PROTECTION PROTOCOL FOR MARINE FAUNA DURING SEISMIC CAMPAIGNS

Circulation:

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11/02/2019

Document description

Report title: PROTECTION PROTOCOL FOR MARINE FAUNA AND SEISMIC CAMPAIGNS

Internal reference: ASTI-2019-148

Circulation:

☒ Free (internet)

☐ restricted

☐ Forbidden (confidential) – date that confidentiality raised: YYYY/MM/DD

Publication date:

Version: 1.0.0

Cover illustration reference

Language(s):

Abstract:

This document explains measures taken by Ifremer to protect marine fauna when using class 1 seismic sources (> 500 in^3). Before presenting the protocol to be applied during marine geoscience campaigns, the noise risk assessment principles are recapped.

Key words: Seismic, marine mammals, turtles, thresholds, PTS, TTS, exclusion zone, MMOs, PAM, pre-shot research, ramp-up, stopping shots

How to quote this document:

Availability of the research data:

DOI:

Revisions:

Index	*Subject*	*Date*	*Written by*	*Checked by*	*Approved by*
1	Creation	19/07/2011	X. Lurton		
2	Revision	09/07/2013	X. Lurton	Y. Le Gall	M. Nokin
3	Revision	04/01/2016	C. Ducatel Y. Le Gall X. Lurton	M. Nokin	P. Cotty O. Lefort
4	Revision	08/03/2019	C. Ducatel Y. Le Gall X. Lurton	M. Nokin	O. Lefort

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GLOSSARY:

ACCOBAMS: Agreement on cetacean conservation in the Black Sea, the Mediterranean and the adjacent Atlantic zone

ASCOBANS: Agreement on the conservation of small cetaceans in the Baltic Sea and the North-East Atlantic

LF: Low Frequency

Good observation conditions: During the daytime, with sea conditions at no more than a 3 on the Beaufort scale, and an entirely visible exclusion zone.

Limited observation conditions: visual observation is still possible up to a 5 on the Beaufort scale if the exclusion zone is clear. Other criteria (sea conditions, cloud cover, etc.) influence observation conditions. Consequently, it comes down to the person in charge of the MMO equipment to judge the weather conditions that allow visual observation.

Class 1: seismic source for which total volume is greater than 500 in^3

Class 2: seismic source for which total volume is less than 500 in^3

CBD: Convention on biological diversity

CMS: Convention on the conservation of migratory species of wild animals.

CPA: Closest Point of Approach

MSFD: Marine Environment Strategy Framework Directive

DFO: Oceanographic Fleet Management

DFO/PON: DFO Naval Operations Centre

Target species (TS): groups together marine species to which this protocol is applied. This refers to all Baleen whales from the large toothed whales (sperm whale, orca, false killer whale, pilot whale, beaked whale, Risso's dolphin), and porpoises. The protocol does not encompass small oceanic dolphins such as *stenella and delphinus*, with the exception of species protected by the host country's regulations in force. Sea turtles are also considered as targeted species and are subject to specific mitigation measures.

HF: High Frequency

MF: Medium Frequency

MM: Marine Mammals

MMO: Marine Mammal Observer

NMFS: National Marine Fisheries Service

NOAA: National Oceanic and Atmospheric Administration (USA)

NW: Non-Weighted

IMO: International Maritime Organisation

OSPAR: Convention for the Protection of the Marine environment of the North-East Atlantic.

PAM (*Passive Acoustic Monitoring*): detection, identification and location system using passive acoustics. This generally refers to a towed streamer with a network of hydrophones, completed by its signal processing system including the specific software.

TL: Transmission Losses

PTS: Permanent Threshold Shift

RMS: Root Mean Square

SEL: Sound Exposure Level

SEL_{CUM}: Accumulated sound exposure level

SIG: Geographic Information System

SL: Sound Level

SL_{PK}: Peak Sound Level

SPL: Sound Pressure Level

SPL_{PK}: Peak Sound Pressure Level

Soft-start (or ramp-up): progressive start-up procedure for seismic emissions intended to increase the sound level up to its nominal value reached after a certain time.

TTS: Temporary Threshold Shift

EU: European Union

VHF: Very High Frequency

WF: Weighted Function

Warning zone: circle around the acoustic source with a radius set at 1.5 km for visual observations with no boundaries for acoustic detections. Reinforced surveillance is applied if a relevant species is spotted inside this zone.

Exclusion zone (Zex): circle around the acoustic source with a radius set at 500 m for class 1 seismic sources. Seismic shots are stopped if a targeted species is spotted inside this zone.

1 GENERAL PRESENTATION

1.1 Context and Goals

The impact of underwater acoustic noise on animals (particularly marine mammals) has been the subject of many national and international papers aiming, on the one hand, to fill in the remaining scientific gaps and, on the other hand, to develop technology and methods to limit consequences. According to Article 1 of the United Nations Convention on the Law of the Sea (UNCLOS, 1982), anthropogenic noise sources can be considered as a cause of pollution [1]. Many inter-governmental decisions have thereby guided several recommendations and regulations. Annexe 1 provides a non-exhaustive list of the main texts concerning underwater anthropogenic noise and marine animals. For this purpose, several states (Australia, Brazil, New Zealand, etc.) have already regulated the use of acoustic equipment at sea.

Out of concern for environmental issues and aware of the sensitive nature of certain sound emissions, since 2011 Ifremer has defined a protection protocol to limit acoustic impact risks on marine mammals. Following modelling work and measures run for several years, noise risks consideration for marine mammals is nowadays limited to the single case of seismic sources. Each scientific campaign using class 1 seismic sources (total volume > 500 in^3) programmed on an oceanographic fleet ship nowadays must systematically run a noise risk analysis and take suitable cautionary measures to be applied at sea [2]. Impacts from other acoustic systems (particularly sounding machines) are considered as negligible and are not subject to precautions for specific use [2,3,4].

Recent scientific progress in the field [4, 5, 6] has led Ifremer to update its assessment method for noise risks from seismic sources by considering new NOAA physiological thresholds, new weighting functions [5, 6] and by calculating the accumulated sound exposure along a Survey profile [4].

Considering this progress and feedback from MMOs and PAM operators on board Ifremer campaigns, the ASTI-2016-5 version of the marine mammal protection protocol against seismic emissions [2] is revised in this document. Before explaining the protection protocol, there is a recap of the noise risk assessment principles.

1.2 Assessment of noise risks from seismic sources: recap

1.2.1 Principle

To assess the potential impact of a sound source on the marine fauna, the signal emitted by this source must be expressed as the maximum sound level received in an instant (*Peak Sound Pressure Level:* SPL_{PK}) and as the cumulated sound exposure level (*Cumulated Sound Exposure Level:* SEL_{cum}). These metrics take into consideration the sound level emitted by the source, the frequency and the angular directivity, meaning the spatial distribution of the sound energy, plus the duration and the pace of signal emission. The received level also depends on sound wave propagation phenomena.

The method used in the document [7] to assess the physiological impact is developed working from the sonar equation [8], that translates an energy balance between the signal levels emitted, received and processed. The definitions and main equations used in this work are presented below:

SL is the sound level on emission, defined as the maximum value of the acoustic pressure at the reference distance R_0= 1 m from the source, expressed in dB ref 1µPa @ 1 m. In this specific study of seismic sources, SL_{PK} is the peak value, with an increase of 3 dB (in the case of a harmonic signal) compared to the mean square value SL_{RMS}.

$$SL_{PK}(R_0) = 20log_{10}(p_{max/}p_{ref})$$

With p_{max} = $\max(p(t))$, $p(t)$ is the pressure level at distance R_0 and $p_{ref} = 1$ µPa.

SPL(R) represents the acoustic pressure level received at a distance R, in dB ref 1 µPa.

SEL(R) expresses the sound exposure level at a distance R. It is calculated working from $SEL(R_0)$ that is given by integrating the acoustic pressure at R_0 = 1 m and then squared depending on the time over the entire useful duration of the received signal and it is expressed in dB ref. 1µPa²×s @1 m.

$$SEL(R_0) = 20log_{10}\left(\int p^2(t)dt \Big/ {p^2}_{ref}\right)$$

$DF(\theta)$ is the value of the Directivity Function from the source at the angle θ, describing the spatial distribution of the intensity transmitted. By convention, *DF* (0°) = 0 dB in the source axis, namely the maximum intensity direction (in general aimed vertically downwards for seismic sources and sounding machines).

PT(R) expresses the transmission losses (in dB) at distance *R* caused by propagation of the sound signal in the surrounding medium. They consider both the geometric losses and the absorption phenomenon [8]. The propagation model used in this study rules out the absorption phenomenon due to the low frequencies used in seismic studies. The equation characterising the transmission losses *(PT)* thereby relies on the spherical divergence law:

$$PT(R) = 20\log R$$

Considering these parameters and in compliance with the sonar equation $SPL(R, \theta)$ and $SEL(R, \theta)$ are expressed as:

$$SPL(R,\theta) = SL(R_0) + DF(\theta) - PT(R)$$

$$SEL(R,\theta) = SEL(R_0) + DF(\theta) - PT(R)$$

In the case of exposure to several signals, $SEL(R, \theta)$ must consider their number and their respective levels.

The sound risk is assessed for a marine mammal exposed to a seismic source implemented along a profile (straight line route that might stretch several tens or even hundreds of km). Exclusion zones are calculated by considering the influence of the directivity of the source and the frequency weighting functions for groups of cetaceans classified by their hearing (LF, HF, VHF) A certain number of hypotheses are performed in the modelling:

- The sound source moves at a constant speed (5 knots) and in the same direction (Ifremer class 1 seismic profile, see Annexe 3 for characteristics of the Ifremer seismic source characteristics),
- The receiver is stationary,
- The seismic shot pace is constant,
- Propagation losses are calculated according to the spherical divergence model [8],
- the SEL_{cum} is calculated by integrating the emission when a ship passes at the closed possible point (CPA) to the marine mammal to consider the exposure that makes the greatest contribution.
- To obtain a relatively simple calculation, the directivity functions in the vertical/longitudinal plane against the source were retained in the modelling, by considering them invariant due to rotation around the vertical axis at the source (hypothesis of a omnidirectional source in azimuth, a priori correct for a single air gun but doubtlessly less so for an array of several air guns).

Calculation of the *SPL*(*R*) :

Vertical to the source, the levels perceived in the water depending on the level emitted and the propagation losses in the surrounding area. Considering these elements, the maximum level received ($SPL\ (R)$) at a distance R from the source is given by:

$$SPL_{PK}(R) = SL_{PK}(R_0) - PT(R)$$

In other terms, the $SPL_{PK}(R)$ does not consider:

- duration of the emitted signal,
- frequency content,
- directivity function,
- shot pace,
- weighting functions.

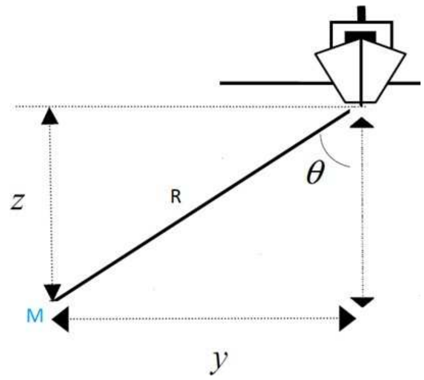

Figure 1: Geometry of the field radiated by a seismic source at a given point

With:

$$\theta = \tan^{-1}(\frac{y}{z})$$
$$R = \sqrt{y^2 + z^2}$$

SEL calculation along an acquisition profile

The geometry of the field radiated by a seismic mobile source along an acquisition profile is represented in Figure 2. The source is located in the plane (*z = 0)* and it moves at constant speed (here V = 5 knots) along the X axis. A marine mammal is present at point M with coordinates (X_M = 0, Y_M, Z_M) where the cumulated sound exposure level is calculated.

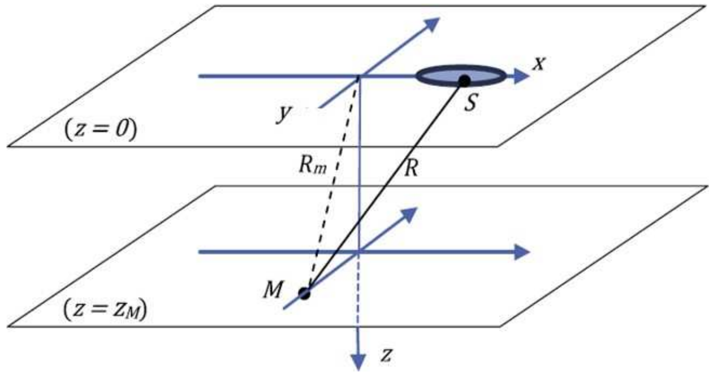

Figure 2: Geometry of the field radiated by a mobile source along an acquisition profile [4]

The cumulated SEL is estimated by integrating the emission corresponding to a ship passing at the CPA. It is calculated by considering the shot pace and the speed of the vessel. Transmission losses, directivity and weighting functions are also considered. The cumulated SEL is determined by:

$$SEL\ (Y_M, Z_M)_{cum} = 10\log_{10} \sum_i \int_{fmin}^{fmax} 10^{\left[\frac{DSP(f)+DF(f,\theta_i)+WF(f)-PT(R(X_i))}{10}\right]}\ df$$

With:

- DSP: the spectrum level of the seismic source given in dB re 1 µPa /Hz @ 1 m,
- DF: the source directivity function value,
- WF: the weighting function.

The point sampling in *x* (axis that the vessel is moving along) is defined so that there is one transmission per coordinate x_i ; the step in *x* is $\Delta x = V \text{x}\ T$, where V is the speed of the vessel (in m/s) and T the duration between two shots (in s).

1.2.2 Auditory thresholds and weighting functions: best practice

In the 1990s, to assess noise risks, the American regulating bodies (NMFS) firstly defined two levels of harassment corresponding to the perceived levels [3]:

- Level A is equivalent to the danger limit, over which physiological effects are likely to occur.
- Level B corresponding to the threshold over which considerable behavioural changes can occur.

For pulsed sources, A and B levels were respectively 180 and 160 dB re 1 µPa (RMS). This definition only considered the perceived level. The frequency, duration, occurrence of the signals and the auditory sensitivity of the different species of marine mammals was not considered. Consequently, these initial thresholds were way too simplistic and have now been discarded.

In 2007, Southall and a team of specialists published a summary [9] of progress in knowledge relating to the auditory capacities of marine mammals, developing several key points:

- Marine mammals are classified into 5 categories depending on their auditory capacities, considering direct and indirect measures made for certain species,[1]
- Weighting functions *M-WF* are defined for each of these groups,
- New thresholds [9] are proposed by considering the nature of the signal, the level received and the duration of the exposure.

Initially proposed in the report [9], weighting functions *M-WF* were developed to consider the auditory sensitivity of marine mammals and assess the potential effects of a sound signal on a given category.

In recent reports [5,6], the NMFS then Southall and his team particularly summarise new knowledge obtained since 2007 [10 to 14]. This progress leads to adjusting the functional hearing ranges for the 6 categories of marine mammals and new weighting functions and thresholds for TTS and PTS. Table 1 presents the 3 categories of cetaceans. Figure 3 illustrates the weighting functions for type M [9], represented by solid lines and those currently used in the NMFS guide [5] and in the review drafted by Southall and his co-authors [6], represented by dotted lines.

[1] NB: no audiometric measurement is available for Baleen whales.

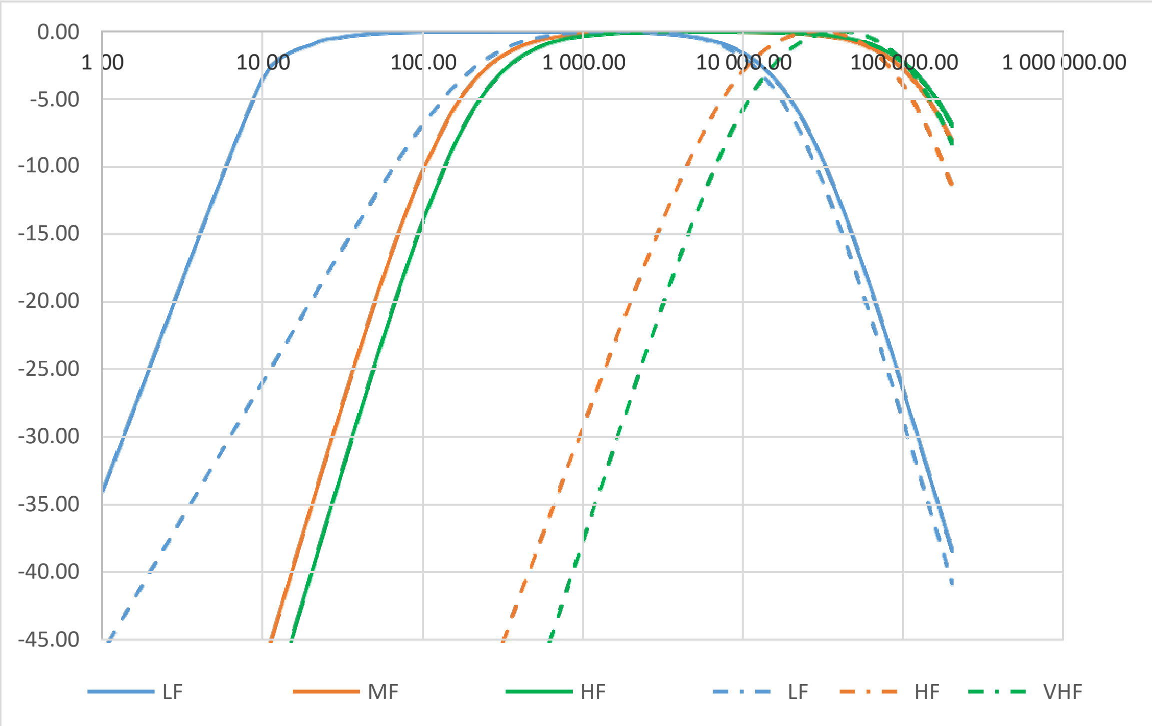

Figure 3: M-WF weighting functions issued by Southall 2007 [9] (solid lines) and NMFS 2018 [5] (dotted lines)

	Marine mammal group	Audible frequency range
LF	**Balaenidae** (*Balaena, Eubalaenidae spp.*) ; **Rorquals** (*Balaenoptera physalus, B. musculus*) ; **Rorquals** (*Balaenoptera acutorostrata, B. bonaerensis, B. borealis, B. edeni, B. omurai; Megaptera novaeangliae*); **Pygmy right whales** (*Caperea*), **Grey whales (***Eschrichtius***)**	7 Hz to 35 kHz
HF	**Physeteroidea** (*Physeter*); **Beaked whale** (*Berardius spp., Hyperoodon spp., Indopacetus, Mesoplodon spp., Tasmacetus, Ziphius*); **Oceanic dolphins** (*Orcinus*); **Oceanic dolphins** (*Delphinus, Feresa, Globicephala spp., Grampus, Lagenodelphis, Lagenorhynchus acutus, L. albirostris, L. obliquidens, L. obscurus, Lissodelphis spp., Orcaella spp., Peponocephala, Pseudorca, Sotalia spp., Sousa spp., Stenella spp., Steno, Tursiops spp.*); **Monodontidae** (*Delphinapterus, Monodon*); Plantanistidae (*Plantanista*)	150 Hz to 160 kHz
VHF	**Oceanic dolphins** *(Cephalorhynchus spp.; Lagenorhynchus cruciger, L. austrailis);* **Porpoises** *(Neophocaena spp., Phocoena spp.,)* **Dall's porpoise); Iniidae (Inia); Kogiidae (Kogia); Lipotidae (Lipotes); La Plata dolphin (Pontoporia)**	275 Hz to 160 kHz

Table 1: Classification of cetaceans according to their functional auditory ranges [5] and [6]

Sufficiently intense sound exposure for an animal can lead to an increase in the hearing threshold. The duration of this increase depends essentially on the exposure time, the breadth and the frequency of the signal. This shift in the hearing threshold can be temporary (*TTS*) or permanent (*PTS*).

For pulsed signals, the sound exposure duration is not the only criteria that can cause physiological damage. It is along these lines that the NMFS proposes a dual approach for pulsed signals by expressing the TTS and PTS thresholds at the same time in SEL_{cum} (cumulated sound exposure level) and in SPL_{PK}. Furthermore, the peak value for acoustic pressure does not consider the frequencies at which the targeted animal is the most sensitive, the weighting functions are therefore not considered for the metrics SPL_{PK}. The PTS thresholds used by the NOAA and Southall's team are given in Table 2 [5,6].

Group	SEL_{cum} (weighted) In dB re 1µPa²s	SPL_{PK} (not weighted) En dB re 1µPa
LF	183	219
HF	185	230
VHF	155	202

Table 2: PTS threshold values for pulsed signals [5,6].

1.2.3 Results

Following Ifremer's sound risk assessment results for seismic sources, two classes of seismic sources were defined:

- Class 1 for source volumes over 500 in^3 namely 8.2 litres, that can potentially affect marine mammals.
- Class 2 for source volumes under 500 in^3 namely 8.2 litres.

This classification is justified in Annexe 2.

The sound emission mitigation protocol is only applied to Class 1. Class 2 is not subject to specific control or mitigation measures.

Table 3 summarises the results from the sound risk assessment for Ifremer's most powerful seismic sources, noted S_1 (V = 2570 in^3) and S_2 (V = 4990 in^3). The detailed characteristics of these sources are provided in Annexe 3. For cetaceans from the LF (impact criterion: SEL_{cum}) and HF groups, the most commonly found species during the Ifremer marine geoscience campaigns, the maximum exclusion radii thereby calculated are around 100 m (Table 3). By taking an exclusion radius of 500 m (chosen in the Ifremer protocol and in most internationally applied protocols), the security factor is therefore close to 5. When considering cetaceans in the VHF group, with a very low probability of finding them in high-sea campaigns, the impact criterion is the SPL_{PK}. The calculation thereby gives a maximum exclusion rate of 420 m, still less than the safety distance of 500 m defined in the Ifremer protocol. This radius is calculated for marine mammals in the source axis. For species swimming on the surface or at shallow depths, the attenuation caused by the array's directivity is around 30 dB, which brings the exclusion radius to 13 m for the VHF category.

In conclusion, defining an exclusion radius of 500 m for seismic sources with a volume over 500 in^3 is therefore a conservative measure.

		Cetacean group		
		LF	HF	VHF
	Thresholds_SPL$_{PK}$ (dB re 1 µPa)	219	230	202
S_1	Rex_SPL$_{PK}$ (m)	41	11	288
S_2	Rex_SPL$_{PK}$ (m)	60	17	422
	Thresholds_SEL$_{cum}$ (dB re 1 µPa².s)	183	185	155
S_1	Rex_SEL_cum (m)	114	0	2
S_2	Rex_SEL_cum (m)	103	0	3

Table 3: Summary of thresholds and exclusion radii (m) for the Sources S_1 and S_2 for all three groups of cetaceans.

Figure 4 represents the SEL$_{cum}$ modelling results for LF cetaceans along a seismic acquisition profile for the most detrimental seismic source: S_1.

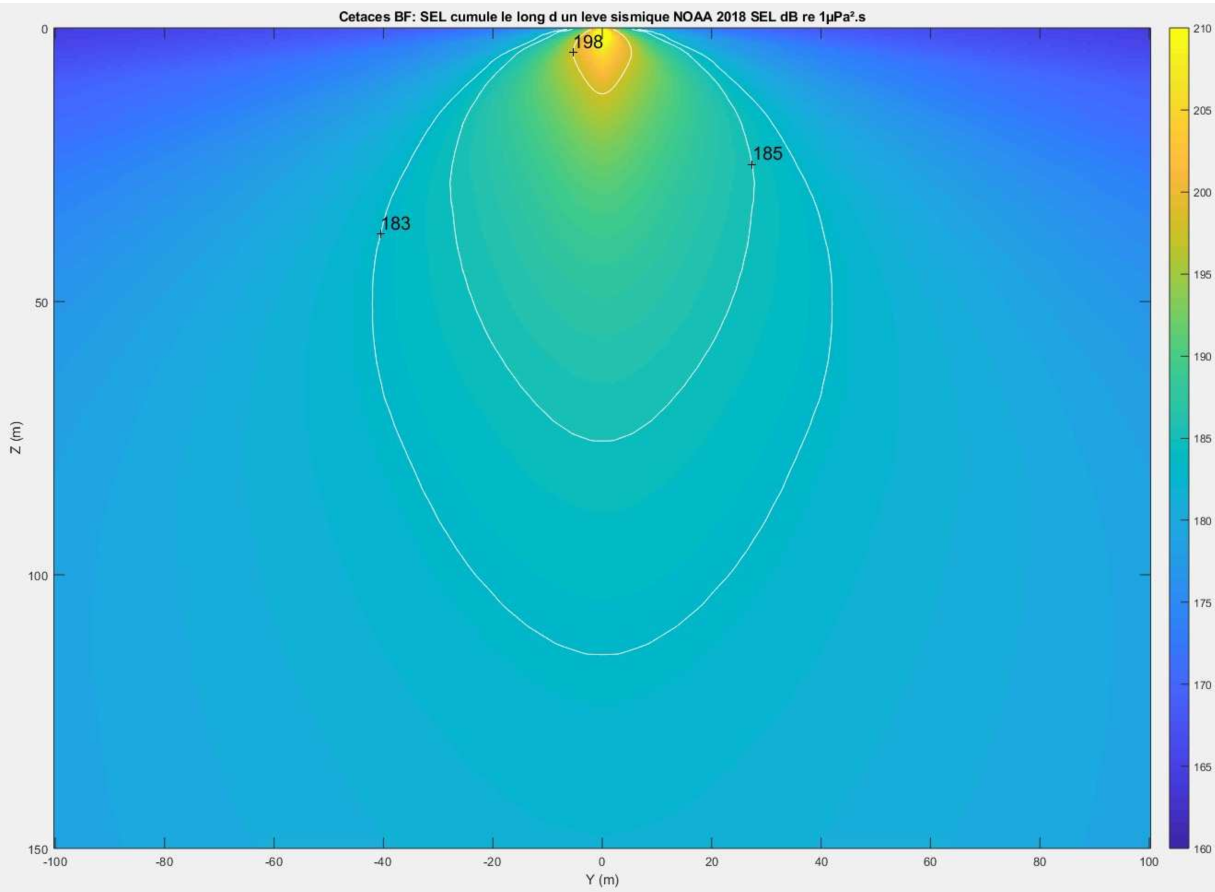

Figure 4: Case of LF cetaceans: SEL$_{cum}$ along a seismic acquisition profile for the source S_1 of 2570 in^3

1.3 Description and summary of Ifremer's mitigation measures

1.3.1 Before the campaign

The scientific teams are informed of the mitigation measures defined by Ifremer when bidding on oceanographic campaigns. Any campaign project implementing class 1 seismic sources is accompanied by a pre-study (run by Ifremer) on the planned operation's compatibility with safeguarding the marine mammals and turtle population in the area (see § 2.1) and secondly, a risk analysis on potential sounds (see § 2.2). The campaign programming (zone and study period) considers the results from this assessment and local measures that might be imposed by the host Country in response to a work authorisation request in the waters within their jurisdiction.

1.3.2 During the campaign

The seismic emission mitigation procedure is applicable for operations involving class 1 seismic source emissions (justification provided in § 2.1.3. and in Annexe 2 of this report), around which a warning zone and a specific exclusion zone are defined. It includes the following points:

- marine mammal observers come on board to run visual surveillance on the zones being explored. These observers aim to detect the targeted species in the exclusion zone and within the warning zone. They also collect information on how marine mammals behave during seismic emissions.
- The seismic emissions can only start after a preliminary observation period, intended to demonstrate that there are no cetaceans in the exclusion zone; this begins with a progressive ramp-up; this phase must allow any animals possibly present in the area to move far enough away from the seismic source.
- If targeted species are detected inside the exclusion zone defined around the seismic source, emissions are immediately stopped. After these animals move away, there is a new preliminary observation period and the emissions begin again following the same initialisation procedure.
- The PAM system is deployed when required by the host country's regulations. Depending on the context, Ifremer reserves the right to deploy it and use it as supplementary equipment, strengthening the visual surveillance resources.
- The authority to request stopping the shots falls to the marine mammal observers and the PAM operators.
- MMO team/PAM operator recruitment is validated by Ifremer.

2 PROTECTION PROTOCOL FOR MARINE FAUNA AGAINST SEISMIC EMISSIONS FROM CLASS 1 SOURCES

N.B. The measures described here, and their frame of applicability, correspond to the self-regulation defined by Ifremer on its own activity implementing its seismic sources. They do not replace application of possible regulations originating from the host country's specific laws.

The protocol presented here is a review of the preceding version (Revision 3). This update considers the latest scientific knowledge concerning sound risk assessment, recent guides and international recommendations [5, 6] not only aiming to protect marine mammals during seismic acquisitions (see Annexe 1) but also provide feedback from on-board observers over the last three years. In this context, this protection protocol defines the best-adapted and most relevant measures to be applied for the campaigns implementing Ifremer's most powerful seismic sources.

2.1 Upstream study and noise risks

Each campaign proposal implementing class 1 Ifremer equipment must be backed up by a prior study of the potential presence of populations of the targeted species in the zone, possibly leading to planning the envisaged operations. This pre-study is sent to Ifremer during the initial submission phase of the campaign proposal dossiers; an ad hoc committee meets to analyse it.

Depending on the pre-study's conclusions, Ifremer reserves the right to propose programme planning for the envisaged jobs (particularly programming dates) or even refuse the request.

The preliminary examination modalities and the assessment results are announced to the teams submitting a campaign proposal which is subject to this procedure.

2.1.1 Protected zones

Ecologically important zones for marine mammals (feeding, reproduction, birthing zones, migration corridors, and zones known for being potential habitats of deep divers) must be subject to in-depth and specific protection measures. The knowledge required to identify these zones is essential and a specific effort should potentially be made to collect this data in the literature.

2.1.2 Species involved

Marine mammals are classified into 6 categories depending on their hearing abilities. Weighting functions and hazard thresholds were defined for each of these groups [5, 6].

The protocol is applied for the following species:

- All Baleen whales,
- The large toothed whales (sperm whale, orca, false killer whale, pilot whale, beaked whale, Risso's dolphin),
- All VHF cetaceans.

As the protocol applies for very powerful seismic sources deployed out at sea, coastal mammals (seals and sea-cows) are not part of the TS.

Sea turtles are, however, considered as targeted species and are subject to specific mitigation measures, see § 2.2.8.

Fast-swimming, small oceanic dolphins are often seen in the ship's wake, therefore at more than 100 m from the seismic source and consequently outside the physiological risk zone for these species (the calculated exclusion radius is around 13 m considering the source directivity, see § 1.2.3). Consequently, the protocol does not consider these small oceanic dolphins (such as *Stenella* or *Delphinus* species which mainly live on the surface or sub-surface). However, in the event of specific regulations to protect these species applied by the host country, they will then be considered as targeted species. Furthermore, if a species in the zone cannot be identified by the observers, they will err on the side of caution.

2.1.3 Noise risk study

The sound emission mitigation protocol is applied only to class 1 and the exclusion radius is set at 500 m, which means that acoustic sources are stopped when a targeted species enters this safety perimeter.

These protection measures adapted by the Ifremer are very cautious for several purposes:

- The cumulated SEL received by the mammal is estimated by integrating the emission corresponding to the passing of the vessel at the CPA in order to incorporate the strongest contribution to the sound exposure. It considers the shot pace and the vessel speed. Transmission losses, directivity and weighting functions are also considered;
- The limit between the two classes after the calculations is situated at 800 in^3. The choice of a limit at 500 in^3 is therefore conservative;
- Depending on the chosen cetacean group and assessment criterion, the calculation gives exclusion radii between 100 m (LF category) and 400 m (VHF category). The choice of a single radius of 500 m is therefore very conservative as it considers the VHF category, that can barely be seen at sea.

2.2 Measures applied during the campaign

2.2.1 Exclusion zone and alarm zone

The exclusion zone is defined by a circle around the seismic source with a radius of 500 m. Outside this zone, the probability of physiological damage among the TS is considered to be negligible. This zone is watched over by the mitigation team during seismic acquisition periods (pre-shot research, ramp-up of sources and full-powered shot). As soon as a TS is detected in this zone, operations are postponed or stopped, depending on the acquisition process phase.

The alarm zone is defined by a 1.5 km radius around the source. Any visual detection of the targeted species inside this zone implies that information must be immediately exchanged by radio between the MMO team, PAM operators and the Genavir seismic team. The animal's behaviour must then be observed very closely.

The alarm zone radius for the PAM system is unlimited. Consequently, in daytime, any acoustic detection must be immediately transmitted (by radio) to the MMOs.

2.2.2 Visual surveillance

Two visual observers must be at their posts for the entire duration of the seismic activities, from sunrise to sunset to monitor the zones and report any presence of the targeted species. This period therefore includes dawn and dusk unless the light is not good enough to make effective observations. The MMO in charge will make a decision on light levels. Given that rest times are required to maintain concentration, it is recommended to bring 3 observers on board so they can rotate their watch. In the event of using PAM, the total number of observers (MMOs + PAM) will be adapted to the specific nature of the campaign (nature and duration of the works).

The observers must be positioned at a point on the vessel that is high enough to give them a clear, effective view to detect marine mammals, generally the top bridge or the gangway.

Animals are detected with the naked eye. Binoculars can then be used to identify and locate the animal. In general, the distance is calculated from the number of crosshairs separating the horizon from the observation.

The observers have full authority to stop the shots if the targeted species are present in the exclusion zone. They also play an advisory and expert role for the ship and for the scientific mission, in situations that require specialist opinions.

2.2.3 Acoustic surveillance

Due to the current limitations of PAM system performances, its deployment is not systematic and depends on the regulations that might be applied in the country in question. However, Ifremer reserves the right to impose this system for some campaigns, defined case by case, depending on the zone and the period being considered plus characteristics of the sources being implemented. If it is used, the specific protocol defined below will be applied.

A PAM operator must be available for the entire duration of the seismic activities. As for visual detection by MMOs, in the event of acoustic detection of TS in the exclusion zone, the order to stop the shots is given by the PAM operators. The PAM data will be systematically recorded for each acoustic and/or visual detection, whether this is inside or outside the zones, and during the operators' break.

In real time, it is very difficult to differentiate the different species of oceanic dolphins acoustically. Out of caution, the order to stop shots is given when the PAM operator can locate several lines of clicks emitted by small non-identified cetaceans when visual observations cannot provide accurate species identification.

For HF (high frequency) clicks (>100 kHz), location is not necessary because the signals emitted at these frequencies are absorbed quickly, practically preventing detection at distances over 500 m. Detecting HF clicks therefore indicates that marine mammals are inside the exclusion zone.

More generally, the acoustic location of marine mammals with the Ifremer PAM 2D system is a complex, inaccurate process because of its specific geometric configuration. In this case, the triangulation calculation is only accurate if the animal is moving slowly, a valid hypothesis for sperm whales and beaked whales, for example. On the other hand, for most oceanic dolphins, this condition is no longer respected, and location inaccuracy can be high. The order to stop shots thereby relies on the PAM operators' skills and experience, judging whether the situation justifies stopping the shots. Possible discussions on detection and location of animals, if necessary, can only take place once the air guns have stopped.

At night or in poor visibility, when the PAM system encounters a technical issue affecting its operation, the seismic acquisitions can continue for 30 minutes, the time allotted to the operator to assess the incident. Once this time is up, if the PAM needs to be repaired, then the seismic shots can continue for one hour, subject to a targeted species being detected by the PAM in the exclusion zone during the two hours before it stops. Once this hour has passed, if the PAM is still not repaired, seismic emissions should be stopped and cannot start again until visual observation conditions are restored.

2.2.4 Pre-shot research

Pre-shot research aims to ensure the absence of TS in the exclusion zone prior to any emissions. Zones that are over 200 m deep are known homes of deep divers (sperm whales, beaked whales) with long apnoea periods (> 30 min). The duration of the pre-shot research or the means for detecting the presence of these deep divers is adapted to optimise observations. Table 4 defines the duration of the pre-shot research depending on the water height and the settings on the mitigation equipment. Depending on the geographic area and the season, these parameters can also be adapted.

Water height	3 MMOs	MMOs/PAM	PAM
0 to 200 m	30 min	30 min	30 min
> 200 m	60 min		60 min

Table 4: Duration of pre-shot research depending on the mitigation equipment settings and the water height

If a visual observation and/or an acoustic detection of a TS takes places in an exclusion zone during the pre-shot research, ramp-up of seismic sources must be postponed until 30 or 60 consecutive minutes (see Table 4) have gone by without detecting TS in the exclusion zone.

2.2.5 Ramp-up of sources

A sequence of full-power seismic shots can only take place after a soft-start or ramp-up of the source, intended to scare off any animals that might be present, and make them leave the potentially hazardous zone. The ramp-up of seismic sources stretches over a duration between 20 and 40 min and begins with emissions of the least powerful air gun on the array, thereby minimising the risk of auditory injury (for example, a Mini GI air gun typically emits a peak level of around 220 dB re 1 µPa @ 1 m when the level of the complete sources can exceed 250 dB). Then the other air guns are successively deployed, until the maximum emission level is attained at the end of the programmed duration.

This protocol aims to protect the targeted species from the seismic emissions and generally limit useless sound emissions. The soft-start should therefore be applied to minimise the time interval between its final phase of full-power shots and the profile start, namely maximum 30 min.

If a TS is observed or detected in the exclusion zone during the ramp-up phase, the air guns are stopped. The pre-watch reappears so that 30 or 60 consecutive minutes pass without a new TS observation.

It is authorised to return to full-power shots without a soft-start phase after stopping for less than 15 minutes and if the detection of TS in the exclusion zones is negative from MMOs and PAM operators. This arrangement does not concern stops caused by the presence of TS in the exclusion zone.

2.2.6 Stopping shots

As soon as a TS enters the exclusion zone, the MMOs and/or PAM operators have the authority to stop the seismic shots: The stopping order is given directly to the Genavir technicians, by UHF radio. Straight after, the MMOs and/or PAM operators inform the deck officer, the captain and the project leader. Shots must be stopped immediately.

The pre-watch starts again when the animals that were detected are outside the observers' field of view, so that 30 or 60 consecutive minutes pass without spotting a TS.

However, when small oceanic dolphins are considered as TS and because they are fast swimmers, ramp-up of sources can restart as soon as they are no longer observed or detected in the exclusion zone.

Furthermore, observers warn the seismic team as soon as animals approach the exclusion zone (concept of warning zone, see §2.2.1) to be able to anticipate a possible stop in the shots and minimise the reaction time.

2.2.7 Change of profile

When the campaign proposal file is handed in, the intention to collect seismic data during gyrations to meet scientific goals must be demonstrated by the project leader. The gyration phases are then considered as seismic survey zones over the study zone and are subject to the same surveillance constraints. Only in this case can the seismic shots continue during the gyrations.

Otherwise, only the smallest air gun can keep working during the gyrations. Before restarting the acquisitions in nominal emission conditions, ramp-up should be applied for 20 to 40 minutes before the profile start.

2.2.8 Specific case of turtles

Sea turtles are capable of perceiving sound signals within a 50 to 1000 Hz range. However, right now, the hazard thresholds are unknown [15 to 21]. Three countries (Brazil, Canada and the United States) have included turtles among targeted species. Because they are small and they swim on the surface, they can only be spotted at short distances even in good weather conditions; therefore, an exclusion radius of 500 m cannot be applied.

Practically, we have a 100 m exclusion distance around the vessel. As soon as a turtle is seen inside this zone, operations are stopped for 5 minutes, giving the vessel time to move far enough away from the turtle. The seismic shots can restart fully after these 5 minutes if the turtle is no longer spotted within a 100 m radius of the vessel.

2.2.9 Qualifications of the MMOs and PAM Operators

It is essential that the MMOs and the PAM operators are independent of Ifremer, Genavir and the on-board scientific team, to be able to do their work impartially with no conflicts of interest.

It is also primordial that the MMOs and the PAM operators are qualified and experienced. The MMOs must be able to justify prior experience[2] in observation at sea and running studies on land, as well as sufficient knowledge on identifying marine mammals and their ecology. They must be capable of following strict scientific protocol and entering data rigorously in a computer database. The MMOs must have quick reflexes, good interpersonal skills and be able to make and assume decisions (stopping shots, engaging a range of procedures) that influence the progress of the scientific mission. They must be capable of offering advice to crew, seismic technicians and the scientific team in certain situations or explain the situation to them and any decisions that have been made.

The PAM operator must be able to prove their experience in real-time detection of marine mammals and appropriate training. He/she must be capable of using the *PamGuard* software and configuring it, be familiar with the equipment and be able to give advice if it is not working properly. He/she must have prior experience of field studies, quick reflexes and be able to make decisions.

Before each campaign, Ifremer and the service provider organise an informative meeting on applying the campaign's mitigation and measurement protocols for the whole mitigation team. Under no circumstances can this meeting be their entire qualification or experience: it aims to inform the MMOs and the PAM operators about any specific measures that will be applied during the campaign and the observation methods recommended by Ifremer, although the personnel should already have the necessary theoretical and practical knowledge. It is also strongly encouraged to recruit personnel with dual MMO/PAM skills to be able to relay operators if necessary (such as during lunch breaks).

The information meeting covers several major topics:

- Basic principles and presentation of the seismic tools.
- Scientific goals and deployment of the seismic campaign,
- Basic knowledge of underwater acoustics,
- Acoustic impacts,
- Species present in the work zone.
- Protection protocol for the species concerned,

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2 However, the MMOs and PAM operator team can be made up of seniors managing juniors in training. We understand a Junior to be a person who has been trained but has no field experience.

- Organisation of the work and responsibilities on-board.

Before the start of seismic operations, the MMOs/PAM team manager must present the mitigation protocol that will be applied and the organisation of his/her on-board team and the responsibilities of each team to the entire scientific team, Genavir operational technicians and crew members involved. Remember that the project leader should be informed about this protocol during the campaign preparation meeting with DFO/PON at the latest.

2.2.10 Data collection

Data collection is a crucial point in this type of campaign. A certain amount of information must be systematically collected to be able to exploit the acquired observation data as much as possible.

Throughout the observation periods, the environmental conditions must be reported regularly, in coherence with the observations made by the crew: sea conditions, weather conditions, dazzle, etc. The vessel's activity must also be reported (on-going works, speed, direction, etc.). These parameters must be updated as soon as one of the conditions has changed. The start and end times must be noted for each observation period during which all parameters are stable. UTC time is used to be compatible with the vessel log recordings (or other navigation software or crew monitoring).

Each TS observation must be noted, whether it took place inside or outside the exclusion zone. The species identification must be filled in as far as possible, plus the number of individuals, the behaviour of the animals, the distance and the bearing from the vessel.

The information is noted on standardised forms (see Annexe 4 and 5) during the observation periods and then entered in the database. Centralisation in a single, unique database is essential to ensure data harmonisation and standardisation.

Abiding by the protocol, standardisation of procedures and data, and collecting all the necessary parameters guarantee scientifically rigorous exploitation of the acquired data. The behaviour observations collected during the seismic emissions are pertinent data to study the impact of this type of activities on marine mammals and possibly make changes to the applicable protocols.

It is encouraged to take photos to be able to subsequently identify the species that could not be identified on the spot or to confirm in situ identifications. However, taking photos should not affect the quality of the observations and the surveillance, or the fast response, that remain a priority.

In addition to spotting the TS during seismic acquisitions, the mitigation team is encouraged to collect data on marine megafauna as a whole and human activities when this is possible (without damaging the Zex mitigation).

Outside the shot period, the MMOs will collect data on the marine megafauna as a whole and human activities according to the non-shooting protocol that will be sent to them during the information meeting.

2.2.11 Reporting

As a result of the campaign, the MMOs and the PAM operators must draft a report on the mission's progress in chronological order, the observations made, the situations encountered, when the shots were stopped and under which circumstances. The report should also sum up the difficulties encountered, whether a solution was found, and improvements that might be made in the future, in compliance with the section given in Annexe 6. Furthermore, a weekly summary report is requested from the MMO/PAM team leader. All these reporting activities are governed contractually. Furthermore, all the digital data (photos, xls data collection and analysis files, GIS maps and shapefiles) should be returned to Ifremer when handing in the provisional report.

3 CONCLUSIONS

The protocol chosen by Ifremer to prevent risks and mitigate sound emissions to protect the targeted species (marine mammals and sea turtles) is applicable when the institute's seismic equipment is implemented, with modalities depending on the characteristics of the sources being used (Class 1 seismic sources).

It includes a set of rules defined according to current scientific knowledge in this field [5, 6]. It is therefore logically very similar to the recommendations defined by other international players in different fields (scientific, industrial, environmental) and based on the same scientific elements.

Remember that this protocol is an autoregulation defined by Ifremer to manage its activity. It does not exclude applying other measures that might be requested, for example, within the framework of a national or regional regulation.

Finally, Ifremer reserves the right to develop this protocol depending on subsequent progress in scientific knowledge, available techniques, acquired field experience and observations.

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5 ANNEXES

5.1 Annexe 1: References to the main guides and conventions

The table below provides a non-exhaustive list of the main texts concerning underwater noise and marine fauna. Most of these recommended international conventions, guides, standards and procedures are political and not legally binding. However, by applying the principle of the Rio Declaration on the environment and declaration, precautionary measures are imposed.

ORGANISATIONS	REFERENCES	DESCRIPTION
ACCOBAMS	Resolution 2.16	Assessment and its impact and impact assessment of man-made noise
	Resolution 3.10	Guidelines to address the impact of anthropogenic noise on marine mammals in the ACCOBAMS air
	Resolution 4.17	Guidelines to address the impact of anthropogenic noise on cetaceans in the ACCOBAMS area.
	Resolution 6.17	Anthropogenic noise
	Resolution 6.18	Implementation of an ACCOBAMS Certification for Highly Qualified Marine Mammals Observers
ASCOBANS:	Resolution 5.4	Adverse effects of sound, vessels and other forms of disturbance on small cetaceans.
	Resolution 6.2	Adverse effects of underwater noise on marine mammals during offshore construction activities for renewable energy production.
CDB	Decision VIII / 28	Voluntary guidelines from the CBD on the biodiversity-inclusive impact assessment.
	Decision XII / 23	Recommendation to use quieter technologies and applying best available practices in all relevant activities.
CMS	Resolution CMS 9.19	Anthropogenic marine/ocean noise impacts for cetaceans and other biota.
	Resolution CMS 10.24	Further steps to abate underwater noise pollution for the protection of cetaceans and other migratory species.
	UNEP/CMS/COP12/Doc.24.2.2	Guidelines on environmental impact assessments for marine noise-generating activities.
	UNEP/CMS/Resolution 12.14	Resolution adopted by all the UN Member States. This refers to a guide

		concerning assessment of environmental impacts for noise-generating marine activities.
OSPAR	ICG-Noise	ICG-Noise was set up in order to organise work into 3 sections (Pulsed noises, coordinated by Great Britain, Ambient noise coordinated by the Netherlands and Attenuation measures coordinated by Germany).
EU	TG Noise	Work group relating to descriptor 11 from the MSFD
France	The National Plan of Action for cetaceans.	(Action 43 from the biodiversity plan) envisages measures to reduce anthropogenic underwater noise.

5.2 Annexe 2: Seismic sources concerned by applying the protocol

Physiological risk thresholds

The peak values (SPL_{PK}) and the cumulated sound exposure level (SEL_{cum}) received by the marine mammals should be compared against the physiological risk thresholds currently defined for cetaceans from all three categories (LF, HF and VHF) and for pulsed signals emitted by air guns [5, 6]. The Ifremer protocol relies on the use of these objective thresholds defined by the physiological risks.

Group	SEL_{cum} (weighted) In dB (re. 1µPa²s)	SPL_{PK} (not weighted) En dB (re. 1µPa)
LF	**183**	219
HF	185	230
VHF	155	**202**

PTS thresholds for pulsed signals (according to [5, 6])

The two thresholds with a significant impact in terms of cumulated sound exposure level and peak level received are:

- **SEL_{cum} = 183 dB (re. 1 µPa²s) for the LF category** [3],
- **SPL_{PK} = 202 dB re. 1 µPa for the VHF category**.

Seismic sources concerned by the protection measures

The Ifremer procedure for emission mitigation is systematically applicable in the case of very powerful seismic emissions for which received level determination stops at exclusion distances over 100 m.

Cumulated sound exposure level

Considering the threshold at 183 dB (re. 1 µPa²s), the exclusion radius in terms of SEL_{cum} was estimated using a calculation along the standard seismic profile, for the two powerful Ifremer sources described in Annexe 3.

For Ifremer sources S_1 (14 air guns; V = 2570 in³ ; shot pace: 20 s) and S_2 (16 air guns; V = 4990 in³; shot pace: 60 s), the exclusion radii are respectively 114 and 103 m, therefore very close to the 100 m limit beyond which the mitigation protocol is applied.

The threshold for the cumulated sound exposure level at a distance of 100 m is therefore only passed by very powerful seismic sources (reflection or refraction) with an important volume (> 2500 in³).

3 Owing to the application of frequency weighting functions that actually eliminate the HF and VHF categories from the impact of seismic signals at very low frequencies

Peak sound level received

For a peak sound level received at 100 m equal to the maximum acceptable value (202 dB re. 1 µPa), it is possible to move up to the source emission level at the reference distance (R_0) of 1 m:

$SL_{PK}(R_0) = 202 + PT(100\text{ m}) = 202 + 40 = 242$ dB re. 1 µPa at 1 m,

for a transmission loss $TL(R) = 20 \log(R/R_0)$.

The emission level can be translated into peak acoustic pressure (p_{max}: a value that is very classically used to characterise seismic sources) at the distance (R_0):

$SL_{PK}(R_0) = 20\log_{10} (p_{max} / p_{ref})$ with p_{ref} = 1 µPa

In our case, we find:

p_{max} = 12.6 bar at 1 m

The *Sisource* software can be used to model the acoustic signature for arrays of air guns, working from measurements taken at sea on individual air guns. It was used here to simulate the array configuration, using *GGUN* type air guns, that generate a peak pressure level comparable with the value of 12.6 bar obtained at 1 m. One array, submerged 6 m and made up of three *GGUN* air guns of 250 in^3 and one GGUN air gun of 45 in^3, transmits this acoustic pressure level:

Figure 5: Acoustic signature (Sisource simulation) of the source made up of 4 GGUN air guns (3x250 in3 + 1x 45 in3)

The received peak sound level at a distance of 100 m is therefore passed for seismic sources with a volume greater than ~800 in^3. The sound level threshold received by the mammals in the VHF category therefore makes a greater impact than the threshold for the cumulated sound exposure level received by mammals in the LF category.

Seismic source classes

Working from this transitional value of 800 in^3, and applying a supplementary security factor, we have conservatively set **a limit volume of 500 in^3**. We therefore chose to classify the seismic sources into two categories:

- **Class 1**: sources for which the total volume is greater than 500 in^3, where the emissions mitigation protocol will be applied,
- **Class 2**: sources for which the total volume is less than 500 in^3, where no emissions mitigation protocol will be applied, unless requested by or specific regulations from the host Country.

As a comparison, New Zealand applies it "standard" protocol (MMOs, PAM, pre- watch, ramp-up, …) for seismic sources whose total volume is greater than 427 in^3, a transitional value that is highly comparable with Ifremer's chosen value.

5.3 Annexe 3: Acoustic characteristics of the sources

Among the Ifremer class 1 seismic sources, two types of array can be used depending on the scientific goals of the oceanographic campaigns. Table 5 summarises the acoustic characteristics of these two sound sources.

	Source 1 (S_1)	Source 2 (S_2)
Total volume (in^3)	2570	4990
Number of air guns	14	16
Immersion (m)	6	10
Dimensions of the source (m)	9 m (longit.) x 15 m (transv.)	10 m (longit.) x 16.5 m (transv.)
Maximum pressure 0-pic (bar.m)	36.52	53.10
Shot pace: T (s)	20	60
Signal duration (s)	0.020	0.029
SL_{PK} (dB re 1µPa @ 1 m)	251.2	254.5
SEL (dB re 1 µPa²s @ 1 m)	229.2	233.6

Table 5: Characteristics of the Ifremer Class 1 seismic arrays

Description of the source S_1

The source S_1 has 14 air guns totalling an air volume of 2570 in^3 and it presents a shot pace of 20 seconds.

The shape of the signal over time for S_1 is represented in Figure 6. The maximum pressure level (in absolute value) measured on the outline $p(t)$ is equal to 36.52 bar @ 1m, namely 36.52 $\times 10^{11}$ µPa @ 1 m. The source peak level (SL_{PK}) at the reference distance R_0 of 1 m is defined as:

$$SL_{PK}(R_0) = 20\log(36{,}52 \times 10^{11}) \approx 251{,}2 \text{ dB } re \text{ 1µPa @ 1m}$$

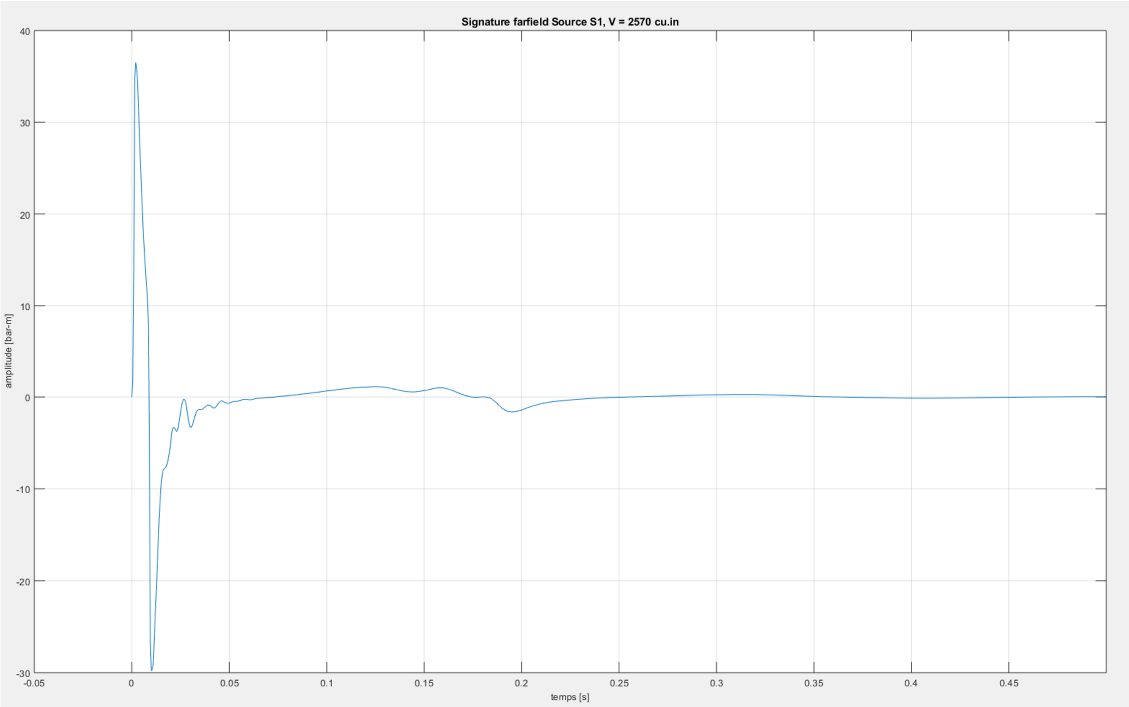


Figure 6: Time signal from the seismic source S (V_1=2570 in³)

Sound exposure level: (*SEL*: in dB re 1µPa²s) for a shot is given by the integration of the intensity over time:

$$SEL = 10 \log \int p^2(t)dt$$

In this case, working from the outline of *p*(*t*) given in Figure 4, the SEL for 1 shot is equal to 229.2 dB re 1µPa²s at 1 m.

The frequency spectrum (power spectrum density) obtained by the Fourier transform. *p*(*t*) is represented on Figure 7.

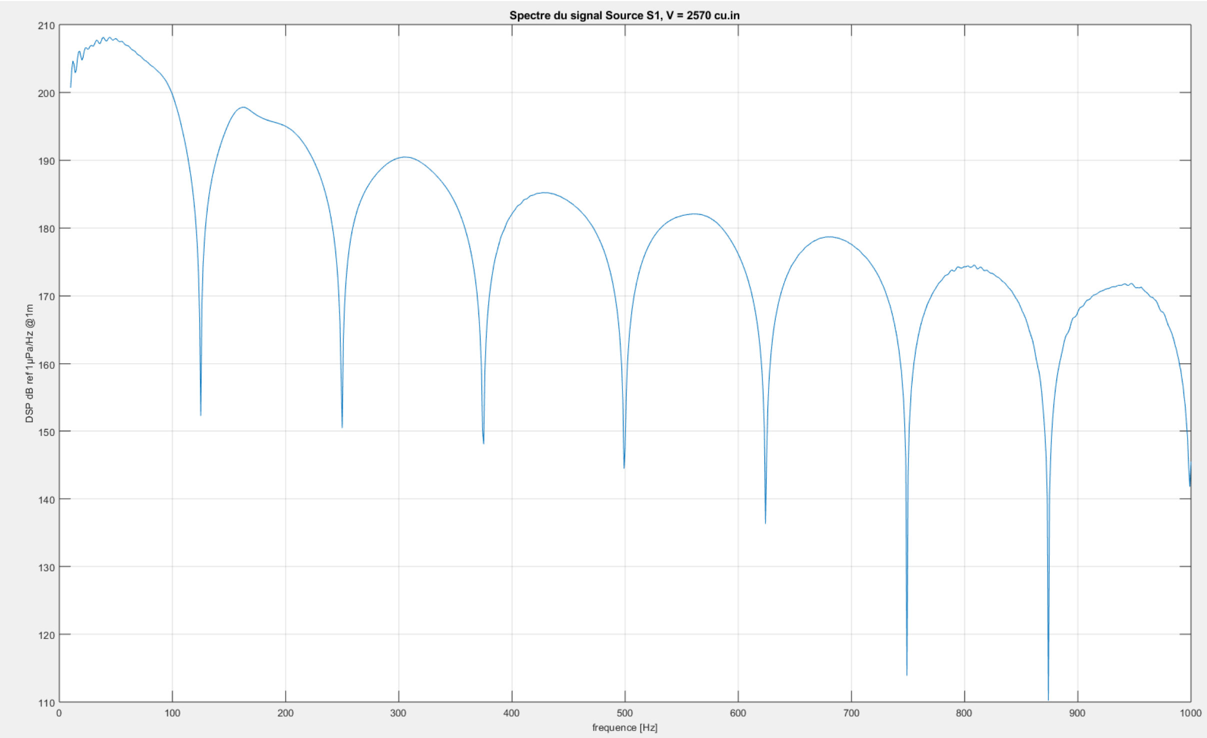


Figure 7: Frequency spectrum of the seismic signal from the source S (V=2570 in³)

The energy maximum (208,1 dB re 1µPa/Hz @ 1 m) is reached for a frequency of 45 Hz. The *SEL* calculated from the energy integral contained in the signal for the frequency range [2- 1000 Hz] is 229.2 dB re 1µPa².s @ 1 m. This value is, of course, coherent with the value obtained by integrating the time signal.

Modelling the Directivity Function

Figure 8 represents the directivity function (*DF*) simulated from the seismic array S_1 in the vertical plane according to the vessel's longitudinal axis, depending on the frequency from 0 to 250 Hz. This angle/frequency modelling is obtained using *Gundalf*® software, a worldwide reference in seismic array simulation.

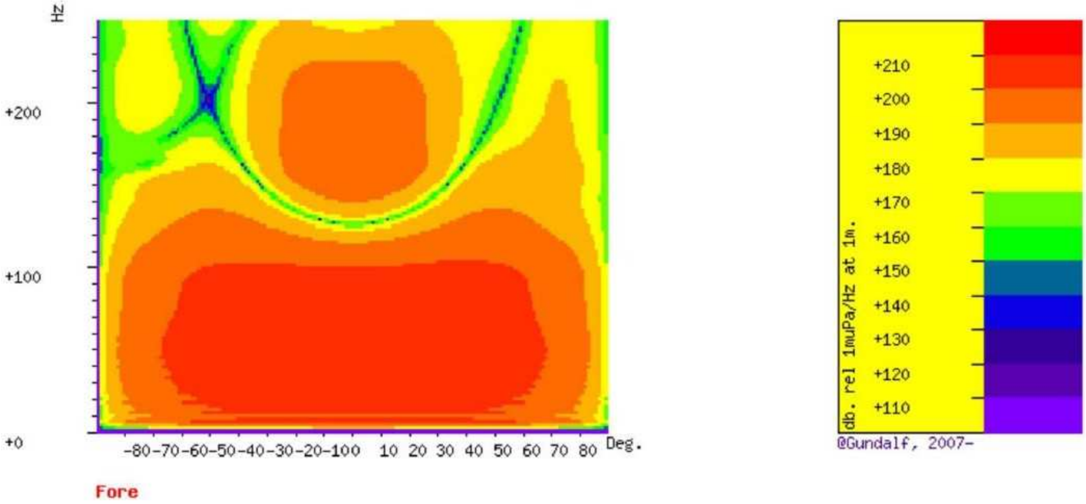


Figure 8: Directivity in the vertical/longitudinal plane, 0° tilt, seismic source S_1, Gundalf ®

Figure 9 represents the directivity, simulated by *Gundalf*®, from the seismic array in the vertical plane and according to the vessel's transverse axis.

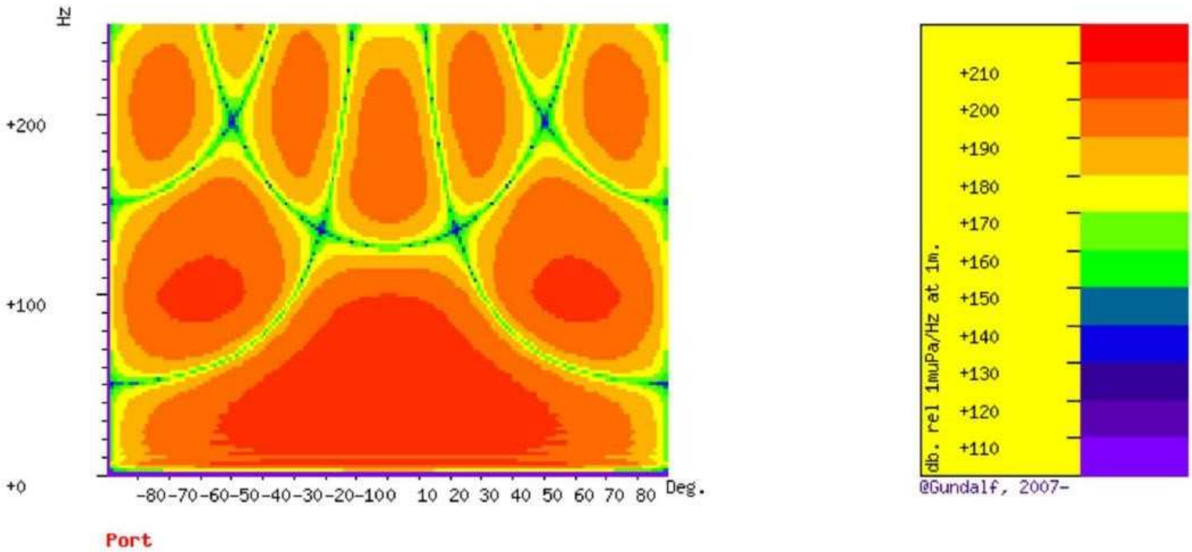


Figure 9: Directivity in the transversal plane, 90° tilt, seismic source S_1, Gundalf ®

Figure 10 represents the vertical/longitudinal directivity diagrams for frequencies from 10 to 50 Hz for the source S_1.

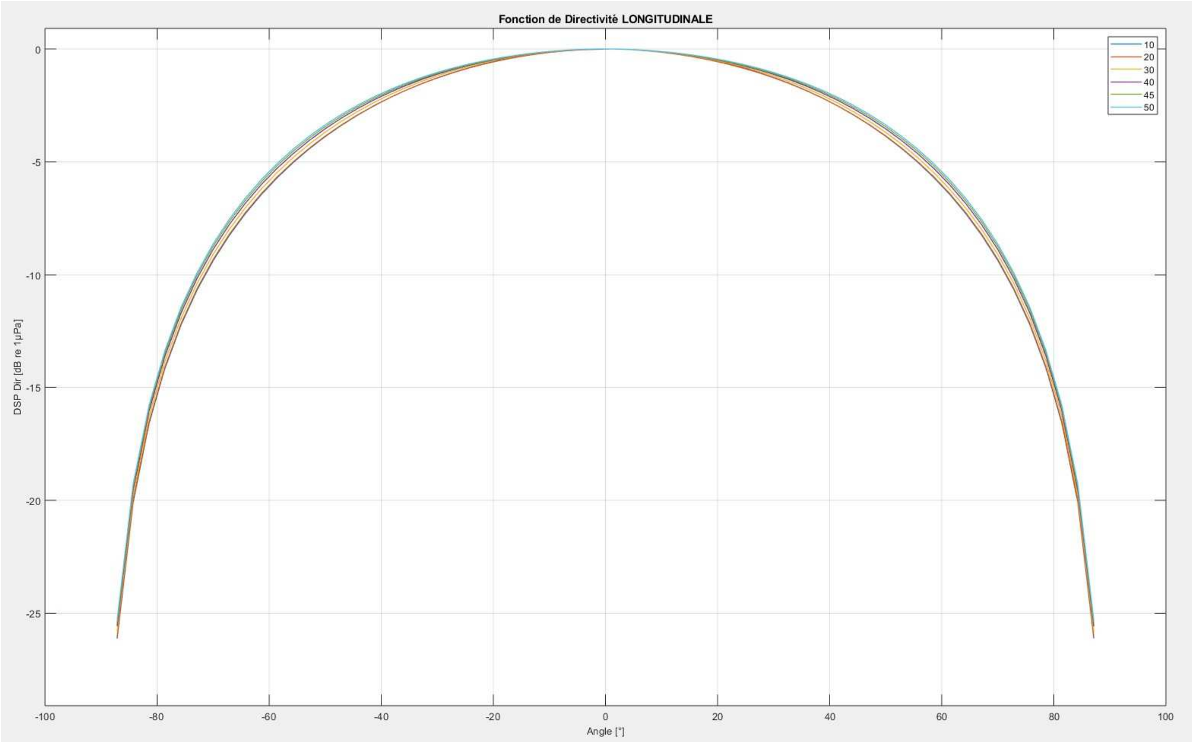


Figure 10: Vertical/longitudinal diagrams for the source (S_1)

Figure 11 represents the vertical/longitudinal directivity diagrams from 60 to 100 Hz.

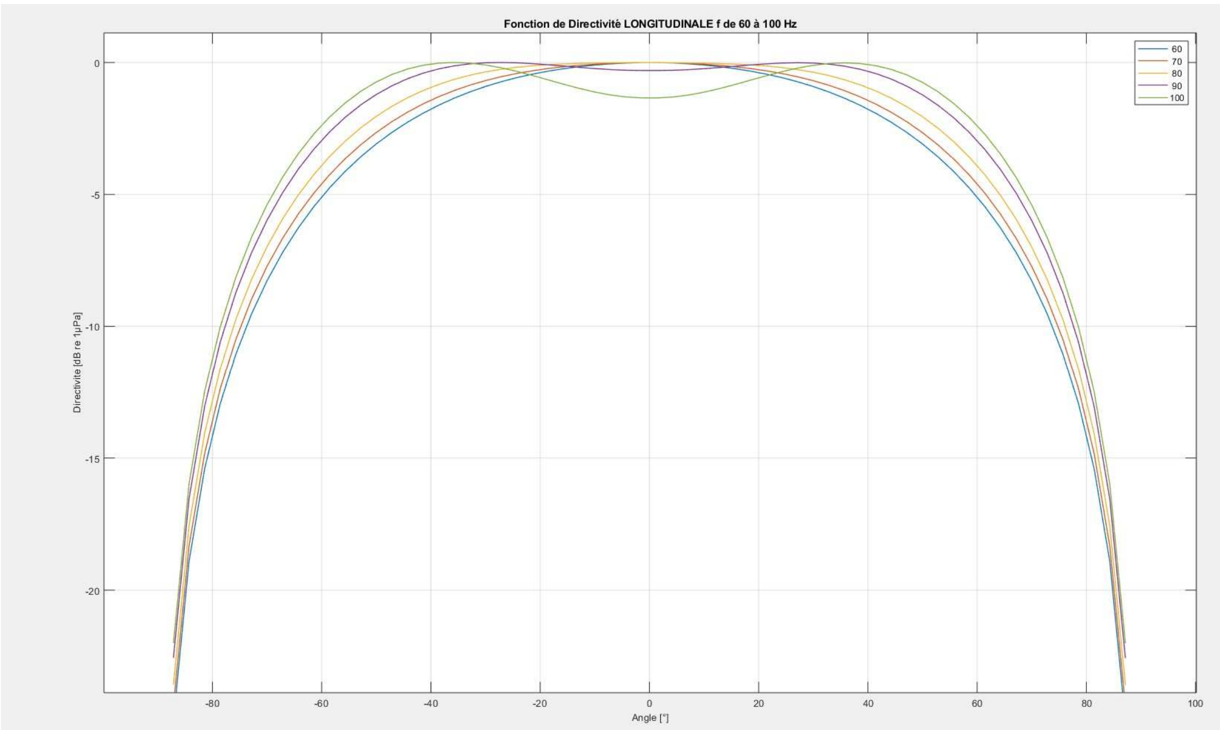


Figure 11: Vertical/longitudinal diagrams for the source S_1

Description of the source S_2

Figures 12 and 13 represent the shape of the signal in the time field and the frequency spectrum for the source S_2, more voluminous (4990 in^3) than S_1, and made up of 16 air guns emitting every 60 seconds, at an SL(R_0) = 254,5 dB re 1 µPa @ 1 m.

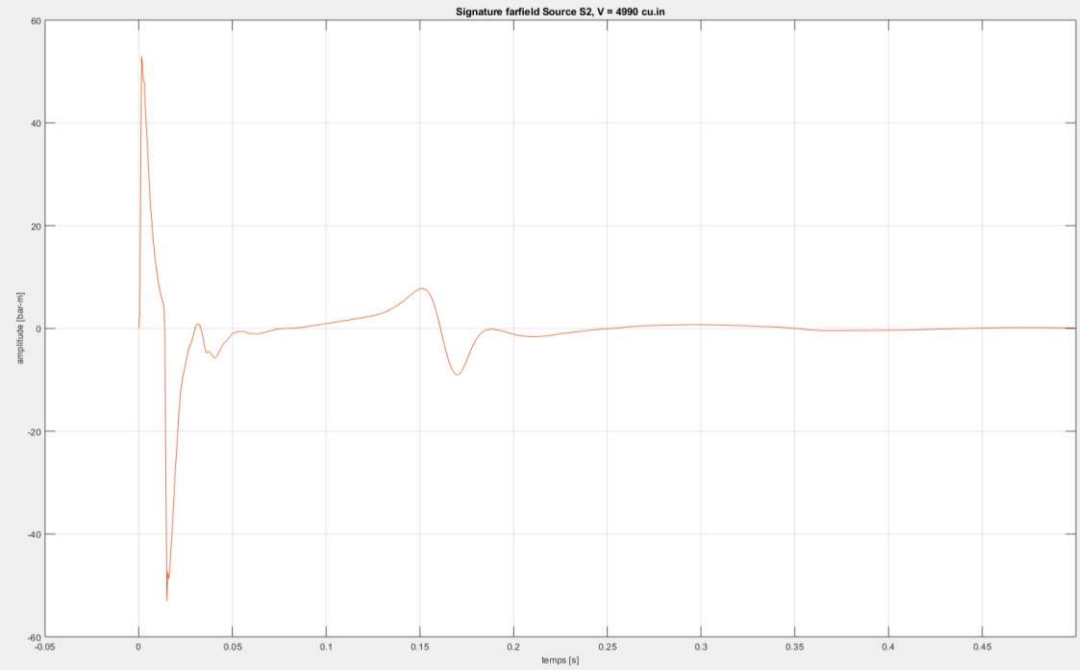


Figure 12: Time signal from the seismic source S_2 (V=4990 in^3)

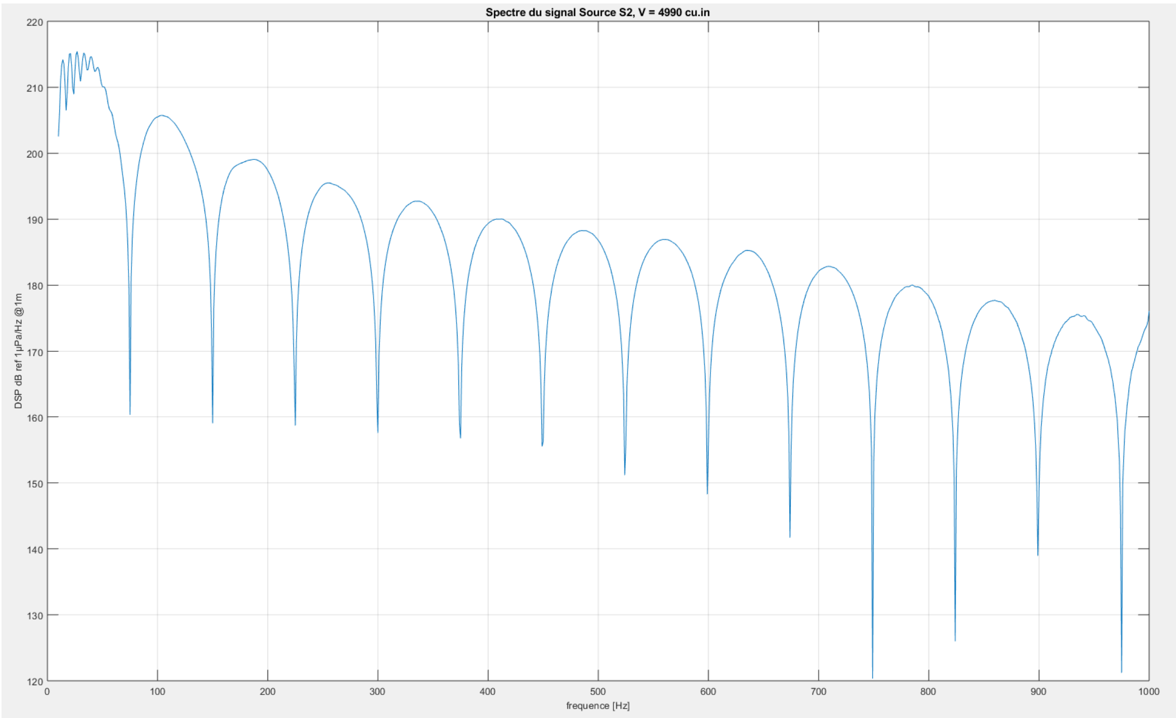


Figure 13: Frequency spectrum of the seismic signal from the source S_2 (V=4990 in^3)

For a shot, this source of 4990 in^3 presents a sound exposure level of 233.6 dB re 1µPa²s @ 1 m. The energy maximum (215,6 dB re 1µPa/Hz @ 1 m) is reached for the frequency of 27 Hz.

<u>Calculation the Directivity Function</u>

Figure 14 represents the directivity function simulated from the seismic array S_2 in the vertical/longitudinal, depending on the frequency from 0 to 250 Hz. This angle/frequency modelling is obtained using the *Gundalf®* software

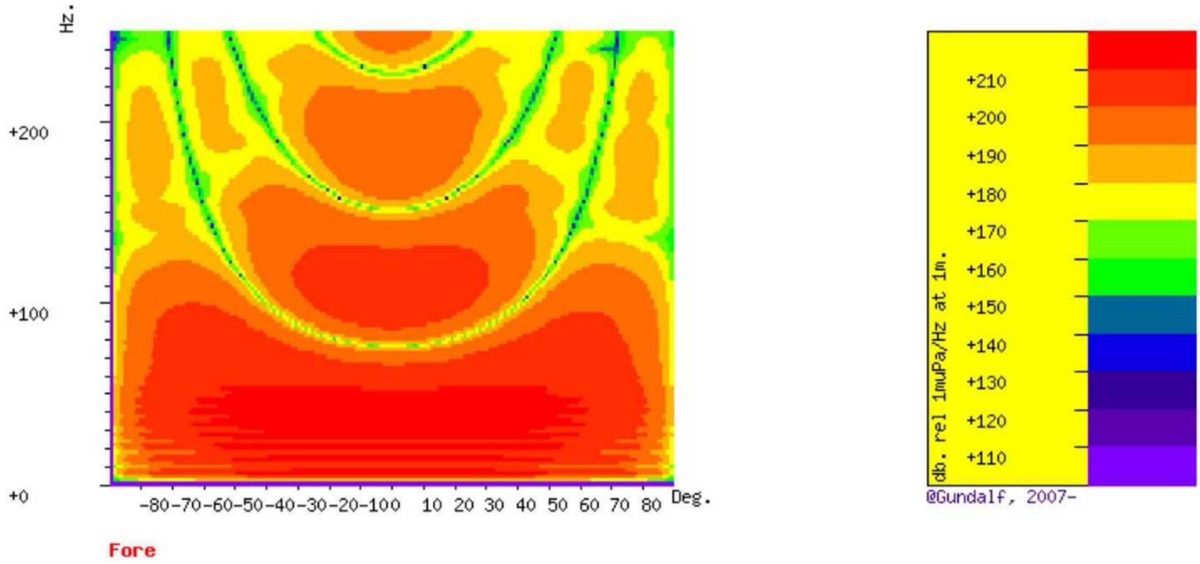


Figure 14: Directivity in the vertical/longitudinal plane, 0° tilt, seismic source S_2, Gundalf ®

Figure 15 represents the directivity, simulated by *Gundalf®*, from the seismic array in the vertical/transversal plane.

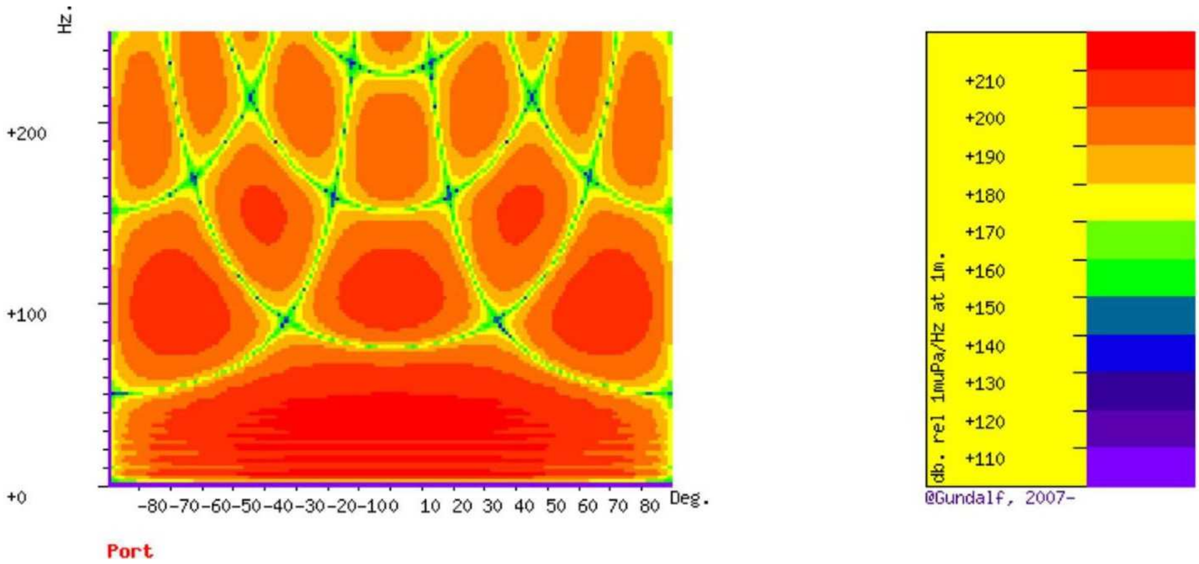


Figure 15: Vertical/longitudinal directivity, 90° tilt, seismic source S_2, Gundalf ®

Figure 16 represents the vertical/longitudinal directivity diagrams for frequencies from 10 to 50 Hz for the source S_2.

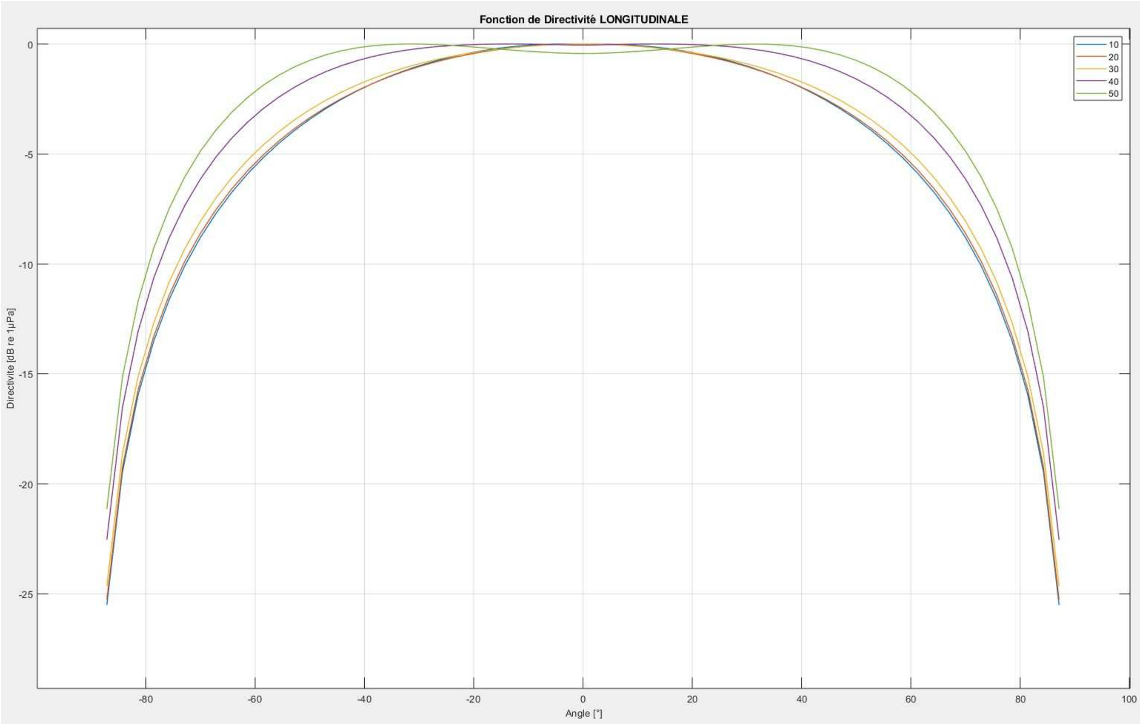


Figure 16: Directivity diagrams in the vertical plane according to the longitudinal axis of the source (S_2)

Figure 17 represents the vertical/longitudinal directivity diagrams from 60 to 100 Hz for the source S_2.

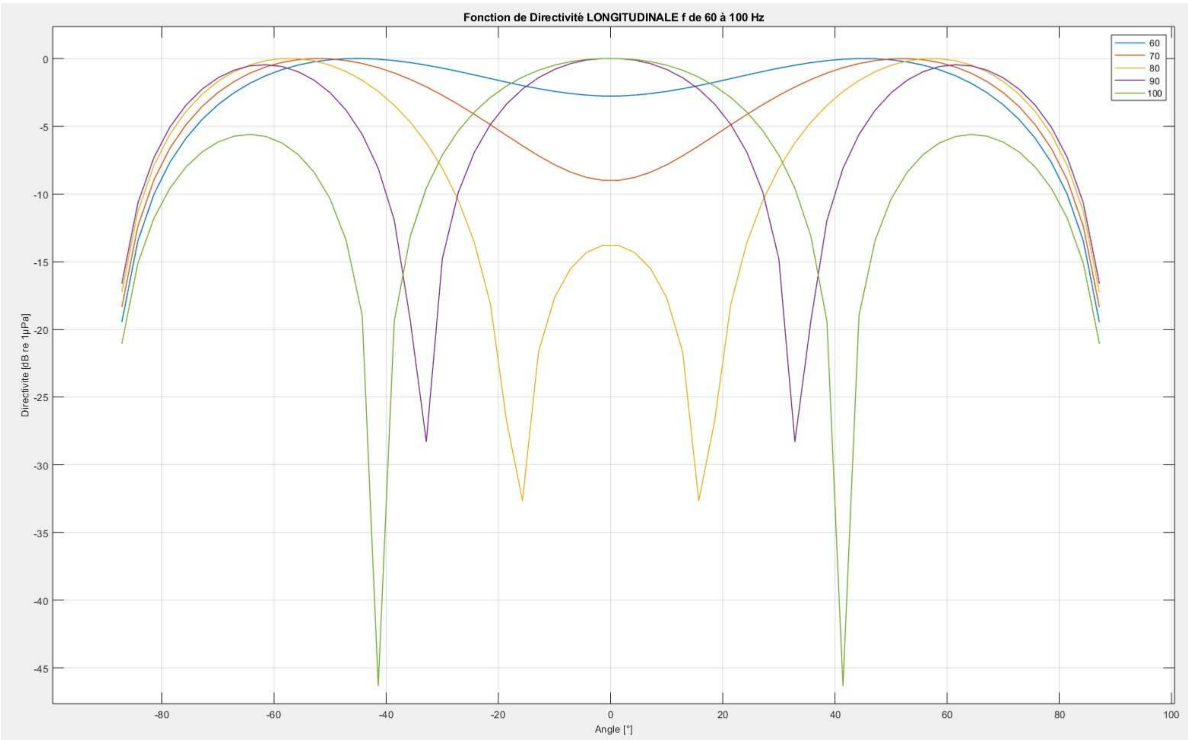


Figure 17: Directivity diagrams in the vertical plane according to the longitudinal axis of the source (S2)

5.4 Annexe 4: Forms for MMOS and PAM operators

Ifremer

Compte Rendu d'observation de Mammifères marins

Campagne :

Navire :

Dates :

Observateur :

Affiliation :

ENVIRONNEMENT

Date :

Heure observation:

Vitesse navire

Cap navire

Zone :

Longitude :

Latitude :

Hauteur d'eau

Etat de mer :

T° air / eau

Pluie

Visibilité

Vitesse vent :

Direction vent :

Emission sismique :

Emission sonar :

Remarques :

ANIMAUX OBSERVES

Espèce :

Nombre :

Adultes/jeunes

Tailles :

Photo/vidéo

Description des animaux

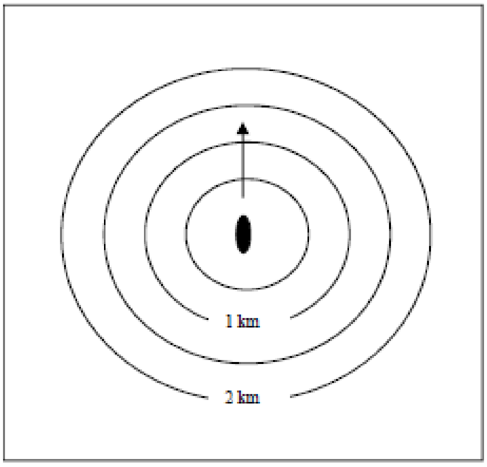
COMPORTEMENT DES ANIMAUX

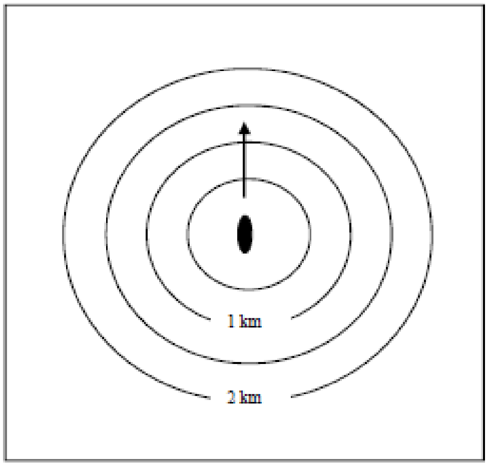
En route ☐ Arrêté ☐ Etrave ☐ Autre ☐

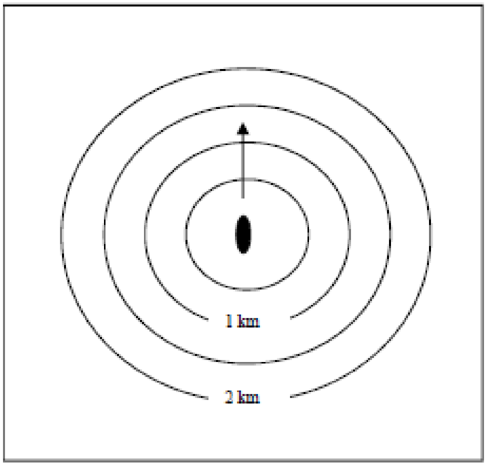
Description du comportement

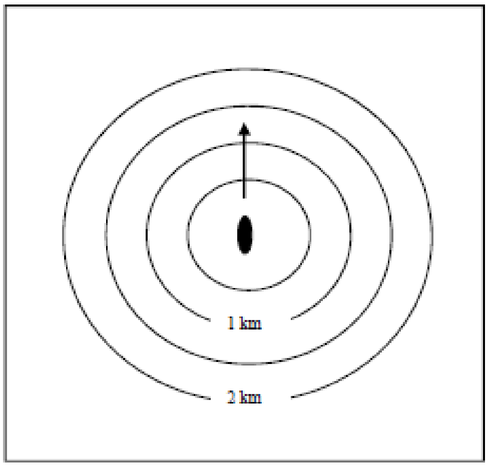
DEPLACEMENTS PAR RAPPORT AU NAVIRE

Distance initiale au navire ☐









Compte-Rendu HEBDOMADAIRE			
Campagne		**Dates globales de la campagne**	
NOM		***DATE***	
Observateurs mammifères marins		**A bord du navire**	
NOM		***NOM***	
COMPTE RENDU N°X			
Date		***Semaine n°X***	
Horaires de travail MMO			
Horaires		Nombre d'heures sans les repas	
Temps bureau à différencier de l'effort d'observation			
Heures de travail hors observations (saisie / tri des photos / identification espèces / planning / concertations)			

RECAPITULATIF DE L'EFFORT D'OBSERVATION					
Effort général (heure)		Effort canons éteints (heure)		Effort canons allumés (heure)	
Détails des phases					
	SISMIQUE				HORS SISMIQUE
	Manoeuvre	Prewatch (pré-tir)	Ramp-up	Profils (tirs à pleine puissance)	Prospection (transit)
Effort d'observation (heure)					
Nombre de phases					

RECAPITULATIF DES OBSERVATIONS		
Moyens visuels de prospection		
Nombre d'arrêts des canons suite à détection de mammifères marins		
Nombre d'observations totales canons en marche		
Nombre d'observations canons éteints		Photos des observations
Nombre d'observations de cétacés		
Nombre d'observations d'oiseaux		

OBSERVATION D'ESPECES		
Espèces	*Estimation du nombre d'individus*	*Distances aux canons*

BILAN SUR LE RESPECT DU PROTOCOLE
.
OBSERVATIONS SUR LES OPERATIONS EFFECTUES ET L'EVOLUTION DE LA CAMPAGNE (résultats, planning opérations prévues, etc.)
REMARQUES DIVERSES SUR LES CONDITIONS A BORD (échanges avec le bord, utilisation du matériel, mise en œuvre des protocoles, etc.)
Conditions d'observations rencontrées (état de la mer et conditions subjectives)

5.5 Annexe 5: EXTRACT FROM THE END OF CAMPAIGN SUMMARY FORM

MITIGATION ACTION ON SURVEY

			NUMBERS OF			
	MARINE MAMMALS		DELAY	SHUTDOWN	NO ACTION	NONE REQUIRED
	SMADEL	*Tursiops spp*				
	SMADEL	*stenella longirostris*				
	SMADEL	*Stenella frontalis*				
	SMADEL	*Stenella attenuata*				
	SMADEL					
	SMADEL					
	SMADEL					
	SMADEL		0	0	0	0
	LARDEL	*Lagenodelphis hosei*				
	LARDEL	*Sousa chinensis*				
	LARDEL					
DELSPP	LARDEL	*orcinus orca*				
	LARDEL					
	LARDEL					
	LARDEL		0	0	0	0
	Blackfish	*Globicephala macrorhyncus*				
	Blackfish	*pseudo crassidens*				
	Blackfish					
	Blackfish					
	Blackfish		0	0	0	0
	U DEL					
		TOTAL DELSPP	0	0	0	0
PHYMAC		*Physeter macrocephalus*				
		Megaptera novaeangliae				
		Balaenoptera physalus				
		Balaenoptera				
BALSPP						
	U BALSPP					
	TOTAL BALSPP		0	0	0	0
		Kogia sima				
KOGSPP		*Kogia breviceps*				
	U KOGIA					
		KOGSPP	0	0	0	0
UTW		Unidentified toothed whale				
UC		unidentified cetacean				
ZISPP		Ziphus				
		TOTAL DURING THE SURVEY	0	0	0	0

Total Shutdown due to SoC dectection	0
Total Delay due SoC detection	0
Total detection airguns ON	0
Total detection airguns OFF	0
TOTAL detection SoC	0

			NUMBERS OF			
	SEA TURTLES		DELAY	SHUTDOWN	NO ACTION	NONE REQUIRED
	TURTLE_Cc	*Caretta caretta*				
	TURTLE_Cm	*Chelonia mydas*				
	TURTLE_D	*Dermochelys coriacea*				
TURTLE	TURTLE_E	*Eretmochelys imbricata*				
	TURTLE_Lk	*Lepidochelys kempii*				
	TURTLE_Lo	*Lepidochelys olivacea*				
	TURTLE_N	*Natator depressa*				
	U TURTLE					
		TOTAL DURING THE SURVEY	0	0	0	0

5.6 Annexe 6: FINAL REPORT OF THE MMO AND PAM OPERATOR ACTIVITY (STANDARD PLAN)

Summary

1. General information

1.1. Context and objectives of the mission (taken from the mission preparation document, showing the dates, geographic areas and types of operations)

1.2. Observation and mitigation measures implemented (recap of Ifremer's specific measures and their possible adaptation to the campaign in question, exclusion zone, phase details).

1.3. Marine mammal populations in the target zone (presentation using provisional elements available, including the status of the species in question).

2. Methodology and organisation

2.1. Seismic sources and equipment: configuration of seismic sources: volume, geometry, acoustic characteristics (SEL, SPL), shot pace; list of the other acoustic equipment that has been activated.

2.2. Operation planning: table summarising the vessel's daily activity (transit, manoeuvre, shot, etc.).

2.3. Visual observation (presentation and organisation): observation posts, observation platform configuration, communication with the ship, equipment, field forms, vessel route, database, identification photo, weekly report

2.4. Acoustic detection (presentation and organisation): system used, deployment and justified parameter-setting from the Pamguard configuration file

2.5. Surveillance team (list of MMOs, PAM operators, including their names, affiliations, training and specialist areas)

3. Results

3.1. Operations: explain possible modifications to the source configuration, the position plane, etc.

3.2. Marine fauna observed during the campaign: observation work, diagram representing the details of the observation work per vessel activity and per phase, table showing the status of the observation work per phase in number of hours, balance report of operations, observation weather conditions, summary of the main observations of the species concerned and their distribution, summary of the main observations of marine fauna, summary of human activity likely to make an impact

3.3. Acoustic detection results: observation work performed, diagram representing the details of the observation work per vessel activity and per phase, table showing the status of the observation work per phase in number of hours, balance report of operations, presentation of the main acoustic detections: distribution of detections, hours of detections, duration of detections, water height during detections.

3.4. Balance report on following the seismic protocol: report on the detections and observations inside the exclusion zone and measures taken, cross checking the visual observations and acoustic detections.

4. Discussion, recommendations and conclusions

Content left to the initiative of the observers and operators

5. Annexes

Annexe A. Detailed table of the observation periods (specifying names of the observers depending on the timeslots, plus the seismic and sonar activity)

Annexe B. Detailed list of marine animal observations (for each observation: date, geographic coordinates and time, species spotted, number of animals and composition of the group, detection distance, state of operations of the air guns, consequences on the air gun activity, possible comments). Can be presented as “event-forms”, see Annexe 4 and 5.

Annexe C. Daily and weekly reports on the observation periods (chronological report on operation progress and observations)

Annexe D. Photos and miscellaneous documents.

5.7 Annexe 7: PAM damage sheet