Preparation of a scientific study on the interaction of orcas population (*Orcinus orca*) in the Strait of Gibraltar with vessels for the design and proposal of prevention, action and management measures

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LIFE IP INTEMARES

Integrated, innovative participatory management of the Natura 2000 Network in the Spanish marine environment.

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DEVELOPMENT OF A SCIENTIFIC STUDY ON THE INTERACTION OF THE POPULATION OF ORCAS (Orcinus orca) IN THE STRAIT OF GIBRALTAR WITH VESSELS, FOR THE DESIGN AND PROPOSAL OF PREVENTION, ACTION AND MANAGEMENT MEASURES

Action A2.4 - Improved knowledge of species for management

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1. EXECUTIVE SUMMARY

Several individuals from an endangered subpopulation of orcas in the Iberian Peninsula started to show disruptive behaviour in 2020, interacting with boats. Most of the interactions occurred with sailing boats, but also with fishing boats, semi-rigid boats and motorboats. The animals bumped, pushed and turned the boats. In some cases, these interactions caused damage to the stern of the vessel, mainly to its fragile parts. A total of 239 interactions have been recorded mainly between the waters of the Strait of Gibraltar and Galicia, including the coast of Portugal, although there have also been interactions in Morocco and France. A total of 14 individuals have been identified, the vast majority of which are juveniles and are distributed in up to 4 interacting groups.

Most of the vessels involved in interactions are medium-sized (<15m) sailboats, with a paddle rudder, sailing at an average of 6 knots, both under sail and motor. Interactions occur throughout the year, although they are mostly concentrated in the spring and summer months. Interactions occur at all times of the day and night, although they are concentrated in the midday hours. These interactions last on average 40 minutes, although most interactions last less than 30 minutes.

The behaviour of orcas when interacting with boats is not identified as aggressive. One of their main motivations has been identified as competition with boats for speed. We are not yet certain what the origin of these interactions is, but it is still suspected that it could be a curious and playful behaviour, which could be self-induced, or on the other hand it could be a behaviour induced by an aversive incident and therefore a precautionary behaviour.

The different groups of interacting orcas have moved independently, and their movements are suspected to be more related to the presence of their main prey (blue-fin tuna, *Thunnus thynnus*) than to the presence of boats. The migratory movements of tuna are very dynamic and predicting exactly where interactions will take place is very difficult. The clearest pattern is the well-known one: between spring and summer, orcas are distributed in the waters of the Strait of Gibraltar-Gulf of Cadiz due to the presence of their main prey, which is migrating between the Mediterranean and the Atlantic. Once this period is over, the groups disperse (although not at the same time), between August and September, passing into Portuguese waters, normally without staying in a specific area, although interactions indicate that the areas of Algarve, Sines and Setúbal may remain for several days. Until they move up to Galicia, usually arriving from the end of August to mid-September, and from there the pattern is no longer so clear, with groups dispersing to different areas and directions in a fan-like pattern.

Some mitigation measures, such as a temporary ban on sailing vessels, were implemented when interactions intensified in certain areas of Galicia and the Strait of Gibraltar. The safety protocol is useful, since it has been proven that when it is not followed, even if the differences are not significant, interactions are more likely to result in damage to the ship.

As a pilot project, an oceanographic campaign has been proposed and designed between spring and summer months, in order to have about 20 days of good conditions at sea, using a medium-sized sailing vessel, equipped with AIS. In the area where most interactions are concentrated, in Barbate waters, in the Gulf of Cádiz. Where we will monitor the behaviour of the orcas, and test different behaviours of the boats (stop/acceleration/reverse gear...), aAs well as two deterrents (metal tubes

and pilot whale sounds) to test their effectiveness as dissuasive measures depending on the response of the animals.

2. STUDY OBJECTIVES

In this framework, it is considered necessary to develop a study that, based on the monitoring and the evidence extracted from these episodes, as well as their evolution, it can be determined the possible causes that have led orcas to develop this new behavior. The objective, essentially, is to define and prioritize the most appropriate measures (regulatory and non-regulatory) to try to minimize both interactions and their consequences. This document tries to collect the advances to achieve this objective.

To this end, the collaboration of the Atlantic Orca Working Group (GTOA) has been counted on at all times. The GTOA is made up of Alfredo López from the University of Aveiro-CESAM/CEMMA and Jose A.M. Cedeira from CEMMA; Ezequiel Andréu Cazalla from Asociación Garum Tarifa, Cristina Martín from Estrecho Natura, Rocío Espada from Ecolocaliza and LBMarina from the University of Seville, Francisco Martinho from ECCO Ocean, Marisa Ferreira from SPVS and Ruth Esteban from Museu da Baleia da Madeira and Ocean Sea, Álvaro Garcia de los Rios from the Center for the Study and Conservation of Marine Animals (CECAM) Ceuta, Jose Carlos Garcia and Liliana Olaya-Ponzone from LBMarina of the University of Seville; Paco Gil from TURMARES; Paula Méndez from Observatoire Pelagis of the University of La Rochelle, France.

It has also had the support of the group of experts that the Ministry for the Ecological Transition and the Democratic Challenge requested their express creation within the International Whaling Commission between scheduled sessions (known as "ICG Strait of Gibraltar orca"), in order to receive their advice on this pilot study and facilitate the proposal of management measures. The ICG is moderated by Ruth Esteban and made up of Lindsay Porter, Julie Creek, Ian Stainland, Marina Sequeira, Elvira García-Bellido, Naomi Rose, Mark Simmons, Mel Consentino, Laetitia Nunny, Robert Pitman, Jaime Bolaños, Tilen Genov, Maria Clara Jimenez, Inês Carvalho, Filipa Samarra, Eve Jourdain, Jared Towers, Christophe Guinet, Paul Tixier, and Courtney Smith.

The actions planned within the framework of "Preparation of a scientific study on the interaction of the orca population (*Orcinus orca*) in the Strait of Gibraltar with vessels, for the design and proposal of prevention, action and management measures" are the following:

- Compilation of new orca records, both sightings and orcas interactions throughout the Iberian Peninsula.
- Analysis of all records of orca sightings and interactions with vessels since 2020, to describe the locations of the events, the type of vessel, navigation speed, interaction time, damage caused, orca specimens involved and in general all the information that can help us to give possible causes for which this phenomenon may be taking place.
- Predictive study, based on the species ecology, phenology and distribution, to determine the possible areas and times of the year in which these events could occur in the coming months.
- Prioritized list of proposals for action, management, regulation and prevention measures aimed to:

- The different appropiate administrations, within the scope of their powers.
- Patterns of sailing boats through these areas of Spanish jurisdiction.
- Any other profile to be determined by the contractor during the execution of its actions.

- Design of a pilot project, to be carried out within the framework of the LIFE IP INTEMARES project, which aims to minimize the problem of the interaction of the orca population in the Strait and Gulf of Cádiz with sailing boats.

- Contents of sensitization and divulgation material (in digital format) on the interaction problem, as well as on the action and prevention measures designed.

These actions are contained within the framework of action A2.4 (Improving knowledge of species for management) of the LIFE IP INTEMAES project (LIFE15 IPE/ES/000012).

3. INTRODUCTION AND BACKGROUND

3.1 ORCAS

3.1.1 IBERIAN ORCA

Orca (*Orcinus orca*) (Linnaeus, 1758) is a species of marine mammal belonging to the family of delphinidae (Carwardine, 2019). It trophic position of predator has made a fearsome animal in human eyes, but it is a complex creature, a species that has a tremendous variety of social skills, as well as exceptional memory and communication skills (Kachar et al., 2018). Orcas are social mammals that demonstrate behavior, body language, and vocalizations that correspond, by the human analogy argument, to emotional states (Anderson et al., 2016), thus they appearing to exhibit a wide range of emotions, including frustration , anger, fear, joy, and even self-awareness, making them fascinating to watch as social mammals. Among their qualities they stand out for their curiosity, playful character and imitation (Ford, 2018).

In Spanish waters we can find orcas in the Atlantic ocean and Cantabrian sea, called Iberian orcas. The area where they are mainly observed is in the waters of the Strait of Gibraltar – Gulf of Cádiz, and their presence is associated, spatially and seasonally, with the stock of red tuna (Thunnus thynnus), which causes their migratory movements (Esteban et al., 2014).

Their basic social group is the pod, with a social structure that has been considered one of the most stable of all animal species. Within pods they generally integrate a group of several generations of related individuals (Bigg et al., 1990). Hierarchies are established within it, in addition to being their cultural unit where they learn and transmit information to each other. Different cultures and behavioral traditions of orcas may have driven population divergence through a process called ecological speciation, although it is still considered as a single species across the globe (Riesch et al., 2012).

One of the essential requirements for the existence of culture in a population and/or species is that it must be transmitted through social learning (Danchin and Wagner, 2010). The specialized hunting techniques, for example, of certain orca populations, such as the intentional stranding observed in the Valdés Peninsula, Argentina, and in the Crozet Islands, are transmitted through social learning

from generation to generation (Guinet, 1991; Hoelzel , 1991). There is evidence in orcas that vocabulary learning is not limited to vertical transmission, from mother to offspring, but also takes place horizontally between matrilineal lines with similar and different dialects (Deecke et al., 2011). In Iberian orcas there are some evidences of horizontal transmission of behaviors (Esteban et al., 2016a). Currently, the social behavior of orcas is not yet fully understood, for example, large aggregations and fission fusion phenomena, may have a complex objective for this species, because these unions, cooperation or separation of groups can occur at expense of other important behaviors, such as foraging, breeding, or resting (Kachar et al., 2018).

Sometimes they jump with their bodie s completely out of the water and turn slightly to fall on their backs, belly, or side. Other times they turn sideways until they hit the water with their dorsal fin. Occasionally they have been observed approaching ships, riding their wakes and jumping on the waves they cause. These behaviors, apparently playful, are more frequent in juvenile specimens, adults assume roles in pods and their behavior is usually more serious and focused on their vital activities: diet, caring for calves, maintaining cohesion, etc. Although they normally swim at speeds between 8-11 knots, they can reach speeds of up to 29 knots (Kachar et al., 2018). Iberian orcas are capable of maintaining a speed of 7 knots for up to 30 minutes when they catching tuna until exhaustion (Guinet et al., 2007).

Currently, the Iberian orca is included in the List of Wild Species under Special Protection Regime (regulated by Royal Decree 139/2011), as well as in Annex IV of the Habitats Directive (Directive 92/43/CEE). It should be noted that precisely the population of Gulf of Cadiz-Strait of Gibraltar is included in the category of "Vulnerable" in the Spanish Catalog of Threatened Species, due to their low population growth rate (almost non-existent) and the strong pressures they are subjected. In fact, this subpopulation is classified as "Critically Endangered" by the red list of species of the International Union for Conservation of Nature (IUCN).

3.1.2 Atunes y orcas: alimentación e interacción

Red tuna *(Thunnus thynnus)* is the specie more important in the diet of Iberian orcas in the Strait of Gibraltar (García-Tiscar, 2009), to such an extent that the marked decline in biomass at the beginning of this century brought populations to a critical point, affecting the orca breeding (Esteban et al., 2016b).

In 2007, the minimum spawning biomass was reached with just over 150,000 tonnes and recruitment was lower than in previous years. As a consequence of the strong measures implemented within the framework of ICCAT for the management of this species, especially since 2009, the last evaluation of July 2020 has obtained a spawning biomass of 870,000 tonness (Figure 1), which represents 6 times more than in the low of 2007-2008. In addition, recruitment in recent years is one of the largest in the historical series, which implies that much more immature tuna arrives in June at the Cantabrian coast in their trophic migrations (Varela Fuentes, 2012; ICCAT, 2020).

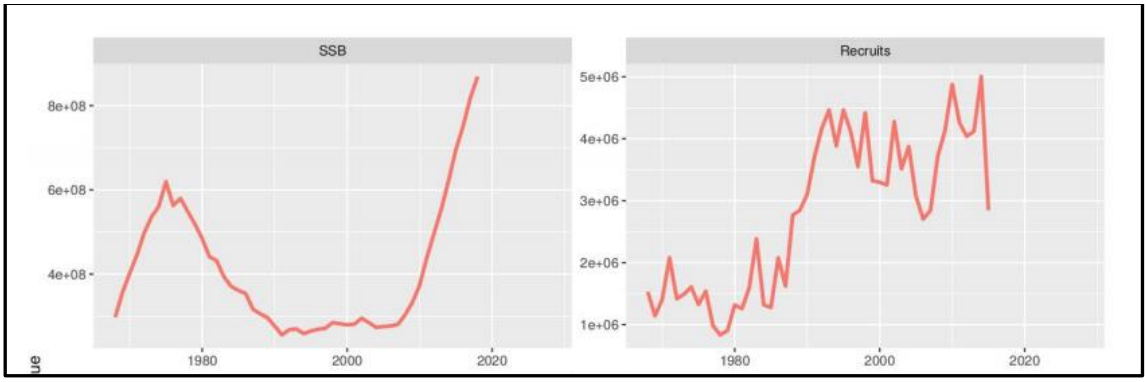


Figure 1. Evolution of the spawning biomass of red tuna in 1980-201 (ICCAT, 2020).

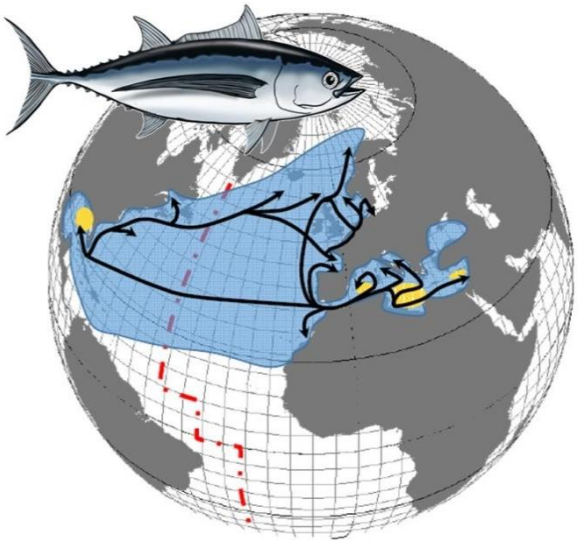


Figure 2. Red tuna magration in the North Atlantic, the yellow areas are spawning areas. Source **(Fromentin, 2006; Schirripa, 2011).**

Red tuna migrate from the Atlantic to the Mediterranean Sea in spring months. After spawning, adult tuna migrate back to the Atlantic in summer months (Figure 2). In Iberian waters, the abundance of tuna skyrockets from July and remains constant until October, although it varies with the years and the abundance of small pelagics on the coasts, which has occurred in recent seasons.

Historically, and due to the fact that the main prey of Iberian orcas is red tuna, orcas have interacted with different fishing gear, in the vicinity of the tuna traps is where orcas actively hunt tuna, chasing them to exhaustion (Guinet et al., 2007). In summer months orcas have been seen interacting with stone longline fishing boats where they wait for the fishermen to catch tuna and when it is closer to the surface orcas prey on the tuna, usually by biting into the tuna's belly or ventresca, or catching the whole tuna from the line (Esteban et al., 2016b).

3.1.3 Concepts of interest in the analysis of orcas behavior

When analyzing the behavior of orcas in relation to their movements and interactions, we consider that some concepts must be defined in order to understand what is exposed in the results.

Migration and displacement

Orca migrations: it is known that orcas move following the migration of tuna, food being the basic physiological need that drives their motivation or drive (ANNEX V) of their movements and a good part of their behaviors. That is why we will define the following concepts:

- **Migration:** travel or geographical movement of individuals or groups of migratory animals. Therefore, based on RAE´s definition, we consider migration to be the entire journey carried out by orcas in their tendency to move from the area of the Strait to the north and back to the Strait.

- **Displacement:** movement, on a micro or meso scale, in the direction or opposite of migration trend. Also unspecific movement or not related to the moments or periods of migration.

Motivation and reinforcement

From the point of view of animal behavior, different concepts are considered in what refers to trying to explain what it is that leads an animal towards an objective and to persist in it, therefore, we will use two concepts: one for the search for a explanation to reach an objective and the other as a complementary element.

- **Motivation**: set of internal or external factors that partly determine someone's actions.
- **Reason:** Cause or reason that moves for something.
- **Reinforcement/reinforce**: complement/strengthen. It can be positive or negative.

Thus we will consider that the **motive** of orcas in their interaction is the reason that leads them to the **objective** they pursue (ANNEX V), although this is unknown to us; and **positive** reinforcement, or incentive, is something that causes a strengthening in their behavior by increasing some aspect of it.

ANNEX V separates in detail different aspects about orca behavior and their possible meaning, among conclusions we can stand out that:

Aggression is part of the social behavior of cetaceans in their intra and inter specific relationships. The presence of teeth marks on the GLADIS indicates an intense intra-specific interaction that leaves consequences on their bodies. The relationship between orcas and boats must be qualified as a type of inter-specific interaction due to it is an encounter between two different species: orcas and humans.

We analyzed terminologically the terms attack and aggression, it has not been possible to relate the interactions between orcas and boats with this terminology. After analyzing the behavior patterns that orcas develop during interactions with boats, we have found no reason to classify the events as: aggressiveness, anger, hostility or violence.

Some behaviors observed during interactions, such as the generation of bubble bursts (a large bubble produced by continued expulsion of air underwater) and tail slapping on the surface, may have different meanings. In this particular case, the production of explosive bubbles by orcas is related to the increased involvement in handling an object, therefore, in social or exploration situations. In humans, it would be open-mouthed, showing interest, surprise, motor play, threat, and response to perceived threat. In the case of tail fin blows, they can be interpreted as intimidating, but there is no clear relationship studied for this behavior.

3.1.4 Behavioral components

Orcas behavioral components involved in the interactions would be: dexterity, pursuit, tactile sensation, strength and intimidation, initiative and innovation, social demonstration.

Dexterity: fast swimming, stealth, unpredictability, spins, running strikes. It's an incomplete hunting sequence. Potentiated by play and predatory behavior.

Pursuit: detection and range of an objective. It is an incomplete hunting sequence. Potentiated by play and predatory behavior.

Tactile sensation: physical contact, friction and bodily push. Potentiated by curiosity, play and sensitive of tactile pleasure behavior.

Display of strength and intimidation: fast swimming noisy starts, splashes and bubbles. Potentiated by fear behavior.

Initiative and innovation: they increase encounters and diversity, and if there are novelties, they exploit them, such as putting the rudder horizontally as a surface to push, that was novel and extraordinary, that is why they took so long with this boat.

Social Demonstration: Group performance may involve a display of skills in front of others. It does not have to imply that the others are performers, maybe just spectators.

Recurrence of interaction with the same type of boat and a type of object on it is possibly associated with a traumatic component derived from a serious emotional impact, of unknown origin, but in which both things, sailboat and rudder, may have a meaning, which makes it obsessive.

3.1.5 Transmission of behavior and culture

Orcas are often presented as a representative species of cultural traditions (Baird, 2002), when culture is defined as behavior, custom, habit or behavioral trait that is transmitted socially and not genetically from one generation to the next (Caicedo, 2016). Animal culture is studied by investigating transmission mechanisms experimentally or by observing patterns of behavioral variation in wild populations that cannot be explained by genetic or environmental factors (Rendell and Whitehead, 2001).

Although the existence of social traditions does not prove the existence of imitative learning, there have been observations of specific behaviors that suggest that imitation may underlie orca learning, such as the intentional stranding to capture sea lions in Crozet or Argentina (Guinet, 1991; Abramson et al., 2013).

The development of behavior is the result of a continuous process of vertical coercion (between elements of different levels of social organization) and horizontal coercion (between elements of the same level), so that all levels actively contribute, acting in concert, and in conflict, to it construction (Carranza, 1994). A model of cultural evolution includes various modes of transmission according to these levels: vertical (between different degrees of kinship, e.g. matrilineal), oblique (unrelated, e.g. from adult members to juveniles) and horizontal (between the same level, e.g. members of the same generation), and several evolutionary processes: mutations, drift and selection (Rendell and

Whitehead, 2001; Filatova et al., 2015). Dawkins (1976) suggested using the term "meme" to refer to a unit of cultural evolution, analogous to "gene" in genetic evolution, in an attempt to find a theoretical analog to the evolution, and transmission, of genetically inherited traits.

When two or more animals have a similar behavior and it is typical of a species, this simultaneous and coordinated action is attributed to contagion, mimesis or response facilitation. In this case, the behavior of an individual serves as a trigger for unlearned behavior of others (Zentall, 2006). **Imitation** skills include simple imitation, called "action-level imitation" or "copying," while **true imitation** is termed "target emulation" (Rendell & Whitehead, 2001), although some researchers believe that this requires that the observer recognizes the intent of the demonstrator's actions (Zentall, 2006). But the transmission of behaviors between different individuals, through instruction, contagion, imitation or emulation, requires different degrees of observation, understanding, initiative, repetition, internalization of the observed action and innovation, which implies, in any case, a complex mechanism that learning by copying relates to the acquisition of skills that contemplate a hierarchical set of responses (Zentall, 2006).

Imitation can be immediate, that is, it occurs at the same time as demonstration, or immediately after in contagious or reflective behavior, or it can be delayed imitation, that is, observational learning that occurs some time after the demonstration of the target behavior. In this case it is no longer reflexive, but must represent the internalization of the demonstrator's behavior because the stimuli associated with the demonstration are no longer present, thus exemplifying a higher level of cognitive behavior (Zentall, 2006).

Perhaps what is best known about orcas are the complex and stable vocal and behavioral cultures of sympatric groups. They appear to have no parallel outside of humans and represent an independent evolution of cultural faculties (Rendell & Whitehead, 2001). Changes in their vocalizations attributed to random learning errors, but also to innovations and horizontal transmission have been verified (Filatova et al., 2015). The transmission of a new behavior has even been observed in these same Iberian orcas, which was the interaction with the tuna longline fishing boats (Esteban et al., 2016a). All these elements, including those of the transmission of behavior, is what we are observing in the construction and transfer of information of this new "meme" that is the interaction of orcas with boats.

3.1.6 Orcas involved in interaction episodes

From the first information about the interactions, an attempt was made to collect the graphic information and immediately three specimens that were repeated in the interactions were recognized. They were called the GLADIS, referring to one of their first vernacular names *Orca gladiator*, this colloquial name was transferred into the media, but also to the nomenclature on the identification of the specimens.

In this way, the most interactive orcas in 2020 have been called: GLADIS NEGRA-GN, BLANCA-GB and GRIS-GG and were previously observed in the Strait, being NEGRA and GRIS juvenile specimens and BLANCA an adult female. In addition to these, up to a total of nine specimens were identified as participants in the interactions: GLADIS DALIA-GD, LAMARI-GL, CLARA-GC, HERBILLE-GH, FILABRES-GF and PEQUE-GP, although they participated in the interactions they did not have a such a direct role and were mere companions or observers.

The GLADIS DALIA, LAMARI and BLANCA are from the same family, as are the GLADIS NEGRA and the PEQUE. Only the GRAY GLADIS was not awarded to any known family. The GLADIS LAMARI and HERBILLE, are non-acting adults, but were occasionally present in the vicinity of the interaction.

Additionally, in 2020 a body report was carried out on the GLADIS NEGRA and GLADIS BLANCA with the intention of analyzing their injuries (ANNEX V). Most of the injuries are typical of those orcas that specialized in picking up tuna from fishing lines.

Figure 3. GLADIS NEGRA. Photo: Rafael Fernández Caballero.

GLADIS NEGRA (Figure 3) is a juvenile (sex not determined), estimated to have been born around 2013. It was found with a large head wound (Figure 4) after the first interactions in the Strait in 2020. This wound was healing, in such a way that in 2021 the wound is not seen in the videos, although we do not have any good quality photos this year. However, this same individual appeared with a very large wound behind the dorsal fin (Figure 5), it has also been seen how it has been healing, although there is no record of the animal since July. In both cases, the wound is of unknown origin, although it is not identified as the typical wounds that these orcas present from fishing lines in their interaction with longline fishing (ANNEX V).

GLADIS NEGRA is always accompanied by GLADIS PEQUE (Figure 6), since they are "sisters", GLADIS PEQUE was born in 2016 and is a female. The mother of both is GLADIS HERBILLE (Figure 7), who is an observer but is usually away from boats, having only been photographed by the whale watching boats in the Algarve after the interactions ended.

Figure 4. Evolution of the wound in the head of GLADIS NEGRA in 2020.

Figure 5. Evolution of the wound behind the dorsal fin of GLADIS NEGRA in 2021

Figure 6. GLADIS PEQUE

Figure 7. GLADIS HERBILLE.

GLADIS GRIS (Figure 8) is another juvenile whose main pod is unknown. It is estimated that it was also born around 2014, and that in 2020 it was always observed interacting with GLADIS NEGRA and

GLADIS PEQUE, but in 2021 it was observed interacting with GLADIS ALBARRACÍN (Figure 9), another juvenile that has only been seen interacting since 2021, and we have not been able to associate a main pod.

Figure 8. GLADIS GRIS.

Figure 9. GLADIS ALBARRACIN.

Another of the acting groups is made up of a complete matrilineal, where the matriarch LAMARI (Figure 10) acts as an observer, having only seen each other a couple of times in the videos of interactions, but always far away. Among her descendants we find GLADIS CLARA (Figure 11), born around 2011; GLADIS DALILA (Figure 12) born in 2017.

Figure 10. GLADIS LAMARI.

Figure 11. GLADIS CLARA.

Figure 12. GLADIS DALILA.

And another of her descendants is GLADIS BLANCA, she is the most active of this group in terms of interactions, she is an adult female since, in turn, she has descendants that also interact. GLADIS FILABRES, born around 2015, and GLADIS TARIK born in 2021.

Figure 13. GLADIS BLANCA.

Figure 14. GLADIS FILABRES.

Figure 15. GLADIS TARIK.

Finally, there is a last group of juveniles that have only been seen interacting with small motor boats, but not with sailboats. They are related to each other, but when they interact they have not been seen with adults around. They are GLADIS ISA-GI (Figure 17) born in 2020, accompanied by her cousins GLADIS ESTRELA-GE (Figure 17) born in 2016 and GLADIS MATTEO-GM (Figure 17) born in 2014.

Figure 16. GLADIS ISA.

Figure 17. GLADIS ESTRELA.

Figure 18. GLADIS MATTEO

In total, there are 14 individuals that are known to have participated in some interaction, most of those that interact with greater intensity are juveniles, with only one adult female, who in 2021 was seen with her new calf (Figure 19), which, although it has not touched the boats, has remained very close to her mother, observing her behaviour.

Figure 19. Relation of orcas identified as acting in the interactions with boats.

3.2 BOATS

3.2.1 Sailing vessels and navigation

With an average annual registration of 1,135 boats in Spain, between 2019-2020, of which 46% of boats are from 8 to 16 meters, with the autonomous communities of Galicia and Andalucia registering 19.4% of all ship registrations. This proportion is 14.4% between the 2011-2020 period for boats on the 6th and 7th list of recreational boats (Figure 1). Of these boats, only 8% are sailing vessels. This is an indicative figure, due to many of the vessels that sail in transit through Spanish waters are foreign.

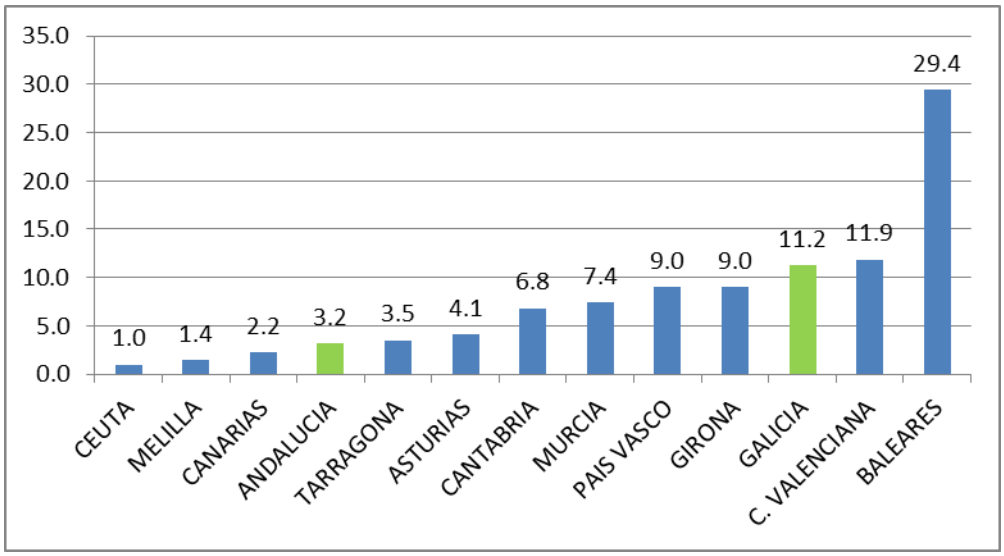


Figure 20. Percentage of registration of recreational boats by autonomous community in Spain for the period 2011-2020, the autonomous communities where the majority of interactions with orcas have occurred are in green.

3.2.2 Evolution and design of sailing vessels

Between the 1960s and 1970s, sailboats of more than 12 meters were designed with a keel that ran the entire lower length of the ship, called keel. These boats had a rudder supported on a hinge on the rear surface of the keel, keeping the propeller protected in the hole before the rudder. They are heavy ships of more than 11 tons (Fuentes, 2019). In the 1980s, sailboats over 12 m were designed with a central extension of the keel, called a fin keel, and with the rudder resting partly on the keel but with a free part, called a skeg. The propulsion is by propeller mounted on a short shaft and separated from the rudder (Fuentes, 2019). In the 1990s, sailboats of more than 12 meters were designed with a fin keel and a rudder free from the keel, only held by its articulated upper part, and which is called a suspended or spade rudder. The propulsion can be by long axis, so the propeller is close to the rudder (Fuentes, 2019). As of the year 2000, sailboats of more than 12 m have been designed with fin keels, occasionally with a bulb at the end of the keel to provide stability (Figure 20).

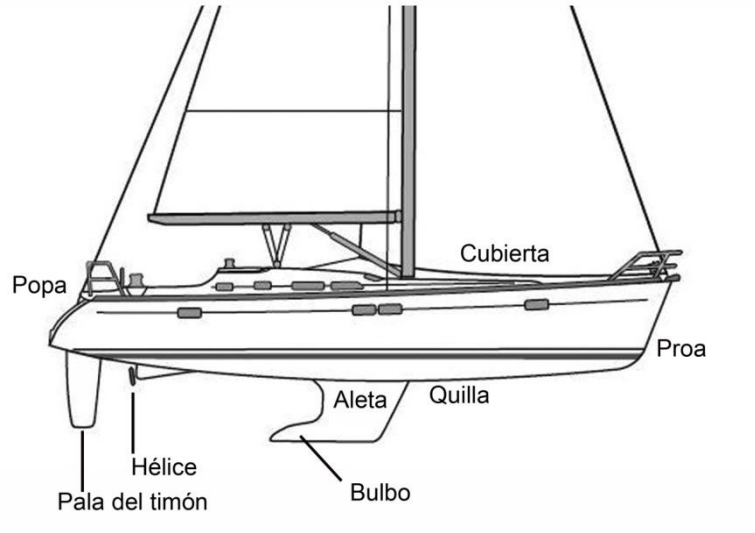


Figure 21. Diagram of the parts of a sailboat.

The rudder is suspended or spade, and propulsion with a horizontal axis and vertical transmission to the propeller support (saildrive) is generalized, so the propeller is further away from the rudder (Figure 21). The advantages over the traditional sailboat drive are: smaller horizontal size, no glands to maintain, and the propeller is mounted horizontally instead of at a lower slanted angle. In addition, folding propellers and other structures are incorporated, such as side fins as keels, which provide greater stability. In this case, they are lighter boats than the older models, from 7 to 11 tons (Fuentes Sánchez, 2019).

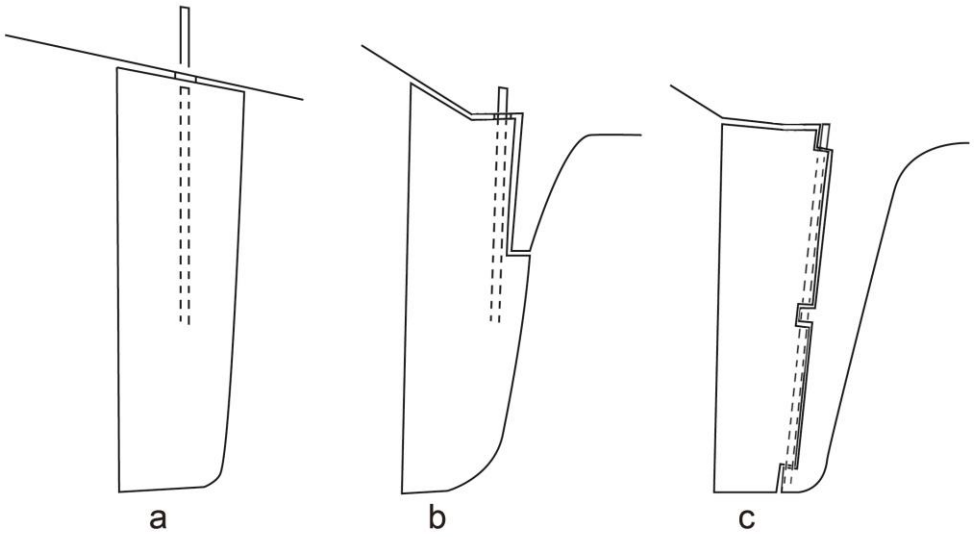


Figure 22. Types of rudders with which orcas have interacted. (a) spade rudder, (b) semi-balanced skeg rudder, (c) full skeg rudder.

3.2.3 Speed in the sea

Sailing boats of 12 m, on average, are estimated to have a cruising speed of 5 knots and a maximum speed of 8.5 knots. The maximum speed is based on the **critical speed of the hull**, which is the one generated by the movement of the ship when it was sailing, discovering itself a wave that acts as a

barrier that it cannot overcome. All this depends on the length, due to the critical hull speed can be defined as: *the speed of a ship in which the wavelength of the bow wave is equal to the length of the ship*. As the speed increases, the size of the bow wave increases and, therefore, it wavelength too, but when the displacement speed is reached, it is as if the ship will be trapped inside the water that it displaces, because it does not it is possible to increase its speed, even if the power of the engine or, in the case of sailboats, the thrust provided by the wind is increased. More power input (by engine, propeller, or wind) will accommodate an increase in wave and not an increase in speed, unless the type of boat is capable of planing on the wave (similar to water skiing). When the ship's critical speed, or displacement, is reached, the bow and stern waves interfere with each other constructively, creating relatively large waves and therefore relatively large value of drag. In relation to the interactions, this drag prevents this type of vessel from passing a certain speed, no matter how much power is given to the engine or the thrust exerted by the wind on the sails, so they cannot flee from orcas since they are among the fastest marine mammals, being able to develop hunting cruising swimming speeds in excess of 9 knots (Guinet *et al*., 2007; Gots & Ronald, 2009; Williams & Noren, 2009; Carwardine, 2019).

3.2.4 Protocol and maritime security

The preventive measures proposed in the safety protocol before an interaction were not designed to avoid an interaction of orcas, since at the moment in which the orcas are under the hull it is considered that they are in full interaction, but **they were designed to reduce the duration and intensity of episodes**; the objective is the reduction of **reinforcements and reasons** for interaction by orcas, the loss of their interest in the ship.

The use of the protocol is always recommended **if the security conditions for navigation make it possible**, in guarantee of the prevailing security protocols.

Therefore, it is also the responsibility of the captain to apply or not the recommendations that are transferred in the security protocol, as long as they consider that they can improve the safety of navigation.

In any case, their decisions or actions cannot contravene the safety of navigation or go against the provisions of current regulations, such as Law 41/2010, on the protection of the marine environment, **Law 14/2014 on Maritime Navigation; Consolidated Text of the Law of State Ports and the Merchant Navy** RD 2/2011), that relative to the protection of species, such as Law 42/2007 of December 13, of Natural Heritage and Biodiversity, or the Royal Decree 1727/2007, of December 21, which establishes protection measures for cetaceans.

Taking into account the number of interactions, in most cases (around 60% of the cases analyzed) it can be deduced that the crew members have not followed the safety protocol suggested by GTOA generally because, in many cases, they do not notify, they do not stop the ship, or because they try some technique that contravenes the aforementioned regulations.

In recent months, all kinds of strategies that are not recommended have been carried out on board the interacting vessels to try to end the interactions, which are being transferred to other sailors as

effective, but have not been proven as such, as the audiovisual materials show, where it is reflected that they are not effective measures. Some of the strategies used have been, for example, sailing backwards (which increases safety risks in navigation), reprimanding animals, throwing objects at them, hitting them directly with a boat hook or similar items, throwing liquids into the sea (oil, gasoline, etc). These "techniques" have been shown to incite even more the interest of the animals (see section 5.3.2) in the interaction, since we suspect that the animals verify that there is a response, that is, they provide reinforcements to their behavior. Additionally, it must be taken into account that these behaviors contravene safety recommendations and incur in punishable actions in relation to the aforementioned regulations regarding pollution and protection of cetaceans.

Therefore, the actions of the captains and their decision-making, in relation to the interaction of orcas, must be limited to the circumstances of navigation and human safety on board.

With regard to giving notice of the presence of orcas, the current legislation (**Law 14/2014 on Maritime Navigation**) contemplates measures to protect the vessel and ensure human life, attributing the decisions and responsibility in navigation to the captain of the ship. Especially in relation to measures to warn of risks and protect the boat and the crew. Articles 29, and 182 to 186 refer to these contents:

Article 29. Notices from captains.

Point 2. Captains must also give notice in the event that they encounter extraordinary storms and any other causes that pose a danger to navigation.

Article 182. Technical obligations of captain.

The captain holds the technical direction of the navigation of the ship, assuming it effective government when he deems it appropriate and, in particular, the provisions set forth in the international standards for the management of the operational safety of the ship are applicable to him in terms of his responsibility and authority and pollution prevention.

Article 183. Danger, abandonment of the ship and rescue.

In the event of bad weather or risk of shipwreck, captain shall take whatever measures they deems necessary to ensure the safety of the ship and the salvation of people and property, seeking shelter, making a forced arrival or resorting without delay to the request for rescue, being able to hire if necessary.

The captain is obliged to come to the aid of human lives that are in danger at sea, as long as he can do so without serious danger to the ship, their crew or passengers, and in any case leaving a record of what has been done in the Journal of Navigation.

Article 184. Primacy of professional criteria.

Neither the owner, the charterer or any other person with an interest in the ship or it load shall place impediments or restrictions on the captain of the ship so that they adopt or execute any decision that, according to their professional judgment, is necessary for the safety of life in the sea and the protection of the marine environment.

Artículo 186. Obligación de comunicar accidentes.

Captains of national ships must notify, immediately and by the fastest possible means, to the nearest Maritime Captaincy or consular authority, any navigation accident that has occurred to the ship or caused by it, any episode of pollution produced or observed and any another extraordinary and important novelty that affects the safety of navigation or the marine environment.

In conclusion, it is therefore the **responsibility** of the **captain** of a boat to give **notice** of the **presence of orcas**, as is the case at hand, if they can be **considered** a **risk** to **navigation** through their interactions with boats.

3.3 INTERACTION OF CETACEANS WITH VESSELS AND ESPECIALLY OF ORCAS WITH VESSELS.

Based on casuistry and navigation experience in presence of dolphins, including orcas, we can say that, in general, some animals can be attracted by the moving parts of boats, such as propellers and rudders, also by turbulence and water projections, provoking in them behavior consistent with behaviors of repeated and even obsessive monitoring. This reciprocal relationship established between cetaceans and boats, and therefore humans, is called **interaction**.

Cases of solitary bottlenose dolphins are known, such as the solitary dolphin Gaspar (Brest, 2003-2007 and Galicia, 2007-2010) that put it head into the hydrojet of boats and swam a few centimeters under the propellers, or the solitary dolphin Confi that accompanies and competes with boats, physically contacting the hulls (Galicia, since 2019).

We also found the case of the orca Luna (Nootka Sound, Vancouver Island, September 1999–March 2006), a specimen that had been disorganized from the pod and had become solitary with a behavior common to what we know of solitary dolphins. In this case, the identification of a close provenance group, as well as the attempt to integrate it into it, was unsuccessful and possibly mistaken. Among the multiple interactions of the orca Luna, the movement of objects, playing in the sterns and dragging boats are described. In these episodes, she printed the necessary and sufficient force to move a boat depending on the person it was carrying. She pushed boats and rudders, caused damage to boats and a seaplane, but never made a sudden move or hurt anyone. She eventually died from cuts from a large ship's propeller being sucked in by it pressure.

But in these cases they are solitary animals, where their behavior is altered and differs from the other socialized wild animals. However, some of these experiences have been collected because they can provide additional information to the case at hand.

3.3.1 Historical interactions of orcas with humans

Historically analyzing the records of interactions between orcas and humans, we find some 21 different cases, from the attack on the shipwrecked whaler Essex in 1820, Old Tom's case with the whalers in 1895, the experiences of the Scott and Shackleton expeditions between 1911-1915, the Bellingham incident when trying to capture a calf, the sinking of the Lucette in 1972, the Guia III incident in 1976 (Notarbartolo di Sciara, 1977), several incidents in Vancouver, between 2003-2018 and even a attack suffered by a surfer (Table 1).

But all of them are specific cases, decontextualized or poorly documented, so it is difficult to extract useful information for the case at hand and, of course, none of them has anything to do with the current cases of interaction, both because of the differences in their characteristics, such as their repetition and frequency.

Table 1. Record of cases of historical interactions between orcas and vessels.

	Date	Place	Type	Boat name	Consequence	Interaction Classification
1	20/11/1820	Pacific	Boat	Whaleboat of Essex	Broken edge	orca/boat
2	1895	Pto. ballenero Eden, New Gales of South	whaling boats	whalers	Mutual benefit	Mutual whaling
3	1911	Antarctica	2ª Scott expedition	Terra Nova	Attempted capture of dogs	Direct with humans
4	1915	Antarctica	Shackleton expedition	Endurance	Attempted capture	Direct with humans
5	1955	Los Angeles Coast	Fishing boat	unknown	No damage	Fishing boat
6	1955	Grand Suttie Bay	Inuit on ice	anonymous	Human capture	Direct with humans
7	1958	Long Island, New York	Fishing boat	Tiger shark	pulled the boat out of the water	Fishing boat
8	1962	Bellingham, US	Orca capture boat	unknown	No damage	Orca capture
9	15/06/1972	Galapagos Islands	Sailing vessel	Lucette	Sank the ship	orca/boat
10	09/09/1972	California	Surfer	Hans Kretschmer i	100 stitches	Direct with humans
11	09/03/1976	Brasil	Sailing vessel	GUIA III	Sunk by water	orca/boat
12	2003-2006	Vancouver Island, Canada	Boats in general	several	Dept sounder	orca/boat
13	2014	Norway	zodiac	oceansounds	No damage	orca/boat
14	2005	Ketchikan, Alaska	12 years old boy swimming	Helm Bay,	No consequences	Direct with humans
15	2010	Lugar desconocido de los hielos	zodiac	Vanessa Berlowitz	No damage	orca/boat
16	2001-2006	Vancouver Island, Canada	ships	several	damage	Orca Luna/boat
17	17/07/2017	Isla Little Biorka SW Alaska	Fishing boat	unknown	Interaction	Fishing boat
18	2018	Comox Valley, Vancouver Island, Canada	Sailing vessel	R-Therapy	No damage	orca/boat
19	15/12/2018	New Zealand	boat	unknown	No damage	orca/boat
20	10/02/2014	New Zealand	diver	anonymous	Minor injuries	Direct with humans
21	20/07/2020	Vancouver, Canada	freighter	unknown	collision	orca/boat

3.3.2 Interactions between iberian orcas and vessels.

Since July 2020, orca interactions have been recorded with various types of vessels, mainly medium-sized sailboats. In these episodes, animals intentionally approach the boats and focus on the moving parts that are submerged, mainly the rudder. Orcas push and hit these parts, immediately making it impossible to control the boat and causing, in some cases, breakdowns and material damage.

4. METHODOLOGY APPLIED TO THE EXECUTION OF THE STUDY

4.1 COMPILATION OF THE NEW RECORDS OF ORCAS

In order to make an exhaustive compilation of all the episodes that have occurred between orcas and ships since July 2020, contacts were established with those key agents who could provide information about them. Among them, it is worth mentioning the contact with the Maritime Rescue and Safety Society (SASEMAR) of the Ministry of Transport, Mobility and Urban Agenda, as well as with local sailing clubs, brotherhoods and underwater activities companies. In addition, the usual channels

continued to be used to promote communication with the crew members of the interacting ships, such as the GTOA website, the CEMMA website, and social media.

Once the actors on whom to collect information were identified, they were sent a questionnaire to collect all the information necessary to record the interaction:

- Start day/time/duration of the interaction.
- Name of the boat, type of boat, type of rudder and provenance.
- Length of the ship.
- Position (GPS/approximate).
- Hull colour.
- Speed and how navigated (motor/sail).
- Description of your performance during the interaction (engine/sail/equipment)
- Effects: apparent damage, repair needs, ship towed
- Number of orcas observed and behavior. Did you observe them before they interacted
- Photos / videos
- Contact person and phone

Templates have been developed in several languages and specialized personnel have been employed to communicate with the crews and gather information.

4.2 ANALYSIS OF ALL ORCAS RECORDS

To execute this project action, the following activities were carried out:

- Compilation and review of the information derived from all the cases registered since 2020, in order to try to find a defined pattern, in terms of the characteristics of the ships, that could influence the interactions. For this, the following were carried out:
    - Review of the information published in the press, social networks, etc., about each episode, including the statements of those affected, if any.
    - Inspections of interacted vessels. In the most recent episodes, the examination of the boats was carried out before boarding or at the slipway. On the other hand, in the case of the underwater examination of the hulls, with the aim of trying to assess the damage and look for marks or signs related to the action of the animals, these dives were carried out by a CEMMA biologist, with a degree in professional diver, using autonomous diving equipment, and underwater photography and video camera, to document the observations made. Due to the lack of visibility in some of the cases, it was necessary to use underwater spotlights to illuminate the hulls of the sailboats and be able to examine them in detail. Additionally, in more complex cases, a support diver participated, in apnea mode, to carry out assistance and surface examination tasks.
    - Review of all the graphic material that the crew members took during the interactions to find specific behavior patterns, as well as to identify the animals.
    - Holding face-to-face interviews with the crew members of the affected vessels, which included video recording of their stories.
    - Maintenance of non-face-to-face contact with the crews in which there were sufficient materials to analyze the episodes.

4.3 PREDICTIVE STUDY

Various maps have shown how the interactions have been moving along the Iberian Peninsula to try to find monthly patterns that can help predict their movements.

4.4 ACTION MEASURES

Through direct contact with the competent authorities and always based on the information and evidence collected, the action measures considered most pertinent at all times have been proposed.

Additionally, within the Whaling Commission, a specific group was created between the scheduled sessions (called "ICG Strait of Gibraltar Killer whale"), to analyze together with various international experts, in order to review the information and try to design and propose appropriate action measures.

4.5 PILOT PROJECT DESIGN

In the same way as in the previous point, and in order to have the maximum scientific background at the international level, the international experts that make up the ICG were also consulted in order to design a pilot project that would allow testing the proposed measures to manage and minimize the consequences of this type of interaction. To do this, a form was distributed to collect your opinion remotely.

The questions asked on the form were:

How should animals be registered?

- Photos
- Videos
- Drons
- Underwater images

Should we test rudder prototypes?

What kind of ship behaviors should we check for that might be triggering the interaction?

- Stop
- Speed up
- Reverse
- Continue with the direction and speed

Should we use dissuasive devices?

If yes, which ones?

- Acoustics
- sounds of pilot whales
- Olfactory

In the case of acoustic deterrent devices, are there any specifications that we should take into account? Or do you know of any trademarks we could use?

Should we measure something specific to the interacting animals?

- Cortisol
- body condition
- Behavior Balances

In case of cortisol, what other parameters should we take into account?

- Sex
- reproductive status
- Presence of ships (sighting/sailboats)
- Time of the day

4.6 AWARENESS MATERIALS

In order to propose specific actions by age groups and possible target audiences, a document has been drawn up that includes the content and ideas that are the driving force for dissemination and outreach about orcas and interactions, as well as the basic lines of communication when preparing content to the media.

5. INFORMATION ANALISYS - RESULTS OBTAINED

The synthesis of the results obtained after the study and analysis of all the collected information is detailed below. Additionally, in Annexes I to III, more detailed information is collected that provides a greater context, the basis for drawing conclusions.

5.1 INTERACTION SUMMARY

5.1.1 Interaction summary in 2020

The interactions began in July in the Strait of Gibraltar, registering ten interactions in the area, followed by eight on the Portuguese coast and two in Galicia in August (20 in total in that period). It should be noted that the intensity of all of them was not similar, being in some cases mere contacts with the ships that did not cause damage. At that time, it was already evident that there were several specimens in various acting groups, at least in two groups, due to great distances between interactions in short periods of time. From there, the interactions focused on Galicia between August 30 and September 30, returning to the Portuguese coast between October 4 and November 14, where they ceased, with a total of 31 interactions during this time (Figure 27).

The balance in 2020 was 51 interactions, 47% in Galicia; 33% in Portugal and 20% in the Strait. The mean depth at which the interactions occur is 180 meters (range 2-1324 meters). However, a difference is observed between the depths between their movements to the north (mean of 98 meters and a range 2-1000 meters) and their movements to the south (mean of 490 meters and a range 47-1324 meters).

Of all the orcas that arrived in Galicia in the summer of 2020, only one pod was observed moving west in the Bay of Biscay. Another was observed moving south again, consistent with the interactions between October and November in Portuguese waters. The remainder either migrated into oceanic waters north of Cabo Ortegal or west off Cedeira, in a fan-like dispersal effect.

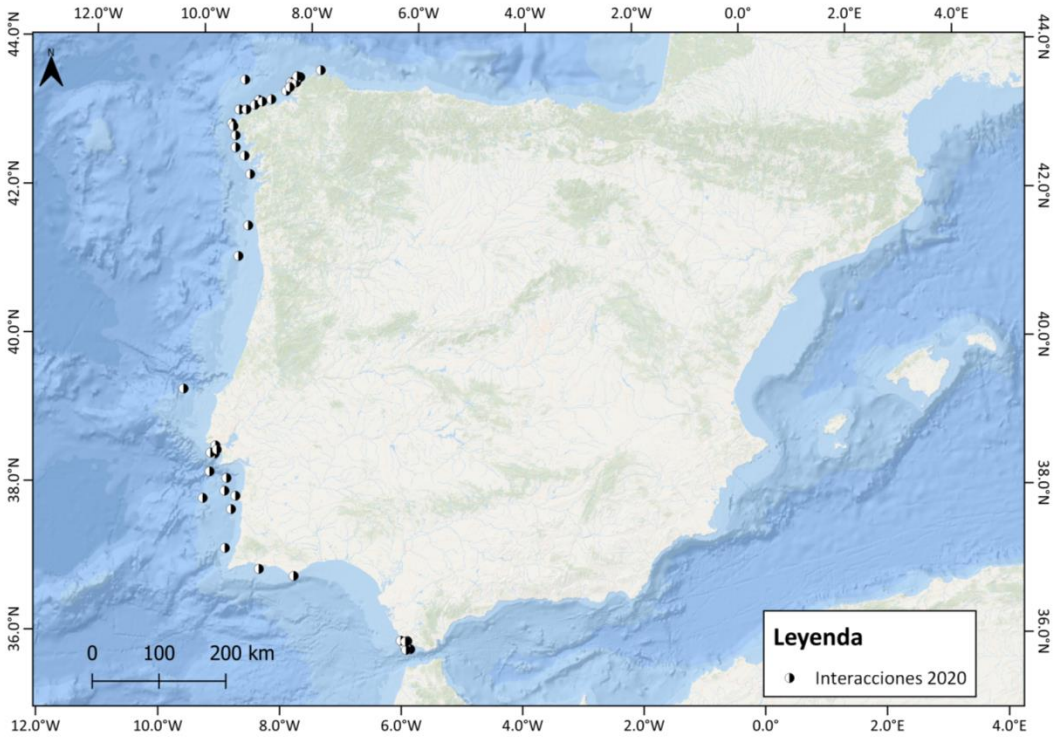


Figure 23. Map of locations of orcas interactions with boats during 2020.

5.1.2 Summary of interactions in 2021

In this year the first interaction was in Moroccan waters in January, then in February in southern Portugal, and in Galicia in the same month. Between February and March, several sightings were recorded between Galicia and Asturias, without record of interactions.

In the month of June interactions intensified in the area of the Strait. At the end of June interactions were detected in Portugal and in July three were detected in Galicia. Subsequently, the first interaction on the French coast is recorded. At that time, at least interactions caused by specimens from three different groups were detected in three different places.

In the month of June, new interactions were observed on the Portuguese south coast, simultaneously with other cases in the Strait, but these interactions did not ascend along the coast to Galicia, but instead focused once again on the Strait with intensity. In the month of August only interactions were recorded in the Strait. In September the orcas begin to move towards Portugal, detecting two separate groups since at the same time interactions are recorded in both Sines and Lisbon, at the end of the month two interactions are recorded in Galicia. In October there is evidence of both interactions in Galicia and Portugal, without concentrating on a specific area.

The balance in this year 2021 is 185 interactions, 56% in the Strait; 27% in Portugal; 9% in Galicia; 7% in Morocco and 1% in France. The mean depth at which the interactions occur is 160 meters (range 8-883 meters).

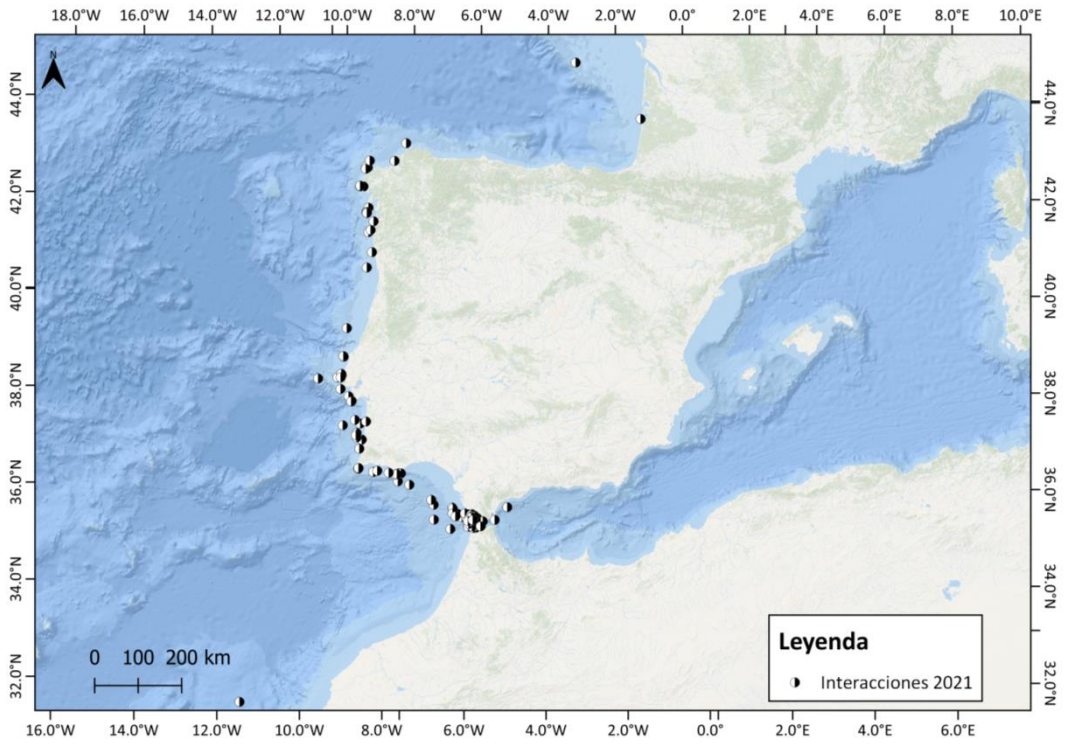


Figure 24. Map of locations of orcas interactions with boats during 2021.

The conclusions of ANNEX III are included, regarding the situation for the month of October 2021:

- This year interactions and sightings moved out of the Strait and northwards to Galicia starting in September.
- In Galician waters, we have identified two specimens involved in the interactions, the Gladis Gris and the Gladis Albarracín.
- The interactions have decreased in frequency and intensity, compared to last year in Galicia and compared to previous months.
- In the last cases, 80% have been registered at night since September.
- The records are not focused, for the moment, on a specific area in Galician waters.
- Perhaps it would be hasty, or excessive, to propose an area restricted to navigation, although recommendations can be made to avoid navigation as much as possible during the night, in the area between C. Fisterra and C. Prioriño or more restrictedly between C. Touriñán and C. San Adrián.
- In the area from C. Prioriño to C. Estaca de Bares there have been no sightings or interactions, up to the Estaca itself, but it is a transit area to the north.

5.2. ORCA RECORDS

5.2.1 Cumulative compilation of records of orca sightings and interactions

From the collection of information on orca records, it has been determined that there have been 236 cases of interaction since they began in 2020. In the case of sightings of the species, the data collected yields a total of 109 records communicated between 2020 and 2021.

However, both the recording of these cases and the collection of information associated with each interactions from the beginning of the episodes were not simple processes for various reasons:

- Because it was a completely new situation and, therefore, there was no procedure or administrative entity in charge of receiving, managing and transmitting information about interactions. In some cases, we knew of the interactions through Salvamento Marítimo or the Maritime Captaincies, but on other occasions, the source of information was the media, social networks, or even the crew members of the ships involved.
- 83% of the interacted ships were of foreign origin (16% from Portugal and 67% from other nationalities), while 17% were from Spain.
- Although with slight differences between 2020 and 2021, the boats interacted were mainly French (20%) and English (15%), the rest (17%) being made up of a wide variety of countries (Belgium, Holland, Scotland, Germany, Brazil, Ireland, Ukraine, Poland, Australia and the United States) (Figure 25). For this reason, the crews did not know which entity they should contact to communicate what had happened, and, although in 2021 the information collection channel had been improved, it is impossible to reach all crew members.

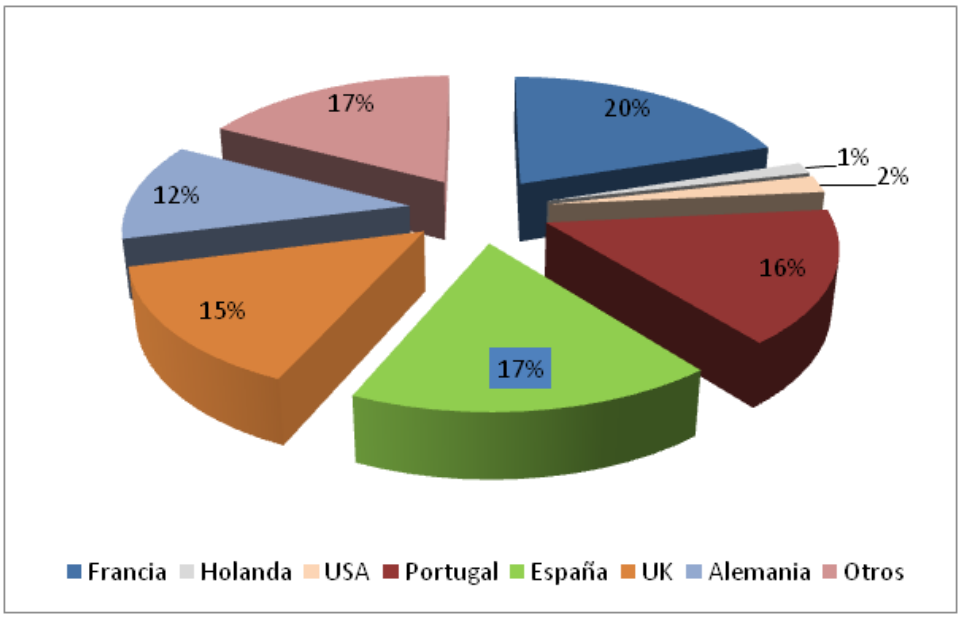


Figure 25. Ship origin interactions by orcas between 2020 and 2021.

- In those cases in which the interactions did not cause significant damage to the ships, the skippers decided to continue their navigation route, and did not stop at the port. To this fact, it must be added that, on the high seas, it is very difficult to establish communication with vessels, for which reason there is no detailed information on some cases.
- Some boaters are reluctant to pass on information about these episodes for fear of interfering with insurers (since in some cases they know that they have used methods, in an attempt to dissuade them, that are out of the law -such as flares, boat hooks, gasoline,

reversing ,…) or because they distrust that the process of collecting information by the GTOA, as it is made up mostly of entities for the study and conservation of cetaceans that, they consider, go against their interests.

All these issues conditioned and limited the information gathering work carried out by the GTOA. Despite all these reasons, the following results have been obtained from the study of the 236 cases:

- Information on 164 vessels (69% of the total) has been collected through:
  - Complete and detailed examination of 19 ships.
  - Information has been received from another 145 boats, including in most cases the telephone contact with the skippers, and the receipt of information, photographs and videos, by email or WhatsApp.
  - A total of 471 photographs of the animals and 274 videos were received, which together totaled a total of 5 hours.
- In 31.8% of the remaining cases, the information available is partial, and has been collected indirectly (press, social networks, etc.), and it has not been possible to establish contact with the crews for various reasons. For this reason, in some of these cases there is insufficient information on whether or not there was damage to the vessels (10.5% of the total), although it is presumed that, if there was, it would be slight and allowed them to continue sailing, given that the trailers are registered through the Maritime Salvage services. Table 2 collects the information of data provided, or not, between 2020 and 2021.

Table 2. Summary of the information flow about interactions between 2020 and 2021. Percentages calculated over the respective years.

	2020	2021	Total
Data	46 (90%)	118 (63%)	164
Without Data	5 (10%)	70 (37%)	75
Total	51	188	239

5.2.2 Dead specimen record

On March 7, 2021, an alert was received of a dead orca floating in North African waters of Ceuta under Spanish management. It was a juvenile male. The fall of a good part of the epidermis, the prolapse of the penis and the tongue, due to the pressure of the gases from internal decomposition, indicate that he had been dead for several days, between 3 and 5 (Figure 26). The difficulties in accessing its collection and its drift towards Moroccan waters led to the loss of the body that could not be examined. A right ventrolateral contact area with a transfer of blue paint was observed. Initially, it was thought to be a death by collision, but the place and position could indicate the approach of a ship to the body, with contact, or a collision of the body already dead in that same position since, in a living and swimming animal, that mark by collision would be very difficult. The loss of the body did not allow the identification of the specimen, the knowledge of more indications or the collection of biological samples.

Figure 26. Dead orca floating in the waters of Ceuta on March 7, 2021.

5.3 VESSELS

5.3.1 Characteristics of the interacted ships

Most of the interacted boats are sailboats, both monohull (72%) and catamarans (14%), although there were also interactions with motor boats (6%), semi-rigid (5%) and fishing boats (barely 3%).

Of all these vessels, the most common type of rudder (Figure 22) was spade rudder (in 67% of cases), followed by semi-balanced skeg rudder (in 22%) and full skeg rudder (in barely 1%). In semi-rigid boats and some motor boats, the engine is outboard (approximately 10% of the cases) so the movement of the boat is controlled by the movement of the engine and not by an independent rudder.

The most common rudder among modern commercial sailboats is the spade rudder (Table 3) and at the same time the weakest since it is normally made up of two joined plates filled with polyurethane on an axis, or wick, which goes through the blade, still with reinforcements, but that does not reach its distal end.

Table 3. Relationship between the type of rudder of the ships interacted by orcas and the type of damage that was caused, the percentages are calculated on the total of each type of rudder.

	Without damage	Light damage	Seriour damage
Spade rudder	22 (26%)	46 (55%)	16 (19%)
Semi-balanced skeg rudder	8 (33%)	12 (50%)	4 (17%)
Full skeg rudder	2 (25%)	2 (25%)	4 (50%)
Outboard	13 (48%)	13 (48%)	1 (4%)

The average size of the boats involved was 12 meters, although there are differences depending on each type of boat (Table 4), in the case of sailboats, they are medium-sized boats, and curiously they are not the most commonly registered in Spain, they sailed at an average of 5.79 knots. The boats interacted at that time were sailing as well as motorized, and no specific color pattern has been

detected that implies a greater or lesser attraction for orcas, it is not recognized as a reason for reinforcement in their behaviour, since all the Hull colors have been interacted.

Table 4. Characteristics of boats interacted by orcas since 2020, mean and range between length brackets in meters, and speed in knots.

	Lenght m	Speed knots
Sailboat	13.07 (6.5-35)	5.65 (0-10)
Motorboat	8.23 (6-12)	9.33 (0-25)
Semi-rigid boat	10	4.25 (2-6)
Fishingboat	7.2 (5-11)	3.5 (3-4)

We highlight the special case of interactions in Algarve, where most were with small semi-rigid boats, which are the most common among whale watching companies in the area. In this case interactions consist of physical contact with the floats.

5.3.2 Damage and breakdowns

As described above, not all boaters who have had an orca sighting or interaction report the situation. Although it is considered that the vast majority do, the exact proportion of those who do not report is unknown. Of all the cases registered, and thanks to the efforts made to gather this information, it can be stated that 10% of the sailors involved in episodes of interaction provided incomplete information, while in 90% of the cases we have details about the interaction, breakdowns and their magnitude.

In this sense, it is known that in 40% of the cases, the interacted ships did not present consequences, damages or breakdowns. In the same way, it can be affirmed that, among those that presented damages (50% of the cases), 60% were light and, although they were of a diverse nature, they did not impede navigation in any case. However, the rest of the interactions with damage or breakdown (40%) were considered serious, that is, they prevented navigation and had to be towed (Table 2). Among the serious damages are broken rudders, which are the most highly regarded cases in terms of failure, or small internal failures of the gears that prevented the normal rotation of the rudder and, therefore, the maneuverability of the boat. Table 5 collects information on cases with damage, or not, and the type of damage (light or serious), between 2020 and 2021.

Table 5. Summary of information with/without damage, as well as the type of damage, between 2020 and 2021. Percentages calculated on the respective years.

INFORMATION OF DAMAGE RECEIVED			
	2020	**2021**	**Total**
Without information	4 (8%)	21 (11%)	25
Without damage	19 (37%)	76 (40%)	95
With damage	28 (55%)	91 (49%)	119
Total	**51**	**188**	**239**

TIPO DE DAÑO	2020	2021	Total
Light	15 (54%)	56 (61%)	71
Serious	13 (46%)	35 (39%)	48
Total	28	91	119

number of serious respect to the total (sightings and serious damage, navigation, accounts records in the two in 2021, a increased by having number of instead a lower number of sightings (Table 6). If we estimate the damage with number of records interactions), that is, that prevents for only 14% of all years, reaching 15% percentage that is registered a greater interactions, but

Table 6. Summary of orca records, both sightings and interactions with vessels since 2020, with respect to damage.

	2020	2021	Total
Interactions	51	188	239
Sightings	68	41	109
Total	119	229	348
Serious damage	13	35	48
%	11	15	14

an external survey, context of this minor carried out on transit along the coasts carried out on a social November 2021. Of 161 had encounters with By way of comparison, carried out outside the contract, which was anonymous sailors in of the Iberian Peninsula, network1, updated until surveyed sailors, 25% orcas, but only 6 have reported breakdowns or breaks (Figure 27). In our case, interactions account for 72% of all cases, although the proportion of cases with serious damage is 13%, possibly overestimated by not reporting sightings, or light interactions, some of the sailors.

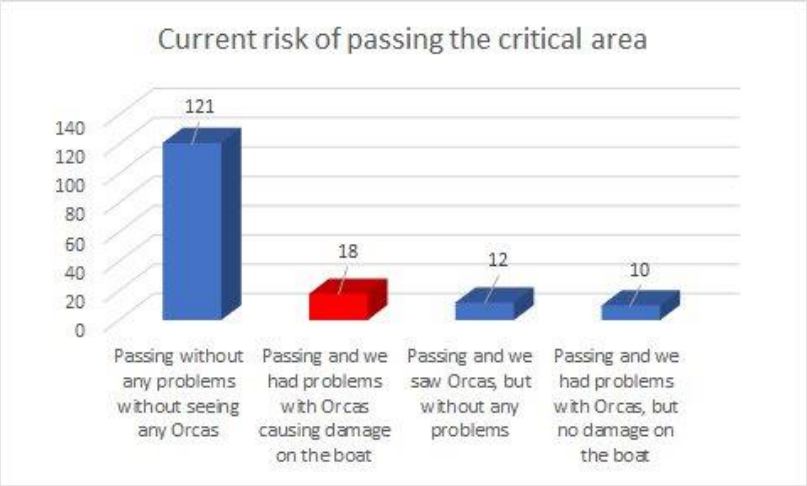


Figure 27. Results of the interview conducted with sailboat users in the Orca Attack Reporting Facebook group.

Another external reference for the number of incidents may be the *Mini transat* transoceanic regatta, in which at least 90 sailboats sailed in Galician waters from September 28 to November 4, coinciding when the orcas ascended to the north (Figure 28). Four boats in the regatta were interacted and only one of them with significant damage, which would mean that 4% of all the boats were interacted, causing serious damage to 25% of interacted boats, but only 1% of all participated boats in the event. However, this is a very imprecise estimate, since there were surely other unreported interactions

with other ships and because we do not know the actual number of ships that could have been in the area during those days, which could even exceed triple the number of the regatta ships.

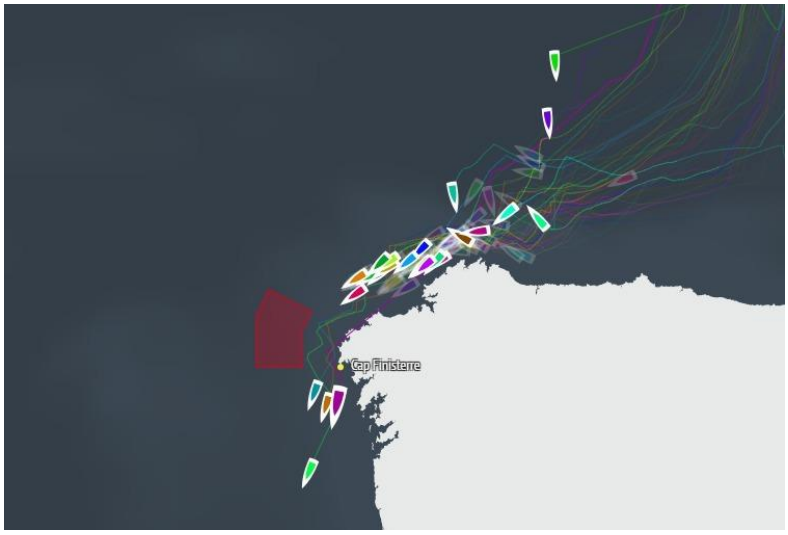


Figure 28. *Mini transat* in it passage through Galicia.

In many testimonies it was recorded that orcas pushed the boat, accelerating the speed of the boat, pushing it forward. This push was carried out indistinctly when the boat was moving or when the boat was stopped, with which orcas push the boat regardless of the speed of the boat. This behaviour has no consequences in terms of damage or failure, unless it is done under the rudder, once the stock (it metal axis) has been previously bent laterally, so that the rudder adopts a horizontal position with a suitable surface for thrust.

It was verified what were the consequences of the interactions depending on the behaviour carried out by crews; It has been analyzed whether or not they followed the security protocol, whether or not they stopped the vessel, regardless of knowing or applying the protocol. We consider that crews did not follow the safety protocol, or did not stop the boat, when they maintained speed, accelerated, or reinforced the behaviour of orcas with the aforementioned occurrences. We believe that crews followed the security protocol when they stopped the ship.

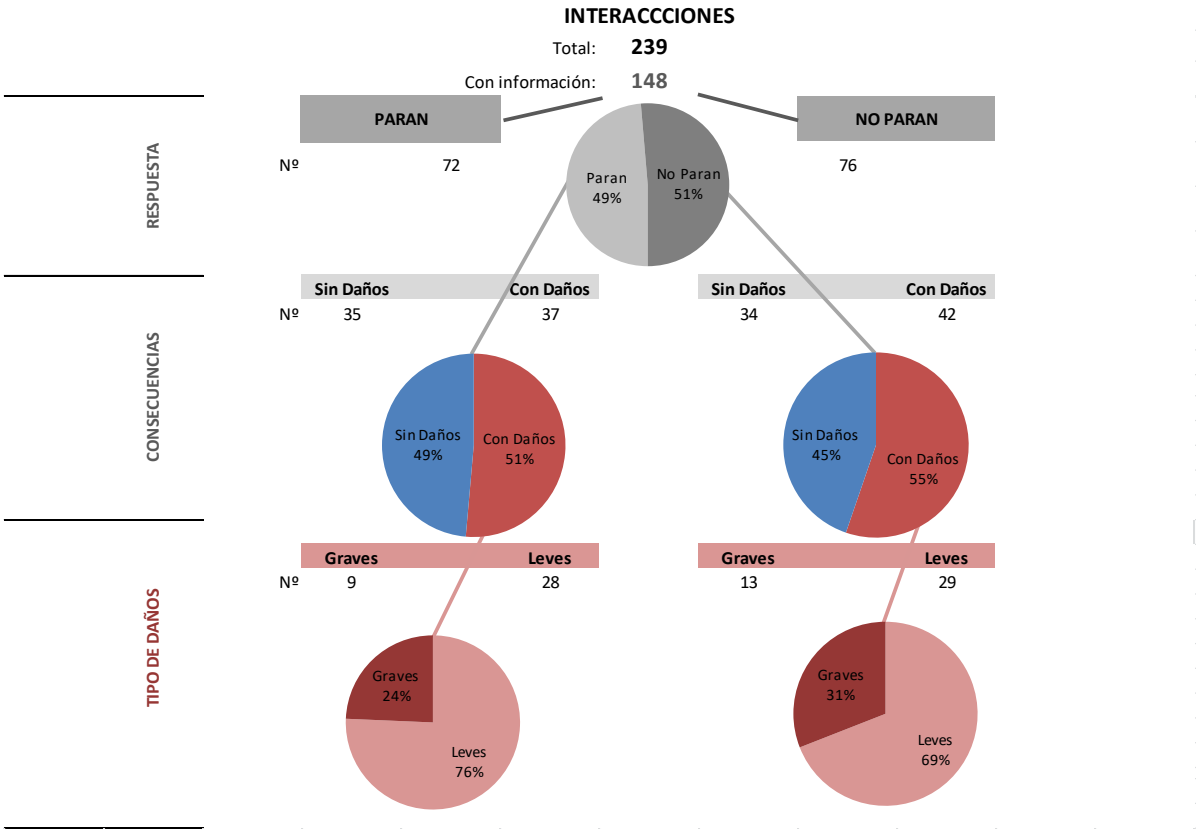


Figure 29. Consequences of the interactions depending on the behaviour of the boats with respect to the stop or not of the boat.

Results show that there is a slight association between not stopping the vessel (with damage: 51% stopping vs. 55% not stopping) and the consequences for the boats, both in terms of damage and serious damage (serious damage: 24% stop versus 31% do not stop), although different cases do not present significant differences. That is to say that by stopping the ship, and keeping calm, the ship can be damaged as well as not, but when the ship is not stopped and/or it behaviour is reinforced positively with speed, it seems more likely that the ship will end up with damage and with more serious damage. However, in 10 cases the interacted boats carry out both behaviours, for example, they stop at the beginning, but then they start the boat, or vice versa, with which the effects of this behaviour of the boat (stop/not stop) can be mixed. These results must be corroborated and reinforced with the studies proposed in the pilot study regarding the behaviour of the ship (see section 7.8.2).

On the other hand, the consequences of the different "techniques" that the boats used to try to deter the orcas during the interactions were analyzed in more detail. These "techniques" can be intentional such as the use of boat hooks, flares, diesel oil, stones and other objects, reversing, releasing sewage, shouting to try to dissuade the animals; or simply the boat already had fishing lines in the water, or music on the boat and its effect has also been considered in terms of consequences on interactions.

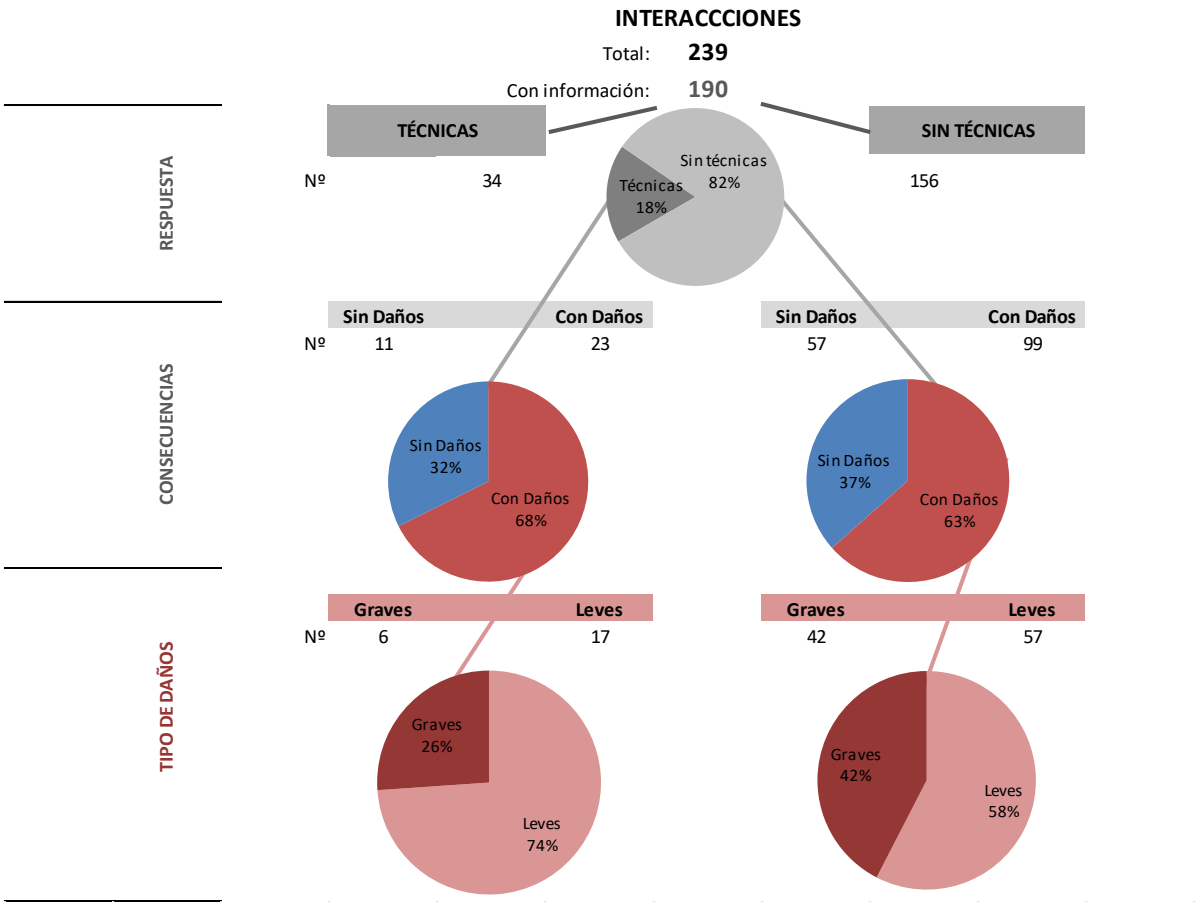


Figure 30. Consequences of the interactions depending on the behaviour of the vessels with respect to the use of dissuasive "techniques".

Results suggest that the use of these "techniques" could lead to more cases with damage (68% with "techniques", compared to 63% without "techniques"), but on the other hand it also suggests that these damages would be mostly light (74% with “techniques”, 58% without “techniques) (Figure 30). Therefore we decided to continue analysing the effect of these "techniques" that were divided into "negative" (baffle, flare, release black water, shouting, music, horn) when the result of their application was a greater number of damages, and " positive” (reversing and fishing lines) in the opposite case.

In this case, the results, as expected, the "negative techniques" present a higher percentage of damage (72% "negative" versus 40% "positive"), and also seems to have an effect in relation to the type of damage , having more serious cases with the negative ones (24% “negative” versus 17% the “positive ones”) (Figure 31). However, we must take into account that in most cases the boats used several types of techniques at the same time, so we cannot attribute the use of each "technique" (positive/negative) to the consequence of having or not having damage on the boat. That is why this type of technique, especially the positive ones, should be checked during the development of the pilot project (see section 7.8.2).

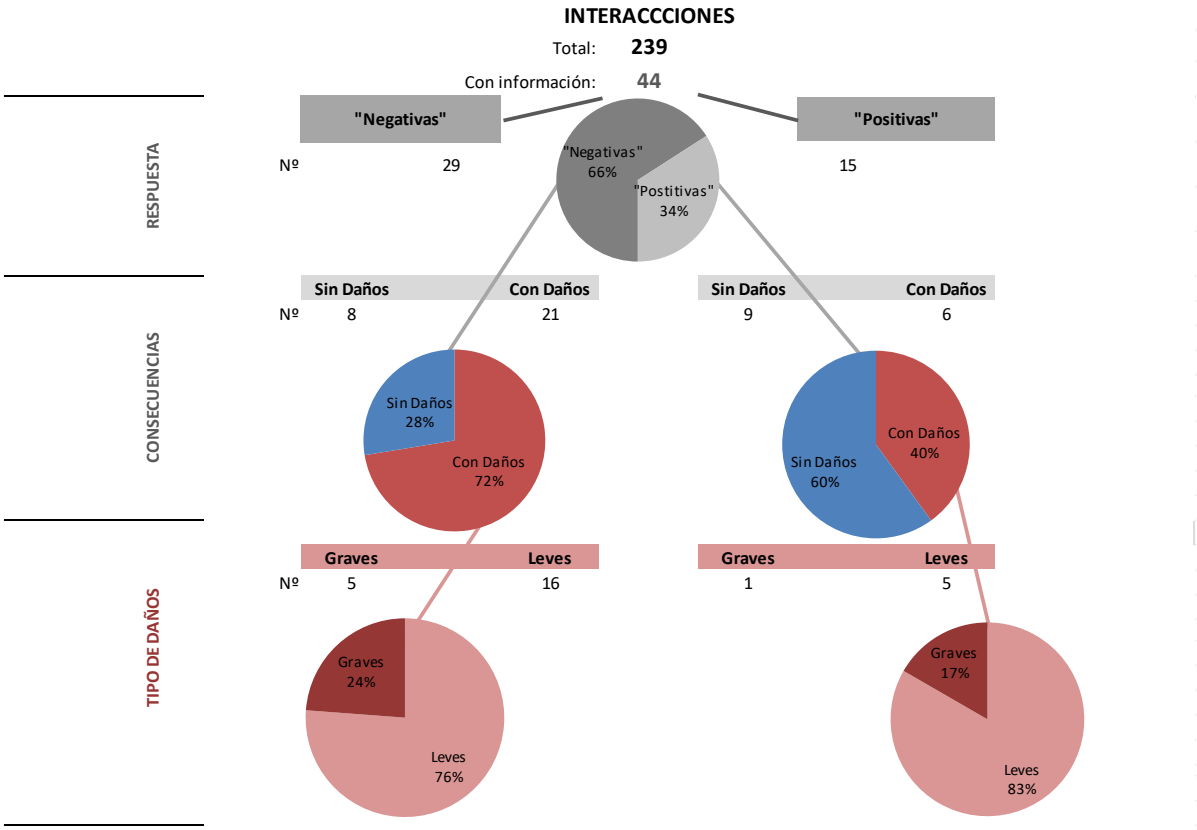


Figure 31. Consequences of the interactions depending on the behaviour of the vessels with respect to the use of dissuasive "techniques" with "negative" and "positive" results.

Finally, the effect of the speed of the boat was verified, considering slow speeds at speeds of less than 4 knots, and fast speeds at more than 4 knots. The results suggest that speed could affect the consequences of the interaction in terms of damage (damage: 47% slow speeds, compared to 61% fast speeds), not so much as the type of damage, the results being very similar (serious: 25% for both speeds) (Figure 32). Once again, relationship between the speed and the consequences of the interaction must be verified during the pilot project (see section 7.8.2), since in this case the speeds are in many cases indicative, in accordance with what was agreed upon by the crew, and only from the moment just before the interaction. The positive effect of the presence of fishing lines in the water could be attributed to the fact that orcas are used to their presence and that they interact with the tuna longline fishery in the strait, the animals going to check if there are any catches in the line. At the same time, the fishing line could prove to be a distraction for the animals, as was observed on three occasions, where the boats dragged a small inflatable boat, and through the videos and testimonies we verified how the animals briefly seemed to be distracted by the small boat, and they ceased to show interest in the helm of the main vessel.

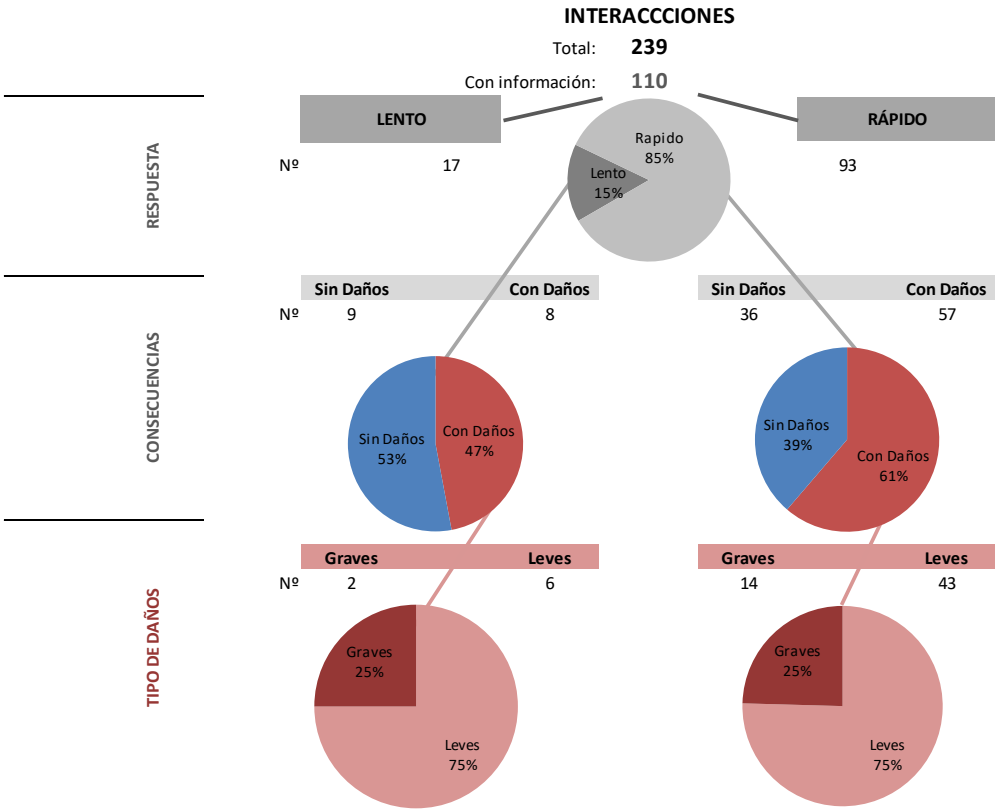


Figure 32. Consequences of the interactions depending on the crew behaviour regarding the use of dissuasive "techniques" with "negative" and "positive" results.

5.4 INTERACTIONS

5.4.1 Characteristics of interactions

Both sightings and interactions of orcas with boats are concentrated in spring and summer months (Figure 33). This may be due to the fact that it is the time when orcas are normally observed in the waters of the Strait, since it is the time that coincides with the migration of their main prey, bluefin tuna, into and out of the Mediterranean. On the other hand, this reality may also be conditioned to the fact that it is the time of year in which the best sea conditions are recorded in the area, and therefore there are also more boats present, which increases the chances of both spotting individuals of the species, as interactions occur. The rest of the year, despite the fact that maritime use is less for leisure activities and sports navigation, the presence of fishermen and ornithological observers, who are habitual reporters of information, is usually constant and, however, orca sightings decrease a lot or are practically exceptional.

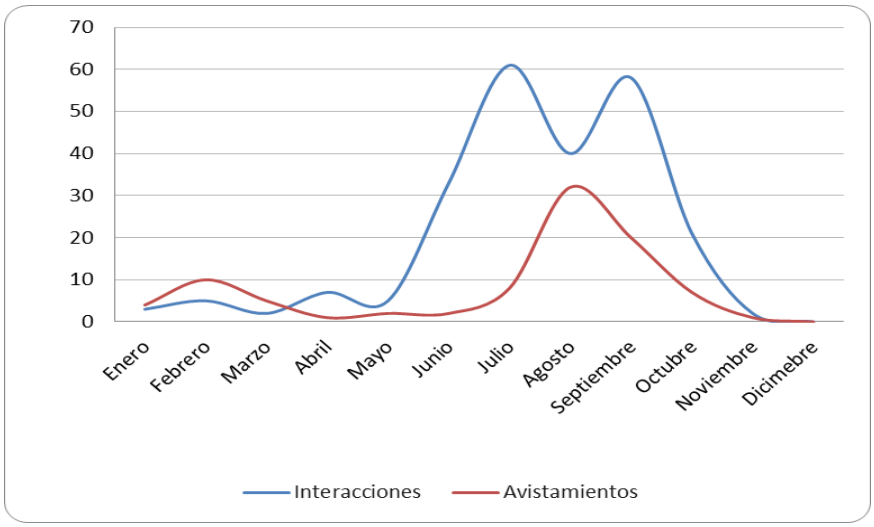


Figure 33. Temporality throughout the months of the orca records, both sightings and interactions with boats since 2020.

Regarding the daily patterns, we can say that interactions occur at all hours of the day and night, although it seems that there is a concentration of interactions throughout the midday hours (Figure 34). This fact may be conditioned by the greater presence of ships at those times, since normally these small sailboats tend to call at the port or anchor overnight.

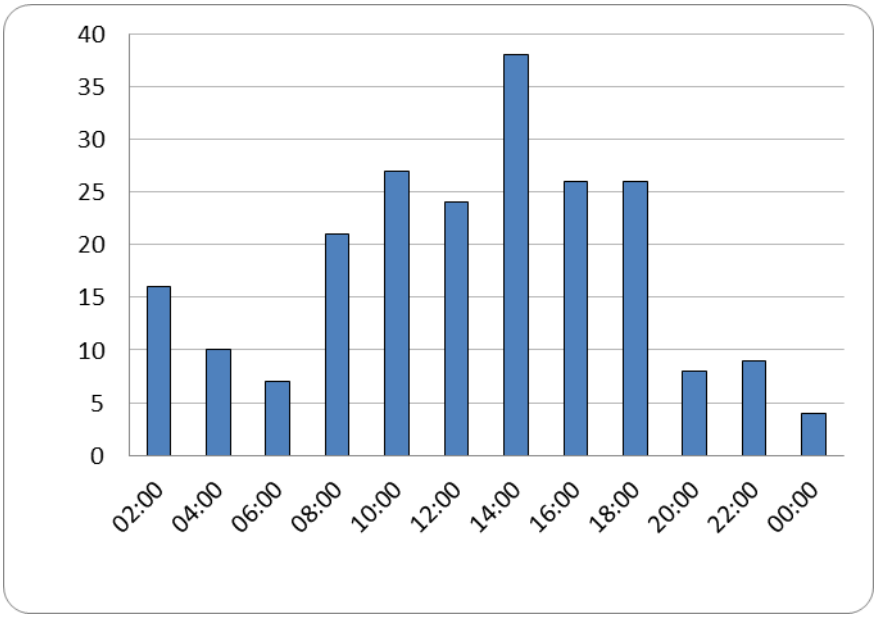


Figure 34. Hourly distribution of orca interactions with boats since 2020.

Interactions lasted an average of 40 minutes, ranging from 1 minute to 3 hours, and 64% of the interactions lasted between 5 and 30 minutes (Table 7).

Table 7. Average duration of interactions between orcas and sailboats.

Duration (min)	Percentage

<5	4%
5 a 30	64%
>30	32%

5.4.2 Phases in interactions

The data from the interviews with the crews of the interacted boats have been compiled and based on their testimonies, as well as the observation of signs of physical contact on the hulls, we have categorized the behaviours.

PHASE 1: APPROACH. Three possibilities are observed:

a) DISCREET.- Orcas approach the ship slowly and stealthily and, in some cases, the crew is even unaware of their presence until they begin to interact with the hull or rudder.

b) DISPLAY.- Orcas show intentional display behaviour, coming out with part of their body out of the water, clearly showing themselves to the crew.

c) NOTICE.- In this case, the orcas are not so effusive showing themselves, they simply approach the boat taking a look before starting the interaction.

In most cases they approach discreetly (78%), sometimes they display themselves before taking the helm (7%) and other times they discreetly announce that they have arrived (14%).

In all the cases studied, the approach from the stern occurs, a habitual behaviour in orcas, which denotes reinforcement of competition with the boat due to speed. Orcas will be around, suddenly they hear the boat and head towards it, following it until they make contact.

PHASE 2: CONTACT. Once under the boat, they begin a series of curious movements, positioning themselves belly up, touching with physical contact, it may be to find out what the shape or texture is like.

In this case, the reinforcement is the movement of the propeller, the projection of the water jet, the water outlets of the sumps and exhaust, the movement of the rudder, any novelty that is found, such as catamarans with two keels, bulbous keel, etc. etc.

On the helmets there are some indications of tooth marks, very scarce, and landing marks from different parts of the body, back, side or face. Also in the blades, when they are not broken, observing these marks in the distal part.

The contacts with the rudder cause movements of the same and therefore of the boat, with which they identify that it is a moving part and that its movement produces a cause-effect, increasing the reinforcement.

On boats with rudder resistance they hit harder. In boats with autopilot, it deactivates or breaks (7 cases of autopilot breakage), possibly due to detecting resistance to movement.

PHASE 3: GOVERNMENT. The tactile action focuses more on the rudder by hitting it safely to analyze its tension and cause the boat to change course with the movement of the blade. The appreciation

of the crew´s testimonies indicates that the more tension they observe, the more they respond by hitting, that is, when an attempt is made to straighten the course of the ship, or when the ship continues at high speed. At this moment the pilot or rudder breaks if resistance persists or if the skipper leaves it **loose** on the track, so it may or may not break but without resistance. The increase or maintenance of speed increases its insistence **since it is understood as a reinforcement of competitiveness. Even without stopping the ship, orcas can push it by increasing its speed.**

PHASE 4: STOP. The increase in repeated hits or a strong hit causes **skipper to be aware that an interaction has occurred, to which he reacts by slowing down** or even **stopping** the boat. With the rudder on the track, it is at the mercy of orcas, which allows them to direct it, which is combined with pushing the hull and pushing the boat with the swimming of the animals. Blade rudders can break in their distal part, the rudders with the shoulder joint are harder and, since they do not break, they transfer the energy of the blow to the stock, thus destroying the gear making them useless. With breakage or damage, the ship is **left to heave** and without government.

PHASE 5: REVIEW AND DISINTEREST. The stopping of the boat, the change of conditions to those of arrival, having broken, disabled, displaced or moved the rudder, seems to provoke in orcas a new examination of the situation and a lack of interest in the action. They show up, they bubble up in many cases and they are gone. Sometimes they come back and repeat the action.

5.4.3 Orcas attitude

In the 274 videos examined, which as a whole added up to a total of 5 hours, in which orcas are observed navigating at the stern of the boats, moving around their rudder and moving ropes, loose parts of the rudder, etc., no aggressive attitude on the part of cetaceans is interpreted, despite the fact that some of the behaviours cited, such as the generation of bubble bursts or tail blows, do not correspond at all to aggressive behaviour (see ANNEX V and section 3.1.3). The most intimidating attitudes observed may be related to loud snorting and vigorous and abrupt swimming, but always in situations of positive reinforcement due to the increase in boat speed, where we understand that the competitiveness and excitement of the animals is reinforced.

5.4.4 Hypothesis of the origin of this behaviour

The trigger for this strange and novel behaviour is unknown precisely, establishing two hypotheses:

Self-induced curiosity and playful behaviour: a behaviour induced by their own interest and curiosity is generated based on the type of intrinsic motivation (ANNEX V), with a playful component and without apparent motivation, since touching moving parts of the boat can move or come to stop a large moving object. This results in an extraordinary "invention" that causes surprise and is therefore fantastic to share with other individuals. In this case, a horizontal cultural transmission would be taking place between specimens of the same social stratum, for example, juveniles, and at the same time a transversal cultural transmission between specimens in different social position, for example, older individuals involving other specimens of less age. This hypothesis fits well with juvenile specimens, although somewhat less so with GLADIS BLANCA, which is an adult specimen. However, it has been observed, now in 2021, how this specimen is transferring this behaviour to it calf GLADIS TARIK. In addition, this hypothesis would also be supported by the fact that juveniles have been increasingly curious about the presence of boats, with the recording of GLADIS NEGRA and GLADIS

PEQUE in 2017 very close to the Tursiops Association sailboat that crossed the Strait of Gibraltar. Since then there has been evidence of various videos in which juvenile specimens got very close to the stern of various boats. Instead, it doesn't adjust well to obsessive behaviour with only one type of ship.

Precautionary behaviour based on an aversive incident: this hypothesis, based on the type of extrinsic motivation (ANNEX V), considers that it could have been an aversive incident that orcas had with a sailboat-type vessel, in which the speed of the boat could be a critical component. From this event, aversive for orcas, a succession of behaviours were triggered in the presence of any sailboat sailing and ending with a preventive behaviour consisting of stopping its speed by manipulating the rudder as a precaution against repeating this evil lived moment.

It is not ruled out that any type of vessel could be involved in the aversive incident, but that orcas identify sailboats as more accessible vessels with larger rudders, with different structures and characteristics, and further away from the propellers.

At the moment we still do not have clear evidence of if it happened, when it happened, we are not even sure what type of ship could be involved, or if the incident was accidental or intentional. This hypothesis fits with the preventive behaviour of GLADIS BLANCA and with vertical cultural transmission, but not so much with juveniles.

En este caso varios ejemplares juveniles con cierto grado de emancipación, o desestructurados, pueden unir sus esfuerzos en la periferia de un grupo, más allá que perteneciesen permanentemente o no a él. En ambas hipótesis se ha desarrollado un comportamiento replicado trasmitido y transformado en una rutina, en el que algunos de los ejemplares ya no conocen su significado original, sea cual sea este.

Orcas are highly adaptive in their behaviour and cooperative predators (Guinet, 1991). Social play and mimicry are two mechanisms that explain the development of predatory behaviour in youngs (Guinet, 1991; Abramson et al., 2013), developing through a reorganization of play behaviour, improving skills and being absolutely necessary for their development (Martín and Caro, 1985; Caro, 1988). Being the play a behaviour that develops in conditions of good health, and nutritional condition, but not under stressful conditions (Sarti et al., 2010). The cooperative behaviour of two specimens is based on the so-called "offensive coalitions between combative individuals", as an optimal strategy to achieve greater effectiveness when searching for food resources or reinforcing their social role (Tobeña, 2002). In this case, several juvenile specimens with a certain degree of emancipation, or unstructured, can unite their efforts on the periphery of a group, regardless of whether or not they permanently belonged to it. In both hypotheses a replicated behaviour has developed, transmitted and transformed into a routine, in which some of the examples no longer know their original meaning, whatever it may be.

5.5 SECURITY PROTOCOL

5.5.1 Security protocol bases

After reviewing 274 videos examined, and collection of testimonies, it was concluded that, even ignoring the main **reason** for their behaviour, a **positive reinforcement** or incentive for orcas to

promote these episodes of interaction is the ship's sailing speed. This can promote competition since, when the boats were sailing at low speed (less than 4 knots) orcas interacted more calmly and when the speed was high (more than 4 knots) they accelerated their swimming speed and the blows against the boat were more intense, and more dangerous in terms of safety (consequences in damage to the vessel see section 5.3.2). In addition, the orcas must appreciate the resistance in the rudder to their blows, that is, when the boat is moving and an attempt is made to maintain the course, the orcas feel resistance to their intention to turn it, so they continue hitting more insistently.

For the vast majority of dolphins, **motivation** for the behaviour of accompanying the boats is simply competition, the speed of the boat being its **positive reinforcement** (Figure 35). To this can be linked a little curiosity, skill, leisure, imitation and courage. The vast majority of dolphins carry out this activity of following the boat at some point, unlike the harbor porpoise, *Phocoena phocoena*, which flees from the presence of (ANNEX V). On the other hand, if the boat makes changes by slowing down, the cetaceans return or leave, most of the time, because for them it is no longer something interesting, they do not feel motivated or reinforced. Therefore, in their accompanying behaviour there is a non-reinforcement or extinction of the behaviour (ANNEX V).

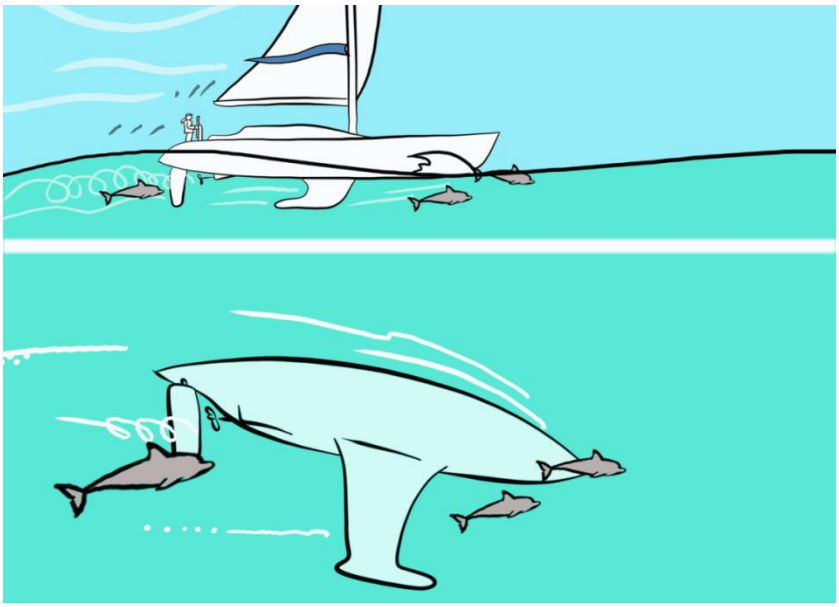


Figure 35. Behaviour of most dolphins in front of moving boats.

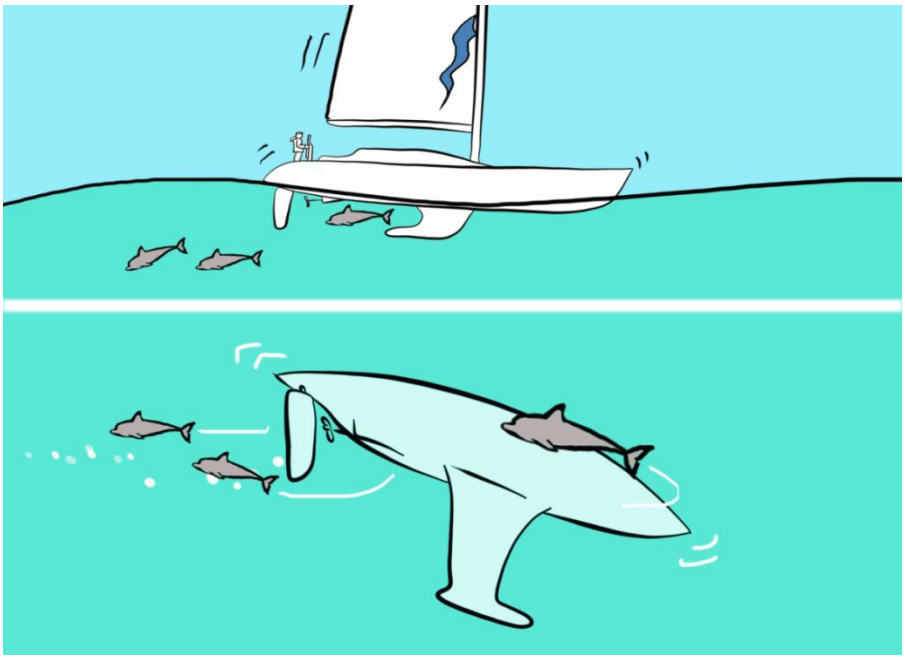


Figure 36. Behaviour of most dolphins in front of stopped boats.

For orcas, we consider that speed continues to be an important **positive reinforcement** in their behaviour, since during the first moments of the interaction they follow the boat at high speed, and even surpass it or sail alongside it (Figure 37). Although the **main motivation** may be different (exactly what it is is still unknown), competitiveness surely becomes a component of the main motive, or **secondary motive**, along with curiosity, dexterity, leisure, imitation and bravery, but it is a means to achieve the boat (which gives rise to the reward, ANNEX V) and be seen. The **main motivation**, in this case of novel behaviour, could be to get to manipulate the boat, direct it, move it and even stop it, it could be one more element in that equation, but rather the reward and reinforcement of it. So, if as soon as we detect an interaction, we stop the ship before we reach the end of their interactive behaviour, due to the tendency towards extinction of the behaviour, we advance their secondary objective, although they still achieve the main one (move it, direct it). **If the boat is not stopped, on the other hand, the positive reinforcement of competitiveness is increased**, as in case of dolphins, and perhaps the frustration of not being able to touch it or move it as desired, which perseveres the behaviour (Figure 38). .

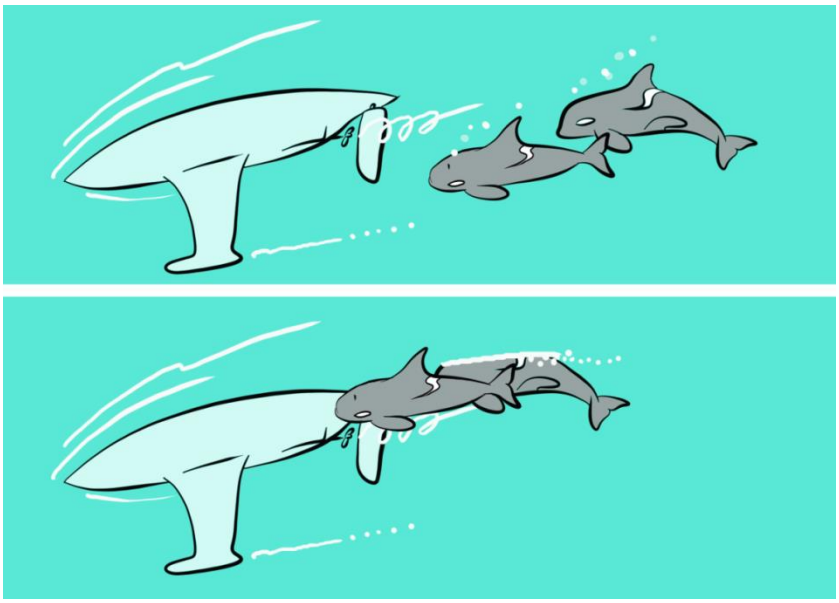


Figure 37. Approach behaviour of orcas to boats since 2020

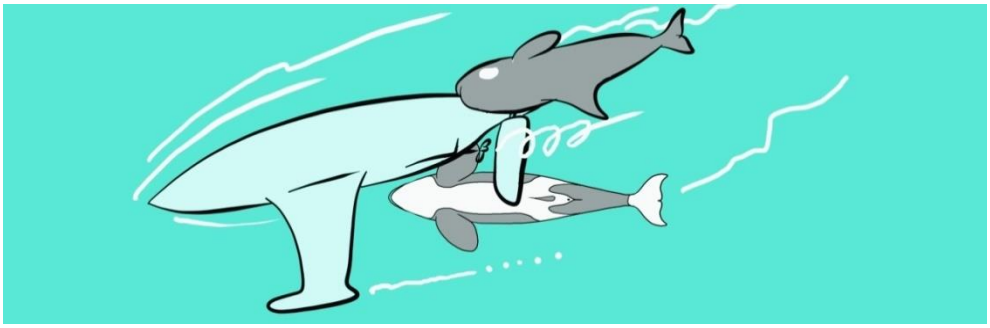


Figure 38. Behaviour of orcas when they interact with boats.

The stopping of the boat does not always cause the extinction of the interaction behaviour, but more than 50% of the time they stop trying and leave. Although they are not very significant figures, because sailors do not follow recommendations or tell us exactly what they do (Figure 39).

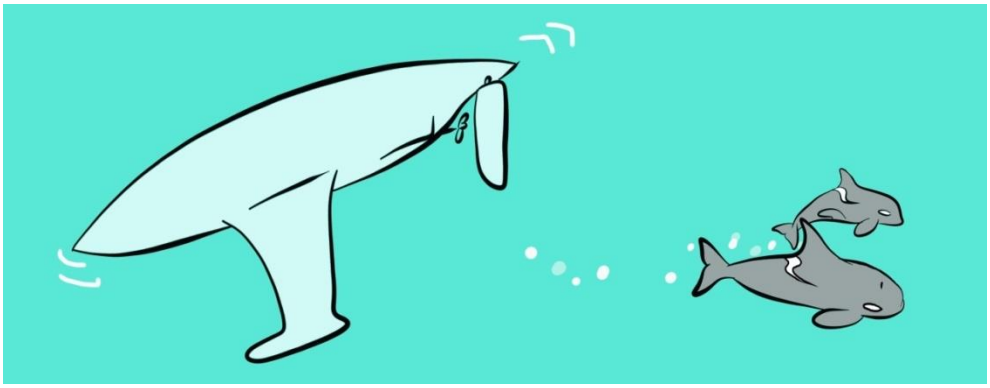


Figure 39. Occasional behavior of orcas when the boat stops.

In order to establish a comparison with other dolphins, the behaviour of the solitary bottlenose dolphin Confi has been analyzed, resulting in a similar behaviour to that described by orcas in previous paragraphs. This behaviour is based on the persecution of boats, hitting them on the hull, especially in the case of canoes and small sailboats. In this case, we know that **motivation** that leads

to this behaviour is the search for direct physical contact with humans, since it tries to encourage them to get into the water, speed also acting as a **positive reinforcement** for competitiveness. In the case of canoes, this element of speed does not exist, which is why it manages to stop the boat and prevent it from rowing. In the case of small sailing boats, it competes with them in speed, hitting the hull or dismounting the daggerboard but, even if they stop the speed, their behaviour does not stop because their **motivation** continues although the intensity can decrease since the speed factor has been eliminated and therefore competitiveness, eliminating the agonistic component of their behaviour.

Within the ICG it became clear that any change in the behaviour of the boat could be interpreted by animals as a reaction and, therefore, as a **positive reinforcement** of their behaviour. After analyzing with the experts the same arguments previously presented (explaining to the experts that the advice to stop the boat is a matter of safety for the crew, since the blows of orcas on the rudder cause the rudder wheel to change abruptly, and that animals also seem to calm down when they slow down) agreed that the action protocol was the best way to proceed until they had a clearer idea of animals' **motivation**.

On the other hand, since the maximum speed of a 12-meter sailboat is 8 knots, a cruising sailboat can never expect to run away from an orca since they are among the fastest marine mammals, being able to develop cruising swimming speeds in hunting that far exceed 9 knots (Guinet et al., 2007) and top speeds of 24-29 knots, even in a few seconds (Gots and Ronald, 2009; Williams and Noren, 2009; Carwardine, 2019).

The effectiveness of the protocol in terms of damage to the vessels is further developed in the damage section.

5.5.2 Security protocol development

From the outset, the need to make a series of recommendations in case of interactions was seen. The first cases set the pattern for the events that occurred in interactions and proposed a series of issues that were considered essential to take into account. These GTOA recommendations are reflected in a security protocol that is based on the analysis of the 274 videos (a total of 5 hours of recording) and 142 testimonies of experiences lived by the crew members of the interacted ships, as well as the analysis of the and the recorded behaviour of orcas.

The intention of the recommendations is to reduce time and intensity of interactions both for the safety of orca specimens and for the safety of boaters; it had been observed that in cases where the boats continued with their speed and tried to maintain the direction, the blows of orcas on the rudder caused the wheel to turn uncontrollably, which could cause serious damage to the crew, as it was registered in one of the first cases of the Strait.

It should be noted that, in the vast majority of cases, orcas are not observed prior to the interactions and very few of them occurred as a result of the boats approaching the pods. In **no case** should an attitude of harassment or aggression towards the orcas be maintained in these circumstances of interaction. There is evidence in other parts of the world that proximity of recreational and commercial boats (whale watching) can cause interruptions in vital activities for orcas, such as feeding or social (Williams et al., 2009; Holt et al., 2021). It has even been observed that noise reduction can increase the times that orcas feed (Williams et al., 2021).

The safety protocol to be followed by sailors that is proposed in the framework of this report in case of interaction with orcas advises stopping the boat, leaving the rudder loose, keeping calm and contacting by radio (VHF channel 16 with Salvamento Marítimo) or by phone (112) that will give you better instructions on how to act in each case and circumstance (Figure 40). It has been translated into several languages and transferred through Maritime Rescue, social networks, Captain's Offices and the media in order to minimize interaction episodes.

It is based on two fundamental aspects:

- Do not approach in case of observing a group of orcas, so as not to encourage interaction.
- If possible, follow the proposed protocol and always communicate by radio about the presence of orcas (VHF channel 16 with Maritime Rescue).

Three points are key in the transmission of protocol information:
1.- It does not prevent interactions, but tries to reduce their duration and intensity.
2.- It must be applied whenever the captain of the ship verifies that it can be applied.
3.- It does not always produce a reaction of disinterest in the boat on the part of orcass, but it does reduce their motivation.

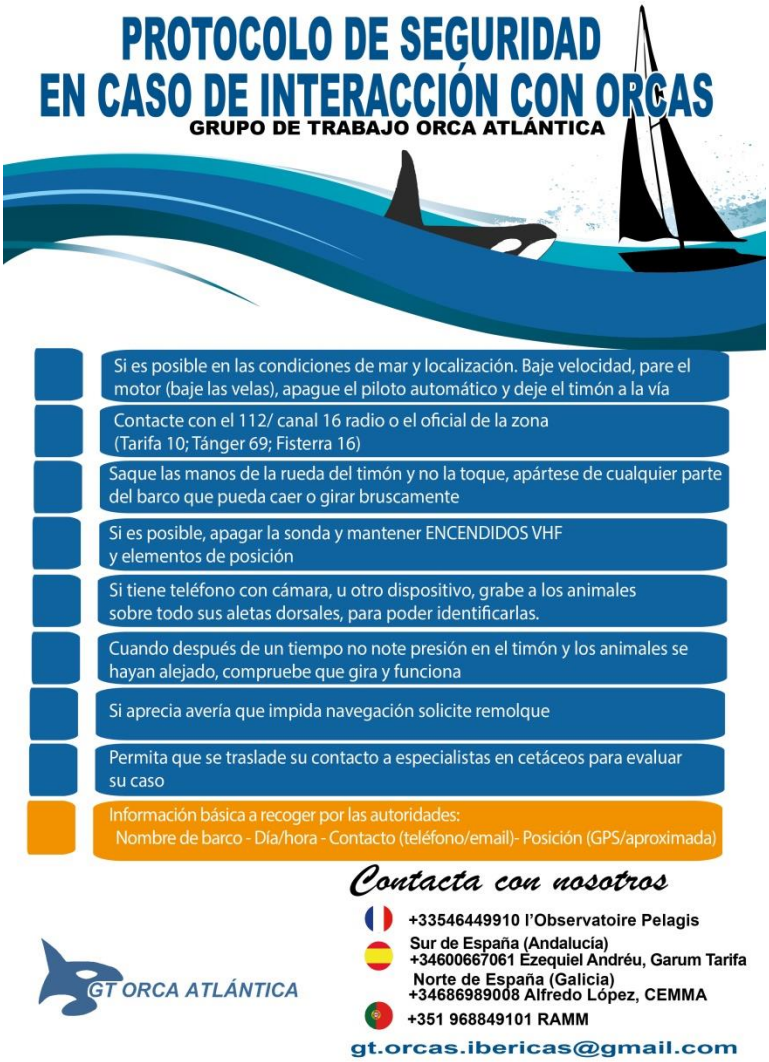


Figure 40. Security protocol aimed at navigators.

6. RESULTS OF THE PREDICTIVE STUDY

An attempt has been made to approach this part of the study through two approaches: on the one hand, checking the distribution of interactions with the presence of sailboats in different areas, thanks to the data processed from AIS (Automatic Identification System) by EMODNET (the which represent the density of sailboats with AIS in the form of hours per square kilometer per month) and, on the other hand, with the representation of the movements of various groups of orcas on the space-time scale that interacted with sailboats.

6.1 SAILBOAT DENSITY

Ship density maps are usually generated from ship positions obtained from AIS. AIS is an automatic ship transponder system used on board some ships. Some boats have to carry it obligatorily by law, this is not the case with sailboats, but more and more it is used voluntarily by other types of boats, such as recreational ones, since it gives them more visibility and therefore less risk of collision with big boats. Therefore, although it gives us an idea of the areas where there are a greater or lesser number of sailboats, not all sailboats have this system, so we will not be representing all the boats that pass through each area.

All this information is collected in EMODNET, a platform that receives the AIS data for one year and processes it in the first quarter of the following year. For this reason, it has only been possible to compare the distribution of sailboats with the interactions of orcas in the year 2020.

For this, the overlap between interactions and density of sailboats in different zones that were taking place was first carried out (Figure 26-30), and it was detected that, although the interactions occur in zones where density of sailboats is considerable, in some cases they are not areas with the highest traffic of this type of sailboats, as for example occurred in July 2020 in the area of the Strait of Gibraltar in which it is verified that, (Figure 41) although the area where interactions were concentrated there is a presence of boats, it is not the area with the highest traffic. Thus, we verify that the frequency of ships is not the only factor in interactions. This same pattern is observed in the month of September in Galicia (Figure 43), where it is verified that, although interactions were focused on areas of sailboat traffic, they did not occur in areas with the highest concentration of this type of boat in Galicia, which according to the EMODNET data, is further south. In November (Figure 45) interactions occur further from the coast, in areas where apparently there is not a high density of sailboats.

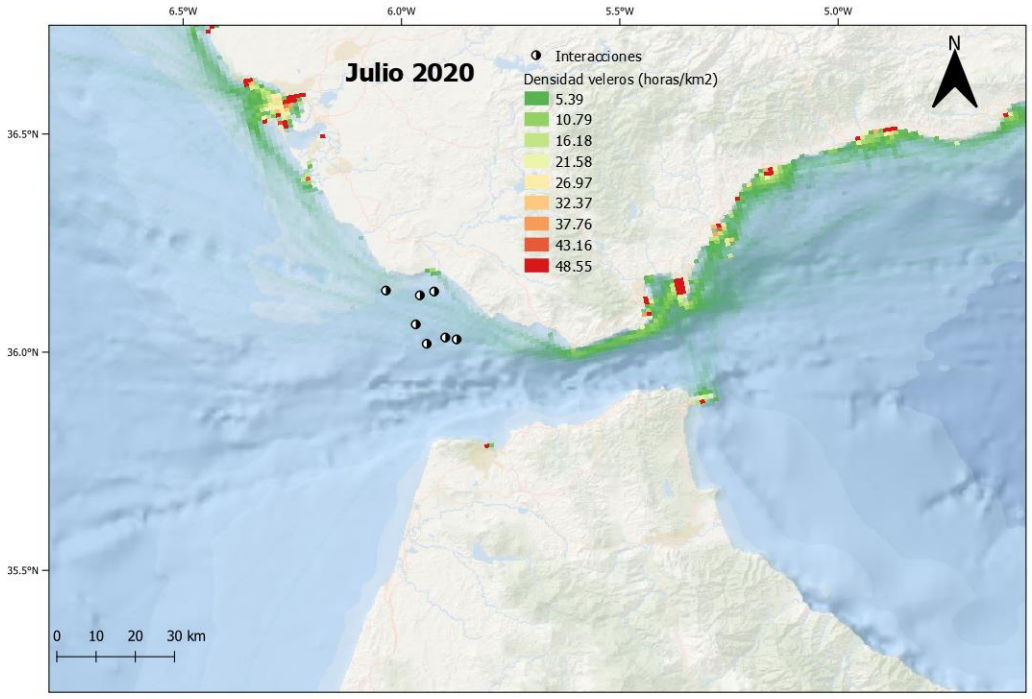


Figure 41. Distribution of orca interactions with boats and the density of sailboats in July 2020.

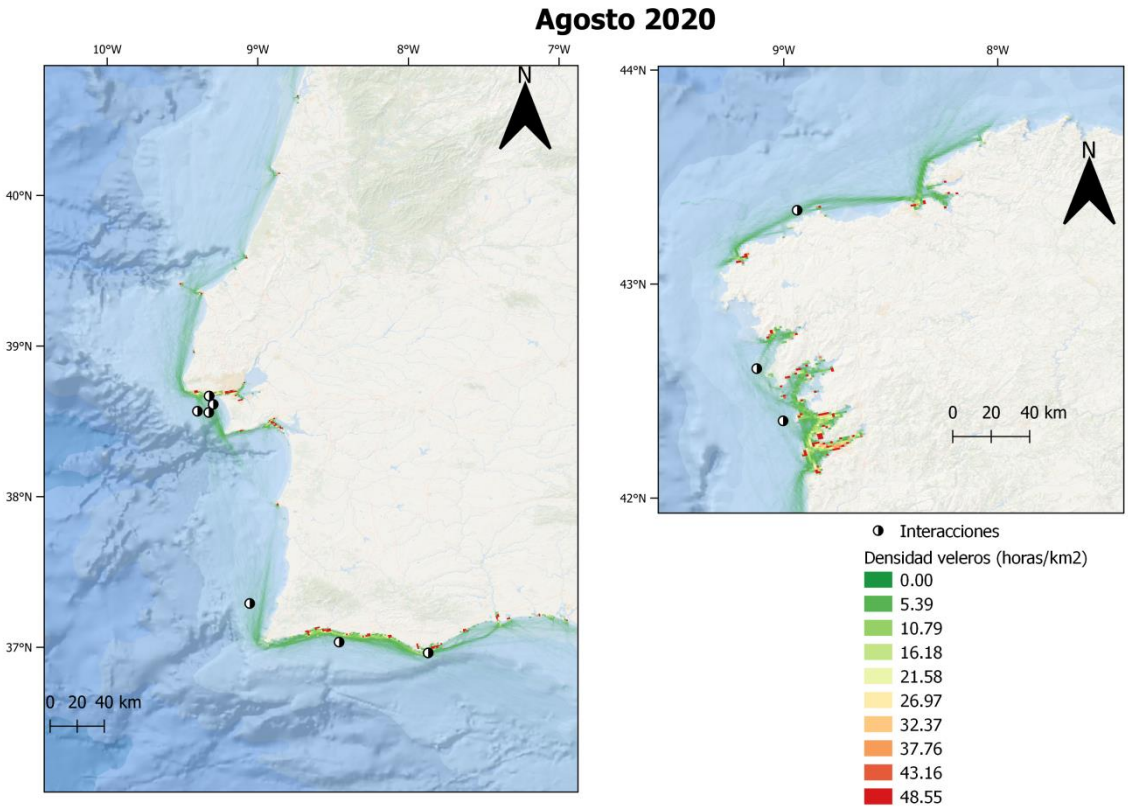


Figure 42. Distribution of orca interactions with boats and the density of sailboats in August 2020.

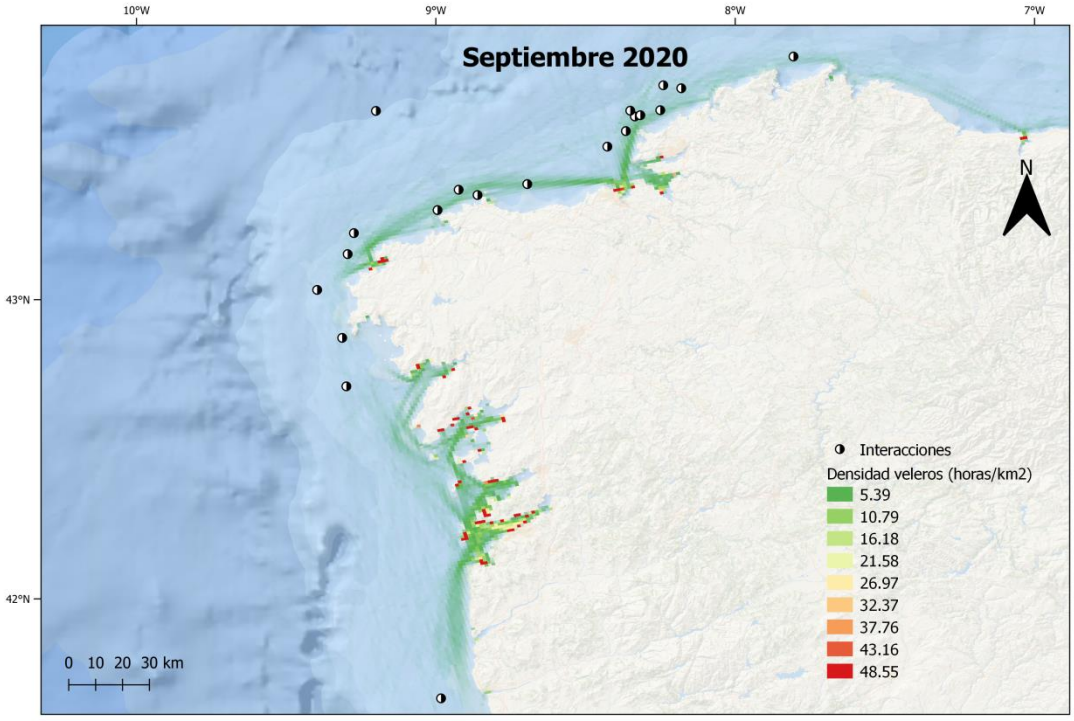


Figure 43. Distribution of orca interactions with boats and the density of sailboats in September 2020.

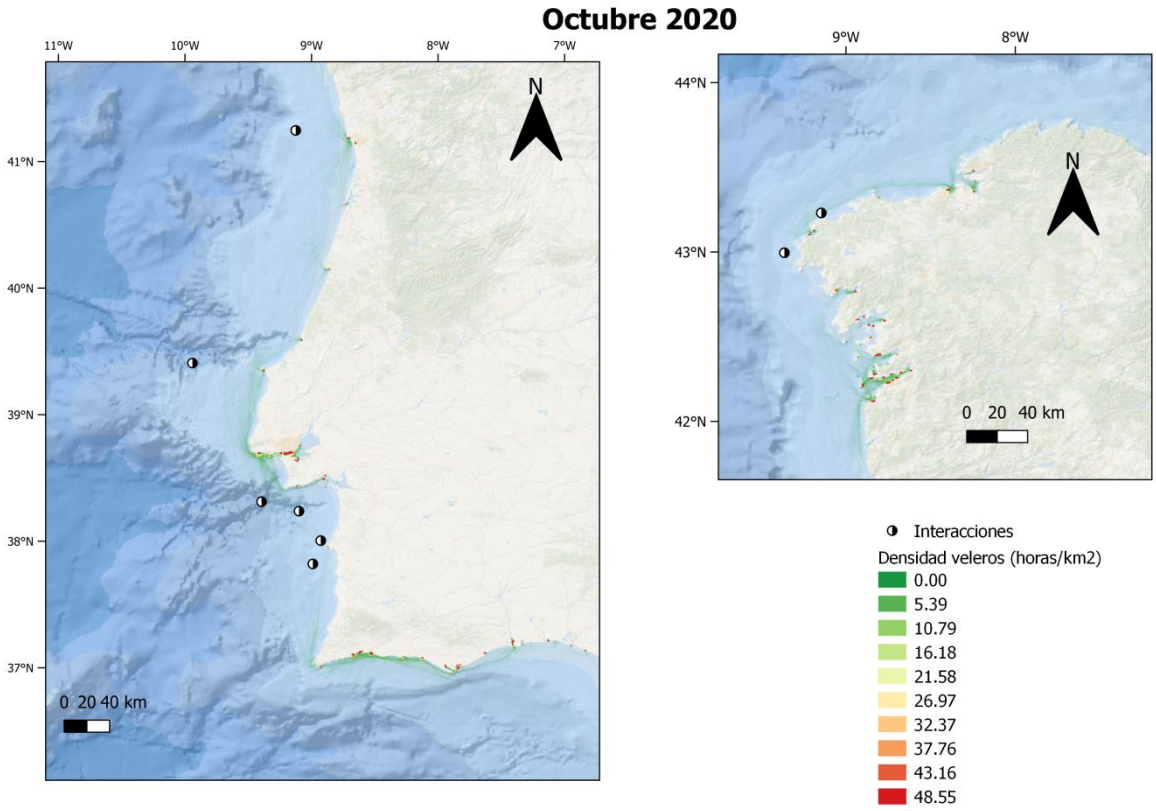


Figure 44. Distribution of orca interactions with boats and the density of sailboats in October 2020.

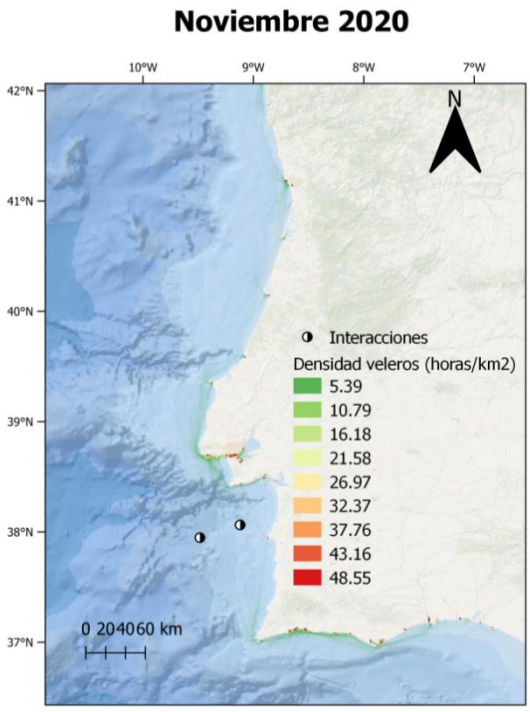


Figure 45. Distribution of orca interactions with boats and the density of sailboats in November 2020.

By overlapping all interactions between 2020 and 2021, with the average density of boats throughout 2020, a clear overlap is observed between the interactions and the areas where there is a higher density of sailboats (Figure 46). Although it could be a coincidence of the shortest routes between the Strait of Gibraltar and the different capes until reaching Galicia, which both sailboats, tuna and orcas would look for to save time and energy.

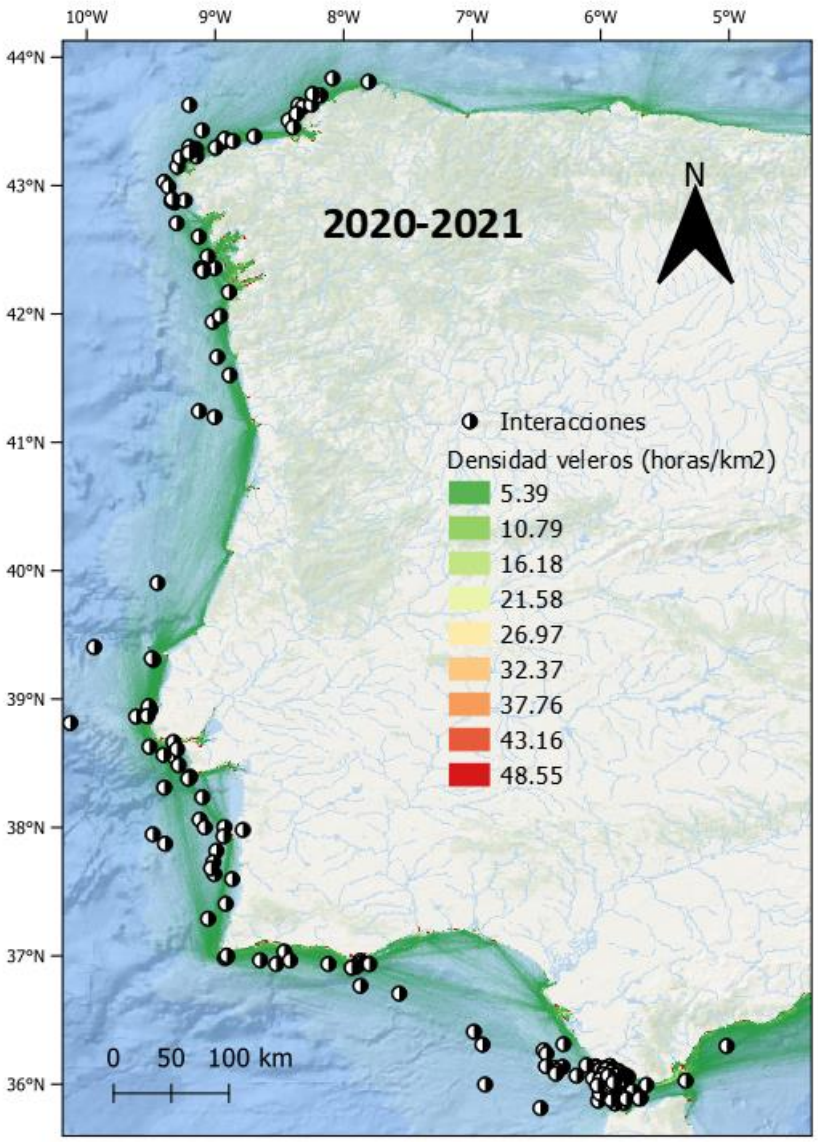
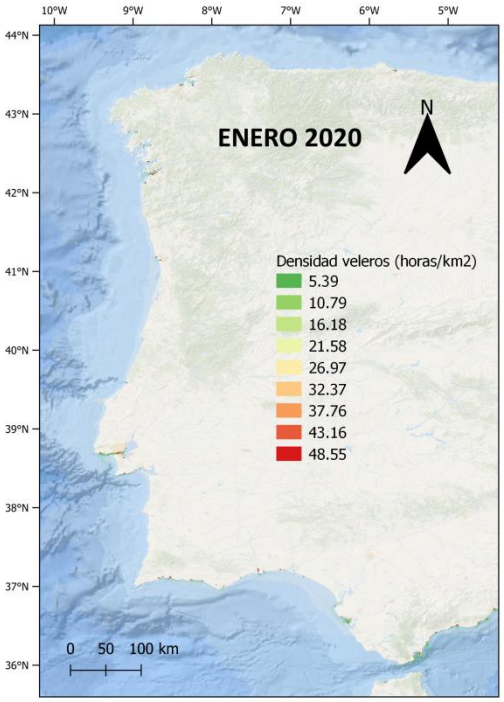


Figure 46. Distribution of orca interactions with boats between 2020 and 2021 with the average density of sailboats in 2020.

In a second step, an attempt was made to analyze the evolution of the movements of the sailboats throughout the year, although we must consider that 2020 is not a fully representative year of the typical movements of these sailboats, due to the COVID-19 pandemic and to confinement worldwide, a fact that caused maritime traffic to be seriously affected in the first months of 2020.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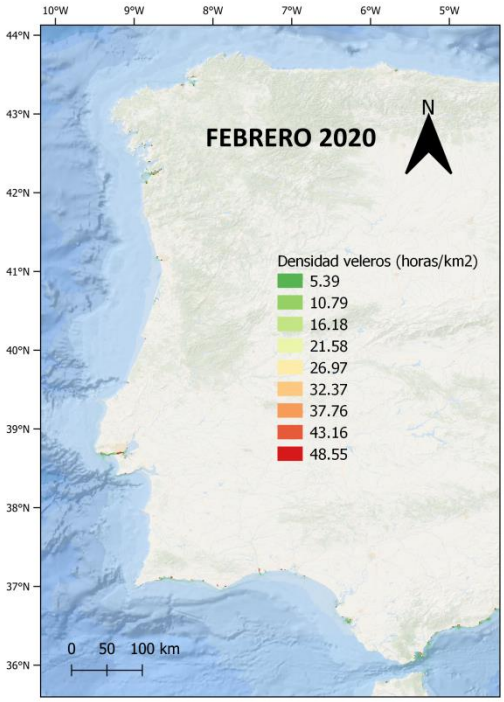
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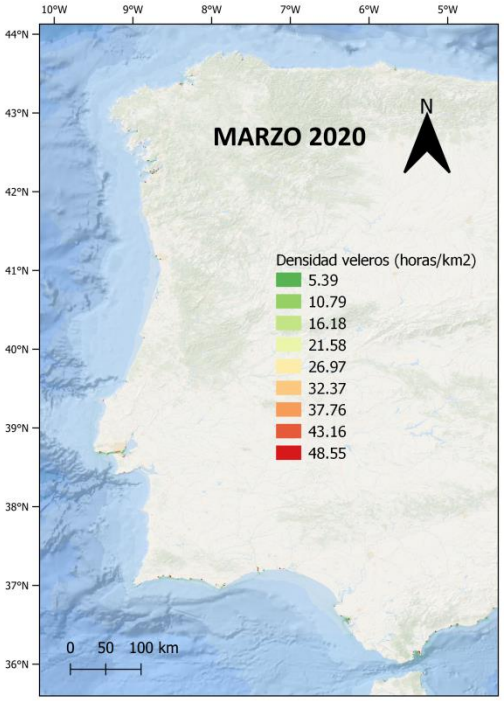
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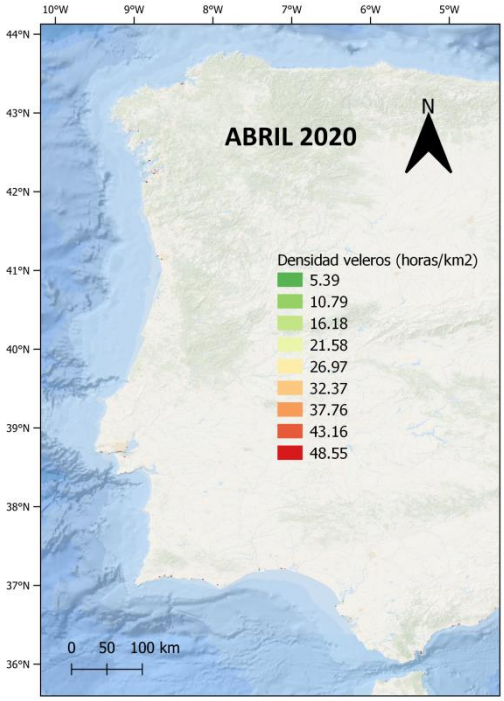
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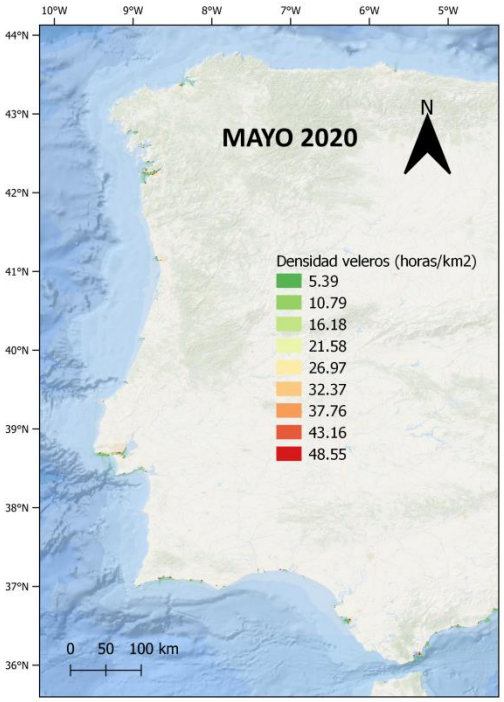
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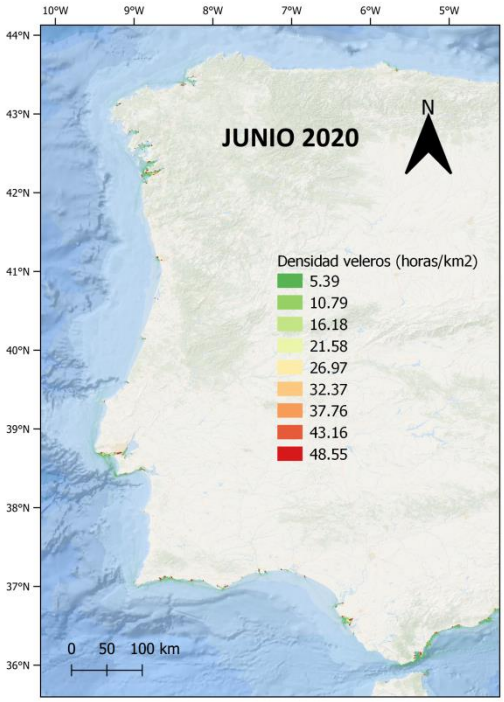
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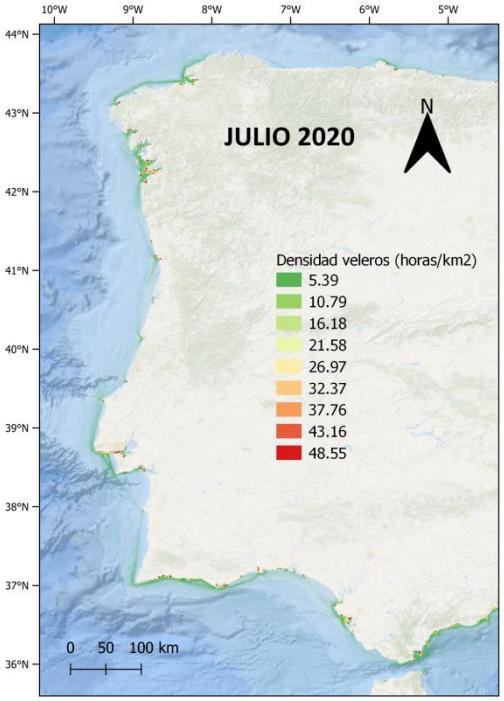
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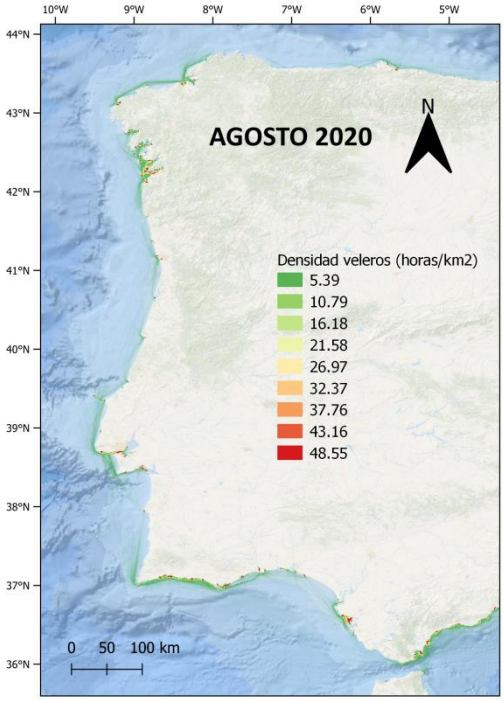
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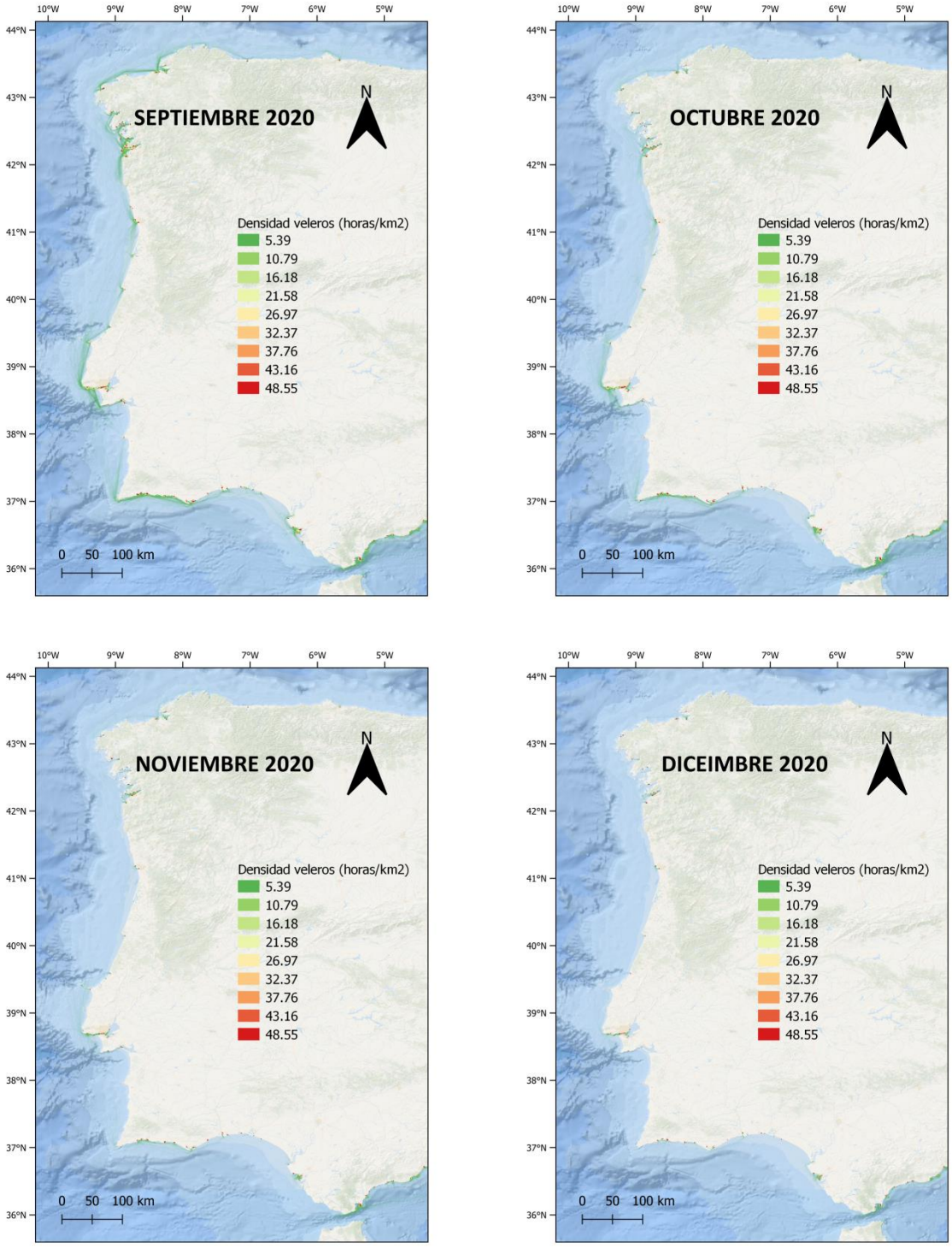
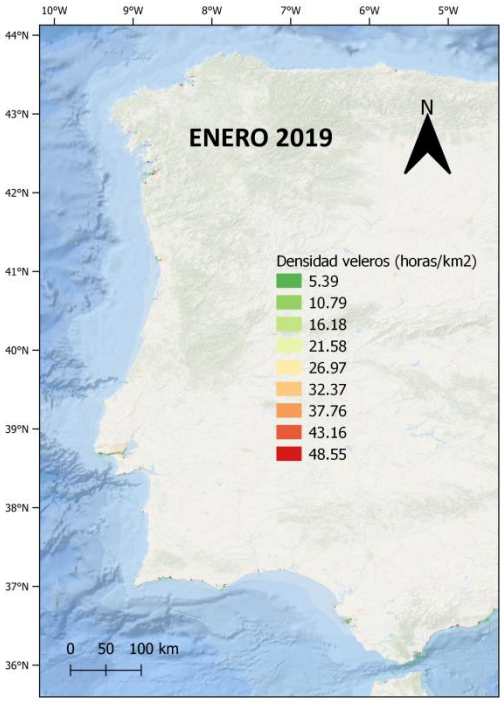


Figure 47. Evolution of the density of sailboats throughout 2020.

In the previous figures it can be seen that the greatest activity of sailboats is concentrated in the months between July and October, being almost non-existent or very limited to waters very close to the ports, the rest of the year (Figure 47). This evolution of density of sailboats in 2020 was compared with density of boats in 2019, a year that could be considered as a control, due to the absence of differential conditions. Thanks to this analysis, it can be seen that the period of greatest activity for sailboats is a little longer, starting to increase from May to October (Figure 48).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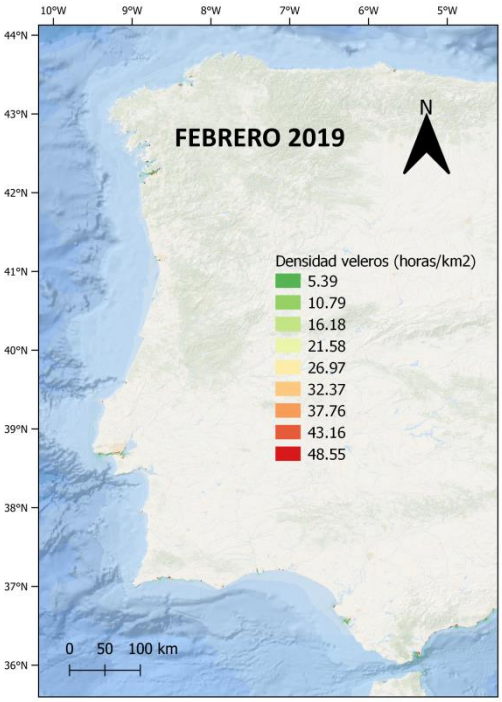
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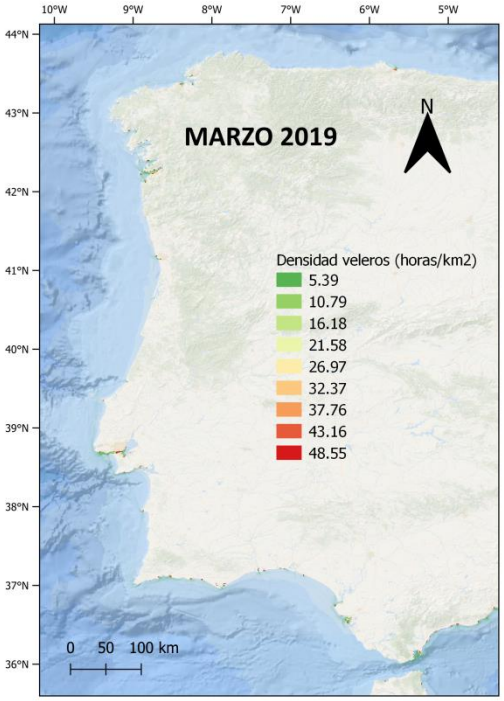
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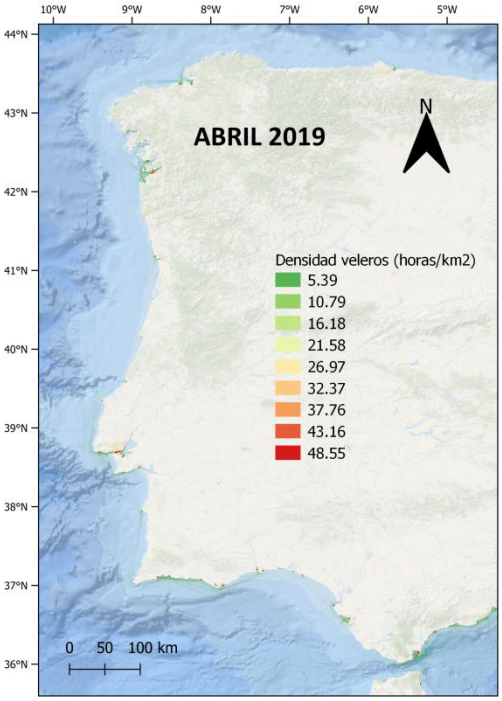
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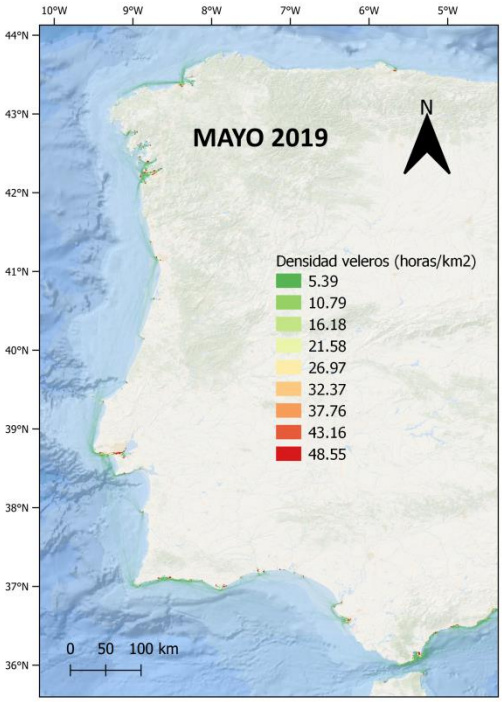
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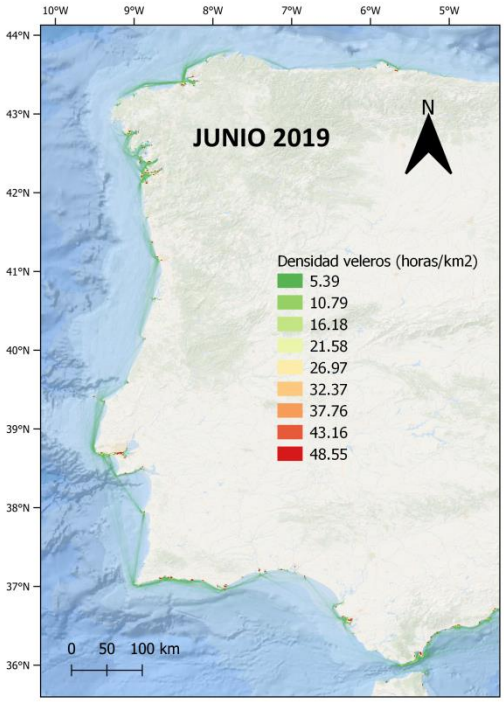
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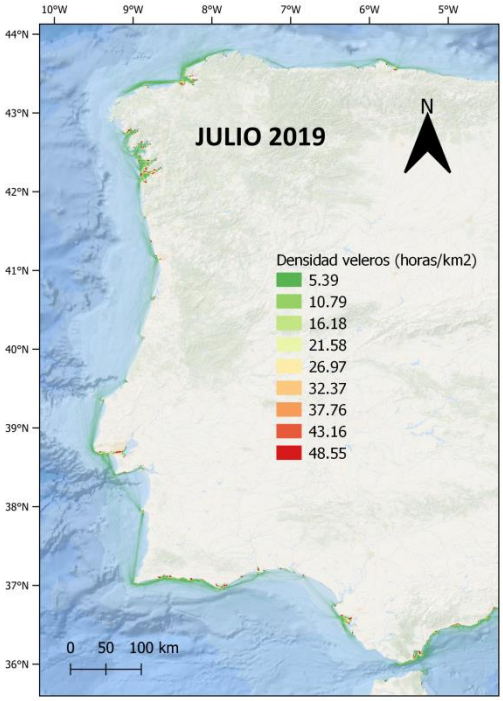
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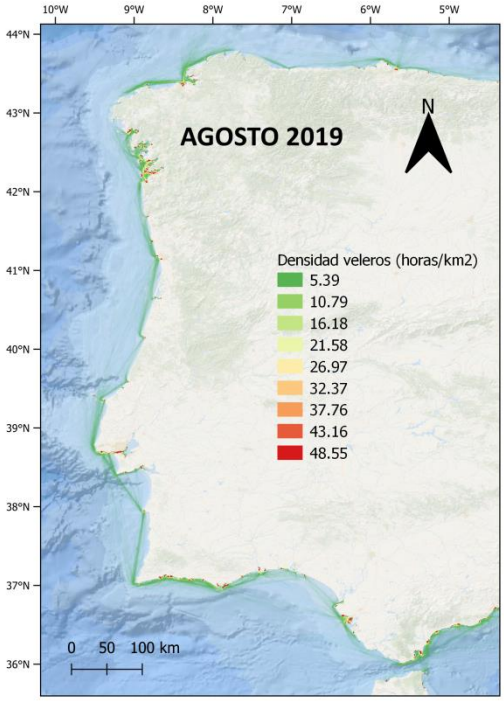
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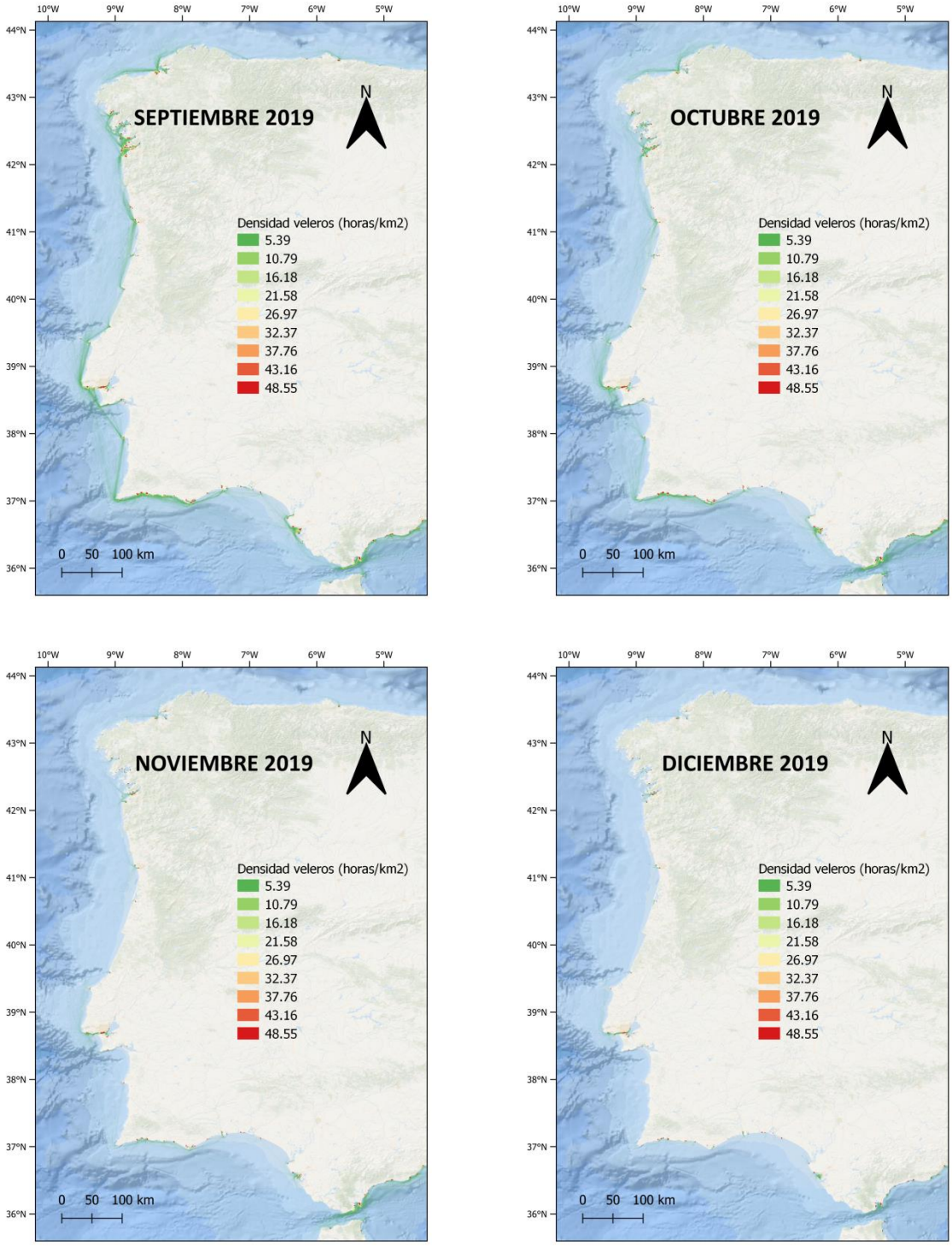

Figure 48. Evolution of the density of sailboats throughout 2021.

6.2 ORCA MOVEMENTS

To try to make a predictive study of orca movements, the movements of the different groups of orcas have been graphically represented.

In 2020 the interacting orcas were clearly separated into two groups. Group 1 was made up of GG, GN and GP (the latter two are sisters), they were already identified from the first interactions in the

Strait, and they moved towards Portugal in mid-August, apparently without temporarily stopping in any particular area of Portugal. They arrived in Galicia shortly before August 30, when they made their first interactions in the Rías Baixas between the Cíes and Ons islands, and their last interaction was recorded in mid-September north of Galicia (Figure 49). But before their arrival, on August 19, there was already a little intense interaction, so it is unlikely that it was attributable to these three orcas. Although it could not be graphically confirmed, it could have been starred by the so-called GA, so it would make up group 3.

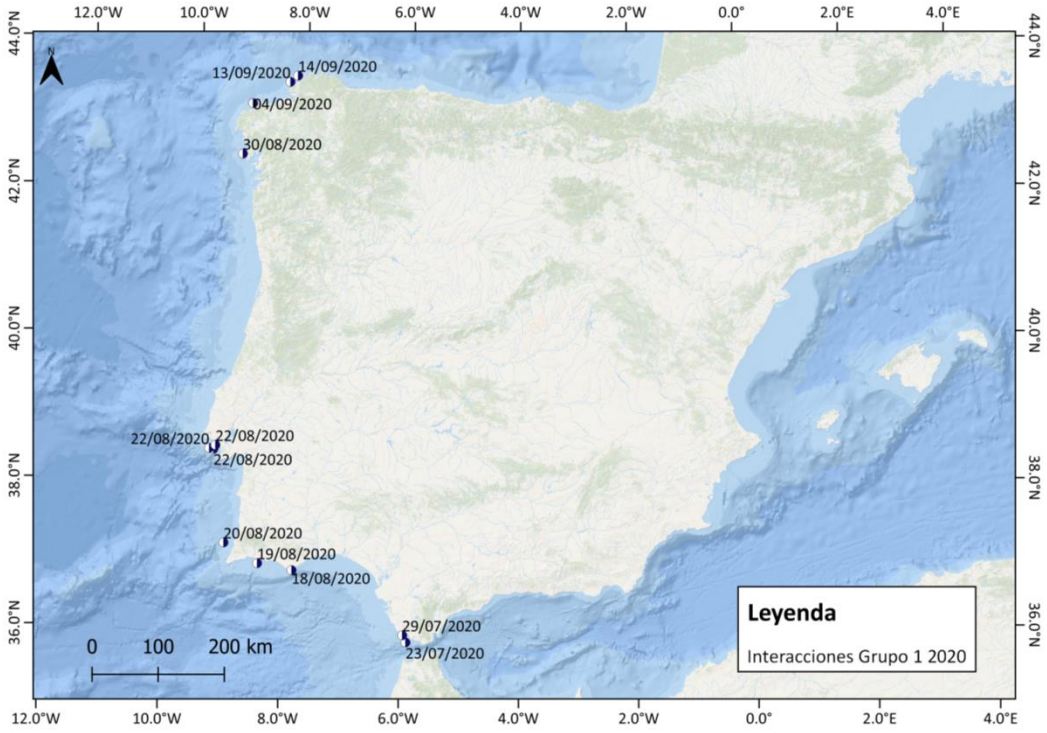

Figure 49. Location map of the interactions of the group formed by GG, GN and GP in 2020.

Group 2 was made up of GB, GC, GD and GF in 2020, specimens of the same family related by kinship. These specimens were also identified in the first interactions in the Strait and, in some cases, even together with the first group. However, this group remained longer in the Strait, a fact confirmed thanks to sightings by cetacean observation companies, in addition to the fact that no information was received on their interactions until September between north of Portugal and Galicia. Once they reached Cape Estaca de Bares, the group returned to the southwest (Portugal) at the end of October, their last interaction being in November in Sines area (Figure 50). From that moment on, since there were no reports of sightings, it is assumed that the group entered the ocean to the west.

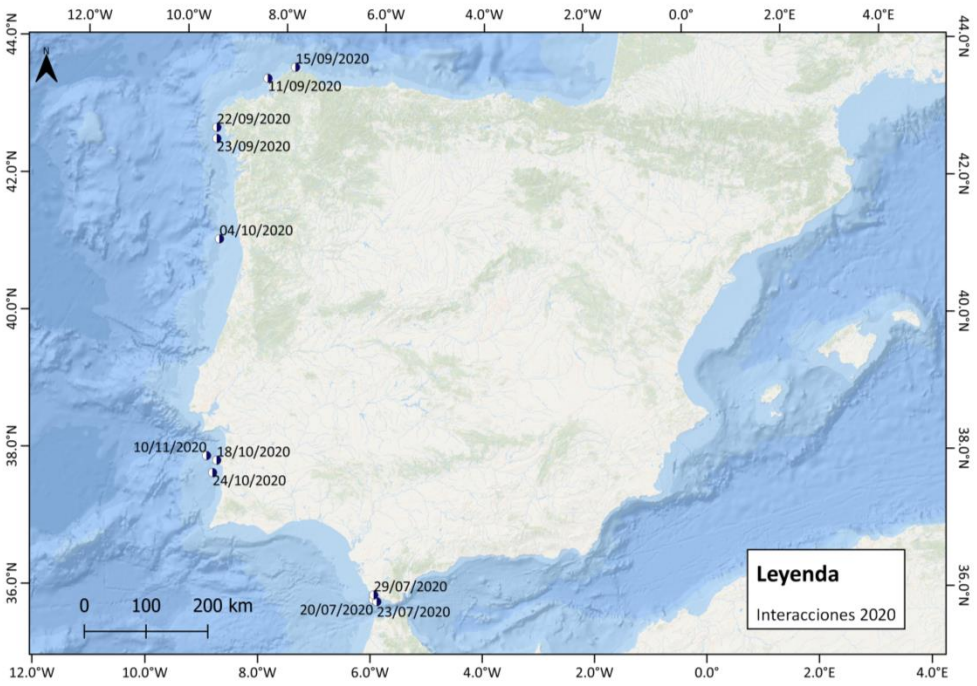

Figure 50. Location map of the interactions of the group formed by GL, GB, GC, GD and GF in 2020.

In 2021 the formation of the first group has not been so clear, being identified together GN and GP (Figure 51) interacting in the Strait from May to June, from where they moved to southern Portugal at the end of June. The last time they were identified in an episode of interaction was in the month of July in Galician waters. At that time, the GN had a huge open wound on the back of the dorsal fin, of unknown origin but identified as the product of a collision. During the months in which it was observed, a clear improvement in wound healing was observed with a very positive evolution.

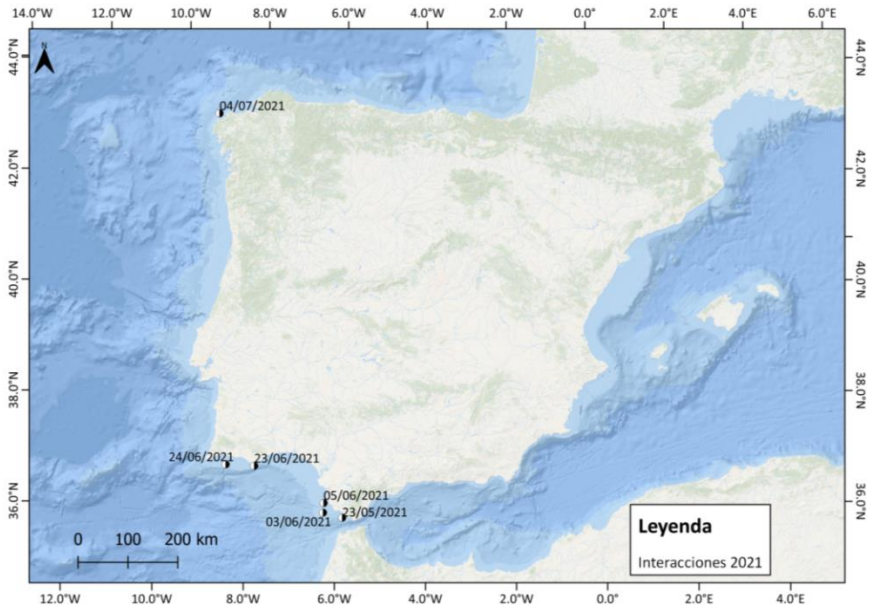

Figure 51. Location map of interactions of the group formed by GN and GP (group 1) in 2021.

In group 1, the presence of GG was not observed in 2021, while it was almost always observed together with GA interacting, so this year 2021 they would make up the so-called group 4.

GA was identified in the first interaction of January 2021 in Atlantic waters of Morocco. From June to August, GA and GG were seen interacting together in the area of the Strait-Gulf of Cádiz (Figure 52). In September they began their migration through movements towards the south of Portugal until they arrived in Galicia at the end of September (Figure 52). Their interactions were especially frequent, although they did not always cause damage, their performance with boats of the *Mini Transat* regatta being significant, small 6.5m sailboats, with which they interacted selecting the boats to touch one after the other in a series of three that sailed together, but did not break up.

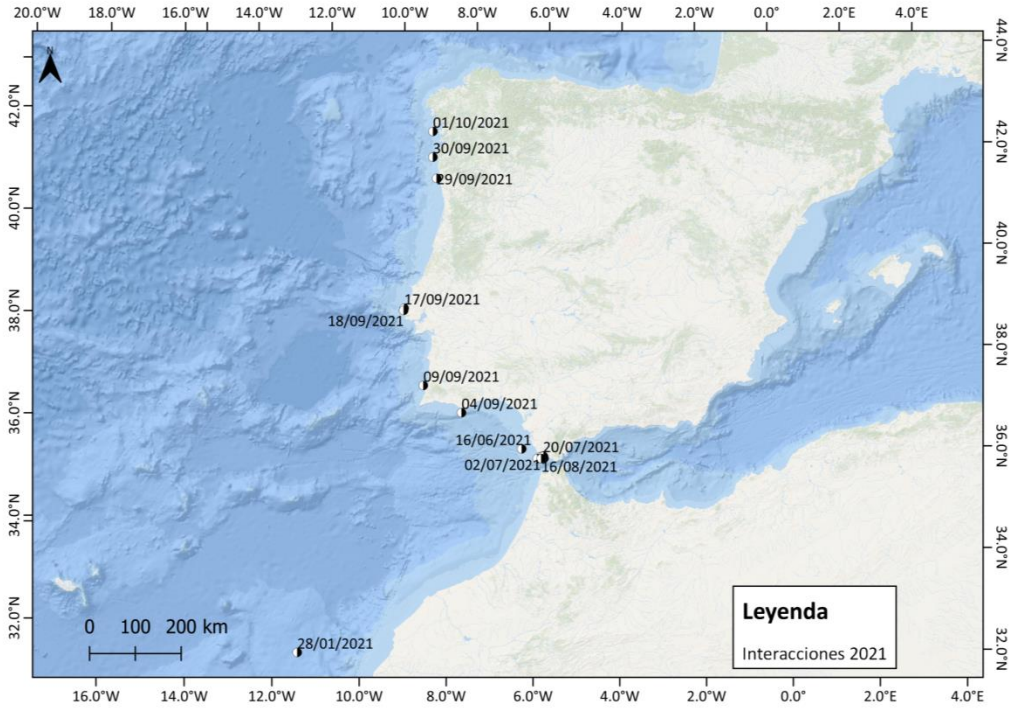

Figure 52. Location of interactions of the group formed by GA and GG (group 4) in 2021.

Group 2 continues to be made up of the same individuals, except that the orca GT, a newborn from GB, has been added. The first interaction of this group was in February in Portuguese waters, and from the end of February to June interactions have been identified in the area of the Strait-Gulf of Cádiz. Once their migration began at the beginning of September, and the group remained in Sines area until at least the end of September (Figure 53).

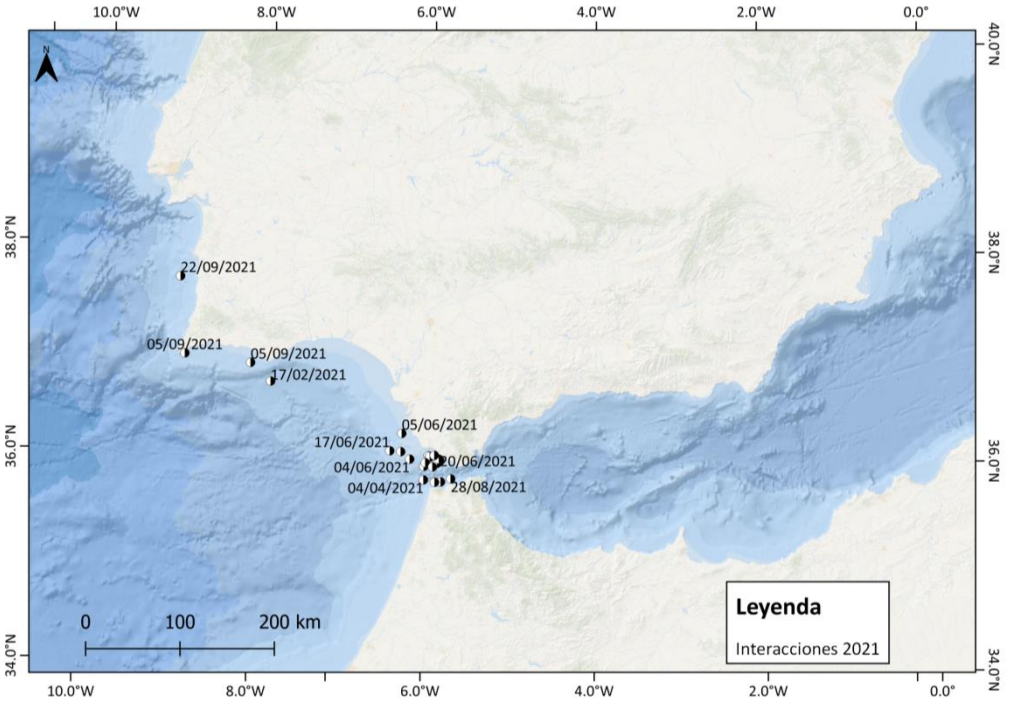

Figure 53. Location map of interactions of the group formed by GL, GB, their newborn, GC, GD and GF (group 2) in 2021.

Group 3, made up of GE, GM and GI, has only been identified as operating during 2021, and seems to mostly interact with small motor boats. Although it has been seen once socially integrated together with specimens of group 2, this group has been detected interacting from January to June in waters of the Strait-Gulf of Cádiz (Figure 54), its intensity in interaction and behaviour differs significantly from of the other groups and their approach to motor boats was already known in previous years, since 2017.

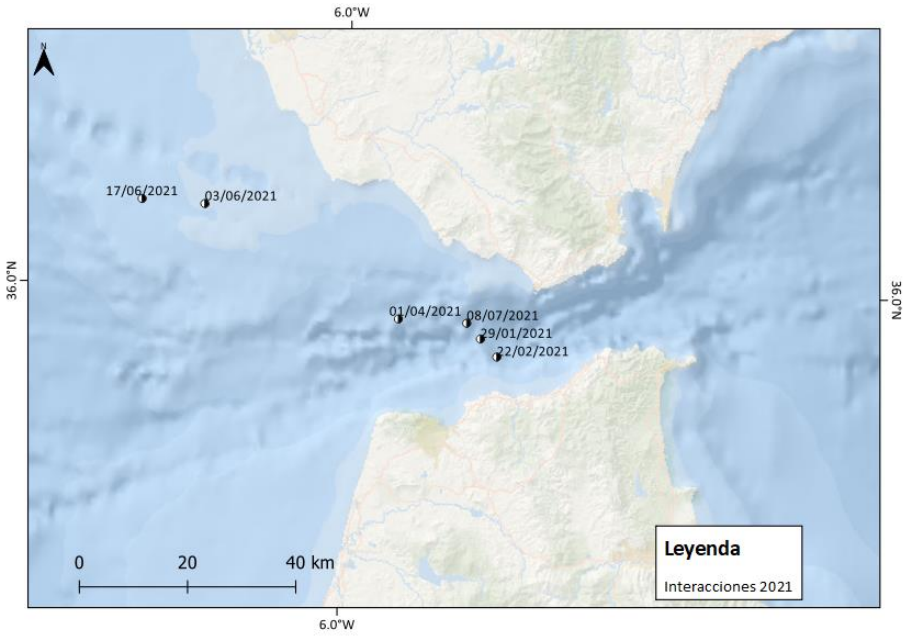

Figure 54. Location map of interactions of the group formed by GE, GM and GI (group 3) in 2020.

En resumen, y dado que los diferentes grupos se mueven independientemente, se agrupan o separan entre ellos, pueden cambiar su composición anualmente y tienen diferente comportamiento, es bastante complicado intentar predecir el movimiento de las orcas.

In summary, and since the different groups move independently, clump together or separate from each other, can change their composition annually and have different behaviour, it is quite difficult to try to predict the orca movements.

The clearest pattern is the one already known: between the end of winter and spring orcas arrive in the Gulf of Cádiz, between spring and summer they are distributed in waters of the Strait-Gulf of Cádiz due to the presence of their main prey, which is found in Migration between the Mediterranean and the Atlantic. Once this period is over for each group, between August and September (in some cases they begin to move in June), the groups disperse progressively, not all at the same time, passing through Portuguese waters, quite quickly and usually without staying in one area in particular, although the interactions indicate that the areas of Algarve, Peniche, Sines and Setúbal can remain for several days. Finally, they reach Galician waters from the end of August to mid-September, where they quickly pass the Rías Baixas and once again occupy an area between Cabo Touriñan and Cabo Ortegal for a while. From there the pattern is no longer so clear, the groups dispersing to different areas and directions in the form of a fan, to return again to the Gulf of Cádiz the following year. Their exact wintering location is unknown, but they possibly occupy a large area, in a dispersed way, between the Bay of Biscay and the western coasts of Galicia and Portugal, concentrating again between the Canary Islands and the African coast before returning to the Gulf of Cadiz (Figure 55).

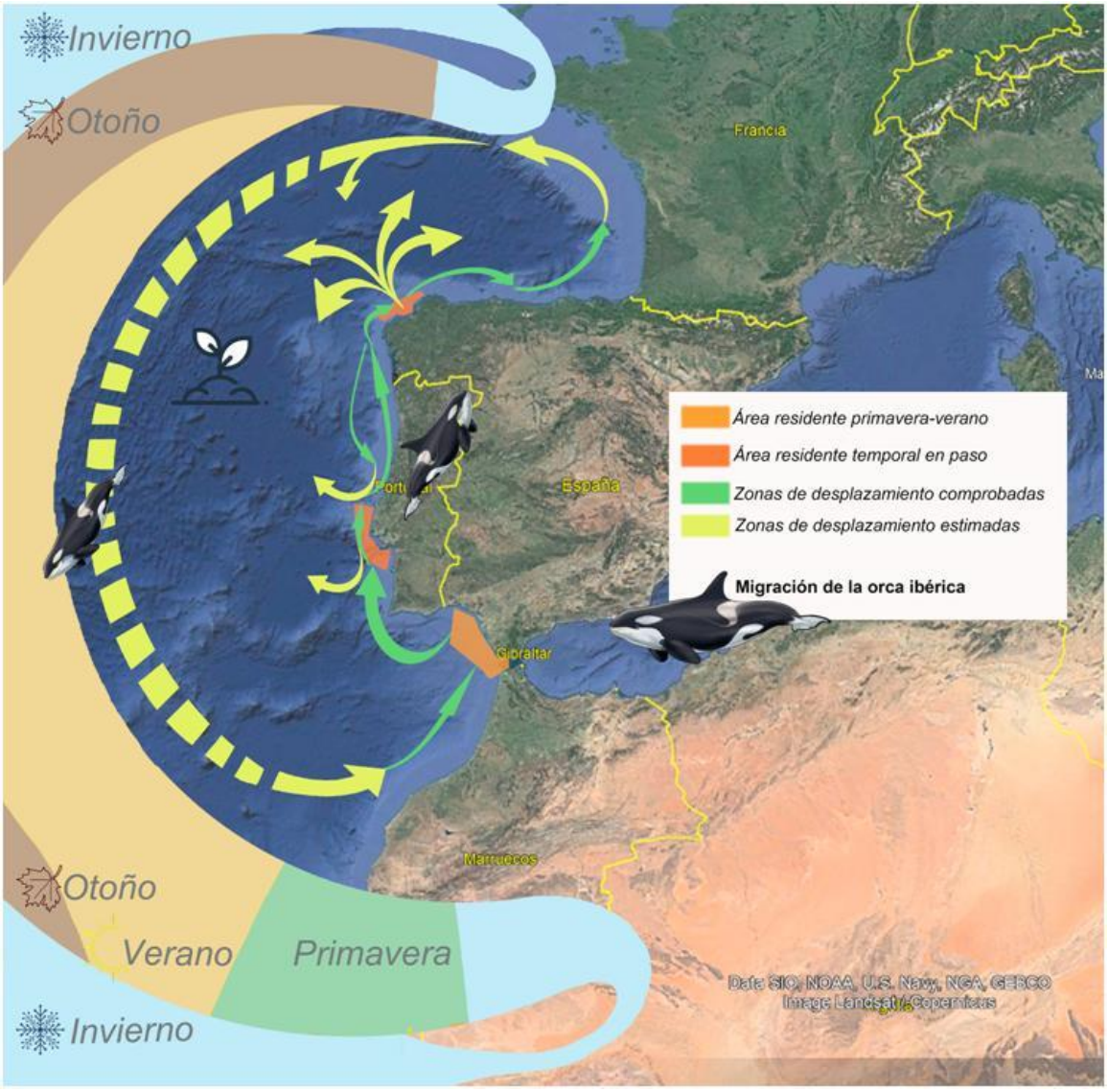

Figure 55. Integrative infographic of predictive information.

However, sightings of orca specimens in Galicia during the months of February and March and the record of the passage of groups in June break these patterns and indicate that the variability of routes and the temporal amplitude in migration is very large, which it makes it even more complicated, if possible, to assess a possible future prediction of the behaviour of the groups.

7. PRIORITIZED LIST OF PROPOSALS FOR ACTION, MANAGEMENT, REGULARIZATION AND PREVENTION MEASURES.

The measures carried out so far are those oriented towards navigation: the distribution of the security protocol, radio alerts of the presence of orcas issued by Maritime Rescue, suggesting at the same time not to approach, as well as the temporary closure to navigation of certain ships approved

by the General Directorate of the Merchant Navy, and the suggestion to keep distant and not approach orcas by whale watching boats, in Portugal exclusively this last case.

The security protocol should be disseminated and known by sailors so that they can apply it in the event of interaction.

Regarding the prioritization of measures and quantification, it is proposed:

1. When a boat makes **a communication** indicating the presence or interaction with orcas, it must be **recommended that they never approach the animals**. Likewise, in all cases it will be recommended to apply the protocol included in this document.

2. In case of registering **more than two interactions in the same maritime area**, it is proposed that radio alerts be issued, insisting that they report on sighting and/or interaction episodes.

3. In case of detecting **more than four interactions with common characteristics in the same maritime area**, it is advisable to issue specific recommendations. For example, if the interactions are only at night, it will be recommended to avoid night navigation in the area. In case, for example, the interactions take place at a distance of between 3 and 6 miles from the coast, it will be recommended to avoid navigation in that range.

4 - In case of detecting **more than five interactions spread over a period of two weeks in the same area**, it is recommended to propose the temporary closure to navigation in a preventive manner.

5 - In case of **detecting interactions with cetacean observation boats**, it is advisable to apply a preventive distance of no approach to herds at less than 400 m.

These recommendations would be progressive based on the intensity and frequency of interactions. **Recommendation 1 should apply any time there is a report of a sighting or interaction of a vessel with orcas. In the same way, recommendation 2 can be applied simultaneously with the rest. Recommendation 3 may be compatible, in different areas, with recommendation 4. Recommendation 5 would be specific** to the recreational activity of whale watching.

In this sense, as a practical tool for applying the proposed measures, the following lines of action are established:

A. If a case of sighting and/or interaction with orcas is reported in an area and at a specific time, it is recommended to apply measure 1.
B. If two or more interactions with common characteristics are reported in an area of 50 square nautical miles and within a period of less than 3 days, it is recommended to apply measures 1 and 2 together.
C. In the event that more than 4 interactions with common characteristics are reported in an area of 50 square nautical miles and within a period of 5 days, it is recommended to jointly apply measures 1, 2 and 3, taking into account that a specific design of the measure to be applied depending on the type/moment of the interaction (night closures, fixed distances to the coast, specific areas).
D. In case 5 or more interactions are reported in an area of 50 square nautical miles and within a period of 2 weeks (14 days), it is recommended to jointly apply measures 1, 2 and 4. It is

recommended to jointly apply measure 3 when from one complementary mode, a case corresponding to action C is detected in an area adjacent to but sufficiently separated from the area limited to navigation.

E. Exclusive for orca interaction with recreational activity vessels for whale watching: if it occurs, it is recommended to apply measures 1, 2 and 5 jointly.

7.1 SECURITY PROTOCOL

The security protocol (See sections 3.2.4 and 5.5) was designed and distributed through social networks, and electronically to yacht clubs, maritime rescue and various competent authorities. This protocol must be publicized and disseminated so that it reaches all users of the sea on the Atlantic side of the Spanish coast. To this end, it is proposed that it be disclosed by:

- Maritime captaincies.

-SASEMAR

- Sailing clubs

- Sport ports

- Social networks

7.2 RADIO ALERTS

They are radio announcements issued by Maritime Rescue Control Centers, on channel 16, in areas where repeated interactions take place. The objective is to warn vessels in transit and insist that they transfer the data of observations and notices of interactions. The radio warning warns of the presence of orcas in the area, suggesting at the same time not to approach them if they are observed (Figure 56). It is proposed that these radio warnings take place as soon as there are more than two interactions between orcas and vessels within a period of one week and a radius of 60km.

GOBIERNO DE ESPAÑA MINISTERIO DE FOMENTO
Salvamento Marítimo
Radioavisos
www.salvamentomaritimo.es

NumNac:	**Código RA:** NR-2057/2020	**Fecha Emisión:**	30/08/2020 19:33
Tipo / Subtipo / Subsubtipo:	*TTT / OBJETOS DERIVA / CETACEOS*		

Posición:	
Zonas:	ESPAÑA COSTA NW
Asunto:	TTT, OBJETOS DERIVA, CETACEOS
Texto Español:	RIAS BAJAS AVISTAMIENTO DE GRUPOS DE ORCAS EN AGUAS DE LAS RÍAS BAIXAS. SE SOLICITA A TODAS LAS EMBARCACIONES QUE EN CASO DE AVISTAMIENTO NO INTENTEN APROXIMARSE, DEN AMPLIO RESGUARDO E INFORMEN A LA ESTACIÓN COSTERA MÁS PRÓXIMA O A SALVAMENTO MARÍTIMO FINISTERRE.
English Text:	RIAS BAJAS SEVERAL ORCAS SIGHTED AT RIAS BAIXAS VICINITIES. ALL VESSELS ARE REQUESTED TO NOT APPROACH AND GIVE A WIDE BERTH AND INFORM ANY NEW SIGHTING TO THE NEAREST COASTAL STATION OR FINISTERRE MRCC.

Figure 56. Example of a radio warning of the presence of orcas.

7.3 COORDINATION WITH COMPETENT AUTHORITIES

Inter-administrative coordination is of great importance to address the problem of interaction episodes in such a way that people safety and orca individuals involved is threatened.

That is why, during 2021, progress was made, through the holding of meetings and meetings with the Maritime Rescue and Safety Society (SASEMAR) and the Marine Species Area of the General Subdirectorate of Terrestrial and Marine Biodiversity of MITECO.

As a result of these meetings, a collaboration protocol was established, especially in the area of the Strait of Gibraltar, through which SASEMAR, thanks to the collaboration of its operators and as long as its main purposes were not compromised, would collaborate in the collection of information about the episodes of interaction that they attended.

In this sense, a file was prepared and provided for the collection of information on the episodes, with two levels of detail, which includes the following aspects:

- Basic data:
  - ship name
  - Day / hour
  - Contact (phone/email)
  - Position (GPS/approximate)
  - Destiny
  - ETA (arrival time)
- Detailed data: (to be filled in only if operators were available):
  - Day/start time/duration of interaction
  - Ship name, ship type, rudder type and provenance
  - boat length
  - Position (GPS/approximate)
  - hull color
  - Speed and how sailed (motor/sail)
  - Apparent damage, does it need repair?
  - Number of orcas observed and behaviour.
  - Did you observe them before they interacted?
  - Photos videos
  - Contact person and phone

Additionally, the commitment was reached that, from the SASEMAR station in the Strait of Gibraltar, recommendations of the safety protocol would be sent to sailors, as they are considered the optimal recommendations to address these episodes.

Those responsible for SASEMAR allude to the possibility of using information brochures as a reference.

It is proposed that this coordination with competent authorities be maintained, and that regular meetings be held (at least once a month) between maritime captaincies, SASEMAR and the Ministry for Ecological Transition and Demographic Challenge.

7.4 TEMPORARY CLOSURE TO NAVIGATION

Based on the information collected on interactions, the temporary closure of several areas to navigation was proposed, in 2020 a navigation area in the north of Galicia and in 2021 a navigation area in the Strait.

Since August 2021, close contact has been maintained with the competent authorities to propose the necessary action measures. At that time, there was an area prohibiting the navigation of sailboats of less than 15 meters in waters of the Strait. To improve the effectiveness of the measure and based on the interactions that had occurred to date, a proposal to expand said area was suggested, both temporally and spatially within the exclusion zone is where fewer interactions have been recorded in the month of August. Outside the exclusion zone, interactions continue to occur at a high frequency. In total there were 27 interactions in the month of August, with a maximum of 5 interactions per day. This leads to the proposal to expand the exclusion zone (Annex II). In Galicia, no navigation restriction area was suggested given that the presence and interaction of orcas was very dispersed in space and time.

In this case, it is proposed that navigation restrictions be established as soon as there are more than four interactions in less than a week, and within a 60km radius.

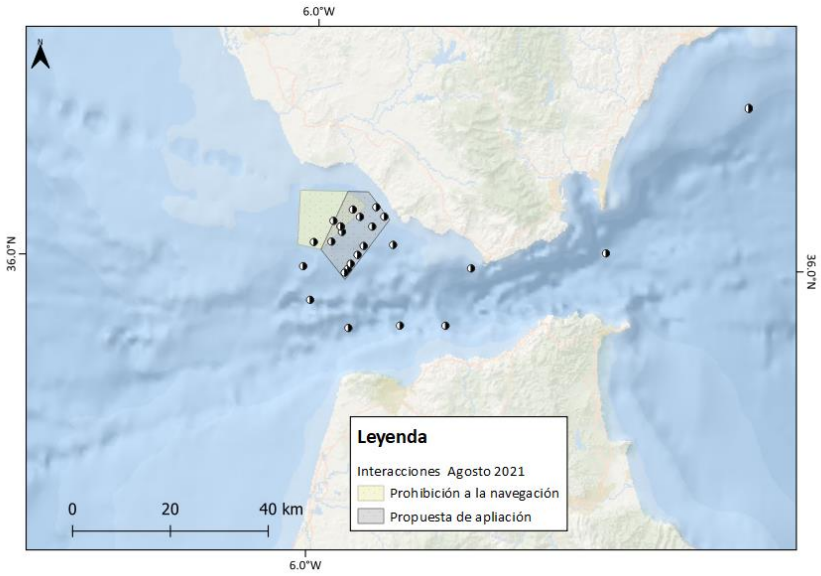

Figure 57. No-Sail Area in the Strait of Gibraltar in August 2021, and the proposal made by the GTOA based on interactions that took place in August.

7.5 KEEP AWAY FROM ORCAS

In all radio warnings and diffusion of the protocol, it is insisted that the boats do not approach the orcas, even knowing that this is not the main reason for the interactions. But, based on interactions of orcas with inflatable boats in the Algarve, it was recommended, exclusively by Portugal, that boats that carry out this activity should not approach groups of orcas. This recommendation was transferred by the Instituto de Conservação da Natureza e das Florestas, I.P. (ICNF), given its powers and attributions (Deliberação Nº101/2019 of January 21).

RECOMENDAÇÃO DE NÃO APROXIMAÇÃO A GRUPOS DE ORCAS POR EMBARCAÇÕES MARÍTIMO-TURÍSTICAS

1) Desde 2020 que se têm registado interações entre orcas e embarcações (maioritariamente veleiros) na zona do Estreito de Gibraltar, costa portuguesa e Galiza (Espanha). Apesar de não se conhecer ainda a razão para este comportamento recente e repetitivo para com as embarcações, sabe-se que as interações iniciais, conduzidas por um reduzido grupo de orcas juvenis, são atualmente realizadas por um conjunto mais alargado de animais.

2) Para além dos veleiros têm sido também alvo do interesse das orcas algumas embarcações marítimo-turísticas de menores dimensões, licenciadas para a observação de cetáceos. Atendendo às dimensões dos exemplares adultos de orcas (que podem atingir um máximo de 8 a 9 metros de comprimento e pesar entre 3 e 5 toneladas) facilmente se compreende que uma interação mais intensa com semirrígidos ou outro tipo de embarcações de menores dimensões utilizadas para a observação de cetáceos poderá ter consequências mais graves.

3) A publicação do Decreto-Lei nº 140/1999 de 24 de abril, que visa a conservação dos habitats naturais e da fauna e da flora selvagens do território da União Europeia, estabelece a proibição de perturbação das espécies listadas no anexo B-IV. Assim o ICNF:

4) Recomenda através do presente Edital, nos termos da alínea b) do nº 1 do artigo 11º do DecretoLei nº 140/1999 de 24 de abril, a não aproximação a grupos de orcas por parte das embarcações marítimo-turísticas. Instituto da Conservação da Natureza e das Florestas, I.P. Rua de Santa Marta, 55, 1169-230 LISBOA, PORTUGAL TEL + 351 213 507 900 FAX + 351 213 507 984 E-MAIL icnf@icnf.pt www.icnf.pt 2/2

5) Determina igualmente que nos casos em que as orcas se tentem aproximar das embarcações estas se devem afastar de modo a evitar situações de possíveis interações.

6) Sempre que as orcas se aproximem das embarcações sem que a tripulação se aperceba a embarcação deverá ser imediatamente parada (se as condições do mar e de segurança o permitirem) deixando no entanto o motor em funcionamento, e o comportamento dos animais deverá ser continuamente vigiado pela tripulação. Só quando as orcas se afastarem poderá ser retomada a navegação.

7) Esta recomendação está em vigor até 31 de dezembro de 2021.

It is proposed for Spain that a recommendation not to approach orcas be issued by any vessel, and specifically by whale watching companies. For this measure to be truly effective, the exclusion area for these animals should be increased to at least 400 meters, measures that have already been carried out in other parts of the world, such as in Canada, where it is prohibited to bring animals closer than 400 meters, because it has been observed how the presence of boats can disturb the animals, and they stop feeding when they are less than 400 meters away (Holt et al., 2021). And in the event that the animals approach the boat, put the engine in neutral until the animals pass by.

7.6 CONSULT EXPERTS

From the form described in section 4.5 sent to the ICG experts of the Whaling Commission, responses have only been received from 9 people (out of a total of 21 people that make up the ICG). The answers obtained in regards to the performance measures mention that measures taken so far are adequate, they simply suggest, additionally, that sailors should be insisted on giving information on the interactions and taking photos and videos of the events.

7.7 DISSEMINATION AND DIVULGATION MATERIALS

One of the keys to receiving data, sightings, and interactions is that sailors and sea users have information about what may be interesting to share, so various materials in different formats were designed to be shared through social networks (Figure 58), WhatsApp and even through the opening of the Iberian orcas website. Currently, these materials are in the process of analysis by the Biodiversity Foundation for their subsequent publication.

Figure 58. Divulgation material.

7.8 PILOT PROJECT DESIGN

In addition to what is described in point 4, the international experts that make up the ICG were also consulted regarding the possible design and execution of a pilot project that allows testing measures that can help manage these episodes in the best possible way, as well as to minimize its consequences. For this, an online form was distributed that was only completed by a total of 9 experts. The following pilot project proposal has been formed thanks to these contributions.

7.8.1 Project objectives

The pilot project will focus on the following objectives:

- **Basic information**: collect basic information on the activity, behaviour and identification of the orcas observed.
- **Vessel behaviour**: find out why the vessels can provoke the interaction of orcas (positive reinforcement) or what causes can discourage or lessen (reinforcement extinction) the effects of the interactions.

- **Deterrents**: evaluate the use of deterrents (negative reinforcement), in a non-invasive way, to orcas from continuing to interact with boats.

Basic information:

During sightings, basic information will be collected on the specimens observed in order to identify them and categorize their behaviour.

Environmental information and circumstances

- Environmental conditions: sea, wind, visibility.
- Presence of ships
    - Type of boats
    - Number of ships
- Distance of the orcas to the boats and behaviour in each case, categorizing by distance (Indifference, attraction, etc.)

Herd information

- Group composition
    - Number of animals (minimum/best estimate/maximum)
    - Animal age class
        - Calves
        - Juvenils
        - Adults (Female/Male)
    - Mean space between individuals
        - Very compact
        - Compact
        - Scattered
    - Surface synchronization
- Activity balances. How much time do animals spend in different behaviours? To do this, the type of activity that animals have every minute in the vicinity of the boat should be recorded (complementary to the graphic record).

Graphic information

- Photographs for identification of the individuals, both the dorsal fin, as well as the saddle and the post-ocular patch since they are distinctive of each individual.
- Videos of animal behaviour. If possible, video on the surface, underwater and even from a zenithal position, using a drone, to give the best possible coverage of the behaviour of the animals.

Orcas behaviour in front of the boat

Try to verify what triggers and/or discourages the interaction of orcas with boats:

- Maintain speed and direction
- Engine shutdown and stop

- Speed acceleration
- Reverse stop

For this, a battery of different actions will be designed to be executed in the presence of the interacting orcass, if they are found and identified.

Deterrents

-Invasive deterrents:

Within the framework of the Working Group of the International Whaling Commission, the use of acoustic emission **deterrent methods** (Acoustic Harassment Devices-AHD) was raised, although experts believe that they should not be used yet (Figure 59). There are several types of commercial deterrent devices that are used mainly in fishing gear where there are predation problems with toothed whales. However, the effectiveness of these devices is not well studied and, especially for orcas, the evidence suggests that there is a high risk of habituation. In Crozet, where there is a great problem with predation by orcas and sperm whales on longlines, experiments were carried out with a high amplitude acoustic harassing device (AHD, 195 dB re 1 mPa 6.5 kHz 1 m from the source), which is It is considered that it already causes hearing damage to the animals, called "Orca Saver" which has an approximate cost of €45,000. In the first attempts the animals moved away from the boat, but after from the third to the seventh attempt they did not move away from the boat, demonstrating orcas habituate quickly and can withstand potentially harmful auditory disturbances (Tixier et al., 2015). In Alaska, fishermen have tried different types of acoustic devices, but the animals simply habituate to them, and it ends up having a dampening effect. “dinner bell” (call to eat) that ends up attracting animals.

On the other hand, in Canada, a movement of orcas was observed during years in which a seal deterrent was used on salmon farms in Broughton Strait (Morton and Symonds, 2002). However, it should be noted that, in this case, orcas did not have a special **motivation** towards the source device, that is, although it is an area where orcas are commonly observed, they were not the ones preying on salmon farms, so the potential hearing damage didn't outweigh the reward of being there.

Apart from its inefficiency, in many cases this equipment is expensive and difficult to deploy and use, which leads us to believe even more that it would not be an ideal solution to the problem of interaction between orcas and vessels.

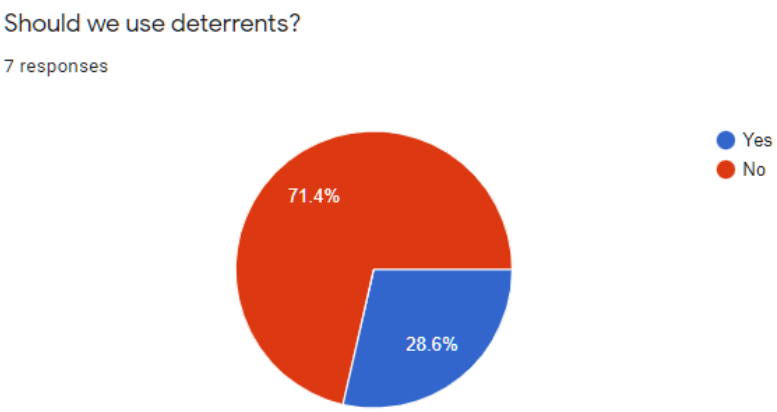

Figure 59. Responses to the form sent to the ICG experts of the Whaling Commission regarding the use of deterrent methods.

-Non-invasive deterrents:

For all of the above, the study of other types of **non-invasive deterrent elements** is proposed, which could cause rejection reactions and abandonment of the area by orcas but without causing them any harm.

- **Oikomi tubes.** These tubes are constructed of reverberant metal, with a cap on top. A handle at the top of the tube and a cone at the bottom enhance reverberation. Oikomi tubes are deployed over the side of ships and are manually operated by striking with a hammer. When numerous tubes are used in multiple lines, they have been effective in moving orcas a short distance. These types of tubes have been used to remove trapped orcas from shallow lagoons in Alaska (Brownell et al., 2008). Orcas were driven by 13 boats, 10 of which were equipped with hollow metal tubes. The tubes were struck with hammers at 3 to 10 second intervals to produce a broadband pulse followed by a resonant tone with a fundamental frequency of about 300 Hz. Depending on how hard the tubes are struck, the levels for the broadband portion of the sound generally ranged from 165 to 175dB re: 1mPa at 1m. Sound levels received by orcas, which remained approximately 300 m from the sound sources, are estimated to have been around 115-125dB (Brownell et al., 2008). This method is included in the oil spill response plan for South Pacific resident orcas. The method is similar to that used in dolphin fishing in Japan.

Figure 60. Oikomi tube.

  - Advantages: Oikomi tubes have been used and are very effective in herding orcas. It is safe for orcas and would have a high level of public acceptance. It would also be an economical and viable measure to be implemented by vessels.
  - Disadvantages: This technique is most effective for herding animals and may not be as effective for keeping animals out of a large area. Deployment requires the

coordination of multiple vessels and could be dangerous at night or in rough sea conditions. Animals can probably get used to it relatively quickly.

Sound reproduction of pilot whales (*Globicephala melas*). in the strait of Gibraltar, pilot whales have been seen chasing orcas, even displacing orcas from their feeding area (de Stephanis et al., 2015). Using an underwater loudspeaker, the reaction of orcas to the emission of pilot whale sounds could be studied, preferably from recordings of pilot whales in the Straits when they chase orcas. These should be interspersed with control sounds, created from sections of the same recordings of pilot whales without vocalizations, to monitor the orcas' responses to any non-specific acoustic stimuli.

- Advantages: Pre-recorded calls and transmission equipment are easy to purchase and could be deployed from any vessel. It is not dangerous for orcas or for other species in the area. This technique needs more study that could even be applicable to the problem of interactions with fisheries if it is determined appropriate, although in orca conservation plan this interaction is considered as advantageous for orcas.

- Disadvantages: There have been no rigorous studies to show that the calls cause orcas to avoid or be attracted to the source. Animals can probably get used to it relatively quickly.

- **Experimental acoustic systems** that are based on the criteria of non-invasiveness or risk of acoustic damage to animals or potential noise pollution.

7.8.2 Pilot project design

The project establishes in order of priorities:

1.- The collection of basic information

2.- Analysis of the orcas behaviour in front of the boat

3.- The analysis of deterrent elements

Being aware of the difficulty of locating specific orcas, that they act before a random vessel, that information can be collected from all of this and that they respond to the actions and elements of analysis, in order to obtain results, it is established to address the least two of the priorities mentioned.

Experimental phases

The experiment of both the deterrent elements and the maneuvers of the boats should be based on three phases. The duration of the phases is established according to the average duration of the interactions between boats and orcas:

- Previous (PRE). Constant previous observation of animals, which will help us to establish the basic conditions of animals. Until the animals approach the ship.

- During (DUR). Observation of the animals behaviour during the use of deterrent elements and depending on the maneuvers of the boats:
  - 5 minutes before testing the deterrent/behaviour
  - 5 minutes with the deterrent/behaviour method
  - 5 minutes without deterrent/behaviour

- 5 minutes with deterrent method/behaviour
- Post (POST). Constant observation of animals afterwards

In order to obtain an adequate sample size, and to find out if we may have habituation problems, the experiments should be repeated at least 10 times throughout the entire pilot project, preferably with individuals already identified as interactants.

The information that must be collected during the different phases of the pilot project in order to be able to compare it later and determine its effectiveness, are those collected in the **Basic Information** part.

7.8.3 AREA AND TIME OF SAMPLING

The pilot project would be based on an **oceanographic survey** in the South Atlantic Marine Demarcation, more preferably in the Ensenada de Barbate where most of the interactions have occurred since its inception in July 2020 (Figure 61). Although the possibility that the survey area may be varied depending on where the interacting orcas are located at that time should be considered, given that we verified variations in the use of the habitat, between 2020-2021, especially in Galicia, possibly motivated by the distribution of the dams.

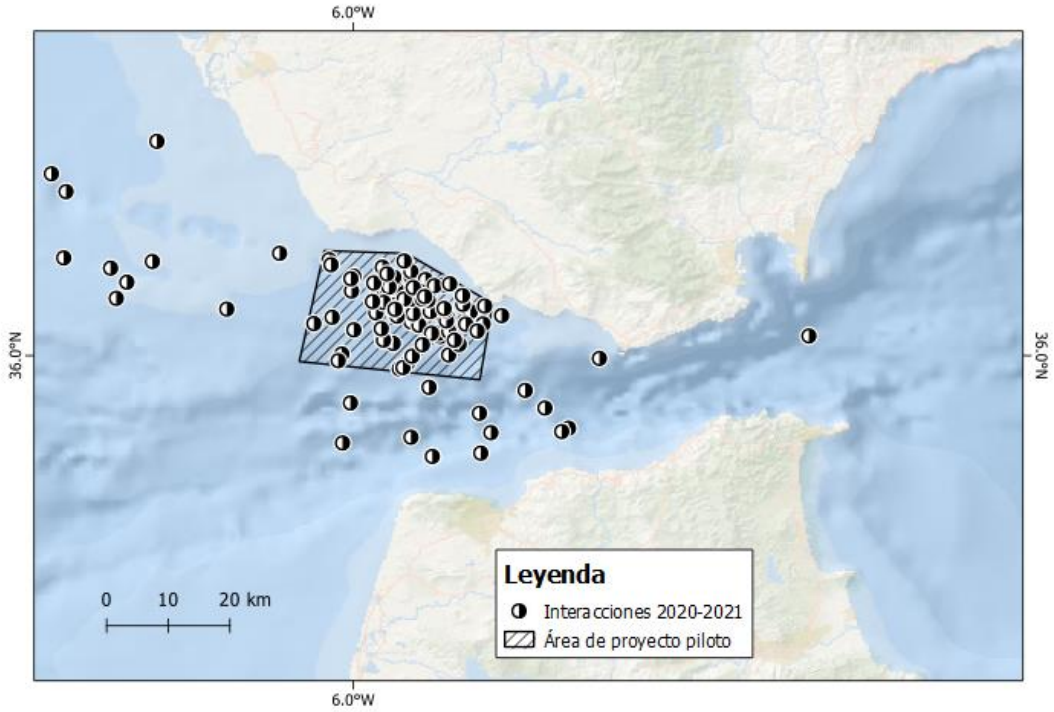

Figure 61. Proposed area for the pilot project. Based on the area of highest concentration of ship interactions since 2020.

Table 8. Coordinates of the points that delimit the area proposed for the pilot project.

Latitude	Longitude

1	36.15	-6.04
2	36.15	-5.92
3	36.07	-5.79
4	35.97	-5.81
5	35.99	-6.08
6	36.15	-6.04

In this specific area, interactions with boats have taken place between the months of April and August, concentrating above all in the months of July and August (Figure 62).

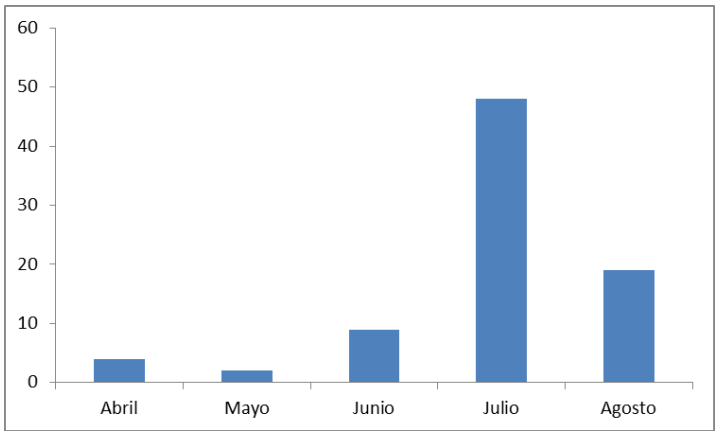

Figure 62. Timing of interactions between orcas and vessels in the pilot project area.

In the proposed study area (Figure 61), historical data from 2018 on average weather conditions were consulted. It was observed that in the months of April to July there are an average of 55 days of suitable conditions to go out to sea (sea state equal to or less than 3 on the Beaufort scale Figure 63).

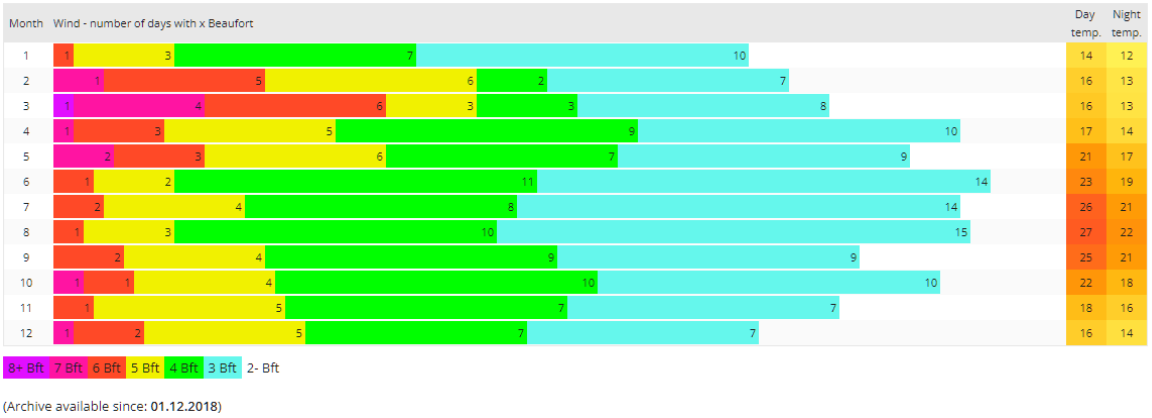

Figure 63. Meteorological conditions counted as number of average days per month according to the Beaufort scale.

Taking all these factors into account, the pilot project **should be carried out between the spring and summer months**, thus ensuring at least 20 days at sea and thereby obtaining a sufficient sample size to draw conclusions. In the case of development further north, in Galician waters, the date could be extended until autumn, if the orcas movements indicate so.

7.8.3 Technical characteristics

The type of boat used will be crucial in the development of the experiment; since most of the interactions have taken place with single hull sailboats of less than 15 meters, this should be the boat used for the experiment. Such a boat should be covered by insurance that covers the potential damage that orcas can cause.

The ship should be equipped with AIS, and this should be permanently connected. In this way, it will be possible to notify the sailboats in the area, so that they stay away from that vessel to avoid further interactions, as well as to be able to be coordinated by the different institutions involved.

7.8.4 Institutions involved

Let us consider that the success of the experiment will only be achieved through teamwork, for this it will be necessary to involve different institutions during the development of the experiment.

- Ministry for the Ecological Transition and the Demographic Challenge. That will coordinate the development of the project, and will serve as a connection between the different institutions involved
- Maritime Captaincies.
- Maritime Safety and Rescue Society.
- Control of maritime traffic in the Strait of Gibraltar.

7.8.5 BUDGET

An indicative amount of €117,810 is estimated to cover all the planned works.

Videographic equipment and prototypes	48.000
Availability of boat and technical equipment	49.500
Expendable	9.600
General expenses	10.710
	117.810 €

8. CONCLUSIONS

8.1 IDENTIFICATION OF ORCAS

- Orcas that have been identified as interacting with boats have been referred to as GLADIS. To date, 14 individuals have been identified, of which there is only one actively interacting adult, the so-called GB; this female has been a mother this year, so any invasive method with respect to her should be minimized, due to the high mortality presented by newborn individuals of Orcas from the Strait (Esteban et al., 2016b). The rest of the individuals have not reached sexual maturity, including even a 2021 newborn, GT, also a daughter of GB.
- Not all animals interact in the same way, there are even individuals that have only been seen observing, staying away from the boat, and never touching the hull of the boats, these observant individuals are normally the mothers of the most active GLADIS (GL and GH).
- The GLADIS can be found separated into up to 4 groups, they are currently classified in order of how they were identified in interactions:
    - Group 1

        - GLADIS HERBILLE-GH
        - GLADIS NEGRA-GN
        - GLADIS PEQUE-GP
    - Group 2:
        - GLADIS LAMARI-GL
        - GLADIS BLANCA-GB
        - GLADIS CLARA-GC
        - GLADIS DALILA-GD
        - GLADIS FLIABRES-GF
        - GLADIS TARIK-GT
    - Group 3:
        - GLADIS GRIS-GG
        - GLADIS ALBARRACÍN-GA
    - Group 4:
        - GLADIS ESTRELA-GE
        - GLADIS MATTEO-GM
        - GLADIS ISA-GI

- These groups sometimes come together in interactions, closely accompanied by their families, and it is when the crew have come to describe dozens of orcas around their boats. GG and GA are two of the animals that change groups the most, since they are not associated with a specific herd.

8.2 CHARACTERIZATION OF VESSELS

- Most of them are interacted sailboats, they have been monohull, medium size (<15 m), and with a blade rudder.
- They sail at an average of 6 knots, both under sail and motor.
- The interactions have no relation to the color of the ship's hull.

8.3 CHARACTERIZATION OF INTERACTIONS

- They occur throughout the year, although they are more concentrated in the spring and summer months.
- They occur throughout all hours of the day and night, although they are concentrated in the midday hours.
- They last an average of 40 minutes, although most of the interactions last less than 30 minutes.
- The phases of the interaction have been described as:
    - Close up
    - Contact
    - Government
    - Stop
    - Review and disinterest
- Orcas' behavior is not identified as aggressive, their arousal is positively reinforced by the speed of the boat with a competitive component.
- Origin hypothesis:
    - Self-induced curious and playful behaviour
    - Precautionary behaviour induced by an aversive incident.

8.4 PREDICTION

- Interactions have been concentrated in areas with a medium density of sailboats, at the same time there have been no interactions in nearby areas with even greater sailboat traffic, so there must be some additional condition, external motivation, that explains the preference of the area where they will have a greater number of interactions, regardless of the number of ships. Surely associated with natural movements of orcas, and, above all, of their prey.
- The different groups of orcas that interact have moved independently, making it very difficult to predict exactly where the orcas will move.
- The clearest pattern is the one already known: orcas are distributed in waters of the Strait-Gulf of Cádiz between spring and summer due to the presence of their main prey, which is migrating between the Mediterranean and the Atlantic. Once this period is over, groups disperse (although not at the same time), between August and September passing to Portuguese waters, usually without staying in a specific area, although interactions indicate that the areas of Algarve, Sines and Setúbal they can stay for several days. Until they go up to Galicia, normally arriving from the end of August to mid-September, and from there the pattern is no longer so clear, the groups dispersing to different areas and directions in a fan shape.

8.5 PROPOSED SOLUTIONS

- The security protocol is useful, when it is not applied there is a greater probability (although not with statistically significant differences) that the interactions end in damages (55%) and larger breakdowns for the ship (31%). In addition, it has been observed that when deterrent techniques have been used, the effect was even greater, up to 72% of damage.
- Radio warnings and recommendations are useful and must be implemented when there is a concentration of interactions in a certain area or under a certain circumstance (night or at specific distances from the coast).
- The temporary closure to navigation is a good measure and should continue to be implemented when there is a concentration of interactions in a certain area.
- Keeping the distance from orcas, and circumstantial recommendations, should be reinforced through radio warning messages.
- Dissemination and dissemination is essential so that:
    - Boaters know how to act in case of interaction.
    - Improve general knowledge about the orca.
- As a complement it would be important:
    - Strengthen the information obtained from whale watching companies in the Strait of Gibraltar, or other areas, to check if the pattern of approaching boats, other than sailboats, could be repeating itself.
    - It would also be very positive to have more coverage of the situation of the specific interaction of orcas with fishing boats.

8.6 PILOT PROJECT DESIGN

It is proposed to carry out an oceanographic campaign, preferably, in the area of Ensenada de Barbate between the spring and summer months, of at least 20 days at sea, from a sailboat of less than 15 meters, equipped with AIS. The vessel may need to move, if necessary, to other areas where orcas are interacting.

It is proposed to monitor the orcas and their behaviours, in front of different navigation patterns of boats (stop/accelerate/reverse...) to observe the response of orcas to each one of them. In addition, it is proposed to use two deterrent elements, such as metal tubes and pilot whale sounds, and to monitor the behaviour of orcas in front of them, in order to identify possible measures to implement that can minimize the risk of interaction and therefore the potential risk of damage.

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