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

CHAPTER 7 – ENVIRONMENTAL IMPACTS ASSESSMENT

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This chapter is aimed at identifying and assessing the main aspects of the project that represent potential environmental impacts. Once identified, mitigation and environmental management measures were designed and established (Chapter 8 - Mitigation Measures and Environmental Management Plan) to prevent, reduce, mitigate or compensate for them.

INTRODUCTION

The environmental impact that a project can generate depends both on the way in which it is implemented, and on the environmental characteristics of the site in which it is inserted. Once identified, modifications can be made in the project design, in such a way as to avoid the occurrence of a negative incidence or, at least, reduce its importance (that is, its intensity, probability of occurrence or its territorial extension).

In order to set up the strategies and measures for the environmental management of a project, it is necessary to identify its impacts and the different components and / or implicit actions. Once the impacts have been identified, they are evaluated and categorized according to their importance or criticality, to subsequently determine the corresponding mitigation measures.

An analysis of the project was conducted from an environmental perspective for the identification of the environmental impacts, and from an analysis of the environment in relation to the specific project. Based on the analysis of the project (Chapter 4 - Description of the Project) and the environmental diagnosis of the area in which it shall be developed (Chapter 5 - Environmental Baseline), the identification and evaluation of the environmental impacts of the “3D” offshore seismic record of CAN_100, CAN_108 and CAN_114 areas have taken place.

Like most human activities, seismic exploration tasks can cause some unwanted effect upon the environment in terms of the high noise levels required for investigations. It should be noted, however, that the effects shall be specifically located and of limited duration so that mitigation measures may be applied.

Other potential impacts are those usually derived from the operation of ships, since a vessel shall be necessary to carry out the seismic survey. These impacts do not differ from those that are already produced by ship traffic in the work area. In fact, the risk is very low as no oil or derivatives are transported apart from the fuel and lubricants necessary for the navigation itself.

Consequently, this assessment underlies the particular aspects of seismic recording related to noise disturbance, considering the possible affectation of fauna and also taking into account the background of specific investigations developed since the beginning of the use of these systems in recent years.

Considering the above, this chapter presents the evaluation of the interactions that could occur between the environmental aspects of the project and the environmental factors likely to be influenced by such actions. Thus, the analysis includes interactions on the natural and anthropic environments (physical and biotic). This chapter initially presents the Environmental Sensitivity Analysis based on the development of the Environmental Baseline in order to identify the susceptibility of the affected factors (Chapter 5).

The outline of this chapter follows different phases for the assessment of impacts. The first involves the identification of the activities or actions of the project that can generate impacts on the environmental factors likely to be impacted. In the second phase, the prediction of how the actions can affect the environmental components (physical, biological or anthropic) is carried out based on previous experiences and evaluation of the interdisciplinary team, and the assessment of the importance of each impact is also considered. Finally and grounded on the development of this section, the environmental impact matrix is presented with the evaluation of the interactions according to the implemented assessment methodology (see Point 3.11).

According to the identified and ranked impacts, the mitigation and environmental management measures detailed in Chapter 8 were designed and established, applying the principle known as the mitigation hierarchy. Taking into account the implementation of these measures, a mitigated matrix was prepared that allows visualizing the impacts of the project before and after the mitigation measures (see Point **Error! Reference source not found.**).

To sum up, this chapter includes the evaluation of the potential cumulative impacts of the project where, from an integration perspective of the activity with the environment, the interaction of the effects of the anticipated seismic activity with the effects of other existing or planned activities is appraised (see Point **Error! Reference source not found.**).

1 ENVIRONMENTAL SENSITIVITY ANALYSIS

1.1 INTRODUCTION

The concept of environmental sensitivity is not easily defined. The "Guide for the Preparation of Environmental Impact Studies" published by the Secretariat of the Environment and Sustainable Development of the Argentine Republic (2019a) defines environmental sensitivity as " *the potential impact (transformation or change) that environmental components might face as a result of the alteration of the physical, biotic and social processes that characterize them due to human intervention or the development of natural destabilization processes*".

According to the "Prevention of Coastal Pollution and Management of Marine Biological Diversity" project, there are three types of conditions that would allow an area to be considered as environmentally sensitive (Atlas of Environmental Sensitivity of the Argentine Coast and Sea, 2008).

On the one hand, those areas that present unstable and / or particularly unfavorable environmental conditions for biological production and recolonization are considered sensitive. Second, those areas with presence of threatened species can be classified as environmentally sensitive. Finally, those that hold some particular ecological value and are vulnerable to natural and anthropic disturbances, and areas with key species or that host sites or fundamental processes from an ecological point of view, can also be considered sensitive.

These conditions are basically of a natural type, and it is necessary to incorporate criteria into the identification of sensitive areas that allow sensitivity to be considered also from the anthropic point of view. In this sense, it is important to mention that in addition to their intrinsic value, biological populations often have enormous economic value, either as a tourist attraction or as a commercial resource, as is the case with fishery resources.

It is extremely important to know the characteristics of the elements involved in order to determine the sensitivity of the environment during a project. In this sense, a detailed description of the various components of the environment in which the project is planned to be developed was presented throughout Chapter 5 (Environmental Baseline) which was drawn up through the collection and analysis of background information.

Beyond any natural or anthropogenic characteristic of a certain area, the level of environmental sensitivity is closely related to the degree of susceptibility of the environment to a given project. Said sensitivity is related to seismic acquisition activities in this particular case.

From the interrelation of these two aspects and within the framework of this project, the sensitivity analysis developed for the area of influence is presented hereinbelow.

1.2 METHODOLOGY

Rebolledo´s proposal (2009) was taken as a reference for the development of the sensitivity study and it defines that for the Environmental Sensitivity Assessment (ESA) to take place, it is necessary to consider a series of criteria that allow describing the behavior of the environment (vulnerability and resilience) upon disruptive actions.

Sensitivity analyzes are a way to assess the susceptibility of resources to a given pressure or stressor, such as the sensitivity of natural resources (eg marine biota) to oil spills. The vulnerable resources are those that are sensitive and are exposed to a certain pressure. Many analytical approaches incorporate elements of vulnerability, but are still commonly referred to as sensitivity analysis. All approaches are referred to as "sensitivity analysis" in this document.

The Sensitivity analysis translates qualitative information about a species or system into a score or range that describes its susceptibility to one or more significant stressors (Stortini et al., 2015). The vulnerability to a certain stress factor, the emission of seismic waves in this particular case, is a function of the sensitivity (susceptibility of a species or population to be negatively impacted by the stressor) and the adaptive capacity (potential of a species or population to cope with stress, recover from adverse effects, or migrate to a more favorable habitat). A species or population can only be highly vulnerable if it is highly sensitive to seismic activity and cannot adapt to its effects because it does not have the ability to evade it. In this way, sensitivity to seismic activity is a function of the biological and ecological characteristics of the species, including hearing capacity, its habitat, type and location of breeding areas, etc. The adaptive capacity is a function of the demographic characteristics of the population, including its natural area of distribution. A common method to analyze different types of impact uses score evaluation methods, which, although not free from subjectivity, seek to mark differences between the most sensitive species, considering the relative weight of factors associated with sensitivity and the ability to adapt (Stortini et al., 2015). The use of scores to assign validity arose from the review of the literature and the information gahtered in the baseline.

This sensitivity analysis follows a widely accepted logical framework. To justify our framework, a bibliographic search was carried out in order to evaluate approaches that could be adequate and it was found that recent risk and vulnerability assessment methodologies (specifically, Reich et al., 2014; Morandi et al., 2018) were well established and tested to identify vulnerabilities (and sensitivities) in marine environments. In the models applied by Reich et al., And Morandi et al. environmental sensitivity reflects the vulnerability of the environment to a given impact or stressor (eg accidental spills, noise, collisions, etc.) and is based on the underlying vulnerability of habitats and species that are representative or present in each region / season, which determines their potential to interact with stressors. The work of Reich et al., 2014 assesses the sensitivity of the marine environment to large-scale hydrocarbon spills, while the work of Morandi et al., 2018 does it for offshore wind turbine projects, and therefore, it also incorporates criteria of acoustic sensitivity.

While neither method has been designed to assess the environmental sensitivity of offshore seismic exploration projects, the basic ecological concepts of habitat and species sensitivity to a given stressor can be well transferred to the offshore seismic sector. In addition to the baseline analyzes examined, other specific studies on the environmental sensitivity and risks of offshore seismic exploration projects were collected and reviewed, which served as the basis for the development of this analysis.

The analysis was developed considering the situation of each factor in different seasons. This division was made based on the typical behavior of meteorological variables, that is, considering possible differences for: spring, summer, autumn and winter.

The different factors belonging to the natural and socioeconomic environment to be considered in the ESA were selected. Given the nature of the project, the physical variables (geological and oceanographic) shall not be affected by the actions of the project, but, on the contrary, some actions shall be limited and affected by these variables on site. The characterization and knowledge of these variables were included as part of the Baseline and enabled the comprehension of the system as a whole. Thus, no particular factors have been identified that should be incorporated in the present analysis.

Regarding the anthropic component, the analysis involved those relevant activities that could be directly and / or indirectly affected in their normal development or potential as a result of the project´s development process.

The main adverse effect on the biotic environment is related to noise generation, although the presence of seismic vessels can lead to collisions or snagging with the seismic gear. The types of effects can be ordered from highest to lowest such as mortality, permanent or temporary hearing damage, confusion in the perception of sounds (discrimination of intensity, frequency, direction or distance), behavioral changes (escape, modification of trajectories), covering up of socialization or echolocation signals (Redondo and Ruiz, 2017).

In this regard, it is important to mention that the sensitivity of marine animals to sounds of different frequencies is expressed through audiograms, which are graphs that show the thresholds of perception. Audiograms are normally obtained by behavioral testing of animals in captivity, although they can also be obtained from electrophysiological responses. The results obtained show great variability, not only between species, but also between individuals of the same species. Even the same individual may not behave the same on different occasions when they are subjected to the same noise level. Despite everything, the similarities are enough to be able to speak of auditory patterns by groups of species (Redondo and Ruiz, 2017).

Since there are no studies that cover all the world's marine vertebrate species or their individual variability, Southall et al. (2007, 2019) recommended the analysis of effects considering the use of groups of species / individuals representative of the different taxonomic groups and their characteristics in relation to sound / pressure, the so-called auditory groups. Species are grouped taking into account their known, suspected or audible frequency range, auditory sensitivity, anatomy adapted to perceive sound waves, and acoustic ecology. Although these authors only considered marine mammals, this approach can be broadened and expanded to other groups of vertebrates, in order to systematize information on their vulnerability and resilience.

Following the methodological framework proposed, an analysis of the main bibliographic reviews on hearing, anthropogenic noise impacts and ecological characteristics commonly used to assess sensitivity was carried out and presented in this chapter by Point **Error! Reference source not found.** in order to:

a) Determine taxonomic groups with differential behaviors / responses. A summary was made for each group, and the species present in the project's area of influence were assigned.

b) Verify the occurrence of criteria that indicate particular characteristics of sensitivity, considering the following aspects:
Location criteria in the project's area of influence and ecological value:
L1. Species that are very abundant or frequent because they feed in the project´s area of influence
L2. Species that breed in the project's area of influence
L3. Rare species or with restricted distribution that includes the project´s area of influence
L4. Presence of critical stages: eg. juveniles, adults with young

Legal protection criteria
P1. Species categorized as threatened with local and global extinction (Categorizations of Argentina, IUCN))
P2. Species with another type of legal protection (Natural monuments, inclusion in appendices such as CMS, fisheries legislation)

Avoidance responses and withdrawal ability
E1. Species that have no avoidance
E2. Species that have the ability to avoid

Population responses (not instantaneous)
RP1. Noises / pressure can mask communication between individuals (for breeding, hunting in groups)
RP2. Noises / pressure affect access to food or decrease its abundance for times that exceed individual reserve capacities.

Other risks of physical harm
DF1. Collisions or snags with vessels or seismic arrays

c) Determine the times of the year when the main species of the group are present in the project's area of influence (described in the Environmental Baseline).

These characteristics form the core of the species sensitivity score. The construction of the score was based on the revision of the approach by Reich et al., 2014 and Morandi et al., 2018 and other applicable environmental sensitivity studies (Thornborough et al., 2017; Stortini et al., 2015; Bergström et al. al., 2014), the existing information and the judgment of the experts.

Next, each attribute (when information is available) requires: a) a brief description of the groups together with a summary of the most relevant information; b) a summary of the verification of any of the criteria considered and, c) summary of the temporary occurrence in the area of influence of the project. The information reported is based mainly on the Environmental Baseline, indicating other information with additional citations.

The analysis matches the areas of influence defined in Chapter 5 (Environmental Baseline). The characterization carried out in the Baseline allows the detailed analysis of species considering biological, ecological, conservation criteria, etc., particularly in the surroundings of the subzone defined as a Detailed Study Area (which widely exceeds the delimited DAI (Direct Area of Influence) depending on the area of maximum incidence of the propagation of the noise generated by the seismic array) and outside said subzone, already within the IIA (Indirect Area of Influence), depending on the behavior of the birds and marine mammals considered, and according to the definition of the areas of influence referred to hereinabove. At a broader general scale or “regional area of influence”, the analysis considers the identification of sensitive environments (ANP, AICAs, Proposed Marine Areas, etc.).

1.3 SENSITIVITY ANALYSIS

CAN_100-108 seismic prospecting area is located in the Argentine Sea, particularly in the middle and lower slopes and the beginning of the continental rise, between 1200 m and 3900 m dep. On the other hand, CAN_114 Area is located on the middle slope between 1400 m and 3000 m deep.

These areas make up an oceanic marine ecosystem of high productivity and biological diversity, which is known as the Argentine Sea Ecoregion.

The analyzed Argentine Sea sector is dominated by Antarctic water masses that circulate from south to north, corresponding to the Malvinas current. The western branch (Patagonian current) presents cold and low salinity waters due to the fact that there is an intrusion of low salinity waters in the Strait of Magellan (given the contribution of continental waters that drain into the strait through important valleys). This current moves northward on the continental shelf.

In front of the Province of Buenos Aires 38 ° S, these bodies of water meet others coming from equatorial zones that circulate from north to south (current of Brazil) finally meeting at the confluence area. The Brazilian current presents warmer and with more saline content waters (exceeding 26ºC on its surface) than the adjacent ones.

In this way, the Brazil / Malvinas confluence zone (Subtropical Front) is generated in the deep-water environment of the slope, one of the regions with the highest concentration of energy of the worlwide oceans. Subtropical and subantarctic waters coexist and mix there creating important physical-chemical gradients which favour the presence of high concentrations of nutrients with important biological consequences for the entire ecosystem. This encounter of currents moves north or south depending on the season of the year.

Likewise, there is a strong seasonal variability imposed by the circulation of two currents: Malvinas current of cold subantarctic waters, low salinity and rich in nutrients, which flows northward, and that of Brazil of subtropical, warm and saline waters, which flows to the south. These currents determine the oceanographic and biological rhythms of the area. Their confluence is characterized by an important high-energy thermohaline front, with numerous eddies and wide meanders.

There are sensitive areas in the coastal zones because they have an important biodiversity. Species of the different trophic levels gather to benefit from Patagonian coastal waters which represent areas of high productivity. The intertidal ones host a particular fauna which feed numerous marine and coastal birds. In addition, the adjacent land areas are sites which host sea, shorebird and marine mammal settlements. However, within the framework of this project, it is important to mention that the coastal areas shall not be directly affected by seismic acquisition activities as they are located more than 300 km from the prospecting areas.

1.3.1 Marine Invertebrates

In general, marine invertebrates cannot detect the pressure changes associated with sound waves**.** owever, all cephalopods, as well as some bivalves, echinoderms, and crustaceans have a saclike structure called a statocyst (Caroll et al. 2017) which develops during the larval stage (Young et al., 2006) and can allow an organism to detect the partition associated with sound waves in water to orient itself (Sekiguchi and Terazawa, 1997; Kaifu et al., 2008). Cephalopods also have epidermal hair cells that help them detect the movement of particles in their vicinity (Kaifu et al., 2008), comparable to lateral lines in fish. Similarly, decapods have sensory bristles on their body (Popper et al., 2001), including on their antennae that can be used to detect low-frequency vibrations (Montgomery et al., 2006). Structures that allow spotting vibrations due to particle movement have been detected in cuttlefish and scallops (André et al., 2016).

The following categories were considered for the present analysis:

- Planktonic Community. Group of microscopic aquatic organisms that lack their own or almost zero mobility and whose movements are dependent on the water masses in which they live, especially up to a depth of 200 meters. It is made up of autotrophic (phytoplankton) and heterotrophic (zooplankton) organisms.

- Benthic community. Both plant and animal organisms that live related to the bottom, semi-buried, fixed or that can move without going too far from it, from the high tide mark to the bottom of the deepest trenches.

- Cephalopods. A Group of great economic relevance in the region where the project shall be implemented. A member of the nekton (together with fish, reptiles and marine mammals) which is a community of organisms embracing those animal species, generally macroscopic, with a great swimming capacity.

1.3.1.1 Planktonic Community

Phytoplankton production on fronts varies depending on the Brazilian and Malvinas currents behavior. The areas influenced by the Brazilian Current show a low concentration of chlorophyll, while those waters under the control of the Malvinas Current show a high concentration of chlorophyll. There are certain areas where concentration becomes very important. One of them is where the confluence of the Brazil / Malvinas currents occurs, where subtropical and subantarctic waters mix, determining important physical-chemical gradients that boost the presence of high concentrations of nutrients with important biological implications for the entire ecosystem.

The indirect area of influence of the project is located in the "Continental slope front" system, with significant concentrations of phytoplankton. The Front of the Slope is defined between the waters of the Malvinas Current and the waters that are on the platform at less than 200 m deep. Upwelling processes occur along the front where the Malvinas Current provides nutrients to the illuminated layers on the adjoining platform, giving rise to an important phytoplankton production that sustains the food web of the region, especially in spring (October to December) and summer (January to March). The zooplankton of this region is very diverse and is composed of great abundances of amphipods hyperidae, euphasids, salps and carnivorous zooplankton species, among which the *Desmonema gaudichaudi* jellyfish stand out due to the large biomasses reached during their frequent demographic explosions.

The phytoplankton assemblage corresponds to the “Transicional del Norte” combination for the edge of the slope in the area of indirect influence of the project. This assemblage is characterized by the presence of 119 registered diatom species, 20 of which are restricted species but invariably not very abundant. Thirteen (13) species of diatoms were found in this area; Among these, *Chaetoceros contortus, Pseudo-nitzschia* multiseries, and *C. rostratus* are particularly abundant.

Phytoplankton production in the Argentine Sea describes an annual increase and subsequent decrease bimodal cycle, typical of temperate-cold water ecosystems with seasonal thermoclines. The maximum phytoplankton production occurs in spring, beginning with intense growth during the months of October and November in shallow coastal waters north of the shelf. The production wave gradually expands towards the South and moves away from the coast as it enters the summer period. A secondary maximum of primary production is observed in the first months of autumn (Campagna et al., 2006).

In general, after the peak of primary spring production there is a reduction in the concentration of nutrients, especially silicates, which limits the growth of diatoms, so that there is a change in the phytoplankton flora in favor of coccolithophores, dinoflagellates and other small flagellates that have the ability to use nutrients from the mineralization of organic compounds (Campagna et al., 2006).

The maximum values of phytoplankton productivity are recorded during the spring and summer seasons in the Slope Front.

The zooplankton production cycle adopts typical patterns of temperate-cold seas, with a seasonal variation in its biomass associated with the explosive spring growth of phytoplankton, which experiences a progressive gradient from the coast to the slope and from North to South, according to the abundance of nutrients and the stabilization of the water column.

Zooplankton production varies along with phytoplankton. The areas influenced by the Brazilian Current which present a low concentration of phytoplankton, also display low densities of zooplankton. On the other hand, where the waters of the Malvinas Current prevail with a high concentration of phytoplankton, a greater abundance of zooplankton is observed. In conclusion, the greatest diversity of species is found in the waters of Malvinas current and in the Confluence or transition zone. The latter which is located in the indirect area of influence of the project, holds 57% invertebrates in the area.

More than 1,000 species of marine zooplankton live in the waters of Malvinas and Brazil currents. Most of the species are scarce and their representation in taxonomic groups is uneven: more than 80% of the individuals correspond to less than 20% of the species. Regarding the composition of zooplankton, mesozooplankton consists mainly of copepods (89%) and occasionally ostracods, pteropods, juvenile forms of euphausiids and amphipods, and also larvae of other crustaceans and fish eggs.

The presence of mytophid larvae is recognized as the most numerous component as regards ichthyoplankton in the project's area of influence. Myctophid larvae occur year-round and during the winter months they dominate in low abundance of ichthyoplankton. The presence of cephalopod larvae occurs after winter spawning in the southern area, the eggs being carried away by the Malvinas Current (sensitivity is analyzed later in point **Error! Reference source not found.**. Cephalopods).

Macrozooplankton (made up of organisms over 5 mm long) mainly include euphausiids (krill), amphipods and chaetognaths (Sabatini et al., 2001). One of the most important zooplankton organisms in the area is krill, since it represents the food source of many species of fish, cetaceans, pinnipeds, penguins and other seabirds visiting the area. The pelagic crustaceans of the genus Euphausia (euphausiids) are known by that name. On the other hand, the amphipod group is practically monospecific and is represented almost exclusively by *Themistho gaudichaudii*. This species makes up the key food for most of the fish species that are distributed in the area (Campagna et al., 2006).

Cepeda et al. (2018) analyzed the distribution and abundance of the main species present throughout the platform and the edge of the Slope. With variable abundances throughout the seasons, the main components for the SASW zone, located in the indirect area of influence of the project, consist of adults and late copepodites of *D. forcipatus*, C5 copepodites and adult females of *C. australis* and the *T. gaudichaudii* amphipoda, while the SASW zone is characterized by C4-5 copepodites of *D. forcipatus*; females and late copepodites of *C. vanus*, *C. brevipes* and *C. smillimus*; the cyclopoid *O.aff.helgolandica* and *O. atlantica*; *T. gaudichaudii*, juveniles of euphasids. Epipelagic seasonal migrants such as *N. tonsus* C5, *Subeucalanus longiceps* and *M. Luces* have been recorded in low numbers on the external platform, near the slope (Ramírez and Sabatini, 2000).

The highest zooplankton biomass is recorded from the beginning of spring to the end of summer, mainly composed of macrozooplankton, with the species *T. gaudichauddi* and *E. lucens* standing out in the Slope Front, in the indirect area of influence of the project. *O.aff.helgolandica* and *O. atlantica* are other important species to the north of the survey area.

There is presence of fish stomachs with ctenophores, with a low ZG diversity in the Project´s area of indirect influence. The main groups of ZG are tenophores, salps and jellyfish. The most frequent in the area of indirect influence are the Ctenophora. No studies were found on the seasonal distribution of the ZG for the survey area.

No protected species have been identified in the bibliography consulted for the project's area of influence.

The species that make up the phytoplankton are not considered especially sensitive for this type of project, and the areas of maximum production do not overlap with the project area.

As regards zooplankton, the species that may present a greater degree of sensitivity to seismic activity are crustacean larvae and Krill. Although this group cannot avoid the effect, it is important to note that the areas of maximum zooplanktonic biomass do not overlap with CAN_100-108 and 114 seismic data acquisition areas, since these are located in front of the slope, 30 km from the prospecting area and 17 km from the operating area, that is, outside the area affected by seismic sources, which is very localized for this component.

When referring to ichthyoplankton, fish larvae and eggs cannot avoid the pressure wave from compressed air sources, however, the damage is limited to areas very close to the source (less than 5 meters). The presence of myctophid larvae is recorded throughout the year with low abundance in winter in the project's area of influence.

For this reason, it is considered that this component presents an intermediate sensitivity during the moments of maximum productivity, that is, during the spring and summer seasons, and also in autumn in relation to the presence of myctophytic larvae, turning out low for the winter.

1.3.1.2 Benthic community

The communities of the Patagonian district are dominated by mollusks (filum Mollusca), echinoderms (filum Equinodermata) and bryozoans (filum Bryozoa) in that order. Brachiopods (phylum Brachiopoda) follow as the next most important group (Bastida et al., 1992). These authors identified two regions within the Patagonian District. The indirect area of influence of the project for CAN_100 and CAN_108 Areas overlaps with area “B” in the internal region of the platform; it presents 112 species of macroinvertebrates, a group sub-dominated by bryozoans and echinoderms, of which only one is exclusive to this area. While CAN_114 Area is located in “C” area under the influence of the Malvinas current (high productivity and low temperatures) with a total of 152 species, it shows a high percentage of exclusive species (16.30%). The community is dominated by bryozoans and brachiopods, the echinoderms being less abundant than in “B” area.

To date, the list of taxa caught incidentally as part of the monitoring of Patagonian scallop fishing areas and identified in routine work reaches about 90 species (Schejter et al., 2014). Specific studies carried out on different zoological groups have contributed to broadening the knowledge about the fauna richness in these areas and have provided information on porifera, echinoderms, hydroids, infaunal organisms, the most frequent demersal and benthic fish and sponge endobionts (Schejter et al., 2017). As a result, the benthic richness known to date has been estimated in about 250 species (Schejter et al 2013), which include more than 50 epibiont organisms from the Patagonic Scallop (Romero et al., 2017; Schejter et al., 2017). CAN_100 - CAN_108 Area is located in close to “B” MU, while CAN_114 to “C” MU. In B area, the main taxa associated with the scallop were the sponge and several species of echinoderms, among which it is worth mentioning *Ctenodiscus australis* and *Diplasterias brandti*, the sea urchin *Austrocidaris canaliculata* and the shaggy brittle star *Ophiactis asperula*. At the southernmost end of “B” MU, patches with high densities of the hermit crab *Sympagurus dimorphus* and the *Sterechinus agassizii* are also found (Schejter and Mantelatto, 2015). The "C" MU presents a lower density of scallops than other areas and is characterized by having a higher species richness than more exploited areas as well as a sponge biomass that represents between 22 and 90 % of the catch (Schejter and Bremec, 2013). South of "C" MU, very high biomasses of ophiuroids are recorded, mainly of *Ophiactis asperula* and *Ophiacantha vivípara*, and high-density patches of coral *Flabellum cf. Curvatum* and the *Sterechinus agassizii* sea urchin in certain sectors (Escolar, 2010).

Patagonian scallop fishing surveys have also made it possible to collect benthic fauna at the outer limit of "C" MU 400 m deep. In these localities there was a predominance of echinoderms as well as the presence of fish-eating stars (Stylasteridae) and soft corals, among which thorny sea pens (Pennatulacea) and primnoids stand out. Cold-water coral reefs were detected in this region in deeper areas in order to find Vulnerable Marine Ecosystems in international waters along the southwestern Atlantic. They were mainly composed of the *Bathelia candida* species, coral gardens that in turn present a large quantity of associated fauna, located between 400 and 1000 meters deep, and sponge fields, located between 250 and 1300 meters deep (Portela et al., 2012; Schejter, 2017; Campodónico, 2019a).

The Patagonian scallop has so far shown a recruitment behavior that suggests a very uncertain dynamic to foresee. Scallop stocks can fluctuate widely from one year to another without presenting a clear pattern, such as populations whose recruitment would be strongly influenced by hydrographic conditions. Currently, this fishery already shows a reduction in the biomass of catches and a limitation of the feasible fishing areas. The biomass that supports the current and immediate future catches of the fishery is due only to localized recruitments, which are not enough to maintain the levels of catches similar to those taking place at the beginning of the fishery (Campodónico et al 2019b; Allegra et al 2020).

The most profitable scallop banks from the fishing point of view are located under the influence of the Front of the Slope and along the 100 m isobath. The activity of the scallop fishing fleet is low or null in CAN_100-108 Area. In CAN_114 Area, a high density of the scallop resource is not observed, however, it surely happens in the first quarter of the year in the area of indirect influence.

Certain groups of benthic invertebrates (sponges, cnidarians, tunicates, brachiopods) are "Taxa Indicators" and they stand out due to their ecological role and their high sensitivity to any natural or anthropic change. When biomasses greater than 10 kg 1,200 m-2 are recorded in these groups, the habitats are framed as Vulnerable Marine Ecosystems (VMEs). Approximately 90 macroinvertebrate taxa were detected in the southern Patagonian zone (48 ° S-55 ° S) between 50 and 400 m-deep, including several TI, some of which are very frequent and abundant (Allega et al., 2020).

In order to detect VMEs in deeper areas of the international waters of the southwestern Atlantic, cold-water coral reefs were detected in this region, mainly composed of the species *Bathelia candida*, which in turn present a large amount of associated fauna, located between 400 and 1000 meters deep, and sponge fields, located between 250 and 1300 meters deep. The Atlantis project (2007-2010) monitored these ecosystems in order to describe, within an ecosystem approach, the VMEs (Vulnerable Marine Ecosystems) and the possible interactions with fishing activities in the study area (Del Rio et al., 2012). The area of direct influence for CAN_114 Area partly overlaps with the presence of fragile species which are also considered Taxa Indicators to the north of the Vulnerable Marine Ecosystems areas.

The area of direct influence of the seismic acquisition areas does not overlap with the areas with the highest coral density, nor is this overlap identified in the Detailed Study Area, inserted in the Indirect Area of Influence.

Recently, campaigns of the Oceanographic Ship ARA Puerto Deseado (BO) during 2012 and 2013, expanded the knowledge of the benthic communities between 200 and 3000 meters deep in front of the city of Mar del Plata.

Decapods are best known for their commercial interest. This group is made up of crabs, lobsters, shrimp, prawns and spider crabs. Another remarkable characteristic of the group is its role as main prey for many species of fish, mollusks and other animals. Therefore, they are considered important links in the food web of the worldwide seas. Five species of ecological-economic interest are registered for the indirect area of influence of the project: The *Munida gregarious* lobster, the *Lithodes santolla* common crab, the *Thymops birsteini* deep-sea lobster, the *Chaceon notialis* red crab, and the *Ovalipes trimaculatus* swimming crab.

Three species of economic interest stand out within the macrocrustaceans; red crab, swimmer crab and lobster. Only the red crab and the spider crab are found in the indirect area of influence of the CAN_100-108 project.

Four effective sectors of the common spider crab can be identified in Argentina. The Central Patagonian Sector, called the Central Management Area for this species (between 43 ° 30´S and 48 ° C), is the most important since it produces a large part of the landing volume (**Fish landings** are defined as the catches of marine fish landed in foreign or domestics ports) (Allega et al., 2019. The most abundant nuclei in the Central Area are located within the San Jorge Gulf (San Jorge Gulf High Yield Sector) and in platform waters (North High Yield Sector and South High Yield Sector). The effective South Patagonia sector is the second in importance and is distributed south of 48 ° S (Allega et al., 2020). Only one breeding and molting site is recorded in the area of direct influence of the CAN_100-108 project, but with a very low density of crabs. CAN_114 Area does not overlap with spider crabs´ breeding or feeding sites and there are no landings from this area.

Regarding the benthic communities, no protected species have been identified in the consulted bibliography for CAN_100-108 and 114 Areas.

The indirect area of influence of the project does not overlap with the areas with the highest coral density. However, the CAN_114 seismic data acquisition area partly overlaps with the north of the areas considered Vulnerable Marine Ecosystems.

In the area of indirect influence of the project, in the case of the Patagonian scallop, *Zygochlamys patagónica*, a low biomass density is observed, with the highest density of the species being recorded in spring-summer, with the first and second quarters of the year being the greater landings of the resource. No feeding or breeding sites of the Patagonian scallop are observed in the area of direct influence of CAN_100-108 and CAN_114 areas.

The decapod crustacean species, registered in the indirect area of influence of the project have no economic importance, presenting bycatch / incidental fisheries, although these species have great ecological relevance. In Argentina, the exploitation of red crab is not carried out, the swimming crab is outside the area of direct and indirect influence in the 50 m isobath (fleet of bay or estuary). The lobster is only occasionally caught by vessels that operate along the slope (with trawls, longlines or pots). Only one breeding and molting site is recorded in the area of direct influence of the CAN_100-108 project, but with a very low density of crabs. The CAN_114 area of direct influence of the project does not overlap with spider crabs´ breeding or feeding sites. There are no landings of *L. santolla* from this area.

Therefore, the benthic community has a medium sensitivity to the project throughout the year.

1.3.1.3 Cephalopods

Cephalopod mollusks

The area of direct influence of CAN_100-108 and CAN_114 sites does not overlap with those areas with the highest cephalopod landings of the 2003-2017 period. The closest fleet to the area of indierect influence is that of freezer trawlers of southern species.

The squid (*Illex argentinus*) stands out within the analyzed area. It is distributed from 23º S to 54º S, with a frequent presence between 35º S and 52º throughout the platform and slope, being the most important cephalopod of the Southwest Atlantic from the point of view of the fisheries.

Its highest concentration, however, is associated with the presence of subantarctic waters and mainly with the cold waters of Malvinas current distributed on the edge of the slope, between 80 and 400 meters deep. They are distributed in breeding stocks based on feeding sites, adult size and seasonal migrations. Apparently, there are four populations (summer spawning, South Patagonian, Buenos Aires-North Patagonian and spring spawning).

The following is observed in the Area of influence of the Project:

- In Autumn-Winter (peak between May and July): important pre-breeding concentrations on the platform and slope corresponding to the Buenos Aires-North Patagonian subpopulation (SBNP).

- In Spring: important concentrations in the Buenos Aires-North Patagonian platform between 50 and 100 m deep corresponding, on the one hand, to juveniles from the spawning of the South Patagonian and Buenos Aires subpopulations, North Patagonia and pre-adults of the summer spawning subpopulation and adults from the spawning subpopulation of spring.

- In Summer: important concentrations between 43 ° and 45 ° S made up of summer spawning adults.

Cephalopods appear to be considerably sensitive to high intensity seismic waves that come from very close emission sources (up to 5 km).

Although the project's area of influence is located within the Argentine squid distribution area, the direct area of influence does not overlap with the spawning, breeding, or feeding sites.

The areas with the highest concentrations and breeding groups would be found in the indirect area of influence of the project in spring and summer, but the area of direct influence would be partially synchronized with the pre-reproductive concentrations of the Buenos Aires-North Patagonian subpopulation grouped in high density at the edge of the platform. An additional impact would occur during the laying of eggs and larvae from winter until spring from the southern zone due to the action of the Malvinas current.

From a fisheries point of view, the most relevant stock corresponds to the area south of parallel 44 ° S (South-Patagonian subpopulation), which implies that the impact on the fishery shall be much less significant in the area of influence of the project. However, and due to the fact that the area of direct influence overlaps with the breeding temporal window during the autumn and winter months, the sensitivity is deemed high for said period and low for the rest of the year, given that the species has a wide distribution and high density in the shelf zones located south of 44 ° S.

1.3.2 Fishes

The a) biological criteria, b) ecological criteria, c) conservation criteria and d) fishing criteria were selected in order to evaluate the impact of seismic waves upon fish. The information to characterize them was obtained from Cousseau and Perrota (2013), Popper and Fay (2009) and other works cited in the Baseline (Chapter 5) corresponding to Fish and Fisheries. These criteria allow, to a certain extent, to influence the evaluation of the degree of exposure to seismic waves, the sensitivity presented and the potential adaptation to recover from the impact. The degree of exposure is related to the habitat that the species occupies and the time window in which the survey is carried out regarding its presence in the area. The sensitivity is given by biological aspects, mainly those related to the mechanisms of hearing and reception of sound waves, but also with biological features such as growth, age and reproductive capacity. These traits make cartilaginous fish more vulnerable than bony fish to sources of unnatural impacts (Cortes, 2000). Another factor that plays a role in sensitivity is the habitat that the species occupies in one or more stages of its life cycle. The adaptability refers to the possibility of avoiding the waves or the impact zone, based on the swimming characteristics or trophic amplitude to have alternative prey when those preferred could be affected. The importance of the fishery of a certain species in the area of direct influence is also considered as a measure of the possible impact that the project may have.

The criteria (and sub-criteria) considered and the assessments defined for each of them are hereinbelow described.

a) Biological criteria

- Hearing sensitivity: Fish species that lack a gas-filled cavity, including jawless fish, elasmobranchs (sharks, skates, and rays), some sole, gobiidae, and certain tuna and other deep-sea and pelagic species are less sensitive to trauma due to extreme changes in sound pressure and mainly detect particle movement.

  The hearing of fish with swim bladder depends much more on sound pressure, but also, to some extent, on the movement of particles. Thus, these species have better hearing capacity which can negatively affect them to mask other sounds. Fish with swim bladders that are not intimately connected to the ear and have a hearing range of up to 500 Hz stand out, including species such as cod (Gadidae), eels (Anguillidae), some grey triggerfish and sea bass (Sciaenidae), etc.

At the other end, there are fish that have special structures that mechanically link the swim bladder to the ear (Weber's organ). These fish called Osteichthyes are sensitive mainly to sound pressure, although they also detect the movement of particles.

The classification according to the degree of hearing sensitivity was considered to vary between 1 (low hearing power), 3 (moderately reactive to noise sources) and 5 (more sensitive) as is displayed by the following table.

Table 1. Classification by hearing sensitivity

Type	Characteristic	Groups	Response
Type 1A	Bony Fish without swim bladder	Fish that do not have a swim bladder and probably only use particle motion for sound detection. The highest audible frequency of these fish may not exceed 400 Hz, with poor sensitivity compared to fish with a swim bladder. Fish within this group would include flatfish, some gobiidae, some tunas, and agnathos.	These groups of fish have poor hearing power, which is why they are less sensitive to the seismic waves of the seismic airguns.
Type 1B	Cartilaginous fish (without swim bladder)	They do not have a swim bladder and include sharks, rays, and chimaerea. These fish have an apparent sensitivity to low frequency waves, which are similar to those emitted by seismic energy sources, and depend on the morphology of the ear.	Varied response to seismic waves
Type 2	Bony fish with swim bladder, but no connection from the bladder to the inner ear	Fish that detect sounds from less than 50 Hz to perhaps 800-1,000 Hz (although probably several only detect sounds at 600-800 Hz). These fish have bladders but there are no known structures in the auditory system that improve hearing, and the sensitivity is not high. These species detect both the movement and pressure of the particles, and the differences between species are related to how well they can use the pressure signal. This category includes a wide range of species, including tuna with swim bladders, sturgeons, salmonids, etc.	They are moderately reactive to noise sources.
Type 3	Bony fish with swim bladder and connection between the bladder and the inner ear	They are characterized by the presence of an evolved and well-developed Weberian apparatus formed by a skeletal complex of small bones that are physically connected to the complex anterior auditory labyrinth and the region of the posterior swim bladder (ostareophysi fish). These fish can perceive sound pressure waves, detect sounds of up to 3,000 Hz or more, and their hearing sensitivity is the most developed.	They are very sensitive, the Weberian apparatus acts as a sound wave amplifier that adds the swim bladder as a resonance chamber where it amplifies the signal to be audible.

- Breeding in the area of influence of the project: It was considered that those species breeding in the area of influence of the project are sensitive because seismic waves can produce temporal and spatial interference in the reproductive process and promote that the larvae lose their window time when ecological conditions are optimal for survival and growth.

  This was considered when the species breeds in the area of influence of the project (1) or outside (0).

  It should be mentioned that it was decided to assign the highest valuation in the cases for which information was not available.

- Breeding period: To complement the previous criterion, for those species breeding within the project's area of influence, those whose reproductive period was seasonal or limited and therefore with the risk of overlapping with prospecting work were considered as more susceptible ones, having less impact in the case of species with longer periods.

  Thus, if the species breeds outside the project's area of influence, this criterion is classified as null (0). For the remaining species, it was considered if the breeding period is longer, even when it is in the area of influence of the project, they shall be less affected (1) than if it is seasonal or limited to a single time window that could be simultaneous with the seismic activity in the area of influence (2).

  It should be mentioned that it was decided to assign the highest valuation in the cases for which information was not available.

- Presence of a breeding area in the project area: Seismic emissions cause a high mortality of eggs and larvae when they are close to the emission source (2 to 5 m), so the species that have breeding areas in the area of influence of the project (particularly in the area of seismic data acquisition given the location of the impact) are more vulnerable. The area of the embryos is considered as a breeding area for viviparous species.

  Thus, the species most susceptible to being affected (1) were those that had their breeding area in the area and with a null assessment (0) when it was far away.

  It should be mentioned that it was decided to assign the highest valuation in the cases for which information was not available.

- Distribution Range: Those fish species that have a wide distribution (cosmopolitan) shall be less affected at the species level (valued as 1), while those that are distributed only on the slope are considered more sensitive (valued as 2).

- Trophic niche specificity: it represents the extent to which there is a specialization of the diet of certain species. Highly specialized species (those limited to a specific type of food) (valued as 1) have less capacity to exploit groups of alternative prey in the case in which the most common are reduced, or have a temporary disappearance due to the effects of seismic waves. On the contrary, those species that have greater trophic range (euryphagous) has the ability to use alternative prey (valued as 0).

b) Ecological criteria

- Trophic importance for other species: It is evaluated if the species is critically important as a key link in the trophic chain for other species, in such a way that its temporary disappearance can unbalance the trophic chain.

The classification according to the degree of importance in the food web is 0, that is, not critically important and 1 when it is highly important for the trophic chain.

- Habitat Use: The habitat that a species occupies is related to its life traits and adaptations, since species with little natural mobility shall be more affected than those that are wandering, migratory or base their feeding strategy on fast swimming. Epipelagic fish are few in number and live from the surface up to 200 m, having fusiform bodies and the capacity to develop high speed and could be considered as those with the best possibility of moving away from seismic waves; the mesopelagic ones are distributed between 200 and 1000 m and make night migrations towards the epipelagic zone; the bathypelagic cover depths of 1000 to 4000 m; Benthic fish are those that live associated with deep-sea bottoms and live mostly above 1000 m deep and can be more sensitive to seismic waves because they have less ability to evade them.

  The classification according to degree of importance in the food web is 1 (epipelagic), 2 (mesopelagic), 3 (bathypelagic) and 4 (benthic). This criterion applies essentially to the area of direct influence, that is, those where the intensity of the waves could produce a change in the behavior of the species.

c) Conservation criteria

Threat status: Its status was considered according to the IUCN Red List of Threatened Species.

The following score was awarded: least concern (1), closely threatened (2) vulnerable (3), and threatened (4). Those not evaluated or being data deficient were assigned a value of zero (0).

d) Fishing criteria

- Fishing importance in the project area: Seismic operations can influence catch rates in fisheries by generating alienation behaviors of the target species, economically damaging the activity in the area of direct influence of the project.

  Taking into account the characteristics of the area of influence of the project, it was considered of zero importance (0) when the species does not present an associated fishery), of low importance (1) when the species is not important in the area or is a bycatch product and (2) if the species is important and its fishing is usual in the project area.

The richness of fish totals some 69 species in the project's area of influence. A total of 33 species of fish are specifically registered for the area of direct influence of the CAN_100-108 and 114 project. Fourteeen (14) species were identified among the most prominent cartilaginous fish, being mostly Rajiformes, as well as 19 species for bony fish.

The evaluation of the factors that can influence the sensitivity of the species present in the direct area of influence of the project and its surroundings is presented in Table 2.

Table 2. Criteria to characterize the sensitivity of the species present in the project area that corresponds to the area of direct influence (*) and adjacent to the slope and edge of the platform. EN: endangered; VU: vulnerable; NT: near threatened; LC: least concern; DD: data deficient; NE: not evaluated. s / d: no data

ORDER	SPECIES	COMMON NAME	Biological criteria						Ecological criteria		Conservation criteria	Fishing criteria
			Sensitivity to detect seismic waves	Breeding Area in the Project Site	Breeding period	Breeding Area in the Project Site	Distribution range	Trophic niche	Critical trophic importance for other species	Habitat use	Conservation status (UICN 2020)	Importance in the area
Rajiformes	*Bathyraja macloviana*	Patagonian skate *	Moderate (without bladder)	yes	Extensive	yes	shelf / slope	Euriphagous	No	Benthic	NT	bycatch
	Bathyraja albomaculata	White-dotted skate *	Moderate (without bladder)	yes	Extensive	yes	shelf / slope	Euriphagous	No	Benthic	VU	bycatch
	Bathyraja griseocauda	Greytail skate	Moderate (without bladder)	yes	Extensive	yes	shelf / slope	Euriphagous	No	Benthic	EN	bycatch
	Bathyraja scaphiops	Cuphead skate*	Moderate (without bladder)	yes	Extensive	yes	Slope	Euriphagous	No	Benthic	NT	bycatch
	Bathyraja brachyurops	Broadnose skate*	Moderate (without bladder)	yes	Extensive	yes	shelf / slope	Euriphagous	No	Benthic	LC	bycatch
	Bathyraja magellanica	Magellan skate*	Moderate (without bladder)	yes	Extensive	yes	shelf / slope	Euriphagous	No	Benthic	DD	bycatch
	Bathyrraja cousseaue	Raya de aletas juntas*	Moderate (without bladder)	yes	Extensive	yes	Slope	Euriphagous	No	Benthic	NE	bycatch
	Bathyraja multispinnis	Multispine skate*	Moderate (without bladder)	yes	Extensive	yes	Slope	Euriphagous	No	Benthic	NT	bycatch
	Zearaja chilensis	Yellownose skate*	Moderate (without bladder)	yes	Extensive	yes	shelf / slope	Stenophagous	No	Benthic	VU	bycatch
	Amblyraja doellojuradoi	Southern Thorny skate*	Moderate (without bladder)	yes	Extensive	yes	Slope	Euriphagous	No	Benthic	LC	bycatch
	Psammobatis normani	Shortfin sand skate*	Moderate (without bladder)	yes	Extensive	yes	shelf / slope	Euriphagous	No	Benthic	DD	bycatch
	Psammobatis rudis	Smallthorne sand snake*	Moderate (without bladder)	yes	Extensive	yes	shelf / slope	Euriphagous	No	Benthic	DD	bycatch
Squaliformes	*Squalus acanthias*	Picked dogfish*	Moderate (without bladder)	no	Seasonal	no	shelf / slope	Euriphagous	No	Epipelagic	VU	bycatch
Carcharhiniformes	*Schorederichthys bivius*	Narrowmouthed catshark*	Moderate (without bladder)	no	Seasonal	no	shelf / slope	Euriphagous	No	Epipelagic	NT	bycatch
Chimeriformes	*Callorhinchus callorhynchus*	Plownose chimaera*	Moderate (without bladder)	no	Extensive	no	shelf / slope	Euriphagous	No	Epipelagic	NE	none
Gadiformes	*Coryphaenoides filicauda*	Grenadier	Moderate (with unconnected bladder)	no	Seasonal	no	Slope	Euriphagous	No	Mesopelagic	NE	none
	Coelorhynchus fasciatus	Banded whiptail*	Moderate (with unconnected bladder)	no	Seasonal	no	Slope	Euriphagous	No	Mesopelagic	NE	none
	Macrourus holotrachys	Bigeye granadier	Moderate (with unconnected bladder)	no	Seasonal	no	Slope	Euriphagous	No	Mesopelagic	NE	none
	Macrourus carinatus	Ridge scales rattail	Moderate (with unconnected bladder)	no	Seasonal	no	Slope	Euriphagous	No	Mesopelagic	NE	none
	Luciogadus nigromaculatus	Blackspotted grenadier	Moderate (with unconnected bladder)	no	Seasonal	no	Slope	Euriphagous	No	Mesopelagic	NE	none
	Haplomacrourus nudirostris	Naked snout rattail	Moderate (with unconnected bladder)	no	Seasonal	no	Slope	Euriphagous	No	Mesopelagic	NE	none
	Muraenolepis marmorata	Marbled moray cod	Moderate (with unconnected bladder)	no	Seasonal	no	Slope	Euriphagous	No	Mesopelagic	NE	none
	Merluccius hubbsi	Argentine Hake*	Moderate (with unconnected bladder)	no	Seasonal	no	shelf / slope	Euriphagous	No	Mesopelagic	NE	moderate
	Merluccius australis	Southern Hake	Moderate (with unconnected bladder)	no	Seasonal	no	shelf / slope	Euriphagous	No	Mesopelagic	NE	low
	Macruronus magellanicus	Patagonian Grenadier*	Moderate (with unconnected bladder)	no	Seasonal	no	shelf / slope	Euriphagous	No	Mesopelagic	NE	low
	Antimora rostrata	Blue Antimora	Moderate (with unconnected bladder)	no	Seasonal	no	shelf / slope	Euriphagous	No	Mesopelagic	LC	none
	Lepidion ensiferus	Patagonian Codling	Moderada (con vejiga no conectada)	no	Seasonal	no	shelf / slope	Stenophagous	No	Mesopelagic	NE	none
	Guttigadus kongi	Austral Cod	Moderate (with unconnected bladder)	no	Seasonal	no	shelf / slope	Euriphagous	No	Mesopelagic	NE	none
	Notophycis marginata	Dwarf codling*	Moderate (with unconnected bladder)	no	Seasonal	no	shelf / slope	Stenophagous	No	Mesopelagic	NE	none
	Salilota australis	Tadpole codling*	Moderate (with unconnected bladder)	no	Seasonal	no	Slope	Euriphagous	No	Mesopelagic	NE	low
	Micromesistius australis	Southern Blue Whiting*	Moderate (with unconnected bladder)	no	Seasonal	no	shelf / slope	Euriphagous	No	Mesopelagic	NE	moderate
	Seriolella porosa	Choicu Ruff	Moderate (with unconnected bladder)	no	Seasonal	no	shelf / slope	Stenophagous	No	Mesopelagic	NE	none
	Urophycis cirrata	Gulf Hake	Moderate (with unconnected bladder)	no	Seasonal	no	shelf / slope	Stenophagous	No	Mesopelagic	LC	none
Pleuronectiformes	*Mancopsetta maculata*	Antarctic armless flounder*	Low (without bladder)	yes	Seasonal	yes	Slope	Stenophagous	No	Benthic	NE	none
	Mancopsetta milfordi	Finless flounder*	Low (without bladder)	yes	Seasonal	yes	shelf / slope	Stenophagous	No	Benthic	NE	none
Scorpaeniformes	*Cottunculus granulosus*	Fathead*	High (with connected bladder)	No data	Seasonal	No data	shelf / slope	Stenophagous	No	Benthic	NE	none
	Psychrolutes marmoratus	Fathead	High (with connected bladder)	No data	Seasonal	No data	Slope	Stenophagous	No	Benthic	NE	none
	Praematoliparis anarthractae	Snailfish	High (with connected bladder)	No data	Seasonal	No data	Slope	Euriphagous	No	Benthic	NE	none
	Paraliparis cf. anarthractae	Snailfish	High (with connected bladder)	No data	Seasonal	No data	Slope	Stenophagous	No	Benthic	NE	none
	Paraliparis eltanini	Snailfish	High (with connected bladder)	No data	Seasonal	No data	Slope	Stenophagous	No	Benthic	NE	none
	Congiopodus peruvianus	Snailfish	High (with connected bladder)	No data	Seasonal	No data	shelf / slope	Stenophagous	No	Benthic	NE	none
	Sebastes oculatus	Patagonian redfish	High (with connected bladder)	No data	Seasonal	No data	shelf / slope	Stenophagous	No	Benthic	NE	none
Anguiliformes	*Ariosoma opistophthalmum*	Conger	High (with connected bladder)	No data	Seasonal	No data	shelf / slope	Euriphagous	No	Bathypelagic	LC	none
	Bassanago albescens	Hairy Conger	High (with connected bladder)	No data	Seasonal	No data	Slope	Euriphagous	No	Bathypelagic	LC	none
	Conger orbignianus	Argentine Conger	High (with connected bladder)	No data	Seasonal	No data	shelf / slope	Euriphagous	No	Bathypelagic	LC	none
	Pseudoxenomystax albescens	Conger eel*	High (with connected bladder)	No data	Seasonal	No data	shelf / slope	Euriphagous	No	Bathypelagic	LC	none

ORDER	SPECIES	COMMON NAME	Biological criteria						Ecological criteria		Conservation criteria	Fishing criteria
			Sensitivity to detect seismic waves	Breeding Area in the Project Site	Breeding period	Breeding Area in the Project Site	Distribution range	Trophic niche	Critical trophic importance for other species	Habitat use	Conservation status (UICN 2020)	Importance in the area
	Diastobranchus capensis	Basketwork eel	High (with connected bladder)	No data	Seasonal	No data	Shelf-slope	Euriphagous	No	Bathypelagic	NE	none
Nocanthiformes	*Aldrovandia palacra*		High (with connected bladder)	No data	Seasonal	No data	Slope	Euriphagous	No	Benthic	LC	none
	Notacanthus sexspinis	Spiny-back eel	High (with connected bladder)	No data	Seasonal	No data	Slope	Euriphagous	No	Benthic	NE	none
	Notacanthus chemnitzii	Snubnosed spiny eel	High (with connected bladder)	No data	Seasonal	No data	Slope	Euriphagous	No	Benthic	LC	none
Myctophiformes	*Myctophidae sp.*	*Myctophidae*	High (with connected bladder)	no	Seasonal	yes	Slope	Stenophagous	No	Mesopelagic	NE	none
Perciformes	*Ophthalmolycus macrops*	Eelpout	High (with connected bladder)	No data	Seasonal	no	Slope	Euriphagous	No	Bathypelagic	NE	none
	Plesienchelys stehmanni	Eelpout	High (with connected bladder)	No data	Seasonal	no	Slope	Euriphagous	No	Bathypelagic	NE	none
	Phucocoetes cf. Latitans	Eelpout	High (with connected bladder)	No data	Seasonal	no	Slope	Euriphagous	No	Bathypelagic	NE	none
	Illucoetes fimbritatus	Eelpout *	High (with connected bladder)	No data	Seasonal	no	Slope	Euriphagous	No	Bathypelagic	NE	none
	Lycenchelys bachmanni	Eelpout *	High (with connected bladder)	No data	Seasonal	no	Slope	Euriphagous	No	Bathypelagic	NE	none
	Stromateus brasiiensis	Southwest Atlantic butterfish*	High (with connected bladder)	No data	Seasonal	no	Shelf-slope	Stenophagous	No	Bathypelagic	NE	none
	Thyrsites atún	Snoek*	High (with connected bladder)	No data	Seasonal	no	Shelf-slope	Euriphagous	No	Bathypelagic	NE	none
	Disssotichus eleginoides	Patagonian Toothfish*	High (with connected bladder)	no	Seasonal	no	Slope	Euriphagous	No	Bathypelagic	NE	low
	Patagonotothen ramsayi	Longtail southern cod*	High (with connected bladder)	no	Seasonal	no	Slope	Euriphagous	No	Bathypelagic	NE	none
	Epigonus robustus	Robust cardinalfish*	High (with connected bladder)	No data	Seasonal	no	Slope	Euriphagous	No	Bathypelagic	NE	none
	Cottoperca gobio	Channel Bull blenny	High (with connected bladder)	No data	Seasonal	no	Shelf-slope	Stenophagous	No	Bathypelagic	NE	none
	Schedophilus griseolineatus		High (with connected bladder)	No data	Seasonal	no	Slope	Stenophagous	No	Bathypelagic	NE	none
Stomiiformes	*Argyropelecus aculeatus*	Lovely hatchetfish	High (with connected bladder)	No data	Seasonal	no	Slope	Euriphagous	No	Bathypelagic	LC	none
	Stomias boa	Boa dragonfish	High (with connected bladder)	No data	Seasonal	no	Slope	Euriphagous	No	Bathypelagic	LC	none
	Bathophilus vaillanti		High (with connected bladder)	No data	Seasonal	no	Slope	Euriphagous	No	Bathypelagic	LC	none
Ophidiiformes	*Genypterus blacodes*	Pink cusk-eel*	High (with connected bladder)	no	Seasonal	no	Slope	Euriphagous	No	Bathypelagic	NE	moderate
	Cataetyx messieri	Patagonian Forkbeard	High (with connected bladder)	No data	Seasonal	no	Shelf-slope	Stenophagous	No	Bathypelagic	LC	none
Aulopiformes	*Scopelosaurus lepidus**		High (with connected bladder)	No data	Seasonal	no	Slope	Euriphagous	No	Benthic	LC	none
	Bathypterois longipes	Abyssal spiderfish	High (with connected bladder)	No data	Seasonal	no	Slope	Stenophagous	No	Benthic	LC	none

Based on the above information, the alternatives of the different criteria were categorized (Table 3) and then a matrix was developed to evaluate the potential sensitivity, assigning values to each of the alternatives of the different criteria for those species with the best available information (Table 4).

Table 3. Assessment of the alternatives of the criteria used to determine the potential sensitivity.

	Criterion	Score
Biological Criteria	**Sensitivity to detect seismic waves**	
	Low (without bladder) - Bony fish	1
	Moderate (without bladder) - Chondrichthyans	3
	Moderate (with unconnected bladder)	3
	High (with connected bladder)	5
	Breeding area in the area of influence	
	No	0
	Yes	1
	Breeding period	
	Outside the area of influence of the project	0
	Extensive in the area of influence of the project	1
	Seasonal in the area of influence of the project	2
	Breeding area in prospecting area	
	No	0
	Yes	1
	Distribution Range	
	Slope and shelf	1
	Slope only	2
	Trophic niche	
	Broad, euryphagous	0
	Narrow, specialized	1
Ecological Criteria	**Trophic importance for other species**	
	Low	0
	High	1
	Habitat use	
	Epipelagic	1
	Mesopelagic	2
	Bathypelagic	3
	Benthic	4
Conservation criteria	**Conservation value**	
	NE, DD	0
	LC	1
	NT	2
	VU	3
	EN	4
Fishing Criteria	**Fishing Interest**	
	None	0
	Low or through bycatch	1
	Target species in the area (moderate)	2

Based on this matrix, a Potential Sensitivity Indicator (PSI) called "relative sum" was determined, which was expressed as:

$$\text{ISP or Relative Sum} = Sj / fmax$$

Sj is the score for j species that results from adding the individual scores for each criterion that affects sensitivity, and fmax represents the maximum possible values that can negatively affect sensitivity.

In the case of ichthyofauna, this value can vary between 0.14 and 1 (the minimum value it can take is 3 and the maximum 23, so the normalized sum divides by 23).

Taking as a reference the assessment scales usually used when conducting environmental sensitivity analysis (Chin et al, 2010; Stortini et al., 2015; AECOM, 2015; Walsh, s / f), sensitivity values were defined by applying similar intervals to the possible range of the Relative Sensitivity Index, and assigning them a categorization, which in this case corresponded to the use of tertiles (the cut-off points being 0.4 and 0.7).

Based on the relative sum (PSI) of the criteria represented in this matrix, the sensitivity of the species was classified as low (less than 0.4), moderate (between 0.4 and 0.7) and high (greater than 0,7).

Relative sum (ISP)	Sensitivity
< 0,4	low
≥ 0,4 y ≤ 0,7	moderate
> 0,7	high

Table 4. Matrix of scores assigned according to the alternatives of the criteria used to evaluate the sensitivity corresponding to the area of direct influence. * Only larval stages.

ORDER	SPECIES	COMMON NAME	Biological criteria						Ecological criteria		Conservation criteria	Fishing criteria	Relative Sum
			Auditory Sensitivity	Breeding Area in the Project Site	Breeding Period	Breeding Area in the Project Site	Distribution Range	Trophic niche	Trophic importance for other species	Habitat use	Conservation Status (UICN)	Importance in the area	
Rajiformes	*Bathyraja macloviana*	Patagonian Skate*	3	1	1	1	1	0	0	4	2	1	0,61
	Bathyraja albomaculata	White dotted skate*	3	1	1	1	1	0	0	4	3	1	0,65
	Bathyraja griseocauda	Greytail skate	3	1	1	1	1	0	0	4	4	1	0,70
	Bathyraja scaphiops	Cuphead skate*	3	1	1	1	2	0	0	4	2	1	0,65
	Bathyraja brachyurops	Broadnose skate *	3	1	1	1	1	0	0	4	0	1	0,52
	Bathyraja magellanica	Magellan skate *	3	1	1	1	1	0	0	4	0	1	0,52
	Bathyrraja cousseaue	Joined-fins skate *	3	1	1	1	2	0	0	4	0	1	0,57
	Bathyraja multispinnis	Multispine skate *	3	1	1	1	2	0	0	4	2	1	0,65
	Zearaja chilensis	Yellownose skate*	3	1	1	1	1	1	0	4	3	1	0,70
	Amblyraja doellojuradoi	Southern thorny skate*	3	1	1	1	2	0	0	4	1	1	0,61
	Psammobatis normani	Shortfin sand snake*	3	1	1	1	1	0	0	4	0	1	0,52
	Psammobatis rudis	Smallthorne sand snake*	3	1	1	1	1	0	0	4	0	1	0,52
Squaliformes	*Squalus acanthias*	Picked dogfish*	3	0	0	0	1	0	0	1	3	1	0,39
Carcharhiniformes	*Schorederichthys bivius*	Narrowmouthed catshark*	3	0	0	0	1	0	0	1	2	1	0,35
Chimeriformes	*Callorhinchus callorhynchus*	Plownose chimaera*	3	0	0	0	1	0	0	1	0	0	0,21
Gadiformes	*Coryphaenoides filicauda*	Grenadier	3	0	0	0	2	0	0	2	0	0	0,30
	Coelorhynchus fasciatus	Banded whiptail*	3	0	0	0	2	0	0	2	0	0	0,30
	Macrourus holotrachys	Bigeye granadier	3	0	0	0	2	0	0	2	0	0	0,30
	Macrourus carinatus	Ridge scales rattail	3	0	0	0	2	0	0	2	0	0	0,30
	Luciogadus nigromaculatus	Blackspotted grenadier	3	0	0	0	2	0	0	2	0	0	0,30
	Haplomacrourus nudirostris	Naked snout rattail	3	0	0	0	2	0	0	2	0	0	0,30
	Muraenolepis marmorata	Marbled moray cod	3	0	0	0	2	0	0	2	0	0	0,30
	Merluccius hubbsi	Argentine Hake*	3	0	0	0	1	0	0	2	0	2	0,35
	Merluccius austral	Southern Hake	3	0	0	0	1	1	0	2	0	1	0,31
	Macruronus magellanicus	Patagonian Grenadier*	3	0	0	0	1	0	0	2	0	1	0,30
	Antimora rostrata	Blue Antimora	3	0	0	0	1	0	0	2	1	0	0,30
	Lepidion ensiferus	Patagonian codling	3	0	0	0	1	1	0	2	0	0	0,30
	Guttigadus kongi	Austral cod	3	0	0	0	1	0	0	2	0	1	0,30
	Notophycis marginata	Dwarf codling*	3	0	0	0	1	1	0	2	0	0	0,30
	Salilota australis	Tadpole codling*	3	0	0	0	2	0	0	2	0	1	0,35
	Micromesistius australis	Southern Blue whiting*	3	0	0	0	1	0	0	2	0	2	0,35
	Seriolella porosa	Choicy ruff	3	0	0	0	1	1	0	2	0	0	0,30
	Urophycis cirrata	Gulf Hake	3	0	0	0	1	1	0	2	1	0	0,35
Pleuronectiformes	*Mancopsetta maculata*	Antarctic armless flounder*	1	1	2	1	2	1	0	4	0	0	0,52
	Mancopsetta milfordi	Finless flounder*	1	1	2	1	1	1	0	4	0	0	0,48
Scorpaeniformes	*Cottunculus granulosus*	Fathead*	5	1	2	1	1	1	0	4	0	0	0,65
	Psychrolutes marmoratus	Fathead	5	1	2	1	2	1	0	4	0	0	0,70
	Praematoliparis anarthractae	Snailfish	5	1	2	1	2	0	0	4	0	0	0,65

ORDER	SPECIES	COMMON NAME	Biological criteria						Ecological criteria		Conservation criteria	Fishing criteria	Relative Sum
			Auditory Sensitivity	Breeding Area in the Project Site	Breeding Period	Breeding Area in the Project Site	Distribution Range	Trophic niche	Trophic importance for other species	Habitat use	Conservation Status (UICN)	Importance in the area	
	Paraliparis cf. anarthractae	Snailfish	5	1	2	1	2	1	0	4	0	0	0,70
	Paraliparis eltanini	Snailfish	5	1	2	1	2	1	0	4	0	0	0,70
	Congiopodus peruvianus	Horsefish	5	1	2	1	1	1	0	4	0	0	0,65
	Sebastes oculatus	Patagonian redfish	5	1	2	1	1	1	0	4	0	0	0,65
Anguiliformes	*Ariosoma opistophthalmum*	Conger	5	1	2	1	1	0	0	3	1	0	0,61
	Bassanago albescens	Hairy conger	5	1	2	1	2	0	0	3	1	0	0,65
	Conger orbignianus	Argentine conger	5	1	2	1	1	0	0	3	1	0	0,61
	Pseudoxenomystax albescens	Conger eel*	5	1	2	1	1	0	0	3	1	0	0,61
	Diastobranchus capensis	Basketwork eel	5	1	2	1	1	0	0	3	0	0	0,57
Nocanthiformes	*Aldrovandia phalacra*	Hawaiian halosaurid fish	5	1	2	1	2	0	0	4	1	0	0,70
	Notacanthus sexspinis	Spiny-back eel	5	1	2	1	2	0	0	4	0	0	0,65
	Notacanthus chemnitzii	Snubnosed spiny eel	5	1	2	1	2	0	0	4	1	0	0,70
Myctophiformes	*Myctophidae sp.*	Myctophidae	5	0	0	1	2	1	0	2	0	0	0,48
Perciformes	*Ophthalmolycus macrops*	Eelpout	5	1	2	0	2	0	0	3	0	0	0,57
	Plesienchelys stehmanni	Eelpout	5	1	2	0	2	0	0	3	0	0	0,57
	Phucocoetes cf. latitans	Eelpout	5	1	2	0	2	0	0	3	0	0	0,57
	Illucoetes fimbritatus	Eelpout *	5	1	2	0	2	0	0	3	0	0	0,57
	Lycenchelys bachmanni	Eelpout*	5	1	2	0	2	0	0	3	0	0	0,57
	Stromateus brasiiensis	Southwest Atlantic butterfish*	5	1	2	0	1	1	0	3	0	0	0,57
	Thyrsites atun	Snoek*	5	1	2	0	1	0	0	3	0	0	0,52
	Disssotichus eleginoides	Patagonian toothfish*	5	0	0	0	2	0	0	3	0	2	0,52
	Patagonotothen ramsayi	Longtail southern cod*	5	0	0	0	2	0	0	3	0	0	0,43
	Epigonus robustus	Robust cardinalfish*	5	1	2	0	2	0	0	3	0	0	0,57
	Cottoperca gobio	Channel bull blenny	5	1	2	0	1	1	0	3	0	0	0,57
	Schedophilus griseolineatus		5	1	2	0	2	1	0	3	0	0	0,61
Stomiiformes	*Argyropelecus aculeatus*	Lovely hatchetfish	5	1	2	0	2	0	0	3	1	0	0,61
	Stomias boa	Boa dragonfish	5	1	2	0	2	0	0	3	1	0	0,61
	Bathophilus vaillanti		5	1	2	0	2	0	0	3	1	0	0,61
Ophidiiformes	*Genypterus blacodes*	Pink cusk-eel*	5	0	0	0	2	0	0	3	0	2	0,52
	Cataetyx messieri	Patagonian Forkbeard	5	1	2	0	1	1	0	3	1	0	0,61
Aulopiformes	*Scopelosaurus lepidus**		5	1	2	0	2	0	0	4	1	0	0,65
	Bathypterois longipes	Abyssal spiderfish	5	1	2	0	2	1	0	4	1	0	0,70

Chondrichthyans have been generally classified as having moderate sensitivity because, despite lacking a swim bladder, the range of auditory perception coincides with that of seismic waves. The highest values are seen in the rajiformes that have been classified as moderately sensitive due to the fact that the seismic data acquisition zone coincides with their breeding area. However, the breeding period of this species is long. Two vulnerable species stand out: the broadnose skate and the white-dotted skate, and one critically endangered: Rio skate.

Although they present a greater sensitivity to noise, Gadiformes can be considered in general terms as of low sensitivity, given that they are not observed in specific breeding sites of the area of direct influence of CAN_100-108 and CAN_114 position. They are not benthic species nor do they fall in any conservation category.

Pleuronectiformes, on the other hand, have been classified as having moderate sensitivity, mainly due to their condition as benthic, since it cannot be ruled out that the breeding area is related to the area of direct influence previously mentioned. In this regard, these species are cited for the slope, which possibly indicates that they also breed in the area of direct influence.

The rest of the groups identified in the area of direct influence of CAN_100-108 and CAN_114, include species with swim bladder connected to the ear, which makes them the main recipients of the effects of seismic activities, being this factor the one that possibly generates more impact for the project. However, all these species were classified as moderately sensitive. It should be noted that there is no information on the breeding area for many of the species; this is why they were assigned the highest overvalued sensitivity rating. It should be noted that none of the bony fish species of commercial interest are bred in the area of direct influence of CAN_100-108 and CAN_114 site.

An equally important aspect is that almost all the species identified in the project area have a wide distribution in the southern zone and some are even frequent in the slope and platform.

Table 5 summarizes the expected sensitivity of the different orders, appreciating that most of them correspond to the medium category and no species with high sensitivity are identified.

Table 5. Summary of the expected sensitivity according to the orders evaluated in the area of direct influence of the project

Low sensitivity	Mean sensitivity
Squaliformes	Rajiformes
Carcharhiniformes	Pleuronectiformes
Chimeriformes	Scorpaeniformes
Gadiformes	Anguiliformes
	Nocanthiformes
	Myctophiformes
	Perciformes
	Stomiiformes
	Ophidiformes
	Aulopiformes

1.3.3 Fisheries

The interaction between fishing and prospecting tasks can occur in two fundamental aspects: one related to the incidence that the repeated sound pulses produce on the species of fishing interest and another related to the obstruction of circulation of the activity on the movements of the fishing fleet in search of areas of greater catch.

When analyzing the fishing zones in the Argentine maritime space with the regulations and closures in force as of March 2020, it is observed that, in the area of direct influence of CAN_100-108 and CAN_114, there are no sectors with restrictions and / or closures in force for fishing. However, according to Resolution 973/1997 Former SAGPyA, the opening to fishing for squid (*Illex argentinus*) north of the 44th parallel is established from May 1 to August 31 of each year, except for conservation reasons the early closure of the fishing season is ordered, with directed fishing of the prohibited species remaining in said sector for the rest of the year.

In the area of direct influence of the project, the fisheries present are mainly the deep-sea Stern trawler fleet and freezer trawlers. Nearby coastal and estuary fishing vessels shall not interfere with prospecting operations due to the existing distances from the exploration area to the coast.

In this regard, a non-binding relationship with the fishing areas is observed for the operational areas of the project. The fishing effort is mainly concentrated in the slope front, which, as mentioned above, is located 30 km from the prospecting area, and 17 km from CAN_100-108 and CAN_114 operational areas. The area of influence of CAN_100-108 and CAN_114, in particular the area of direct influence, supports a very low fishing effort that registers an annual variation.

The species of rays and sharks present on the Argentine coastline make up the accompanying fauna of the main Argentine fisheries that operate up to the slope area. Its catch is therefore lower than on the platform, since these fisheries in the slope area are of less intensity.

The main species of fishing interest in the area of influence of the project are the following: hake, hoki, haddock, southern cod, black hake, southern hake, southern blue whiting and squid. However, not all these species have the same fishing relevance in the areas of direct influence of CAN_100-108 and CAN_114.

There are two different stocks of the common hake located north and south of 41 ° S respectively.

The one located to the north is the most important from the point of view of the catch and its contribution to the fishing of this resource, which is mainly developed on the platform (Macchi et al. 2010; Allega et al., 2020). This species represents the main resource of the Argentine Sea and its fishery almost does not include the area of direct influence of CAN_100-108 and CAN_114 areas. The greatest interference with the catch of this species, minor in any case, could occur in the months of March to June.

The haddock, in general, is a species caught as a companion fauna to hake fishing, with very low catches in the study area. The highest catches are recorded only in the second and third quarters.

The impact would be negligible for the Patagonian grenadier, since the most important fishing area for this species is outside the seismic survey area. The southern cod is not considered an important species in the direct area of influence of the project. This is caught as a companion species for the Patagonian grenadier and the southern blue whiting on the Argentine continental shelf.

The Patagonian toothfish, on the other hand, is a species of high commercial value, and although it does not present important catch values in the area of direct influence of the project, the catch area of the northern sector extends beyond 1000 m deep overlapping the depths of the seismic data acquisition area.

The fleet that catches southern hake exerts minimal fishing effort in the project's area of influence.

The catch of the southern blue whiting is very low in the study area.

Finally, squid is a species of high economic importance in the indirect area of influence of the project. North of 44 ° S, the Buenos Aires-North Patagonian subpopulation is exploited from March or April to June before migrating to deep waters. The trawlers activity is already registered in April and also extends into winter. Another possible impact may occur on the drift of its larvae, which, depending on oceanographic conditions, may include the project area.

Table 6 summarizes the temporal characteristics of the fisheries that are related to the direct area of the project and its adjacencies.

Table 6. Temporal distribution of the fishing activity of the species that may have a temporal and spatial link with the project area. *¨ species with greater fishing importance.

Species	E	F	M	A	M	J	J	A	S	O	N	D
Plownose chimaera												
Hake												
Patagonian Grenadier												
Pollock *												
Patagonian toothfish *												
Southern Blue Whiting												
Atlantic cod												
Southern hake												
European Squid *												

In this sense, the sensitivity of the fishing activity is considered of low intensity since, as previously mentioned, the greatest fishing efforts are observed mainly outside the area of direct influence. Only the pollock, the Patagonian toothfish and squid fisheries could be affected depending on when the fishery survey is conducted. The activity becomes very important in the front area of the slope, especially during the autumn and winter periods. However, it is located 30 km from the prospecting area and 17 km from CAN_100-108 and CAN_114 operational areas.

The area of direct influence is not identified as a breeding area of commercial species. Squid larvae are recorded for the indirect area of influence of CAN_100-108 and CAN_114, but it is also possible to find them in the prospecting area. However, these larvae come from spawning areas located in other zones of the Argentine Sea. As said, species of fishing interest do not have their spawning site in said area of influence. In any case, summer is the most convenient season for seismic work from the point of view of fisheries, and in order to avoid potential interference they should not be carried out during autumn/winter periods.

1.3.4 Sea Turtles

Sea turtles are considered the least vocal of the reptiles. The only period for which vocalizations have been documented is during egg laying, but there are no records of underwater vocalizations (Cook y Forrest, 2005). Turtles do not have an external ear and the eardrum is a continuation of the skin plate tissue. Like certain groups of marine mammals, they present fatty deposits adjacent to the tympanic plates, which are interpreted as adaptations for conducting and detecting sounds in water.

Based on electrophysiological studies (ABR) it was determined that sea turtles hear better in the ranges between 100 and 800 Hz, some with sensitivity up to 60 Hz, and do not respond well to sounds above 1 kHz (Ridgeway et al., 1969, Moein-Bartol et al., 1999). The ranges of sensitivity vary according to populations of the same species (Bartol and Ketten, 2006). As turtles grow and age their sensitivity to sounds shifts to lower frequencies; a range between 200-500Hz was determined in the only measurement carried out in a larger green turtle (Ketten and Bartol, 2005).

Sea turtles exhibit high fidelity to fixed migration corridors, foraging grounds, and nesting areas, and this inflexibility may affect the ability to avoid survey areas in search of less noisy locations. The lack of movement behavior can also imply a lack of feeding in the case of carnivorous turtles, since the prey move away.

Controlled experiments on the exposure of sea turtles to noise found that the animals increased their swimming speed and had erratic behaviors implying avoidance behaviors, but could also be as a result of the effect of the experimental environment (McCauley et al 2000a). Open water studies with caged animals showed that, although there are initial avoidance responses, turtles become accustomed to noise after several days of being tested (McCauley et al., 2000a).

Of the currently known species, only 3 of them have been reported for the detailed study area of the project: the green sea turtle (*Chelonia mydas*), the loggerhead sea turtle (*Caretta caretta*), and the leatherback sea turtle (*Dermochelys coriacea*).

Given the limited information available, all these species were considered as a single group (TM), specialized in low frequencies (Table 7).

Table 7. Auditory range for sea turtles.

Code	Group	General auditory range	Present taxa, members of the group	
			Species	Common name
TM	Sea Turtles	60 – 900 Hz	*Caretta caretta*	Loggerhead sea turtle
			Chelonia mydas	Green sea turtle
			Dermochelys coriacea	Leatherback sea turtle

Loggerhead and leatherback sea turtles have confirmed occurrences in the area by satellite monitoring data, and the literature indicates that juveniles and pre-adults of the three species could be present in the area of oceanic gyres of the confluence of Brazil - Malvinas current. The highest occurrence is verified in the months of warm temperatures.

All species of sea turtles are included in the IUCN Red List, in the CMS and CITES appendices. Sea turtles are protected by Decree 144/98 that prohibits its use and commercialization in Uruguay. National Law 26,600, National Law 22,421, Decree 666/97 and 1089 (of 1998), 3 (of 2001) and 91 (of 2003) Resolutions protect sea turtles at the National level in Argentina. Besides, Uruguay and Argentina are signatories to various international agreements for the protection and conservation of different species, including sea turtles (CITES, IUCN, among others).

The Río de la Plata estuary is an important feeding area from spring to autumn for the Loggerhead Turtle, with areas of high fidelity by tagged individuals. The presence of the green sea turtle in the latitude of the project would be more frequent in the summer months, while the leatherback sea turtle is registered between July and December, with medium to high densities of the tagged specimens.

Next, the sensitivity of the turtle species present in the project's area of influence is analyzed, taking into account their presence, the conservation status and the breeding areas.

As a starting point for the sensitivity analysis, 2 key criteria were considered to understand the sensitivity of the species to the project:

- Presence
- Conservation status

The abovementioned were considered equally important, and they had to be evaluated with the same assessment scale, which was defined between 1 and 3. In no case was a null assessment considered, since the sole identification gives it an estimation.

Then, 1 additional criterion of relevance was added to this particular group:

- Presence of Breeding Areas

In this case, the null estimate was considered.

Presence categories

As mentioned in Chapter 5, a list of probable sea turtle species for the project's area of influence was drawn up from the global or regional distribution maps present in field guides and portals (see details of sources consulted in Point 4.3.2.1 of Chapter 5). The presence of these species was confirmed by consulting open databases of georeferenced occurrences and recent publications.

Based on this information, the following categories of presence were drawn up.

1 Species only reported through global distribution maps.
2 Publications that present data on the occurrence of the species for the area of influence of the project.
3 Publications with data on the occurrence of the species within the operational areas of the seismic data acquisition zones.

Conservation status categories

Both the national and international assessment were considered to evaluate the conservation status (see details of sources consulted in Point 4.3.2.2 of Chapter 5). Although the diagrams are equivalent in terms of the definition of the categories, the species do not necessarily coincide in their categorization. Considering this situation, it was decided to adopt the most conservative one, assigning the highest valuation according to the following description:

1 Species of least concern or not threatened
2 It is considered vulnerable or near threatened (VU - NT)
3 The species presents one of the most critical extinction threat categories (CR / EP / EN / A)

Categories of Presence of Breeding Zone

It was considered:

0 Distant
2 Close

Table 8. Criteria analysis for the sensitivity assessment of the sea turtle species present in the area.

Species	Common name	Presence	MAyDS[a]	UICN[b]	Breeding Site
Caretta caretta	Loggerhead sea turtle	Frequent and abundant	A	VU[1]	Distant
Chelonia mydas	Green sea turtle	No confirmed records	A	EN[2]	Distant
Dermochelys coriacea	Leatherback sea turtle	Frequent	EP[3]	VU	Distant

[a] MAyDS. Res. 1055/13. Categorization of Reptiles and Amphibians of Argentina. EP: endangered, A: threatened, V: vulnerable, NA: not threatened, IC: insufficiently known.

http://servicios.infoleg.gob.ar/infolegInternet/anexos/215000-219999/219633/norma.htm.

[b] IUCN (International Union for Conservation of Nature and Natural Resources) 2020-1: Red List of Endangered Species (www.iucnredlist.org LC: least concern, does not qualify for conservation categories; NT: low risk, near threatened. VU: vulnerable; EN: endangered; CR critically endangered.

[1] Although the species is considered a vulnerable category (VU) globally, the review by Casale and Tucker (2017) would consider the populations of the Southwest Atlantic as of Least Concern (LC).

[2] Although the species is considered in a vulnerable category (VU) at a global level, the review by Broderick and Patricio (2019) considers that the populations of the southwest Atlantic are increasing as a result of the conservation measures that have been put into practice and qualify them as Least Concern (LC).

[3] This is the most critical species locally as it is endangered.

Table 9. Assessment of criteria used to determine potential sensitivity.

Criterion	Score
Presence	
No confirmed records	1
Frequent	2
Frequent and abundant	3
Conservation value	
NA / LC	1
NT / VU	2
CR / EP / EN / A	3
Breeding areas	
Distant	0
Close	2

In the case of sea turtles, the ISP can vary between 0.25 and 1 (the minimum value it can take is 2 and the maximum 8, so the normalized sum divides by 8). Applying intervals similar to the possible range of the Relative Sensitivity Index, which in this case corresponded to the use of tertiles, the cut-off points would be 0.5 and 0.75.

However, it was decided to decrease the lower limit to 0.3, since it was established that in order to be considered of low sensitivity a species should:

- only be detected through global distribution maps
- Have a conservation status considered of Least Concern or Not Threatened
- not present nearby breeding areas

Based on the relative sum (PSI) of the criteria represented in this matrix, the sensitivity of the species was classified as low (less than 0.4), moderate (between 0.4 and 0.7) and high (greater than 0,7).

Relative sum (ISP)	Sensitivity
< 0,3	low
≥ 0,3 y ≤ 0,7	moderate
> 0,7	high

Table 10. Criteria Score

Species	Common name	Presence	Conservation value	Breeding site	Relative sum
Caretta caretta	Loggerhead sea turtle	3	3	0	0,75
Chelonia mydas	Green sea turtle	1	3	0	0,50
Dermochelys coriacea	Leatherback sea turtle	2	3	0	0,63

Table 11 shows the periods of probable occurrence for the area of influence. The area is not characterized by the frequent presence of green and leatherback sea turtles, but telemetry studies have confirmed the occasional occurrence of individuals, and based on the bibliography, it is assumed that there may be juveniles and sub-adults of the three species associated with the gyres from the confluence of the Brazilian and Malvinas currents during the warm months. The loggerhead turtle holds the highest records.

Table 11. Periods of greater temporal sensitivity for sea turtle species in the project's area of influence. In grey: probable occurrence.

Species	Summer			Autumn			Winter			Spring		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Loggerhead turtle (Juveniles and sub-adults)												
Green turtle (juveniles and subadults adults)												
Leatherback Turtle (juveniles and adults)												

The data available so far indicate that they do not respond to the soft start measures, so it is considered that the known avoidance capacity is not adequate to achieve escape.

Sea turtles appear to react more to the physical presence of the vessel and towed equipment than to survey noises. Their evasion technique is fast immersion, being able to get injured or trapped.

Stranding and incidental catches of adults have been recorded in the coastal areas of Argentina near the project site. The Samborombón Bay Ramsar site is the current Argentine protected area with the highest conservation value for sea turtles. However, it is located more than 350 km from the seismic data acquisition areas, so the aforementioned site shall not be affected by the project.

The project's area of influence is not a breeding zone for sea turtles with a probable presence in the area, since there are no breeding sites for sea turtles in our country. CAN_100-108 and CAN_114 seismic data acquisition areas are located in the migratory corridor of the sea turtle species considered to be present in the project's area of influence.

Given that the estuary of Río de la Plata is an important feeding area for most of the species of sea turtles in the region between spring and autumn months, the study area sector would act as a temporary area and, seasonally, as a feeding one. The warm months are those that register the greatest number of sightings, therefore, for the turtles the period of greatest sensitivity would be spring and summer, being valued as high - moderate (depending on the species). This group would present a low sensitivity for the rest of the year.

1.3.5 Seabirds

Seabirds are amphibian species, which have to listen in environments that have huge differences in acoustic impedance. Most seabirds spend most of their lives at sea. The mechanisms for listening in each environment may be different, since they have anatomical adaptations to listen underwater (Sadé et al 2008, Hawkins and Popper 2014). Seabirds are highly vocal in the terrestrial environment where acoustic communication plays a fundamental role. Hearing studies in seabirds indicate that sound provides information for individual recognition. Sound is also used to locate food sources and provides clues about the presence of predators (Aubin, 2004). There are numerous audiograms for land birds performed by electrophysiological and psycho-acoustic methods since their auditory system works in air. Birds on average hear best between 2-5 kHz, with sensitivity losses below 1kHz of 20 dB / octave and also at frequencies above 4kHz of 60 dB / octave (Dooling, 2000). Birds are generally considered to be more tolerant of anthropogenic noise than mammals.

As regards the Detailed Study Area, 49 potentially present species were counted, with 46 confirmed occurrences in recent years. The following order is displayed in the project area: Spheniciformes (penguins), with 6 species) Procellariiformes (petrels, albatrosses and shearwaters) with 34 species, Pelecaniformes with 1 species and Charadriformes (plovers and jaegers) with 8 species.

None of the identified species is under any CITES appendix. Although the national and international conservation valuation schemes are equivalent in terms of the definition of the categories, the species do not necessarily match their categorization. According to the categorization of birds in Argentina (2017), 8 of the identified species are under some category of threat of extinction (EC, EN y AM) and 9 are almost threatened (VU). According to the most recent publication of the IUCN Red List (2020), 12 species are presented under threat categories (CR, EN and VU) and 7 as near threatened (NT).

The very frequent and abundant species in the region are: Magellanic Penguin (*Spheniscus magellanicus*), Wandering Albatross (*Diomedea exulans*), Sooty Albatross (*Phoebetria fusca*), Yellownosed Albatross (*Thalassarche chlororhynchos*), Black-browed Albatross (*Thalassarche melanophris*), Common Giant Petrel (*Macronectes giganteus*), Hall´s Giant Petrel (*Macronectes halli*), Atlantic Petrel (*Pterodroma incerta*), White-chinned Petrel (*Procellaria aequinoctialis*), Sooty Shearwater (*Ardenna grisea*), Great Shearwater (*Ardenna gravis*) and Wilson´s storm petrel (*Oceanites oceanicus*).

Next, the sensitivity of the bird species present in the project's area of influence is analyzed. As a starting point for the sensitivity analysis, 2 key criteria were considered to understand the sensitivity of the species to the project:

- Presence
- Conservation status
- Hearing Sensitivity

The abovementioned were considered equally important, and they had to be evaluated with the same assessment scale, which was defined between 1 and 3. In no case was a null assessment considered, since the sole identification gives it an estimation.

Then, 2 additional criteria of relevance to this particular group were added:

- Probability of Collision / Snagging
- Presence of Colonies

In this case, the null assessment was definitely considered.

Presence categories

As mentioned in Chapter 5, a list of probable sea turtle species for the project's area of influence was drawn up from the global or regional distribution maps present in field guides and portals (see details of sources consulted in Point 4.3.2.1 of Chapter 5). The presence of these species was confirmed by consulting open databases of georeferenced occurrences and recent publications.

Based on this information, the following presence categories were drawn up.

1 Species only reported through global distribution maps.
2 Species for which there are between 1 to 5 publications giving data on its occurrence
3 Species with more than 5 publications with data on the occurrence and / or estimates of abundance or more frequent times.

Conservation status categories

Both the national and international assessment were considered to evaluate the conservation status (see details of sources consulted in Point 4.3.2.2 of Chapter 5). Although the diagrams are equivalent in terms of the definition of the categories, the species do not necessarily match their categorization. Considering this situation, it was decided to adopt the most conservative one, assigning the highest valuation according to the following description:

1 Species of least concern or not threatened
2 It is considered vulnerable or near threatened (VU – NT)
3 The species is under one of the most critical extinction threat categories (CR / EP / EN / A)

Categories of Hearing Sensitivity

Many seabirds have the ability to dive, but most only make short, shallow dives (Del Hoyo et al. 2017). Diving penguins, auks, cormorants and petrels are considered specialists that alternate long periods of feeding underwater with periods of time resting or manipulating prey on the surface (Martin, 2017). Difficulties in accessing the characteristic habitat of seabirds and the fact that most of them have some degree of protection have determined that auditory studies in these species, particularly those related to underwater hearing, are very scarce and recent (Mooney et al., 2019).

An ad-hoc grouping of species was developed to facilitate sensitivity analysis, since there is very little information on underwater hearing studies in seabirds (Mooney et al., 2019), and there are no agreed-upon classification schemes for seabirds based on potential damage or threats from anthropogenic noises in the water, as they do exist for marine mammals. The grouping rests upon the classification of diving birds by Martin and Crawford (2015) based on the type of prey, the known diving depths, together with the information available on aquatic hearing.

- Auditory groups present

Deep divers (P). There are 4 potential penguin species in the area, with a confirmed and frequent presence only for the Patagonian penguin, and potential for the king penguin, rockhopper penguin and macaroni penguin that occasionally reach southern Brazil. All species are under some category of threat and have legal protection. They may be present in the project's area of influence during their autumn migrations to the north of the confluence area and also when returning to their breeding colonies at the end of winter, but juveniles that are isolated from groups and migrants may also be found. They have escaping, diving and swimming abilities to move away from the source of disturbance. Available studies recommend that surveys be carried out more than 100 km from the colonies.

Shallow divers (B). The group is represented mainly by the white-chinned petrel, the sooty shearwater and the great shearwater, which are among the most abundant species in the area. These species dive shallowly to catch their food among tuna and squid shoals. They follow boats and are usually at risk of collision or snagging.

Non-divers Group (NB). Made up of most of the species registered in the project's area of influence with species of Procellariformes from the families Diomedeidae (albatrosses), Procellaridae (gyring petrels), Hydrobatidae (petrels) and Characiformes from the families Laridae (terns) and Stercoraridae (skuas). The albatrosses are all under both national and international threat categories, as well as many of the petrels, due to the decrease in their populations affected by the bycatch. The most recent studies suggest avoidance, but that may be dependent on the response of their prey.

Therefore, the species of birds present can be classified as follows (Table 12);

Table 12. Auditory groups of seabirds. Own elaboration based on Martin and Crawford (2015) and Crowell (2016).

Code	Group	Generalized hearing ranges in water	Normal and maximum immersion depths	Present taxa, members of the group
P	Deep divers	30 Hz – 15 kHz	20 - 50 m maximum > 110m	Family: Spheniscidae (all penguins)
B	Shallow divers	----	5 - 20 m	Order: Procellariiformes: Family: Procellaridae: diving petrels (white-chinned petrel, grey petrel), all shearwaters. Family Pelecanoididae (Peruvian diving petrel).
NB	Non-divers	----	0-1 m	Order: Procellariiformes: Family: Diomedeidae (all albatrosses), Family Procellariidae (giant petrels, prions, petrels, other petrels not included in B2). Order: Charadriformes: Families: Strecorariidae (skuas), Laridae (terns and gulls)

In this way, the assessment was carried out based on the groups that could be more or less affected by the project, considering that the most significant effects would be in the species of birds that spend more time submerged in search of food:

1. Non-divers
2. Shallow and inshore divers
3. Deep divers

Probability of Collision / Snagging Categories

This criterion was considered to have a lower contribution to sensitivity, since it does not constitute the main danger of the activity analyzed. In this sense, it was considered:

- 0 Without being recognized in the bibliography consulted as a group at risk of collision / snagging.
- 1 It is recognized in the bibliography consulted as a species at risk of collision / snagging.

Although there is an enormous lack of information on observations of the physiological and behavioral effects of diving birds in relation to seismic prospecting, the effect of lights and flashes from vessels as potential attractors of seabirds flying at night is well documented. Artificial lights can cause collisions and mortality, particularly in conditions of poor nighttime visibility from the moon or stars (mist, haze), in which birds can become disoriented and crash into the boat or on deck, or become trapped between the seismic equipment deployed in the water. (Wiese et al., 2001, Poot et al., 2008). Species of the Procellariformes order are the most susceptible to this type of collision, since they feed on prey that are bioluminescent and are also naturally attracted to lights (Imber, 1975). This attraction to lights can also cause birds to circle around boats, using additional energy, delaying their migration or feeding, which can result in starvation (Bourne, 1979).

Presence of Colonies Categories

The work carried out by Pichegru et al. (2017) on Penguins was taken as a reference to establish greater sensitivity to the project if the species has colonies smaller than 100 km.

- 0 Distant. They are more than 100 km from the project area
- 2 Close. The species colonies are less than 100 km from the limit of the survey area.

Table 13. Criteria analysis for the sensitivity analysis of the bird species present in the project's area of influence.

Order	Family	Common name	Scientific name	Presence	CAT-AR 2015 [1]	UICN-2020 [2]	Hearing Sensitivity	Probability of Collision / Snagging	Colonies
Spheniciformes	Spheniscidae	King Penguin	*Aptenodytes patagonicus*	Frequent	NA	LC	P	No	distant
		Emperor Penguin	*Aptenodytes forsteri*	Unconfirmed presence	VU	NT	P	No	distant
		Chinstrap Penguin	*Pygoscelis antarcticus*	Unconfirmed presence	VU	LC	P	No	distant
		Magellanic Penguin	*Spheniscus magellanicus*	Frequent and Abundant	VU	NT	P	No	distant
		Macaroni Penguin	*Eudyptes chrysolophus*	Frequent	AM	VU	P	No	distant
		Rockhopper Penguin	*Eudyptes chrysocome*	Frequent	EN	VU	P	No	distant
Procellariiformes	Diomedeidae	Royal Albatross	*Diomedea epomophora*	Frequent	VU	VU	NB	Yes	distant
		Northern Royal Albatross	*Diomedea sanfordi*	Frequent	VU	EN	NB	Yes	distant
		Wandering Albatross	*Diomedea exulans*	Frequent and Abundant	AM	VU	NB	Yes	distant
		Tristan ALbatross	*Diomedea dabbenena*	Frequent	NA(oc)	CR	NB	Yes	distant
		Sooty Albatross	*Phoebetria fusca*	Frequent and Abundant	NA(oc)	EN	NB	Yes	distant
		Light-mantled Albatross	*Phoebetria palpebrata*	Frequent	NA	NT	NB	Yes	distant
		Yellow-nosed ALbatross	*Thalassarche chlororhynchos*	Frequent and Abundant	EN	EN	NB	Yes	distant
		Black-browed Albatross	*Thalassarche melanophris*	Frequent and Abundant	VU	LC	NB	Yes	distant
		Grey-headed Albatross	*Thalassarche chrysostoma*	Frequent	EC	EN	NB	Yes	distant
		Shy Albatross	*Thalassarche cauta*	Frequent	NA	NT	NB	Yes	distant
		White-capped Albatross	*Thalassarche steadi*	Frequent	NA(oc)	NT	NB	Yes	distant
	Procelariidae	Common Giant Petrel	*Macronectes giganteus*	Frequent and Abundant	VU	LC	NB	Yes	distant
		Hall´s giant Petrel	*Macronectes halli*	Frequent and Abundant	NA	LC	NB	Yes	distant
		Southern Fulmar	*Fulmarus glacialoides*	Frequent	NA	LC	NB	Yes	distant
		Pintado Petrel	*Daption capense*	Frequent	NA	LC	NB	Yes	distant
		Soft-plumaged Petrel	*Pterodroma mollis*	Frequent	NA	LC	NB	Yes	distant
		Atlantic Petrel	*Pterodroma incerta*	Frequent and Abundant	NA	EN	NB	Yes	distant
		White-headed Petrel	*Pterodroma lessonii*	Frequent	NA(oc)	LC	NB	Yes	distant
		Trinidade Petrel	*Pterodroma arminjoniana*	Frequent	NA(oc)	VU	NB	Yes	distant
		Blue Petrel	*Halobaena caerulea*	Frequent	NA	LC	NB	Yes	distant
		Atlantic Prion	*Pachyptila desolata*	Frequent	NA	LC	NB	Yes	distant
		Slender-billed Prion	*Pachyptila belcheri*	Frequent	VU	LC	NB	Yes	distant
		Grey Petrel	*Procellaria cinerea*	Frequent	NA(oc)	NT	B	Yes	distant
		White-chinned Petrel	*Procellaria aequinoctialis*	Frequent and Abundant	AM	VU	B	Yes	distant
		Large Shearwater	*Calonectris borealis*	Frequent	NA	LC	B	Yes	distant
		Cory´s Shearwater	*Calonectris diomedea*	Frequent	NA	LC	B	Yes	distant
		Sooty Shearwater	*Ardenna grisea*	Frequent and Abundant	NA	NT	B	Yes	distant
		Great Shearwater	*Ardenna gravis*	Frequent and Abundant	NA	LC	B	Yes	distant
		Manx Shearwater	*Puffinus puffinus*	Frequent	NA	LC	B	Yes	distant
		Little Shearwater	*Puffinus assimilis*	Frequent	IC	LC	B	Yes	distant
	Hydrobatidae	White-bellied Storm Petrel	*Fregetta grallaria*	Frequent	NA(oc)	LC	NB	No	distant

Order	Family	Common name	Scientific name	Presence	CAT-AR 2015 [1]	UICN-2020 [2]	Hearing Sensitivity	Probability of Collision / Snagging	Colonies
		Black-bellied Storm Petrel	*Fregetta tropica*	Frequent	NA	LC	NB	No	distant
		Wilson´Storm Petrel	*Oceanites oceanicus*	Frequent and Abundant	NA	LC	NB	No	distant
		White-faced Storm Petrel	*Pelagodroma marina*	Frequent	NA(oc)	LC	NB	No	distant
Pelecaniformes	Pelecanoididae	Common diving Petrel	*Pelecanoides urinatrix*	Unconfirmed presence	NA	LC	B	No	distant
Charadriformes	Stercorariidae	Chilean Skua	*Stercorarius chilensis*	Frequent	EN	LC	NB	Yes	distant
		Brown Skua	*Catharacta antárctica (=Stercorarius antarcticus)*	Frequent	VU	LC	NB	Yes	distant
		South Polar Skua	*Catharacta maccormicki*	Frequent	AM	LC	NB	Yes	distant
		Great Skua	*Catharacta pomarinus*	Frequent	NA(oc)	LC	NB	Yes	distant
		Arctic Skua	*Stercorarius parasiticus*	Frequent	NA	LC	NB	Yes	distant
		Long-tailed Skua	*Stercorarius longicaudus*	Frequent	NA	LC	NB	Yes	distant
	Laridae	Arctic Tern	*Sterna paradisaea*	Frequent	NA	LC	NB	Yes	distant
		Antarctic Tern	*Sterna vittata*	Frequent	NA	LC	NB	Yes	distant

[1] Res. MADS 795/17 Ref. Wild Fauna - Categorization of the Conservation Status of Native Birds 2015. 13/11/2017 (BO 14/11/2017). EP endangered, A threatened, V vulnerable, NA not threatened, NA (oc) not threatened because it occurs occasionally, IC insufficiently known. (https://avesargentinas.org.ar/sites/default/files/Categorizacion-de-aves-de-la-Argentina.pdf)

[2] IUCN (International Union for Conservation of Nature and Natural Resources) 2020-1: Red List of Endangered Species (www.iucnredlist.org): CR Critically Endangered, EN Endangered, VU Vulnerable, NT Near Threatened or Low Risk, LC Least Concern (Not Threatened).

Table 14. Assessment of criteria used to determine potential sensitivity.

Criterion	Score
Presence	
Unconfirmed records	1
Frequent	2
Frequent and abundant	3
Conservation value	
NA / LC	1
NT / VU	2
CR / EP / EN / A	3
Auditory Sensitivity	
Non-divers (P)	1
Shallow divers (B)	2
Deep divers (NB)	3
Probability of Collision / Snagging	
Low	0
High	1
Presence of Colonies	
Distant	0
Close	2

Based on this matrix, a Potential Sensitivity Indicator (PSI) called "relative sum" was determined, which was expressed as:

$$\text{ISP or Relative Sum} = Sj / fmax$$

Sj is the score for j species that results from adding the individual scores for each criterion that affects sensitivity, and fmax represents the maximum possible values that can negatively affect sensitivity.

In the case of birds, this value can vary between 0,25 and 1 (the minimum value it can take is 3 y and the maximum 12, so the normalized sum divides by 12).

Applying intervals similar to the possible range of the Relative Sensitivity Index, which in this case corresponded to the use of tertiles, the cut-off points would be 0.5 and 0.75.

However, it was decided to decrease the lower limit to 0.3, since it was established that in order to be considered of low sensitivity a species should meet the following requirements:

- The presence should only be informed through global distribution maps
- Have a conservation status considered of Least Concern or Not Threatened
- Not be divers, presenting less hearing sensitivity
- Not be at risk of collision
- Do not present close colonies

Therefore, the rest of the classifications are rated as moderate or high sensitivity.

Based on the relative sum (PSI) of the criteria represented in this matrix, the sensitivity of the species was classified as low (less than 0.3), moderate (between 0.3 and 0.7) and high (greater than 0,7).

Relative Sum (ISP)	Sensitivity
< 0,3	low
≥ 0,3 y ≤ 0,7	moderate
> 0,7	high

Table 15. Criteria Score

Order	Family	Common name	Scientific name	Presence	Conservation Value	Auditory Sensitivity	Probability of Collision / Snagging	Colonies	Relative Sum
Sphenisciformes	Spheniscidae	King Penguin	*Aptenodytes patagonicus*	2	1	3	0	0	0,50
		Emperor Penguin	*Aptenodytes forsteri*	1	2	3	0	0	0,50
		Chinstrap Penguin	*Pygoscelis antarcticus*	1	2	3	0	0	0,50
		Magellanic Penguin	*Spheniscus magellanicus*	3	2	3	0	0	0,67
		Macaroni Penguin	*Eudyptes chrysolophus*	2	3	3	0	0	0,67
		Rockhopper Penguin	*Eudyptes chrysocome*	2	3	3	0	0	0,67
Procellariiformes	Diomedeidae	Royal Albatross	*Diomedea epomophora*	2	2	1	1	0	0,50
		Northern Royal Albatross	*Diomedea sanfordi*	2	3	1	1	0	0,58
		Wandering Albatross	*Diomedea exulans*	3	3	1	1	0	0,67
		Tristan ALbatross	*Diomedea dabbenena*	2	3	1	1	0	0,58
		Sooty Albatross	*Phoebetria fusca*	3	3	1	1	0	0,67
		Light-mantled Albatross	*Phoebetria palpebrata*	2	2	1	1	0	0,50
		Yellow-nosed Albatross	*Thalassarche chlororhynchos*	3	3	1	1	0	0,67
		Black-browed Albatross	*Thalassarche melanophris*	3	2	1	1	0	0,58
		Grey-headed Albatross	*Thalassarche chrysostoma*	2	3	1	1	0	0,58
		Shy Albatross	*Thalassarche cauta*	2	2	1	1	0	0,50
		White-capped Albatross	*Thalassarche steadi*	2	2	1	1	0	0,50
	Procelariidae	Common Giant Petrel	*Macronectes giganteus*	3	2	1	1	0	0,58
		Hall´s Giant Petrel	*Macronectes halli*	3	1	1	1	0	0,50
		Southern Fulmar	*Fulmarus glacialoides*	2	1	1	1	0	0,42
		Pintado Petrel	*Daption capense*	2	1	1	1	0	0,42
		Soft-plumaged Petrel	*Pterodroma mollis*	2	1	1	1	0	0,42
		Atlantic Petrel	*Pterodroma incerta*	3	3	1	1	0	0,67
		White-headed Petrel	*Pterodroma lessonii*	2	1	1	1	0	0,42
		Trinidade Petrel	*Pterodroma arminjoniana*	2	2	1	1	0	0,50
		Blue Petrel	*Halobaena caerulea*	2	1	1	1	0	0,42
		Antarctic Prion	*Pachyptila desolata*	2	1	1	1	0	0,42
		Slender-billed Prion	*Pachyptila belcheri*	2	2	1	1	0	0,50
		Grey Petrel	*Procellaria cinerea*	2	2	2	1	0	0,58
		White-chinned Petrel	*Procellaria aequinoctialis*	3	3	2	1	0	0,75
		Large Shearwater	*Calonectris borealis*	2	1	2	1	0	0,50
		Cory´s Shearwater	*Calonectris diomedea*	2	1	2	1	0	0,50
		Sooty Shearwater	*Ardenna grisea*	3	2	2	1	0	0,67
		Great Shearwater	*Ardenna gravis*	3	1	2	1	0	0,58
		Manx Shearwater	*Puffinus puffinus*	2	1	2	1	0	0,50
		Little Shearwater	*Puffinus assimilis*	2	1	2	1	0	0,50
	Hydrobatidae	White-bellied Storm Petrel	*Fregetta grallaria*	2	1	1	0	0	0,33
		Black-bellied Storm Petrel	*Fregetta tropica*	2	1	1	0	0	0,33
		Wilson´s Storm Petrel	*Oceanites oceanicus*	3	1	1	0	0	0,42
		White-faced Storm Petrel	*Pelagodroma marina*	2	1	1	0	0	0,33
Pelecaniformes	Pelecanoididae	Common Diving Petrel	*Pelecanoides urinatrix*	1	1	2	0	0	0,33

Order	Family	Common name	Scientific name	Presence	Conservation Value	Auditory Sensitivity	Probability of Collision / Snagging	Colonies	Relative Sum
Charadriformes	Stercorariidae	Chilean Skua	*Stercorarius chilensis*	2	3	1	1	0	0,58
		Brown Skua	*Catharacta antárctica (=Stercorarius antarcticus)*	2	2	1	1	0	0,50
		South Polar Skua	*Catharacta maccormicki*	2	3	1	1	0	0,58
		Great Skua	*Catharacta pomarinus*	2	1	1	1	0	0,42
		Arctic Skua	*Stercorarius parasiticus*	2	1	1	1	0	0,42
		Long-tailes Skua	*Stercorarius longicaudus*	2	1	1	1	0	0,42
	Laridae	Arctic Tern	*Sterna paradisaea*	2	1	1	1	0	0,42
		Antarctic Tern	*Sterna vittata*	2	1	1	1	0	0,42

Deep divers (P). They include all species present in the Sphenisciformes order. They are benthic predators that dive less than 50 m deep but can exceed 150 m, and the food is eaten completely under water as a distinctive feature. This characteristic gives them a special sensitivity toward the project.

During the breeding season, they can move away more than 100 km from the colonies in the daily feeding trips. Pichegru et al. (2017) studied the behavioral responses of the African penguin (*Spheniscus demersus*), before, during and after 2D seismic surveys, observing that the penguins showed strong evasion behavior from their usual foraging areas during seismic activity, feeding significantly further from the seismic ship while in operation.

The sensitivity in the study area for the 6 penguin species with potential presence in the area was classified as moderate. The Patagonian penguin is the most frequent species identified in the area. All species are under some category of threat and have legal protection, except for the King Penguin. They may be present in the project's area of influence during their autumn migrations north of the confluence area and also when returning to their breeding colonies in late winter. They have escaping, diving and swimming abilities to move away from the source of disturbance.

Shallow divers (B). This group is made up of shearwaters and diving petrels, which are medium and small sized Procellariiformes. A significant portion of their time is spent underwater chasing their prey. The species of the group are characterized by presenting diving in hours of low light. They typically dive in open water in a superficial way, between 2 to 5 m, and can reach up to 15-20 m with numerous and short dives. In this way, although not as much as the previous group, this group can also be affected by the sound waves that are generated during seismic activities.

The species in this group were broadly classified as moderately sensitive, because they are frequent divers in the area, although at shallower depths than penguins, and because they follow ships and may be subject to collision or snagging.

The B group is represented mainly by the white-chinned petrel, the sooty shearwater and the great shearwater, which are among the most abundant species in the area. These species dive shallowly to catch their food among tuna and squid shoals. It is important to highlight the situation of the white-bearded petrel, which, in addition to being abundant, faces a high degree of threat. Hence, their sensitivity to the project is considered high during the warmer months (Table 16). This species is considered as Threatened at the local level but Vulnerable at the regional level.

Non-divers (NB). This group consists of medium to large Procellariformes and Charadriformes. They are superficial diving predators that feed on the surface (0-1 m), or scavengers that eat carcasses and remains left by other species. In general, they are not divers and those who are make short dives that do not exceed 5 m, although some species can reach greater depths. Many species are known to be ship followers. Scavengers take particular advantage of the waste from fishing operations. Individuals can get caught in fishing gear, but also between cables and rigging, when they are attracted by the night lights of the boats.

This group is made up of most of the registered species in the area of influence, with Procellariformes species from the families Diomedeidae (albatrosses), Procellaridae (giant petrels), Hydrobatidae (petrels) and Characiformes from the families Laridae (terns) and Stercoraridae (skuas). Sensitivity was defined as moderate for all species.

The albatrosses are all under both national and international threat categories, as well as many of the petrels, due to the decrease in their populations affected by the bycatch. The most recent studies suggest avoidance, but that may be dependent on the response of their prey.

Although there is no auditory information for groups B and NB, different works carried out by on-board observers during offshore seismic surveys may account for changes in behavior during the sound stage.

According to Favero et al (2005), the specific richness of pelagic birds in the Argentine Sea shows peaks of abundance between May and October reaching coastal waters in some cases. There are many more where the temperature gradient coincides with the slope, as occurs along the northwestern edge of the Malvinas Current. This area exerts a particular attraction on seabirds due to the concentration of planktonic organisms, fish and cephalopods that feed and breed in these waters (Orgeira, 2001).

The following Table summarizes the information on the temporary presence of each species in the project's area of influence. The estimates of temporal abundances in the area are inferred in the interpretation of the breeding cycles, the location of the nesting areas, the feeding behavior during the rearing stage, and that of the published satellite records of both reproductive and non-reproductive individuals, when the time of analysis corresponding to the area of influence of this project is reported. Neither have there been any separations between reproductive and non-reproductive individuals, nor between sexes, which can present highly differential patterns.

Table 16. Periods of greater temporal sensitivity of the species. In dark gray: more often or expected abundance; in light gray: occasional. 1-12 correspond to the months of the year.

Scientific name	Common name	Presence	1	2	3	4	5	6	7	8	9	10	11	12	References
Aptenodytes patagonicus	King Penguin	2													Barquete et al 2006, Kylin 2013
Aptenodytes forsteri	Emperor Penguin	1													No data
Pygoscelis antarcticus	Chinstrap Penguin	1													No data
Spheniscus magellanicus	Magellanic Penguin	3													Atlas of the Patagonian Sea, OBIS, Barquete et al 2006
Eudyptes chrysolophus	Macaroni Penguin	2													Veit 1995, Sick 1997, Barquete et al 2006
Eudyptes chrysocome	Rockhopper Penguin	2													Putz et al 2002, Costa2016, Veit 1995, Barquete et al 2006
Diomedea epomophora	Royal Albatross	2													OBIS, Seabird tracking database
Diomedea sanfordi	Northern Roayal Albatross	2													OBIS, Seabird tracking database, Atlas of the Patagonian Sea
Diomedea exulans	Wandering Albatross	3													OBIS, Seabird tracking database, Atlas of the Patagonian Sea
Diomedea dabbenena	Tristan Albatross	2													OBIS, Seabird tracking database
Phoebetria fusca	Sooty ALbatross	3													OBIS, Seabird tracking database
Phoebetria palpebrata	Light-mantled Albatross	2													OBIS, Seabird tracking database, Atlas of the Patagonian Sea
Thalassarche chlororhynchos	Yellow-nosed Albatross	3													OBIS, Kylin 2013
Thalassarche melanophris	Black-browed Albatross	3													OBIS, Atlas of the Patagonian Sea, Carneiro et al 2020, Copello et al 2013, Orgeira 2001
Thalassarche chrysostoma	Grey-headed ALbatross	2													OBIS, Atlas of the Patagonian Sea, Clay et al 2016
Thalassarche cauta	Shy Albatross	2													Savigny and Carbajal 2015, Seco Pon and Tamini 2013, ACAP
Thalassarche steadi	White-capped Albatross	2													Savigny andCarbajal 2015, Seco Pon and Tamini 2013
Macronectes giganteus	Common Giant Petrel	3													OBIS, Quintana et al 2005, Atlas del Mar Patagónico
Macronectes halli	Hall´s Giant Petrel	3													OBIS, Atlas of the Patagonian Sea
Fulmarus glacialoides	Southern Fulmar	2													Seabird tracking database, Kylin 2013
Daption capense	Pintado Petrel	2													Seabird tracking database, Kylin 2013
Pterodroma mollis	Soft-plumaged Petrel	2													OBIS, Ramos et al 2017
Pterodroma incerta	Atlantic Petrel	3													OBIS, Veit 1995, Orgeira 2001, Pastor-Prieto et al, 2019, Ramos et al 2017
Pterodroma arminjoniana	Trinidade Petrel	2													Ramos et al 2017, Krüger et al 2016, Savigny et al 2005, GBIF.
Halobaena caerulea	Blue Petrel	2													Quillfeldt et al 2017
Pachyptila desolata	Antarctic Prion	2													OBIS, Navarro et al 2015, Quillfeldt et al 2013,Quillfeldt et al 2017
Pachyptila belcheri	Slender-billed Prion	2													OBIS, Kylin 2013,Quillfeldt et al 2017
Procellaria cinerea	Grey Petrel	2													OBIS, Orgeira 2001

Scientific name	Common name	Presence	1	2	3	4	5	6	7	8	9	10	11	12	References
Procellaria aequinoctialis	White-chinned Petrel	3													OBIS; Atlas of the Patagonian Sea
Calonectris borealis	Large Shearwater	2													Ramos et al., 2019
Calonectris diomedea	Cory´s Shearwater	2													OBIS; Veit, 1995
Ardenna grisea	Sooty Shearwater	3													OBIS; Veit, 1995; Seabird tracking database
Ardenna gravis	Great Shearwater	3													OBIS;Seabird tracking database
Puffinus puffinus	Manx Shearwater	2													OBIS; Seabird tracking database
Puffinus assimilis	Little Shearwater	2													OBIS
Fregetta grallaria	White-bellied Storm Petrel	2													Kylin, 2013; Orgeira, 2001
Fregetta tropica	Black-bellied Storm Petrel	2													Kylin 2013
Oceanites oceanicus	Wilson´s Storm Petrel	3													OBIS; Quillfeldt et al., 2015; Veit, 1995
Pelagodroma marina	White-faced Storm Petrel	2													Olney and Scofield, 2010; Montalti and Orgeira, 1997; Veit 1988; Kylin 2013
Pelecanoides urinatrix	Common Diving Petrel	1													Fromant et al., 2020
Catharacta chilensis	Chilean Skua	2													Tagging data
Catharacta antárctica	Brown Skua	2													OBIS; Phillips et al., 2007
Catharacta maccormicki	South Polar Skua	2													Kopp et al., 2011; Kylin, 2013, Weimerskirch et al., 2015
Catharacta pomarinus	Great Skua	2													Kylin, 2013
Stercorarius parasiticus	Arctic Skua	2													Gilg et al., 2013; Kylin, 2013
Stercorarius longicaudus	Long-tailed Skua	2													Gilg et al., 2013; Veit, 1985; Kylin, 2013
Sterna paradisaea	Arctic Tern	2													OBIS, Egevang et al., 2010; Hromádková et al., 2020; Seabird tracking database
Sterna vittata	Antarctic Tern	2													Sterna vittata https://www.freebirds.com.ar/315.htm
															time of greatest observation of albatrosses in this area according to Domingo et al., 2017

According to the bibliography surveyed, the project area is a very important feeding area throughout the year as well as a transit zone for inter-hemispheric migrants. However, the species do not breed in the high seas, having their nesting and breeding sites hundreds or thousands of kilometers from their feeding areas. In this sense, it is concluded that this group presents an average sensitivity throughout the year for the area of operation and direct influence of the project, becoming more important in the sector of the face of the slope (which is located 30 km from the prospecting areas and 17 km from the area of direct influence).

Although Favero et al (2005) identify that the specific richness of pelagic birds in the Argentine Sea shows abundance peaks generally observed between May and October, and the data of non-reproductive juvenile and adult tagged individuals show that they may also be present in other periods. In the case of penguins, the identified species may be present in the study area during their autumn migrations north of the confluence area and also when returning to their breeding colonies in late winter.

1.3.6 Marine Mammals

Fourty-one (41) potentially present species were counted for the detailed study area, with confirmed occurrences for only 13 of them. Four species of Pinnipeds (Carnivora) have been recorded: the South American Fur Seal (*Arctocephalus australis*), the Antarctic fur seal (*Arctocephalus gazella*), the South American Sea lion (*Otaria flavescens*) and the southern elephant seal (*Mirounga leonina*). Regarding Cetaceans (Cetartiodactyla), there are recorded occurrences for 4 species of whales - the right whale, the blue whale, the sei whale and the fin whale, 4 species of dolphins - the long-finned pilot whale (Globicephala melas), the bottlenose dolphin (Tursiops truncatus), dusky dolphin (Lagenorhynchus obscurus) and killer whale (Orcinus orca) and sperm whale (Physeter macrocephalus).

Four of the confirmed species in the study area are threatened. For example, the sei, blue and fin whales are endangered (EN) in Argentina, but the fin whale is only vulnerable (VU) at a global scale (IUCN). The sperm whale is vulnerable in both categories, while the bottlenose dolphin is vulnerable for Argentina, but it is not threatened globally. Although it has a low probability of presence in the area of influence, the sei whale (*Balaenoptera borealis*) stands out, as it is considered endangered by both names.

Next, the sensitivity of the mammal species present in the project's area of influence is analyzed. As a starting point for the sensitivity analysis, 3 key criteria were considered to understand the sensitivity of the species to the project:

- Presence
- Conservation status
- Auditory Sensitivity

The abovementioned criteria were considered equally important, and they had to be evaluated with the same assessment scale, which was defined between 1 and 3. In no case was a null assessment considered, since the sole identification gives it an estimation.

Then, 1 additional criterion of relevance was added to this particular group:

- Breeding or Reproduction Area

The null assessment was considered for this case.

Presence categories

As mentioned in Chapter 5, a list of probable marine mammal species for the project's area of influence was drawn up from the global or regional distribution maps present in field guides, web pages and reference books (see details of sources consulted in Point 4.3.4.1 of Chapter 5). The presence of these species was confirmed by consulting open databases of georeferenced occurrences and recent publications.

Based on this information, the following presence categories were drawn up.

1 Species only reported through global distribution maps.
2 Species for which there are between 1 to 5 publications giving data on its occurrence
3 More than 5 publications with data on the species occurrence and / or estimates of abundance or more frequent times.

Conservation status categories

Both the national and international assessment were considered to evaluate the conservation status (see details of sources consulted in Point 4.3.4.2 of Chapter 5). Although the diagrams are equivalent in terms of the definition of the categories, the species do not necessarily match their categorization. Considering this situation, it was decided to adopt the most conservative one, assigning the highest valuation according to the following description:

1 Species of least concern or not threatened (LC – NT)
2 It is considered vulnerable or near threatened (VU – NT)
3 The species is under one of the most critical extinction threat categories (CR / EN / NT / T)

Certain species have been classified as Data Deficient in both assessments. In all cases, they were species contained in the analysis since the study area was included within its general distribution range, but no specific reports were found for that area. In this sense, it was given the lowest valuation.

The highest rating was given to the Southern right whale as it is considered a natural monument.

Categories of Auditory Sensitivity

Marine mammals depend on sound to communicate, locate prey, avoid predators, and obtain information about their environment (Richardson et al., 1995, Tyack, 2008). The knowledge on the effects of anthropogenic sound on marine mammals, particularly those of seismic prospecting, has been summarized in numerous works, such as Southall et al., 2019, the NMFS (2018), and the CMS (Prideaux, 2016), Finneran reviews (2015), Southall et al., 2007, and Erbe et al (2016). Most of the statements presented below are based on these documents, with additional references to the species present in the project's area of influence.
Species are grouped based on their audible frequency range (known or suspected), auditory sensitivity, ear anatomy, and acoustic ecology (i.e., how they use sound). The groups considered here are based on the publication by Southall et al. (2007) updated with more recent information from Southall et al., 2019. The descriptions of each group are mostly taken from NMFS (2018) and

Finneran (2016), where more complete descriptions of the hearing mechanisms, generalized audiograms and filter functions are presented to evaluate how these groups would perceive a given anthropogenic sound.

The acronyms for cetaceans follow the English designations from the work of Southall et al. (2019), but those of NMFS (2018) have been maintained for carnivores. Table 17 presents the auditory groups with their generalized ranges of hearing and the corresponding species or taxa that are present in the area of influence.

Table 17. Auditory groups with their hearing ranges and member species. Source: modified from Southall et al. (2019) and NMFS (2018), Melcon et al. (2019), with assignment of the corresponding species according to those present in the study area.

Code	Group	General auditory range	Present taxa, members of the group
LF	Low-frequency cetaceans	7 Hz to 35 kHz	Balaenidae family (southern right whale) Balaenopteridae family (whales, fin, blue)
			Familia Balaenopteridae (ballenas minke, sei, Family Neobalaenidae (pygmy sperm whale)
HF	High frequency cetaceans	150 Hz to 160 kHz	Family Ziphiidae (Arnoux, Gray, Hector, Layard, Sheperd, Cuvier, southern bottlenose whales) Family Physeteridae (sperm whale) Family Delphinidae (Killer whale)
			Family Delphinidae (common, Risso's, Fraser's, Sheperd's, pantropical spotted, striped, bottlenose, southern right whale dolphin, dusky, pilot whale, pygmy killer whale, false killer whale)
VHF	Very high frequency cetaceans	275 Hz to 160 kHz	Family Phocoenidae (spectacled porpoise, spiny porpoise) Family Kogiidae (pygmy sperm whale, dwarf sperm whale) Family Delphinidae, species of the Cephalorhynchus genus (Commerson´s dolphin) and Lagenorhynchus (southern dolphin and Hourglass dolphin)
PW	Focid Carnivores	50 Hz to 86 kHz	Phocidae family (leopard, Weddell, crabeater, southern elephant seal)
			Phocidae family (Ross seal)
PO	Pinniped Otarida and other carnivores	60 Hz to 39 kHz	Familia Otariidae (Family Otariidae (subantarctic fur seals, Antarctic fur seal, one-haired fur seal) .

In this way, the valuation was assigned based on the groups that could be affected to a greater or lesser extent by the project, considering that the most significant effects would be in the species of mammals whose auditory range could overlap with the main range of the project. As indicated in Chapter 4, the maximum emissions from the compressed air power source occur between approximately 5 Hz and 100 Hz in frequency, then the maximum values steadily decay at an approximate rate of 4.5 dB. every 100 Hz.

1 No Overlap
3 With Overlap

Breeding or Reproduction Zone Criterion

0 Does not breed in the area
1 With breeding records in the area
2 Breeds in the area

The highest score was assigned to those species for which information was not available.

Table 18. Criteria analysis for the sensitivity analysis of the mammal species present in the project's area of influence.

Family	Scientific name	Common name	Presence	CatAr-2019[a]	UICN-2020-1[b]	Overlap with Project Main Frequency Range	Breeding
Otaridae	*Arctocephalus australis*	South American fur seal	Frequent and abundant	LC	LC	PO (with overlap)	Does not breed in the area
	Arctocephalus gazella	Antarctic Fur seal	Frequent and abundant	LC	LC	PO (with overlap)	Does not breed in the area
	Arctocephalus tropicalis	Subantarctic Fur seal	Unconfirmed presence	LC	LC	PO (with overlap)	Does not breed in the area
	Otaria flavescens	South American sea lion	Frequent	LC	LC	PO (with overlap)	Does not breed in the area
Phocidae	*Hydrurga leptonyx*	Leopard seal	Unconfirmed presence	LC	LC	PW (with overlap)	Does not breed in the area
	Leptonychotes weddellii	Weddell seal	Unconfirmed presence	LC	LC	PW (with overlap)	Does not breed in the area
	Lobodon carcinophaga	Crabeater seal	Unconfirmed presence	LC	LC	PW (with overlap)	Does not breed in the area
	Mirounga leonina	SOuthern Elephant seal	Frequent and abundant	LC	LC	PW (with overlap)	Does not breed in the area
Balaenidae	*Eubalaena australis*	Southern right whale	Frequent and abundant	LC	LC	LF (with overlap)	Does not breed in the area
Balaenopteridae	*Balaenoptera acutorostrata*	Northern Minke whale	Unconfirmed presence	DD	LC	LF (with overlap)	Does not breed in the area
	Balaenoptera bonaerensis	Antarctic Minke whale	Unconfirmed presence	DD	NT	LF (with overlap)	Does not breed in the area
	Balaenoptera borealis	Sei whale	Frequent	EN	EN	LF (with overlap)	Does not breed in the area
	Balaenoptera edeni	Eden´s whale	Unconfirmed presence	DD	LC	LF (with overlap)	Does not breed in the area
	Balaenoptera musculus	Blue whale	Frequent	EN	EN	LF (with overlap)	Does not breed in the area
	Balaenoptera physalus	Fin whale	Frequent	EN	VU	LF (with overlap)	Does not breed in the area
	Megaptera novaeangliae	Humpback whale	Frequent	LC	LC	LF (with overlap)	Does not breed in the area
Neobalaenidae	*Caperea marginata*	Pygmy right whale	Unconfirmed presence	DD	LC	LF (with overlap)	Does not breed in the area
Delphinidae	*Delphinus delphis*	Common dolphin	Unconfirmed presence	LC	LC	HF (without overlap)	No data on breeding
	Feresa attenuata	Pygmy killer whale	Unconfirmed presence	NA	LC	HF (without overlap)	No data on breeding
	Globicephala melas	Long-finned pilot whale	Frequent	LC	LC	HF (without overlap)	No data on breeding
	Grampus griseus	Risso´s dolphin	Unconfirmed presence	LC	LC	HF (without overlap)	No data on breeding
	Lagenorhynchus australis	Peale´s dolphin	Unconfirmed presence	LC	LC	VHF (without overlap)	No data on breeding
	Lagenodelphis hosei	Fraser´s dolphin	Unconfirmed presence	DD	LC	HF (without overlap)	No data on breeding
	Lagenorhynchus cruciger	Hourglass dolphin	Unconfirmed presence	DD	LC	VHF (without overlap)	No data on breeding
	Lagenorhynchus obscurus	Dusky dolphin	Frequent	LC	LC	VHF (without overlap)	No data on breeding
	Lissodelphis peronii	Southern right whale dolphin	Unconfirmed presence	DD	LC	HF (without overlap)	No data on breeding
	Orcinus orca	Kller whale	Frequent	LC	DD	HF (without overlap)	No data on breeding
	Pseudorca crassidens	False killer whale	Unconfirmed presence	DD	NT	HF (without overlap)	No data on breeding
	Stenella attenuata	Pantropical spotted dolphin	Unconfirmed presence	NA	DD	HF (without overlap)	No data on breeding
	Stenella coeruleoalba	Striped dolphin	Unconfirmed presence	LC	LC	HF (without overlap)	No data on breeding
	Tursiops truncatus	Bottlenose dolphin	Frequent	VU[c]	LC	HF (without overlap)	No data on breeding
Ziphidae	*Berardius arnuxii*	Arnoux beaked whale	Unconfirmed presence	DD	DD	HF (without overlap)	No data on breeding
	Hyperoodon planifrons	Southern bottlenose whale	Unconfirmed presence	DD	LC	HF (without overlap)	No data on breeding
	Mesoplodon grayi	Gray´s beaked whale	Unconfirmed presence	DD	DD	HF (without overlap)	No data on breeding
	Mesoplodon hectori	Héctor´s beaked whale	Unconfirmed presence	DD	DD	HF (without overlap)	No data on breeding
	Mesoplodon layardii	Strap-toothed whale	Unconfirmed presence	DD	DD	HF (without overlap)	No data on breeding
	Tasmacetus shepherdi	Shepherd´s beaked whale	Unconfirmed presence	DD	DD	HF (without overlap)	No data on breeding

Family	Scientific name	Common name	Presence	CatAr-2019[a]	UICN-2020-1[b]	Overlap with Project Main Frequency Range	Breeding
	Ziphius cavirostris	Cuvier´s beaked whale	Unconfirmed presence	DD	LC	HF (without overlap)	No data on breeding
Kogidae	*Kogia breviceps*	Pygmy sperm whale	Unconfirmed presence	DD	DD	VHF (without overlap)	No data on breeding
	Kogia sima	Dwarf sperm whale	Unconfirmed presence	NA	DD	VHF (without overlap)	No data on breeding
Physeteridae	*Physeter macrocephalus*	Sperm whale	Frequent and Abundant	VU	VU	HF (without overlap)	Does not breed in the area

[a] Categorization of Mammals in Argentina according to their Extinction Risk - 2019 (CAT-Ar) (http://cma.sarem.org.ar/es/especies-nativas) : CR critically endangered, EN en peligro, VU vulnerable, LC preocupación menor NA no amenazada, DD Datos Insuficientes.

[b] UICN (International Union for Conservation of Nature and Natural Resources) 2020-1: Lista Roja de Especies Amenazadas de Extinción (www.iucnredlist.org): CR en peligro crítico, EN endangered, VU vulnerable, NT near threatened or low risk, LC least concern (not threatened), DD Data deficient.

[c] Two populations of *Tursiops truncatus* would co-occur in Argentine waters.: *T. t. gephyreus* corresponds to the population present in Bahía San Antonio, Río Negro and has EN category, which differs genetically from *T. t. truncatus* that forms the populations of Uruguay and southern Brazil and for which there is no information to categorize it (DD).

Table 19. Assessment of criteria used to determine potential sensitivity.

Criterion	Score
Presence	
Unconfirmed records	1
Frequent	2
Frequent and abundant	3
Conservation value	
NE, DD, LC	1
NT - VU	2
EN - CR - Heritage	3
Auditory Sensitivity	
No overlap	1
With overlap	3
Breeding	
Does not breed in the area	0
With breeding records in the area	1
Breeds in the area	2

Based on this matrix, a Potential Sensitivity Indicator (PSI) called "relative sum" was determined, which was expressed as:

$$\text{ISP or Relative Sum} = Sj / fmax$$

Sj is the score for **j** species that results from adding the individual scores for each criterion that affects sensitivity, and **fmax** represents the maximum possible values that can negatively affect sensitivity.

In the case of seabirds, this value can vary between 0,27 and 1 (the minimum value it can take is 3 y and the maximum 11, so the normalized sum divides by 11).

Applying intervals similar to the possible range of the Relative Sensitivity Index, which in this case corresponded to the use of tertiles, the cut-off points would be 0.5 and 0.75.

However, it was decided to decrease the lower limit to 0.3, since it was established that in order to be considered of low sensitivity a species should meet the following requirements:

- The presence should only be informed through global distribution maps
- The conservation status should be considered of Least Concern or Not Threatened
- Its hearing range should not overlap with the main presence range
- The project area should not overlap with a breeding area

Hence, the rest of the classifications are rated as moderate or high sensitivity.

Based on the relative sum (ISP) of the criteria represented in this matrix, the sensitivity of the species was classified as low (less than 0.3), moderate (between 0.3 and 0.7) and high (greater than 0,7).

Relative sum (ISP)	Sensitivity
< 0,3	low
≥ 0,3 y ≤ 0,7	moderate
> 0,7	high

Table 20. Criteria Score.

Order	Family	Scientific name	Common name	Presence	Conservation value	Overlap with Project Main Frequency Range	Breeding	Relative Sum
Carnivora	Otaridae	*Arctocephalus australis*	South American Fur Seal	3	1	3	0	0,64
		Arctocephalus gazella	Antarctic Fur seal	3	1	3	0	0,64
		Arctocephalus tropicalis	Subantarctic Fur seal	1	1	3	0	0,45
		Otaria flavescens	South American sea lion	2	1	3	0	0,55
	Phocidae	*Hydrurga leptonyx*	Leopard seal	1	1	3	0	0,45
		Leptonychotes weddellii	Weddell seal	1	1	3	0	0,45
		Lobodon carcinophaga	Crabeater seal	1	1	3	0	0,45
		Mirounga leonina	Southern elephant seal	3	1	3	0	0,64
Cetartiodactyla	Balaenidae	*Eubalaena australis*	Southern right whale	3	3	3	0	0,82
	Balaenopteridae	*Balaenoptera acutorostrata*	Northern Minke whale	1	1	3	0	0,45
		Balaenoptera bonaerensis	Antarctic Minke whale	1	2	3	0	0,55
		Balaenoptera borealis	Sei whale	2	3	3	0	0,73
		Balaenoptera edeni	Eden´s whale	1	1	3	0	0,45
		Balaenoptera musculus	Blue whale	2	3	3	0	0,73
		Balaenoptera physalus	Fin whale	2	3	3	0	0,73
		Megaptera novaeangliae	Humpback whale	2	1	3	0	0,55
	Neobalaenidae	*Caperea marginata*	Pygmy right whale	1	1	3	0	0,45
	Delphinidae	*Delphinus delphis*	Common dolphin	1	1	1	2	0,45
		Feresa attenuata	Pygmy killer whale	1	1	1	2	0,45
		Globicephala melas	Long-finned pilot whale	2	1	1	2	0,55
		Grampus griseus	Risso´s dolphin	1	1	1	2	0,45
		Lagenorhynchus australis	Peale´s dolphin	1	1	1	2	0,45
		Lagenodelphis hosei	Fraser´s dolphin	1	1	1	2	0,45
		Lagenorhynchus cruciger	Hourglass dolphin	1	1	1	2	0,45
		Lagenorhynchus obscurus	Dusky dolphin	2	1	1	2	0,55
		Lissodelphis peronii	Delfín liso austral	1	1	1	2	0,45
		Orcinus orca	Orca	2	1	1	2	0,55
		Pseudorca crassidens	False killer whale	1	2	1	2	0,55
		Stenella attenuata	Pantropical spotted dolphin	1	1	1	2	0,45
		Stenella coeruleoalba	Striped dolphin	1	1	1	2	0,45
		Tursiops truncatus	Bottlenose dolphin	2	2	1	2	0,64
	Ziphidae	*Berardius arnuxii*	Arnoux´s beaked whale	1	1	1	2	0,45
		Hyperoodon planifrons	Southern bottlenose whale	1	1	1	2	0,45
		Mesoplodon grayi	Gray´s beaked whale	1	2	1	2	0,55
		Mesoplodon hectori	Hector´s beaked whale	1	1	1	2	0,45
		Mesoplodon layardii	Strap-toothed whale	1	1	1	2	0,45
		Tasmacetus shepherdi	Shepherd´s beaked whale	1	1	1	2	0,45
		Ziphius cavirostris	Cuvier´s beaked whale	1	1	1	2	0,45
	Kogidae	*Kogia breviceps*	Pygmy sperm whale	1	1	1	2	0,45
		Kogia sima	Dwarf sperm whale	1	1	1	2	0,45
	Physeteridae	*Physeter macrocephalus*	Sperm whale	3	2	1	0	0,55

Low-frequency cetaceans (LF). This group contains all the cetaceans of the Mysticeti order (whales, baleen whales). Although no direct measurements of hearing sensitivity have been made in any individual in the group, an audible frequency range of approximately 10 Hz to 30 kHz has been estimated from the recorded vocalization frequencies, the observed reactions to the reproduction of sounds, anatomical analyzes of the auditory system and modeling, also considering taxonomic variations. There may be a natural division within the mysticetes, with some species having better sensitivity to low frequencies such as the blue whale or fin whale, and others having better sensitivity to higher frequencies, such as the humpback or minke whale; however, there is not yet enough knowledge to justify the separation into more groups. Different models indicate that the best range of frequencies for hearing would be found above the lower limit of their vocalization frequencies.

This group presents a moderate to high sensitivity to the project, mainly due to the fact that the estimated hearing range overlaps with the main frequency range of the proposed seismic activity.

The southern right whale is the most frequent in the study area, which is an important feeding site for other whale species as well. All species are legally protected. It is not a breeding area for the southern right whale. Although it is unknown if it is so for other species, known references do not identify it as such.

Regarding the species classified as high sensitivity, it is important to mention that the right whale received the highest conservation assessment because it is a World Heritage Species, although it presents less concern both in Argentina and internationally. Considering this situation, the sensitivity would be classified as moderate. The other 3 species of whales classified as highly sensitive do show conservation problems. However, they are not considered abundant in the analyzed sector.

Several studies have shown that acute exposure to noise at close range generates spatial displacements, which generally persist as long as the noise is maintained (Southall et al., 2007). Migration studies indicate that they respond actively to noise by deviating, but without significant changes in the migration route (Dunlop et al., 2013). Therefore, the feeding habitats and the breeding season are key aspects to evaluate the noise impact at the population level.

High frequency cetaceans (HF). This group is characterized by complex sound production and the production of different types of clicks for echolocation of their prey (clicks BBHF, FM y MP, Fenton et al., 2014). This group of cetaceans includes most of the species of the Delphinidae families (such as the common dolphin, the pilot dolphin, killer whale), the Ziphidae family (e.g. Hector's beaked whale) and the Physiteridae family (sperm whale). Auditory sensitivity has been directly measured for a number of species within this group using psychophysical (behavioral) or auditory evocation potential (AEP) measurements).

This group displays a moderate sensitivity to the project, mainly due to the fact that its estimated hearing range does not overlap with the main frequency range of the proposed seismic activity.

Although there are many probable species for the study area, only five are considered frequent: the killer whale, the dusky dolphin, the pilot dolphin, the sperm whale and the bottlenose dolphin. The sperm whale is the most abundant. For the HF group species typical of offshore habitats, measurements of displacements and some indirect measurements of disturbances have been made, such as changes in the behavior of vocalizations in beaked whales, Atlantic spotted dolphins and striped dolphins (Castellote, 2017). Sperm whales chronically exposed to seismic surveys in the Gulf of Mexico did not show avoidance behavior, but reduced their movement and feeding speed (Miller et al., 2009).

While the breeding areas of these species are largely unknown, some generalizations can be made for some of them. Sperm whale distribution is related to topography (Pirotta et al., 2011) and solitary individuals use habitat differently than in groups. The occurrence of oceanic gyres and areas of varied topography such as canyons and seamounts should always be considered as sensitive areas for cetaceans, even if there are no records or they are not abundant. Given that there is no information for the area of influence of the project, the possibility that it is a breeding area for these species was considered, in which case, the assessment made could be overestimated.

Very high frequency cetaceans (VHF). This group carries out vocalizations with very high frequency sound peaks (NBHF-type clicks), different from HF cetaceans. In this group, there are five of the species mentioned for the project's area of influence, the dusky dolphin, the hourglass dolphin, the southern dolphin, the pygmy sperm whale and the dwarf sperm whale, although only the first has a confirmed presence. This group is mostly made up of species that are opportunistic predators, exploiting prey that are seasonally abundant. They can be affected by displacement of the usual areas of action, including staying longer in deep areas.

They generally have a higher upper limit and better sensitivity to high frequencies compared to higher frequency cetacean species. For this reason, the species identified for this group were classified as moderately sensitive, even though the area was defined as a possible breeding site as a precautionary principle.

As regards pinnipeds:

- **Phocid Carnivores in water (PW).** This group contains all the species of carnivores of the Phocidae family, which is characterized by not having auricles (ears) and other anatomical adaptations that give them abilities similar to those of cetaceans to hear sounds in the water. It has a more extended hearing range than other pinnipeds, particularly at the high end. Seals and elephant seals are included in this group. There are underwater hearing thresholds for some Northern Hemisphere species in this group.

- **Otariid pinnipeds and other carnivores (PO).** It includes marine mammals that can hear both in air and in water. This group contains the species of the Otaridae family for our region, (the sea lions) and Mustelidae (the sea otter or chungungo), but also includes the polar bears, walruses and sea lions of the northern hemisphere.

The species of both groups of pinnipeds were classified as moderately sensitive, since, like the whales, the hearing range estimated for this group overlaps with the main frequency range of the proposed seismic activity.

There are 3 species with the highest frequency in the area. The South American fur seal (Arctocephalus australis), the Antarctic fur seal (Arctocephalus gazella) and the southern elephant seal (Mirounga leonine). All classified as Least Concern.

For both groups of pinnipeds, there are documented responses to anthropogenic noise, including hearing threshold shifts, alarm howls, and feeding cessation. The most vulnerable times are during nursing and weaning. Also many pinnipeds show high fidelity to their breeding colonies and their distance may increase the risk of local extinction of the colonies. In this regard, it should be noted that all the colonies are far from the study area.

Table 21 summarizes the information on the temporary presence of each species in the detailed study area. These data are biased to the times for which the sources consulted detail or break down the temporal occurrence. Due to the fact that very few species had strict temporal information for the area of direct influence, studies reporting on records of marine mammals in the area of the slope and the Brazil-Malvinas confluence were analyzed, mostly in Uruguayan and international waters.

Table 21. Periods of greater temporal sensitivity of the species. In dark gray: more often or expected abundance; in light gray: occasional. The species that are not included are those without available information for the area of influence. **The temporality information was completed with data from observations in the south of the Uruguayan common fishing area and in nearby international waters. 1-12: months of the year.

Common Name	Scientific Name	1	2	3	4	5	6	7	8	9	10	11	12
South American Fur seal	*Arctocephalus australis*												
Antarctic Fur seal	*Arctocephalus gazella*												
Subantarctic Fur seal**	*Arctocephalus tropicalis*												
South American sea lion**	*Otaria flavescens*												
Southern elephant seal	*Mirounga leonina*												
Southern right whale	*Eubalaena australis*												
Northern minke whale**	*Balaenoptera acutorostrata*												
Antarctic minke whale**	*Balaenoptera bonaerensis*												
Sei whale **	*Balaenoptera borealis*												
Eden´s whale**	*Balaenoptera edeni*												
Blue whale	*Balaenoptera musculus*												
Fin whale**	*Balaenoptera physalus*												
Humpback whale	*Megaptera novaeangliae*												
Common dolphin**	*Delphinus delphis*												
Long-finned pilot whale**	*Globicephala melas*												
Risso´s dolphin**	*Grampus griseus*												
Fraser´s dolphin**	*Lagenodelphis hosei*												
Dusky dolphin	*Lagenorhynchus obscurus*												
Killer whale**	*Orcinus orca*												
Striped dolphin**	*Stenella coeruleoalba*												
Bottlenose dolphin**	*Tursiops truncatus*												
Héctor´s beaked whale**	*Mesoplodon hectori*												
Pygmy sperm whale**	*Kogia breviceps*												
Dwarf sperm whale**	*Kogia sima*												
Sperm whale**	*Physeter macrocephalus*												

According to the surveyed bibliography, the area of influence would work as a passage area and a feeding area. It is not a breeding area for the more abundant marine mammals. However, this possibility cannot be ruled out for some species with probable presence due to lack of

information.

The sensitivity could be considered moderate throughout the year. In the case of the 4 species of whales classified as highly sensitive, a clear period of greater sensitivity is not identified, but spring could be considered more critical.

1.3.7 Protected and Sensitive Areas

Argentina holds 61 coastal marine protected areas (APCM), including national parks, provincial and municipal reserves, biosphere reserves (MaB) and Ramsar sites. The Legal instruments for the creation of these areas are also diverse: municipal ordinances, provisions, resolutions, decrees and Provincial laws, National laws and, the Provincial Constitution when it comes to Tierra del Fuego. The APCM are registered within the Federal System of Protected Areas (SiFAP).

In relation to the analyzed project, given that CAN_100-108 and CAN_114 seismic data acquisition areas are located more than 300 km from the coastal zone, the interaction with these protected areas is generally irrelevant. However, it is worth mentioning that the Restinga del Faro Natural Reserve of Geological and Fauna Defined Objects and the Natural Botanical, Faunistic and Educational Reserve "Puerto Mar del Plata" are inserted within the area of direct influence of the logistics route that connects the seismic data acquisition areas with the Port of Mar del Plata.

On the other hand, Special Protection Zones on the Argentine Coast have been defined by Ordinance No. 12/98 of the Argentine Coast Guard (PNA). These areas arise as a result of a cooperation agreement signed in 1993, and redone in 2015 between the Ministry of Environment and Sustainable Development and the Argentine Coast Guard (PNA), in order to define those especially protected areas against potential polluting actions that could come from navigation, port activity and related tasks. All of these are coastal-marine areas far from the seismic prospecting site. None of these areas is close to the support Port.

Given the nature of the project, marine protected areas (MPAs) should be especially considered, which constitute one of the most powerful tools to avoid overexploitation of resources and degradation of marine habitats. It is aimed at preserving and managing the existing biodiversity. They are flexible tools that can be adjusted to meet different needs, from strict preservation to multipurpose designs and reserves with mobile and seasonal limits. At present, Argentina has 3 entirely marine protected areas (MPAs): Yaganes and Namuncurá / Burdwood Bank I and II, which are all located in the South Atlantic more than 1000 kilometers from the study area.

According to the Convention on Biological Diversity and the UN Sustainable Development Goals to which Argentina adhered, at least 10% of its marine surface must be protected by 2020. The future marine areas to be protected have already been defined within this framework, although there are no proposals for their creation yet. The closest to the prospecting area is the "Frente del Talud" (FT), located 30 km from CAN_100-108 and CAN_114 operating areas (and 17 km from the area of direct influence) and hence, situated in the indirect area of influence of the seismic acquisition zones. The Middle Platform Front (FPM) is located 114 km from the prospecting areas and outside its area of influence. The "Profundo" and "El Rincón" RCP are at greater distances. Both the Slope Front (FT) and the Middle Platform Front (MPF) shall be crossed by the logistics route that connects the CAN_114 Area with the Port of Mar del Plata.

In addition to these legally protected areas, there are certain sectors of the Argentine territory that have been identified as ecologically relevant due to some particular aspect. This is the case in the areas of importance for the conservation of birds (AICAS). As for the APMC and ZPE, the AICAs correspond to terrestrial or coastal areas, far from CAN_100-108 and CAN_114 seismic data acquisition areas. However, it is worth mentioning that the AICA "Playa de Punta Mogotes and Puerto de Mar del Plata" is inserted within the area of direct influence of the logistics route.

Considering that there are particular situations requiring special treatment, (Dellacasa et al., 2018), 55 Marine AICAS were defined in Argentina after having considered the different activities and life stages of seabirds (for example breeding, feeding, maintenance and migration). It is important to mention that these areas are "candidate sites" to date, awaiting the final confirmation by BirdLife International.

As part of the work, several pelagic AICAS have been defined, the so-called “North Patagonia Slope Waters” standing out for its proximity to the seismic data acquisition areas. This is an area on the continental slope in front of El Rincón, crossed by the 100, 200 and 1,000 m isobaths. It is characterized by the presence and use of space by two large albatrosses, the wandering and the northern royal, very long-lived species that begin to breed between 11 and 12 years of age. The feeding trips are extensive and can cover more than 7,000 km in two weeks. Both species follow ships with the goal of consuming their discards, thus increasing the threat of a negative interaction. The abovementioned area shall be crossed by the logistics route that connects the Port of Mar del Plata with CAN_114 Area.

In this sense, the area of regional influence is part of the Atlantic Migratory Route. Migratory birds must fly distances of thousands of kilometers without stopping. The feasibility of successfully carrying out its annual migratory cycle is the combined product of the probability of completing each component: breeding, migration and wintering. Any event threatening one of them shall put the entire process at risk. To this end, the Hemispheric Network of Shorebird Reserves has been created to protect the most important sites for these birds. None of these RHRAPs defined in Argentina are located in the vicinity of the areas affected by the project.

The identification of Priority Aquatic Areas (AAP) was carried out in the Río de la Plata and its Maritime Front within the context of the FREPLATA Project (2004). The Southern Slope Front is the closest highest priority core area, which is nevertheless located 250 km from the seismic survey area, so it shall not be affected. The APP containing it is the Slope Edge located 93 km from CAN_114 seismic data acquisition area and therefore overlaps, only marginally, with the area of indirect influence of the prospecting areas. On the other hand, the "Costa Atlántica Argentina" APP is located in the area of influence of the port of logistical support and the logistics route, while the latter crosses the "Banco de Mejillones" APP.

To sum up, the seismic data acquisition areas do not directly affect any declared or proposed protected area. However, it is worth mentioning that the Restinga del Faro Natural Reserve of Defined Geological and Faunal Objects and the Botanical, Faunistic and Educational Natural Reserve "Puerto Mar del Plata" is inserted within the area of direct influence of the logistics route that connects the seismic data acquisition areas with the Port of Mar del Plata. The area of direct influence of the logistics route also involves the AICA called "Playa de Punta Mogotes and Puerto de Mar del Plata".

Within the indirect area of influence, the future marine protected area Frente del Talud (FT) is located 30 km from the prospecting area and 17 km from the area of direct influence. This area shall be crossed by the logistics route that connects CAN_114 Area with the port. This route also involves the future marine protected area named "Frente de Plataforma Media" (FPM).

The AICA candidate "Aguas del Talud Patagonia Norte" is also within the area of indirect influence. It shall be crossed by the logistics route that connects the Port of Mar del Plata with CAN_114 Area.

The protected areas are intended to safeguard the natural heritage and are generally chosen as representative samples of a natural formation or because they have characteristics that make them unique. Given that they are aimed at protecting representative samples of ecosystems, biodiversity, genetic, landscape and cultural resources, they are sensitive areas and therefore have been considered as highly sensitive.

1.3.8 Navigation

As part of this factor, a potential interference in normal vessel traffic in the study area is considered.

As mentioned in Point **Error! Reference source not found.**, there is fishing activity in the vicinity of the project's area of influence, mainly the deep-sea stern trawler fleet and freezer trawlers. Nearby coastal and estuary fishing vessels shall not interfere with prospecting operations due to the existing distances from the exploration area to the coast. Particularly for CAN_100-108 and CAN_114 operative areas, a marginal relationship with the fishing areas is observed where the fishing effort is mainly concentrated at the front of the slope, located 30 km from the prospecting area and 17 km from the aforementioned operational areas.

Fishing boats, followed by tankers and cargo ships stand out as regards the type of vessels that can be seen in the area corresponding to the navigation routes that connect the Port of Mar del Plata and CAN_100-108 and 114 seismic data acquisition areas. To a lesser extent there are also tugboats and special vessels and pleasure boats, some unspecified vessels and passenger vessels only in the Port of Mar de Plata.

The density of marine traffic could be considered moderate according to what was surveyed in the Environmental Baseline within CAN_100-108 and CAN_114 operational areas.

Taking into account both what refers to the fishing activity and the current use of the area by other vessels, it is considered a medium-low sensitivity factor in relation to the project.

1.3.9 Offshore Infrastructure

It considers the impact of facilities located offshore that could be affected by the actions of seismic vessels.
Numerous communication cables have been laid on the Argentine sea front, linking Argentina, Uruguay and other worldwide countries. Most of them are located under sediment, although in some cases cables rest on the seabed. Currently, eight active cables in the Argentine EEZ can be seen in the cartography: “ARBR”, “Atlantis-2”, “Bicentenario”, “Malbec”, “SAm-1”, “SAC”, “Tannat” and “Unisur”.

The operational area of the project is located approximately 400 km south of the underwater cable "Atlantis-2", which is the southernmost of all the cables present in the area. Therefore, the presence of said infrastructure shall not be interfered with by the project, and shall be considered as sensitive.

1.3.10 Hydrocarbon Activity

Argentina has an extensive submarine platform with great potential for hydrocarbon resources; However, the offshore is one of the least explored areas of the territory which, if exploited, would expand the horizon of gas and oil reserves to a global scale. As for the North Argentina Basin, where CAN_100, CAN_108 and CAN_114 Areas under study are located, operations in ultra-deep waters shall be discussed.

On the website of the Ministry of Energy, you can consult a database of geographic information, linked to basins, areas of exploitation and seismic activity in Argentina. **When consulting the information presented on said page, it was observed that the study area does not have hydrocarbon wells, pipelines or concession areas, beyond those that were tendered. However, there is a record of the existence of 2D exploratory activities.**

1.4 CONCLUSIONS

The sensitivity analysis carried out was focused on the area of influence defined for the present work in Chapter 5 (see point 2 AREA OF STUDY AND AREA OF INFLUENCE).

The analysis of the sensitivity of the species present in this area is extremely valuable, so this information is taken as input for the assessment of impacts that is developed in the subsequent points of this chapter.

It also highlights the existence of areas located in the project's area of influence that are associated with high sensitivity and which were included in a sensitive or critical areas map, since many of them are used by the species present in the analyzed area.

Among these, the coastal protected areas stand out, which, however, are located more than 300 km from the operational area and are directly influenced by CAN_100-108 and CAN_114. However, it is worth mentioning that the Natural Reserve of Defined Geological Objects and Wildlife "Restinga del Faro" and the "Puerto Mar del Plata" Botanical, Wildlife and Educational Nature Reserve are inserted within the area of direct influence of the logistics route that connects the seismic data acquisition areas with the Port of Mar del Plata.

Given the nature of the project, marine protected areas (MPAs) should be especially considered). At present, Argentina has 3 entirely marine protected areas (MPAs): Yaganes and Namuncurá - Burdwood Bank I and II, which are all located in the South Atlantic more than 1000 kilometers from the study area. The interaction with these protected areas is negligible.

In view of this situation, the future marine areas to be protected are of particular importance. These sites relevant to the biodiversity of the Argentine Sea have no creation proposals for now. The closest to the prospecting area is the "Frente del Talud" (FT), located 30 km from CAN_100-108 and CAN_114 operating areas (and 17 km from the area of direct influence) and hence, situated in the indirect area of influence of the seismic acquisition zones. The Middle Platform Front (MPF) is located 114 km from the prospecting areas and outside its area of influence. Both areas shall be crossed by the logistics route that connects the CAN_114 Area with the Port of Mar del Plata.
The Slope front (FT) is one of the most extensive and persistent ocean fronts of the Patagonian Sea, with a key ecological and functional role for the Patagonian marine ecosystem. This area of high productivity of the outer platform that borders the slope extends for more than 2,000 km.

In addition to these legally protected areas, there are certain sectors of the Argentine territory that have been identified as ecologically relevant due to some particular aspect.

The core area closest to the CAN_100, CAN_108 and CAN_114 seismic prospecting area is the so-called Edge of the South Slope, which is located 250 km away. The APP (Priority Aquatic Area) that contains said area is the Slope Edge located 93 km from CAN_114 seismic data acquisition area. On the other hand, the "Costa Atlántica Argentina" APP (Priority Aquatic Area) is located in the area of influence of the port of logistical support and the logistics route, while the latter crosses the "Banco de Mejillones" APP (Priority Aquatic Area).

The “Important Bird Areas” (IBAs) program led by the BirdLife International Federation emerges internationally considering the protection of valuable sites for biological diversity one of the most effective measures for Bird conservation. The "Aves Argentinas" foundation identified Areas of Importance for Bird Conservation (AICAS). Likewise, and although the AICAs correspond to terrestrial or coastal areas, far from CAN_100-108 and CAN_114 seismic data acquisition areas, it is worth mentioning that the "Playa de Punta Mogotes and Puerto de Mar del Plata" AICA is inserted within the area of direct influence of the logistics route.

Considering that there are particular situations requiring special treatment, (Dellacasa et al., 2018), 55 Marine AICAS were defined in Argentina after having considered the different activities and life stages of seabirds (for example breeding, feeding, maintenance and migration). These areas have been considered "candidate sites" to date, awaiting the final confirmation by BirdLife International.

Many of these are close to the coast, so they do not pose any risk of being affected by the project. As part of the work, however, several marine AICAS have been defined such as the so-called “North Patagonia Slope Waters” for its proximity to the study area. This is an area on the continental slope in front of El Rincón, characterized by the presence and use of space by two large albatrosses, the wandering one and the northern royal, very long-lived species whose feeding journeys are long and can fly 7,000 km in two weeks. It shall be crossed by the logistics route that connects the Port of Mar del Plata with CAN_114 Area.

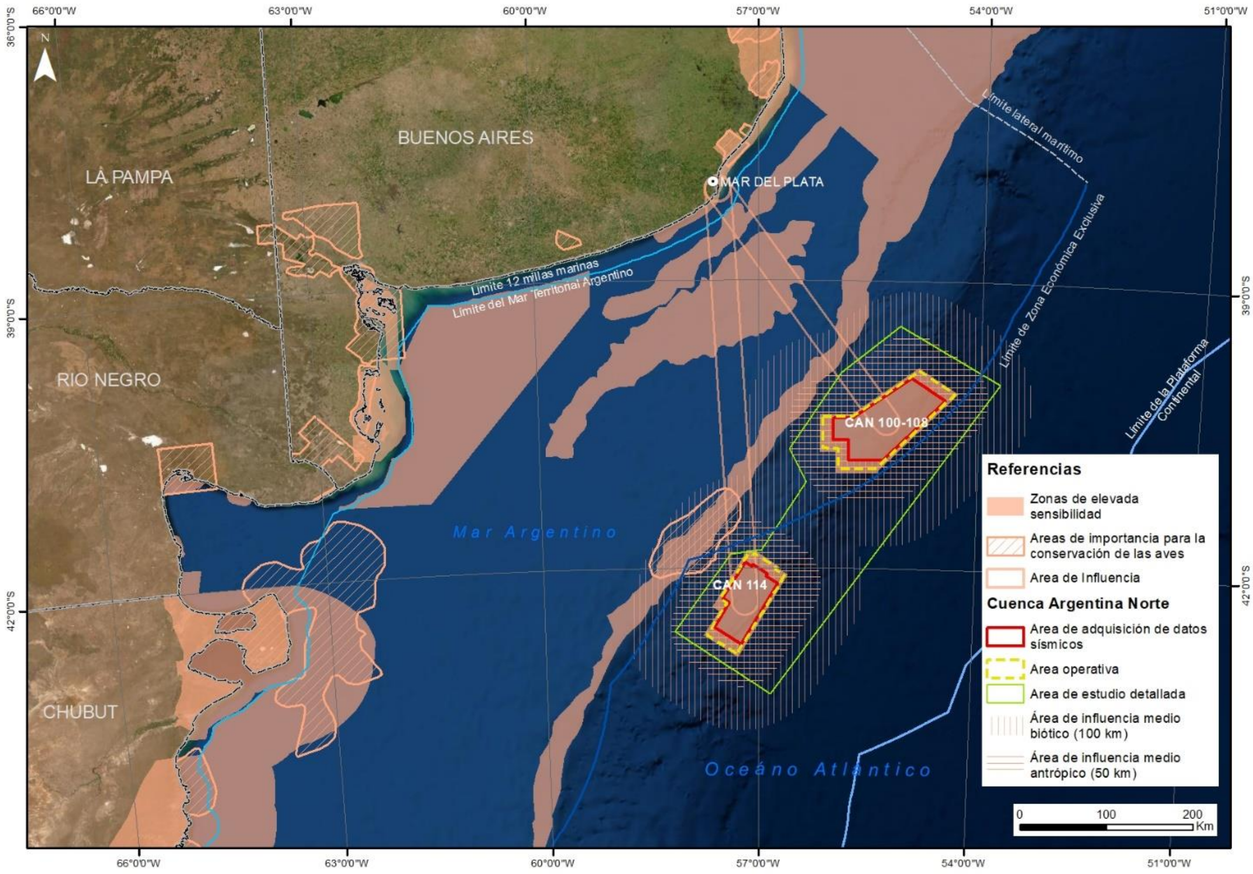


Figure 1. Map of sensitive areas.

(**Translation of Figure 1**: Límite 12 millas marinas: 12 Nautical-mile limit. Límite del mar Territorial Argentino: Limit of the Argentine Territorial Sea. Límite Lateral Marítimo: Maritime lateral Limit. Límite de Zona Económica Exclusiva: EEZ Limit. Límite de la Plataforma continental: Continental Shelf Limit. Reference box: Zonas de elevada sensibilidad: High Sensitivity Areas. Areas de importancia para la conservación de las aves: Areas of importance for Bird conservation. Area de Influencia: Area of Influence.

Cuenca Argentina Norte: North Argentine Basin. Area de Adquisición de datos sísmicos: Seismic Data Acquisition Areas. Area Operativa: Operational Area. Area de estudio detallada: Detailed study área. Area de influencia del medio biótico: Area of influence of the biotic environment. Area de influencia del medio antrópico: Area of influence of the anthropic environment).

The analysis has shown that the study area presents a moderate sensitivity throughout the year as regards benthic invertebrates. The zooplankton shows intermediate sensitivity but only during spring and summer. The rest of the year is low. Autumn is also of moderate sensitivity, considering the presence of myctophid larvae.

Regarding cephalopods, the areas with the highest concentrations and breeding groups of squid (*Illex argentinus*) would be found in the indirect area of influence of the project in spring and summer, but during autumn and winter the area of direct influence would partially coincide with the pre-reproductive concentrations of the Buenos Aires-North Patagonian sub-population that are grouped at the edge of the platform. An additional impact would occur during the laying of eggs and larvae from winter until spring from the southern zone due to the action of the Malvinas current. For this reason, the sensitivity rate is high during the autumn /winter months and low during the rest of the year. The area of influence of the project does not overlap with the areas with the highest landings of cephalopods in the 2003-2017 period. The freezer vessels fleet of southern species is the closest to the area of indirect influence.

In the case of fish, the sensitivity has been defined as low or medium depending on the species analyzed. The results indicate that most of the taxonomic orders fall into the category of medium sensitivity. It should be noted that there is no information on the breeding area for many of the species; this is why they were assigned the highest overvalued sensitivity rating. Taking into account this situation, the effects of the study at the population level shall be low, and in general, the species identified in the project's area of influence have a wide distribution (some are even frequent on the slope and the platform.

It is also reckoned that the seismic activity shall have a low interference on the most relevant fisheries. The greatest fishing efforts are observed mainly outside the area of direct influence. Only the pollock, Patagonian toothfish and squid fisheries could be affected depending on the moment when the fishery survey is conducted. Particularly during the autumn and winter periods, the activity becomes very important in the slope front area. However, it is outside the area of direct influence of CAN_100-108 and CAN_114 areas. Squid larvae are recorded for the indirect area of influence of CAN_100-108 and CAN_114, but it is also possible to find them in the prospecting area, turning the latter into a sensitive site for this species. However, these larvae come from spawning areas located in other zones of the Argentine Sea. The area of direct influence is not identified as a breeding area of commercial species. As said, species of fishing interest do not have their spawning site in the previously mentioned area of influence. In any case, summer is the most convenient season for seismic work from the point of view of fisheries, and in order to avoid potential interferences, they should be completely avoided during the autumn and winter periods.

The area of influence of the project is not a breeding area for sea turtles, since there are no such areas in our country. CAN_100-108 and CAN_114 seismic data acquisition areas are located in the migratory corridor of the sea turtle species considered to be present in the project's area of influence. The area is not specially visited by sea turtles, but telemetry studies have confirmed the occasional occurrence of individuals and it is assumed that there may be juveniles and sub-adults. The warm months are those that register the greatest number of sightings. Therefore, the period of major sensitivity would be spring and summer for the turtles in general whose sensitivity has been considered moderate, and high for the loggerhead turtle which has been regularly seen in the study area lately. This group would present a low sensitivity for the rest of the year.

The project area is a very important feeding site for birds throughout the year and also a temporary area for inter-hemispheric migrators. The analyzed sector is located on the continental slope, which exerts a particular attraction on seabirds due to the concentration of planktonic organisms, fish and cephalopods that feed and breed in these waters. However, the species do not breed in the high seas, having their nesting and breeding sites hundreds or thousands of kilometers from their feeding areas. Those breeding in the Malvinas Islands (e.g., black-browed albatross) or in the South Georgia Islands (eg, wandering albatrosses) use the platform and its slope from 60 ° S to 35 ° S as a feeding area, in front of the Río de la Plata near the Brazil-Malvinas confluence. They all carry out large migrations between their breeding and feeding areas.

Procellariiformes and Charadriformes stand out for their extraordinary flying abilities and their extensive travels of several thousand kilometers. They carry out daily or seasonal migrations, moving between breeding and feeding areas using migratory routes or corridors that pass over the slope. All species are top predators and good divers, feeding on squid, pelagic fish (anchovies and myctophids), salps, crustaceans (krill), and also floating garbage, such as fisheries waste.

In this sense, it is concluded that this group presents, in general, a medium sensitivity for the area of operation and of direct influence of the project, becoming more important at the front of the slope (which is located 30 km from the prospecting area). After analysing data from incidental catches of birds, Favero et al (2005) mention that the abundances are greater where the temperature gradient coincides with the slope, as occurs along the northwest edge of the Malvinas Current, with abundance peaks generally observed between May and October. However, data from tagged non-reproductive juvenile and adult individuals show that they may also be present at other times. In the case of penguins, the identified species may be present in the area of influence of CAN_100-108 and CAN_114 during their autumn migrations north of the confluence area, and also when returning to their breeding colonies in late winter. It is important to highlight the White-chinned Petrel´s situation, which is not only common but also abundant in the area. In addition, it faces a high degree of threat, being considered Threatened at the local level but Vulnerable at the regional level. For this reason, their sensitivity to the project is considered high during the warmer months.

In the case of mammals, the area of influence would work as a passage and feeding area. It is not a breeding area for the more abundant marine mammals. However, this possibility cannot be ruled out for some species with probable presence due to lack of information. Although the sensitivity could be considered moderate throughout the year, a clear period of greater sensitivity is not identified but spring could be considered more critical in the case of the 4 species of whales classified as highly sensitive.

From the anthropic point of view, the area of influence of the project presents a medium - low sensitivity in terms of navigation. Regarding CAN_100-108 and CAN_114 operative areas, a marginal relationship with the fishing areas is observed where the fishing effort is mainly concentrated at the front of the slope, located 30 km from the prospecting area and 17 km from the aforementioned operational areas. The density of marine traffic could be considered moderate according to what was surveyed in the Environmental Baseline within CAN_100-108 and CAN_114 Operative areas.

2 IDENTIFICATION OF ENVIRONMENTAL IMPACTS

The potential impacts of the 3D Offshore Seismic Record of CAN_100, CAN_108 and CAN_114 Areas have been identified through a systematic process by which the activities (both planned and unplanned) associated with the project have been considered as to their potential interaction with environmental factors.

A Matrix of Potential Interactions has been used as a tool to carry out this identification (Table 22). In said matrix, the rows correspond to the various actions of the project that could act as a source of impact. The relevant environmental factors have also been listed in the columns.

Each resulting cell in the Potential Interaction Matrix therefore represents a potential interaction between a Project activity and an environmental factor. Each of the possible impacts has been classified into one of two categories:

- No interaction (blank cell) or probable interaction without impact: where the Project is unlikely to interact with the environmental factor (for example, projects that are fully developed in marine environments may not have interaction with the terrestrial environment); or where an interaction is likely to exist, but the resulting impact idoes not change baseline conditions; and

- Identified potential interaction (X): where an interaction is likely to exist and the resulting impact could potentially cause an effect on the receptor factor.

This preliminary analysis allows avoiding detailed analysis of those resources without being significantly affected, and concentrates the analysis on those with the highest risk of being impacted.

It should be noted that the list of actions is not intended to be exhaustive, but rather an identification of the key aspects of seismic prospecting operations that can potentially interact with the environment / cause environmental impacts. The list of environmental factors is a list of key aspects of the environment that are considered vulnerable or important within the context of marine seismic survey activities in CAN_100 - 108 and 114 areas.

2.1 IDENTIFICATION OF ACTIVITIES OR ACTIONS OF THE PROJECT

Based on the Project Description (Chapter 4), the following actions are considered within the ordinary activities or planned events:

- **Operation of seismic sources (compressed air emissions):** it refers to the underwater sound emission generated by compressed air energy sources during the acquisition of seismic data process.

- **Navigation of the seismic and support vessels and physical presence of the seismic equipment:** it covers the navigation of the vessels in the operational areas, during the acquisition of seismic data and from / to the support port in the Port of Mar del Plata, along with the presence of deployed seismic equipment (streamers) during seismic data acquisition activities.

- **Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other operations):** it involves the environmental aspects associated with the normal operation of vessels and their proper maintenance. It includes the sound emissions that shall be produced on the surface and in the water due to the operation of the vessels involved in the project, mainly associated with the propulsion propellers and the helicopter used in the event of an emergency; the light emissions of ships; gaseous emissions associated with the combustion of engines for propulsion and power generation, and other operations that produce gaseous emissions (for example, waste incineration). The following should be noted regarding the generation of liquid effluents and waste in the vessels:

    - Generation of liquid effluents in ships: Inadequate management of wastewater could lead to water pollution and, in turn, secondary impacts on aquatic life, sensitive ecosystems, etc. However, discharges from ships into the marine environment must comply with MARPOL 73/78 standards, so this aspect of ship operations is not expected to have significant effects on any of these receivers.

    - Waste on ships: Inadequate waste management could lead to water pollution, which could have secondary effects on aquatic life and sensitive ecosystems, among other factors. However, the amount of waste generated by seismic prospecting activities is expected to be low. These shall be separated and stored on board the vessels associated with the project, awaiting their proper final disposal at the port facilities. Food waste shall be triturated up to 25mm before discharge into the sea, while combustible waste, eg wood, paper and general waste, shall be incinerated on board. Thus, this aspect of vessel operations is not expected to have significant effects on any of these receivers.

- **Demand for labor and goods and services:** the development of the project requires mainly qualified labor, although it also includes basic services in terms of navigation operations. 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. The project establishes the port of Buenos Aires as a port of call (mobilization / demobilization) and the Port of Mar del Plata as a port for supplies or logistics services. The operations of the vessels associated with the project do not differ from those of any other vessel docking in these ports.

Unplanned/accidental events, or contingencies are considered separate from routine activities, as they only occur as a result of technical failure, human error, or other emergencies. Equinor and the seismic contractors shall maintain high operational performance and adherence to good industry practices at all times. However, as in most projects, there is a low probability of an accidental event to occur.

Possible accidental events that can result in potentially significant environmental impacts during project development have been identified and include the following:

- **Hydrocarbon spills:** considering fuel or lubricating oils spills used by the Project ships.

- **Accidental discharge of chemical substances and / or solid, non-hazardous / hazardous waste:** considering the chemical substances used in the project vessels for cleaning and maintenance and the management of waste generated on board.

2.2 IDENTIFICATION OF ENVIRONMENTAL FACTORS

Based on the environmental diagnosis of the project's area of influence, the environmental factors likely to be affected by the project under analysis have been identified (see Table 22).

Based on the actions identified in the previous section and the possibility that these might interact with the environment, the following factors were identified that are not expected to be affected by the project.

- **Geology:** Although the geological environment is relevant for the development of the project, the geological processes shall not be altered.

- **Oceanography:** The activities carried out from the survey vessel shall necessarily take into account local and regional oceanographic conditions. The characteristics of ocean currents, the stratification of the density of the water column, the vertical structure of the currents, among other factors, shall be taken into account during the planning, operation and post-processing of data from prospecting activities. However, they shall not be affected by the exploratory operations under study.

- **Hydrocarbon activity:** Hydrocarbon activity: As previously mentioned, there are not hydrocarbon wells, pipelines or concession sites in the study area, beyond those that were already tendered. However, there is a record of the existence of 2D exploratory activities. In this sense, no interferences with these activities are foreseen; however, the PGA considers measures in relation to interferences with potential adjoining exploratory activities in the tendered areas.
- **Offshore Infrastructure:** The operational area of the project is located approximately 400 km south of the underwater cable "Atlantis-2", which is the southernmost of all cables. Therefore, the presence of said infrastructure shall not be affected by the project.

- **Population:** There are no receptors near the Project site. The seismic data acquisition area is approximately 300 km from the closest coastal area in the Province of Buenos Aires, beyond 12 miles from the territorial sea. Given the nature of the project, no interactions are foreseen between the project and the territorial coastal strip. Modern marine seismic exploration does not produce significant pulses of airborne noise.

- **Archaeological heritage:** The seismic data acquisition area is located offshore in open waters. No archaeological sites of interest have been detected in the study area and project activities are carried out far from the seabed.

A total of 12 factors were then considered, including: Surface water, Air, Marine mammals, Fish and cephalopods, Sea turtles, Benthos and Plankton, Birds, Protected and sensitive areas, Fishing activity, Maritime Transit, Economic activities and Infrastructures, resources and terrestrial use.

Table 22. Matrix of Potential Interactions

COMPONENTES AMBIENTALES / ACCIONES			MEDIO FÍSICO				MEDIO BIÓTICO						MEDIO ANTRÓPICO							
			Agua superficial	Aire	Geología	Oceanografía	Mamíferos marinos	Peces y cefalópodos	Tortugas marinas	Bentos y plancton	Aves	Áreas protegidas y sensibles	Actividad pesquera	Actividad hidrocarburífera	Tránsito Marítimo	Infraestructura subacuática	Actividades económicas	Población	Patrimonio arqueológico	Infraestructuras, recursos y usos terrestres
Registro Sísmico Offshore 3D Áreas CAN 100-108 y CAN 114	**Actividades planificadas**																			
	Operación de las fuentes sísmicas (emisiones de aire comprimido)						X	X	X	X	X	X	X							
	Navegación de los buques sísmicos y de apoyo y presencia física del equipo sísmico						X		X		X	X	X		X					
	Emisiones, efluentes y residuos asociados a la operación normal y el mantenimiento de los buques sísmicos y de apoyo (y otras operaciones)	Emisiones lumínicas de los buques									X	X								
		Emisiones gaseosas		X																
		Emisiones sonoras de los buques (y helicóptero)					X	X	X		X	X								
		Generación de efluentes líquidos en los buques																		
		Generación de residuos en los buques																		
	Demanda de mano de obra y de bienes y servicios																X			X
	Eventos no planificados (contingencias)																			
	Derrames de hidrocarburos		X				X	X	X	X	X	X	X							X
	Descarga accidental de sustancias químicas y/o de residuos sólidos, no peligrosos/peligrosos		X				X	X	X	X	X	X								

	Sin interacción o Interacción sin impacto
X	Interacción potencial identificada

3 ENVIRONMENTAL IMPACTS ASSESSMENT

3.1 INTRODUCTION

3.1.1 Potential effects of noise on marine organisms caused by seismic operations

There are numerous studies on the potential effects of seismic operations on marine organisms (particularly marine mammals). A milestone in this regard was the "Seismic and Marine Mammals Workshop", held in London in June 1998, which brought together representatives of these companies, geophysical contractors, environmental regulatory bodies and NGOs, together with marine biologists, academics and bio-acoustics experts, to develop a common understanding of the impact of seismic operations on marine mammals.

The event was jointly organized by the "Atlantic Margin Joint Industry Group", the "International Association of Geophysical Contractors", the "UK Joint Nature Conservation Committee" (JNCC), the "National Environment Research Council, Sea Mammal Research Unit" and the " International Fund for Animal Welfare" attracting more than 100 delegates from Europe, the Far East and the United States.

One of the main works that arose from that event is "The effects of seismic surveys on marine mammals" (Gordon, J. et al, 1998, 2003), which was carried out by a large group of specialists and included background studies.

The implementation of mitigation measures is mandatory to minimize the eventual effects of seismic registration on marine organisms or their behavior.

In order to determine these measurements with an adequate scientific basis, detailed studies have been carried out grounded on hundreds of marine seismic surveys carried out in different parts of the world.

In particular, the 1998 Workshop was the basis to prepare "The effects of seismic activity on marine mammals in UK waters, 1998-2000" report (Stone, CJ 2003). It collected 1,652 observations of marine mammals (28,165 individuals) that occurred during 201 seismic studies in the waters of the United Kingdom and some adjacent areas between 1998 and 2000 (plus two studies in 1997). The results of these studies led to the development of guides or guidelines to minimize the impact on marine mammals, which shall be mentioned in more detail in the mitigation measures chapter.

The best known Guide is the one produced by the JNCC (Joint Nature Conservation Committee), which since its first publication in 1998 has been revised five times so far, the most recent version being published in August 2017 (JNCC guidelines for minimizing the risk of injury to marine mammals from geophysical surveys, 2017)[1]. This Guide has been adopted by many countries to establish mitigation measures for the impacts of these surveys.

3.1.2 Influence of frequency, sound intensity and exposure thresholds

As described above, the responses of marine organisms to underwater sound have been investigated in the scientific literature for many years, and as a product of these studies threshold criteria have been proposed for various species and groups of species. Thresholds are often

[1] These guidelines were developed by the JNCC in order to facilitate the integration of the considerations raised in the European Union Directives on the conservation of protected species and habitats and implemented into British legislation (2007 and 2009 amendments to the Regulations of 1994 on Natural Habitats and the Offshore Marine Conservation Regulations of 2007, 2009, 2010 and 2017 amendments, currently in force http://archive.jncc.gov.uk/pdf/jncc_guidelines_seismicsurvey_aug2017.pdf

considered in terms of one or more different sound level measurements and for different levels of potential impact ranging from physiological damage to behavioral responses.

As explained in Chapter 4, there are different metrics to express the level of an acoustic signal, each of which is more or less appropriate to each type of signal or type of effect on different groups of fauna species. Sounds are often described by various acoustic parameters, including Sound Pressure Level (SPL) and Sound Exposure Level (SEL). The first is a measure of the pressure amplitude or its average in the duration of the pulse and the second a measure of the sound energy of the signal, therefore it depends on both its amplitude and its duration. In turn, the sound pressure level can be defined as a maximum value, from positive peak to negative peak, from zero to peak or RMS (root mean square or mean square value) which makes it even more complex.

Currently, there are no final conclusions on the most appropriate metric to express each type of effect on each group of species, and even less on the corresponding noise thresholds (Redondo and Ruiz Mateo, 2017). Much of the available literature provides a mix of both metrics, although many sound sources are primarily described in units of pressure level. In order to address these two measures and to take into account all relevant acoustic characteristics that can affect marine organisms, dual criteria thresholds are often defined for sound exposure, using both sound pressure and sound exposure levels. In particular, one of the most recent methodologies that has a broad consensus is the one proposed by Southall and others (2019), which considers a dual “metric” to define the thresholds of affectation, corresponding to the values of peak SPL, and to the SEL values accumulated over a certain period of exposure to noise emissions.

Mammals have been the most studied group so far. In this group, high-intensity noises can cause physiological damage to hearing (ruptured eardrum, damage to the ossicles of the middle ear or overstimulation of hair cells that convert fluid movements caused by noise into neurological impulses that are sent to the brain). Minor exposures can cause hearing loss called *Threshold Shift* (TS), which can be permanent (PTS) or temporary (TTS), and therefore, physiological impacts are generally considered at these two levels:

- Permanent Threshold Shift (PTS) is a permanent and irreversible increase in the audibility threshold at a specific frequency or portion of an individual's hearing range above a previously established reference level. This is considered a hearing loss.

- Temporal Threshold Shift (TTS) is a temporary and reversible increase in the audibility threshold at a specific frequency or portion of an individual's hearing range above a previously established reference level.

The degree of TS is influenced by the amplitude, duration, frequency and temporal evolution of the noise exposure. Exposures of equal energy produce roughly the same effects for continuous sounds. As for intermittent sounds, the degree of TS for the same energy is lower than if the sound is continuous because a certain recovery occurs between the pulse intervals.

The frequencies emitted by cetaceans of the odontoceti suborder produce a wide range of sounds, including hissing, clicking, pulsing and echolocation sounds. The emitted frequency ranges are between 100 Hz and 20kHz, with levels between 100 and 180 dB re 1 Pa. For example, the Killer whale uses a call frequency of 0,5 to 25 kHz, with a level of 160 dB re 1 μPa, and an echolocation frequency of 12 to 25 kHz, with 180 dB re 1 μPa. Beaked dolphins use a calling frequency of 0.8 to 24 kHz, with a level of 125 to 173 dB re 1 μPa, and an echolocation frequency of 110 to 130 kHz, with 218 to 228 dB re 1 μPa (Richardson et al., 1995, in Pidcock et al., 2003).

These examples show that the frequency range used by marine mammals is generally higher than that used in seismic surveys (with some exceptions such as gray whales that hear very well at low frequencies < 1 kHz).

The hearing capacity of marine mammals is not very efficient for seismic sounds, as can be seen in the following audiograms, which show the hearing threshold as a function of frequency, for different species, such as seals (seal), porpoises (porpoise), whales (whale) and fish such as cod (cod) and American flounder (dab).

It can be seen that fish have a more similar hearing range than mammals have to the frequency range generated by seismic activities, so the latter are less affected.

Also, since low frequencies are less attenuated in their propagation than high frequencies (as they bounce off the seabed), the effective attenuation of the frequencies heard by marine mammals is greater than the average global attenuation.

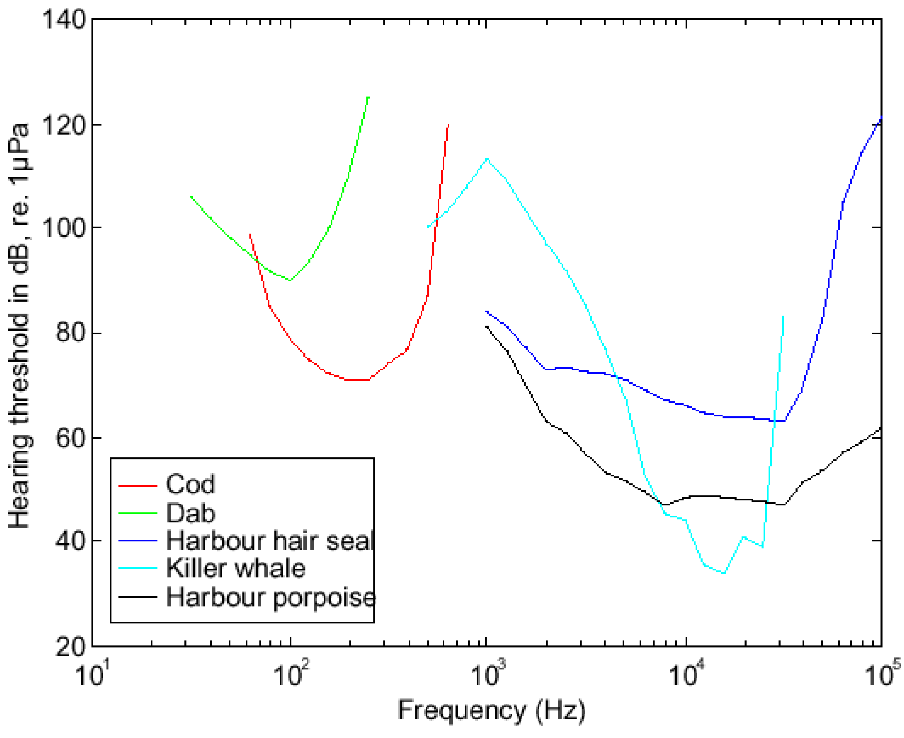


Figure 2. Typical audiogram of fish and marine mammals.

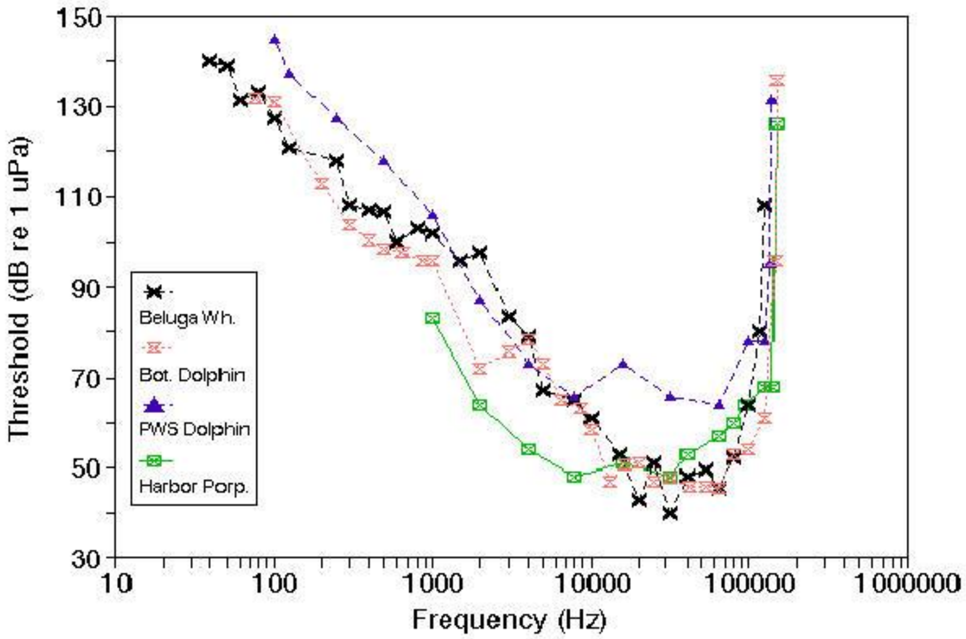


Figure 20. Underwater audiograms of selected toothed whale species showing the minimum detectable sound pressure level for tonal sounds at various frequencies. Adapted from Richardson et al. (1995) based on beluga data (averaged) of White et al. (1978), Aubrey et al. (1988), and Johnson et al. (1989); bottlenose dolphin data of Johnson (1968); Pacific white-sided dolphin data of Tremel et al. (1999); and harbour porpoise data of Andersen (1970).

Figure3. Typical audiogram for whales.

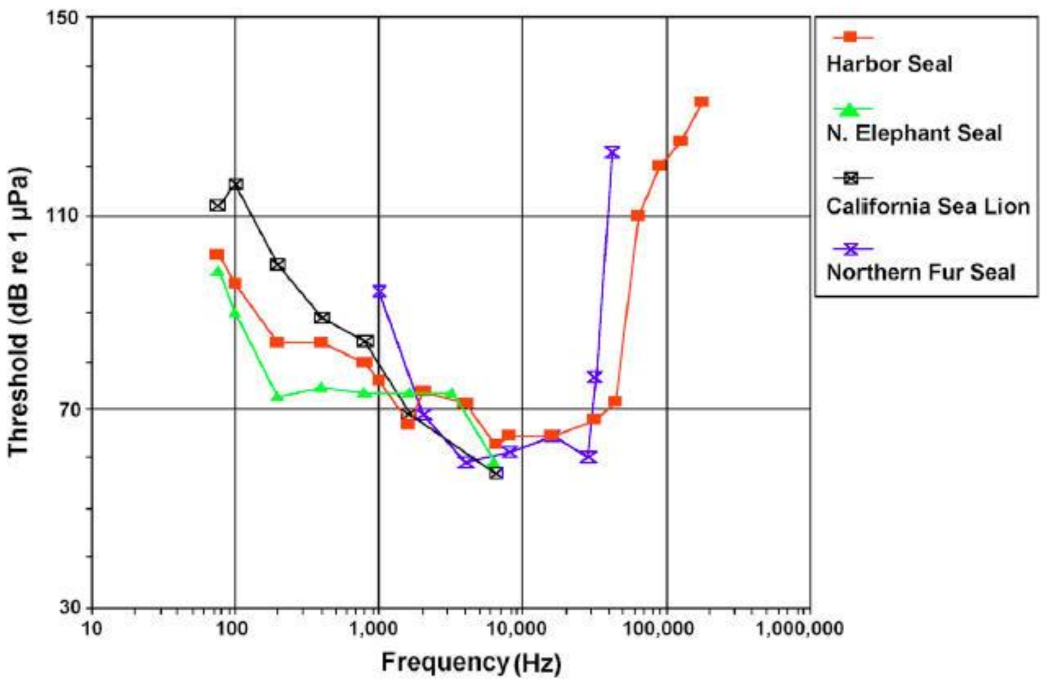


Figure 21. Underwater audiograms of selected pinniped species. Adapted from Richardson et al. (1995), based on the Northern elephant seal and California sea lion (7 year-old) data of Kastak and Schusterman (1998); averaged harbour seal data of Møhl (1968), Kastak and Schusterman (1995, 1998), and Terhune and Turnbull (1995); and Northern fur seal data of Moore and Schusterman (1987).

Figure 4. Typical audiogram for pinnipeds (seals, sea lions).

It can be seen that the hearing ranges in frequency for marine mammals are generally out of phase with the range corresponding to seismic pulses that typically occurs at low frequencies, mainly below 200-250 Hz, with their maximum energy between 10- 120 Hz and with a maximum energy peak around 50 Hz (Richardson et al., 1995). The maximum emissions from the compressed air power source for this project approximately occur between 5 Hz and 100 Hz in frequency, then the maximum values steadily decay at an approximate rate of 4.5 dB. every 100 Hz.

This fact originated an interesting work carried out by Subacoustech (Nedwell, J., 1999), in which the intensity of sound based on the “filter” offered by the hearing capacity of each species is analyzed.

The field work consisted of carrying out measurements of the sound radiated by a 3D seismic campaign in 14 / 14a blocks of the North Sea in 1998.

In addition to expressing the sound in dB as up to now, in this work a dBha (Species) is calculated, for which the sound is “weighed” by a frequency-dependent filter. The suffix **ha** indicates that the sound is heavy due to the species' hearing ability. The level expressed on this scale is different for each species and corresponds to the species´perception of sound.

The following diagrams show the (not weighed) pressure diagram corresponding to the energy emission of compressed air from a compressed air energy source, and its time series, measured at a depth of 10 m and a distance of 3000 m from the source.

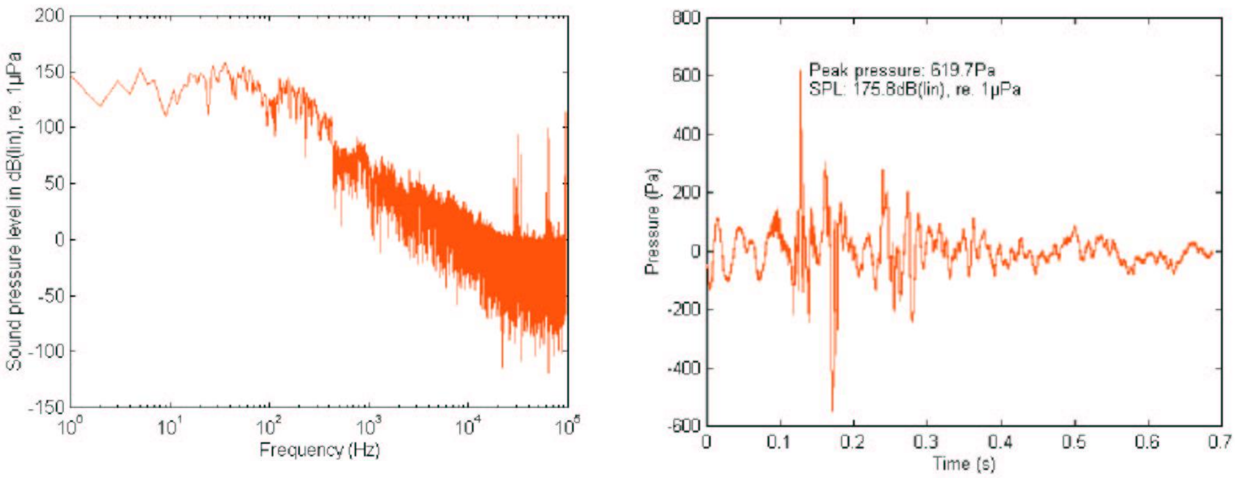
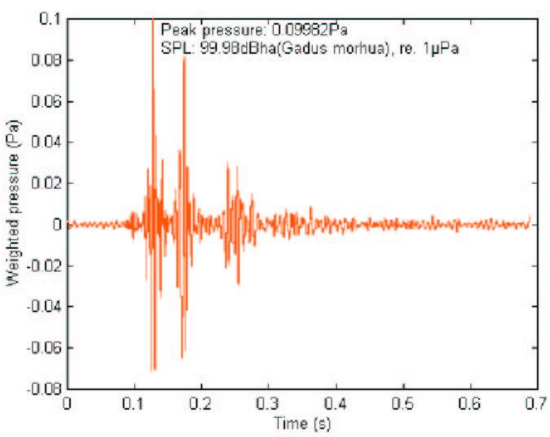
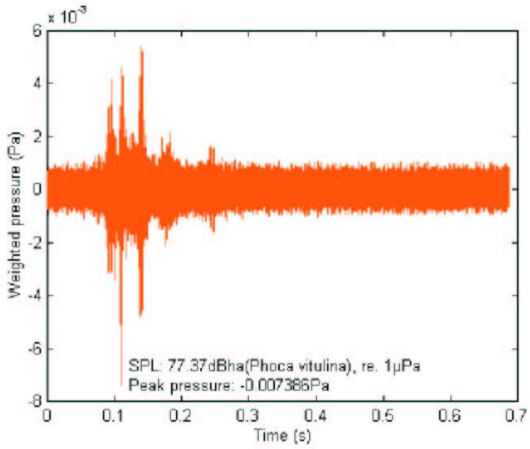


Figure 5. Pressure diagram of a compressed air energy emission and time diagram of light (linear) sound pressure (Nedwell J. et al., 1999).

The following figures represent the filtered diagrams corresponding to a fish (cod) and a marine mammal (seal), measured at the same point:



SPL = 100 dB$_{ha}$(cod)



SPL = 77 dB$_{ha}$(seal)

Figure 6. Typical sequence of pressures of a compressed air energy emission filtered according to the audiogram of two different species (Nedwell J. et al., 1999).

If Figure 5 (right) and Figure 6 are compared, you can see the strong decrease that occurs in relation to the unfiltered noise level (from 176 dB to 100 dB for the fish and 77 dB for the seal), which gives an idea of the different resistance to sound that each species can have, and shows the relative validity of the dB values expressed in a conventional way.

In line with this approach and recognizing that the establishment of safe limits for the exposure of marine mammals to underwater noise is controversial and suffers from a lack of sufficient evidence, Southall et al. (2007) conducted an exhaustive review of the available evidence, defining protection criteria for marine mammals. This report has become a mandatory reference on this subject and has been widely taken into account by various Administrations such as the US National Marine Fisheries Service (NMFS) to set up the criteria. In recent reports, the NMFS (2018) and then Southall et al. (2019) particularly summarized the new insights gained since 2007. This progress led to the adjustment of functional hearing ranges for the different categories of marine mammals and to new thresholds for TTS and PTS.

3.2 MARINE MAMMALS

According to the analysis carried out in Point **Error! Reference source not found.** and summarized in Table 22, the actions of the project that can cause potential impacts on the mammals present in the area of influence of the project include the following:

- Operation of seismic sources (compressed air emissions);
- Navigation of seismic and support vessels and physical presence of seismic equipment (in terms of possible physical disturbance and risk of collision);
- Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other operations) (in terms of noise emissions from the vessels and the helicopter to be used in the event of emergency situations);
- Oil spills; and
- Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste.

3.2.1 Operation of seismic sources (compressed air emissions)

Sound waves move through a certain environment transferring kinetic energy from one molecule to the other. The sea is full of sounds. Marine organisms use sound for many vital functions to inform themselves about their environment, to detect prey and predators, and for orientation and social communication purposes (Hawkins and Popper 2014).

Certain natural events are associated with near-threat situations for certain marine organisms, which present evolutionarily developed adaptive strategies to minimize their exposure to such predictable sources of threat. As an example, marine eruptions with escaping gases and lava can be announced by sound waves and seismic waves (Matsumoto et al. 2011) which are perceived above the background noise, and trigger physiological alarms that translate into escape behaviors (Kaniklides 2014). Other extremely loud sounds are considered annoying or unpleasant noises which generate displacement or avoidance behaviors. Most marine vertebrates have auditory mechanisms, but it is important to note that animals also detect sound waves by non-auditory mechanisms (Wartzok and Ketten 1999).

Animals have not evolved with anthropogenic noises, which are highly varied, do not follow natural cyclical patterns and are not necessarily predictable in space and time by organisms.

Animals that are exposed to high anthropogenic noises, or for long periods of time, may experience passive resonance that generates direct damage ranging from bruising or organ damage, to extreme cases of death from barotrauma (e.g: by explosions). These damages can cause a temporary (TTS) or permanent (PTS) shift of hearing thresholds affecting communication and detecting threats capabilities. Mitigation measures have been developed to avoid this situation which alert organisms of the presence of an intense noise source (eg Soft start protocols) and also guidelines to calculate these thresholds and define safe distances to suspend seismic operations if an organism of a species of interest penetrates within that radius (NMFS, 2018; Prideaux, 2016).

Masking is considered one of the main threats posed by anthropogenic noise. In this process, an individual's hearing threshold is raised by the presence of another (masking) sound (ANSI, 2008). Erbe et al. (2016) point out that underwater sound can interfere with the ability of organisms to receive and process relevant sounds and could potentially impact individual physical fitness, but there is still not enough information to incorporate it into regulatory strategies or mitigation approaches.

Anthropogenic noises can displace animals from breeding, shelter or feeding areas and can also mask natural sounds such as those of prey, predators or potential reproductive partners. Noise can also generate stress, distraction, confusion and panic for many vertebrates, affecting body growth, reproduction, and survival of individuals as well as their populations in the long run (Popper et al., 2014, Hawkins and Popper, 2016).

Tabla 23 presents a synthesis of the potential impacts of sound prospecting on marine vertebrates.

Tabla 23. Potential impacts of sound surveying activities on marine vertebrates. Source: modified from Hawkins and Popper (2016).

Impacts	Effect on individuals
Tissue damage, physiological disruption	Damage to body tissues due to bruising, internal bleeding, breakage or loss of functionality.
Damage to the hearing system	Damage to cells with sensory hairs, temporary (TTS) or permanent (PTS) shifts of hearing thresholds, rupture of hearing accessory organs.

Masking	Masking of biologically relevant sounds, including those of individuals of the same species.
Behavioral changes	Disruption of normal activities, changes in diving and breathing patterns, displacement and migration deviation, changes in social behavior, changes in vocalization patterns, changes in cognitive processes and ecological effects such as masking or obstruction of the passive acoustic detection of prey, predators and conspecifics or also anthropogenic threats, and hindering the use of critical habitats or the usual or preferred area of action or use, and modification of migration routes.

3.2.1.1 Sound effects on marine mammals

In this section an analysis and review of the expected potential impacts for the different groups of marine mammals is made, with emphasis on the species of interest for the project.

Potential effects of seismic survey on marine mammals include behavioral disturbance (feeding, breeding, resting, migration), localized displacement, change in vocalizations, masking of sounds necessary for communication and navigation, physiological stress, and physical injury, including temporary or permanent hearing damage. The scope of the effects varies depending on the mammal species, sound level / proximity to the seismic source and pre-exposure activity (Dalen et al. 2007). It is believed that there is a link between noise from seismic surveys and cetacean stranding based on a dozen recorded events (Castellote and Llorens, 2016) but there are no documented cases with conclusive evidence of marine mammal stranding directly related to seismic studies.

Brief exposure to loud sounds can cause a temporary hearing threshold shift (TTS) (Davis et al. 2000). Long exposure to loud and continuous sound can cause a permanent change in hearing threshold (PTS), with permanent hearing loss in those marine mammals that do not have a seismic avoidance behavior (for example, seals).

Hearing groups are especially used to indicate susceptibility to hearing loss due to loud sounds (NIHL noise-induced hearing loss). Auditory impact risks are considered to be associated with sounds within the generalized auditory range, while that impact risk is unlikely or very low once it is outside the range (Yost, 2007, Finneran 2015, Southall et al 2019).

Table 24 presents the sound values from which situations of auditory impact can be verified by temporary (TTS) or permanent (PTS) shift of the hearing thresholds. SPL pk (SPLpeak) is the minimum exposure criterion for injured mammals, a level at which it is estimated that a single exposure causes a shift in hearing thresholds, and SELcum refers to the sound energy that builds up over a period of time for a receiver with multiple exposures. These values are also used to estimate safe distances, that is, distances from the source for which a certain threshold is not exceeded (Sivle et al., 2015), using the isoline that gives the greatest distance for the set of groups that can be potentially impacted.

Table 24. PTS and TTS levels for different hearing groups. Sources: Southall et al., 2019. Non-analyzed values are usually used for SPL (pK). The analyzed values for SEL are based on the generalized 7 Hz to 160 kHz hearing range for marine mammals. An accumulation of 24 hours, or during the actual exposure is considered in the case of SEL.

Code	Auditory Group	PTS Start		TTS Start	
		SPL pK [1] (non-analyzed)	SELcum[2] (analyzed)	SPL pK [1] (non-analyzed)	SELcum[2] (analyzed)
LF	Low-frequency cetaceans	219	183	213	168
HF	High frequency cetaceans	230	185	224	170
VHF	Very high frequency cetaceans	202	155	196	140
PW	Phocidae Carnivora	218	185	212	170
PO	Pinniped Otaridae and other carnivores	232	203	226	188

[1] SPL pK (L*p*,0-pk, flat) Re: 1 µPa (flat: non-analyzed values)
[2] SELcum (LE,*p*, 24h) Re: 1µPa^{2}s (analyzed values)

It can be seen that the most demanding category corresponds to very high frequency (VHF) cetaceans, although their hearing range (275 Hz to 189 kHz) is above the frequencies with the highest sound intensity to be emitted during the seismic survey. As indicated in Chapter 4, the maximum emissions from the compressed air power source occur between approximately 5 Hz and 100 Hz in frequency, then the maximum values steadily decay at an approximate rate of 4.5 dB. every 100 Hz.

According to the Acoustic Modeling presented in Chapter 6 whose results for the group of mammals are summarized in Table 25 for CAN_100-108 Area, and in Table 26 for CAN_114 Area, the most demanding condition of SPL pk (0 - p) coincides with the threshold of temporary hearing loss (TTS) of marine mammals of the very high hearing frequency (VHF) type cetaceans. This threshold is reached in a radius of about 1006 meters with center on the source in CAN_100-108 area, and in a 945 meter-radius for CAN_114 Area. The most restrictive permanent hearing loss threshold (PTS) is also for the VHF group, which is reached at about 391 meters for CAN_100-108 area, and at 377 meters for CAN_114 Area. These last distances, those corresponding to the PTS criterion, are used to establish the mitigation zones that in this case could be established at 400 meters for both CAN_100-108 and CAN_114 areas.

Table 25. Distances to the source (meters) to reach the various thresholds and hearing groups assessed. CAN_100-108 Area, based on SW-1000 Point.

Auditory Group	SPL pK (0-p) (dB re 1 μPa)	F1 variant Mud Soil on G3 Gravel variant		AB "base" Sand Soild on GB "base" Gravel	
		0º Azimuth 70º Dip	90º Azimuth 70º Dip	0º Azimuth 70º Dip	90º Azimuth 70º Dip
PTS – LF	219	<50	50	<50	50
PTS – HF	230	<50	<50	<50	<50
PTS – VHF	202	205	391	205	391
PTS – PW	218	<50	52	<50	52
PTS – PO	232	<50	<50	<50	<50
TTS – LF	213	50	97	50	97
TTS – HF	224	<50	<50	<50	<50
TTS – VHF	196	514	1006	524	1006
TTS – PW	212	55	110	55	110
TTS – PO	226	<50	<50	<50	<50
Conventional Limit of Affectation	190	2144	4240	2200	3737

Table 26. Distances to the source (meters) to reach the various thresholds and hearing groups assessed. CAN_114 Area, based on W-1000 Point

Auditory Group	SPL pK (0-p) (dB re 1 μPa)	F1 variant Mud Soil on G3 Gravel variant	
		0º Azimuth 70º Dip	90º Azimuth 70º Dip
PTS – LF	219	<50	50
PTS – HF	230	<50	<50
PTS – VHF	202	200	377
PTS – PW	218	<50	52
PTS – PO	232	<50	<50
TTS – LF	213	50	96
TTS – HF	224	<50	<50
TTS – VHF	196	505	945
TTS – PW	212	54	109
TTS – PO	226	<50	<50
Conventional Limit of Affectation	190	2149	4314

Likewise, as part of Chapter 6, the SELcum criterion was applied in order to verify whether the exclusion distance previously obtained should be extended by exceeding the PTS thresholds for any of the hearing groups.

For this, a minimum duration of the soft start procedure of 20 minutes was considered, verifying that if it increases, the SELcum accumulation shall be lower.

The most restrictive situation of SELcum is generated for cetaceans with low auditory frequencies (PTS - LF). However, if scenarios of reasonable escape trajectories according to the bibliographic antecedents are proposed, SELcum values are lower than the PTS threshold, so the exclusion distance of the SPLpeak criterion is valid.
As for the LF group made up of whales, several studies have shown that acute exposure to noise at close range generates spatial displacements, which generally persist as long as the noise is

maintained (Southall et al., 2007). Chronic exposures of long duration and also of greater spatial extension, generate displacements that extend while the noise is maintained. This displacement may imply loss of access to high-quality foraging habitats, particularly if foraging behavior is seasonal or foraging areas are temporary, fragmented, or highly localized. Displacement can reduce breeding opportunities if it occurs during the mating season. Whales rely on acoustic communication to communicate socially, and they use sounds to mate, breed, feed, and migrate. Although their hearing abilities have not been determined, the impacts of exposure to noise, physiological effects of increased stress levels and behavioral impacts have been documented. Displacements, changes in vocalizations, feeding behavior, abandonment of traditional breeding areas, and sound masking have been registered. Migration studies indicate that they respond actively to noise by deviating, but without significant changes in the migration route. (Dunlop et al., 2013).

Therefore, the feeding habitats and the breeding season are key aspects to evaluate the noise impact at the population level. In the Northwest Atlantic, Moulton and Holst (2010) observed blue whales maintaining greater distances from seismic vessels while batteries of compressed air sources were in operation. Studies carried out during seismic surveys in the United Kingdom from 1997 to 2000 reported that while there were no differences in sighting rates of mysticetes with good visibility based on seismic operations, the whales showed localized evasion when sound energy sources were on operation (Stone and Tasker 2006). It is also well documented that blue whales change vocalization patterns and frequencies during seismic studies (Di Lorio and Clark, 2010).

For the HF group species typical of offshore habitats, measurements of displacements and some indirect measurements of disturbances have been made, such as changes in the behavior of vocalizations in beaked whales, Atlantic spotted dolphins and striped dolphins (Castellote, 2017). Sperm whales chronically exposed to seismic surveys in the Gulf of Mexico did not show avoidance behavior, but reduced their movement and feeding speed (Miller et al 2009). Determinations of TTS in captivity have not been made and there is only an anecdotal description of possible physiological damage due to exposure to noise from compressed air sources in a pantropical spotted dolphin (Gray and Waerebeek 2011). The problems of spatial displacement can end up having undesirable indirect effects such as displacement of the dolphins towards fishing areas where they can be hooked by the nets. In the case of sperm whales, mitigation procedures imply that the animals avoid areas with loud noise, but there is no evidence in favor of their avoidance behavior. While the breeding areas of these species are largely unknown, some generalizations can be made for some of them. Sperm whale distribution is related to topography (Pirotta et al., 2011) and solitary individuals use habitat differently than in groups. The occurrence of oceanic gyres and areas of varied topography such as canyons and seamounts should always be considered as sensitive areas for cetaceans, even if there are no records or they are not abundant.

For the VHF group, it is considered that the most likely impacts shall be due to displacement of the usual areas of action, including staying longer in deep areas. This group is mostly made up of species that are opportunistic predators, exploiting prey that are seasonally abundant. Some species present daily patterns of approach to the coast, either to rest or to feed in the coastal zone. Some species have reduced action areas and are more vulnerable if sound prospecting occurs right there. River mouths and underwater canyons are usually areas where many individuals are concentrated. Alterations in swimming behavior (diving and foraging) could produce effects such as gas exchange problems resulting from repetitive shallow diving patterns (Zimmer and Tyack 2007).

There are documented responses to anthropogenic noise for both PW and PO groups of pinnipeds, including hearing threshold shifts, alarm howls, and feeding cessation. Feeding strategies put them at risk of noise exposure, since many feed at night, others make daily movements to feeding areas by moving along the bottom, and many move deep or for considerable distances to feed. In addition to having ears adapted to aquatic hearing, they have vibrissae that are very sensitive to vibrations in the water and provide information on potential prey. Seismic sound activities affect this sensitivity and mask the movements of prey. Displacements have been observed as the main response to anthropogenic noise. The most vulnerable times are during nursing and weaning. Also many pinnipeds show high fidelity to their breeding colonies and their distance may increase the risk of local extinction of said colonies. Deep-sea diving species may be exposed to sounds greater than those predicted by simple propagation models, particularly in areas of oceanic convergence, which are areas with higher natural noise levels. Many pinnipeds do not have a displacement response with distance from the noise source, but remain on the surface, which means they stop feeding.

3.2.1.2 Avoidance behavior of marine mammals

Some marine mammals can avoid the potential damage that noise can cause from compressed air energy emissions by moving away from the source. They must, therefore, determine where this source is, either by phase differences (arrival time) to their two ears, or by intensity differences.

Richardson et al. (1995) conducted background analyzes on the behavior of marine mammals, concluding that there is a great diversity of abilities for the different species, depending on the frequency range, intensity-duration of the sound peak, seabed morphology, etc. The sound can also arrive directly and then its echo by reflection in the seabed. Observations indicate that marine mammals tend to avoid areas with intense noise. The following graph illustrates the recorded movement of a group of marine mammals when the source of compressed air energy emission is inactive (upper part) and when it is emitting compressed air energy (lower part). Isolines can be seen in the form of concentric circles of equal sound intensity (in dB).

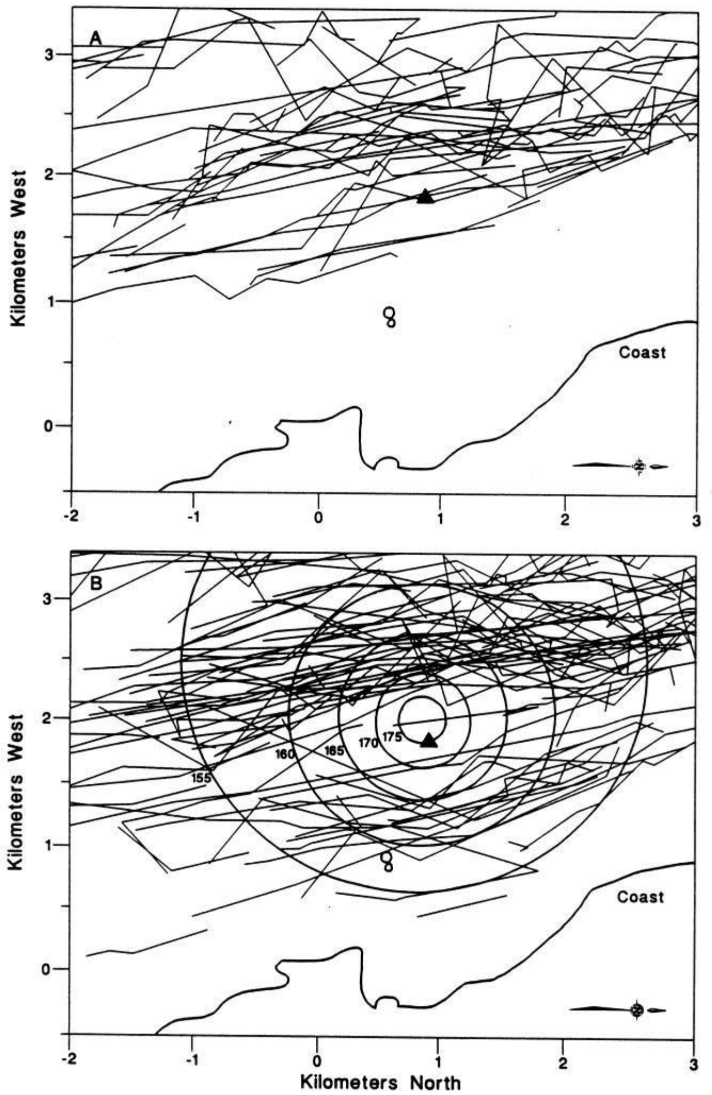


Figure 7. Trajectories of marine mammals (gray whales) with and without the operation of a seismic vessel, and iso-sound intensity lines.

There is background information showing similar behavior, such as the typical experiment presented in the following figure, which corresponds to a crossing between a whale and a seismic vessel in operation. The whale increased its speed from about 7 to 20 km / h as it passed close to the crossing line, preventing the whale-boat distance from being reduced to less than 1.5 to 2 km. The graph on the left shows the trajectories of the vessel, the tracking vessel, and the whale.

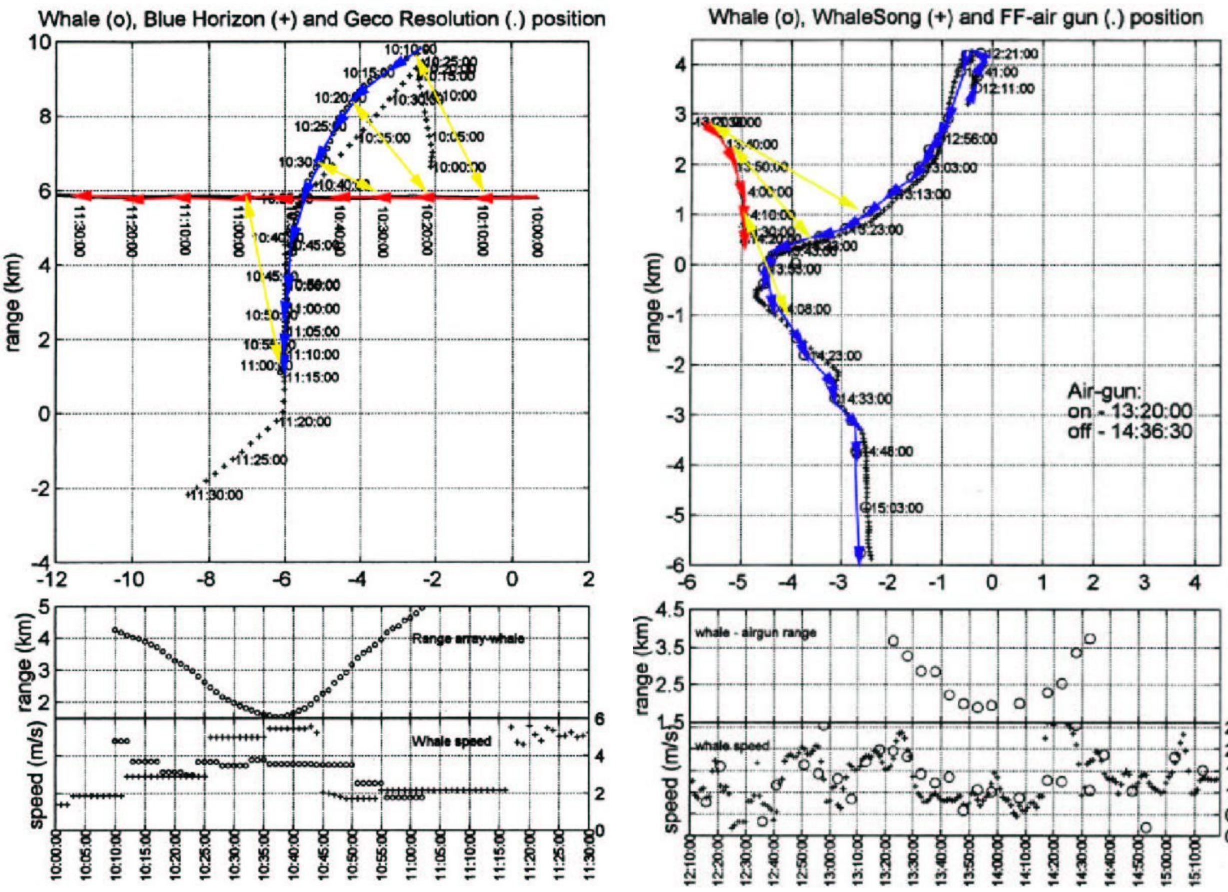


Figure 8. Trajectory of a marine mammal (whale) near an operational seismic vessel.

Another example of moving away from a marine mammal without crossing trajectories is presented in the graph to the right. Again, the animal evolves in order to stay away from the sound source.

Taking into account these characteristics of animal behavior, considering that they tend to move away from the seismic source, the question is whether they shall be able to do so quickly enough to avoid damage or severe impact.

It is important that the noise level increases progressively, so that the animals are not surprised by a high intensity shot when they are a short distance from the source.

This is the principle that applies to the Soft Start, a mitigation procedure that is required in many parts of the world - in particular, in the “Guidelines to minimize the risk of damage to marine mammals from geophysical studies" of the United Kingdom Joint Nature Conservation Committee (JNCC, 2017).

In practice, since the sound of a compressed air energy emission from an individual source generally reaches 220 dB re 1 Pa-m, the sources are activated in a slow sequence until reaching full power, higher than 250 dB re 1 Pa-m real, between 20 and 40 minutes after the start.

The following figure shows results of an experiment carried out by Subacoustech (Nedwell, J., 1999) to measure the sound intensity as a function of the detonation air volume, which indicate a clear upward trend:

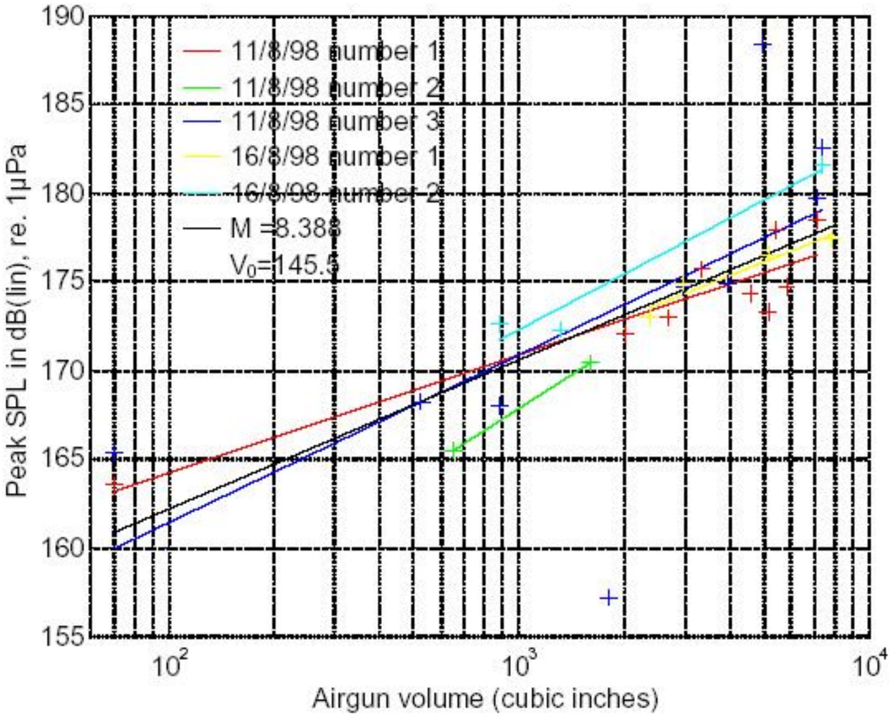


Figure 9. Sound intensity as a function of the volume of the source of compressed air energy emission.

Figure 10 shows that this procedure may be enough to prevent mammals from approaching the source. It shows the distances from the source where the lines of 160 dB re 1 Pa (possible threshold of evasive behavior) and 196 dB re 1 Pa are shown (possible threshold of damage considered in the experiment).

The distance from the source corresponding to a cetacean moving away at a speed of 8 knots (14 km / h) is shown, escaping from a vessel moving at 5 knots (9 km / h), in the worst possible direction (which is the forward direction of the ship). The speed difference shall then be 3 knots, and in this example it can be seen that the animal can be kept at a safe distance from the source.

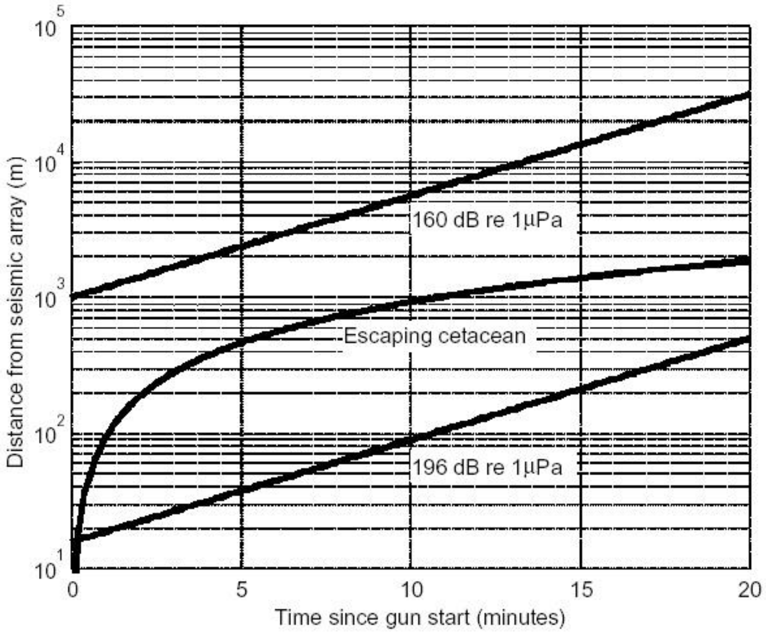


Figure 10. Distance from source based on time for a Soft Start.

Although this system does not guarantee that all marine mammals shall be able to get away from the source in all circumstances, and that there may also be a negative factor which implies an increase in the amount of “not useful” noise, it is considered an appropriate measure to minimize risks to both individual and animal populations.

3.2.1.3 Importance of impact

According to the Environmental Sensitivity Analysis, the area where the seismic prospecting is planned would work as transit and feeding areas. It is not a breeding area for the most abundant marine mammals, however, for some with a probable presence, this possibility cannot be ruled out due to lack of information. The sensitivity could be considered moderate throughout the year. In the case of the 4 species of whales classified as highly sensitive (Southern Right Whale, Sei Whale, Blue Whale and Fin Whale) a clear period of greater sensitivity is not identified, but spring could be considered the most critical.

In this sense, it is possible to consider that the existing controls associated with the project include the use of a soft start procedure that shall be carried out each time the set of sources is activated after a period of inactivity (greater than 20 minutes) when the sound gradually increases over a period of time, and specialized personnel check that there is no presence of mammals in the exclusion radii established around the sound emission sources before the seismic source soft start is activated.

Considering the implementation of mitigation measures (soft start), the acoustic modeling establishes that the most restrictive permanent hearing loss threshold (PTS) of cetacean marine mammals of the very high auditory frequency (VHF) is reached within a radius of about 391 meters centered on the source for CAN_100-108 area, and 377 meters for CAN_114 Area.

Based on the proposed assessment methodology, and taking into account the sensitivity of the project's area of influence, the intensity of the impact is cautiously considered high during the spring period and moderate in summer bearing in mind the project period (spring 2021 - summer 2022). The impact shall be partial considering the affectation of only a portion of an important feeding area that has a much wider distribution. The effect shall be immediate since the development of the acquisition action and the beginning of the effect would be contiguous. Persistence shall be temporary since it is valid only during the emission of the sound and reversible in the short term, since the most common effects shall be behavioral changes and shall be reversed at the end of the tasks. The effect could be direct (due to sound) or indirect (due to the modification of the trophic chain due to alteration of their food sources - fish, invertebrates-); The direct impact is considered for the evaluation since it would constitute the worst condition, while, as shall be seen later, no high-magnitude effects are expected on the lower levels of the trophic web affecting this component. The impact shall be periodic (in the sense that it is not an unpredictable or constant effect in time) since all the activity is programmed, and can be mitigated through the application of the aforementioned protocols. By definition, seismic impulses produce a cumulative effect on mammals. Considering the most unfavorable condition that would occur when the surveys are carried out in spring 2021, the importance of the impact of the seismic acquisition on marine mammals is moderate.

The numerical assessment adopted for each of the qualifiers and the importance value of the resulting impact according to the matrix methodology is presented in Table 36.

3.2.2 Navigation of seismic and support vessels and physical presence of the seismic equipment

Seismic vessel navigation and support vessels can present a potential physical hazard to marine mammals.

If these impacts occured, they would take place mainly in the high seas environment. The activities are planned to last approximately 159 days and involve the seismic vessel, the towed seismic equipment and the support vessels. The logistics vessel shall in turn participate in the transfer of waste, supplies and crew from the seismic vessel to the Port of Mar del Plata, which may imply an impact outside the operational areas of the seismic data acquisition areas, but limited to navigation routes.

Many species of marine mammals can be vulnerable to physical disturbances or collisions with moving ships. Most collision reports involve large whales, but collisions with smaller species also occur (van Waerebeek et al., 2007). Marine mammal species of concern about potential collision with speeding vessels are primarily slow-moving species and those that dive deep while on the surface (eg, sperm whales, beaked whales) (BOEM, 2014).

The consequences of a ship colliding with a marine mammal can range from a minor disturbance or injury to the worst case of death. This risk is considered limited given the relatively low volume of Project-related traffic and the speed at which Project vessels are expected to move (less than 5 knots) and that the movement of the seismic vessel is generally in a straight line, although the logistics vessel can move faster (10-12 knots) while in transit to and from seismic data acquisition areas during refueling / crew change operations. The seismic vessel shall also travel faster (13-15 knots) during mobilization to the seismic data acquisition areas, but these operations are limited to a few days (around 2 days of mobilization, 2 days of demobilization and one of transit between CAN_100-108 areas and CAN_114 area). Ship speed is a key factor in determining the frequency and severity of ship collisions, and the potential for a collision increases as from a speed of 15 knots (NOAA, 2016).

Behavioral effects such as collision risk are usually more significant in the case of small, fast vessels that change direction frequently, as opposed to the large and relatively slow vessels associated with the project (NOAA, 2019).

In general, it is assumed that the probability of impact is very low. However, vessel operations within breeding or migration corridors can increase the probability of a vessel colliding with these species.

As mentioned above, although the area where the vessels associated with the project shall operate would not constitute a breeding or nursery area for the most abundant marine mammals, it would work as a passage area and a feeding area. Although no clear period of increased sensitivity is identified, spring could be considered highly sensitive, and moderate for the rest of the year. Although the project covers a part of this period of greater sensitivity (beginning during the month of October 2021), it is likely that the trajectory and movements associated with the seismic and support vessels shall not be significant considering the vast surface of the environment in open waters and the low number of vessels associated with the project (3), so the intensity of the impact is considered medium. In addition, the waters surrounding the prospecting vessel during it shall be closely monitored by Marine Fauna Observers to detect the presence of marine mammals. The scope of the impact would be specific, given the low frequency of occurrence and the non-random distribution of both marine mammals and exploration activity in the project area. The persistence shall be temporary since it is valid only for the duration of the project and reversible in the short term, as the most common effects shall be behavioral changes that shalll be reversed at the end of the campaign, and dealt with through the application of the protocols already mentioned. Having considered the above, the importance of this impact on marine mammals is low.

3.2.3 Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other operations)

3.2.3.1 Sound emissions from ships (and helicopters)

Underwater and aerial sound emissions shall be produced as a result of the operation of the project vessels and eventually the helicopter that shall operate upon emergency situations.

The dominant source of ship noise comes from the operation of the propellers, including cavitation and propulsion, and the intensity of this noise is largely related to the size and speed of the ship.

In general terms, the larger the size or speed of the vessel, the higher the emission levels (Richardson et al., 1995). Depending on the size and speed, emission levels can vary between (Gotz et al., 2009) the following:

- 160 – 175 dB re 1µPa (SPL) for boats up to 50 m in length (usually used for recreational use and water sports)

- 165 – 180 dB re 1µPa (SPL) medium vessels between 50 and 100 m in length (as the seismic and support vessels are for the project under study)
- 180 – 190 dB re 1µPa (SPL) vessels greater than 100 m in length (container / loader vessels, supertankers and cruise ships)

In the case under study, the seismic vessel shall operate at speeds between 4 and 5 knots, while the support vessels shall be able to operate at higher speeds to effectively travel the area around the seismic vessel.

The BGP Prospector is 100 m long. In this sense, the seismic vessel is expected to have the greatest acoustic impact of the total number of vessels involved in the operation, with an estimated emission level of approximately 180 dB re 1µPa (SPL).

Under normal operating conditions and with the exception of logistics vessel transfers, the impacts associated with emissions from support vessels shall be limited to the vicinity of the seismic vessel within CAN_100-108 and CAN_114 operational areas.

The seismic vessel shall operate at speeds between 4 and 5 knots, while container ships and other cargo ships move at typical speeds between 13 and 23 knots, so the noise levels of the vessels associated with the project shall not exceed those of any other vessel that normally operates in the area. Likewise, given the small number of vessels associated with the project (3), the additional volume of vessels is not expected to constitute a significant increase in the existing vessel traffic in the project's area of influence.

Since these ships are generally quiet, machinery and other propulsion-related noises are temporary and generally do not propagate long distances from the ship. During most of the time that the seismic vessel is navigating, it shall be operating its compressed air sources, for which there shall be very limited periods of time in which the acoustic assembly is not operational, hence, the sound of the vessels may be the predominant sound source in the project.

The effects of noise produced by moving seismic and support vessels on marine mammals still lack firm conclusions. There is a wide range of reports of their observed behavioral responses, differing between species. Several species of small toothed cetaceans have been observed to avoid boats when they approach within 0.5-1.5 km (0.3-0.9 mi), with occasional reports of avoidance at greater distances (Richardson et al., 1995). Reports of responses of cetacean species to moving motor vessels are variable, both between species and temporarily. North Atlantic right whales can change behaviors, specifically calling behavior (changing the calling frequency), to compensate for increased low-frequency noises, such as ship-associated noise (Parks et al., 2007). Most beaked whales tend to avoid approaching vessels (Würsig et al., 1998) and can submerge for an extended period when approaching one (Kasuya, 1986). On the other hand, dolphins can tolerate boats of all sizes, often approaching and riding the prow and stern waves (Shane et al., 1986). At other times, dolphin species known to be attracted to boats shall avoid them. Such evasion is often related to previous harassment of animals by ships (Richardson et al., 1995). Pantropical spotted dolphins (*Stenella attenuata*) and spinner dolphins (*S. longirostris*) in the eastern tropical Pacific, where they have been targeted by the tuna fishing industry due to their association with these fish, are shown to avoid study vessels up to 11 km away (Au and Perryman, 1982; Hewitt, 1985), while spinner dolphins in the Gulf of Mexico were observed skirting the bow of the seismic boat in all 14 sightings of this species during a survey (Würsig et al., 1998).

Therefore, it could be assumed that noise associated with project-related survey vessels may, in some cases, cause behavioral changes in individual marine mammals near these vessels. These behavior changes can include evasive maneuvers, such as diving or changing direction and / or swimming speed.

Based on the sound level generated by the vessels, the potential impacts are expected to be limited to non-physiological effects such as behavior change and localized avoidance. The effects of noise from ships on marine mammals are considered insignificant taking into account the small number of vessels associated with project activities within the operational area and on the assumption that individuals or groups of marine mammals may be familiar with the various and frequent noises related to vessels.

Also the noise of the engine, the propellers, and the physical presence of the helicopter flying low can disturb marine mammals both through noise and visual disturbance. Helicopter operation produces loud underwater sounds for brief periods when the helicopter is directly overhead (Richardson et al. 1995). The sound level received underwater depends on the altitude of the aircraft, its direction and angle in relation to the receiver, the depth of the receiver, the depth of the water, and the type of seabed. The sound emitted by helicopters is usually below 500 Hz and the sound pressure is higher on the surface of the water directly below the helicopter, but decreases rapidly with depth. The duration of the underwater sound of passing aircraft is much shorter in the water than in the air; For example, the literature identifies that a Bell 214 helicopter (declared one of the loudest) is audible in the air for 4 minutes before the helicopter passes over the underwater hydrophones and is audible underwater for only 38 seconds at 3 meters deep and 11 seconds at 8 meters deep (PGS, 2018). Due to these physical variables, the exposure of marine mammals to aircraft-related noise (including airborne noise and underwater noise) is expected to be short-lived.

Considering the eventual use of the helicopter that shall only operate in the event of an emergency that requires air evacuation, along with the short duration of potential noise exposure and visual disturbance, the potential impacts of this activity are expected to be insignificant.

3.2.4 Oil spills

Another potential environmental impact derived from the project is related to the inherent risk of accidental hydrocarbon spills. These risks are common to all ship operations, and must be managed through proper planning and aplicable measures in case of contingencies. Such measures would reduce the risk avoiding any damage to the aquatic ecosystem.

In general, an oil spill on ships involves small amountsand the hazards associated with oil and fuel spills during the development of the project (which are considered more plausible) are the following:

- Small amounts of hydraulic oil or lubricating oil leak or spill on the decks of the seismic vessel and support vessels.

The size of possible spills of hydraulic oil or lubricating oil on the decks of the seismic vessel and of the support vessels is estimated to be less than 50 liters (based on the leak frequency analyzes of the shipping industry[2]). This quantity is mainly related to the capacity of the containers that are commonly used, in addition to the volumes of hydraulic oil contained in the hoses of the equipment. In this case, most of the spilled material shall be kept in the collection trays and directed to the bilge tanks, preventing its discharge into the water. Containers used on ships for hydrocarbon storage range in size from less than one liter to 200 liters (barrels). The larger barrels, up to 200 liters, can be used for oils such as motor lubricating oil, but they shall always be used and stored in internal and / or fenced areas where any spill or leak would be fully contained on board.

- Loss of MGO during refueling operations, as a result of hose connection failure, hose break, or tank overfill.

[2] Max Roser (2013) - "Oil Spills". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/oil-spills

In the case of overfill spills, these shall be directed to the ship's drainage system and contained in the slops tank system. In the worst case, the volume of MGO spilled during refueling operations could be due to the total loss of the contents of the transfer hose. Actually, a more likely hypothesis is a leak through a small hole or a crack in the hose (caused by abrasion or mechanical damage), which would result in a very visible shine on the water surface if it occurs, which shall allow measures to be taken to stop the leak (by the supervisors of the operation) before a few liters have been spilled. The bibliography indicates that a spill in the transfer of fuel in seismic vessels ranges between less than 150 and 2,000 liters (NOAA, 2016). The minimum volume of less than 150 liters represents a spill in which the quick disconnect and positive pressure hoses are working properly. The maximum spill volume of 2,000 liters represents a spill in which prevention measures fail or fuel lines are broken.

Likewise, the probability of a large fuel spill is remote (BOEM, 2014; NOAA, 2016). Loss of all fuel from the seismic vessel is considered particularly unlikely as it is stored in a series of smaller double bottom tanks (the BGP Prospector seismic vessel is equipped with 17 fuel tanks, the two largest ones contain 321 and 281 m3, the remainder does not exceed 200 m3) and the content loss of all tanks is completely remote. Fuel tanks are never 100% full, they are usually only up to 90% full. In addition, the valves connecting the fuel tanks are kept closed, minimizing the loss of fuel if one of the tanks breaks, while the leaks in the storage tanks are directed to the oily bilge water tanks. Only rarely can a ship-to-ship collision cause the fuel tank to break and spill into the water. The analysis of accident statistics in water transport carried out by the International Association of Oil and Gas Producers (OGP, 2010) shows that collisions between ships represent only 12% of the total ship leakage and that the probability is extremely low. For this to occur, the collision must be strong enough to penetrate the ship's hull in the exact place of the fuel tank, which is unlikely. In addition, the hull of the seismic vessel is double-lined. Therefore, in the extremely unlikely event that a fuel tank breaks as a result of a collision, the maximum size of the spill would correspond to the volume of the affected tank. In this sense, it is worth noting that a collision of this type is highly unlikely to occur during seismic prospecting since the seismic vessel and the support vessels shall have to comply with the general maritime and navigation safety procedures (use of lights, beacons, radio contact, etc.), added to the navigation exclusion zone that is established around the seismic vessel and the array for its safe navigation (up to 4 km in front of the vessel and on each side, and up to 12 km behind).

The potential impact of a fuel spill is highly dependent on its location, the weather conditions at the time of release, and the proper response and cleanup operations. Diesel is a refined petroleum product that is lighter than water. It can float on the surface of the water or be dispersed in the water column by the action of waves It is assumed that the spilled fuel would spread rapidly to form a layer of varying thickness and break into narrow bands or rows parallel to the direction of the wind. Diesel is a distillate of crude oil and does not contain the heavier components that contribute to the longer persistence of crude oil in the environment. Small diesel spills (200-20,000 liters) tend to evaporate and disperse in a day or less, even in cold waters (BOEM, 2014); therefore, oil seldom remains on the surface for response teams to retrieve. However, what is commonly referred to as "marine diesel" is usually a heavier intermediate fuel oil that persists longer when spilled. When spilled into water, diesel spreads very quickly to form a thin film of rainbow and silver sheen, except for marine diesel, which can form a thicker film of slightly duller colors (BOEM, 2014). In turn, there is the possibility that a small proportion of the heavier components of the fuel shall adhere to the particles at the top of the water column and sink.

Given that most of the project activities shall take place in open water, any diesel fuel spill would be subject to rapid dispersion, weathering, evaporative losses and dissipation throughout the water column, so the temporary and spatial extension of any adverse effect is limited.

The effects of a small fuel spill that are considered more likely to be associated with fuel transfers would depend on the sea conditions at the time of the spill. With strong winds and rough seas, the MGO would quickly dilute and disperse, and the effects of the spill would be of little consequence. In calmer waters, the evaporation of the diesel would be rapid and the area covered by the dispersion of the remaining hydrocarbon would depend on the speed and direction of the wind, and the temperature of the water.

The spill can affect marine mammals through several routes: superficial contact of the fuel with the skin and other mucous membranes, inhalation of concentrated petroleum vapors or ingestion of the fuel (direct ingestion or by ingestion of oily prey). The potential impacts to marine mammals shall largely depend on the size and location of the spill, as well as the weather conditions at the time of the spill.

Marine mammals are generally less sensitive to oil spills than seabirds, as they tend to avoid and move away from affected areas and avoid any breeding or feeding behavior, thus reducing direct physiological impacts, and returning as the environment recovers. However, marine mammals remain sensitive to the impacts of oil spills and, in particular, to the hydrocarbons and chemicals that evaporate from the oil, especially in the first few days after a spill.

Direct contact of oil with the surface appears to have little harmful effect on whales, possibly due to the effectiveness of the skin as a barrier to toxicity. Since cetaceans mostly have smooth skins and limited areas of fur, the possibility of oil sticking to the species is limited, as oil tends to stick to rough surfaces. However, the species can be affected by exposure to oil at the surface during surges to the surface, which carries aspiration hazards that are present in fresh spills (GESAMP, 2002). Such exposure could damage the mucous membranes or airways during surfacing.
Given the rapid evaporation of the fuel, it is likely that the temporal and spatial extent of the oil slick is limited, so it is expected that only individual marine mammals may be affected, however this is not considered significant at the population level. Considering the presence of threatened species in the area of influence of the project, the loss of a specimen is estimated to be of high intensity, its punctual extension is a non-reversible direct impact, but limited in time (temporary) because, in any case, exposure to an impact of this type is limited to the duration of the project. In the case of an accidental event, its periodicity is computed as irregular, so the impact is moderate.

3.2.5 Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste

Chemicals used on board during seismic operations are limited to small amounts of cleaning products, solvents, and paints. These chemicals could accidentally spill during storage and / or handling and enter the aquatic environment through the deck drainage system. Chemicals (e.g. solvents and detergents) are typically stored in small 5 to 25 liter containers and are stored / used in internal areas where any leaks would be retained on board and cleaned in accordance with associated spills leaning procedures.

Deck drainage consists of two distinct areas:

- Drainage of covered areas (which contain chemicals and are spill risk areas) that are isolated from the open deck area; and

- Open deck areas that manage "uncontaminated" water runoff (wash water, rainwater, and sea spray) and drain directly into the aquatic environment.

However, some spills could occur when small containers of chemicals are used in open areas, where there is a risk of reaching the sea if spilled. Given the size of the chemical containers, the volume of liquid that could be released is limited to the volumes of the individual containers stored on deck and is likely to be small. The realistic volume is 25 liters in the worst spill situation.

In addition, ships operate with safety data sheets (SDS) available for chemicals on board that detail clean-up procedures for any spills. In turn, the crew receives training on these spill clean-up procedures.

Chemicals released into the sea can cause a reduction in water quality with direct or indirect effects on marine organisms. In any case, the impacts would be limited to the immediate area surrounding the discharge point, before dilution with the surrounding seawater.

In the open sea environment of the study area, a release is expected to dilute and spread rapidly so any contamination would be temporary and localized. With the on-board controls (for example, inspection, placement of barriers, spill clean-up procedures) such incidents are considered unlikely so the impact is deemed insignificant.

On the other hand, small amounts of non-biodegradable and hazardous solid waste may be produced during the development of the project.

These wastes shall be generated, handled and stored on ships in accordance with the Waste Management Program of each ship, which the waste minimization hierarchy shall adopt to avoid its discharge into the sea.

Non-biodegradable / hazardous solid waste shall be handled in accordance with the ship's Waste Management Program, which is governed by the policy of "not throwing non-biodegradable / hazardous solid waste overboard". Under normal circumstances, there should be no impact on the marine environment. However, accidental spillage to the marine environment is possible, especially in rough sea conditions, when items can roll or be thrown off the deck.

The individual impacts are evaluated below:

- In the case of material dispersed by the wind, the volume shall be small, but in the case of materials such as plastic, impacts on individual animals can occur. Given the presence of threatened species in the study area, the worst possible impact as the mortality of a protected species (a single animal) has been assessed. With the controls applied on board, the impacts of such incidents are considered unlikely and insignificant.

- Hazardous waste spilled in the aquatic environment can cause a reduction in water quality with direct or indirect effects on marine organisms. Impacts would be limited to the immediate area surrounding the spill, prior to dilution with the surrounding seawater. In the open ocean of the study area, a release is expected to be small in volume and to dilute and disperse rapidly. Therefore, the contamination of the surrounding waters would be temporary, localized and recoverable. With the controls applied on board, these incidents are considered highly unlikely (see section on spills on deck) and the impact is considered insignificant.

The analysis allows us to assume that the impact corresponding to contingencies in the disposal of waste and accidental spills, should not be significant and would result in a very low probability of occurrence, if we consider that ships must comply with all the environmental requirements specified by current regulations and by EQUINOR standards.

3.3 FISH AND CEPHALOPODS

According to the analysis carried out in POINT **Error! Reference source not found.** that is summarized in Table 22, the actions of the project that can cause potential impacts on the ichthyofauna and cephalopods present in the area of influence include the following:

- Operation of seismic sources (compressed air emissions);
- Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other operations) (in terms of light and sound emissions from ships);
- Oil spills; and
- Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste

3.3.1 Operation of seismic sources (compressed air emissions)

Various international investigations have shown that the noise energy generated during seismic studies can cause physiological damage and / or behavioral responses of fish and invertebrates (Carroll et al. 2017, Przeslawski et al. 2016). The possible effects on marine fauna have been classified into different types (Hawkins and Popper 2017):

a) Physical and / or Physiological Effects: Tissue damage and other physical damage or physiological effects, which are recoverable but which can place animals at lower levels of physical fitness, can make them more open to predation, feeding and poor growth, or lack of breeding success, until recovery occurs.

b) Hearing damage: Short-term or long-term changes in hearing sensitivity (temporary threshold change - TTS or permanent threshold change - PTS) may or may not reduce fitness and survival. Hearing impairment can affect the ability of animals to catch its prey and avoid predators, and can also ruin communication between individuals; affecting growth, survival and reproductive success.

c) Masking: The presence of man-made sounds can make it difficult to detect biologically significant sounds against background noise. Masking the sounds produced by prey organisms can lead to reduced feeding with effects on growth. Masking the sounds of predators can result in reduced survival. Masking the spawning signs can reduce spawning success and affect recruitment. Masking the sounds used for orientation and navigation can affect the ability of fish to find preferred habitats, including spawning grounds, affecting recruitment, growth, survival, and breeding.

d) Behavioral responses: Behavioral changes can occur in a large proportion of sound-exposed animals, as these responses can take place at relatively low sound levels. Some of these behavioral responses can have adverse effects. Displacement of preferred habitats can affect feeding, growth, predation, survival, and breeding success. Changes in movement patterns can affect energy assumptions, diverting it from egg production and other vital functions. Migrations to spawning or feeding grounds can be delayed or prevented, with detrimental effects on growth, survival and breeding success. Preventing recruitment and settlement in preferred habitats can affect colonization and population size in any area exposed to high noise levels.

3.3.1.1 Hearing sensitivity of Fish

Fish can detect sounds in a comparatively low frequency range of the spectrum, ranging from several tens to hundreds with thresholds that can exceptionally reach 6000-7000 Hz (Popper and Fay, 1993). In fish, the spectral range of the detected frequencies depends a lot on the presence of the accessory structures and the specialization it possesses (Kasumyan, 2005). The more general species of hearing, which do not have accessory structures, normally detect sounds at frequencies below 1000-1200 Hz, while this is notably increased when there are species with specializations which are less common in marine fish.

Virtually all research on the impacts of anthropogenic underwater sounds has focused on the sound pressure component (Carroll et al. 2016); many fish, especially those lacking a gas-filled bladder, such as all elasmobranchs and marine invertebrates, are sensitive only to the particle motion component of sound (Edmonds et al. 2016; Solan et al. 2016). Seismic studies result in large horizontal particle motion components (in addition to pressure components). It is important to take into account that there are substantial differences in the effects of emissions on the behavior and hearing sensitivity of different fish species for the assessment of seismic emissions impacts (Popper and Fay 2011; Popper et al. 2014). Fish lacking a swim bladder are only sensitive to the movement of sound particles and only show sensitivity to a narrow band of frequencies (e.g., flat-Pleuronectiformes fish and Chondrichthyes). Thus, fish species that lack a gaseous cavity, including jawless fish, elasmobranchs (sharks, rays, and skates), some species of freshwater fish, some gobids, and some tunas, and other pelagic and deep waters species are not as vulnerable to trauma caused by extreme changes in sound pressure. These species are normally only capable of detecting low frequency sounds (<1500 Hz). Cartilaginous fish are very sensitive to low-frequency sound (~ 20 Hz to ~ 1500 Hz) and the lack of a swim bladder or other gas-filled chambers in this group restricts their detection ability to the particle movement component of sound (Myrberg, 2001, Casper et al., 2012). These species mainly detect the movement of the particles and not the sound pressure (Casper and Mann, 2007; 2009). On the other hand, evidence suggests that pelagic species have more sensitive hearing (thresholds at lower frequencies) than demersal ones (Casper, 2011).

Fish with a swim bladder in which that organ does not appear to play a role in hearing come second. These fish are sensitive only to the movement of the particles and show sensitivity only to a narrow band of frequencies. This group includes salmonids (Salmonidae) and some tunas (Scombridae), but many other species may also fall into this category. It is important to note that gas bladders, and their anatomical location within the body, make fish more susceptible to pressure injuries (sound pressure and barotrauma) to the ears and body tissues in general than species without gas bladders (Popper et al. 2014).

In the next degree of sensitivity are fish with swim bladders that are close to, but not intimately connected to the ear. These fish are sensitive to both particle movement and sound pressure, and show a frequency range that extends to around 500 Hz. This group includes cod fish (Gadidae), eels (Anguillidae), some triggerfish and sea bass (Sciaenidae), and perhaps other fish. At the other end, there are fish with special structures that mechanically link the swim bladder to the ear (Weber's organ). These fish called Osteichthyes are sensitive mainly to sound pressure, although they also detect the movement of particles.

Species with various accessory structures belong to different orders such as Osteoglossiformes, Elopiformes, Perciformes, Beryciformes, Clupeiformes, Cypriniformes, Siluriformes, Characiniformes and various other orders). As these species hear better than others, their hearing is more likely to be affected by lower levels of masking, which could lead to greater behavioral effects. As regards bony fish, the proximity of the swim bladder to the inner ear is an important component in hearing, as it acts as a pressure receptor and vibrates in phase with the sound wave. Direct contact of the bladder with the labyrinth or with the surrounding bones of the skull can be found in fish of different systematic groups. In several representatives of the Holocentridae family (Beryciformes), this contact is made by means of the prolongation of protrusions of the bladder or ending at a distance from the labyrinth (Coombs and Popper, 1979). The protuberances of the swim bladder are common in many fish belonging to the Gadiformes order.

The vibrations of the otoliths thus result from both the velocity component of the sound particles and the stimulation of the swim bladder. In general, species known to possess potential sound pressure sensing specializations (i.e. a body of gas near or in contact with the ears) have lower sound pressure thresholds (55-83 dB re 1 µPa) at the best frequency, and respond to higher frequencies (200 Hz-3 kHz) than fish lacking these morphological adaptations (Ladich and Fay 2013). The proximity of the gas retention chambers and / or their direct mechanical connection to the inner ear, allow fish to detect sound pressure and improve their hearing ability by increasing their detectable frequency range and lowering their sound pressure threshold (Lechner and Ladich 2008, Popper et al., 2014). This group of species with this type of hearing includes some of the squirrel fish (Holocentridae), triggerfish and sea bass (Sciaenidae), and herring (Clupeidae). For example, all clupeids are capable of detecting sounds at around 4 kHz, and a group of clupeids of the Alosinae subfamily can detect and respond to ultrasonic sounds at more than 180 kHz (Mann et al. 1998, Mann et al. 2012; Popper et al., 2004). Some species have a functional physical connection between the swim bladder, or some other gas chamber, and the inner ear (Braun and Grande, 2008).

Although the high-frequency energy of the received seismic impulses must be taken into account, the low-frequency sounds from seismic surveys would be the most damaging and fish with specialized hearing systems have lower thresholds and respond to higher frequencies. Pelagic species also have lower thresholds than demersal ones. There is some evidence that the divisions among fish defined above may apply not only to their hearing abilities, but also to the effects in terms of injuries derived from exposure to high-level sounds (Popper et al., 2014). Sudden pressure changes, either hydrostatic pressure or sound pressure, can cause rapid movement of the walls of gas-filled cavities, particularly impulsive sounds. These movements can cause damage to nearby tissues, such as the kidney and gonads.

Hearing loss is a direct consequence of the impact of seismic waves and can be permanent or temporary. A temporary change threshold (TTS) is recognized that represents the loss of hearing for a certain period of which the fish usually recovers within a period of one day, while the permanent change threshold (PTS) does not allow recovery. Although the TTS level is lower than the PTS level, the cumulative effect of the waves on the TTS level, particularly if they are emitted continuously, can cause the fish to reach the PTS. This is very important in the experiences of seismic explorations since precisely these emissions are not punctual but continuous over several days, generating a level of cumulative exposure sensitivity. In this sense, McCauley et al. (2000) note that even though a species may receive an emission of only 155 dB re 1µPa2.s (equivalent energy) in an area of 60x90 km in the course of a one-month survey, the number of discharges represents a daily rate of 300 daily emissions on the same organism if it only moves within the seismic area and does not leave it permanently. Figure 11 presents the relationship between threshold levels and the expected effects due to the impact of seismic waves.

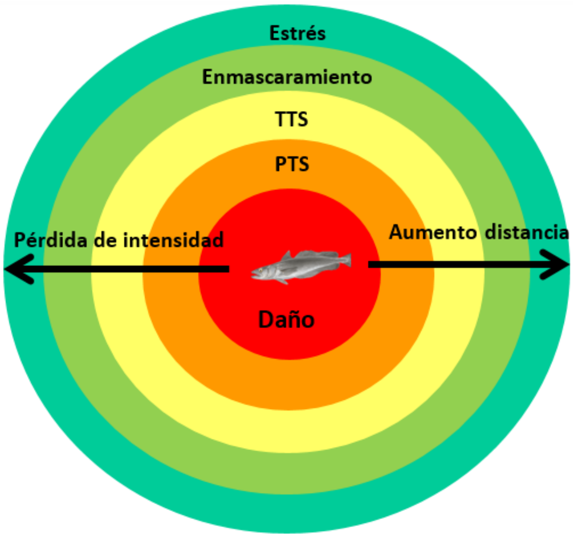


Figure 11. Category of anthropic noise effects linking distance to source and intensity. Damage occurs near the source origin while stress occurs farther away as intensity is reduced. TTS: temporary change threshold; PTS: permanent change threshold (adapted from Putland et al., 2019).

(Translation of Figure 11: Stress. Masking. Loss of intensity (left). Increased Distance (right). Damage)

The TTS has been verified in some fish, and its extension is of variable duration and magnitude. Popper et al. (2014) suggest that TTS occurs at> 186 dB SELcum for fish without a swim bladder using particle motion detection, and <186 dB SELcum for fish with a swim bladder involved in hearing. Data from exposure to impulsive sources suggest that the effects of seismic impulses would be greater in fish with a swim bladder (Casper et al. 2012). Studies of adult fish caged in a shallow bay and exposed to seismic waves (0.33 l, source level at 1 m 222.6 dB re at 1 µPa pp) at a distance of 5-15 m, suffered extensive hearing damage, with no evidence of recovery almost 2 months after exposure (McCauley et al. 2003).

These authors exposed some 15 species of fish to seismic impulses of varying intensity, keeping the fish in captivity and conducting the experiments after a period of acclimatization. The fish showed type C alarm responses (involuntary contractions of muscle fibers on one side of the body, causing a strong general bow of the fish) at high intensities. Likewise, the results of the analysis of the auditory epithelium of Chrysophrys auratus showed ablation of the cells. However, the fish did not show hormonal signs of stress as a result of the experiment. These studies showed that the caged Silver seabream (Pagrus auratus) suffered extensive damage to the hair cells located in the sensory epithelium of the inner ear, after being exposed to sounds from experimental sources of compressed air for two periods of time with a 1:12 hour-break in between. The experiments were carried out at distances from 400-800 meters up to 5 m from the cage. The damage was severe, with no evidence of repair or replacement of damaged sensory cells for up to 58 days after exposure. The sources emitted at 223 dB re 1 µPa PP 1m / 204 dB re 1 µPa RMS at 1m. The inner ear of the Silver seabream is typical of most commercially important species (eg, salmon, tuna, cod, haddock), making this study particularly interesting.

There is evidence of injury to the hearing organs of adult fish from sound levels lower than those expected to be in close proximity to seismic sources (McCauley et al. 2003). Repeated discharges from compressed air sources onto caged fish caused severe damage to the sensitivity of the inner ear hair cells after 18 hours of exposure, and the damaged cells did not recover after 58 days (DFO 2011). The maximum sound levels corresponded to those found <500 m from the source (180-190 dB RMS). Through cage experiments, McCauley et al. (2000) indicate that at 156-161 dB RMS the fish show alarm signals, and as from 171 dB RMS a process of otolith displacement begins. In short, fish with auditory specializations have lower threshold values for sound pressure and a wider frequency range than non-specialized species that are only sensitive to the movement of particles (Popper et al 2014).

Regarding fish larvae, although little data are available, the species studied seem to have hearing frequency ranges similar to those of adults (and similar acoustic distress thresholds) (Wright et al. 2011). Swim bladders can develop during the larval stage and can make larvae susceptible to pressure-related injuries (e.g., barotrauma).

Table 27 shows the threshold levels for fish with and without a swim bladder, differentiating those that have Weber's apparatus (ostareophysi). The value of SPL (peak) and SELcum is presented. The effects on fish tissues can be very different depending on the time between wave impacts and recovery is possible with periods of some separation between sounds. Carlson et al. (2007) suggested that for fish larger than 2 g (small larvae), the SELcum value for non-auditory tissue damage should be 190 dB re 1 µPa^2.s, and for fish less than 1 g, they suggested a SELcum of 183 dB re 1 µPa^2. s. They also pointed out that as the fish grow, the exposure value must increase even more. They recommended a conservative value of 197 dB re 1 µPa^2.s SELcum for fish over 8 g, and a value greater than 213 dB re 1 µPa^2.s SELcum for fish over 200 g. In any case, Popper et al. (2006), based on the advantages and limitations of the different types of measurement used, suggest applying SPL (peak) and SEL thresholds.

Table 27. Threshold sensitivity values proposed for fish with and without a swim bladder (adapted from Popper et al., 2014)

Type of fish	Level of mortality or potential mortality	Recovery level	TTS
Without swim bladder (particle motion detection only)	>213 dB peak or >219 dB 24 h SELcum	>213 dB peak or >216 dB 24 h SELcum	>> 186 dB 24 h SELcum
With swim bladder not connected to the ear (particle motion detection only)	> 207 dB peak or 201 dB 24 SELcum	>207 dB peak or >203 dB 24 h SELcum	>>186 dB 24 h SELcum
With swim bladder connected to the ear (mainly sound pressure detection)	>207 dB peak or 207 dB 24 h SELcum	>207 dB peak or 203 dB 24 h SELcum	>>186 dB 24 h SELcum

According to the Acoustic Modeling presented in Chapter 6 and whose results for fish are summarized in Table 28 and Table 29, the most demanding SPL pk (0 - p) condition that corresponds to the potential mortality and recovery threshold for fish with swim bladder (both for those who have it connected to the ear and those who do not) is reached about 206 meters from the source in CAN_100 and CAN_108 areas, and about 200 meters for CAN_114 area.

Table 28. Distances to the source (meters) to reach the various thresholds and hearing groups assessed. CAN_100-108 Area, based on SW-1000 Point

Auditory Group	SPL pK (0-p) (dB re 1 μPa)	F1 variant Mud Soil on G3 Gravel variant		AB "base" Sand Soild on GB "base" Gravel	
		0º Azimuth 70º Dip	90º Azimuth 70º Dip	0º Azimuth 70º Dip	90º Azimuth 70º Dip
Fish WITHOUT swim bladder	213	50	97	50	97
Fish WITH swim bladder	207	106	206	106	206

Table 29. Distances to the source (meters) to reach the various thresholds and hearing groups assessed. CAN_114 Area, based on W-1000 Point

Auditory Group	SPL pK (0-p) (dB re 1 μPa)	F1 variant Mud Soil on G3 Gravel variant	
		0º Azimuth 70º Dip	90º Azimuth 70º Dip
Fish WITHOUT swim bladder	213	50	96
Fish WITH swim bladder	207	104	200

Regarding the SELcum metric, fish with swim bladders may be within 50 m of the array at the beginning of the soft start procedure, and if they were to remain static as the vessel moves away, the potential mortality threshold would not be exceeded. If they were just near a survey line and did not move when the array passes by emitting at full power (which is unlikely to occur as avoidance behaviors have been documented), the potential mortality threshold would be exceeded if the array distance were less than 170 m.

In contrast, fish without a swim bladder can be found within 50 m of the array without exceeding the potential mortality threshold for SELcum.

Although the implementation of mitigation measures with respect to fish is not required or feasible, it can be seen that only those around the array would be affected, and they would probably move not only during the soft start process, but also during the prospecting of each line if the array got closer to their location.

3.3.1.2 Behavior change

Behavioral responses to impulsive sounds are varied and include a withdrawal from noise sources (Dalen and Rakness 1985; Dalen and Knutsen 1987; Skalski et al., 1992; Engås et al., 1996; Wardle et al., 2001), changes in depth distribution (Chapman and Hawkins, 1969; Pearson et al., 1992), and spatial changes in the behavior of the shoal (Slotte et al., 2004). Lower catch rates have also been reported after seismic studies (Løkkeborg and Soldal, 1993; Engås et al., 1996; Engås and Løkkeborg, 2002; Slotte et al., 2004; Løkkeborg et al., 2012).

Discharges from acoustic sources have been reported to cause different degrees of distress and alarm response in teleost fish, and there is some evidence that a sudden appearance of sounds may also cause a startle response in sharks (Myrberg et al., 1978). A startle response (commonly referred to as the C-start response) is a stereotypical response that involves a significant contraction of the muscles on one side of the fish's body, forming a C-shape that normally points away from the sound source (Løkkeborg et al., 2012). Field experiments in cages have shown that sound energy transmitted by compressed air sources initiates this type of behavior in captive rockfish (*Sebastes* spp.) (Pearson et al. 1992), European seabass (*Dicentrarchus labrax*) (Santulli et al., 1999), saithe (*Pollachius virens*), pollack (*Pollachius pollachius*), Atlantic cod (*Gadus morhua*), whiting (*Merlangius merlangus*) (Wardle et al. 2001), lesser sandeel (*Ammodytes marinus*) (Hassel et al., 2004), and some reef fish (*Lutjanus apodus, Lutjanus synagris, Chaetodipterus faber*) (Boeger et al., 2006). Other behavioral changes under exposure to sound included vertical distribution changes in which stationary schoals of black rockfish collapsed to the bottom, where they remained out of sync, while vermilion and olive rockfish either rose in the water column and eddies at higher speed or they approached the bottom and became almost immobile, all of them behaviors that differed from those observed under control conditions (Pearson et al. 1992). Dalen and Knutsen (1987), in turn, comment that demersal fish respond by moving towards the bottom of the ocean, while pelagic fish exhibit a response of migrating outside the area of influence of seismic energy sources.

Other similar observations of behavior in response to noise from seismic emissions, including alarm responses and changes in shoal formation patterns, position in the water column, and swimming speeds were observed in the case of the Silver seabream (*Pagrus auratus*) and the White trevally (*Pseudocaranx dentex*) captive off the coast of Western Australia (Fewtrell and McCauley, 2012). As noise levels from seismic energy sources increased, the fish responded by swimming faster in more tightly cohesive groups and toward the bottom of the cage. Other experiences showed significant increases in alarm responses in fish exposed to acoustic exposure levels (SEL) exceeding 147-151 dB re 1 μPa^2.s, and an increase in the frequency of alarm responses was observed as the sound level raised (Fewtrell and McCauley 2012). Captive fish returned to their pre-exposure position within 31 minutes after the final signal from the airgun. It is suggested that above an airgun level threshold of around 171 dB re 1 μPa^2 [3], there is a rapid increase in absolute displacement parameters of the fish's auditory system, which would indicate that the associated behavior and response and susceptibility to mechanical damage shall increase accordingly. On the other hand, it has also been found that emissions from seismic energy sources cause behavioral responses from some fish up to several kilometers from the sound source.

Different magnitudes of startle and alarm reactions have been observed in the case of European seabass in a captive experiment and small sandeel at distances of up to 2.5 and 5 km from a seismic source, respectively (Santulli et al., 1999; Hassel et al., 2004). A few individuals showed a rapid startle response to discharges from compressed air sources 2.5 km from the cage, visible as a

[3] For practical purposes, the unit can be considered referred to the SEL

sudden change in swimming speed and a steep curve to the side synchronized with the emission of the airgun. The proportion of seabass exhibiting a startle response increased as the air cannon sound source approached less than 800 m. Once the seismic equipment was less than 180 m away from the cage, the seabass grouped in the central part of the enclosure and exhibited a random orientation and appeared more active than the pre-exposure conditions. The startle response was no longer evident once the vessel passed ~ 1.5 km away from the cage, and within one hour the confined seabass returned to their normal state (i.e. reoriented against the flow of the current) (Santulli et al., 1999). Hassel et al., (2004) also examined the possible effects of a set of moving compressed air sources (with an estimated source of 256 dB re 1 µPa-m - no unit specified -) on the behavior of small sandeels in a state of captivity. The fish showed similar startle responses during exposure to sound sources that increased as the seismic array approached the cages and stopped once the discharge ceased.

On the other hand, adult fish caged in a shallow bay and exposed with an intensity of 222.6 dB re at 1 µPa pp at a distance of 5-15 m, suffered extensive damage to the ear, with almost no recovery evidence 2 months after exposure (McCauley et al. 2003). Likewise, McCauley et al. (2000) experimented with different species that were placed in cages at a variable distance from the source with an intensity of 146-195 dB re 1 µPa^2. Captive fish showed a generic "alarm" response of increased swimming speed, downward movement, and shoals were squeezed about 2-5 km from a compressed air power source. Fish hearing modeling predicts that the fish's auditory system could be damaged when they are at less than 2 km from an airgun, but they state that these effects should not necessarily be transferred to stocks or fisheries anymore as avoidance behavior may exist in open sea. In contrast to these results, fish and marine invertebrates monitored with a video camera on a coastal reef did not move away from the sounds of compressed air sources with maximum pressure levels up to 218 dB (at 5.3 m in relation to 1 µPa peak-to-peak) (Wardle et al. 2001). The greatest risk of physiological damage from seismic sound sources is for species found on shallow-water reefs or for those gathering in coastal waters to spawn or feed, and those that show an instinctive alarm response to hide in the seabed or on the reef instead of fleeing. Reef species with a swim bladder are more sensitive than those without this organ. Such species can suffer severe hearing or physiological damage and the adverse effects can be intensified and last for a considerable time.
Studies on the behavioral changes of free-swimming fish exposed to the sounds of seismic sources have also been carried out in coastal waters. During the assessment of the vertical distribution of *Merlangius merlangus* it was found to change in deeper waters over a seismic study (Chapman and Hawkins 1969). *Sebastes spp.* and *Micromesistius poutassou* (blue whiting) were found in deeper waters mostly during discharges from compressed air sources than during periods without discharges (Skalski et al. 1992; Slotte et al. 2004). Chapman and Hawkins (1969) investigated the reactions of silver hake (*Merluccius bilinearis*), to an intermittent discharge with a SPL source of 220 dB re 1 µPa - m0-p. The received sound pressure levels were estimated at 178 dB re 1 µPa 0-p. Before any discharge, the fish were located with an echo sounder at a depth of 25 to 55 m. In apparent response to the sound of the sound energy sources, the fish descended, forming a compact layer at depths greater than 55 m. After one hour of exposure to sound the fish appeared to have become familiar, as indicated by their return to the pre-exposure depth range, despite continuous discharge from the compressed air source. The discharge ceased for a time and when it resumed, the fish descended to greater depths, indicating only temporary familiarity.

Studies of Lesser sand-eel (*Ammodytes marinus*), which is a species without a swim bladder in the North Sea, revealed different but lesser reactions to seismic impulses (Hassel et al., 2004). No increase in mortality was found during this experiment. Dalen and Knutsen (1987) observed that the distribution of several different species at 100 - 300 m deep changed along the course lines of a seismic vessel towing a set of compressed air sources. Slotte et al. (2004) also observed that different species (Atlantic herring and blue whiting - *Micromesistius poutassou* -) from an area in which seismic discharges had occurred, moved out of the area or to deeper waters (10-50 m deep). Chapman et al (1969) mention that when the seismic pulses began, the "*Merlangius merlangus*" whiting showed a sudden downward movement, forming a more compact layer below 30 fathoms (55m, 192 dB re 1 µPa maximum pressure). After an hour, the fish seemed to get used to the sound as evidenced by a period during which the fish steadily moved up and continued when the compressed air source was turned off. When the compressed air source was discharged again, another downward response was observed. Likewise, Wardle et al. (2001) noted small changes in the position of the pollack (*Pollachius pollachius*) in response to the seismic emission. However, the startle responses observed in the Saithe (*Pollachius virens*) were caused by the visual stimulus associated with the cloud of bubbles caused by the seismic pulses.

An important aspect regarding the startle effect in fish is how far away from the sound source said effect reveals itself. There is relatively little research on this and the results provide different and often contradictory evidence, which has led to divergences on what the minimum distances that impact on the fish may be. The distance and the way in which sound waves travel depends on the prevailing horizontal and vertical salinity and temperature conditions. These change throughout the year and often from region to region. Some studies suggest that this distance could be up to 20 miles but the results show that catches increase or decrease depending on the species and the fishing gear. Furthermore, seismic exposure can cause short-term behavioral effects on fish. Surprise responses are observed (e.g., changes in swimming patterns, changes in distribution), with short-term effects noticed up to a radius of 30 km (Worcester, 2006). In some cases, behavioral responses were observed up to 5 km away from the sound emission (Santulli et al., 1999; Hassel et al., 2004). Nevertheless, the behavioral effects are usually short-term, with the duration of the effect being less than or equal to the duration of the exposure, although these vary between species and individuals, and depend on the properties of the sound received. In some cases, the behavioral patterns returned to normal within a few minutes of starting the study, indicating familiarity to noise. Therefore, the ecological significance of these effects is expected to be low, except where they influence breeding activity. Engås, et al (1995) point out that the fish escape reaction in open water represents a behavior to protect themselves from the impacts of seismic waves.

It has been estimated that adult fish react to an operating seismic array at distances of more than 30 km, and that intense avoidance behavior can be expected within a radius of 1 to 5 km. In Norwegian studies, decreases in fish density were measured at distances greater than 10 km from sites of intensive seismic activity (3D). Consequently, negative effects on fish populations can occur if adult fish are driven away from localized spawning grounds during the spawning season. Fish populations are probably not affected by the disturbance outside of spawning grounds, but they may be temporarily displaced from important feeding and fishing areas (Engås et al. 2003, Slotte et al. 2004). Dalen et al. (1996) recommended that discharges from compressed air sources over a distance of 50 km be avoided in areas with spawning concentrations. In tests to verify the reaction of hake and other mesopelagic fish, it was found that they moved to deeper waters during seismic exposure compared to periods without discharges (20 and 50 m depth respectively), indicating vertical movement as a short-term reaction. The average density of fish was lower in the seismic study area, increasing the abundance at a distance. Fish density appeared to be higher about 37 km (20 nm) from the center of the study area. The effects of a 3D seismic study in North Australia did not show any significant effect upon the abundance or richness of pomacentric and non-pomacentric fish species (a family that exhibits a high degree of fidelity to the site. Another study used omni-directional fishing sonar to investigate the behavior of real-time shoals of herring exposed to a 3-D seismic study in the same area and no changes were observed in their size, speed or direction of swimming, which could be attributed to the transmitting seismic ship, since they approached from a distance of 27 to 2 km during a 6 h-period (Peña et al., 2013). In the case of *Micromesistius* and *Clupea arengus* which are mesopelagic species, the density was lower in the seismic area (less than 5 km) but increased at a distance (Slotte et al. 2004).

It is concluded that fish react to sound in various ways. The weakest form of behavioral response is small changes in swimming activity in which the fish changes direction and swimming speed increases, while, at the other extreme, there is a rapid escape reaction. McCauley et al. (2000) suggest that an active avoidance of the sound source is initiated between 161-168 dB re 1 mPa^2 and that this corresponds to a range of the measured 3D set of 1-2 km. Any value above this threshold can affect the behavior of the closest fish and therefore influence nearby fisheries. On the other hand, spawning success is affected if during migration to spawning grounds or during spawning itself, fish change behavior due to the acquisition of seismic data. The spawning migration pattern may change and spawning may be more or less displaced in time and space. Consequently, the larvae may miss the time window of optimal biological conditions for survival and growth. In this sense, it is usual that restrictions are applied to seismic activity in the breeding areas and in those sites where concentrated spawning migrations take place. Fish populations are probably not affected by the disturbance outside of spawning grounds, but they may be temporarily displaced from important feeding and fishing areas (Engås et al. 2002; Slotte et al. 2004). This is of particular interest when it comes to esophageal species that can thus be severely affected. A distance of 40-50 km could be considered as a convenient buffer to avoid greater scare away effects.

Figura 16 of Annex I to this Chapter summarizes different results of the impact of seismic sounds on biological aspects and on fisheries.

3.3.1.3 Eggs and Larvae

It is considered that fish larvae and eggs cannot avoid the pressure wave of compressed air sources and can die less than 2 m away, generating sublethal injuries at less than 5 m (Boertmann et al., 2009). Carrol et al. (2016); Popper et al. (2005) mentions different experiments where numerous studies have been carried out that experimentally expose the eggs and larvae of various species of fish to air sources (Booman et al., en Popper et al., 2014). In these studies, deaths and physiological injuries were generally identified at very close range (<5 m) only. For example, a mortality rate of 40-50% was recorded for yolk sac larvae (particularly turbot) at a distance of 2 to 3 m, although mortality figures for yolk sac larvae of anchovies were lower at the same distances. The impacts of noise on marine fish eggs and larvae may include decreased egg viability, increased embryonic mortality, or decreased larval growth (Kostyuchenko, 1973; Booman et al., In Popper et al 2014). Increased mortality rates (10-20%) in later stages (larvae, post-larvae and fingerlings) were demonstrated for various species at distances of 1-2 m. Changes have also been observed in the buoyancy of organisms, in their ability to avoid predators and the effects that impact the general state of the larvae, growth and, therefore, their ability to survive. Swimming fish larvae may be more receptive to the sounds produced by seismic sets, and the range of effects may be more extended for these species than for others. Sætre and Ona (in Popper et al., 2014) calculated that the number of dead larvae during a typical seismic survey is 0.45% of the total larval population. Natural mortality is estimated at 5-15% per day of the total population for eggs and larvae of species such as cod, herring and capelin. This decreases to 1-3% per day once the species reaches age 0, that is, to approximately 6 months (Sætre & Ona, in Popper et al., 2014). Consequently, Dalen et al. (1996) concluded that mortality is so low at the population level that it can be considered to have a negligible impact on the recruitment of populations.

Larval stages are often considered more sensitive to stressors than adult stages (Byrne and Przeslawski, 2013), but exposure to seismic does not reveal differences between larval mortality or fish abundance (Dalen et al. al., 2007), crabs (Pearson et al., 1992), or scallops (Parry et al., 2002). However, intense and long periods of exposure to low-frequency sounds, such as those adopted for scallops (Booman et al., In Popper et al., 2014; Aguilar de Soto et al., 2013) can increase the rates of abnormality and mortality, indicating that larvae exposed to discharges from compressed air sources may be vulnerable. Aguilar de Soto et al. (2013) produced evidence that the reproduction of seismic pulses during larval development caused developmental delays and, in 46%, body malformations in scallops, which may affect the recruitment of wild scallop larvae. Table 30 displays a summary of the expected impacts on fish according to their stage.

Table 30. Synthesis of the impacts identified in fish (adapted from Webster et al. 2018)

Life stage	Type of impact	Potential impact of Prospecting activities
Adults and juveniles	Mortality	Death up to 12 months
	Physical impacts	Lateral line damage Damage to the hearing system Damage to the swim bladder
	Physiological impacts	Increased cortisol, glucose and lactate Hearing loss and changes in hearing thresholds Increased ventilation
	Behavioral impacts	Temporary confusion Startle and erratic swimming Change in vertical position Change in horizontal position Change in swimming behavior Change in breeding behavior Acoustic masking Displacement
	Cumulative impacts and mortality	Cumulative effect of all physical and behavioral impacts on direct and indirect mortality and breeding capacity
	Cumulative impacts and catchability	Cumulative effect of all physical and behavioral impacts on fish catchability, direct and indirect mortality and breeding capacity
Eggs and Larvae	Physical impacts	Yolk sac damage Hearing / Motion Detection Disruption Bad larva formation Change in larval development
	Behavioral impacts	Change in swimming behavior Acoustic masking
	Cumulative impacts and mortality	Cumulative effect of all physical and behavioral impacts on direct and indirect mortality and breeding capacity

3.3.1.4 Cephalopods

Research suggests that cephalopods may be receptive to far-field sounds from seismic sources with alarm responses (e.g., the ability to squirt ink), behavioral changes (aggression and spawning), and position in the water column and swimming speeds (Fewtrell and McCauley, 2012). The behavioral response ranges from attraction to a pure 600 Hz tone (Maniwa, 1976), through startle responses at received levels of 174 dB re 1 μPa^2, to increasing levels of alarm responses once the levels have reached 156 - 161 dB re 1 μPa^2 (McCauley et al. 2000; Fewtrell and McCauley 2012). The effect of seismic pulses on cephalopods has been experimentally studied by McCauley et al. (2002), who measured changes in the swimming behavior of southern rock lobster (*Sepioteuthis australis*) at 156- 161 dB re 1µPa RMS. These squids also showed alarm reactions, such as squirting ink, after sudden seismic pulses with received levels of 174 dB re 1µPa RMS, although the squirts were lower if the level was gradually increased. The results of the cage experiments suggest that squid would significantly alter their behavior at an estimated distance of 2 to 5 km from an approaching large seismic source, although the alarm responses were stronger during the first exposure to source noise of compressed air compared to subsequent exposures, suggesting that the animals became accustomed to noise at low levels (Fewtrell and McCauley 2012). Thus, for these species and other cephalopods, a 5 km zone of acoustic influence is assumed around the point of acoustic origin. Cephalopod mortalities directly associated with exposure to seismic studies have not been observed (DOF, 2016). Laboratory studies that exposed two species of squid to a seismic source of 260 dB re 1µPa levels (no unit is documented) showed that *Alloteuthis sublata* was tolerant in the short term, but *Loligo vulgaris* suffered great damage at 246 - 252 dB re 1µPa 0-p levels within 3-11 minutes of exposure (Norris and Mohl 1983 in DOF, 2016). André et al. (2011) demonstrated that squid can be injured by sweep waves of 50-400 Hz at 157 dB SPL levels continuously produced for up to two hours. However, the exposure experiments in both of these studies are difficult to relate to commercial seismic studies due to the exposure levels or the duration of the exposure event. Based on the results of the cage experiments, McCauley et al. (2000) suggest that squid would significantly alter its behavior at an estimated distance of 2 to 5 km from a large seismic source. Two atypical mass strandings involving nine giant squid, *Architeuthis dux*, were associated with seismic studies being conducted simultaneously in nearby submarine canyons where these species were concentrated (Guerra et al., 2004; 2011). Two specimens suffered extensive damage to internal muscle fibers, gills, ovaries, stomach, and digestive tract. Other squids were probably disoriented due to extensive damage to their statoliths. Damage to the sensory epithelium was also observed in four species of coastal cephalopods (*Sepia officinalis, Loligo vulgaris, Illex coindetii* and *Octopus vulgaris*) by exposure to two hours of low-frequency sweeps at 100% service (André et al., 2011; Solé, 2012; Solé et al., 2013). Fewtrell and McCauley (2012) also reported that the squid *Sepioteuthis australis*, exposed to seismic pulses from a single airgun of 156- 161 dB re 1µPa RMS showed alarm reactions, such as squirting ink from the ink sac after sudden seismic pulses with received levels of 174 dB RMS re 1µPa, although the squirts were lower if the level increase was carried out gradually.

On the other hand, anecdotal evidence shows pronounced organ damage in seven stranded giant squids after close seismic studies (Guerra et al., 2004). After two hours of continuous sound treatment (1 second sweep, 50-400 Hz) in 200-liter glass tanks, four species of cephalopods exhibited acoustic trauma, including injury, hair cell loss and damage, and swelling of neurons. Another species of squid exposed to noise from seismic energy sources showed an alarm signal at: 156-161 dB 1µPa RMS and a strong startle response involving ink squirting and rapid swimming at: 174 dB re 1µPa RMS (McCauley et al. 2000). These authors suggest that the behavioral threshold for squid is161-166 dB 1µPa RMS.

3.3.1.5 Importance of impact

Fish communities (in their different stages) can be affected by seismic prospecting activities for different reasons; one of them is the indirect impact due to the modification of the trophic chain due to loss of benthos or plankton, and another is that generated directly by the injury at the individual level or the temporary displacement of these species towards less disturbed areas.

According to the Environmental Sensitivity Analysis, the fish groups known to be present in the project area include those with low and moderate sensitivity, depending on biological (including hearing sensitivity, seasonal activity, distribution and trophic niche) ecological and conservation criteria, as well as on the fishing interest exposed.

The scientific background collected indicates that, although seismic activities affect the behavior of fish near the source, the magnitude of this effect would not generate long-term changes in the size of fish populations.

The results of the acoustic modeling establish that the most demanding threshold (fish with a swimming bladder) which indicates that possible fatal or life-threatening injuries may occur in the fish, is found within a source centered 206 meter-radius for CAN_100 and CAN_108 areas, and within a 200-meter radius for CAN_114 Area for the present project.

In this regard, the existing mitigation measures associated with the project include the use of a soft start protocol at the beginning of each data acquisition line, in which the sound gradually increases over a period of time. Sound levels shall also slowly rise and fall as ships move. This would allow fish in the vicinity of the sound source to move away before the sound levels become harmful. Therefore, the risk of injury to individual fish is low and fish populations are unlikely to be affected, particularly considering that most of the species identified in the project area are widely distributed, and some are even frequent on the slope and the platform.

The project area overlaps with the breeding area of the Rajiformes, and the fact that it coincides with the breeding area of some other species cannot be ruled out due to the lack of information. It should be noted that none of the bony fish species of commercial interest breed in CAN_100-108 and CAN_114 area of direct influence, whereas the early stages of life (eggs and larvae) that cannot avoid the sound pressure wave, the bibliography indicates that the damage is limited to areas close to the source (less than 5 meters), therefore, that mortality is so low that it can be considered to have a negligible impact at the population level.

The data collected indicates that, although cephalopod mortality directly associated with exposure to seismic studies has not been observed, the results of experiments with animals in captivity indicate that squid would significantly alter their behavior at a distance of less than 5 km from a seismic source. As previously mentioned (Point **Error! Reference source not found.**), and although the project's area of influence is located within the range of the Argentine squid (*Illex argentinus*), the area of direct influence does not overlap with the spawning, rearing or feeding areas. The areas with the highest concentrations and breeding groups would be found outside the area of direct influence of CAN_100-108 and CAN_114 in spring and summer, however, during autumn and winter the area of direct influence would overlap with the pre-reproductive concentrations of the Buenos Aires-North Patagonian subpopulation that are grouped in high density at the edge of the platform. In this sense, there is high sensitivity during the autumn and winter months and low for the rest of the year. Likewise, an additional impact could occur from winter until spring, coinciding with the drift of eggs and larvae from the southern zone due to the action of the Malvinas current.

According to the proposed environmental impact assessment methodology, the impact due to prospecting activities shall be of medium intensity for fish considering that some of their groups present moderate sensitivity due to factors such as their hearing sensitivity or in relation to the development of sensitive life stages in the project's area of influence. The impact was classified as moderate bearing in mind that, although the injuries at the individual level of the fish may be registered in a limited space near the source, and therefore may present a low risk at the population level (which could be solved considering the soft start measure), the behavioral responses could imply the temporary distancing from the feeding and spawning areas of those species that overlap with the project area. Considering the displacement to less disturbed areas, the impact shall be of partial extension since the development of the prospecting action and the beginning of the effect would be contiguous. The persistence shall be temporary and reversible in the short term since the most common effects would be the movements to less disturbed areas, which shall return to its initial state at the end of the acquisition tasks. The effect could be direct (due to sound) or indirect (due to modification of the trophic chain due to loss of benthos or plankton); The direct impact is considered as the worst condition for the evaluation, while no significant effects on the lower levels of the trophic web are expected to affect this component. In turn, it would be a periodic effect since all the activity is programmed and, by definition, the seismic impulses produce a cumulative effect on fish. All this means that the significance of the impact of the seismic survey on the fish fauna is classified as moderate.

In relation to the cephalopods, the impact is considered of low intensity considering that the sensitivity for the squid (*Illex argentinus*) would be low during the seismic activities (spring - summer). The impact upon eggs and larvae of this species, as indicated above, is subject to the drift that the Malvinas current may produce, since the project area does not overlap with the spawning site; and on the other hand, it is limited to the surroundings of the sources (5 m), so the effect is negligible at the population level, and is very precisely localized. The rest of the evaluation criteria are identical to those mentioned for fish, therefore, the impact on cephalopods would also be of moderate importance.

3.3.2 Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other operations)

3.3.2.1 Sound emissions from ships

Previously, Point **Error! Reference source not found.** described the noise emissions associated with the operation of the vessels involved in the project. The ways these emissions could affect the fish fauna and cephalopods present in the project's area of influence are hereinbelow assessed.

Vessel sound source levels below those that can cause mortality, physiological / anatomical damage or hearing loss can induce behavioral responses such as avoidance, alteration of swimming speed and direction, and behavioral changes of the shoal (Sarà et al., 2007). Furthermore, this noise can mask sounds that affect communication between fish (Purser and Radford, 2011). Although the noise of the boats would increase in the operational area of the project as a result of its development, it is expected that the negative effects on the behavior of the fish shall be short-term and shall be located in the areas where the activity is to the fullest. Taking into account the small number of vessels associated with project activities within the operational area and on the assumption that individuals or groups of fish and cephalopods present in the area may be familiar with the various and frequent noises related to vessels, the impacts of ship noise on this component are expected to be insignificant.

3.3.3 Oil spills

Previously, Point **Error! Reference source not found.** described hydrocarbon spills that could be associated with the project under study. The following is an evaluation of how these accidental events could affect the fish fauna and cephalopods present in the project's area of influence in the event of their occurrence.

In the open ocean, most pelagic species are highly mobile and demersal fish live relatively deep in the water column, making it unlikely that they shall come into contact with surface spills. Fish do not generally emerge to the surface of the sea, however, it is possible for some individuals to feed on the surface. Given the limited period of presence of a diesel slick after a spill and its limited areal extent, the impacts on fish species due to ingestion are considered insignificant.

Dissolved hydrocarbons in the water column can physically affect fish if they are exposed over a long period (weeks to months). Suffocation from gill covering can cause lethal and sublethal effects by reduced oxygen exchange, and covering of body surfaces can lead to increased incidence of irritation and infection. Fish can also ingest oil droplets or contaminated food, causing growth reduction. The effects shall be the greatest in the upper first meters of the water column and in areas close to the origin of the spill, where oil concentrations are likely to be higher, so demersal fish communities are not expected to be impacted.

The water soluble fraction (dissolved phase) that contains the aromatic fraction is the most important component when evaluating impacts on fish. MGO has low levels of aromatics that evaporate rapidly after spill (~ 24 hours), and fish species, if exposed, would require substantially long exposure times (e.g., 96 hours) for impacts to take place.

For fish eggs and larvae, there is the possibility of localized mortality of fish due to reduced water quality and toxicity. Eggs, larvae and young fish are comparatively more sensitive to oil (particularly dispersed oil), as demonstrated in laboratory toxicity tests; however, there are no case records to suggest that oil pollution has significant effects on fish stocks in the open ocean. This is due, in part, to the fact that any oil-induced kills of young fish are often minor compared to the natural losses each year from natural predation because fish spawn over large areas (AMSA, 2011 in PGS, 2018).

Free-swimming pelagic fish are not expected to suffer long-term damage from exposure to the oil spill because dissolved hydrocarbons in the water are not expected to be sufficient to cause damage (ITOPF, 2010). Given the limited spatial and temporal presence of the spill and the limited number of potentially affected fish, the impact is assessed as moderate.

The impacts on the eggs and larvae distributed in the upper water column are not expected to be significant given the temporary period of deterioration in water quality and the limited extent of the area affected by the spill. Since the dispersal of eggs / larvae is widely distributed in the upper layers of the water column, current-induced drift is expected to quickly replace any oil-affected populations. The impact is assessed as moderate.

3.3.4 Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste

The scenarios that could lead to the accidental discharge of chemical substances and / or solid waste (both dangerous and non-dangerous) were described in Point **Error! Reference source not found.** evaluating that in any situation the impacts on the marine environment would be insignificant depending on the scarce volumes that would be involved and the prevention and response measures to be implemented on board. In this sense, the impact on the fish fauna is considered to be of little significance.

3.4 SEA TURTLES

According to the analysis carried out in Point **Error! Reference source not found.** that is summarized in Table 22, the actions of the project that can cause potential impacts on the sea turtles present in the area of influence of the project include the following:

- Operation of seismic sources (compressed air emissions);
- Navigation of seismic and support vessels and physical presence of seismic equipment (in terms of possible physical disturbance and risk of collision);
- Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other operations) (in terms of light and sound emissions from ships)
- Oil spills; and
- Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste.

3.4.1 <u>Operation of seismic sources (compressed air emissions)</u>

3.4.1.1 Effects of seismic surveys on sea turtles

Very few countries present guidelines to mitigate the effects of seismic arrays on sea turtles (Nelms et al., 2016). In Brazil, IBAMA regulations define a minimum distance of 500 m between the turtle and the vessel to temporarily shut down the seismic source.

Publications of data from sea turtle observations in relation to seismic surveys are also scarce.

Parente et al., 2006 analyzed the daytime sightings of sea turtles during several sound survey campaigns in the Brazilian northeast, without finding significant differences in the position or activity of the turtles in relation to the operation of the seismic sources. Weir (2007) analyzed daytime sea turtle sightings during 3D seismic prospecting campaigns offshore Angola, in deep waters (1000-3000 m). The sounds produced by the array had source levels in the region of 220-248 dB re. 1 uPa at 1m, with peak energy in the 10-200 Hz range, and soft-start procedures of 20 minute-duration were performed. The rate of sightings during the period without shooting was double that when the array was active, but the author points out that these sound emissions could be biased by the occurrence of periods of extremely calm waters, which the turtles use to thermoregulate on the surface. No evasion behaviors associated with seismic energy emissions were recorded, but there were individual reactions to the presence of the ship and equipment, when the vessels passed within 10 m of the turtles that were floating on the surface.

3.4.1.2 Importance of impact

As mentioned above, the area where the survey is planned does not constitute a breeding site for sea turtles likely to be present in the area, nor is it characterized by their particularly frequent presence. It would predominantly work as a passage area and as a seasonal feeding area. According to the sensitivity analysis developed, the most sensitive seasons would be spring and summer. Given that the greatest number of sightings are recorded during said period, the impact is considered high - moderate (depending on the species). This group would present a low sensitivity for the rest of the year.

It should be noted that the lack of research makes understanding the impacts on individuals difficult and the implications on populations almost impossible to figure out. Furthermore, the frequency and duration of exposure to seismic surveys is not discussed in the literature, which is clearly important when it comes to determining the level of risk to turtles. Based on the studies that have been conducted to date, it is considered unlikely that sea turtles are more sensitive to seismic operations than cetaceans or some fish. Therefore, mitigation measures designed to reduce the risk or severity of exposure of cetaceans to seismic sounds can be informative about measures to reduce the risk or severity of exposure of sea turtles to seismic sounds. However, sea turtles are more difficult to detect visually than many species of cetaceans, so sighting-based mitigation strategies are expected to be less effective for turtles than for cetaceans.

For all the above, the impact on this faunal group is considered, in a precautionary way, of high intensity during spring and summer - period in which the seismic prospecting under study shall be carried out -, of partial extension due to the propagation of sound in the marine environment, of immediate action since the development of the prospecting action and the beginning of the effect would be contiguous. Persistence shall be temporary since it is valid only during the emission of the sound and reversible in the short term as the most foreseeable effects would be behavioral changes. In turn, it would be a direct, periodic effect since all the activity is programmed and in turn mitigable considering the protocols to be applied in terms of visual monitoring by Marine Fauna Observers, exclusion radii, etc. Taking into account the above, the significance of the impact of the seismic survey on the turtles is moderate.

3.4.2 Navigation of seismic and support vessels and physical presence of the seismic equipment

The navigation of the seismic and support vessels can present a potential physical risk for the turtles of the area of influence of the project. In addition, there is a potential risk of turtles being trapped in the tail buoys that are attached to the end of each seismic cable or *streamer*[4], which are usually located several kilometers from the stern of the boat, so it is not easy to monitor those interactions.

Collision and propeller injuries to sea turtles from their interactions with vessels are common. Little information is available on the types of vessels responsible for turtle deaths, and although attention has focused on recreational boats, it is speculated that ferry traffic is also responsible for this type of damage (USGS, 2011).

Collision of sea turtles with seismic vessels and with deployed or towed equipment is possible, including airgun assemblies (on or off), buoys, cables and hydrophones. However, this risk is expected to be minimized due to the low speed typical of seismic vessels.

[4] At the end of each streamer line, a tail buoy or terminal is connected to provide information about the position and also warn of the presence of the streamer being towed under water (especially at night).

The entanglement of sea turtles with waste, fishing gear, dredging equipment, etc. is a documented fact and very worrying for this species. Turtles can become entangled in cables, lines, nets, or other objects suspended in the water column, resulting in injury, fatal injury, drowning, or suffocation (Hofman 1995). During the proposed seismic operations, numerous cables, lines, and other objects associated with the airguns and hydrophones are towed behind the study at about 18 m-deep and could trap sea turtles. Weir (2007) pointed out that there were cases in West African surveys in which turtles were trapped in the tail or terminal buoys, so he recommends the use of specially modified equipment in areas where sea turtles are expected to be found.

Sea turtles spend at least 20 to 30 percent of their time on the surface breathing, basking in the sun, feeding, orienting themselves, and mating (Lutcavage et al., 1997). In this sense, the array's trailer and seismic equipment (streamers) are not expected to significantly interfere with the movements, including migration of sea turtles that spend most of their time swimming below the surface of the water unless they get trapped as above. Sea turtles are expected to be able to swim around, under or avoid such equipment as long as they can detect it, so there is a potential, albeit low, risk that turtles shall come across seismic lines and equipment and become entangled.

As mentioned above, the area where the survey is planned is not frequently visited by sea turtles. It would predominantly work as a passage area and as a seasonal feeding site. However, depending on the number of sightings, the most sensitive seasons would be spring and summer. Since it is during this period that the seismic under study is expected to be carried out, this impact of moderate intensity.

Considering that sea turtles can spend a significant amount of their lives under water, the chance of a collision between project-related vessels and a sea turtle is considered low. On the other hand, the real volume / area "occupied" by the seismic equipment (streamers) is tiny compared to the surrounding environment, so the impact would be punctual. If collisions occur, they are likely to be fatal to individuals. However, since turtle aggregations in pelagic waters tend to be rare, such incidents are expected to be negligible for regional populations. In addition, it is expected that the risk of collisions of vessels with sea turtles shall be minimized taking into account the relatively low operating speed of these vessels during seismic operations, since monitoring of sea turtles from the seismic vessel would reduce adverse effects. Modification of equipment in which sea turtles can become entangled is also a possible mitigation measure (adoption of terminal buoys equipped with appropriate turtle protectors).

All this means that the importance of this impact on the group of sea turtles is classified as low.

3.4.3 Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other operations)

3.4.3.1 Sound emissions from ships

Previously, Point **Error! Reference source not found.** described the noise emissions associated with the operation of the vessels involved in the project. The way in which these emissions could affect the turtle species present in the project's area of influence is hereinbelow assessed.
Ship noise is transitory and generally does not propagate long distances from the vessel. Source levels are considered too low to cause death, injury, or threshold changes (BOEM, 2014). Due to the uncertain role of hearing in the ecology of sea turtles, it is unclear whether masking would have any effect on them. Behavioral responses to ships have been observed, but it is difficult to attribute them exclusively to noise and not to visual or other signals.

Based on the collected data, it is conservative to assume that the noise associated with the operation of vessels can cause behavioral changes in sea turtles that are close to them. These behavioral changes can include evasive maneuvers, such as diving or changing direction and / or swimming speed. This evasive behavior is not expected to negatively affect these individuals or the population, so the impacts are expected to be insignificant.

3.4.4 Oil spills

Petroleum, including refined diesel, can affect sea turtles in many ways, such as direct contact, inhalation of the fuel and its volatile components, and ingestion (directly or indirectly through consumption of contaminated prey) (Geraci and St. Aubin, 1987). Various aspects of the biology and behavior of sea turtles endanger them, such as a lack of avoidance behavior and inhalation of large volumes of air prior to dives (Milton et al., 2003).

Studies have shown that direct exposure of sensitive tissues (eg, eyes, nostrils, other mucous membranes) and soft tissues to volatile hydrocarbons can cause irritation and inflammation. Oil can adhere to the skin or shell of turtles. Turtles surfacing in or near an oil spill could inhale oil vapors, causing respiratory stress. Ingested fuel, particularly the lighter fractions, can be very toxic to sea turtles.

Previously, Point **Error! Reference source not found.** described hydrocarbon spills that could be associated with the project under study. Exposure can range from no effect to injury to the respiratory tract, lungs, eyes, or mucous membranes. Given the rapid evaporation of the fuel, the temporal and spatial extent of the oil slick is limited, so it is expected that only individual marine mammals may be affected, however this is not considered significant at the population level. Considering the presence of threatened species in the area of influence of the project, the loss of a specimen is estimated to be of high intensity, its punctual extension is a non-reversible direct impact, but limited in time (temporary) because, in any case, exposure to an impact of this type is limited to the duration of the project. In the case of an accidental event, its periodicity is computed as irregular, so the impact is moderate.

3.4.5 Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste

Point **Error! Reference source not found.** described the scenarios that could lead to the accidental discharge of chemical substances and / or solid waste (both hazardous and non-hazardous). In particular, wastes dumped into the marine environment, especially those made from synthetic materials, are a major form of marine pollution (Laist, 1997). Marine debris has two types of negative impacts for sea turtles: (1) entanglement and (2) ingestion.

Taking into account the prevention and response measures to be applied on board, it is unlikely that significant amounts of chemicals and / or solid waste (hazardous and non-hazardous) shall be released into the marine environment from prospecting activities, which greatly reduces the probability of sea turtles encountering chemical residues or spills from the proposed activity. Therefore, the impacts of entanglement and ingestion of waste, or exposure to toxic substances in sea turtles are expected to be insignificant.

3.5 BENTHIC AND PLANKTON COMMUNITIES

According to the analysis carried out in Point **Error! Reference source not found.** summarized in Table 22, the project actions that may cause potential impacts on the benthic and planktonic communities present in the project's area of influence include the following:

- Operation of seismic sources (compressed air emissions);
- Oil spills; and
- Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste.

Regarding the presence of seismic equipment (streamers), it should be noted that since it shall be towed to a maximum depth of 18 m from the water surface, there is no possibility that the equipment shall affect habitats or benthic species.

3.5.1 Operation of seismic sources (compressed air emissions)

3.5.1.1 Effects of seismic operations on benthic communities and plankton

The behavioral responses of invertebrates to the movement of low-frequency stimulation particles have been measured by numerous researchers (reviewed in McCauley, 1994). Non-evasion responses are reported by free-distribution invertebrates (crustaceans), echinoderms, and mollusks from reef areas subjected to seismic waves (Wardle et al., 2001). Exposure to low-frequency sound can cause anatomical damage to marine invertebrates, although research is limited. Although many invertebrates cannot sense the pressure of a sound wave or the lower amplitude component of high-frequency sounds, low-frequency, high-amplitude sounds can be detected through mechano-receptors, particularly in the near field of such sound sources (McCauley 1994).

Scientific studies that have examined the effects of seismic studies on scallops (Parry et al., 2002; Harrington et al., 2010; Aguilar de Soto et al., 2013; Day et al., 2016), have not indicated that seismic activities can cause catastrophic or short-term mortality in scallops with realistic exposure scenarios. Harrington et al. (2010) evaluated scallops (*Pecten fumatus*) before and two months after exposure to a power source with an operating pressure of 2000 psi. They found no evidence of short- or long-term impacts on adult survival or health. Przeslawski et al. (2016) also did not record any impact of seismic exposure in adults two months after exposure to maximum sound at levels of 146 dB re $1\mu Pa^2$. s. Day et al. (2016) found out that exposure to a seismic source (191 – 213 dB re 1µPa p-p) did not cause immediate mass mortality. However, repeated exposure (54 - 393 sound impulses) significantly increased mortality, and the associated risk increased significantly over time.

However, sensitivity to low-frequency sounds has been reported for the *Homarus americanus* lobster (and several other invertebrate species (Packard et al., 1990; Turnpenny and Nedwell, 1994). Likewise, lethal and sublethal effects have been observed under experimental conditions in which invertebrates were exposed to compressed air sources up to five meters away. These include reduced growth, reproduction rates and behavioral changes in crustaceans (DFO, 2004; McCauley 1994; McCauley et al. 2000). No physiological damage was observed in the snow crab (Chionoecetes opilo) on the Atlantic coast of Canada, for example, but there was damage in the effects on the development of eggs fertilized at 2 m distance (Christian et al., 2003) with delayed effects on the development of the embryo, the existence of smaller larvae, and indications of a greater loss of legs. However, no acute or long-term mortality was observed, nor was there any change in embryo survival or larval mobility after hatching (DFO, 2004).

On the other hand, Day et al. (2016) found that exposure to airguns caused statocyst damage in rock lobsters up to a year later. However, no such effects were detected in snow crabs after exposure to 200 sound impulses at 10 s and 17-31 Hz intervals (Christian et al. 2003). Therefore, the dissimilar results between these studies appear to be due to differences in sound exposure levels and duration, in some cases due to tank interference, although taxa-specific differences in physical vulnerability to acoustic stress cannot be ruled out. A bivalve, *Paphia aurea*, showed acoustic stress as evidenced by hydrocortisone, glucose and lactate levels when subjected to seismic noise (Moriyasu et al., 2004). Catch rates also decreased with exposure to seismic noise by the *Bolinus brandaris* gastropod (Moriyasu et al., 2004). Southern Australian scallops (*Pecten fumatus*) and Doughboy scallops (*Mimachlamys asperrima*) from dredging samples and in situ images were observed to have great variability in abundance and size between locations and time periods, but this was not related to the seismic study, no scallop mortality attributable to the seismic study was observed (Przeslawski et al., 2016). In New Zealand, scallop larvae, *Pecten novaezelandiae*, exposed to reproductions of low-frequency pulses in the laboratory showed significant developmental delays and body developed abnormalities (Aguilar de Soto et al., 2013). Annex I to this Chapter through Figura 17 summarizes various impacts on different invertebrate taxa.

In relation to plankton, experimental studies have established that severe damage or death occurs only within a radius of a few meters around compressed air energy sources, where energy levels are the highest.

Regarding zooplankton, little is known about the effect of seismic noise on these organisms since they lack auditory structures, although they are sensitive to pressure changes and their bodies generally have the same density as the surrounding water.

According to the results obtained by McCauley and others (2017) about the impact of seismic activity on zooplankton communities, it was recorded that experimental exposure to simulated noise from an airgun caused a decrease in the abundance of zooplankton, and an increase in the mortality of adults and larvae from a natural level of 19% / day to 45% / day, being 100% in krill larvae. This mortality was observed up to the maximum range of 1.2 km sampled, much higher than the previous 10 m, thus invalidating the conventional idea of limited and localized impact.

In addition, Richardson et al. (2017) analyzed the impact of seismic surveys on zooplankton through modeling in the Northwest Australian shelf. The results showed that there would be a substantial impact of the seismic activity on the zooplankton populations on a local scale within or near the survey area, with a maximum decrease of 22% in the zooplankton populations in the direct affected area and 14 % within 15 km of the seismic area. However, the impacts were minimal on a regional scale: 2% in 150 km, and undetectable on a larger scale. It was also found that the time for the zooplankton biomass to recover to an offshore seismic survey within the direct affected area and up to 15 km was only 3 days after the completion of the tasks.

3.5.1.2 Importance of impact

As mentioned above, no protected species have been identified in the consulted bibliography both for the benthos component and for plankton, for CAN_100-108 and 114 areas.

The area does not overlap either with zones of maximum phytoplankton productivity, nor of maximum zooplankton biomass. However, zooplankton, crustacean larvae and Krill have a higher (intermediate) sensitivity during the spring and summer seasons since it is the maximum productivity period. The sensitivity of this component is low for the rest of the year.

Although the emerging bibliography indicates that seismic activity can cause a mortality increase in zooplankton communities, this impact is significantly revealed locally and within the area limited to the operation of the seismic source. Additionally, its effect can be considered temporary, since a substantial recovery has been verified after 72 hours.

Regarding the benthic communities, the area of influence of the project presents an intermediate sensitivity throughout the year. The indirect area of influence of the project does not overlap with the areas with the highest coral density. However, the CAN_114 seismic data acquisition area partly overlaps with the north of the areas considered Vulnerable Marine Ecosystems. The Patagonian scallop is observed with low biomass density in the indirect area of influence of the project, however, no reproduction, feeding or breeding sites of this species are found in the area of direct influence of CAN_100-108 and CAN_114 areas. The decapod crustacean species registered in the indirect area of influence of the project are not economically important, presenting bycatch / incidental fisheries, although these species have great ecological relevance. Only one breeding and molting site is recorded in the area of direct influence of the CAN_100-108 project, but with a very low density of spider crabs. CAN_114 area of direct influence of the project does not overlap with spider crabs´ breeding or feeding sites.

It must be taken into account that when referring to benthic organisms, the seismic vessel shall always operate between 1200 and 3900 meters-deep waters. Consequently, and considering that the revised bibliography indicates that these organisms can be affected in the field close to the sound sources (5 meters away) and that these sources shall be located 6 meters deep, they shall not be affected.

According to the above, the impact due to prospecting activities is related only to the affectation of zooplankton (excluding the affectation of fish eggs and larvae that was previously evaluated – see Point 3.3.1 -), which shall be of medium intensity given the sensitivity associated with crustaceans and krill (mean). The extension is considered specific since, as mentioned, the significant effects may occur in any case within the limited area in which the seismic source is operating. The moment of impact is immediate since the development of the prospecting action and the beginning of the effect would occur in sync. Persistence shall be temporary since it is valid only during the emission of the sound and reversible in three days (consistent with the recovery period of the zooplankton according to the background information), while the effect would be direct. It would be a periodic effect since all the activity is scheduled. All this makes the significance of the impact of the seismic survey on plankton low.

Based on the low impact of this component, a negative effect on fish, birds and marine mammals that feed on these benthic and plankton communities is definitely ruled out.

3.5.2 Oil spills

Point **Error! Reference source not found.** described the hydrocarbon spills that could be associated with the project under study. Lower trophic levels might be exposed to small spills that are associated with fuel transfers.

Benthic invertebrates are often protected from direct hydrocarbon contamination by their floating nature, although the depth of penetration of oil into the water column depends on turbulence. Since these species live at a relative depth in the water column and are unlikely to come into contact with spills on the surface or be exposed to dispersed hydrocarbons in the water column, a surface spill of diesel from limited size shall not affect this fauna.

Regarding plankton, exposure to hydrocarbons on the surface or in the water column can cause changes in the composition of the species, with decreases or increases of one or more species or taxonomic groups (Batten, 1998). Phytoplankton can also experience decreased photosynthesis rates (Goutz et al., 1984; Tomajka, 1985). In the case of zooplankton, the direct effects of contamination may include suffocation, behavioral changes, or environmental changes that make them more susceptible to predation (Chamberlain and Robertson, 1999). The seasonal productivity of plankton is essential for krill production, which supports the presence of local megafauna.

Dispersed hydrocarbons can cause lethal and sublethal impacts on part of the plankton in the affected area when the thresholds for surface concentration or dispersion in the water column are exceeded. However, since plankton is widely but unevenly distributed and dispersed on the surface of the water column, current-induced drift is expected to quickly replace any populations affected by the spill (ECOS, 2001). Once background water quality conditions are restored, planktonic communities shall quickly reestablish due to high population turnover and short generation time that buffers the potential for long-term population decline (ITOPF, 2011).

Based on the limited areas temporarily affected by surface and dispersed hydrocarbons, the impacts are short-term (with recovery on the days-to-weeks time scale), recoverable, and are not expected to have a significant impact on the populations of plankton.

3.5.3 Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste

Point **Error! Reference source not found.** described the scenarios that could lead to the accidental discharge of chemical substances and / or solid waste (both hazardous and non-hazardous), evaluating that the impacts on the marine environment would be insignificant in any situation depending on the scarce volumes that would be involved and the prevention and response measures to be implemented on board. In this sense, the impact on the benthic and planktonic communities is considered to be of little significance.

3.6 BIRDS

According to the analysis carried out in Point **Error! Reference source not found.** that is summarized in Table 22, the actions of the project that can cause potential impacts on the birds present in the area of influence of the project include the following:

- Operation of seismic sources (compressed air emissions);
- Navigation of seismic and support vessels and physical presence of seismic equipment (in terms of risk of collision);
- Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other operations) (in terms of noise emissions from the vessels and the helicopter to be used in the event of emergency situations);
- Oil spills; and
- Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste.

3.6.1 Operation of seismic sources (compressed air emissions)

Birds are generally considered to be more tolerant of anthropogenic noise than mammals. The effects of noise in air include damage to the auditory system and behavioral responses. In air, continuous exposures to noise levels above 90-95 dB SPL cause TTS and above 110 dB (a) SPL can cause PTS (Dooling and Therrien, 2012).

Seabirds are amphibian species, which have to listen in environments that have huge differences in acoustic impedance. Most seabirds spend most of their lives at sea. The mechanisms for listening in each medium can be different, since they have anatomical adaptations to listen under water.

The general literature mentions that the possible effects of seismic activities on seabirds would include: (i) disturbance of the usual feeding, breeding and migration patterns; (ii) feeding limitations due to the effects of seismic pulses on the fish that constitute the bird's food, and; (iii) physical affectations of birds that spend a lot of time submerged in search of food, there is an enormous lack of information on observations of physiological and behavioral effects of seabirds, particularly in relation to seismic surveys.

Specific elements for the evaluation of impacts on seabirds are presented below, following the grouping made regarding depths and the information available on hearing (see Point **Error! Reference source not found.**).

3.6.1.1 Sound effects on seabirds

Deep divers (P)

In the '80s intimidation techniques were applied to reduce the mortality of penguins by underwater explosives detonations during construction or port access operations, as well as distribution and preparation of explosive charges so that most of the wave dispersed in the air. Cooper (1982) and Brown and Adams (1983) report that the use of fireworks of the deafening type prior to detonations worked to scare away penguins that were in the vicinity or floating on the surface, but not for those who were swimming in the bottom, who were left floating unconscious on the surface and when they recovered they showed signs of concussion and lack of muscular coordination, an indicator of PTS.

Penguins feed completely under water. They emit vocalizations from the surface while moving between sites and also underwater to feed on certain prey (Thiebault et al., 2019; Sorensen, 2020), a behavior possibly associated with group hunting.

Pichegru et al. (2017) studied the behavioral responses of the African penguin (*Spheniscus demersus*), before, during and after 2D seismic surveys carried out within a radius of 100 km from their breeding colonies, using GPS and compared them with multi-year records of the same population. Penguins dived an average of 30 m deep, with dives of up to 3 minutes, in a range of 30–40 km from their colonies. They showed strong evasion behavior from their usual foraging areas during seismic activity, feeding significantly further from the seismic vessel while it was in operation (Figure 1). The birds changed to their normal behavior when operations ceased, although it is unknown whether there were long-term effects on the birds' auditory system. The authors consider that the evasion behavior is probably due to the fact that the sounds emitted by the vessels are annoying noises, disturbances, since the echo sounder surveys did not show decreases in the abundance of their prey fish. The authors consider that seismic prospecting activities would affect group communications. Based on this study and taking into account that penguins are an endangered species, and that the colonies show great variability in their population numbers (and many are even decreasing due to raising rainfall and other climatic phenomena and problems of interaction with fisheries), the authors recommend restricting seismic prospecting activities to more than 100 km from spawning colonies.

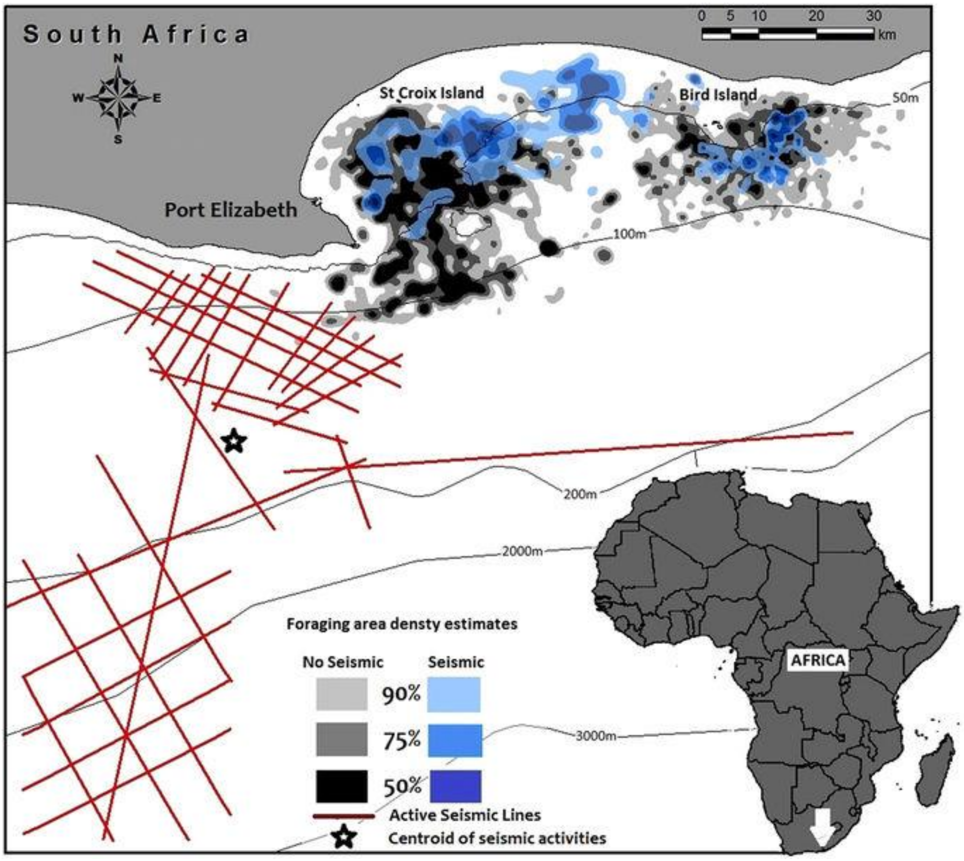


Figure 12. Overlapping of the foraging areas of the African penguins of the two main colonies in Algoa Bay, before (2009–2013 in gray) and during (March 2013, in blue); seismic prospecting activities are in red. Source: Pichegru et al. (2017).

It is known that the reproductive success of the Patagonian penguin is related to the distance from the colony to the feeding place of the adults, less than 180 km and less than 70 km maximum (Boersma and Rebstock, 2009).

Outside the breeding season (winter), the rockhopper penguin that nests in Isla de los Estados usually makes trips that on average do not exceed distances of 100 km from their nesting area (Putz et al., 2006).

Shallow divers (B)

The diving petrels stand out in this group, which are small birds, specialized in preying mesozooplankton, particularly euphausiids and copepods (Reid et al., 1997). A significant part of the day is spent underwater chasing their prey, with average values of 76 dives per hour (Dunphy et al., 2015). They differ from other Procellariiformes because, during the breeding season, they make local feeding trips that last all day, moving no more than 45 km in linear distance from the colony and returning at night (Dunphy et al., 2020).

Non-divers (NB)

Rubio et al (2015) made observations of seabirds during a seismic prospecting campaign in a nearby region, offshore the Río de la Plata. They did not find a relationship between the abundance of seabirds and the distance to the survey vessel, but these results can be interpreted as biased since bird watching was done in parallel during fishing activities, and almost the highest abundance of species recorded corresponded to species of this type.

Outside the study area, Seco Pon et al. (2019) analyzed the sector between San Sebastián Bay and Río Grande during a seismic survey carried out between August and November 2012. Seabirds were more abundant during exploration operations in the absence of seismic activity (i.e., seismic energy sources were not active). This also happened when groups of seabirds with contrasting feeding habits (snorkelers and shallow divers / scavengers) were considered. At least 16 species of seabirds were identified, more than 60% of which were Procellariiformes, the most abundant in terms of number and occurrence being the dark shearwater, the black-browed albatross, the imperial cormorant and the Patagonian penguin.

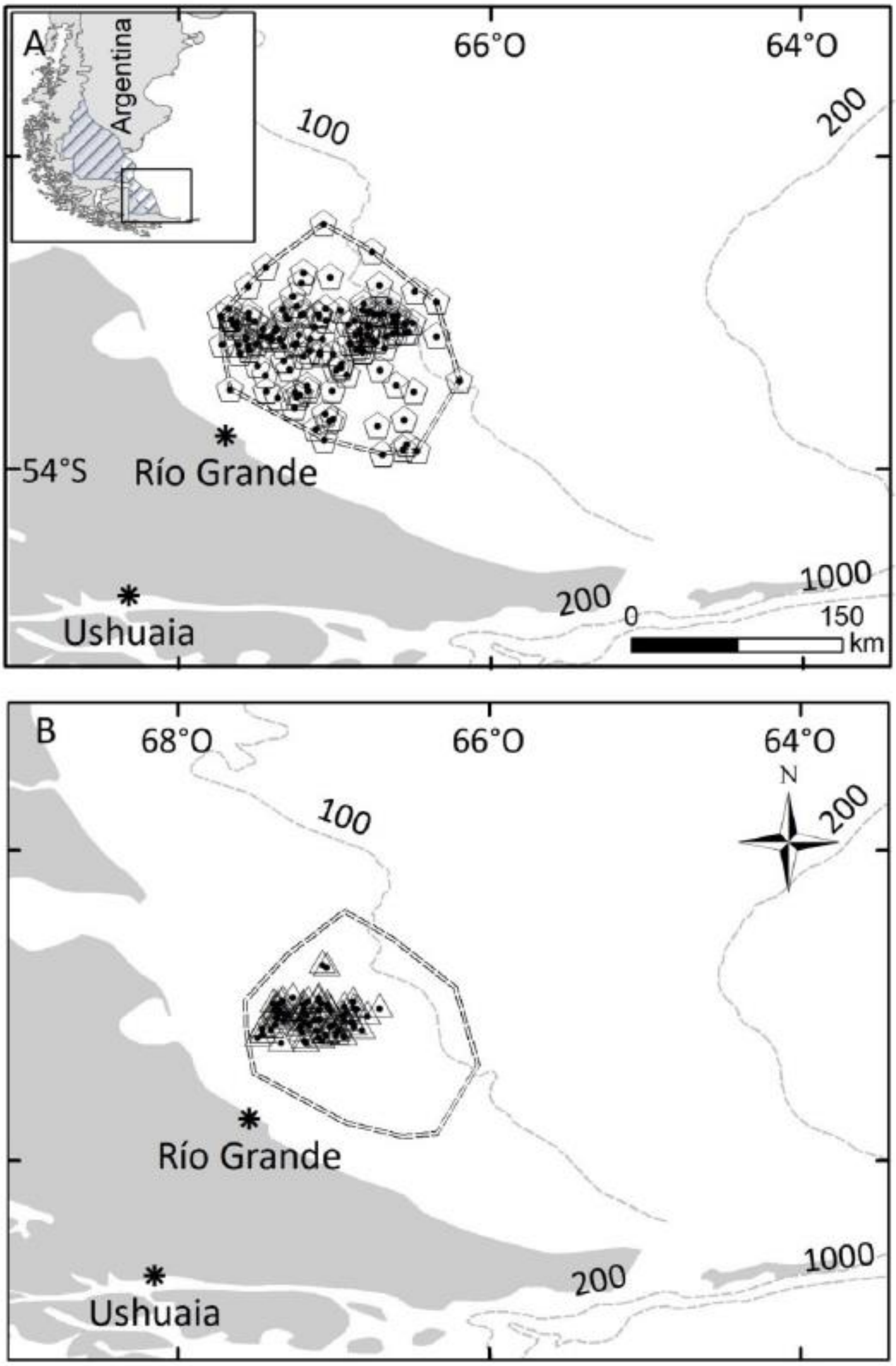


Figure 13. Distribution of the total abundance of seabirds (counts with the presence of birds) in waters east of San Sebastián Bay, between August 21 and November 6, 2012, during the prospecting of a seismic vessel when seismic exploration activity was at a standstill. Each mark represents an individual count. The double dotted line represents the outer limit of the surveyed area. Source: Seco Pon et al., 2019.

3.6.1.2 Importance of impact

As mentioned above, the project area is very important as a feeding area for seabirds throughout the year and also as a passage area for inter-hemispheric migrators. However, the species present do not breed in the high seas, having their nesting and breeding sites hundreds or thousands of kilometers from their feeding areas, for which the project area is considered to have medium sensitivity throughout the year. In this regard, it is also worth noting the situation of the white-bearded petrel, which, in addition to being abundant, faces a high degree of threat. For this reason, their sensitivity to the project is considered high during the warmer months. This species is considered as Threatened at the local level but Vulnerable at the regional level.

According to bibliographic information, it is inferred that seabirds can suffer changes in behavior during the sounding stage, which shall be reverted once operations have ceased. The latest research suggests that behavioral displacement or avoidance responses occur, but it may depend on the response of its prey. Given that the effects of the project on the components of plankton and fish on which the birds feed shall be temporary, this behavioral response may, at most, also be temporary. In the case of the group of depth divers, represented by the penguins in the study area, the available bibliography indicates that the avoidance behavior of their feeding areas could be due to the fact that the sound impulses from seismic sources interfere with their group communications.

According to the methodology adopted for the environmental assessment, the impact due to prospecting activities shall be of medium intensity considering that the bibliography consulted indicates that seismic sounding fundamentally produces behavioral effects on seabirds, which were classified with intermediate sensitivity given that the area of influence of the prospecting zone is far from the nesting and breeding sites of this group. It affects only a portion of a feeding area that is much larger, so it is classified as a partial range impact, at most. The development of the prospecting actions and the beginning of the effect would occur simultaneously, and would be reversible in the short term since the most common effects shall be behavioral changes that shall be recovered at the end of the tasks. The persistence shall be temporary since it is valid only during the emission of the sound. At the same time, it would be a direct, periodic effect since all the activity is programmed and in turn mitigable considering that there are mitigating measures to be adopted with regard to prospecting activities (soft start). Pursuant to the abovementioned, the impact of the project on birdlife is moderate.

3.6.2 <u>Navigation of seismic and support vessels and physical presence of the seismic equipment.</u>

Another possible effect for seabirds linked to the presence of vessels and seismic equipment is related to attraction towards vessels and subsequent collision or entanglement.

As part of the seismic record under study, 3 vessels shall participate. This level of ship traffic does not represent a significant increase compared to the existing ship traffic in waters close to the coast or on the high seas. Furthermore, a seismic vessel moves relatively slowly (4 to 5 knots) during the search, which would allow seabirds to easily get out of the way.

In this sense, the possibility of birds colliding with a ship is not expected to be significant to individual birds or their populations. However, a number of species of seabirds, including members of the Procellariidae families, are generally attracted to vessels. It is believed that this attraction is due to the night lights of the vessel which is discussed below in Point 3.6.3.1. However, some birds follow boats as a foraging strategy, especially commercial or recreational fishing boats.

As mentioned above, the black-headed shearwater, included within the group of shallow divers, is one of the most abundant species in the project area. This migratory species feeds in the area during the breeding season. They dive at shallow depths to catch their food among shoals. It is a species that follows ships and can present a risk of collision or snagging.

Notwithstanding the above, even if the birds of the Procellariidae families were attracted by the survey vessels or perched near one, the potential collision or entanglement is very low, as the Seismic vessel moves at a relatively low speed (4 to 5 knots) and seismic equipment (streamer) shall be towed behind vessels at depths of up to 18 meters below the surface. There is no empirical evidence indicating that these types of seabirds can become entangled in seismic arrays, despite their particular attraction to them (BOEM, 2014). Since there is a low possibility of collision or entanglement, impacts are expected to be of low importance to individual birds and their populations. In any case, this impact may occur in a very localized manner around the vessels.

3.6.3 Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other operations

3.6.3.1 Light emissions from ships

Seismic activities that require lighting include the following:

- Marine safety, in terms of ship navigation lighting to provide clear identification to other marine users (collision avoidance);

- Deck lighting to allow safe movement of personnel around the deck during hours of darkness; and

- During discontinuous periods in the night hours, spot lighting may be required for the inspection, deployment and recovery of seismic equipment in the water (this would mainly involve the use of reflectors at the stern of the ship that are focused towards the sound source). It should be noted that weather and wave conditions may prevent these nighttime water inspections for personnel safety reasons.

The presence and movement of vessels can affect the behavior of seabirds. As mentioned above, the effect of lights and flashes from vessels as potential attracting situations for seabirds flying at night is well documented. Artificial lights can cause collisions and mortality, particularly in conditions of poor nighttime visibility from the moon or stars (mist, haze), in which birds can become disoriented and crash into the boat or on deck, or become trapped between the seismic equipment deployed in the water. This attraction to lights can also cause birds to circle around ships, using additional energy, delaying their migration or feeding, which can result in starvation. These risks are particularly important for those species that feed on bioluminescent prey, and are naturally attracted by lights, such as the black-headed shearwater, one of the most abundant species in the area of influence of the project. This migratory species feeds in the area during the breeding season. They dive at shallow depths to catch their food among shoals. It is a species that follows ships being at risk of collision or snagging.

The level of impact, however, depends on the location of the offshore lighting and the weather conditions. Birds tend to be attracted to lighting during foggy nights and / or with cloud cover greater than 80% (Van de Laar, 2007)[5]. Birds that are attracted to light shall use up their energy to reach the vessels, but this shall only cause a small increase in the total energy used.

This impact may occur mainly in the offshore environment but may extend to the near shore environment due to the movements of the support vessel involved in refueling / crew changes.

A greater presence of marine and coastal birds is expected within the AICAS. The "Aguas del Talud Patagonia Norte" AICA candidate is located in the indirect area of influence of the project about 28 km from the western limits of CAN_114 operational Area, and shall be crossed by the logistics route that connects the Port of Mar del Plata with CAN_114 Area. Likewise, the logistics route includes the "Playa de Punta Mogotes and Puerto de Mar del Plata" AICA in the coastal zone. The birds are expected to be found in small numbers when crossing the areas and, in some cases, could be attracted to vessels.

Given the temporary and constantly moving nature of light sources, no significant impacts are expected for seabird species. The disturbance shall be very localized and periodical throughout the Project, affecting only a small number of birds on the high seas and in the coastal environment.

3.6.3.2 Sound emissions from ships (and helicopters)

Another possible effect for marine and coastal birds related to the presence of vessels is related to the noise of the latter.

[5] Van de Laar, F.J.T 2007. Green light to birds Investigation into the effect of bird-friendly lighting. NAM LOCATIE L15-FA-1.

Some seabirds rest on the surface of the water, skim the surface of the water, or dive shallowly for short periods only. Due to these behaviors, the members of these families would not come into contact with the underwater noise of the boats, or the contact would be so brief that it would cause little alteration of the behavioral patterns or other non-harmful effects. Therefore, the impacts of ship noise for these seabirds would be insignificant.

Diving seabirds could be sensitive to underwater noise generated by prospecting vessels. However, the number of vessels associated with the project (3) does not represent a significant increase in existing environmental noise, in addition the seismic vessel moves at low speed and noise levels fade rapidly with distance. Therefore, the impacts of submarine noise from ships are also not expected to be significant for this group of birds.

The helicopter also generates noise from its engines, fuselage and propellers, and its physical presence flying low can disturb sea and shorebirds, including those on the surface of the sea and in flight, both through noise and through visual disturbance. Behavioral responses to aircraft flight include flinging to the sea surface in flight or rapid changes in speed or direction of flight. These behavioral responses can cause a collision with the aircraft that can be used in the event of an evacuation emergency (eventually).

It is worth noting that the operation of helicopters, if it occured, would only be circumstantial and with planned routes, so the impact on birds would be of little significance.

3.6.4 Oil spills

Previously, Point **Error! Reference source not found.** described hydrocarbon spills that could be associated with the project under study. This accidental spill could occur both offshore and near the coast, and the species of marine and coastal birds affected and the type of effect would differ depending on the location of the spill (Wiese and Jones, 2001; Castege et al., 2007).

Shorebirds and coastal seabirds could be directly or indirectly affected if the accident occurred in waters close to shore. Direct impacts would include physical oiling of individuals. The effects of oil spills on shorebirds and seabirds include tissue and organ damage from oil ingested during feeding and grooming from oil inhalation, as well as stress could lead to alteration of food detection, predator avoidance, location of migratory species, and breathing problems.

Indirect effects could include oil contamination of nesting and feeding habitats and displacement to secondary sites. The chance of a collision with a ship is quite low, and the chance of a spill is even lower. An accidental event could result in a fuel spill by one of the project vessels, but such an event is not likely to occur, and if it did, the area of impact is expected to be limited.

Therefore, an accidental fuel spill in waters close to shore is not expected to cause significant impacts on these types of shorebirds and seabirds. mpacts on shorebirds and seabird species would range from insignificant to low, depending on timing and location. Given the presence of threatened species, if there were an accidental spill of fuel affecting them, it would produce a moderate impact, since birds are very susceptible to the impacts of oil.

If the accidental event were to occur offshore, the fuel would float on the surface of the water. There is a potential for seabirds to be directly and indirectly affected by spilled fuel. Impacts would include plumage lubrication and ingestion (resulting from grooming). Indirect impacts could include contamination of feeding habitats and displacement to secondary sites. Taking into account the aforementioned regarding the size of the spill, its impact would be limited, while dispersion, erosion and evaporation would reduce the amount of fuel that remains on the surface. The impacts to seabirds from a spill incident involving the vessels under study on the high seas would range from insignificant to low. Given the presence of threatened species, if there were an accidental spill of fuel affecting them, it would produce a moderate impact, as already mentioned, since birds are very susceptible to the impacts of oil.

A greater presence of marine and coastal birds is expected to appear within the AICAS. As mentioned above, the "Aguas del Talud Patagonia Norte" AICA candidate is located in the project's area of influence, about 28 km from the western limits of CAN_114 operating area. Likewise, the area of influence of the logistical support port, in the coastal area of Mar del Plata, involves the “Playa de Punta Mogotes and Puerto de Mar del Plata” AICA.

If the spill occurred within or near these AICAS, there would be a greater impact on these regional birds. These impacts would range from low to moderate, depending on timing and location.

3.6.5 Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste

Point **Error! Reference source not found.** described the scenarios that could lead to the accidental discharge of chemical substances and / or solid waste (both hazardous and non-hazardous), evaluating that the impacts on the marine environment would be insignificant in any situation depending on the scarce volumes that would be involved and the prevention and response measures to be implemented on board. In this sense, the impact on bird life is considered to be of little significance.

3.7 PROTECTED AND SENSITIVE AREAS

According to the analysis carried out in Point **Error! Reference source not found.**, that is summarized in Table 22, the actions of the project that can cause potential impacts on the birds present in the area of influence of the project include the following:

- Operation of seismic sources (compressed air emissions);
- Navigation of seismic and support vessels and physical presence of seismic equipment (in terms of possible physical disturbance and risk of collision);
- Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other operations) (in terms of noise emissions from the vessels and the helicopter to be used in the event of emergency situations);
- Oil spills; and
- Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste.

3.7.1 Operation of seismic sources (compressed air emissions)

Protected or biodiversity preservation areas represent places of special sensitivity as they correspond to breeding, spawning, or feeding of species of ecological interest. In this way, any activity carried out in the vicinity of these areas must be specially controlled in such a way that it does not affect the normal development of the local species.

As mentioned above, the area of operation and that of direct influence of CAN_100-108 and CAN_114 seismic data acquisition areas do not directly affect any declared or proposed protected area. However, the "Frente del Talud" (FT) future marine protected area and the "Aguas del Talud Patagonia Norte" AICA candidate stand out for their proximity, located about 30 and 28 km respectively, from the prospecting area, in the indirect area of influence.

The FT (Slope Front) supports a complex trophic web, includes spawning areas for commercially important species and is a feeding area and migratory passage for top predators. At least seven species of threatened seabirds feed in the area. Although it is outside the area of maximum influence of seismic waves, the possibility of effects on marine fauna cannot be ruled out.

In this regard, the FT (Slope Front) is located at distances much greater than those that could generate physiological impacts on marine mammals. According to the modeling carried out, these effects are limited to a maximum of approximately 1,000 meters from the source (see Table 25 and Table 26), According to the modeling carried out, these effects are limited to a maximum of approximately 1,000 meters from the source (see and), so the effects would be limited to changes in behavior, possibly attenuated by the distances to the prospecting area, which shall be reversed upon completion of the tasks. Considering the evaluation carried out in Point 3.2.1, these effects are moderate, although they would occur in the IIA (they are deemed indirect).

When it comes to fish, the FT (slope Front) is located at distances much greater than those that could generate physiological impacts on them. According to the modeling carried out, these effects are limited to a maximum of approximately 1,000 meters from the source (see Table 25 and Table 26), According to the modeling carried out, these effects are limited to a maximum of approximately 1,000 meters from the source (see and), so the effects would be limited to changes in behavior, possibly attenuated by the distances to the prospecting area, which shall be reversed upon completion of the tasks. Considering the evaluation carried out in Point 3.3.1, these effects are moderate, although they would occur in the IIA (they are deemed indirect). While for the early stages of life of the fish (eggs and larvae) that cannot avoid the sound pressure wave, the collected bibliography indicates that the damage is limited to areas very close to the seismic source (less than 5 meters), so an impact of this type on the FT (Slope Front) is ruled out. Regarding cephalopods, the antecedents exposed under Point 3.3.1 indicate that squid would significantly alter their behavior at a distance of less than 5 km from a seismic source. Since the FT (Slope Front) is about 30 km from the seismic data acquisition areas, this impact is discarded.

Regarding sea turtles, it refers to what was analyzed under Point **Error! Reference source not found.** whereby the impact, although possibly attenuated by the distances to the prospecting area, is also considered moderate, although they are classified as indirect because they shall take place in the AII.

Regarding the benthic communities, given the depths at which the project shall be developed and that these organisms can be affected only in the near field of the compressed air sources (5 meters away), their affectation is not expected (see point 3.5.1). The impact on planktonic communities is not considered either, since the significant effects on this component would be limited in any case, to the limited area of operation of the seismic source (see point 3.5.1).

As hereinabove described, the impacts of compressed air emissions would primarily produce behavioral effects on seabirds. Considering the evaluation carried out in Point 3.6.1, this impact which shall possibly be attenuated by the distances to the prospecting area, is equally moderate, both in terms of the FT (Slope Front) and the "Aguas del Talud Patagonia Norte" AICA candidate, although they would occur in the AII (they are deemed indirect).

Considering the maximum valuation of the inserted components in the sensitive areas close to the seismic prospecting areas, the impact on this factor is classified as moderate.

3.7.2 Navigation of seismic and support vessels and physical presence of the seismic equipment

As mentioned above, the logistical routes and the area of influence of the Port of Mar del Plata defined for logistical support directly involve the "Restinga del Faro" Natural Reserve of Defined Geological and Fauna Objects, the Natural Botanical, Faunistic and Educational Reserve "Puerto Mar del Plata" and the AICA named "Playa de Punta Mogotes and Puerto de Mar del Plata".

On the other hand, the logistics route that connects CAN_114 Area with the port also crosses "Aguas del Talud Patagonia Norte" AICA candidate, and "Frente del Talud (FT) (Slope Front) and "Frente de Plataforma Media" (Middle Platform Front) future marine protected areas. Likewise, "Costa Atlántica Argentina" APP is located in the area of influence of the port of logistical support and the logistics route, while the latter crosses the "Banco de Mejillones" APP.

As part of the evaluation, the effects of vessel navigation on marine mammals (Point **Error! Reference source not found.**), turtles (Point **Error! Reference source not found.**) and birds (Point **Error! Reference source not found.**) have been analyzed. In all cases, the impacts have been classified as of low importance. Taking into account that the operational zones of CAN_100-108 and CAN_114 areas where vessels shall operate most of the time, do not directly overlap with protected or sensitive areas, and that in any case navigation outside these zones is limited to specific activities (mobilization / demobilization and re-supply) , which are not expected to imply an impact on the sensitive resources involved in the protected and sensitive areas that may be affected by these routes other than the one evaluated. On the other hand, port operations of the ships associated with the project do not differ from those of any other ship that calling on those ports, while the operations that involve the navigation of the logistics ship shall be carried out every 2 or 3 weeks throughout the project that shall approximately take up 159 days.

3.7.3 Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other operations)

3.7.3.1 Sound and light emissions from ships (and helicopters)

As noted above, the area of operation and that of direct influence of CAN_100-108 and CAN_114 seismic data acquisition areas do not directly affect any declared or proposed protected area. However, the "Frente del Talud" (FT) (Slope Front) future marine protected area and the "Aguas del Talud Patagonia Norte" AICA candidate stand out for their proximity, located about 30 and 28 km respectively, from the prospecting area in the indirect area of influence.

The logistics routes and the area of influence of the Port of Mar del Plata defined for logistical support directly involve the "Restinga del Faro" Natural Reserve of Defined Geological and Fauna Objects, the "Puerto Mar del Plata" Natural Botanical, Faunistic and Educational Reserve and the "Playa de Punta Mogotes and Puerto de Mar del Plata" AICA.

On the other hand, the logistics route that connects CAN_114 Area with the port also crosses the "Aguas del Talud Patagonia Norte" AICA candidate and the "Frente del Talud (FT) and Frente de Plataforma Media (FPM)" future marine protected areas. Likewise, the "Costa Atlántica Argentina" APP is located in the area of influence of the port of logistical support and the logistics route, while the latter crosses the "Banco de Mejillones" APP.

As part of the assessment, the effects of sound emissions from ships (and helicopters) on marine mammals (Point 3.2.3.1), fish (Point **Error! Reference source not found.**) and turtles (Point **Error! Reference source not found.**) have been analyzed. In the case of birds, the effects of sound emissions from ships (and helicopters) (Point 3.6.3.2) and light emissions (Point 3.6.3.1) have also been evaluated.

In all cases the impacts have been classified as of low importance. These activities are not expected to imply an impact on the sensitive resources involved in the protected and sensitive areas other than those evaluated, in particular considering that the operational zones of CAN_100-108 and CAN_114 areas where the vessels shall operate most of the time do not directly overlap with protected or sensitive areas.

3.7.4 Oil spills

As mentioned above, the area of operation and that of direct influence of CAN_100-108 and CAN_114 seismic data acquisition areas do not directly affect any declared or proposed protected area. However, the "Frente del Talud" (FT) (Slope Front) future marine protected area and "Aguas del Talud Patagonia Norte" AICA candidate stand out for their proximity, located about 30 and 28 km respectively, from the prospecting area, in the indirect area of influence.

The logistics routes and the area of influence of the Port of Mar del Plata defined for logistical support directly involve the "Restinga del Faro" Natural Reserve of Defined Geological and Faunal Objects, the " Puerto Mar del Plata" Natural Botanical, Faunistic and Educational Reserve and the "Playa de Punta Mogotes and Puerto de Mar del Plata" AICA.

On the other hand, the logistics route that connects CAN_114 Area with the port also crosses the "Aguas del Talud Patagonia Norte" AICA candidate and the "Frente del Talud (FT) and Frente de Plataforma Media (FPM)" future marine protected areas. Likewise, the "Costa Atlántica Argentina" APP is located in the area of influence of the port of logistical support and the logistics route, while the latter crosses the "Banco de Mejillones" APP.

As part of the evaluation Point **Error! Reference source not found.** described the hydrocarbon spills that could be associated with the project under study and their effects on marine mammals (**Error! Reference source not found.**), fish (**Error! Reference source not found.**) turtles (**Error! Reference source not found.**), benthic and plankton communities (**Error! Reference source not found.**) and seabirds (**Error! Reference source not found.**) having been rated as moderate.

Taking into account the fact that CAN_100-108 and CAN_114 operational areas, where most of the vessel operations shall take place, do not overlap with protected or sensitive areas, it is considered that if a spill occurs within their surroundings, impacts would range from minor to moderate, depending on time and location.

3.7.5 Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste

According to Point **Error! Reference source not found.** the scenarios that could lead to the accidental discharge of chemical substances and / or solid waste (both hazardous and non-hazardous) were described, evaluating that the impacts on the marine environment would be insignificant in any situation depending on the scarce volumes that would be involved and the prevention and response measures to be implemented on board, the impact on protected and sensitive areas is considered to be equally insignificant.

3.8 FISHERIES

As regards the analysis carried out in Point **Error! Reference source not found.** which is summarized in Table 22, the actions of the project that can cause potential impacts on the fisheries present in the area of influence of the project include the following:

- Operation of seismic sources (compressed air emissions);
- Navigation of the seismic and support vessels and the physical presence of the seismic equipment (in terms of the interference that the activity can produce in relation to the movement of the fishing fleet circulating in that sector in search of catch areas); and
- Oil spills;

3.8.1 Operation of seismic sources (compressed air emissions)

3.8.1.1 Effects of seismic operations on species of fishing interest

Fish

The effect of seismic energy sources on fisheries still lacks firm conclusions although it has been considered disruptive (Carroll et al. 2016). The results indicate that the effects of seismic impacts on the catch seem to vary between studies, species and types of fishing gear. Several studies have shown that exposure to emission from seismic energy sources has an impact on fish catch, presumably as a result of changes in fish behavior and distribution during and after exposure to sound (e.g. Pearson et al., 1992; Skalski et al., 1992; Engås et al. 1996; Engås and Løkkeborg, 2002; Slotte et al. 2004; Løkkeborg et al., 2012). A reduction in the abundance of fish and lower catches have been reported after seismic activity in different studies (eg Løkkeborg and Soldal, 1993; Engås et al., 1996, Engås and Løkkeborg, 2002; Slotte et al., 2004; Løkkeborg et al., 2012). The distance of impact of seismic emissions can extend for several kilometers. It has been estimated that adult fish react to an operational seismic array at distances of more than 30 km, and that intense avoidance behavior can occur within a radius of 1 to 5 km.

In Norwegian studies, the decrease in fish density was measured at distances of more than 10 km from the fishing sites, with intensive 3D-type seismic activity. The possible effects of seismic operations on fish distribution have examined the abundance or catch of some teleost species with varying results, possibly due to gear and species specific effects (Løkkeborg et al., 2012). For example, longline and trawl catches of the Atlantic cod (*Gadus morhua*) and Atlantic haddock (*Melanogrammus aeglefinus*) have shown a 45% and 70% drop, respectively, five days after seismic surveys in the Barents Sea (Engås et al. 1996). Engås et al. (1995) have shown that 3D seismic studies (a compressed air discharge every 10 seconds and 125 m between 36 lines of 10 nm long) reduced the catches (trawl and longline) of Atlantic cod (Gadus morhua) and the Atlantic haddock (*Melanogrammus aeglefinus*) at 250-280 m depth. This occurred up to 18 nautical miles away. Catches did not return to normal levels within 5 days after seismic activities. These authors hypothesized that the reduction in catch was most likely the result of fish moving away from the seismic zone due to avoidance behavior, but this was not quantified. Skalski et al. (1992) suggested that the effects on fishing may be temporary, occurring mainly during exposure to sound itself.

An analysis of the official catch statistics of an area with seismic studies in that area also showed very different results (Vold et al. 2009 in Kyn et al. 2011). The catch rates for Atlantic cod (*Gadus morhua*), ling (*Molva molva*), cusk (*Brosme brosme*) and Atlantic halibut (*Hippoglossus hippoglossus*) did not change significantly. Catch rates for redfish and anglerfish (Lophius piscatorius) appeared to be increasing, while catch rates for saithe and haddock caught in gillnets were declining and catches with other gear were unaffected. Most of the seismic studies included in the analysis were two-dimensional and dispersed in time and space, so no major influences on fisheries were expected.

Engås et al. (1996) analyzed the effects of seismics in two important fisheries that suffered a 45% percentage reduction in the number of fish during the discharge of the sound impulses and a reduction of 64% once they were completed. Catch rates within the seismic acquisition area decreased 68% during the survey; in the surrounding areas the catches were also significantly lower during and after the survey. The abundance and catch rates did not return to previous levels during the 5-day period after the completion of the seismic survey. Practically all the large specimens of cod (more than 60 cm) left the emission area (see Annex I to this Chapter).

Similar reductions in catch rates were found due to seismic activity by commercial fishing vessels that happened to be operating in the fishing grounds where seismic surveys were conducted (Løkkeborg and Soldal, 1993). This analysis found a 55-80% reduction in longline catches of *Gadus morhua* and an 80-85% reduction in bycatch of *Gadus morhua* in shrimp trawl fisheries. A study in which a single seismic survey was conducted in 2015 found that of the fifteen commercial species examined, six showed increased catch after the study, three showed reduced catch, and five species showed no change at all (Przeslawski et al., 2016). After exposure in a Norwegian fishing ground, gillnet catches increased substantially for the Golden redfish (*Sebastes norvegicus*) and the Greenland halibut (*Reinhardtius hippoglossoides*) (by 86% and 132%, respectively), while halibut and haddock catches with Longline decreased 16% and 25%, respectively, compared to pre-release levels (Løkkeborg et al., 2012). Løkkeborg et al. (2009), on the other hand, showed that the differences in the reactions of the species with the halibut, redfish and ling increase their level of swimming activity, which makes them more likely to be caught by gillnets and reduce the efficiency of longline catching. Løkkeborg et al. (2012) found that gillnet catches doubled their catches during emissions compared to previous records. Engås et al. (1996) hypothesized that the reduction in Atlantic cod and haddock catch rates with longlines and commercial trawls was most likely the result of fish moving away from the seismic zone due to avoidance behavior, but this may be due instead to a lower responsiveness to baited hooks associated with a behavioral response to impacts related to fishing in the same area for more than two weeks (Skalski et al., 1992). Løkkeborg (1991), in turn, indicates reductions in the cod catch rate from 55 to 80% for longlines placed within the seismic survey area. The effects persisted for 24 hours within 5 nautical miles of the seismic survey. Løkkeborg, S. and Soldal (1993) conclude that seismic operations can significantly influence cod catch rates in longline and trawl fisheries. These reductions are likely due to the behavioral responses of the fish to the sound source, including downward movement and distancing from the study area.

Turnpenny and Nedwell (1994) also reported on the effects of seismic discharge on shallow coastal seabass fisheries in the UK (5 to 30 m depth). The set of seismic energy sources used had a source level of 250 dB re 1 µPa m0-p. The received levels in the fishing areas were estimated to be 163-191 dB re 1 µPa0-p. Using fish tagging and catch recording methodologies, it was concluded that there was no distinguishable migration from the affected area, nor was there any reduction in sea bass catches on the days when the compressed air sources were discharged. It thus seems likely that the effects on fishing are temporary and only take place upon exposure to sound itself (Skalski et al. 1992). Engås et al. (1996), in turn, observed that the catch of cod with a trawl net was reduced by 69% in the seismic survey area, and by 45-50% outside it. Catches of haddock decreased by 68% within the seismic survey area, by 56% at 1.9-5.6 km and 13-17 km from the survey, and 71% at 30-33 km from the study area. There were no increases in catch in 5 days. Longline catch rates were reduced by 45% in the study area, 16% at 1.9-5.6 km from the study itself, and 25% at 13-17 km from the latter. No reductions were observed at 30-33 km from the seismic survey zone. Longline catches of cod tended to increase after exposure, except at the furthest point where catches decreased. La Bella et al. (1996) found no significant differences with trawl nets used to assess the abundance of *Merluccius merluccius* before and after discharges from compressed air sources.

Other studies showed a reduction in catch rates from 40% to 80% and a decrease in abundance near the seismic zone in species such as haddock, rockfish, herring, sandeel and blue whiting (Dalen and Knutsen, 1987; Løkkeborg, 1991; Skalski et al. 1992; Engås et al., 1996; Hassel et al., 2004; Slotte et al. 2004). These effects can last up to 5 days after exposure and at distances of more than 30 km. Similar reductions in catch rates have been observed (52% decrease in catch per unit of effort (CPUE) in hook and rod fishing directed at a demersal species (*Sebastes* spp.). The authors suggested that the mechanism underlying the decrease in CPUE was not dispersion, but rather a decreased responsiveness to baited hooks associated with a behavioral alarm response (Skalski et al., 1992).

In the case of the Argentine Sea, there is little history of studies aimed at verifying the impacts of seismic emissions on fisheries. An antecedent is provided by Ezcurra and Schmidt (2010), where the results of a seismic survey are described that was accompanied by fishing monitoring before, during and after operations in order to obtain a greater knowledge about the behavior of the epibenthic and demersal communities in the face of exploratory seismic activity, with special reference to Common Hake and Prawn. No anomalies and / or losses were observed in the catches of common hake, before, during and after the seismic survey campaign.

Different examples of impacts on fisheries of different species are presented in Annex I to this Chapter, Tabla 40. It is observed that most of the impacts occur above 160-170 dB1µPa RMS and at generally less than 10 km away.

Invertebrate fisheries

In the case of marine invertebrate fisheries, no potential effects of seismic signals on catch rates or abundances of cephalopods, bivalves, gastropods, decapods and stomatopods have been detected between the sites exposed to seismic operations and those not exposed (Wardle et al., 2001; Parry et al., 2002; Christian et al., 2003; Parry and Gason, 2006; Courtney et al., 2015). The potential effects on catch rates or abundances have been tested in cephalopods with no differences detected between sites exposed to seismic operations and those not exposed (Carroll et al. 2016). Therefore, cephalopods may show a behavioral response to the seismic activities and move away from the source. There is not enough information to measure the scale of this movement, and the distance of travel, however, they shall probably return to the area once the seismic source has passed.

During a study of the effects of the 2D seismic studies of catch rates of snow crabs in the banks of Terranova, no changes were observed (Morris et al., 2018). There was no reduction in the catch rates of brown shrimp (Webb and Kempf 1998), prawns (Steffe & Murphy 1992, in McCauley, 1994) or rock lobsters (Parry and Gason, 2006) in the near field during or after seismic studies. Various actors indicate that seismic studies have had no effect on the catch rates of crustaceans in the surroundings of the emission areas (Andriguetto-Filho et al., 2005; Parry & Gason, 2006), and little effect on invertebrates of reefs (crustaceans, echinoderms and mollusks) exposed to seismic energy sources (Wardle et al. 2001). Andriguetto-Filho et al. (2005) examined bottom trawl yields from a non-selective Brazilian shrimp fishery before and after seismic exposure and did not identify any statistically significant change in catch performance after exposure to seismic prospecting activity. The limited dispersal capacity of shrimp (compared to migratory fish species) suggested that any attempted movement outside the survey area was not detectable (DOF, 2016). Christian et al. (2003) identified that post-seismic snow crab catches were higher than pre-seismic catches, but this was likely due to physical, biological, or behavioral factors unrelated to the seismic source. They concluded that there was no significant relationship between catch and distance from the seismic source (197-237 dB re 1 μPa (pp) received levels). In a study carried out in the Isle of Man, Brand and Wilson (1996) evaluated the effect of seismic activities in field studies comparing the long-term catch per unit of effort (CPUE) of commercial scallops with CPUE after a seismic study. They found no evidence that seismic studies affected scallop CPUE and instead attributed a decrease (coinciding with a 3D seismic study) to two years of poor recruitment prior to the seismic study. In a study conducted by the Victoria Freshwater and Marine Research Institute (MAFRI), the effects of seismic noise were measured by comparing the mortality and adductor muscle strength of scallops deployed in an area exposed to the passing of a reconnaissance vessel that tows a set of 24 compressed air sources in operation, with those found in a control zone 20 km from the test zone (Parry et al., 2002). This study showed that the mortality rate and adductor muscle strength of scallops suspended in the water column and exposed to airgun emissions (at a minimum distance of 11.7 m) was not significantly different from controls.

3.8.1.2 Importance of impact

The impact on the performance of the fishing activity in the seismic acquisition area could occur as an indirect result of the affectation of the project on the fauna of fish and invertebrates, since these communities may be affected by seismic prospecting activities. However, the incidence of seismic acquisition activities still lacks firm conclusions regarding their impact upon catches. Possibly, any potential effect on fish does not necessarily turn into population-scale effects or disruptions to fishing. While different studies have shown that exposure to emission from seismic sources has an impact on fish catch, possibly as a result of behavioral responses and their distribution during and after exposure to sound, some authors suggest that the effects on fishing can be temporary, occurring mainly during exposure to the sound itself.

In this regard, a non-binding relationship with the fishing areas is observed for CAN_100-108 y CAN_114 operational areas of the project. The fishing effort is mainly concentrated on the slope front, which, as mentioned above, is located 30 km from the prospecting area, and 17 km from CAN_100-108 and CAN_114 operational areas. The area of influence of CAN_100-108 and CAN_114, in particular the area of direct influence, supports a very low fishing effort that registers an annual variation.

The main species of fishing interest in the area of influence of the project are the following: hake, hoki, haddock, southern cod, black hake, southern hake, Pollock and squid. However, not all these species have the same fishing relevance in the areas of direct influence of CAN_100-108 and CAN_114. Only the pollock, Patagonian toothfish and squid fisheries could be affected depending on the moment when the fishery survey is conducted.

As described in Point **Error! Reference source not found.**, the pollock has low catches in the study area and its highest ones are recorded in the second and third quarters. Given that the project shall be conducted during the first and fourth quarters, specifically between October 2021 and the end of March, it shall not overlap with the time of highest catches of this species. Patagonian toothfish is caught almost all year round, with greater activity between September and December and much less in the summer season, so the project would coincide with the time of greatest catch, however, it is minimal in the area of direct influence of the project. North of 44 ° S, the Buenos Aires-North Patagonian subpopulation is exploited from March or April to June before the squid migrate to deep waters[6]. In this way, the development of the project does not temporarily overlap with squid fishing.

[6] Resolution 973/1997 of former SAGPyA establishes the opening to fishing of squid (*Illex argentinus*) north of the 44th parallel from May 1 to August 31 of each year.

According to the foregoing and taking into account that the fishing activity has a low sensitivity given that the greatest fishing efforts are mainly observed outside the area of direct influence, the impact on the fisheries is of low intensity. The area of direct influence is not identified as a breeding area of commercial species. Although squid larvae are recorded for the indirect area of influence of CAN_100-108 and CAN_114 and it is also possible to find them in the prospecting area, these larvae come from spawning areas located in other areas of the Argentine Sea due to the action of the Malvinas current between winter and spring. And in any case, the impact would be limited to the proximity of the array (5 m), as previously evaluated. Nor is it recognized that the bony fish species of fishing interest have their spawning or breeding area in said area of influence. As mentioned in Point **Error! Reference source not found.**, the highest concentrations and breeding groups of squid would be found outside the area of direct influence of CAN_100-108 and CAN_114 during the seismic acquisition period (spring - summer). In any case, taking into account that the reviewed antecedents indicate that adult fish react to seismic operations at distances that in some cases would reach 30-33 km (although most of the impacts appear to occur at distances generally less than 10 km), and that the fishing effort is concentrated in the slope front, being very important during the autumn and winter, the seismic operations in the western sector of the seismic data acquisition area closest to said front could have some incidence on fisheries that might temporarily overlap. However, the execution of the seismic activity under study is proposed for the spring 2021 - summer 2022 period, that is, outside the period of greatest sensitivity for fishing.

The extension is considered partial as the project area represents only a marginal portion of the wide area in which the fisheries are distributed in the region, and only the western sector of the acquisition areas has some proximity to the slope front. The impact is classified as immediate since the effect shall begin along with the development of the prospecting action. Persistence shall be temporary, since it would mainly occur during exposure to sound itself, and therefore reversible in the short term. It would be a periodic effect since all the activity is programmed. All this means that the importance of the impact of the seismic survey on the fisheries is classified as low.

3.8.2 Navigation of seismic and support vessels and physical presence of the seismic equipment

Seismic prospecting tasks can also affect fisheries due to the interference that the activity can produce in relation to the movement of the fishing fleet that travels through the sector in search of catch areas.

In this regard, a non-binding relationship with the fishing areas is observed for CAN_100-108 y CAN_114 operational areas of the project. The fishing effort is mainly concentrated on the slope front, which, as mentioned above, is located 30 km from the prospecting area, and 17 km from CAN_100-108 and CAN_114 operational areas. The area of influence of CAN_100-108 and CAN_114, in particular the area of direct influence, supports a very low fishing effort that registers an annual variation.

In this sense, the sensitivity of the activity of fishing vessels is considered to be of low intensity, that is to say that the interference of seismic operations with these activities is estimated to be low, in particular given that they shall be carried out during the spring and the summer, outside the peak period of fishing activity in front of the slope, which turns very important during autumn and winter.

3.8.3 Oil spills

The impacts of oil spills on fish and cephalopods have been assessed in Point **Error! Reference source not found.**. Dissolved hydrocarbons in the water column can affect fish and early life stages (eggs and larvae). This can reduce catch rates and make the resource unsafe for consumption, leading to economic losses.

Also, significant levels of hydrocarbons on the surface can damage equipment used to catch commercial fish, and transfer contaminants to the catch. This can occur for example when demersal trawls and traps are retrieved through surface oil slicks.

An oil spill can cause the area to be temporarily closed to fishing.

Regarding the species that may be affected by a hydrocarbon spill, the intensity of this impact is considered high. However, it is classified as moderate given its limited time and extent.

3.9 MARINE TRAFFIC

3.9.1 Navigation of seismic and support vessels and physical presence of the seismic equipment

In relation to maritime traffic, the main impacts could be associated with an eventual interference in the normal traffic of vessels that are on the route that connects the seismic data acquisition area with the coastal support base and those navigating in the project area.

Fishing activity of deep-sea freshwater fleet and freezer trawlers is recorded in the vicinity of the project's area of influence. Due to the distances from the exploration area to the coast, the activity of the bay or estuary fishing vessels and nearby coastal fishing vessels shall not be interfered with by the prospecting operations. In particular, the operational areas of CAN_100-108 and CAN_114 hold a non-binding relationship with the fishing areas, since the fishing effort is mainly concentrated in front of the slope, which is located 30 km from the prospecting area and 17 km from the aforementioned areas. The area of direct influence supports a very low fishing effort with an annual variation.

Regarding the type of vessels that can be seen in the navigation routes connecting the Port of Mar del Plata and CAN_100-108 and 114 seismic data acquisition areas, fishing vessels prevail, followed by tankers and cargo vessels. To a lesser extent, there are also tugs and special craft and pleasure boats, some unspecified ships and passenger vessels only in the location corresponding to the Port of Mar del Plata.

According to the Environmental baseline, the density of marine traffic could be generally considered moderate in CAN_100-108 and CAN_114 operational areas, and taking into account both the fishing activity and the current use of the area by other vessels, this factor has been regarded as having medium - low sensitivity in relation to the project.

However, if possible interferences are generated, they can be minimized through planning and effective communication with the port authorities and the Argentine Coast Guard. Thus, the impact on marine traffic is considered low.

3.10 ECONOMIC ACTIVITIES

3.10.1 Demand for labor, goods and services

Regarding economic activities, the demand for logistics services may have some very focused effects as to the benefits provided by the port of logistics services (Port of Mar del Plata) and possibly in some other locations as to other supplies / services, but, in any case, there would be scattered aspects of little relevance, which shall not affect local economies. The impact on economic activities shall be of little relevance, but positive, in terms of the demand for labor, due to the number and qualification of the personnel required for the project and its development period.

However, at the macroeconomic level, the project involves the first stage of hydrocarbon exploration that shall lay the basis for planning and continuing with the subsequent drilling and exploitation. Beyond the important demand for labor and services, the benefits hydrocarbon exploration generates for the country from the energy point of view allows confirming new hydrocarbon reserves to be exploited commercially. In this way, the country strengthens its energy matrix to ensure its self-sufficiency, improving the trade balance and future exports with a potential development of offshore hydrocarbon basins. As an indirect benefit, these future exports shall allow an important foreign exchange to improve national reserves.

3.11 INFRASTRUCTURE, RESOURCES AND LAND USES

According to the analysis carried out in Point **Error! Reference source not found.**, summarized in Table 22, the actions of the project that can cause potential impacts on the infrastructure, resources and land uses present in the area of influence of the port logistics base of the project include the following:

- Demand for labor, goods and services; and
- Oil spills

3.11.1 Demand for labor, goods and services

The use of existing ports is not expected to generate conflict with their current use. Given that the vessels associated with the project are between 40 and 100 meters in length, they shall require a modest docking space, and in any case, the largest seismic vessel shall dock in the port during the mobilization and demobilization stages, and during the survey period only if staying on the high seas turned dangerous (See Chapter 4 – Operation Conditions). Both the port of Buenos Aires to be used as a port of call (mobilization / demobilization), and the port of Mar del Plata designated as a port for logistics services can regularly accommodate much larger cargo ships. During the survey, crew changes and supplies provision shall be carried out every 2 to 3 weeks by the smaller logistics vessel.

Given the size of the metropolitan areas surrounding the aforementioned ports and the short term of the seismic record, the scale of the land resources and services demanded (fuel, food supplies, water, waste disposal, etc.) is not expected to cause a significant indirect impact on other users.

3.11.2 Oil spills

In the event of a hydrocarbon spill associated with the project in the port area, the operation of the port facilities could be temporarily affected depending on the deployment of response actions. The spill would be addressed through the use of ships and local spill response capabilities. Nevertheless, this impact is considered of low importance based on the limited volumes that would be involved in the event of an accident of this type, which would most likely be linked to failures in fuel transfer operations (see Point **Error! Reference source not found.**).

3.12 SURFACE WATER

According to the analysis carried out in Point **Error! Reference source not found.**, summarized in Table 22, the actions of the project that can cause potential impacts on the quality of the water in the area of influence of the project include the following:

- Oil spills; and
- Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste.

3.12.1 Oil spills

En el punto **Error! Reference source not found.** described the hydrocarbon spills that could be associated with the project under study.

The effects of a small fuel spill that are considered more likely to be associated with fuel transfers would depend on the sea conditions at the time of the spill. With strong winds and rough seas, the MGO would quickly dilute and disperse, and the effects of the spill would be of little consequence. In calmer waters, the evaporation of the diesel would be rapid and the area covered by the dispersion of the remaining hydrocarbon would depend on the speed and direction of the wind, and the temperature of the water.

An oil spill like this would introduce temporary toxicity to surface waters. However, its effects would in turn be limited by the required deployment of barrier equipment during fuel transfers and the automatic shutdown of fuel lines caused by a drop in pressure. In this sense, the effects are expected to be local and short-term, so the impact is classified as moderately important.

3.12.2 Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste

Point **Error! Reference source not found.** described the scenarios that could lead to the accidental discharge of chemical substances and / or solid waste (both hazardous and non-hazardous) evaluating that the impacts on the marine environment would be insignificant in any situation depending on the scarce volumes that would be involved and the prevention and response measures to be implemented on board. In this sense, the impact on water quality is considered insignificant.

3.13 AIR

3.13.1 Gaseous emissions

During the development of the project, gaseous emissions shall be generated associated with the following activities:

- Fuel combustion (MGO) for ship propulsion and power generation (continuously);
- Combustion of liquid and solid waste in the ship's incinerator (intermittent); and
- Use of aviation fuel for the transport of personnel in case of emergency by helicopters (possible).

The potential environmental impacts associated with gaseous emissions are as follows:

- Localized and temporary decrease in air quality due to combustion gases and particles emitted from diesel combustion; and
- Contribution to the global effect of greenhouse gases (GHG).

The operation and movement mechanism of the seismic vessel and support vessels is similar to vessels already sailing in the area. The use of fuel for propulsion engines, generators and any incineration of waste shall lead to gaseous GHG emissions, such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), as well as emissions of non-GHG particles such as sulfide oxides (SOX), nitrous oxides (NOX), volatile organic compounds (VOCs) and particulate matter.

The gaseous emissions of the project are mainly associated with the combustion of the engines for the propulsion of the ships, so the quality of the emissions shall be associated with the efficiency of the combustion process and the incorporated gas treatment systems.

The emission of non-GHG particles can cause a reduction in local air quality in terms of health risk. However, the product of the combustion of fuels and waste in such a remote location is not expected to affect the health or comfort of the receivers located more than 300 km away, since the winds shall rapidly disperse and diffuse the gases and emissions.

These gaseous emissions also make a contribution to GHG emissions (albeit very small) that contribute to global warming (albeit very slight). To evaluate their potential impact, the calculation of the estimated volume of GHG emissions to be generated by seismic prospecting activities is presented based on the characteristics of the vessels described in Chapter 4.

Regarding fuel consumption, the seismic vessel has two Rolls-Royce model B32: 40L8P CD engines, which fully comply with IMO Tier II emission regulations in Annex VI of the MARPOL 73/78 convention. These engines consume a total of 35 tons per day of MGO (Marine Gas Oil) which, together with the generators and propellers, total a consumption of 50 tons per day of MGO, according to data provided by the client.

The Candela S and GEO SERVICE I logistics support vessels shall have a daily consumption of 2 and 5 tons of MGO, respectively.

The operating times of each vessel differ according to their functions. In this sense, both the seismic vessel and Candela S shall have an operation time of 165 days, while the logistics vessel GEO SERVICE I, shall take up 145 days. This is due to the fact that the latter shall supply provisions and transport crew members to and from the port of Mar del Plata, unlike the support vessel that must accompany the seismic 100% of the exploration time.

The following table summarizes the daily consumptions and based on these, the total consumption throughout the prospecting operation.

Table 31. Total fuel consumption for each vessel.

Vessel	Name	Fuel	Daily Fuel Consumption (tons)	Operating Time (hours)	Total Fuel Consumption (tons)
Seismic	BGP PROSPECTOR	MGO	50	3.816	7.950
Support/Tug	CANDELA S	MGO	2	3.816	318
Logistics	GEO SERVICE I	MGO	5	3.480	725

Regarding the Emission Factors, the values for navigation established in the National Greenhouse Gas Inventory are used and based on the calorific powers that are expressed there, and that coincide with the emission factors presented in the "2006 IPCC Guidelines for the National inventories of greenhouse gases”.

Table 32. Emission Factors according to fuel for navigation.

Parameter	Emission Factor for Diesel	Unit
CO_2	74,1	t/TJ
CH_4	0,007	t/TJ
N_2O	0,002	t/TJ
NO_X	1,5	t/TJ
CO_2	1	t/TJ
COVNM	0,2	t/TJ
SO_2	0,036	t/TJ

The emissions for the proposed ships are estimated quantitatively based on the tons of fuel consumed in the total exploratory operation and emission factors indicated in the preceding table.

In this way, using the expression:

$$\text{Emission}_{ij} = (\text{Emission factor})_{ij} \times (\text{Fuel consumption})_{j}$$

The emissions of the different gases (subscript i) are obtained for the different ships (subscript j)

Additionally, for the project under study, the Global Warming Potential GWP is calculated, in tons of CO2 equivalent, for a 100 year-period. As it is usually recommended, the values expressed in the most current report (Fifth Assessment Report, AR5) are used for the different greenhouse gases indicated below.

Table 33. Global Warming Potential (for 100 year-period).

Greenhouse Gas (GEI)	Global Warming Potential (GWP)
CO_2	1
CH_4	28
N_2O	265

The GWP defines the integrated warming effect over time that today produces an instantaneous release of 1 kg of greenhouse gas, compared to that caused by CO_2. It is a measure of how much of a given amount of GHG is estimated to contribute to global warming. It is a relative scale that compares the gas in question with the same mass of CO_2, whose GWP by convention is unity.

In this sense, the values in the previous table are related by the following expression:

$$CO_2eq = \text{mass GEI} \times GWP_{GEI}$$

To obtain the GWP in tons CO_2eq.

The following table summarizes the atmospheric emissions for each vessel involved, the total according to the gaseous compound and the global warming potential.

Table 34. Emissions to the Atmosphere. Values expressed in tons.

Compound	Vessel			Total
	Seismic	Support	Logistics	
CO_2	25.331,09	1.013,24	2.310,07	28.654,40
CO	341,85	13,67	31,18	386,70
NO_X	512,78	20,51	46,76	580,05
N_2O	0,68	0,03	0,06	0,77
SO_2	12,31	0,49	1,12	13,92
CH_4	2,39	0,10	0,22	2,71
VOCs	68,37	2,73	6,24	77,34
GWP (tCO2eq)	**25.579**	**1.023**	**2.332**	**28.935**

On the other hand, knowing the technical specifications of the main engines of the seismic vessel, and the regulations they comply with regarding gaseous emissions, the maximum emissions are calculated during the operational stage.

Table 35. Consumption of MGO engines of the seismic vessel.

Engine		Power (kW)	Specific Consumption (g/kWh)	Operating time (h)	Unit consumption (tons)	Total consumption (tons)
Type	Quantity					
RRM Bergen B32:40L8P CD	2	4.000	184	3.816	2.809	5.618

A maximum value of 93.7 kg / h for NOx emissions and 1,430 tons for the total operation could be estimated for the Seismic Vessel. These extreme values arise from considering the IMO Tier II value of 11.71 g / kWh, maximum specific emission for 750 rpm. That is to say, that in fact the emissions would always be lower since the manufacturer's specifications comply with said regulations.

In this regard, it should be noted that the maximum emissions calculated according to the technical specifications of the engines and the emissions regulations that they comply with, are lower than those calculated from emission factors, the latter being more general. In turn, it is worth mentioning that the regulations moderate the sulphur content in fuels, not SO_2, being 0.1% (m / m) for IMO Tier II.

According to the emission estimate made, the seismic acquisition activities shall generate 28,935 tons of gases equivalent to CO2 in total (or 0,029 $MtCO_2eq$). In comparison with the total 364 $MtCO_2eq$ (Million Tons of equivalent CO2) estimated for the country based on the National GHG Inventory corresponding to the Third BUR prepared in 2018-2019 (SAyDS, 2019b), it is considered that the impact of the project on the GHG emissions is not significant.

The impact in relation to the gaseous emissions of the project is of low intensity, localized (punctual) around the ship (it is expected to rapidly dilute and dissipate in the environment as the ships move), of temporary persistence (duration of the project) and reversible in the short term, hence, its importance is classified as low.

4 ASSESSMENT OF ENVIRONMENTAL IMPACTS

4.1 METHODOLOGY USED

For the identification, evaluation and assessment of the potential environmental impacts associated with the project under study, the methodology proposed by Vicente Conesa Fernández - Vitora (1997, Methodological Guide for Environmental Impact Assessment, Importance Matrix) was followed. This methodology integrates the attributes of magnitude, temporality, synergy and accumulation, among others, in the quantification of the impacts complying with the requirements of Annex IV of Joint Resolution 3/19 of the Government Secretariats for Energy and Environment.

The impacts are classified according to their sign (positive, negative), intensity (low, medium, high, very high, total), extension (punctual, partial, extensive, total, critical), among other variables, which are detailed according to the following algorithm:

$$I = \pm [3i + 2EX + MO + PE + RV + SI + AC + EF + PR + MC]$$

Where:

± = sign

I = Importance of impact

i = intensity or probable degree of destruction

EX = Extension or area of influence of the impact

MO = Moment or time between the action and the appearance of the Impact.

PE = Persistence or permanence of the effect caused by the impact

RV = Reversibility

SI = Synergy or reinforcement of two or more effects caused by the impact

AC = Accumulation or progressive increase effect

EF = effect

PR = Periodicity

MC = Recoverability or possible degree of reconstruction by human means.

The development of the Importance equation was carried out by evaluating each of the algorithm terms together with the group of specialists involved in the present study, according to the illustrative table presented below.

Sign		**Intensity (i)**	
Beneficial Detrimental Neutral	+ - 0	Low Mean High Very High Total	1 2 4 8 12
Extension (EX)		**Moment (MO)**	
Punctual Partial Extensive Total Critical	1 2 4 8 12	Long term Medium-term Immediate Critical	1 2 4 8
Persistence (PE)		**Reversibility (RV)**	
Brief Temporal Permanent	1 2 4	Short term Medium-term Irreversible	1 2 4
Synergy (SI)		**Accumulation (AC)**	
No synergy Synergy Very synergistic	1 2 4	Simple Cumulative	1 4
Effect (EF)		**Periodicity (PR)**	
Indirect Direct	1 4	Irregular Periodic Continuous	1 2 4
Recoverability (MC)		**Importance of impact**	
Immediately recoverable Recoverable Mitigable Unrecoverable	1 2 4 8	**I = ± [3i + 2EX + MO + PE + RV + SI + AC + EF + PR + MC]**	

The following describes the meaning of the attributes of the importance matrix:

Sign
The sign of the impact refers to the beneficial (+) or harmful (-) nature of the different actions that shall act on the different factors considered.
Intensity (i) [1]
It refers to the degree of incidence of the action on the factor, in the specific area in which it operates. The evaluation range shall be between 1 and 12, in which 12 shall express a total destruction of the factor in the area in which the effect occurs and 1 a minimal affectation.
Extension (EX)
It refers to the area of theoretical influence of the impact in relation to the project environment (% of area, with respect to the environment, in which the effect is manifested).
Moment (MO)
The period of manifestation of the impact refers to the time that elapses between the appearance of the action and the beginning of the effect on the factor of the environment considered.
Persistence (PE)
It refers to the time that, supposedly, the effect would remain and after which the affected factor would return to the initial conditions.
Reversibility (RV)
It refers to the possibility of rebuilding the factor affected by the project, that is, the possibility of returning to the initial conditions prior to the action, by natural means, once it stops acting on the environment.
Recoverability (MC)
It refers to the possibility of reconstruction, total or partial, of the affected factor as a consequence of the project, that is, the possibility of returning to the initial conditions prior to the action, through human intervention (introduction of corrective measures).
Synergy (SI)
This attribute contemplates the reinforcement of two or more simple effects. The total component of the manifestation of simple effects, caused by actions that act simultaneously, is higher than that which would be expected from the manifestation of effects when the actions that cause them act independently and not simultaneously.
Accumulation (AC)
This attribute gives an idea of the progressive increase in the manifestation of the effect, when the action that generates it continuously or repeatedly persists.
Effect (EF)
This attribute refers to the cause-effect relationship, that is, to the form of manifestation of the effect on a factor, as a consequence of an action.
Periodicity (PR)
Periodicity refers to the regularity of manifestation of the effect, either cyclically or recurrently (periodic effect), unpredictably over time (irregular effect) or constant over time (continuous effect).
[1] The assessment intrinsically considers the sensitivity of the affected component in the present study.

Based on this model, the extreme values of Importance (I) can vary between 13 and 100. According to this variation, the impacts have been classified in the following categories according to the significance obtained in the valuation.

Positive Impact	Negative Impact

Significance	Valuation	Significance	Valuation
< 25	Low	> -25	Low
25 a 49	Moderate	-25 a -49	Moderate
50 a 75	High	-50 a -75	Severe
> 75	Relevant	< -75	Critical

An additional "Less Significant" category of impact has been included to classify the interactions that have been evaluated but their effects are not relevant enough to cause an impact.

The advantage of the application of this type of matrix lies in its usefulness to determine impacts in a global way from a comprehensive and little particularized analysis, in which it is quickly evident where the greatest impacts are concentrated and what type or group of activities of the project are impacted. It identifies impacts of different stages of the project. In addition, this type of matrix allows determining both positive and negative impacts, from the incorporation of signs (+/-).

In this sense, this evaluation made it possible to identify the potential environmental effects and impacts associated with the project, and based on this, to develop the most appropriate mitigation and control measures to apply to avoid or minimize them (Chapter 8 - Mitigation Measures and Environmental Management Plan).

4.2 IDENTIFICATION AND ASSESSMENT OF IMPACTS

The Environmental Impact Assessment Matrix for the project is presented below.

The columns represent the actions of the project that were identified as potential modifiers of the different environmental factors. The rows correspond to the aforementioned environmental factors. The Summary Matrix of Environmental Impact is presented below with the connections between actions and factors of the potential environmental impacts identified, and the final assessment obtained.

Table 36. Environmental Impact Assessment Matrix

3D Offshore Seismic Record of CAN_100, CAN_108 and CAN_114 Areas															
Action		Enviroment	Enviromental factor	Sign (+/-)	Intensity (IN)	Extension (EX)	Moment (MO)	Persistence (PE)	Reversibility (RV)	Synergy (SI)	Accumulation (AC)	Effect (EF)	Periodicity (PR)	Recoverability (MC)	IMPORTANCE (I)
Planned Activities															
Operation of seismic sources (compressed air emissions)		Biotic	Marine mammals	-	4	2	4	2	1	1	4	4	2	4	-38
			Fish and Cephalopod	-	2	2	4	2	1	1	4	4	2	4	-32
			Sea turtles	-	4	2	4	2	1	1	4	4	2	4	-38
			Benthos and plankton	-	2	1	4	2	1	1	1	4	2	1	-24
			Birds	-	2	2	4	2	1	1	1	4	2	4	-29
			Protected and sensitive areas	-	4	2	4	2	1	1	4	1	2	4	-35
		Anthropic	Fishing activity	-	1	2	4	2	1	1	1	1	2	2	-21
Navigation of seismic and support vessels and physical presence of the seismic equipment		Biotic	Marine mammals	-	2	1	4	2	1	1	1	1	2	4	-24
			Sea turtles	-	2	1	4	2	1	1	1	1	2	4	-24
			Birds	-	1	1	4	2	1	1	1	4	2	4	-24
			Protected and sensitive areas	-	1	1	4	2	1	1	1	4	2	4	-24
		Anthropic	Fishing activity	-	1	1	4	2	1	1	1	4	2	4	-24
			Marine Traffic	-	1	1	4	2	1	1	1	4	2	4	-24
Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other	Gaseous emissions	Physical	Air	-	1	1	4	2	1	1	1	4	2	4	-24
	Light emissions from ships	Biotic	Birds	-	1	1	4	2	1	1	1	4	2	4	-24
			Protected and sensitive areas	-	1	1	4	2	1	1	1	4	2	4	-24
	Sound emissions from ships (and helicopters)	Biotic	Marine mammals												Less significant
			Fish and Cephalopod												Less significant
			Sea turtles												Less significant
			Birds												Less significant
			Protected and sensitive areas												Less significant
Demand for labor, godos and services		Anthropic	Economic Activities	+	1	1	2	2	1	1	1	1	1	2	16
			Infrastructures, resources and land uses												Less significant
Unplanned events (contingencies)															
Oil Spills		Physical	Surface water	-	4	2	4	2	1	1	4	4	2	2	-36
		Biotic	Marine mammals	-	4	2	4	2	4	1	4	4	1	4	-40
			Fish and Cephalopod	-	4	2	4	2	2	1	4	4	1	4	-38
			Sea turtles	-	4	2	4	2	4	1	4	4	1	4	-40
			Benthos and plankton	-	1	2	4	2	1	1	4	4	1	2	-26
			Birds	-	4	2	4	2	4	1	4	4	1	4	-40
			Protected and sensitive areas	-	4	2	4	2	4	1	4	4	1	4	-40
		Anthropic	Fishing Activity	-	4	2	4	2	2	1	4	1	1	4	-35
			Infrastructure, resources and land uses	-	1	1	4	2	2	1	1	4	1	4	-24
Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste		Physical	Surface water												Less significant
		Biotic	Marine Mammals												Less significant
			Fish and Cephalopod												Less significant
			Sea turtles												Less significant
			Benthos and plankton												Less significant
			Birds												Less significant
			Protected and sensitive areas												Less significant

REFERENCES

Positive Impact		Nagative Impact	
Significance	Valuation	Significance	Valuation
< 25	Low	> -25	Low
25 a 49	Moderate	-25 a -49	Moderate
50 a 75	High	-50 a -75	Severe
> 75	Relevant	< -75	Critical

Table 37. Summary Matrix

ACCIONES \ COMPONENTES AMBIENTALES		MEDIO FÍSICO		MEDIO BIÓTICO						MEDIO ANTRÓPICO			
		Agua superficial	Aire	Mamíferos marinos	Peces y cefalópodos	Tortugas marinas	Bentos y plancton	Aves	Áreas sensibles y protegidas	Actividad pesquera	Tránsito Marítimo	Actividades económicas	Infraestructuras, recursos y usos terrestres
Registro Sísmico Offshore 3D Áreas CAN 100, CAN 108 y CAN 114	**Actividades planificadas**												
	Operación de las fuentes sísmicas (emisiones de aire comprimido)			-38	-32	-38	-24	-29	-35	-21			
	Navegación de los buques sísmicos y de apoyo y presencia física del equipo sísmico			-24		-24		-24	-24	-24	-24		
	Emisiones, efluentes y residuos asociados a la operación normal y el mantenimiento de los buques sísmicos y de apoyo (y otras operaciones): Emisiones gaseosas		-24										
	Emisiones, efluentes y residuos asociados a la operación normal y el mantenimiento de los buques sísmicos y de apoyo (y otras operaciones): Emisiones lumínicas de los buques							-24	-24				
	Emisiones, efluentes y residuos asociados a la operación normal y el mantenimiento de los buques sísmicos y de apoyo (y otras operaciones): Emisiones sonoras de los buques (y helicóptero)			Poco significativo	Poco significativo	Poco significativo		Poco significativo	Poco significativo				
	Demanda de mano de obra y de bienes y servicios											16	Poco significativo
	Eventos no planificados (contingencias)												
	Derrames de hidrocarburos	-36		-40	-38	-40	-27	-40	-40	-35			-24
	Descarga accidental de sustancias químicas y/o de residuos sólidos, no peligrosos/peligrosos	Poco significativo		Poco significativo	Poco significativo	Poco significativo	Poco significativo	Poco significativo	Poco significativo				

REFERENCES

Positive Impact		Negative Impact	
Significance	Valuation	Significance	Valuation
< 25	Low	> -25	Low
25 a 49	Moderate	-25 a -49	Moderate
50 a 75	High	-50 a -75	Severe
> 75	Relevant	< -75	Critical

5 ENVIRONMENTAL IMPACT MATRIX WITH IMPLEMENTATION OF MITIGATION MEASURES

According to the “Guide for the preparation of environmental impact studies” (SAyDS, 2019a), the approach to mitigation measures considers the conceptual model of early planning of the mitigation of impacts, known as the principle of mitigation hierarchy.

This principle sets up a sequence of steps, to be implemented in a linked and hierarchical way, that are intended to avoid, minimize, restore and ultimately compensate for the residual significant negative impacts in order to achieve at least zero loss and preferably an additional gain of environmental values, at the project scale.

Table 38. Mitigation Hierarchy (SAySD, 2019)

Avoid	The first instance consists of preventing environmental impacts, which can be carried out through technological changes, scale or location of the project or any of its components or activities. These types of prevention measures shall be effective if implemented early in the project cycle.
Minimize	The next level seeks to reduce negative impacts that could not be avoided, both in their duration, magnitude or scope. They can also be approached from the technological changes, location or scale of the project.
Restore	It includes the recovery of the values of the environment that are inevitably altered by the project, and only when the preceding measures cannot be applied. Restoration actions can be implemented during project execution, operation, and after project closure.
Compensate	Last stage that is implemented on those residual significant negative impacts that could not be avoided, minimized or restored. Compensation should only be implemented after the previous instances have been duly applied.

The priority in mitigation is to first apply the mitigation measures to the source of the impact (that is, avoid or minimize the magnitude of the impact of the activity associated with the project), and then address the resulting effect on the resource / receptor through mitigation, restoration or compensation measures (i.e. reducing the significance of the effect once all reasonably feasible mitigations have been applied to lessen the magnitude of said impact).

The summary matrix of environmental impacts considering the implementation of the mitigation measures prepared to address the significant impacts of the project is hereinbelow presented and detailed in Chapter 8. The level of residual impact has been assigned qualitatively using the categories defined in Point **Error! Reference source not found.**. As a result of the implementation of the measures, the residual impacts have been classified between low and negligible.

Table 39. Matrix of environmental impact implementing mitigation measures

Action	Environment	Environmental Factor	IMPORTANCE (I)	Mitigation measure / Environmental Management Program	RESIDUAL IMPACT
Operation of seismic sources (compressed air emissions)	Biotic	Marine mammals	Moderate	► ONBOARD SEA WILDLIFE OBSERVERS PROGRAM - General - Soft start procedure and visual (and acoustic) monitoring of marine mammals and sea turtles - Monitoring of seabirds, marine mammals and sea turtles - Mitigation of random impacts upon occasionally discovered species ► PROGRAM FOR PREVENTION OF IMPACTS DUE TO POTENTIAL INTERFERENCES AND COORDINATION WITH ADJOINING ACTIVITIES - Coordination with adjoining explorations (distancing from other seismic prospecting activities)	Low
		Fish and Cephalopod	Moderate	► ONBOARD SEA WILDLIFE OBSERVERS PROGRAM - General - Soft start procedure and visual (and acoustic) monitoring of marine mammals and sea turtles ► PROGRAM FOR PREVENTION OF IMPACTS DUE TO POTENTIAL INTERFERENCES AND COORDINATION WITH ADJOINING ACTIVITIES - Coordination with adjoining explorations (distancing from other seismic prospecting activities)	Low
		Sea Turtles	Moderate	► ONBOARD SEA WILDLIFE OBSERVERS PROGRAM - General - Soft start procedure and visual (and acoustic) monitoring of marine mammals and sea turtles - Monitoring of seabirds, marine mammals and sea turtles - Mitigation of random impacts upon occasionally discovered species ► PROGRAM FOR PREVENTION OF IMPACTS DUE TO POTENTIAL INTERFERENCES AND COORDINATION WITH ADJOINING ACTIVITIES - Coordination with adjoining explorations (distancing from other seismic prospecting activities)	Low
		Birds	Moderate	► ONBOARD SEA WILDLIFE OBSERVERS PROGRAM - General - Soft start procedure and visual (and acoustic) monitoring of marine mammals and sea turtles - Monitoring of seabirds, marine mammals and sea turtles - Mitigation of random impacts upon occasionally discovered species ► PROGRAM FOR PREVENTION OF IMPACTS DUE TO POTENTIAL INTERFERENCES AND COORDINATION WITH ADJOINING ACTIVITIES - Coordination with adjoining explorations (distancing from other seismic prospecting activities)	Low

Action	Environment	Environmental Factor	IMPORTANCE (I)	Mitigation measure / Environmental Management Program	RESIDUAL IMPACT
		Benthos and plankton	Low	► ONBOARD SEA WILDLIFE OBSERVERS PROGRAM - General ► PROGRAM FOR PREVENTION OF IMPACTS DUE TO POTENTIAL INTERFERENCES AND COORDINATION WITH ADJOINING ACTIVITIES - Coordination with adjoining explorations (distancing from other seismic prospecting activities)	Low
		Protected and sensitive areas	Moderate	► ONBOARD SEA WILDLIFE OBSERVERS PROGRAM - General - Soft start procedure and visual (and acoustic) monitoring of marine mammals and turtles - Monitoring of seabirds, marine mammals and sea turtles - Mitigation of random impacts upon occasionally discovered species ► PROGRAM FOR PREVENTION OF IMPACTS DUE TO POTENTIAL INTERFERENCES AND COORDINATION WITH ADJOINING ACTIVITIES - Coordination with adjoining explorations (distancing from other seismic prospecting activities)	Low
	Anthropic	Fishing activity	Low	► ONBOARD SEA WILDLIFE OBSERVERS PROGRAM - General - Soft start procedure and visual (and acoustic) monitoring of marine mammals and sea turtles ► PROGRAM FOR PREVENTION OF IMPACTS DUE TO POTENTIAL INTERFERENCES AND COORDINATION WITH ADJOINING ACTIVITIES - Coordination with adjoining explorations (distancing from other seismic prospecting activities)	Low
Navigation of seismic and support vessels and physical presence of the seismic equipment	Biotic	Marine mammals	Low	► IMPACT PREVENTION PROGRAM ON MARINE FAUNA - Measures to reduce the speed of ships - Monitoring of seabirds, marine mammals and sea turtles	Low
		Sea turtles	Low	► IMPACT PREVENTION PROGRAM ON MARINE FAUNA - Terminal buoys equipped with sea turtle guards - Monitoring of seabirds, marine mammals and sea turtles	Low
		Birds	Low	► IMPACT PREVENTION PROGRAM ON MARINE FAUNA - Prevention for birdlife - Monitoring of seabirds, marine mammals and sea turtles	Low
		Protected and sensitive areas	Low	► IMPACT PREVENTION PROGRAM ON MARINE FAUNA - Measures to reduce the speed of ships - Terminal buoys equipped with sea turtle guards - Prevention for birdlife - Monitoring of seabirds, marine mammals and sea turtles	Low
	Anthropic	Fishing activity	Low	► PROGRAM FOR PREVENTION OF IMPACTS DUE TO POTENTIAL INTERFERENCES AND COORDINATION WITH ADJOINING ACTIVITIES	Negligible

Action		Environment	Environmental Factor	IMPORTANCE (I)	Mitigation measure / Environmental Management Program	RESIDUAL IMPACT
					Mitigation measures for potential interference with fisheries and activities related to the fishing sector	
			Marine Traffic	Low	► PROGRAM FOR PREVENTION OF IMPACTS DUE TO POTENTIAL INTERFERENCES AND COORDINATION WITH ADJOINING ACTIVITIES - Mitigation measures for potential interference with navigation	Negligible
Emissions, effluents and waste associated with the normal operation and maintenance of seismic and support vessels (and other operations)	Gaseous emissions	Physical	Air	Low	► ENVIRONMENTAL MONITORING AND FOLLOW-UP PROGRAM - General (Maintenance of engines to ensure appropriate emission and noise levels) ► ENVIRONMENTAL EDUCATION AND STAFF CONDUCT PROGRAM	Low
	Light emissions from ships	Biotic	Birds	Low	► IMPACT PREVENTION PROGRAM ON MARINE FAUNA - Prevention for birdlife ► ONBOARD SEA WILDLIFE OBSERVERS PROGRAM - Monitoring of seabirds, marine mammals and sea turtles	Low
			Protected and sensitive areas	Low	► IMPACT PREVENTION PROGRAM ON MARINE FAUNA - Prevention for birdlife ► ONBOARD SEA WILDLIFE OBSERVERS PROGRAM - Monitoring of seabirds, marine mammals and sea turtles	Low
	Sound emissions from ships (and helicopters)	Biotic	Marine mammals	Less significant	► ENVIRONMENTAL MONITORING AND FOLLOW-UP PROGRAM - General (Maintenance of engines that ensure appropriate emission and noise levels) ► ENVIRONMENTAL EDUCATION AND STAFF CONDUCT PROGRAM	Negligible
			Fish and Cephalopod	Less significant	► ENVIRONMENTAL MONITORING AND FOLLOW-UP PROGRAM - General (Maintenance of engines that ensure appropriate emission and noise levels) ► ENVIRONMENTAL EDUCATION AND STAFF CONDUCT PROGRAM	Negligible
			Sea Turtles	Less significant	► ENVIRONMENTAL MONITORING AND FOLLOW-UP PROGRAM - General (Maintenance of engines that ensure appropriate emission and noise levels) ► ENVIRONMENTAL EDUCATION AND STAFF CONDUCT PROGRAM	Negligible
			Birds	Less significant	► ENVIRONMENTAL MONITORING AND FOLLOW-UP PROGRAM - General (Maintenance of engines that ensure appropriate emission and noise levels) ► ENVIRONMENTAL EDUCATION AND STAFF CONDUCT PROGRAM	Negligible
			Protected and sensitive areas	Less significant	► ENVIRONMENTAL MONITORING AND FOLLOW-UP PROGRAM - General (Maintenance of engines that ensure appropriate emission and noise levels) ► ENVIRONMENTAL EDUCATION AND STAFF CONDUCT PROGRAM	Negligible
Demand for labor, goods and services		Anthropic	Economic Activities	Low	► LOCAL STAFF HIRING AND PURCHASING PROGRAM	Low

Action	Environment	Environmental Factor	IMPORTANCE (I)	Mitigation measure / Environmental Management Program	RESIDUAL IMPACT
		Infrastructures, resources and land uses	Less significant	▶ LOCAL STAFF HIRING AND PURCHASING PROGRAM	Negligible
Oil spills	Physical	Surface water	Moderate	▶ HYDROCARBON MANAGEMENT PROGRAM - Fuel and oil management - Waste management ▶ ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ▶ HYDROCARBON MANAGEMENT PROGRAM ▶ EMERGENCY RESPONSE PROGRAM	Low
	Biotic	Marine mammals	Moderate	▶ HYDROCARBON MANAGEMENT PROGRAM - Fuel and oil management - Waste management ▶ ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ▶ HYDROCARBON MANAGEMENT PROGRAM ▶ EMERGENCY RESPONSE PROGRAM	Low
		Fish and Cephalopod	Moderate	▶ HYDROCARBON MANAGEMENT PROGRAM - Fuel and oil management - Waste management ▶ ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ▶ HYDROCARBON MANAGEMENT PROGRAM ▶ EMERGENCY RESPONSE PROGRAM	Low
		Sea turtles	Moderate	▶ HYDROCARBON MANAGEMENT PROGRAM - Fuel and oil management - Waste management ▶ ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ▶ HYDROCARBON MANAGEMENT PROGRAM ▶ EMERGENCY RESPONSE PROGRAM	Low
		Seabirds	Moderate	▶ HYDROCARBON MANAGEMENT PROGRAM - Fuel and oil management - Waste management ▶ ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ▶ HYDROCARBON MANAGEMENT PROGRAM ▶ EMERGENCY RESPONSE PROGRAM	Low
		Benthos and plankton	Moderate	▶ HYDROCARBON MANAGEMENT PROGRAM - Fuel and oil management - Waste management	Low

Action	Environment	Environmental Factor	IMPORTANCE (I)	Mitigation measure / Environmental Management Program	RESIDUAL IMPACT
				▶ ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ▶ HYDROCARBON MANAGEMENT PROGRAM ▶ EMERGENCY RESPONSE PROGRAM	
		Protected and sensitive areas	Moderate	▶ HYDROCARBON MANAGEMENT PROGRAM - Fuel and oil management - Waste management ▶ ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ▶ HYDROCARBON MANAGEMENT PROGRAM ▶ EMERGENCY RESPONSE PROGRAM	Low
	Anthropic	Fishing activity	Moderate	▶ PROGRAM FOR PREVENTION OF IMPACTS DUE TO POTENTIAL INTERFERENCES AND COORDINATION WITH ADJOINING ACTIVITIES - Mitigation measures for potential interference with navigation ▶ HYDROCARBON MANAGEMENT PROGRAM - Fuel and oil management - Waste management ▶ ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ▶ HYDROCARBON MANAGEMENT PROGRAM ▶ EMERGENCY RESPONSE PROGRAM	Low
	Anthropic	Infrastructures, resources and land uses	Low	▶ ONSHORE LOGISTICS BASE OPERATIONS PROGRAM ▶ HYDROCARBON MANAGEMENT PROGRAM - Fuel and oil management - Waste management ▶ ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ▶ HYDROCARBON MANAGEMENT PROGRAM ▶ EMERGENCY RESPONSE PROGRAM	Negligible
Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste	Physical	Surface water	Less significant	▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM - Waste management ▶ ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ▶ HYDROCARBON MANAGEMENT PROGRAM ▶ EMERGENCY RESPONSE PROGRAM	Negligible
Accidental discharge of chemical substances and / or non-hazardous / hazardous solid waste	Biotic	Marine mammals	Less significant	▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM - Waste management ▶ ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ▶ ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ▶ HYDROCARBON MANAGEMENT PROGRAM ▶ EMERGENCY RESPONSE PROGRAM	Negligible

Action	Environment	Environmental Factor	IMPORTANCE (I)	Mitigation measure / Environmental Management Program	RESIDUAL IMPACT
		Fish and Cephalopod	Less significant	► ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM - Waste management ► ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ► ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ► HYDROCARBON MANAGEMENT PROGRAM ► EMERGENCY RESPONSE PROGRAM	Negligible
		Sea turtles	Less significant	► ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM - Waste management ► ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ► ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ► HYDROCARBON MANAGEMENT PROGRAM ► EMERGENCY RESPONSE PROGRAM	Negligible
		Seabirds	Less significant	► ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM - Waste management ► ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ► ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ► HYDROCARBON MANAGEMENT PROGRAM ► EMERGENCY RESPONSE PROGRAM	Negligible
		Benthos and plankton	Less significant	► ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM - Waste management ► ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ► ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ► HYDROCARBON MANAGEMENT PROGRAM ► EMERGENCY RESPONSE PROGRAM	Negligible
		Protected and sensitive areas	Less significant	ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM - Waste management ► ENVIRONMENTAL EDUCATION AND PERSONNEL CONDUCT PROGRAM ► ON-BOARD WASTE AND EFFLUENT MANAGEMENT PROGRAM ► HYDROCARBON MANAGEMENT PROGRAM ► EMERGENCY RESPONSE PROGRAM	Negligible

6 CUMULATIVE IMPACTS

While an impact may be relatively small when considering the project or activity alone, it can be magnified in combination with the impacts of other projects and activities; these combined effects are known as "cumulative" impacts.

Cumulative impacts can arise as a result of:

1. Interactions between independent residual impacts related to the project, which could include the effect of multiple environmental interactions of said project (for example, underwater sound, interference from vessel movements, etc.) on a receptor or environmental component, with the resulting effect being greater than each individual impact in isolation.

2. Interactions between the residual impacts of the 3D Offshore Seismic Record project in CAN_100-108 and CAN_114 Areas in combination with the impacts of other projects and their related activities within the same area of influence. This effect can occur as a result of the combined impacts of several projects, which individually may not be significant, but when together could create a significant cumulative effect on a single receptor or environmental component.

The former have been evaluated as part of the previous point, since, on the one hand, the methodology used (Conesa, 1997) particularly considers this aspect of the impacts; and on the other hand, the project considers a single focus of action, given by the seismic vessel and its array, and the support vessels, which shall cover the entire area to be surveyed.

In this sense, this point of the study focuses on the latter, those related to the potential interaction of the project with other activities or projects within the area of influence.

The cumulative impact assessment comprises the following:

- Identify other known projects and activities in the vicinity of the Project for the 3D Offshore Seismic Record of CAN_100, CAN_108 and CAN_114 Areas causing simultaneous cumulative impacts.
- Evaluate the project's interaction with other activities or projects both spatially (that is, the impacts are so close in space that their effects overlap) and temporarily (that is, the impacts are so close in time that the effect of one does not dissipate before the next occurs);
- Evaluate the possible cumulative impacts on the environmental receptors potentially affected by the 3D Offshore Seismic Record of CAN_100, CAN_108 and CAN_114 Areas and the projects or activities identified; and
- Where necessary, define measures to avoid, reduce or mitigate to the extent possible any potentially significant cumulative impacts.

A list of the activities and projects identified around CAN 100, CAN 108 and CAN 114 areas with potential cumulative impacts are hereinbelow described.

1 - As can be seen in the figures below, there are blocks bordering the acquisition areas under study that were part of the Offshore International Public Tender No. 1. CAN_100 and CAN_108 blocks are adjacent to CAN_105, 106, 107, 109 and 110 blocks; while CAN_114 block adjoins CAN_111, 112 and 113 blocks. According to Resolution 276/2019 of the former Secretariat of Energy of the Government, the bidding for CAN 105, 106, 110 and 112 blocks was declared void since no offers were received for those areas. CAN_107 and 109 blocks were granted to Shell Argentina SA group and Qatar Petroleum International Limited, and CAN_111 and 113 blocks to Total Austral SA group and BP Exploration Operating Company Limited. The foregoing would make it possible to rule out the possibility of prospecting tasks with temporal overlap in CAN 105, 106, 110 and 112 adjacent areas (until they are granted).

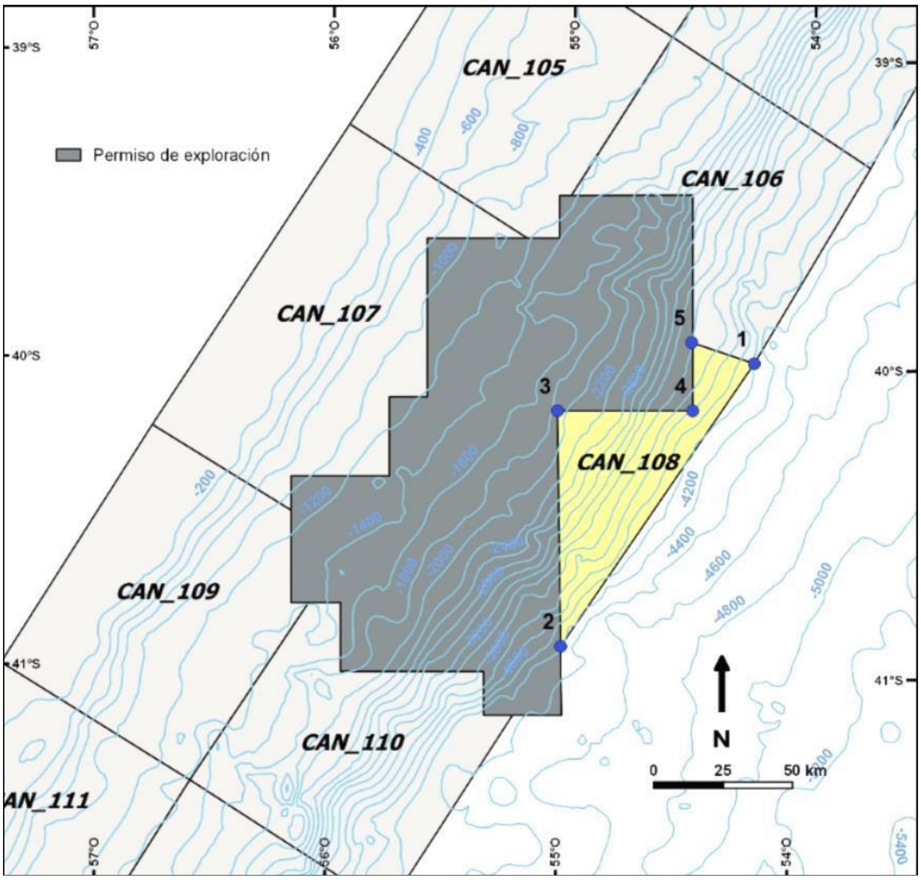


Figure 14. Blocks bordering CAN_108 Area (and CAN_100 in gray) granted by the Offshore International Public Tender No. 1.

(Translation of Figure 14: Permiso de exploración: Exploration Permit)

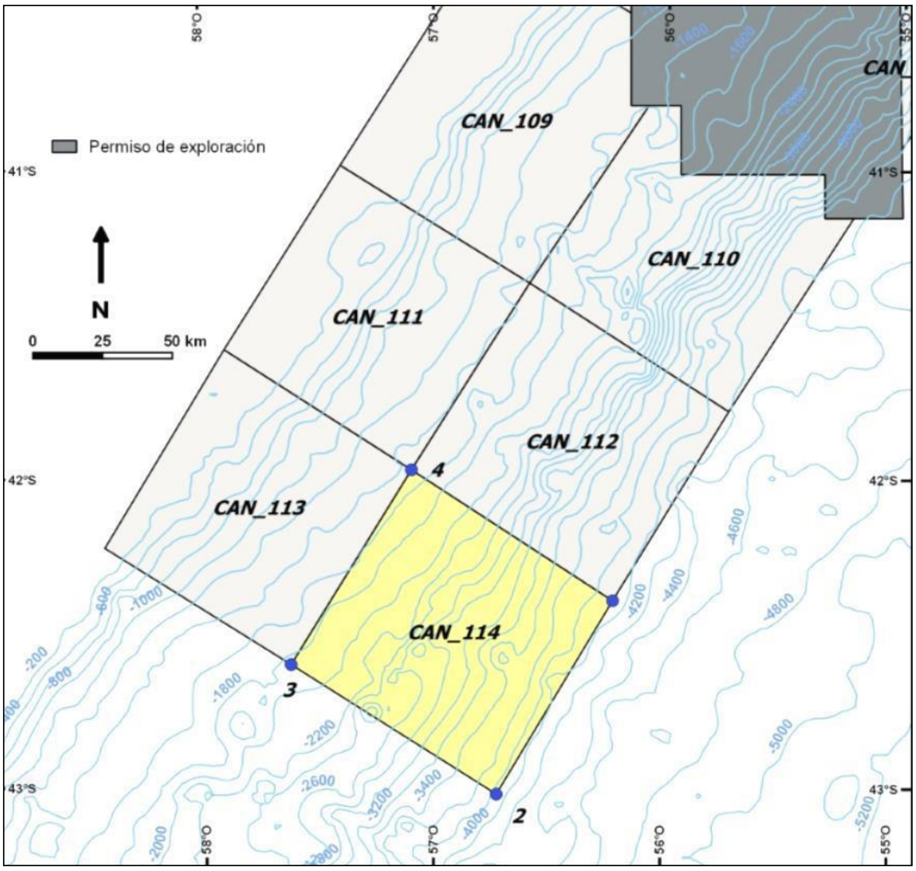


Figure 15. Blocks bordering CAN_114 area licensed in the Offshore International Public Tender N ° 1.

(Translation of Figure 15: Permiso de exploración: Exploration Permit)

Through the additional information request report IF-2020-88272623-APN-DNEA # MAD, the MAyDS stated that within the framework of Joint Resolution SE-SAYDS N° 3/2019 Project Notices for seismic exploration activities in the Argentine Basin have been submitted by the following proponents:

• SPECTRUM: Cuenca Argentina (Argentine Basin) (EX-2020-25269675- -APN-DNEP#MHA) TGS: CAN 107, CAN 108, CAN109, CAN101, CAN102, CAN103, CAN104 (EX-2020-17648170- -APN-DNEP#MHA, EX-
2020-17643202- -APN-DNEP#MHA andEX-2020-73992409- -APN-DNEYP#MEC)

• YPF: CAN 102 (EX-2020-43785653- -APN-DNEYP#MDP)

• SHELL: CAN 107 and CAN 109 (EX-2020-17578657- -APN-DNEP#MHA)

As mentioned above, CAN_107, CAN_109, CAN_111 and CAN_113 blocks are of particular interest due to their proximity, and CAN_102 block is located more than 200 km from the seismic acquisition areas of CAN_100-108 and the others (CAN_101, CAN_103 and CAN_104 are located at greater distances).

EQUINOR has initiated conversations with Total and Shell to find out their plans regarding any seismic operations. Based on the plans reported by EQUINOR to prospect CAN_100-108 and CAN_114 areas during the spring of 2021 and the summer of 2022, Total has confirmed that its operations in CAN_111 and CAN_113 areas would not overlap, as they are planning them for later, in the year 2022. On the other hand, Shell would be planning 3D operations in CAN_107 and CAN_109 areas in the fourth quarter of 2021, which would temporarily overlap with the campaign under study.

CAN_107 and CAN_109 blocks are located 5.4 km and 15.3 km respectively from CAN_100 - 108 seismic data acquisition area; and they are 77 km and 180 km away, respectively, from CAN_114 acquisition area. However, the distances would indicate that the operations in the adjoining blocks shall be outside the area of maximum incidence of the noise propagated by the prospecting activity (area of direct influence), at greater distances than the thresholds of physiological damage are reached on hearing (PTS and TTS) for mammals (Table 25 and Table 26) and fish (Table 28 and Table 29). However, these distances are tentative given that the details of which the polygons shall be to effectively prospect within the licensed blocks are not known. Neither are other details of the operation known (number and type of vessels involved, planned schedule for each block, exploration sequence, survey pattern, characteristics of the seismic array, etc.).

Equinor proposes to plan the operations in a coordinated way with SHELL at all times, to be as far away as possible from each other. Equinor proposes, in a preliminary way, to plan the operations later in the fourth quarter, in October 2021, to begin in the easternmost part of CAN_100-108 area, which is about 65 km from CAN_107 block at its closest point. However, this shall be jointly defined in detail by both companies closer to the start date in order to ensure the greatest distance between operations. This measure is considered regarding the development of the survey in Chapter 4 and is included in the PGA as part of Equinor´s commitments.

2 – As mentioned above, the interaction of the project with coastal areas is basically limited to the use of the port infrastructure of the support port (Puerto de Mar del Plata) by the support vessel from the seismic data acquisition area and, to a lesser extent, from the port of Buenos Aires, in mobilization and demobilization operations. These operations are common and shall not differ from those normally carried out by a fishing vessel or cargo ship calling from another navigation. Given the low relevance of this aspect of the project, the idea of a cumulative effect is competely ruled out.

3 – In relation to the interaction of the effects of the project with the present fishing activities, it is possible to point out two aspects previously analyzed. On the one hand, since the project foresees the implementation of a soft start protocol at the beginning of each data acquisition line that would allow the fish in the vicinity of the sound source to move away before the sound levels become harmful, the risk to individual fish is low, and fish populations are unlikely to be affected; particularly considering that most of the species identified in the project's area of influence have a wide distribution and some are even frequent on the slope and the platform. In this way, the effects on fish populations would fundamentally comprise behavioral responses that could imply the temporary removal from feeding areas and spawning areas of those species that overlap with the project area. Although the area of influence of the project overlaps with the breeding area of the Rajiformes, and it cannot be pointed out that it coincides with the reproduction area of some of the species of other orders since there is no information, none of these groups are subject to fisheries. Regarding the activity or fishing pressure, a non-binding relationship with the fishing areas is observed for CAN_100-108 and CAN_114 operative areas. This activity becomes very important during the autumn and winter periods in front of the slope which is 17 km from the project's operational area, and 30 km from the seismic acquisition area (where the seismic array shall effectively operate), and therefore, it does not overlap spatially with the project. Given that the project under study shall be carried out during the spring of 2021 and the summer of 2022, there shall also be no temporal overlap with the peak of the fishing activity in front of the slope. According to the foregoing, the cumulative impact on the group of fish is not expected to be more significant than that evaluated for the project in isolation (qualified as moderate - see Point **Error! Reference source not found.**). As mentioned above, the impact of seismic operations is considered mitigated to the extent possible through the application of the soft start protocol associated with the project, while the project schedule is adequate from the fisheries point of view given that it avoids the period of greatest sensitivity of the activity (autumn-winter).

4 – It is also known that for many species of birds, turtles and marine mammals, interaction with fishing activity constitutes one of the main threats to their survival. As has been herein explained, seismic activities have the potential of increasing the vulnerability of individuals to anthropogenic threats, among other effects. Although, as previously indicated, fishing activities are carried out at a certain distance from the prospecting area, the possibility of a cumulative impact occurring when the activities coincide temporarily cannot be discarded, however this is minimized to a certain extent given that the project shall be carried out outside the peak period of the fishing activity in front of the slope (autumn - winter). However, given that these effects may occur at the individual level, and therefore the risk to populations is considered low, the cumulative impact on these groups is not expected to be more significant than that evaluated for the project itself. As mentioned in the previous point, the impact of seismic activity is considered mitigated to the extent possible with the implementation of the soft start protocol.

5 – Regarding the light emissions with consequences for the seabirds that are attracted by the lights of the boats at night, the interaction of the project with the fishing fleet is of interest, especially with the jigger boats used to catch squid which strongly illuminate the surface of the sea during the night shift. North of 44 ° S, the Buenos Aires-North Patagonian subpopulation is exploited from March or April to June before the squid migrate to deep waters[7]. In this sense, this activity does not temporarily overlap with the development of the project since it shall take place during spring 2021 and summer 2022. Likewise, it is worth noting that the exclusion areas foreseen around the seismic vessel as a whole and its array, and the clearance of its trajectory, also guarantee a certain distancing of prospecting activities from other vessels. Based on the foregoing, the cumulative impact on marine organisms and fisheries is not expected to be more significant than that assessed for the project itself. This impact may be mitigated as far as possible through the application of actions to prevent impacts on birds (decrease in lighting).

6 - The information on the seismic activities previously carried out in the study area has been presented in the Environmental Baseline (Chapter 5), and all of them correspond to 2D campaigns. According to the information gathered, only the extensive campaign of 2018 (5/5/2018) carried out by SPECTRUM ASA ARGENTINE BRANCH (now TGS), involved the seismic acquisition areas targeted in this study. Two more recent campaigns of lesser extension are close to these areas. The one identified on 10/11/2019 was located immediately west of the seismic data acquisition area of CAN_100-108 areas and the 2020 campaign identified on 1/2/2020 was located northeast of CAN-114 area. Although the details of these campaigns are not known in terms of the number and type of vessels involved, the survey pattern, characteristics of the seismic array used, etc., mitigation measures were adopted which included the use of procedures for soft start to minimize possible underwater sound impacts in the marine environment, since these procedures have been implemented in the seismic industry for several years and have been required in explorations in our country. Temporal (and also geographic) differences between past and anticipated seismic studies, and the use of the soft start procedure mean that there is a limited range of cumulative impacts to marine organisms due to underwater sound. The impacts of injuries to mammals and fish are avoided through soft start and the behavioral impacts are minor and temporary as previously assessed. Considering that this project shall start in October 2021, the nearby antecedent campaigns are more than 18 months apart (and in more than 3 years with the TGS campaign, which is the only one that overlaps spatially), so the same seasons shall not be affected. Based on the foregoing, the cumulative impact on marine organisms and fisheries is not expected to be more significant than that assessed for the project itself.

7 – Although there is a theory that seismic activities can cause stranding, there is no conclusive evidence to date. In any case, these phenomena are aspects to consider in shallow areas near the coast, which is not the case of the present project that is developed in areas with depths between 1,200 and 3,900 meters.

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CONSULTED WEB PAGES

OBIS, Sistema de Informacion sobre Biodiversidad Oceanica (Ocean Biogeographic Information System. https://www.obis.org/

Seabird tracking database http://www.seabirdtracking.org/mapper/index.php.

ANNEX I – ADDITIONAL BACKGROUND

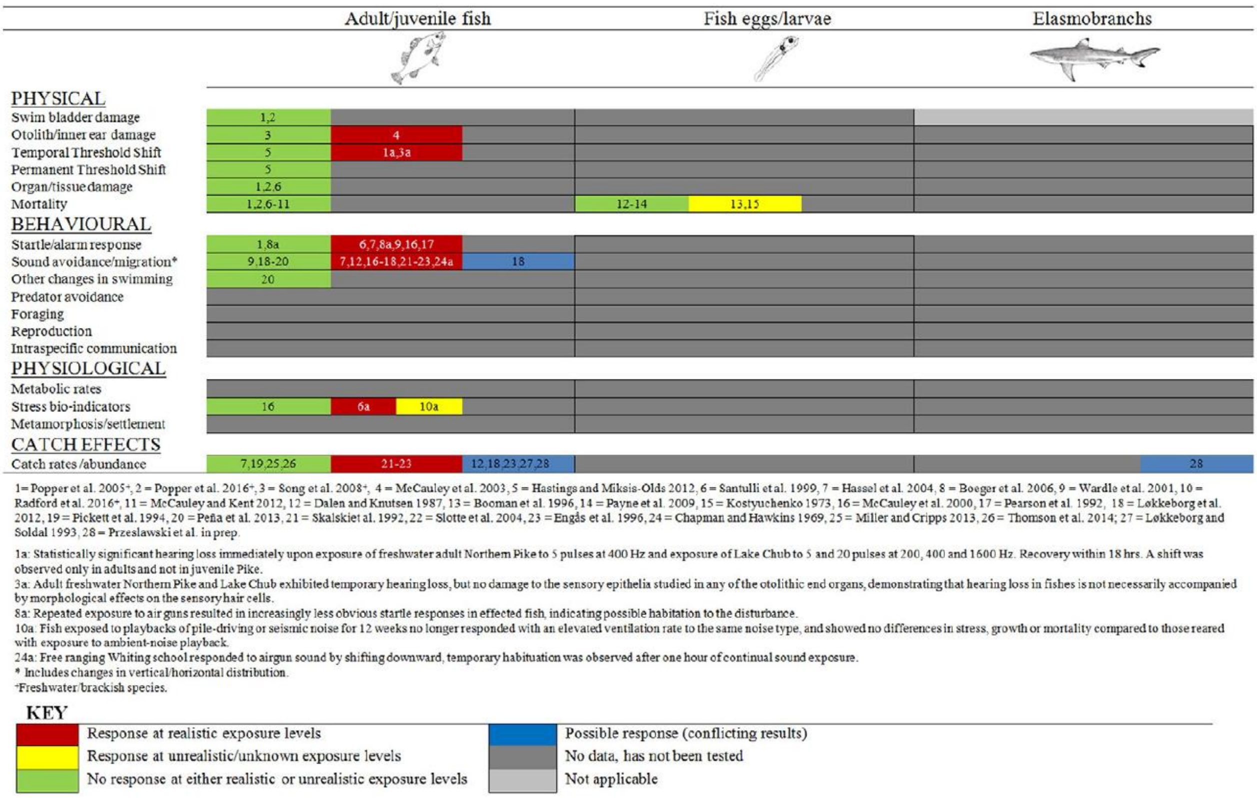
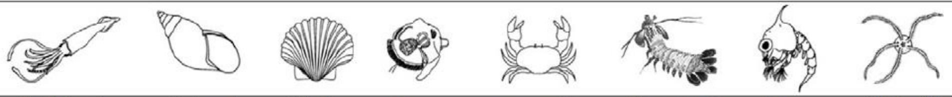


Figura 16. Resumen de los posibles impactos de los sonidos sísmicos de baja frecuencia en los peces. Los impactos se clasifican según los tratamientos de exposición al sonido como realistas (es decir, ráfagas cortas de sonido de baja frecuencia a una distancia de >1-2 m) o desconocidos/no realistas (es decir, de larga duración y/o corta distancia de <2 m a la fuente de sonido, exposición al sonido de campo cercano en acuarios). Hay diferencias significativas entre los estudios sísmicos relativos a la exposición al sonido y el medio ambiente en el que se realizaron los estudios (tomado de Carroll et al 2016).



	Molluscs				Crustaceans			Echinoderms
	Cephalopod	Gastropod	Bivalve	Larvae	Decapod[a]	Stomatopod	Larvae	Ophiuroid
PHYSICAL								
Air bladder damage								
Otolith/statocyst damage	1-3				4,5 5			
Organ/tissue damage	6		7,8		9			
Mortality/abnormality	6		7,8,10[c] 5	11	5,9,12		4,13,14	
BEHAVIOURAL								
Startle response	15-19		5,20		4,21			
Sound avoidance	18				22			
Predator avoidance			5		5,12,23			
Foraging					23			
Reproduction					24			
Bioturbation			25		25			25
PHYSIOLOGICAL								
Metabolic rates[b]	26			11	4,12,27,28		13	
Stress bio-indicators	25		25,29 5		4,5,12,22,25,27,30			25
Immune response					5			
Energy stores			10					
Metamorphosis/settlement							31 13	
CATCH EFFECTS								
Catch rates / abundance	29	29	7 10,29	8	4,9,27,29,32,33	29		

1 = André et a; 2011, 2 = Solé et al 2013a, 3 = Solé et al 2013b, 4 = Christian et al 2003, 5 = Day et al 2016a, 6 = Guerra et al 2004, 7 = Harrington et al 2010, 8 = Parry et al 2002, 9 = Courtenay et al 2009, 10 = current study 11 = Aguilar de Soto et al 2013, 12 = Payne et al 2007, 13 = Pearson et al 1994, 14 = Day et al 2016, 15 = Fewtrell and McCauley 2012, 16 = McCauley et al 2000, 17 = Samson et al 2014, 18 = Komak et al 2005, 19 = Mooney et al 2016, 20 = Roberts et al 2015, 21 = Roberts et al 2016, 22 = Celi et al 2013, 23 = Wale et al 2013a, 24 = Lagardere 1982, 25 = Solan et al 2016, 26 = Kaifu et al 2007, 27 = Christian et al 2004, 28 = Wale et al 2013b , 29 = La Bella et al 30 = Filiciotto et al 2014, 31 = Branscomb and Rittschof 1984, 32 = Andriguetto-Filho et al 2005, 33 = Parry and Gason 2006

a DFOC 2004 also examined the effects of various physical and physiological effects of seismic signals on snow crabs but is not included here because no baseline data acquired before seismic survey, and refined experiments in Courtenay et al 2009 supersede these results.

b Includes proxies for metabolic rate such as food consumption, growth, respiration, developmental rate

c Also includes Chalmer (1986), Kosheleva (1992) and Matishov (1992) as cited in Parry et al. (2002)

KEY

Response at realistic exposure levels	Possible response / conflicting or anecdotal results
Response at unrealistic/unknown exposure levels	No data, has not been tested
No response	Not applicable

Figura 17. Resumen de los posibles impactos del sonido de baja frecuencia en diversas respuestas de los invertebrados marinos. Los impactos se clasifican según los tratamientos de exposición al sonido como realistas para estudios sísmicos (es decir, pocas ráfagas cortas de sonido de baja frecuencia a > 1-2 m) o desconocido/no realista (es decir, exposición continua al sonido, ráfagas de > 100 de exposición al sonido de campo cercano, en acuarios). Hay diferencias significativas entre los estudios sísmicos relativos a la exposición sonora y el medio ambiente en que se realizaron los estudios (tomado de Carroll et al 2016).

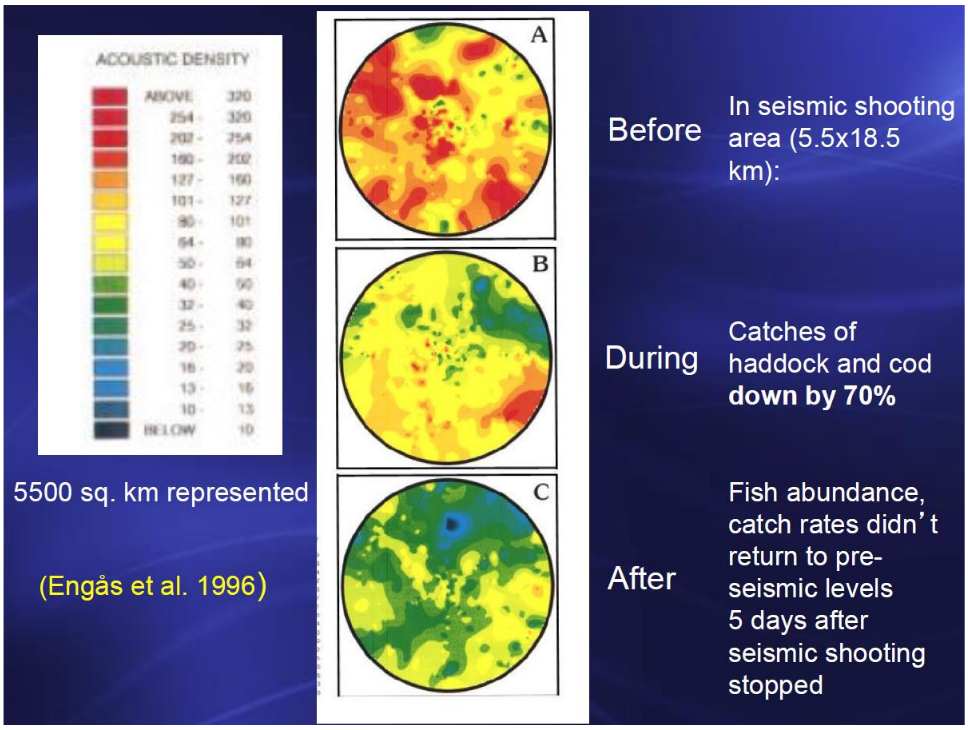


Figura 18. Evaluación de impactos antes, durante y después de realizar descargas de fuentes sísmicas sobre dos pesquerías (tomado de Engås et al. 1996)

Tabla 40. Valores de emisión, recepción y efectos observados en diferentes especies (tomado de Russel (2018)

Effect Type	Source levels (dB@1m)	Meters from source	Received levels (dB)	Results	Reference
Physical Effects					
Mortality	226[1]	2	220[2]	Some cod and plaice died within 48 hrs; internal injuries reported. No controls to test for significance.	Matishov (1992
	20 cui (2000 psi)	1	234	One salmon died (n=10) 60 hours after exposure; however, no external aberrations or internal hemorrhaging were observed. Subsequent reports make no mention of this fatality.	Weinhold and Weaver (1972)
Physical damage	230[1]	0.6-1.5	226-234[2]	Swim bladder damage in 2 arctic cisco (n=14).	Falk and Lawrence (1973)
		~3	234 (p-p)	Swim bladders damaged in 73% of exposed adult anchovy as compared to 11% of controls (p=0.01).	Holliday et al. (1987)
	220- 240[1]	0.5	226-246[2]	Half of exposed fish suffered damage to blood cells or internal bleeding. Eye injuries also reported.	Koshleva (1992)
	226[1]	4	214[2]	Blindness in cod and plaice. No controls used.	Matishov (1992

	222.6 (p-p)	5-800	< 212	Significant damage to sensory epithelia (ablated ear cells) in pink snapper examined 58 days after exposure. No mortality.	McCauley et al. (2003)
	20 cui (2000 psi)	10	208	Dislocated tissue within swim bladder of one salmon (n=10). This result is not mentioned subsequently and may have been discarded as unrelated to airgun exposure.	Weinhold and Weaver (1972)
	240 cui (2000 psi)	1	241	Damaged operculum in one salmon (n=10). This was considered to be unrelated to exposure as missing tissue did not appear to be of recent removal.	
Hearing loss	202	13, 17	205-210	Statistically significant hearing loss immediately upon exposure of adult northern pike to 5 pulses at 400 Hz and exposure of lake chub to 5 and 20 pulses at 200, 400 and 1600 Hz. Recovery within 18 hrs.	Popper et al. (2005)
No hearing loss	202	13, 17	205-210	No hearing differences between exposed and control broad whitefish or juvenile northern pike.	

No physical damage	256 (o-p)	180	210[3]	No physical damage observed in European sea bass.	Santulli et al. (1999)
	230[1]	3.0-3.4	219-220[2]	Stress observed in 2-15 arctic cisco but no overt signs of physical damage.	Falk and Lawrence (1973)
		~3	215-222 (p-p)	Healthy ("groomed") anchovy exhibited no swim bladder damage at these levels. Results are not considered statistically significant.	Holliday et al. (1987)
	222, 231	1-10	202-231[2]	No mortality of cod fry observed.	Dalen and Knutsen (1987)
	202	13, 17	205-210	No mortality of fish held for 24 hours after exposure. No obvious morphological damage to swim bladder, eyes, gills or other organs.	Popper et al. (2005)

	220- 240[1]	1	220-240[2]	No acute effects observed at this distance.	Koshleva (1992)
Physiological Effects					
Change in physio- logical measures	256 (o-p)	180- 6500	194-210[3]	Increase in sea bass serum cortisol, glucose and lactate immediately after exposure with recovery in 72 hrs. Decrease in serum adenylates. Muscle and liver cortisol increased initially but returned to normal in 72 hrs. Glucose and lactate levels in liver increased over 6 hrs. Glucose and lactate levels in muscle increased from 6-72 hrs. Camp in muscle and liver increased over 72 hours with no return to pre-exposure levels.	Santulli et al. (1999)
No effect		200- 9800	146-195 (rms)	No statistically significant stress increases which could be directly attributed to airgun exposure.	McCauley et al. (2000)
Behavioural Effects					
Startle response	256 (o-p)	180- 2500	199-210[3]	Startle response from European sea bass starting when vessel approached within 2500 m, return to pre-exposure behaviour when vessel passed to 1 nm.	Santulli et al. (1999)
	223 (o-p)		200-205	Startle response by black and olive rockfish.	Pearson et al. (1992)
		5.3-195	195-218	Startle (c-start) reaction of pollock to all airgun shots.	Wardle et al. (2001)

			182-195 (rms)	Persistent startle (c-start) response in all trials. Greater response in small fish.	McCauley et al. (2000)
Change in vertical	220[1]	< 55	~185[2] at 55 m	Downward movement of whiting to form compact layer at 55 m.	Chapman and Hawkins (1969)

position	223 (o-p)	~82- 183	186-191	Decrease in average rockfish aggregation height.	Skalski et al. (1992)
	249.9	100- 300	200-210	Statistically significant reduction in echo sounder abundance of demersal fish (36% reduction); fish presumably forced to bottom since catch rates increased by 34 and 290%.	Dalen and Knutsen (1987)
	222.6	20, 50	197, 189[2]	Blue whiting and mesopelagics descended in water column (20 and 50 m deeper respectively).	Slotte et al. (2004)
	223 (o-p)		177-180	Black rockfish schools collapsed to bottom when airgun started. Returned to pre-exposure behaviour within 20-60 min.	Pearson et al. (1992)
	223 (o-p)		186-199	Vermillion and olive rockfish either rose in water column and eddied at increased speed or moved closer to bottom and became almost motionless. Returned to pre-exposure behaviour within 20-60 min.	

			>156-161 (rms)	Aggregation in bottom centre of enclosure.	McCauley et al. (2000)
	256 (o-p)			Change in vertical distribution of pelagic fish. In particular, reduced acoustic density within the top 16 m.	La Bella et al. (1996)
Change in horizontal distribution	249	< 37 km		Acoustic density of cod and haddock reduced by 45% during exposure, continued decrease to 64% 5 days after exposure. (250-280 m water depth)	Engas et al. (1996)
	223	< 37 km		Average density of mesopelagic fish (including herring and blue whiting) was lower in seismic survey area, with increasing abundance at distance. Fish density seemed higher about 37 km from center of survey area.	Slotte et al. (2004)
	249.9	100- 300	200-210	Statistically non-significant reduction in echo sounder abundance of blue whiting (54% reduction) and small pelagics (13% reduction).	Dalen and Knutsen (1987)

				Presumed to have migrated out of area (100-300 m water depth).	
Change in swimming behaviour			156-161 (rms)	Faster swimming and formation of tight groups.	McCauley et al. (2000)
	256	180	210[3]	Sea bass bunched in the center of the enclosure with random orientation and increased swimming speed. Recovery within 1 hr of exposure.	Santulli et al. (1996)
	222, 231	1-10	202-231	Temporary problems with balance in cod fry. Recovery after a few minutes. No significant difference in feeding behaviour as compared to controls (202-222 dB).	Dalen and Knutsen (1987)
	223 (o-p)		177-180	Increasingly tighter schools of blue rockfish with increasing sound levels.	Pearson et al. (1992)
			< 218	Day-to-night movements of two tagged pollock altered during longer-term exposure to airguns.	Wardle et al. (2001)

No behavioural effect	250[1]			Most tagged sea bass were recaptured within 10 km of release site (5-30 m water depth).	Pickett et al. (1994)
			< 218	Two tagged pollock did not move away from reef (10-20 m water depth).	Wardle et al. (2001)
	202	13, 17	205-210	Normal swimming behaviour of northern pike, broad whitefish and lake chub during exposure.	Popper et al. (2005)

Fisheries Effects					
Change in catch or effort	249.9	100- 300m	> 200 at depth[2]	Increase in demersal fish catch by 34% and 290%.	Dalen and Knutsen (1987)
–	239	< 9.3 km	161[1] at 5 km	Reductions of 55-80% in longline catches of cod within 9.3 km (5 nm) of seismic survey area.	Løkkeborg (1991)
	239- 250	< 9.3 km	160-171[1]	Reductions in shrimp trawl by-catch of cod by 79 and 83% within 9.3 km (5 nm) of seismic survey area. Increases of cod by-catch in saithe trawl of 300%. Return to pre- exposure catches within 12-24 hrs.	Løkkeborg and Soldal (1993)
	223 (o-p)	< 165 m	186-191	Average decline in rockfish catch-per-unit effort of 53% within seismic survey area.	Skalski et al. (1992)
	249	< 33 km		Statistically significant reductions in trawl and longline catch of cod and haddock within a 74 km^2 study area upon exposure to a seismic source. Trawl catch of cod reduced by 69% within the 5.6x18.5 km seismic survey area and 45-50% outside seismic survey area. Trawl catch of haddock reduced by 68% within seismic survey area, 56% 2-17 km from survey area and 71% 30-33 km from survey area. Longline catch reduced by 45% in survey area, 16% at 1.9-5.6 km from survey, 25% at 13- 17 km from survey. Longline catches of cod tended to increase within the seismic survey area, while haddock longline catches were reduced by 67% within the seismic survey area.	Engas et al. (1996)
No effect on fisheries	250[1]	1-23 km		No significant change in hook and line catch rate of European sea bass.	Pickett et al. (1994)
	256 (o-p)			No significant changes in trawl or gillnet catch.	La Bella et al. (1996)
–					
				Statistical analysis of logbooks showed no statistically significant effect of seismic surveying on catch rates; however, 75% of fishermen believed they had observed an effect. No lasting impacts on fisheries success.	Jakupstovu et al. (2001) reported in Gausland (2003)

[1] source levels as estimated by Turnpenny and Nedwell (1994). [2] received levels as estimated by spherical spreading (20logR). [3] received levels as estimated using spherical spreading, 20logR, to water depth and cylindrical spreading, 10logR, for remaining distance.