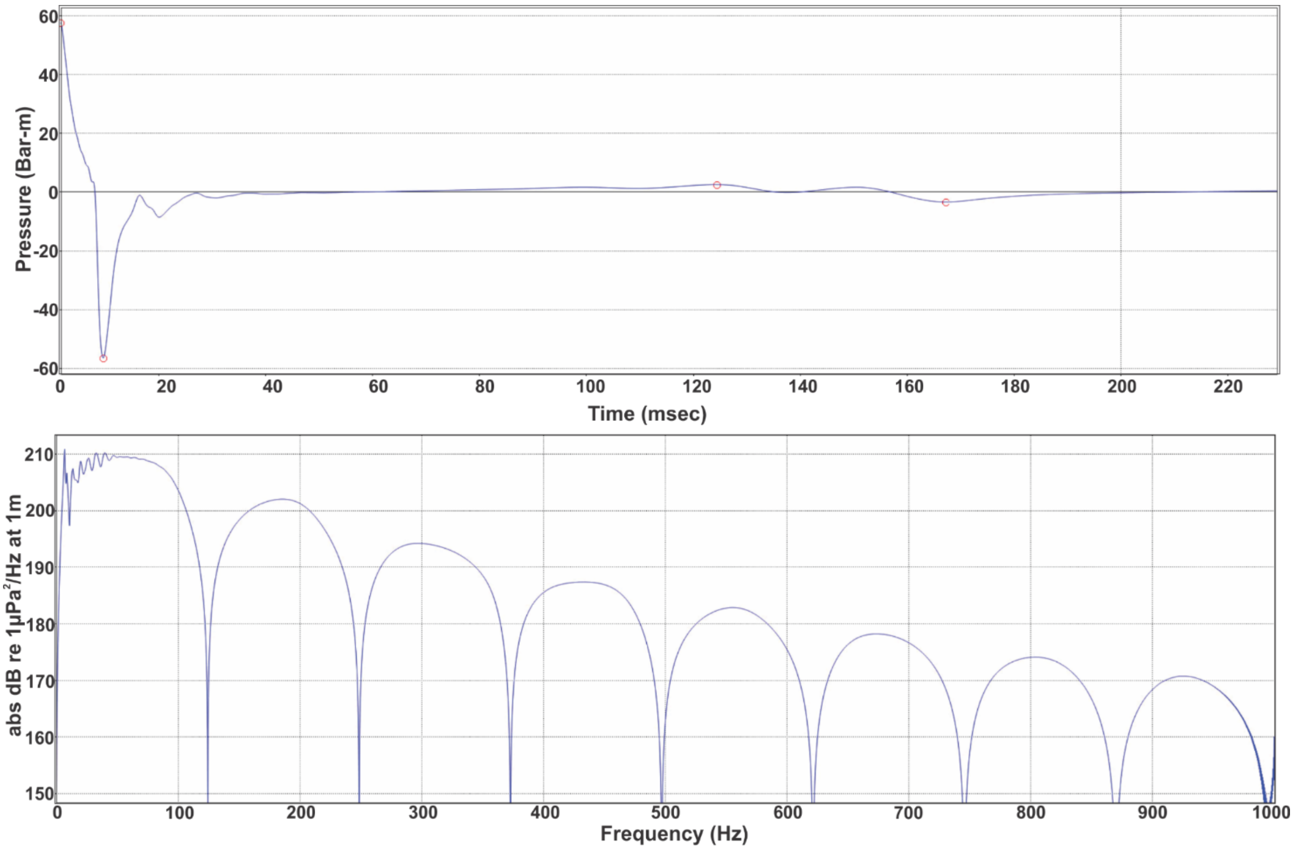
SPLpeak = 20 log (57,5 0-p bar.m) + 220 = 255,2 dB re 1µPa-m [8]

According to the recommendation of the European Community, “Monitoring Guidance for Underwater Noise in European Seas” - Part II (Dekeling et. Al, 2014) the Triple array is classified as a High-Level source, as SPLpeak is above 253 dB re 1µPa -m.

The FFS Far Field Acoustic Signature has been calculated based on an assumed water temperature of 10ºC and a water velocity of 1490 m / s. The phantom source has been taken into account using a reflection coefficient of -1 for the interface of the sea surface. The signature is extracted in the forward direction of the array (Azimuth = 0) and directly below the source (Dip = 0).

The acoustic signature of the array in the time domain and the spectrum in the frequency domain down to 1 kHz are illustrated in Figure 26.

It is possible that the maximum of emissions occurs between approximately 5 Hz and approximately 100 Hz in frequency, the maximum values then progressively decaying at an approximate rate of 4.5 dB per 100 Hz.



Far Field Signature Time and Amplitude spectra for the Triple Source. Far Field is computed at a distance of 9000m in the inline direction(Azimuth = 0) and directly below the source array (Dip = 0).
Primary 57.5 Bar-m, Peak-Peak 114 Bar-m.

Figure 26. Vertical acoustic signature of the 3,280 cu.in. Triple array spectrum.

The field of pressure waves emitted by a set of air sources varies depending on the angle of emission and the Azimuth. This in turn usually depends on the spatial distribution of the elements in the matrix. The theoretical signatures modeled from each gun location are used to calculate the frequency-dependent far-field signature for each possible emission source, tilt angle, and source Azimuth.

The reflectivity of the sea surface in the model is set to -1 to represent ideal sea state conditions.

Figure 27 shows a two-dimensional energy distribution in frequency for 3 different Azimuths, 0º (forward direction), 45º and 90º (direction perpendicular to the advance). In every case, the normalized values are relative to the maximum corresponding to Azimuth 0º and vertical direction.

For each azimuth graphic, the frequencies are displayed down to 1 kHz and expanded to show the range where the greatest amount of downward directed energy is emitted between 0-125 Hz.

The angles indicated on the edges of the semicircles are relative to the vertical direction (below the array), where the 90º (horizontal) direction has very low energy.

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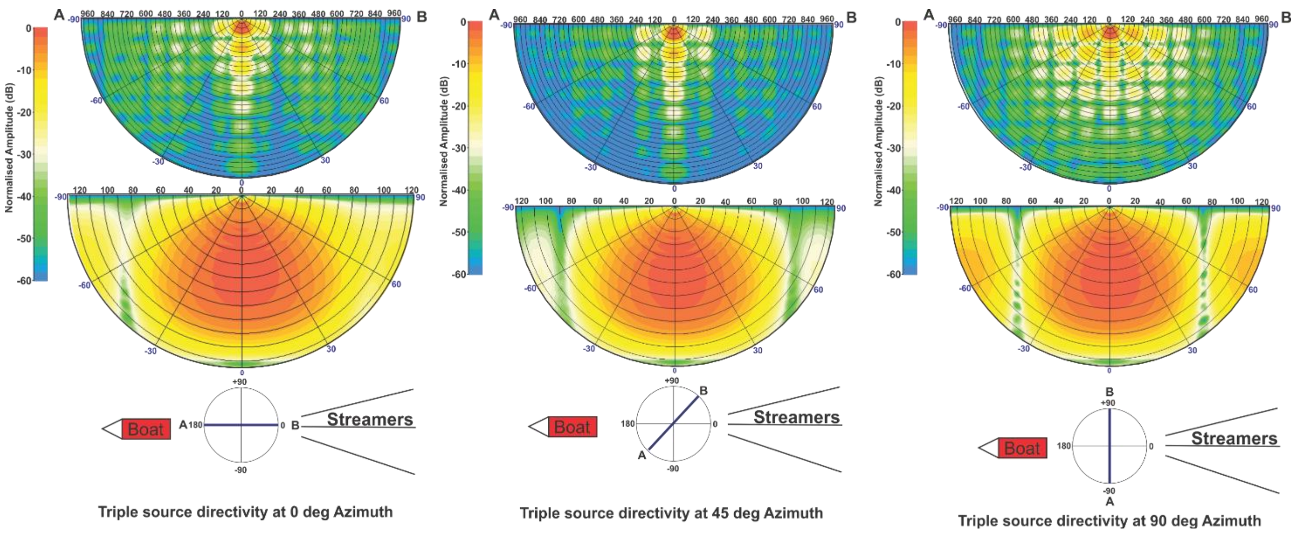


Figure 27. 2D spectrum for different Azimuths regarding the progress direction of the survey for the 3,280 cu.in Triple array.

Figure 28 illustrates in polar form the angular distribution of energy per octaves between 32 Hz and 1,000 Hz. The angles indicated on the edge of the circles are the Azimuths relative to the direction of the ship´s progress. The radial distances represent the angles from the vertical (in the center) to the horizontal (in the periphery), where the weakening of the energy with the angle (Dip) can be appreciated. The center of the circle represents a 0º angle, and each successive circle represents 30º, 60º and 90º.

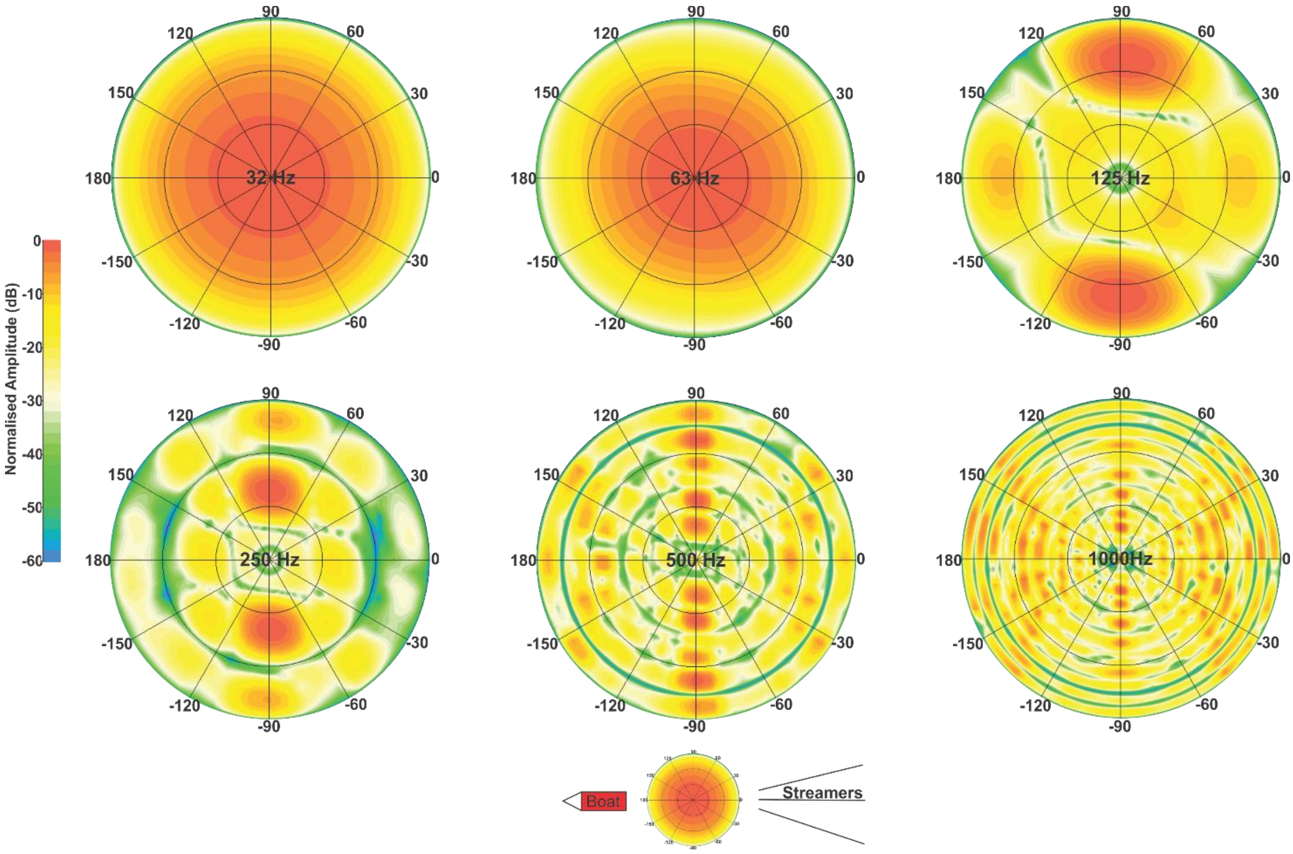


Figure 28. Polar graphics of angular distribution of sound energy for frequencies in octaves.

The following figures illustrate the spectra emitted for (Azimuth) 0º (forward direction) and 90º (perpendicular direction) directions, and for angles with (Dip) 0º vertical, 70º (20º from the horizontal), 80º (10º from the horizontal) and 90º (horizontal). The Units are: dB re 1 μPa^2 /Hz a 1 m.

The vertical spectra (Dip 0º) do not logically depend on the Azimuth, so they are identical.

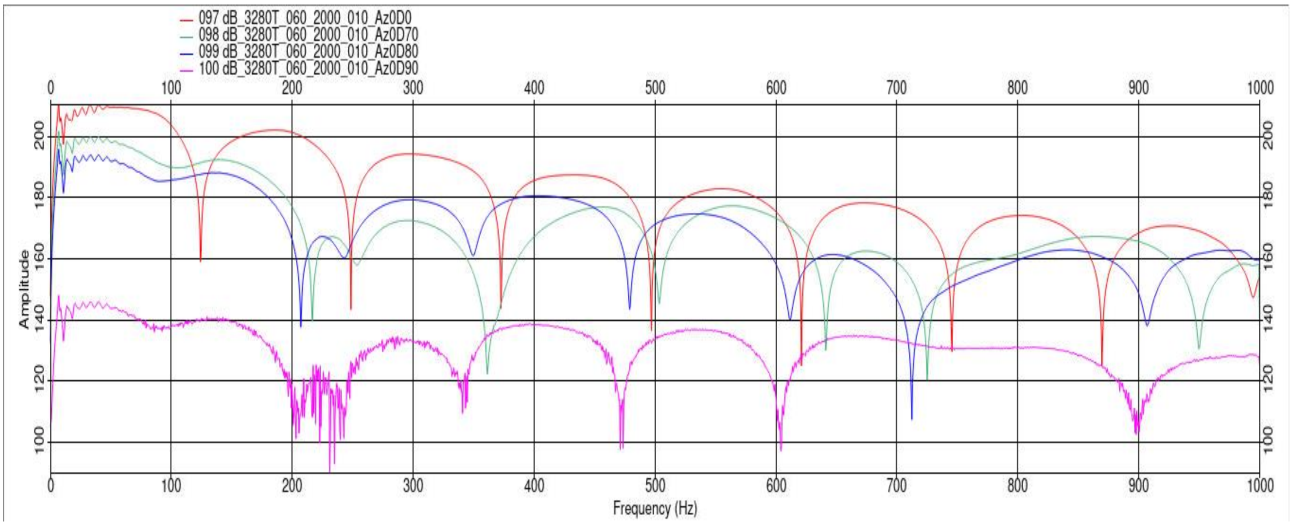


Figure 29. Energy spectrum for different angles with the vertical and 0º Azimuth regarding the forward direction for the 3,280 cu.in array.

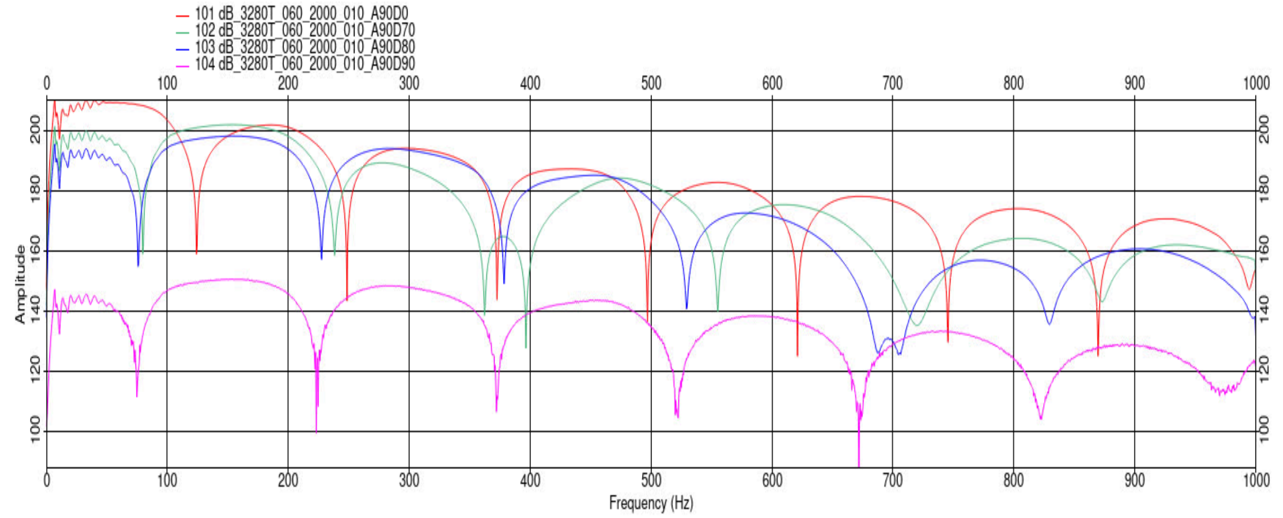


Figure 30. Energy spectrum for different angles with the vertical and 90º Azimuth regarding the forward direction for the 3,280 cu.in array.

It can be seen that the energy emitted horizontally is practically negligible with respect to that emitted vertically (about 40 to 60 dB lower depending on the frequency). On the other hand, the energy emitted with 10º and 20º angles with respect to the horizontal, presents smaller amplitudes but closer to that emitted vertically, showing a pattern similar to that presented previously in Figure 24, which allows to verify the difference between the radiated energy in vertical direction and that radiated in a horizontal direction. This is generally considered to be around 20 dB (Caldwell et al, 2000).

Figure 31 and Figure 32 display the accumulation of energy, calculated by adding, in a linear way, the contributions of each frequency with a 0.48 Hz discretization interval, for the (Dip 0) vertical direction at two different frequency scales. Vertically speaking, the energy is 85% concentrated up to 120 Hz and 95% up to 210 Hz.

Figure 33 to Figure 36 illustrate the accumulation of energy for 0º and 90º Azimuth, considering two different angles with the vertical (Dip), equal to 70º and 80º (that is, 20º and 10º with respect to the horizontal).

It can be seen that, on the one hand, there is a strong decrease in SEL when the Dip increases (that is, it gets closer to the horizontal) and, on the other hand, that the frequency distribution of the energy is broadened, encompassing higher frequencies as the emission direction is more horizontal.

In the case of 90º Azimuth, the total energy is greater than for 0º Azimuth and there is a greater participation, between 200 and 300 Hz, in the percentage of energy for higher frequencies.

The maximum values of total SEL are shown by Table 7 according to the angle with respect to the vertical, and the Azimuth regarding the forward direction.

Table 7. SEL (dB re 1 µPa^2 s a 1 m) total emitted for different angles with respect to the vertical and Azimuth regarding the forward direction.

Angle from vertical (Dip)	0º Azimuth (forward direction)	Difference with vertical for 0º Azimuth (dB)	90º Azimut (perpendicular)	Difference with vertical for 90º Azimuth (dB)	Difference 0º Azimuth - 90º Azimuth (dB)
0º (vertical)	232,02	-	232,02	-	0
70º (20º horiz.)	220,69	11,33	225,70	6,32	-5,01
80º (10º horiz.)	215,34	16,68	222,61	9,41	-7,26
90º (horizontal)	168,89	63,12	175,79	56,23	-6,90

It should be mentioned that the SEL value equal to 232.0 dB re 1µPa2 s at 1 m represents the energy contained in the entire vertical emission spectrum, while the maximum value of 210 dB re1 µPa2 / Hz at 1 m that is shown in the different figures for 0º Azimuth represents the spectral value of SEL with reference to 1 Hz at the maximum frequency, so they correspond to different physical quantities that should not be compared with each other.

The difference between the “nominal” value of the total SEL emitted vertically (232.0 dB re 1µPa2 s at 1 m), calculated by integrating the corresponding energy spectrum, and the total value of SPLpeak previously calculated from the emission in Bar. m of the array (255.2 dB re 1µPa at 1 m), is equal to 23.2 dB. This value is within the range indicated in the section where, although the units of the SEL and the SPL are different, the numerical value of the SEL is typically 20 to 25 dB lower than SPLpeak.

The spectral signature of the Triple array is presented in Figure 37 corresponding to the energy accumulated in the bands of thirds of octaves, for 0 Azimuth (in the forward direction of the array), in linear and logarithmic scales. Figure 38 shows the same information for 90º Azimuth.

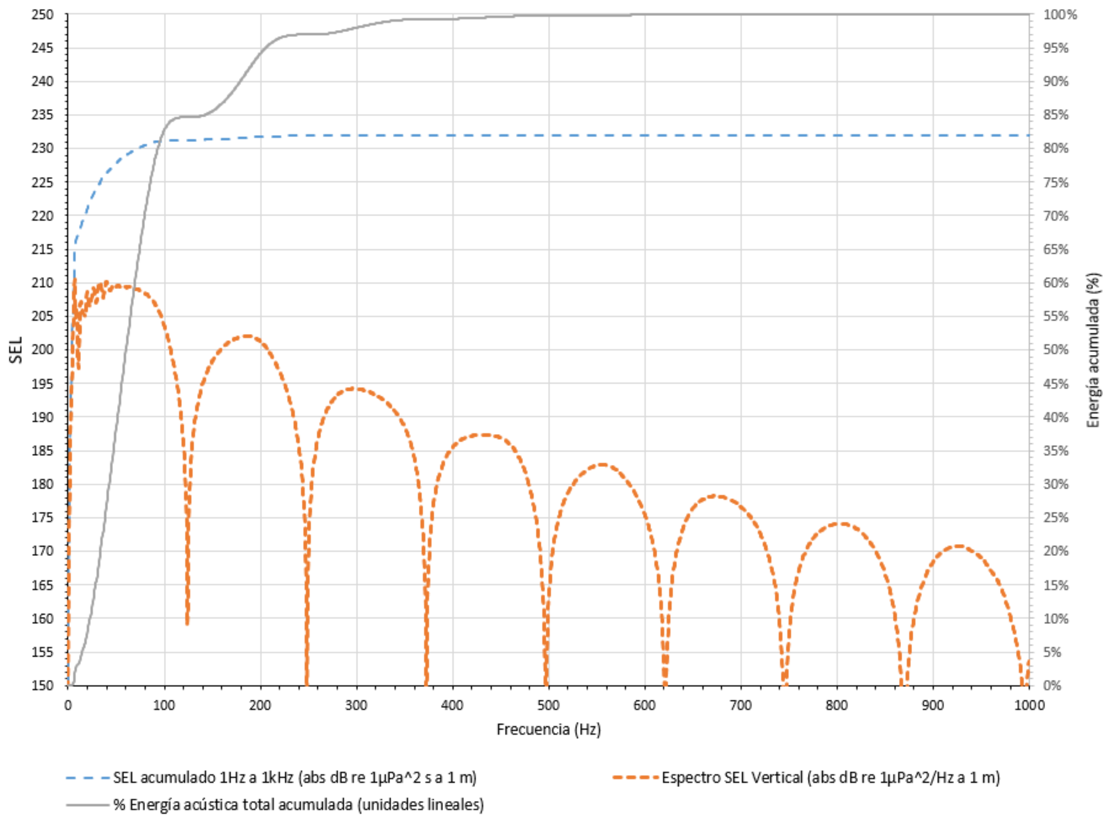


Figure 31. Vertical accumulated energy (Dip 0) in 0º and 90º Azimuth up to 1 kHz

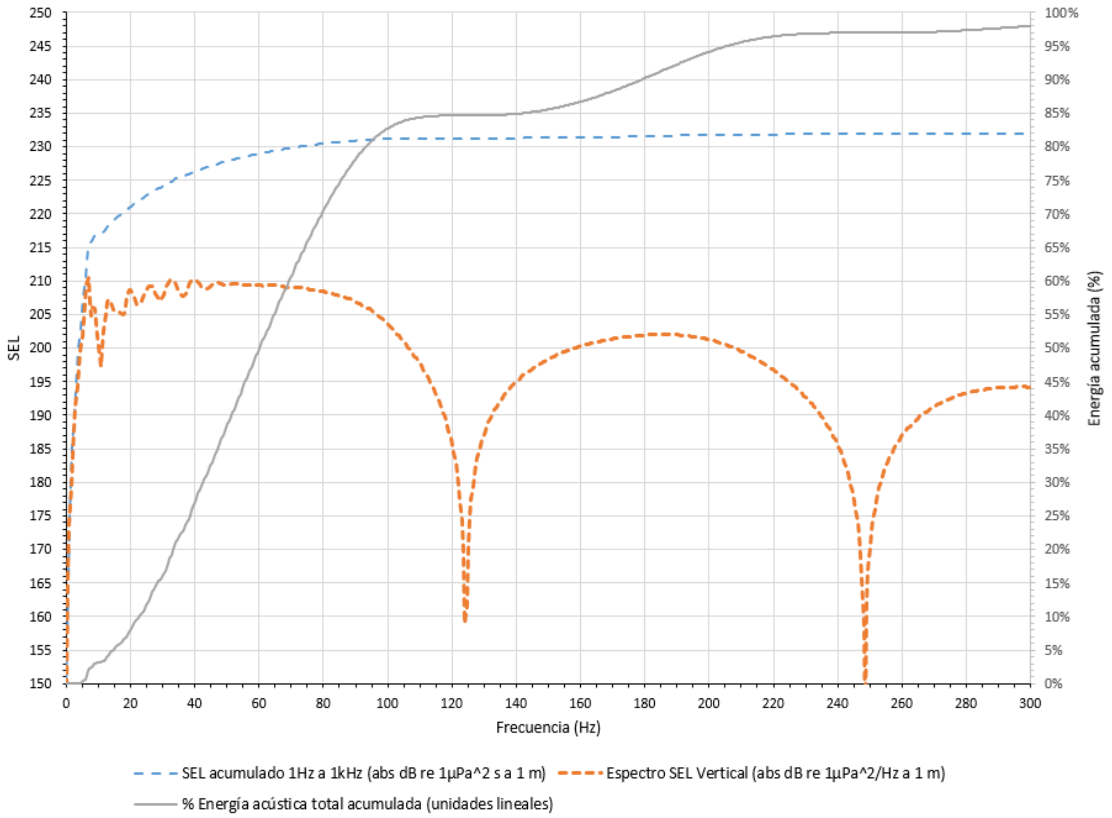


Figure 32. Vertical accumulated energy (Dip 0) in 0º and 90º Azimuth up to 300 Hz

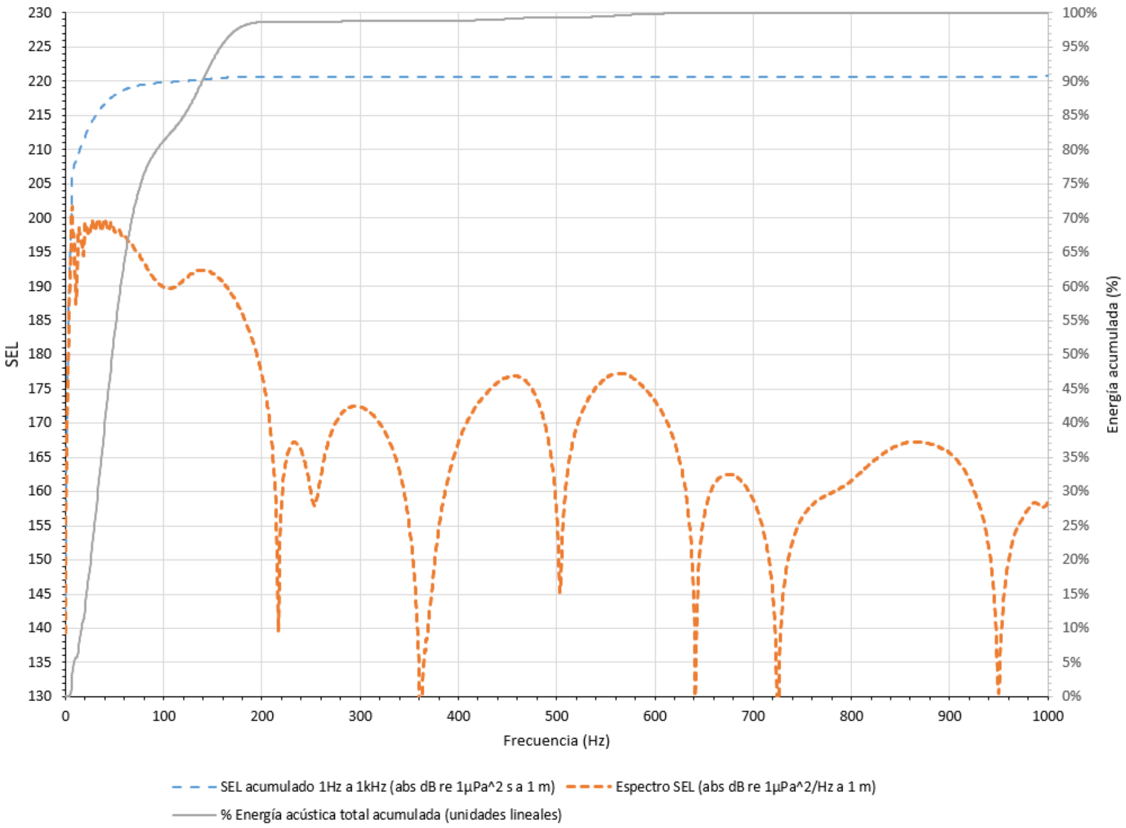


Figure 33. Accumulated energy in 0º Azimuth (forward direction of the survey) vertical angle 70º Dip (20º from the horizontal)

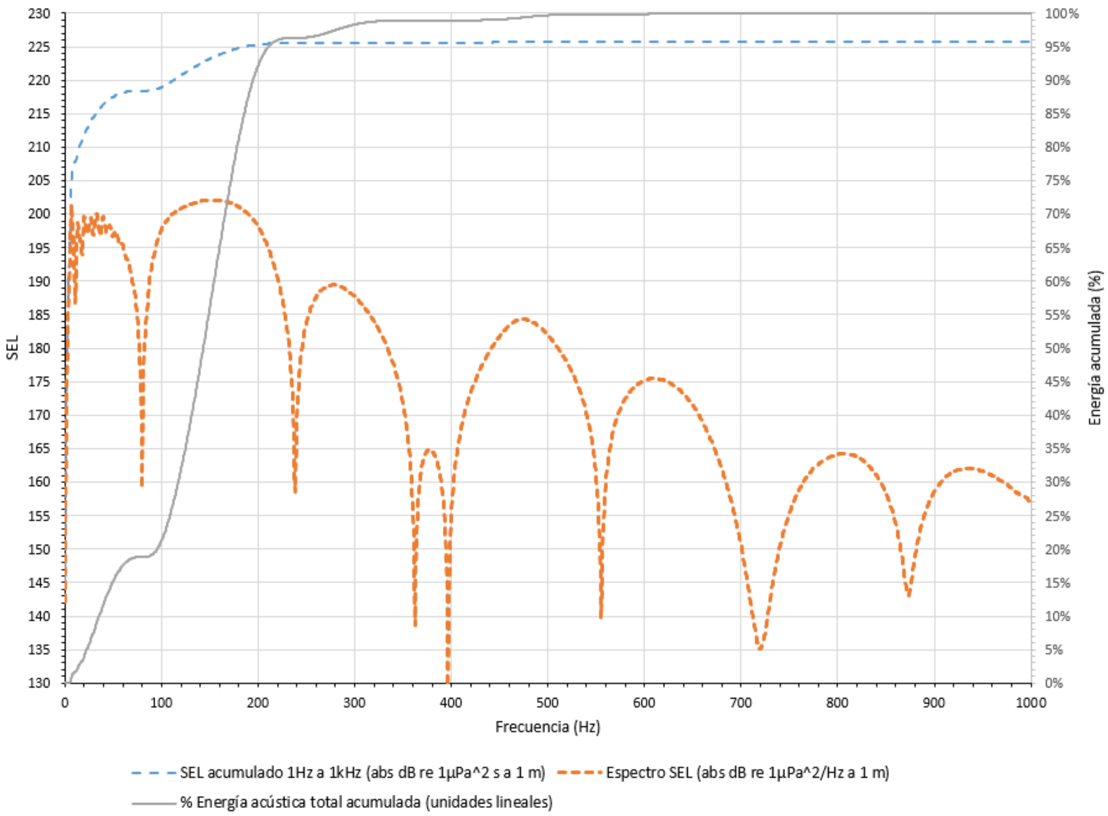


Figure 34. Accumulated energy in 90º Azimuth (direction perpendicular to the forward direction of the survey) vertical 70º Dip angle (20º from the horizontal)

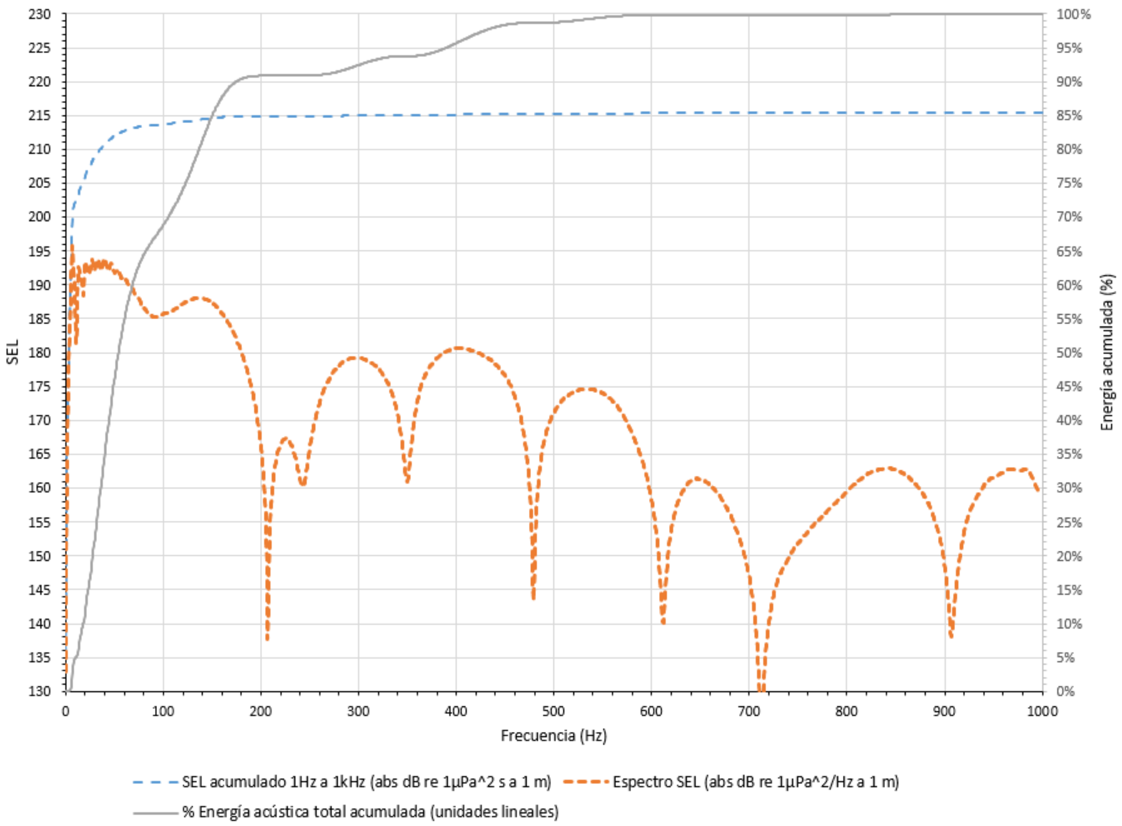


Figure 35. Accumulated energy in 0º Azimuth (forward direction of the survey) 70º Dip vertical angle (20º from the horizontal)

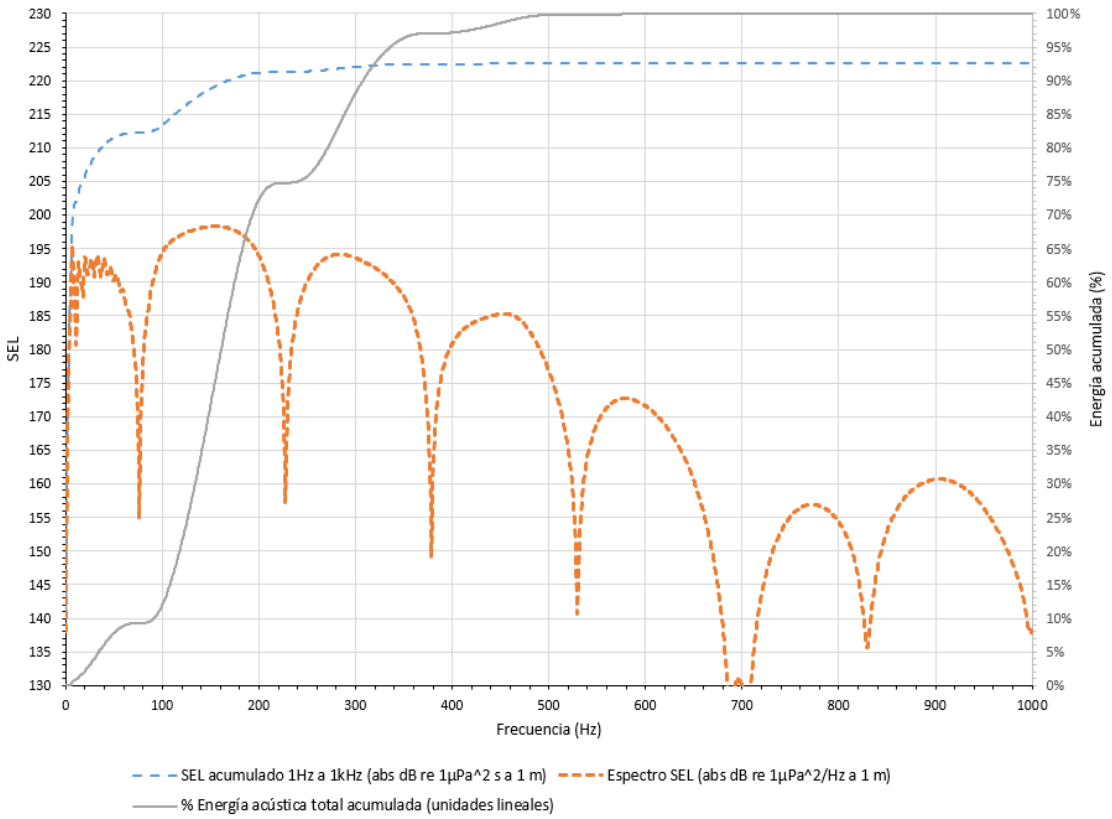


Figure 36. Accumulated energy in 90º Azimuth (direction perpendicular to the forward direction of the survey) vertical 70º Dip angle (20º from the horizontal)

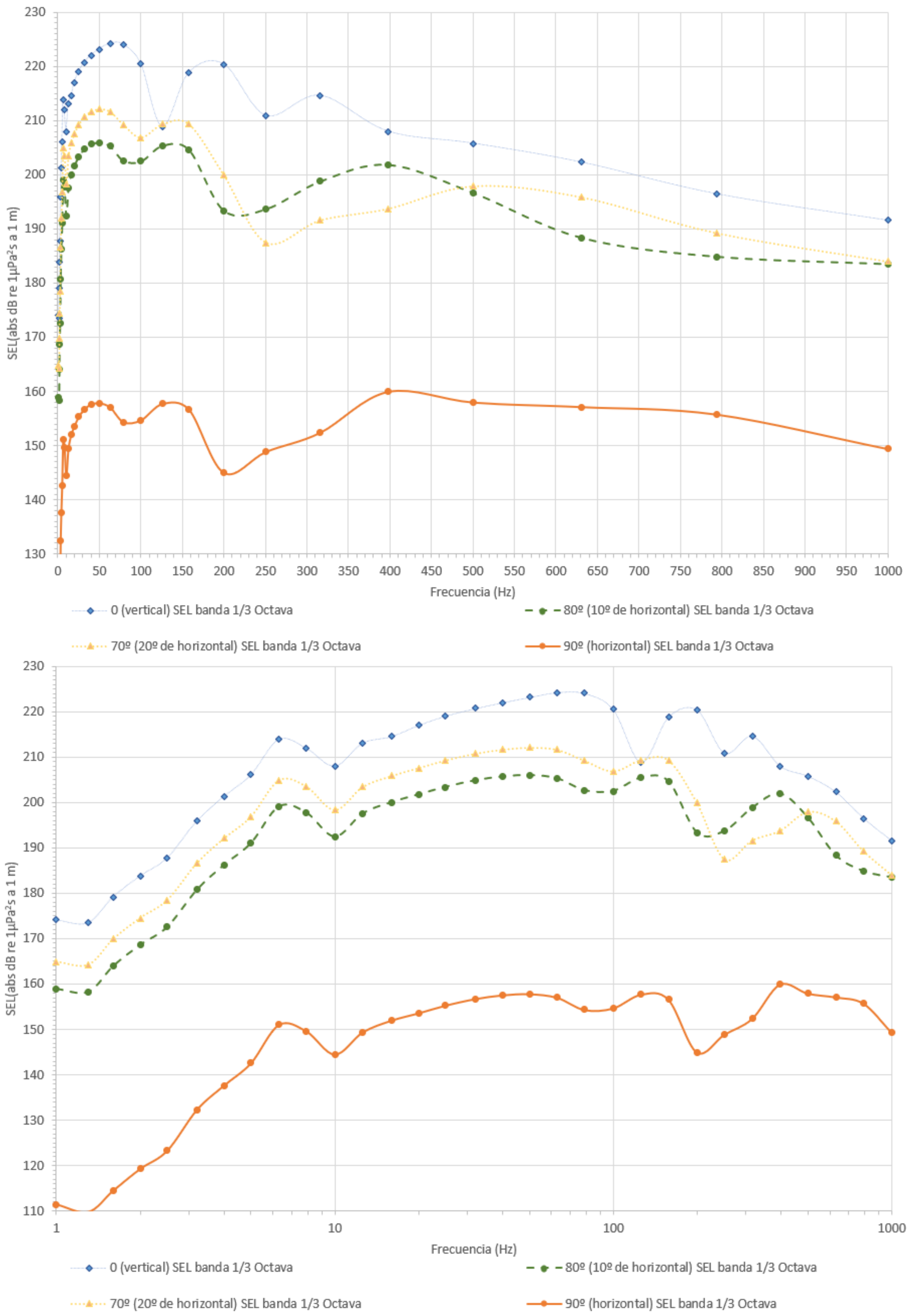


Figure 37. Energy per octave for different angles in 0º Azimuth (forward direction)

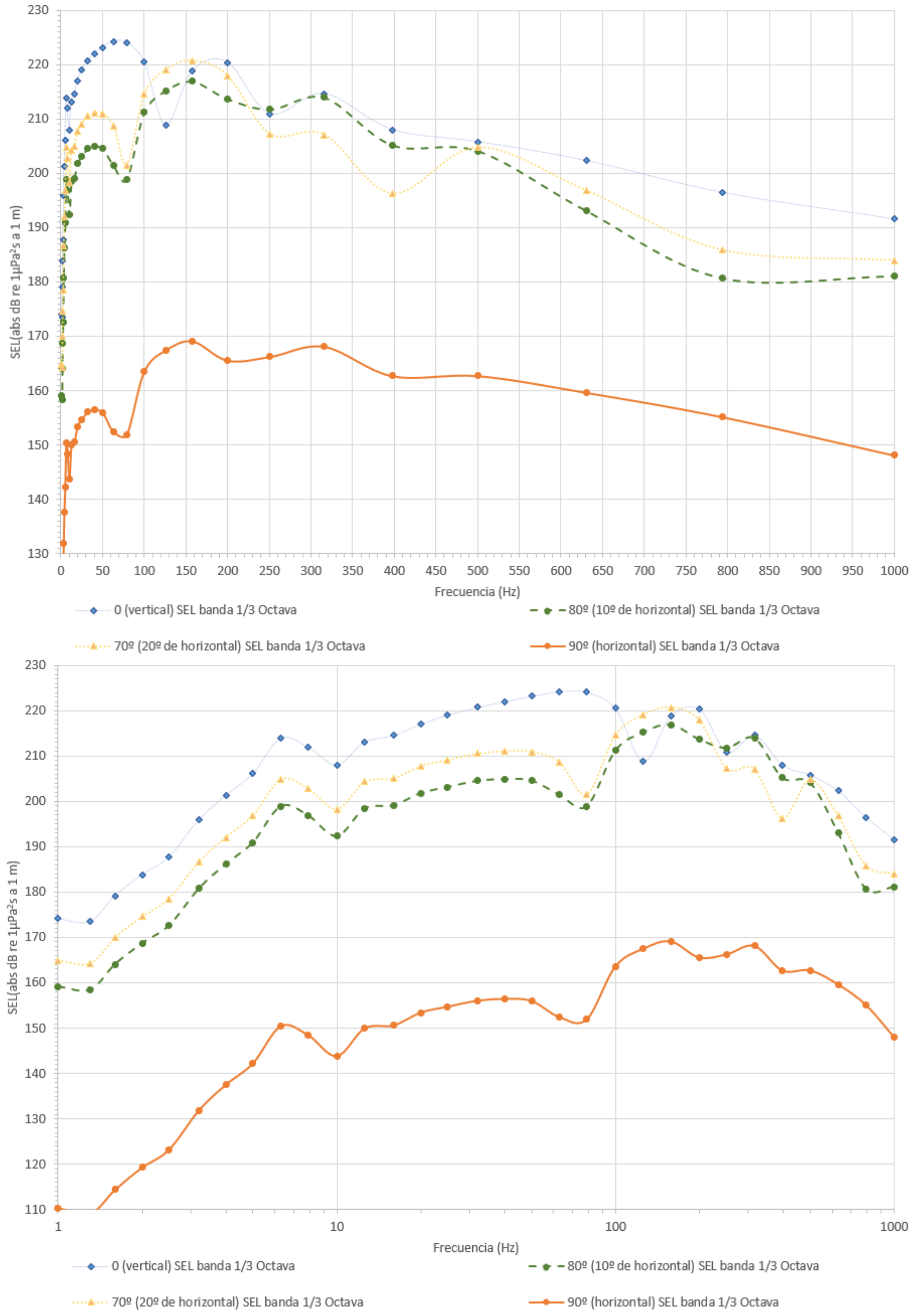


Figure 38. Energy per octave for different angles in 90º Azimuth (perpendicular to the advance)

2.10 PASSIVE ACOUSTIC MONITORING

The limitations of visual surveillance of marine biota at night and in low visibility conditions have led to the development of new methodologies to mitigate the effects of seismic surveys on marine fauna. This innovation process has so far produced at least one functional technology: Passive Acoustic Monitoring, known internationally as Passive Acoustic Monitoring (PAM).

A basic PAM system is made up of an array of hydrophones, which detects the vocalization of marine mammals; a system for amplifying and adjusting the signal; a signal acquisition device; and a computer to run the PAM software. The system is capable of locating, identifying and monitoring marine mammals in real time.

PAM operators duly trained by experts are required for the installation, deployment of the equipment and interpretation of the detected sounds.

When using a PAM system, the following should be obtained as far as possible:

- Detect the range of frequencies of the vocalizations of marine mammals that are expected to be present in the study area;

- Detect and identify the vocalizations of marine mammals and establish marking and range in a reasonable period of time;

- Immediately communicate relevant information to the PAM operator (in real time) so that appropriate and timely mitigation measures can be taken (eg, delay soft start).

The PAM system to be used shall have the characteristics of the Towed PAM System. This basic system comprises a 250m cable, deck cable, audio processing unit, computer, and headphones. This system is equipped with PAMGuard software, a standard marine mammal detection and localization system.

Towed PAM System Specifications

- Hydrophones: 4
- Acoustic sensitivity: 10 Hz to 200 kHz
- Power requirements: 110 VAC, 240 VAC
- Weight: 3 pallets, 400 kg

The Towed PAM System manufacturer's specifications are included in Annex VI.

2.11 PREPARING FOR CONTINGENCIES

2.11.1 General procedure

The 5 emergency response procedures are reflected as follows:

1) *MOB (man over board):* man over board fall. The alarm voices are practiced, visual monitoring of a fallen person, throwing life jackets, stopping machines and lowering the rescue boat.
2) Fire on board: alarm, action roles, assistance with a lifejacket placed at the meeting point, counting of those present, the fire brigade goes to their equipment positions, puts on their suits / equipment and goes to the site to act upon the emergency.
3) Ship abandonment: alarm, put on the life jacket, line up before each assigned boat, people counting. They can board or not. It is not necessary to release the boats.
4) Only fluid spill on deck: assigned brigade in charge. They have the tools to act accordingly: rubber boots, disposable white overalls, absorbent material, rubber gloves, plastic bags, sticks, brushes and other utensils.
5) Loss of command: the trained person goes to the stern and, by means of a suitable telephone, receives orders from the bridge to make manual command of the rudders.

An accident can be simulated answering to each particular situation, be it burn, fracture, cuts, etc. There is a doctor onboard the seismic vessel, with an office that has all the emergency equipment and, if necessary, evacuation, which shall be different depending on the type of accident or opportunity to evacuate (at night the helicopter does not fly; by day with zero visibility either). The office can admit up to 2 patients.

2.11.2 Safety equipment

In the event of an uncontrollable fire on board the seismic vessel, FiFi (Fire Fighting) means (monitors) for water shall be available).

Typical secondary generator sets are around 1500 kW (2000 HP diesel).

The detection systems include smoke detectors in the engine room, bays and common places.

The fire control equipment for the engine room consists of batteries of CO_2 tubes or similar and specific pumps for fires in other places, with a flow rate of 150 m^3/ h, sprayers in the flammable paint and chemicals room.

There is a tool kit at the heliport to open helicopter doors, a fire control kit and adjustable water nozzles.

They have redundant lifeboats / life rafts that double the number of personnel on board, that is, double for each band.

3 ACTIVITIES TIMELINE

The acquisition is planned to take place during the fourth quarter of 2021 and the first quarter of 2022.

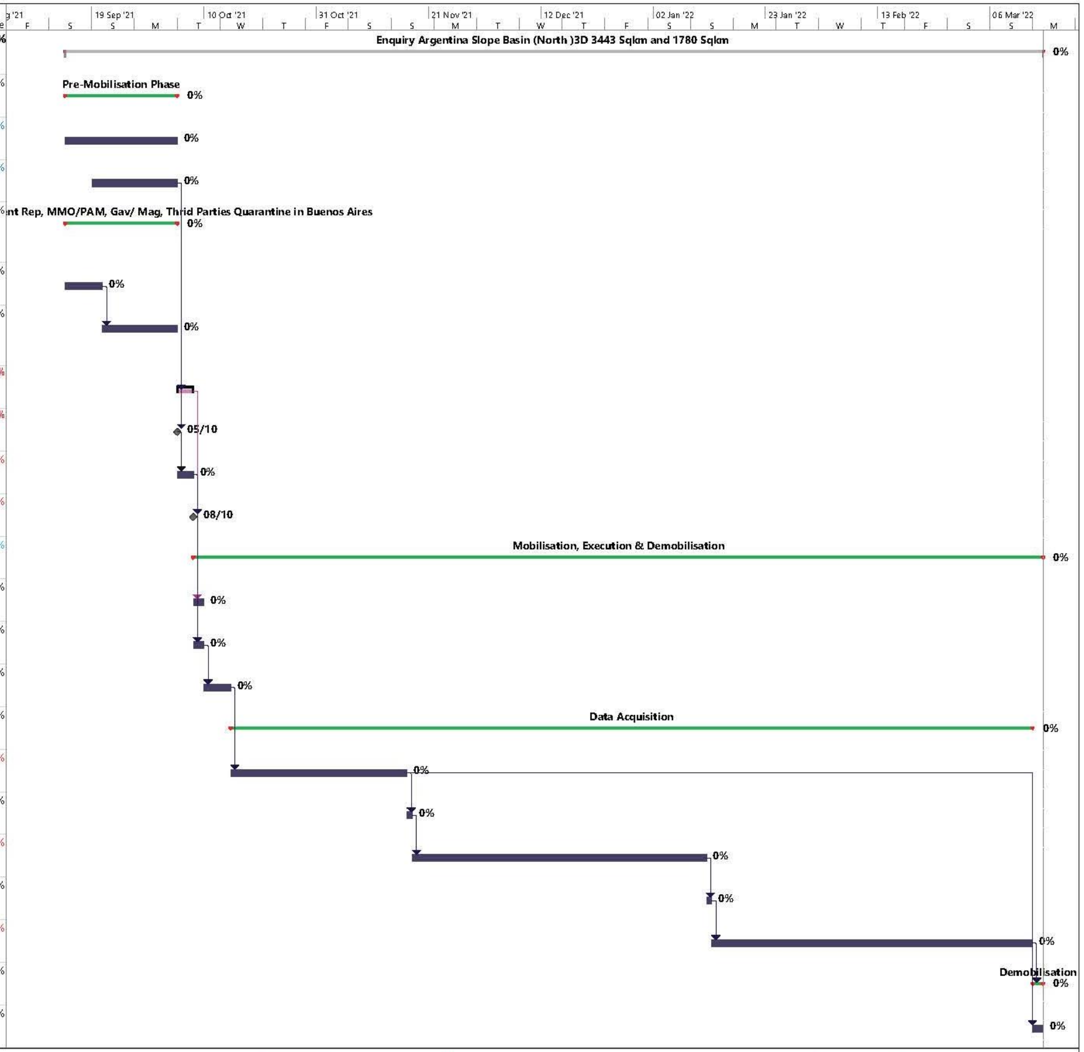
- The acquisition shall begin in the CAN_108-100 area by mid-October 2021, acquiring data in the northeast part for approximately 1 month.
- Then it shall go to the CAN_114 area to cover the entire area. The CAN_114 area is deemed to be completed around the end of January 2022.
- Finally, the ship shall return to the CAN_108-100 area to work there for another 2 months and cover the remaining areas, so the acquisition would be completed at the end of March 2022.

The Project shall be developed according to the following conventional steps:

- Mobilization of the seismic vessel, the monitoring vessel and the logistics vessel to the Project area;
- Seismic acquisition campaign, including the deployment of seismic equipment (source and streamers) and data acquisition operations; and
- Demobilization: once the survey is completed, the seismic and support vessels shall leave the study area to sail back to the port of embarkation. No trace of prospecting activity shall be left in the study area after demobilization.

The schedule defined for the project is hereinbelow presented.

ID	WBS	Task Name	Duration	Start	Finish	% Complete
0	0	**Enquiry Argentina Slope Basin (North)3D 3443 Sqkm and 1780 Sqkm**	183 days	Tue 14/09/21	Wed 16/03/22	0%
1	1	**1 Pre-Mobilisation Phase**	21 days	Tue 14/09/21	Tue 05/10/21	0%
2	1.1	1.1 Geo Service 1 transit to Argentina	21 days	Tue 14/09/21	Tue 05/10/21	0%
3	1.2	1.2 BGP Prospector, transit to Argentina	16 days	Sun 19/09/21	Tue 05/10/21	0%
4	2	**2 Local Marine Crew and Client Rep, MMO/PAM, Gav/ Mag, Thrid Parties Quarantine in Buenos Aires**	21 days	Tue 14/09/21	Tue 05/10/21	0%
5	2.1	2.1 BGP Prospector / Geo Service 1 / Client reps / BGP local crew self-isolation at home	7 days	Tue 14/09/21	Tue 21/09/21	0%
6	2.2	2.2 BGP Prospector / Geo Service 1 / Client reps / BGP local crew arrives Buenos Aires, Quarantine in the Hotel	14 days	Tue 21/09/21	Tue 05/10/21	0%
7	3	**3 BGP Prospector and Geo Servcie 1 Arrival and port call Buenos Aires, Argentina**	3 days	Tue 05/10/21	Fri 08/10/21	0%
8	3.1	3.1 Local crew, Client reps onboard	0 days	Tue 05/10/21	Tue 05/10/21	0%
9	3.2	3.2 BGP Prospector and Geo Service 1 clearence from Customs	3 days	Tue 05/10/21	Fri 08/10/21	0%
10	3.3	3.3 Kick-off Meeting	0 days	Fri 08/10/21	Fri 08/10/21	0%
11	4	**4 Mobilisation, Execution & Demobilisation**	159 days	Fri 08/10/21	Wed 16/03/22	0%
12	4.1	4.1 Local Chase Boat transit to Survey Area	2 days	Fri 08/10/21	Sun 10/10/21	0%
13	4.2	4.2 BGP Prospector and Geo Service 1 transit from Buenos Aires to project area	2 days	Fri 08/10/21	Sun 10/10/21	0%
14	4.3	4.3 Deployment of in- sea equipment, Test.	5 days	Sun 10/10/21	Fri 15/10/21	0%
15	4.4	**4.4 Data Acquisition**	150 days	Fri 15/10/21	Mon 14/03/22	0%
16	4.4.1	4.4.1 CAN 108-100 Data Acquisition	33 days	Fri 15/10/21	Wed 17/11/21	0%
17	4.4.2	4.4.2 Transit from CAN 108-100 CAN 114	1 day	Wed 17/11/21	Thu 18/11/21	0%
18	4.4.3	4.4.3 CAN 114 Data Acquisition	55 days	Thu 18/11/21	Wed 12/01/22	0%
19	4.4.4	4.4.4 Transit from CAN 114 to CAN 108-100	1 day	Wed 12/01/22	Thu 13/01/22	0%
20	4.4.5	4.4.5 CAN 108-100 Data Acquisition	60 days	Thu 13/01/22	Mon 14/03/22	0%
21	4.5	**4.5 Demobilisation**	2 days	Mon 14/03/22	Wed 16/03/22	0%
22	4.5.1	4.5.1 Recovery in water equipment	2 days	Mon 14/03/22	Wed 16/03/22	0%



Project: Enquiry Argentina Slop
Date: Wed 03/02/21

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

Page 1

Justification of the timeline selected for the development of the project

The acquisition schedule was adjusted to oceanographic conditions to guarantee the safety of operations. Based on the meteorological information, it is estimated that the survey would last, on average, 20% longer if it was carried out in winter instead of summer. This means that exposure - health and safety, environmental, financial, etc.- would increase significantly in winter and that is why summer is preferred. Additionally, personnel accidents are more likely to happen in the harshest winter conditions, and that is something Equinor shall always mitigate.

Operating Conditions

Regarding the safety of the operations, they shall be carried out normally as long as the waves are less than 3 m high and the wind is less than 20 knots.

If the weather conditions deteriorate and / or it is considered unsafe to operate, the vessel shall stop production and follow the most suitable navigation given the wind and wave direction. When weather conditions improve, the ship would return to the nearest production line to restart operations.

When the captain of the ship deems that it is not safe to stay on the high seas under extreme conditions (cyclone, etc.), the ship would collect its equipment at sea and go back to port. Once the weather conditions improve, the ship would return to the area of operations, redeploy its equipment to sea, and resume production.

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ANNEX I –TOTAL AUSTRAL AUTHORIZATION

TOTAL

TOTAL AUSTRAL S.A.

Ciudad Autónoma de Buenos Aires, 17 de diciembre de 2020

Señores
EQUINOR ARGENTINA AS SUCURSAL ARGENTINA
Bouchard 680, Piso 19
Ciudad Autónoma de Buenos Aires
At: Bard Krokan
Vicepresidente Exploración - Apoderado

Ref: Acuerdo para la realización de relevamiento sísmico.

De nuestra mayor consideración:

Pascal Desegaulx, en mi carácter de apoderado de TOTAL AUSTRAL S.A. (SUCURSAL ARGENTINA) ("**Total**"), con domicilio en Moreno 877, piso 17°, de esta Ciudad Autónoma de Buenos Aires, respetuosamente digo:

Se hace referencia a (i) el acuerdo celebrado entre Total y Equinor Argentina AS Sucursal Argentina ("**Equinor**") celebrado el 17 de diciembre de 2020 (el "**Acuerdo**") en relación a la campaña de adquisición sísmica para el Área CAN_114 (el "**Área de Equinor**") que fuera otorgada a Equinor en el marco de los permisos de exploración de hidrocarburos mediante Resolución Nº 702/2019de la Secretaría de Gobierno de Energía; y (ii) los permisos de exploración otorgados a Total sobre las Áreas "CAN_111" y "CAN_113", mediante Resoluciones N° 597/2019 y 600/2019, respectivamente (las "**Áreas de Total**").

Por medio del presente prestamos conformidad para la realización de las tareas de adquisición de información sísmica que debe realizar Equinor sobre las Áreas de Equinor y cuya superficie abarca ciertas porciones de las Áreas de Total, todo ellos de conformidad con los términos y alcances descriptos en el Acuerdo.

Sin otro particular, saludamos a Uds. atentamente.

TOTAL AUSTRAL S.A. (SUCURSAL ARGENTINA).

Pascal DESEGAULX
Digitally signed by Pascal DESEGAULX
Date: 2020.12.22 06:26:18 -03'00'

Nombre: Pascal Desegaulx
Cargo: Apoderado

ANNEX II –EQUINOR ARGENTINA BV AUTHORIZATION

Permission to acquire geophysical data

Buenos Aires, March 09, 2021.

EQUINOR ARGENTINA AS (Sucursal Argentina) (hereinafter referred to as the "**Survey Company**") as holder of an exploration permit for Block CAN_108, granted through Resolution 691/2019 dated 01 of November, hereby requests, **EQUINOR ARGENTINA BV (SUCURSAL ARGENTINA)** acting as operator on behalf of the *Union Transitoria de Empresas* for Block CAN_100 (hereinafter referred to as the "**Operator**"), permission to record geophysical data pertaining to the planned "CAN_108" 3D seismic survey over the area as set out in the enclosed survey map which is within the following Blocks: "CAN_108" and "CAN_100" (hereinafter referred to as the "**Operation**").

The permission requested, once granted, will be subject to the following terms and conditions:

1. Survey Company shall comply with all governing rules and regulations as apply to the conduct of marine geophysical data acquisition on the Argentinian Continental Shelf. Survey Company assumes full responsibility before the Argentine Government, the Operator, the Operator's partners in the respective of their exploration permits mentioned above (referred to as "**Licensees**") and third parties for all consequences that could derive, directly, from the carrying out of the Operation, and shall indemnify and hold harmless the Operator, its Licensees and their affiliated companies from any and all costs and claims, including but not limited to legal expenses, resulting from Survey Company's failure to comply with the above in relation to the Operation.

2. Survey Company shall indemnify and hold harmless the Operator, its Licensees, Operator's contractors and subcontractors, and their affiliated companies from any and all costs and claims, including but not limited to legal expenses, resulting from the Operation and arising from the following circumstances:
   a) Personal injury or illness to or death of the Operator's and/or its Licensees', contractors' and subcontractors', and their affiliated companies to the extent involved in the Operation, employees, and loss of or damage to the property and/or equipment of any of the above.
   b) Personal injury or illness to or death of Survey Company's and its subcontractors, and their affiliated companies to the extent involved in the Operation, employees, and loss of or damage to the property and equipment of any of the above;
   c) Personal injury or illness to or death or property loss or damage suffered by any other third party; and
   d) Any pollution or from the vessel used for the Operation.

3. Survey Company shall have adequate liability insurance for liability under section 2.

4. If so requested by the Secretary of Energy (SE) pursuant to Annex III of Resolution SE 319/93, Survey Company shall forward the raw acquired data to the SE.

5. Survey Company will agree with the Operator the time and duration for conducting the Operation. Survey Company agrees that at all times shall Operator's License operations and geophysical data acquired as part of the PL's mandatory work program take precedence and that Survey Company shall upon Operator's instructions divert its operations if conflict may occur with such operations.

6 Survey Company shall at his own cost and expense obtain and maintain or excluding any provisions with respect to the conflicts of laws, cause his contractors and subcontractors to obtain and maintain in full force and effect throughout the duration of the Operation, the insurances from solvent insurers of good repute.

7. An updated survey map shall be provided when the Operation is completed.

8. This permission is governed and interpreted in accordance with the laws of Argentina law excluding any provisions with respect to the conflicts of laws.

9. All disputes arising out of or in connection with the present permission shall be finally settled under the Rules of Arbitration of the International Chamber of Commerce by one or more arbitrators appointed in accordance with the said Rules. The Emergency Arbitrator Provisions shall not apply. The arbitration shall be held in Buenos Aires, Argentina and shall be conducted in the English language. The arbitrators shall decide according to law and not *ex aequo et bono*. A dispute shall be deemed to have arisen when either Party notifies the other Party in writing to that effect.

10. Survey Company shall provide the following information for each seismic survey before the date of commencement of the same:
    a. Copy of ESIA with the due approval from Secretary of Energy.
    b. Copy of the authorization to navigate.
    c. Navigation plan.
    d. Details of the vessels, acquisition, support and chase boats with copy of respective assurances, last authorizations and audits.
    e. Upon request copy of insurance policy covering third-party liabilities
    f. Detail on the acquisition responsible and main contacts, both contractors and operator, in land and on board, HSE and technical.
    g. Detail of type of acquisition, parameters, configuration and processing sequence to be applied.
    h. Expected detailed planning from preparation to processed data delivery.

11. Survey Company shall provide Operator access to courtesy data as follows:
    a. Migrated data (all migrated stacked data and velocity models as per processing sequence) within the areas operated by Equinor Argentina BV (Sucursal Argentina).
    b. Copy of Nav merged SEGY Field data and observer logs within the areas operated by Equinor Argentina BV (Sucursal Argentina) plus migration margins (0.5 streamer length full fold) within the neighbour non operated block attached to the boundary.

12. All communications between the parties with respect to this permission shall be sent to the following addresses:

Equinor Argentina BV (Sucursal Argentina)	**Equinor Argentina AS, Sucursal Argentina**
Reconquista 458, 14th floor	Forusbeen 50
City of Buenos Argentina	4035 Stavanger, Norway
Argentina	Email Address (tilar@equinor.com)
Att: Tine Lærdal	Att: Tine Lærdal

13. It is not the intention of the parties to create, nor shall the permission be deemed or construed to create, a partnership, joint venture, association, trust, fiduciary relationship, or any relation of service provider or contractor.

EQUINOR ARGENTINA AS, Sucursal Argentina

Signed:
Name: Tine Lærdal
Character: Exploration Manager
Attorney at Law

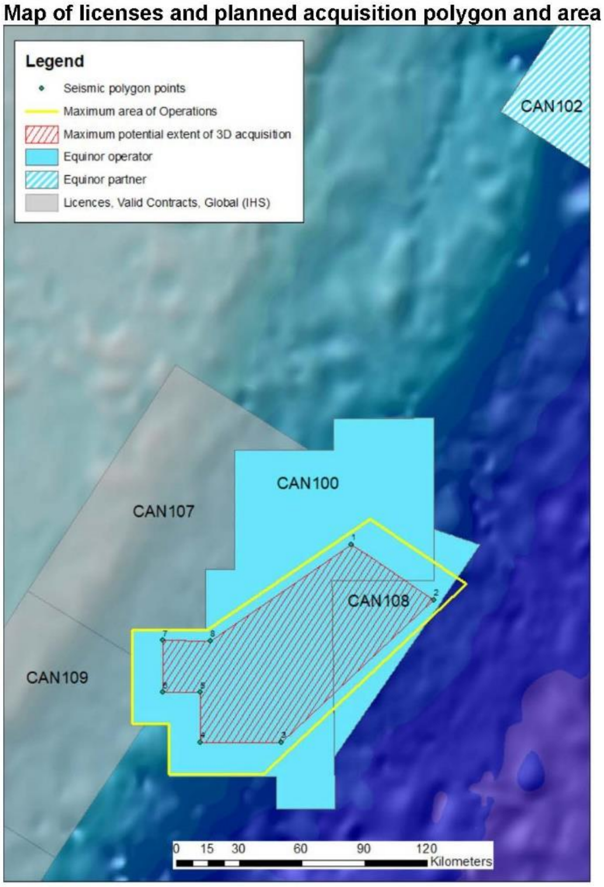
Agreed:

Equinor Argentina BV (Sucursal Argentina)

Signed:
Name: Tine Lærdal
Character: Exploration Manager
Attorney at Law

Appendix A

Map of licenses and planned acquisition polygon and area of opeartion (vessel turning, etc).



Appendix B

Acquisition Polygon coordinates

3D Seismic Acquisition_CAN 108/100		
	WGS84	
Id	Latitude	Longitude
1	-40,007661	-54,931412
2	-40,236893	-54,4626
3	-40,866984	-55,303278
4	-40,876875	-55,764536
5	-40,658525	-55,769297
6	-40,659973	-55,978747
7	-40,435815	-55,982579
8	-40,434293	-55,717299

ANNEX III – BGP PROSPECTOR SPECIFICATIONS

Appendix - Fleet

BGP PROSPECTOR

Clean-Design High-Capacity 3D Seismic Vessel

General	
Port of Registry:	Nassau
Flag:	Panama
Class:	DNV
Year of Built:	2011
IMO Number:	9545986
Length:	100 m
Breadth:	24 m
Draft (min / max):	6.4 m / 7.3 m
Gross Tonnage:	10732
Economy Speed:	15 knots
Fuel Capacity:	3400 m³
Main Thruster:	2 x RRM Bergen B32:40L8P CD 2 x 4000 kw
Bow Thruster:	TT 200 Rolls Royce 883 kw
Auxiliary Engine:	2 x RRM Bergen C25:33L8A CD
Generators:	Main generator 2 x 2880 Kw Shaft generator 2*2765 Kw
Accommodation:	66 persons
Life Rafts:	6x 35 person, davit launch type
Life Boat:	2 x 35 person Norsafe
Workboat:	2 x Norpower 30 ft
FRC:	1* Norsafe Magnum 750

Vessel Navigation & Communication	
Radar:	Kongsberg, S-Band 30 kw Kongsberg, X-Band 25 kw
Communications:	Inmarsat C, F and VSAT
Gyro Compass:	Sperry NAVIGAT x MK1 x 2
Auto Pilot:	Kongsberg K-Pos and K-Bridge
Echo Sounder:	Kongsberg EA600 Skipper GDS101
GPS Receiver:	Furuno GP-150
Speed Log:	Furuno DS-80
Weather Facsimile:	Furuno Fax-80

Recording Instrument	
Manufacturer:	Sercel
Type:	Seal 428 System
No. of Channels:	640 CH x 12
Sample Rate:	0.25,0.5,1, 2, 4 ms
Recording Media:	IBM 3592

Streamer	
Manufacturer:	Sercel
Type:	Solid Streamer
Section Length:	150 m
Group Interval:	12.5 m
Streamer Configuration:	12 x 8000 m
Hydrophone Type:	Sercel Flexible Hydrophone
Hydrophones / Group:	8

Navigation Equipment	
Manufacturer:	ION
Integrated Navigation System :	ORCA V.1.12.1
Navigation Processing:	Iris&Sprint
Binning Software:	Reflex
Depth Controller:	DigiCOURSE 5011E/ 5110
Compass System:	DigiCOURSE 5011E
Acoustic System:	DigiRANGE II, CMX
Streamer Steering:	DigiFIN 5120
Primary DGPS:	Veripos Ultra
Secondary DGPS:	Veripos Apex
Tail Buoy & Source Positioning:	Kongsberg Seatrack

Source Equipment	
Manufacturer:	Sercel
Type:	G.GUN II
No. of Sub-array:	8
Array Volume:	2 x 5660cu.in.
Compressor:	3 x LMF 62s / 138-207-E60
Compressor Capacity:	3 x 2200 cfm
Operating Pressure:	2000 psi - 3000 psi
Source Controller:	SmartSource

Onboard Processing	
Processing CPU:	96 CPU (48 nodes) IBM x 3550 M3
Processing Software:	GeoEast 3.0.5, KL-Streamer

Fuel Tanks of BGP PROSPECTOr	Capacity (m^3)
TANK T04PS FO	321,4
TANK T05P FO	268
TANK T05S FO	281,39
TANK T06P FO	168,9
TANK T06S FO	183,83
TANK T07P FO	197,87
TANK T07S FO	197,87
TANK T08P FO	139,75
TANK T08S FO	95,72
TANK T09P FO	142,54
TANK T09S FO	142,45
TANK T10P FO	160,88
TANK T10S FO	160,88
TANK T11P FO	122,6
TANK T11S FO	122,6
TANK T12P FO	77,25
TANK T12S FO	77,25
TANK T21P FO	169,94
TANK T21S FO	190,43
TANK T51 FO DAY TANK	45,05
TANK T52 FO DAY TANK	45,05
TANK T71 FO OVERFLOW	61,92
TANK T74 FO SETTLING	44,66
TANK T75 FO SETTLING	47,7
TANK T77 FO EG	2,58

ANNEX IV – CANDELA S SPECIFICATIONS

CANDELA S

Nombre del buque	Ship's name	Candela S
Tipo	Type	Remolcador / Tug
Señal distintiva	Call sign	LW 3128
Bandera	Flag	Argentina
Puerto de registro	Port of registry	Buenos Aires
N° IMO/MAT	IMO/MAT No.	7509495
N° MMSI	MMSI No.	701006646
Armador	Owner	Zapor SA
Año de Construcción	Building Year	1975
Ton. Registro Bruto	Gross Tonnage	543 T
Ton. Registro Neto	Net Tonnage	101 T
a) Eslora total	L.O.A.	44,71 M
b) Manga	Breadth moulded	10,66 M
c) Puntal	Depth moulded	5,7 M
Coeficiente fiscal	a x b x c / 800	4
Francobordo	Freeboard	0.66 M
Altura quilla-mástil	Height keel-top mast	29,17 M
Porte Bruto Verano	Summer Deadweight	403 T
Calado max. Verano	Draft for Summer D.W.	5,50 M
Despl. Verano	Summer Displacement	1286,81 T
Desplazamiento Liviano	Light Ship Displacement	1060 T
Tipo de motor	Main engine	EMD / DIESEL
Potencia	MCR	4288 KW / 5800 HP
Helices	Propeller	4 palas / Paso fijo 3070 mm
Velocidad de servicio	Service speed	10 Ns
Cap. Residuos oleosos	Slop tank capacity	8,857 m3
Cap. de carga combustible	Cargo tank capacity GO	569,76 m3
Capacidad de remolque	Bollard Pull	60 T
Capacidad de Grua	Crane	26 T
Equipos salvamento	Salvage tool	4 jumbo fenders/ others

www.serviciosmaritimos.com

ANNEX V - GEO SERVICE I SPECIFICATIONS

Technical Specifications of GEO SERVICE I
Supply Boat of BGP PROSPECTOR

Shipyard	Rizhao Kingda Shipbuilding Heavy Industry Co., Ltd. Shanghai Road, Rizhao City, Shandong Province, People's Republic Of China
Ship Owner	Longzhu Oilfield Servicces (S) Pte. Ltd. 10 Anson Road, #14-19/20 International Plaza, Singapore 0799
Ship Design Office	Khiam Chuan Marine Pte. Ltd.
Hull No.	KD401
ABS ID No.	YY223553
Class Notation	ABS +A1 (E) Offshore Support Vessel, +AMS, +DPS-1
Vessel Name	Geo Service I
Keel Laid Date	4-December-2010
Undocking (Launching) Date	23-June-2011 (14:00H)
Port Of Registry	Singapore
IMO Number	9621546

Official No.	397009
Signal Letters/Call Sign	9V9391
Length Overall	59.25 m
MMSI	566347000
AAIC	RS01
Length Waterline	56.00 m
Length BP	52.20 m
Breadth Moulded	14.95 m
Depth Moulded	6.10 m
Draft Moulded	4.80 m
Complement	49
Fuel Oil	990 m3
Fresh Water	230 m3
Cold Room (Freszzer + Chiller)	~30 m3
Deck Cargo	500 tonnes at 0.7m above main deck
Clear Deck Area	375 m2
Deck Loading (Main Deck)	7.0 tonnes/m2
Deadweight	~1335 tonnes
Gross Tonnage	1736
Net Tonnage	520
Main Engine	2 x 2575 HP at 1600 RPM
Reduction Gear Ratio	7.526
Propulsion	2 x CPP, 2650 mm diameter in kort nozzle
Propeller Speed	212.60 RPM
Main Diesel Generator	2 x 245 kWe, 415V/3P/50Hz 0.8 PF
Shaft Alternator	2 x 800 kWe, 415V/3P/50Hz 0.8 PF
Bow Tunnel Thruster	1 x 390 kW, 1480 RPM/388 RPM, 62 kN thrust, 1300mm dia.
Stern Tunnel Thruster	1 x 390 kW, 1480 RPM/388 RPM, 62 kN thrust, 1300mm dia.
Towing Winch	1 x 10 tonnes at 15 m/min, 120 tonnes break holding, electro hydraulic
Capstan	2 x 5 tonnes at 15 m/min, electro-hydraulic
Deck Crane	6 tonnes at 14m
Fast Rescue Craft	10 men jet propulsion, not less than 20 knots (with 3 men)
Fuel Oil Transfer Equipment	For inter-ship with 90m hose
Seismic Winch	Electro-hydraulic
Trial Speed	~12.0 knots
Crew Accommodation, No Of Bunks	48

ANNEX VI - TOWED PAM SYSTEM SPECIFICATIONS

PRODUCT DATASHEET

www.seiche.com
info@seiche.com
+44 (0)1409 404050

Seiche
Marine Acoustic Solutions

TOWED PAM SYSTEM

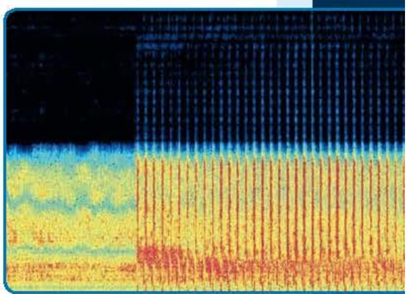
Our flagship Passive Acoustic Monitoring system is extensively deployed worldwide. It is robust, reliable and available at short notice in a number of configurations.

Towed PAM is able to detect, localise and track vocalising marine mammals in real-time. It is vital for mitigation during hours of darkness and poor visibility.

The base system comprises an array cable of 250m, deck cable, electronics processing unit, computer and headphones. Equipment is provided with 100% back-up. PAMGuard software is integrated as standard to aid detection and localisation of marine mammals.

The system can readily be configured to suit the project. A heavy tow 230m cable with a detachable array section of 20m may be preferred for harsh environments.

A networked system can enable monitoring from the most convenient location onboard. Frequency sensitivity, within a range of 10 Hz and 200 kHz, can also be customised for species of interest and optimal performance.



SPECIFICATIONS
Hydrophone elements: 4
Acoustic sensitivity: 10 Hz to 200 kHz
Power Requirement: 110 VAC, 240 VAC
Weight: 3 pallets, 400kg

APPLICATIONS

- Marine mammal mitigation
- Marine mammal monitoring

SEICHE WATER TECHNOLOGY GROUP

ANNEX VII – TELEDYNE BOLT EMISSION SOURCE SPECIFICATIONS

TELEDYNE BOLT
Everywhereyoulook™

Teledyne Bolt
4 Duke Place, Norwalk, CT USA
Tel. +1-203-853-0700 • Fax +1-203-854-9601 • E-mail: bolt.sales@teledyne.com
www.bolt-technology.com

A Teledyne Marine Company

A Teledyne Bolt Product Line

A Teledyne Bolt Product Line

Teledyne Bolt

Worldwide Leader in Seismic Sources

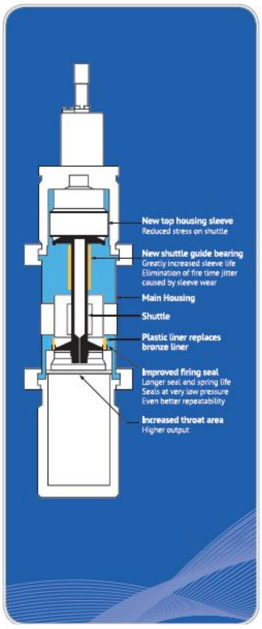
LL
Long Life Seismic Source

TELEDYNE BOLT
Everywhereyoulook™

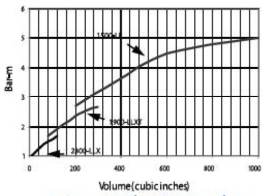
A Teledyne Bolt Product Line

Long-Life Technology Solution

For more than 20 years the Bolt Long-Life Sources have been the workhorse of the seismic industry. The Long-Life Sources are designed as a stable, trouble-free, low maintenance energy source that produce high acoustic output.



The following graph illustrates peak output vs. chamber volume for Bolt Long-Life Sources 0 -128 Hz (filter).



Peak Output vs. Volume (Out-128 Hz Filter)

The Long-Life Source is available in three models spanning volumes from 5 in³ to 2,000 in³.

2800-LLX

The 2800-LLX Source is designed for volumes ranging from 5 in³ to 120 in³. The source is very light weight, and is ideally suited for shallow water source vessels with limited deck space. For maximum energy output, it can easily be configured in 2-gun and 3-gun cluster elements.

2800-LLX Source

1900-LLXT

The 1900-LLXT Source is designed for volumes ranging from 10 in³ to 250 in³. The source is extremely versatile, and is sufficiently light-weight for shallow draught vessels while powerful enough for blue water seismic surveys.

1900-LLXT Source

1500-LL

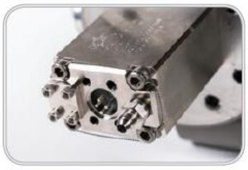
Due to its large throat area, the 1500-LL Source is capable of generating very high peak output with excellent low frequency content associated with large chamber volumes. Using heavy-duty cluster spreader bars, it is possible to configure cluster elements in excess of 1,000 in³ without sacrificing peak output.

1500-LL Source

The 1500-LL Source produces the highest peak output over the largest range of chamber volumes. The gun can be configured with chamber volumes ranging in size from 70 in³ to 2,000 in³. Large chamber sizes require heavy duty towing frames to withstand the shock generated by the gun.

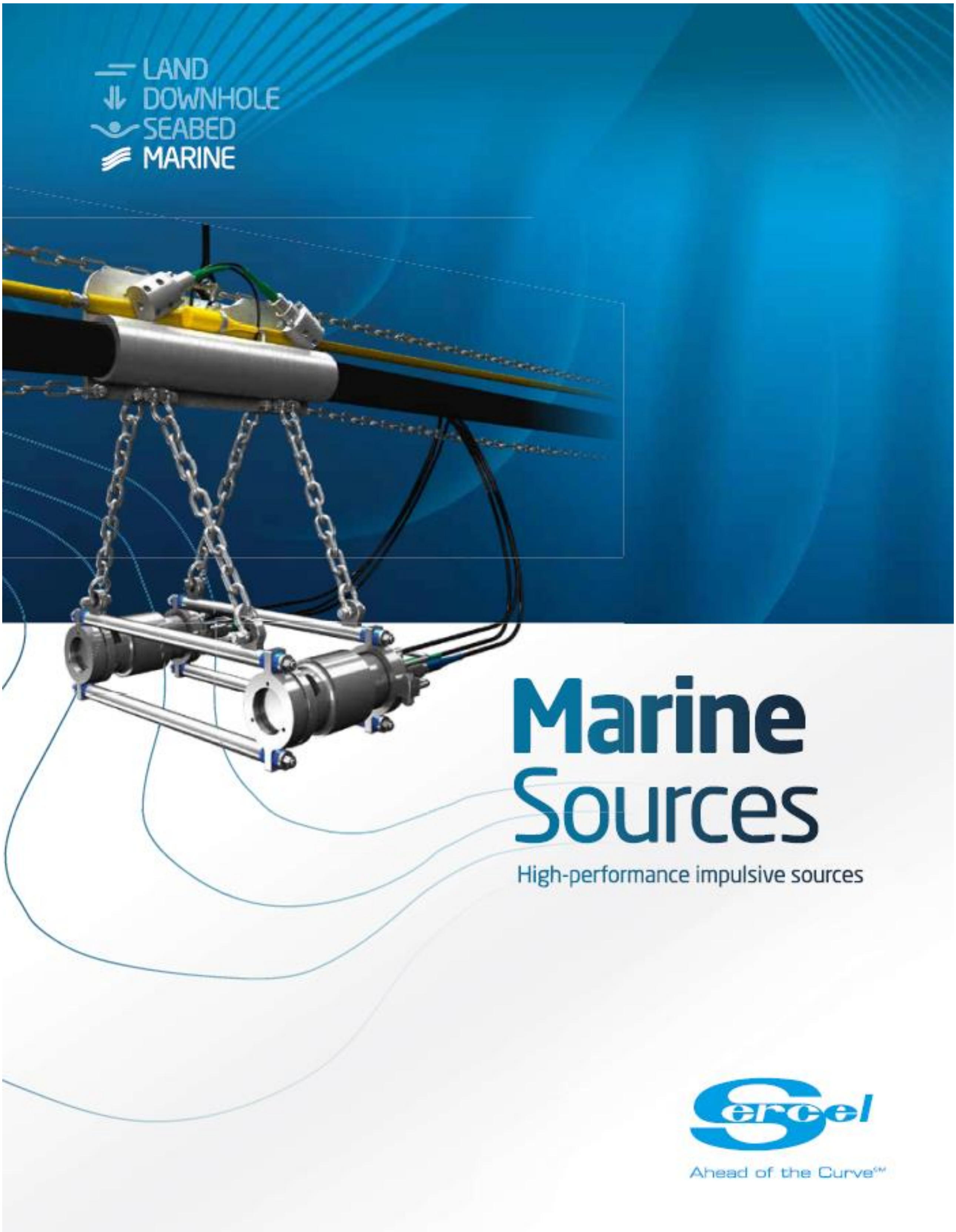
Firing Control

Bolt offers the most advanced firing control mechanisms in the Industry. From clean time-break signatures to advanced distributed control and QC, Bolt has a solution for you.



Smart Source

ANNEX VIII – SERCEL G-GUN IMPULSIVE SOURCE SPECIFICATIONS



Marine Sources

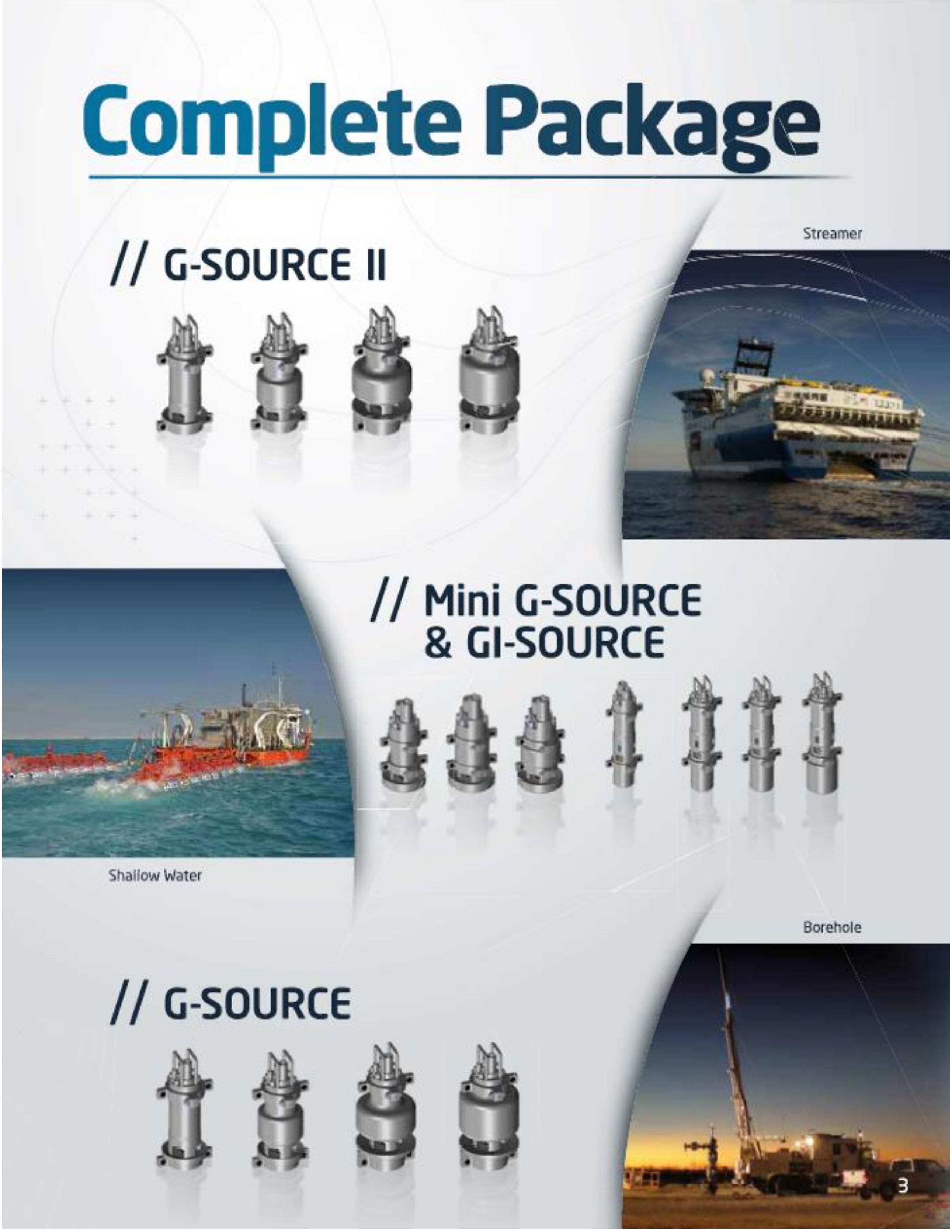
// HIGH-PERFORMANCE IMPULSIVE SOURCES

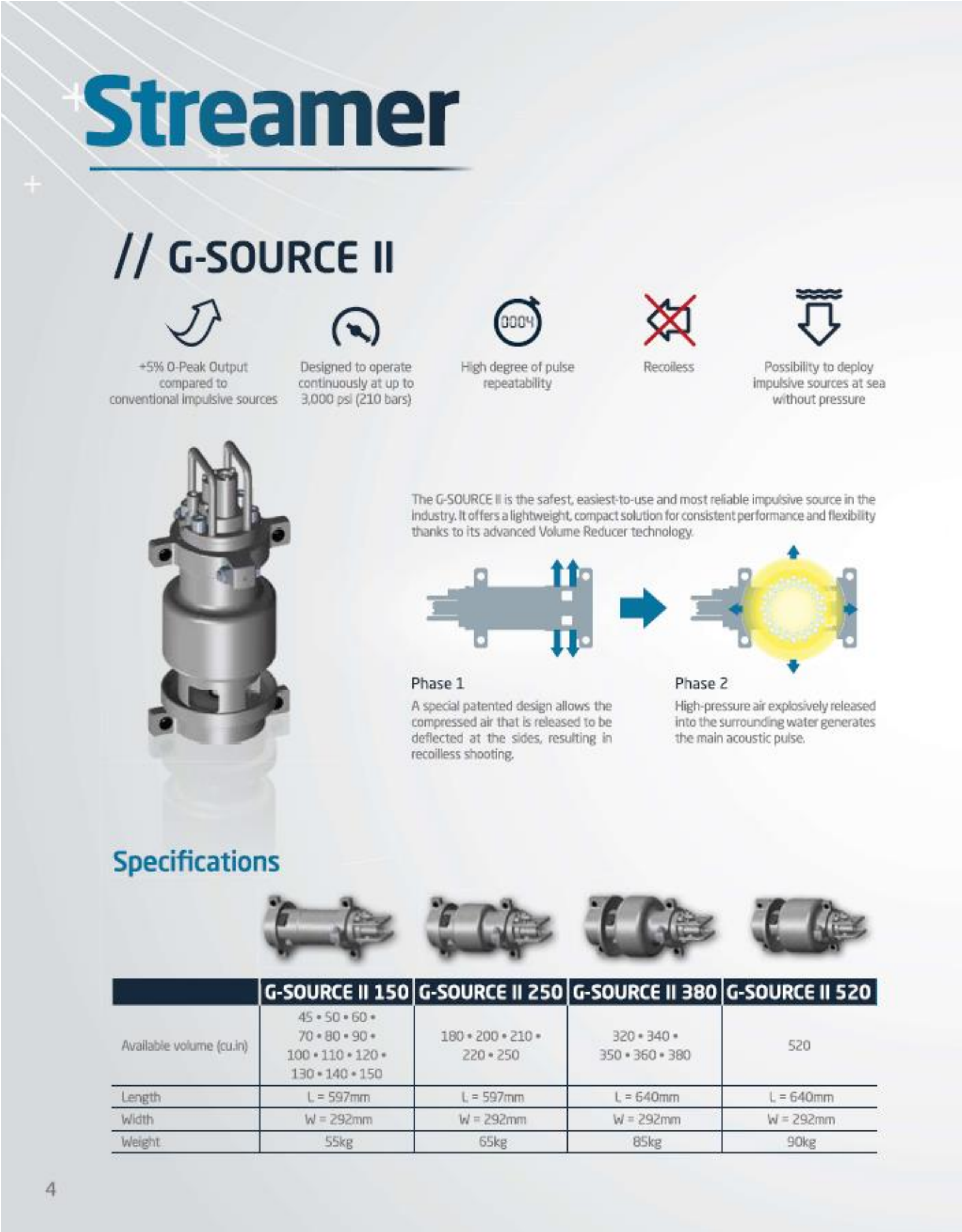
Sercel has 30 years of experience in the design and manufacture of marine sources. Throughout this time, Sercel has developed sources for all applications encountered within the seismic industry, including the most demanding environments.

This expertise has provided us with the foundations for designing a turnkey marine seismic source solution that can be adapted to every customer's need and operating environment as well as be built on for future source solutions and other in-sea equipment such as float systems.

The design philosophy driving all our marine source products is ease-of-use, safety and reliability. Sercel offers the most comprehensive air impulsive source portfolio in the industry that can be used for seismic & engineering applications such as towed streamer, shallow water/OBC/OBN and VSP surveys.

2


Complete Package
// G-SOURCE II
Streamer
// Mini G-SOURCE
& GI-SOURCE
Shallow Water
Borehole
// G-SOURCE
3



Streamer

// G-SOURCE II

+5% 0-Peak Output compared to conventional impulsive sources

Designed to operate continuously at up to 3,000 psi (210 bars)

High degree of pulse repeatability

Recoilless

Possibility to deploy impulsive sources at sea without pressure

The G-SOURCE II is the safest, easiest-to-use and most reliable impulsive source in the industry. It offers a lightweight, compact solution for consistent performance and flexibility thanks to its advanced Volume Reducer technology.

Phase 1

A special patented design allows the compressed air that is released to be deflected at the sides, resulting in recoilless shooting.

Phase 2

High-pressure air explosively released into the surrounding water generates the main acoustic pulse.

Specifications

	G-SOURCE II 150	G-SOURCE II 250	G-SOURCE II 380	G-SOURCE II 520
Available volume (cu.in)	45 • 50 • 60 • 70 • 80 • 90 • 100 • 110 • 120 • 130 • 140 • 150	180 • 200 • 210 • 220 • 250	320 • 340 • 350 • 360 • 380	520
Length	L = 597mm	L = 597mm	L = 640mm	L = 640mm
Width	W = 292mm	W = 292mm	W = 292mm	W = 292mm
Weight	55kg	65kg	85kg	90kg

4


Single impulsive source type
Single sleeve
Range of casings
Each impulsive source volume can be easily changed by means of inexpensive "Volume Reducers" or by changing the external casing.
• Single set of spare parts for the entire G-SOURCE II range.
• Assemble/disassemble within minutes without special tooling.
• Firing/sensor/sleeve/shuttle system for all G-SOURCE II.
With its mechanical advantages and strong acoustic performance the G-SOURCE II is the impulsive source of choice for high-production seismic vessels.
For maximum energy output and high signature consistency shot after shot, G-SOURCE II impulsive sources can be configured in impulsive source clustered elements using our patented parallel cluster assembly design.
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Marine Sources

High-performance impulsive sources

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Ahead of the Curve℠

ANNEX IX – MAP-BASED NAVIGATION