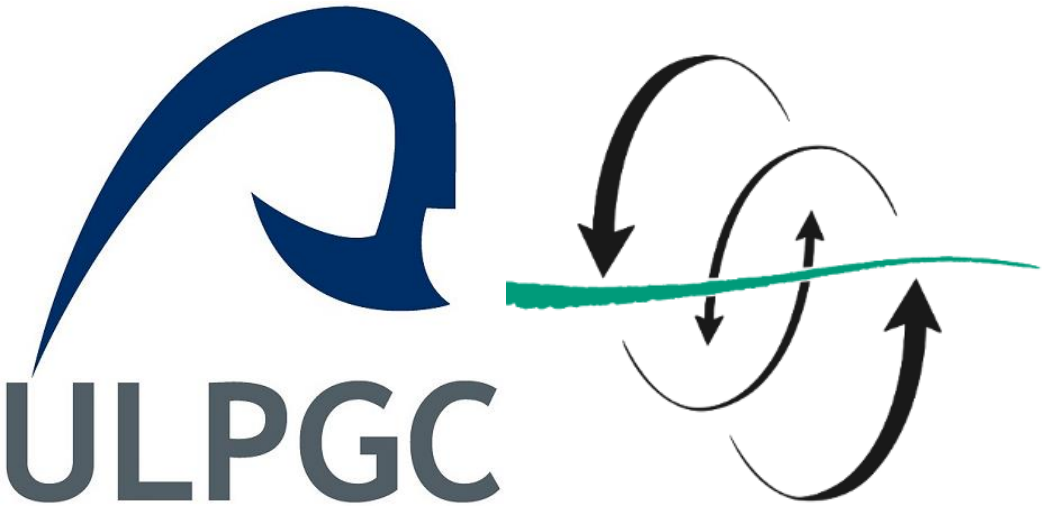

Abundance, distribution and site fidelity of gray whale *Eschrichtius robustus* in Magdalena-Almejas lagoon complex (Baja California Sur, Mexico) during 2019

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Final Degree Project to obtain a Degree in Marine Sciences

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Abstract

Eastern Gray Whale is known for its population recuperation success and it is one of the most studied whale species because of its near-shore habitat. The abundance, distribution and side fidelity of eastern gray whales on their calving and nursing grounds in Magdalena-Almejas Bay coastal lagoon system were evaluated with boat surveys counts and photo-identification in 2019. A total of 845 whales (single and female-calf pairs) were observed during boat transects as well as four species of other cetaceans. The highest number of single whales was registered on 25th of February with 234 individuals in Almejas Bay and the highest number of mother-calf pairs was registered on 27th of February with 7 pairs in Santo Domingo Channel. A total of 242 sightings were made with a group size range from one to eight during photo-identification effort. A total of 319 whales were classified in 2019 Catalog using photographic identification. Approximately 10% of the whales which arrived this year has already visited same breeding grounds in previous years. Furthermore, 32% of the photo-identificated animals presented nutritional stress condition. Decrease in population stock and body mass could be a consequence of the presence of El Niño event and global warming. Whale-watching activities and scientific research influence was also evaluated. More detailed research and comparations with previous year's dataset should be required for more precise results.

1. Introduction

The gray whale, *Eschrichtius robustus* (Liljeborg, 1861), is a marine mammal belonging to the order *Cetacea* and the suborder *Mysticeti* (also known as baleen whales). It is the last living representative of the family *Eschrichtiidae* and the most primitive species of the baleen whales. Gray whales are characterized by the absence of dorsal fin (Rice and Wolman, 1971), instead of which they present a small hump followed by a series of knuckles, which can vary in number from 9 to 14 (Jones and Swartz, 1984). These animals can reach a length of 15 meters (Jones and Swartz, 2002).

Nowadays, the gray whale can only be found in the North Pacific Ocean, with two subpopulations, whereas it became extinct in the North Atlantic Ocean a few centuries ago (Rice and Wolman, 1971). The western North Pacific population is quite small, remarkably unusual and migrates along the coast of Asia. The eastern North Pacific population is much larger and has suffered over exploitation over the last centuries. Its migration route goes along the coast of North America. (Berta and Sumich, 1999).

According to the UICN Red List of Threatened Species, the gray whale is considered as a species of Least Concern (LC), globally speaking. The estimated population size exceed every IUCN Red List threatened species category and it has increased, considering the last three generations (Cooke, 2018). The North Pacific eastern gray whale population is a great example of species recovery after a high exploitation period during commercial whaling era in XIX century (Jones and Swartz, 1984), becoming a symbol of biodiversity conservation. It was removed from the endangered species list in 1994 because of the unexpected increase to 21,000 individuals (Jones and Swartz, 2002). According to Moore and others (2001), eastern gray whale population could be even surpassing its carrying capacity level.

At national level, Mexico approved The General Law of Wildlife on 27th April, 2000 (SEMARNAT, 2000) which was actualized on 10th of January 2002 with an Article 60 *bis* that indicates 'No marine mammal specimen of any species can be the subject of subsistence or commercial use, with the exception of captures with scientific research and educational purposes'. Gray whales are under special protection since 1994 with The Mexican Official Norm, NOM-059-SEMARNAT-2010, which determine all the species and subspecies of the Mexican wild flora and fauna, terrestrial or aquatic, in danger of extinction, threatened, rare and subject to special protection, establishing specifications towards its protection (SEMARNAT, 2010). In recent decades it has become an important ecotourism resource with many visitors arriving to the Mexican shorelines to observe these magnificent marine mammals.

Warm waters around the peninsula of Baja California are an important congregation area of the eastern North Pacific gray whales which arrive there every winter in order to breed and calve (Jones and Swartz, 1984). Every year, they travel between 10,000 and 12,000 miles across the globe from their feeding grounds in the north pole seas to their breeding grounds in Mexico and back (Jones and Swartz, 2002). This winter calving lagoons located offshore the peninsula of Baja California are considered to maintain appropriate conditions for the newborn whales which still have a thin layer of blubber used as a protection from the much colder water in adult whales (Rice and Wolman, 1971). These animals, known for their coastal lagoon habitats, has been under intensive studies over the last years (Urbán *et al.* 2003).

The purpose of this bachelor's degree thesis is to evaluate the ecological characteristics of the population of eastern gray whales (*E. robustus*) in Mexican

Pacific, specifically in the Magdalena-Almejas lagoon complex (Baja California Sur, Mexico) during winter season 2019 as part of a large project entitled: *Laguna San Ignacio Ecosystem Science Program*, funded by *The Ocean Foundation*.

Seasonal abundance, distribution and site fidelity are important parameters for studies about population size, reproduction, survivorship, demography and behavior (IWC, 1990). With seasonal abundance data compared with other years and even other aggregation areas, we will be able to discuss anomalies like an abrupt increase or reduction and its possible causes. We will also obtain information about nutritional state of whales. With distribution map we will acquire data about 'hotspots' of this gray whale population. With site fidelity we will be able to calculate a percentage of new and recurrent individuals within the study area.

2. Material and methods

2.1 Material

Single-lens reflex cameras (SLR) Nikon D7100 and Canon EOS D50 with 70-300 mm zoom lenses both were used for photo-identification. Garmin GPSMAP 76CSx device was used daily for census navigation and waypoint marking. Binnacles for census, photo-identification, stranding, humpback whales and other cetaceans like dolphins were used to record data collection. Three pairs of binoculars were used for observation. Thermometer was used for temperature measurements and laser depth gauge was used for depth measurements. All the photos, binnacle and GPS data were saved on the laboratory computer and hard disk with a database from all the previous project fields trips. Photos were edited and cut with *ACDSee* software. Photo-identification was conducted using *Hot Spotter*. Low quality photos were compared manually.

2.2 Study Area

The Magdalena-Almejas Bay coastal lagoon system (Zaytsev *et al.* 2010) or the Magdalena-Almejas lagoon complex (Palomares-García, 1996) is a system of bays and channels surrounding Magdalena Bay, located in central position of all the components and connected with the ocean by a wide four-kilometer entrance (Palomares-García, 1996). It is located between 24° 20' and 25° 20' latitude N and 111° 30' and 112° 10' longitude W. The Magdalena-Almejas lagoon complex divides into three parts: Almejas Bay in the south, Magdalena Bay and the zone of interconnected shallow channels which we are going to denominate the Channel Zone, a northern part of the complex, also known by the name of Santo Domingo Channel. The Channel Zone is surrounded by two species of mangroves, *Avicenia germinans* and *Rizophora mangle* (Zaytsev *et al.* 2010). Two channels are interconnecting all three bodies of water, the Gaviotas Channel and the San Carlos Channel (Palomares-García, 1996) (Figure 1).

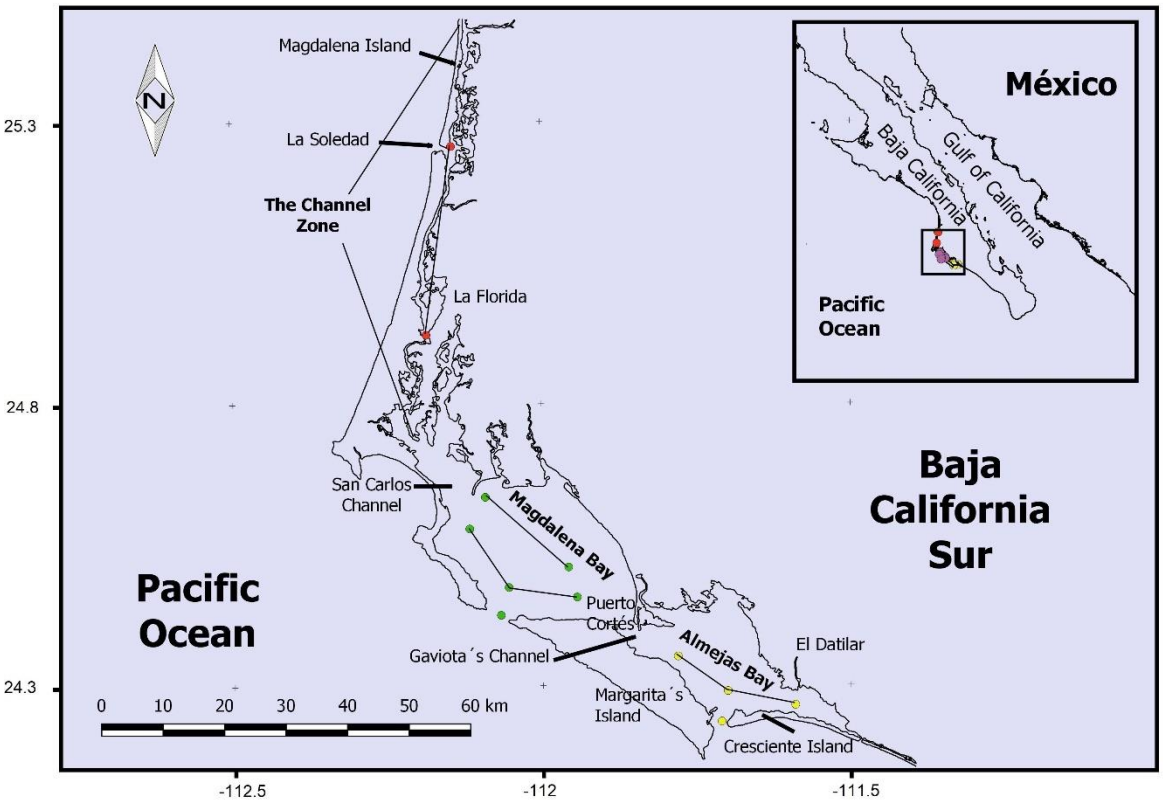

Figure 1.- Study zone (Magdalena-Almejas lagoon complex) with all three bodies of water (The Channel Zone, Magdalena Bay and Almejas Bay). Lines between marked points correspond to boat survey line transects. Points correspond to boat survey point transects. Source: Authors' own elaboration.

2.3 Methods

The gray whale datasets were collected between January and March of 2019, during daily monitoring on three field trips. Monitoring program consisted

of conducting boat surveys (censuses) for abundance data and photo-identification for distribution data and side fidelity. Side fidelity will be realized comparing this year photo-identificated animals (2019 Catalog) with all the other years (2012-2018) of the gray whale project in Magdalena-Almejas Bay coastal lagoon system. This type of study continues to contribute valuable information about population stock and side fidelity of gray whales.

Field trips dates were selected to correspond the arrival of the gray whales to the lagoon complex from the southern migration, that is between January and March. Every field trip lasted 11 days, with 10 days of sea navigation each trip and 10 to 12 hours of navigation per day. Four days of observations were lost due to unfavorable climatic conditions (wind speed over 20 km/h and strong swell). Observations were made each day of navigation to leverage all daylight hours, additionally censuses were conducted during first three days of every field trip. All whales were identified positively as gray whales.

2.3.1 Boat surveys

Boat surveys of gray whales in the Bahía Magdalena-Almejas lagoon complex in 2019 duplicated surveys conducted in the previous winters of the gray whale project. The transects included three different areas where gray whales aggregate within the Magdalena-Almejas lagoon complex: the Channel Zone (Santo Domingo Channel) in the south from La Florida north to Boca la Soledad (red waypoints); in Magdalena's Bay center, west and southwest areas (green waypoints); and in Almejas Bay in the south from a point in the center of the bay south of El Datilar north to a point north-east of Puerto Cortés on Santa Margarita Island (yellow waypoints). Additionally, in Almejas Bay and Magdalena Bay there were conducted stationary censuses (for 12 minutes) from a point in the middle of the entrance to the open ocean, also marked in the map of the study area (Figure 1).

Table 1.- Line and point transects done during boat surveys in 2019 in Magdalena Bay and adjacent areas. Distance values are presented in kilometers. (Key: AB = Almejas Bay; MB = Magdalena Bay; CZ = The Channel Zone; N/A = not applicable; SE = southeast; W = west).

Area	Initial Point	Final Point	Transect	Distance
AB	24°28'N 111°45'W	24°25'N 111°40'W	W	10.17
AB	24°25'N 111°40'W	24°23'N 111°34'W	SE	11.24
AB	24°22'N 111°41'W	24°22'N 111°41'W	Entrance	N/A
MB	24°43'N 112°04'W	24°37'N 111°56'W	Center	18.35
MB	24°34'N 111°55'W	24°35'N 112°01'W	W-I	11.19

MB	24°35'N 112°01'W	24°40'N 112°05'W	W-II	12.22
MB	24°32'N 112°02'W	24°32'N 112°02'W	Entrance	N/A
CZ	24°59'N 112°09'W	25°17'N 112°07'W	Channel	34.69

Surveys were conducted at a speed of 11 km/h using 25 feet vessel and Suzuki 115 hp outboard motor. This speed allows observers to notice surfacing whales and avoid double counts of the same whales (Jones and Swartz, 1984). Observations were made by pair of observers with binoculars located on both sides of the boat maintaining separate sighting area of 180º (Figure 2). One assistant and one annotator were also present and helping with observations. Mother-calf pairs were considered as a single unit and counts of these pairs are equivalent to calf counts. "Single whales" refer to females without calves, adult males, and immature animals. Whales travelling together were defined as a group with a range from one to eight. Information about temperature, Beaufort scale, depth, cloudiness, wind direction and visibility were recorded at the beginning of every new transect. Time, number of whales and its direction (north, south or no direction when it is perpendicular to the boat) were recorded at the time of every sighting.

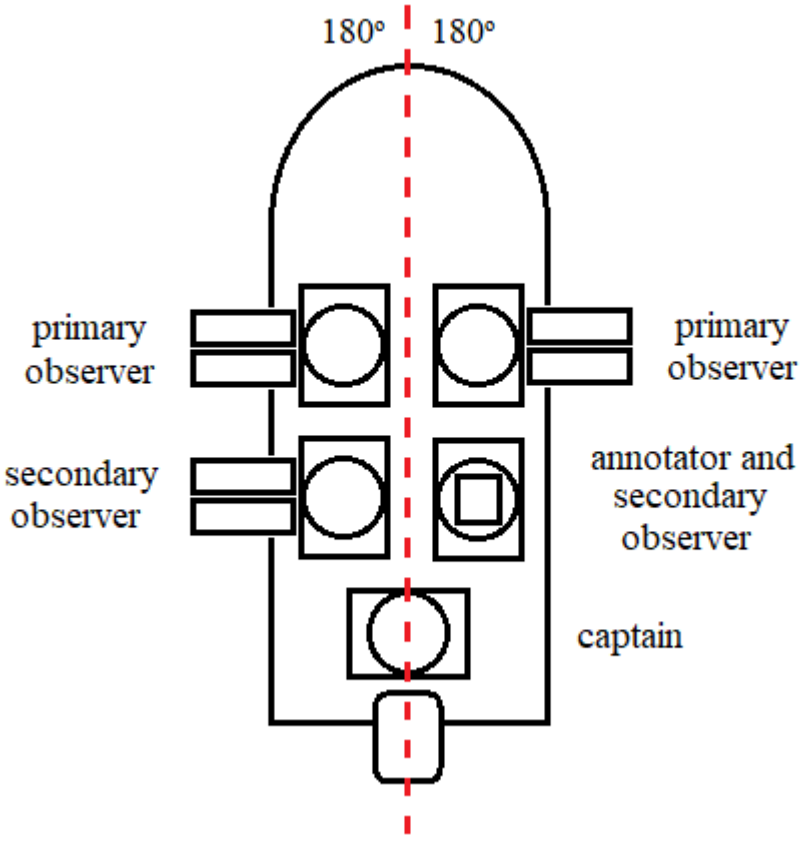

Figure 2.- Distribution of the observers during boat survey transects (census). Source: Authors' own drawing.

2.3.2 Photo-identification

Photographs were taken of the dorsal part of the gray whales, both on the right and left side, with a shooting speed of 1/1000 per second and a sensitivity of light 200 ISO (Figure 3). The boat approached parallel to the whales at a safe distance from 5 to 20 meters in order to have a good resolution photo of the animal and find the perfect angle to avoid reflections of the sunlight. The photos were taken as perpendicular as possible, after the whale emerged for taking a breath, aiming for the middle part of the dorsum, including dorsal hump and the series of bumps, also valid in the photo-identification process. In case of appropriate conditions, more photos were taken to assure the best quality of at least one image (centered, focused and with a good light). After every day on the boat, photos were edited and compared to avoid recaptures.

All the observations were made according to the NOM-131-SEMARNAT-2010 (SEMARNAT, 2011), which established instructions for development of whale watching activities relative to its protection and conservation of its natural habitat. The norm indicates details such as the allowed distance between the animal and the boat while waiting or observing the animal, the prohibition of using sonars to localize the whale or the maximum permitted velocity to navigate inside the observation area. This norm derived from the Modification Project of the Official Mexican Norm NOM-131-SEMARNAT-1998.

Figure 3.- Example photos of gray whale dorsum. Right (a) and left (b) correctly taken gray whale dorsum photos used for the photo-identification. We can observe killer's whale teeth on the first dorsal bump of the right dorsum (a) and some characteristic natural pigmentation on the left dorsum (b). Furthermore, we can observe different sizes and shapes of the bumps, also helpful in the identification process.

2.3.3 Cataloging

After completing the field work and reviewing all the photos with each other, each of the photo-identified individuals was assigned an identification key with the following information: the first two digits for the year in which it was registered, followed by a four digits corresponding to a serial number, then the letter D or I according to the side of the whale dorsum which was photographed, followed by the initials of the lagoon where it was registered (BM for Magdalena Bay) and finally the letter M in case of being a female with breeding. For example: 19-0001-D-BM-M.

All the catalogs are available on the website of the Laguna San Ignacio Ecosystem Science Project (www.sanignacioecosystem.com) in the section *Research*.

3. Results

3.1 Abundance

Twelve boat surveys were conducted in the whole Magdalena-Almejas lagoon complex, four per every study zone between 25th of January and 8th of March in 2019. In Almejas Bay the highest number of whales was registered on 25th of February, with 235 individuals (234 single whales and 1 female-calf pair), in Magdalena Bay on 10th of February with 56 single whales and none female-calf pair and in The Channel Zone on 27th of February with 65 individuals (58 single whales and 7 female-calf pairs) (Table 2).

Table 2.- Boat survey counts of gray whales. (Female-calf pairs, Singles (whales without calves), and total Adults) in Magdalena-Almejas Bay coastal lagoon system during the 2019 winter breeding and calving season. Number of female-calf pairs equals the number of calves observed. (Key: AB = Almejas Bay; MB = Magdalena Bay; CZ = The Channel Zone).

Survey	Date	Female-calf pairs	Singles	Total adults	Location
1.	25-Jan-19	0	37	37	AB
2.	26-Jan-19	1	19	20	MB
3.	27-Jan-19	2	7	9	CZ
4.	09-Feb-19	0	127	127	AB
5.	10-Feb-19	0	56	56	MB
6.	12-Feb-19	5	52	57	CZ
7.	25-Feb-19	1	234	235	AB
8.	26-Feb-19	0	46	46	MB
9.	27-Feb-19	7	58	65	CZ
10.	06-Mar-19	3	138	141	AB
11.	07-Mar-19	2	30	32	MB
12.	08-Mar-19	3	17	20	CZ

In the above table we can observe all the surveys conducted in year 2019. Normally, there are conducted exclusively nine surveys, three per every field trip (one per every study zone), but in this year March surveys were significantly lower so the investigator responsible for the project decided to conduct one more in every part of the Magdalena-Almejas lagoon complex for more precise results.

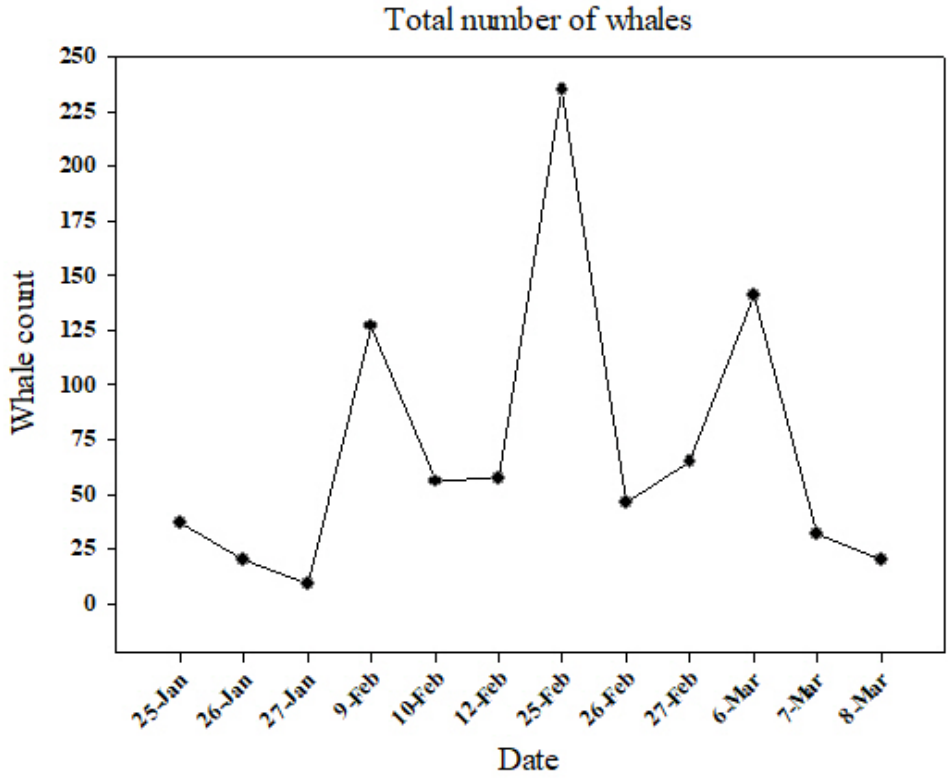

Figure 4.- Results of boat survey counts for all gray whales. Graphic representation of all the conducted surveys of all the gray whales in Magdalena-Almejas Bay coastal lagoon system in 2019. Source: Authors' own elaboration.

We can observe a population peak between the middle of February and the beginning of March in every part of the lagoon complex (the population is growing constantly until reaching its peak in late February and then begin to decrease as the whales leave the lagoon complex) (Figure 4). All the peaks from separated parts of the lagoon complex correspond to the same month and occurred between 10th and 27th of February.

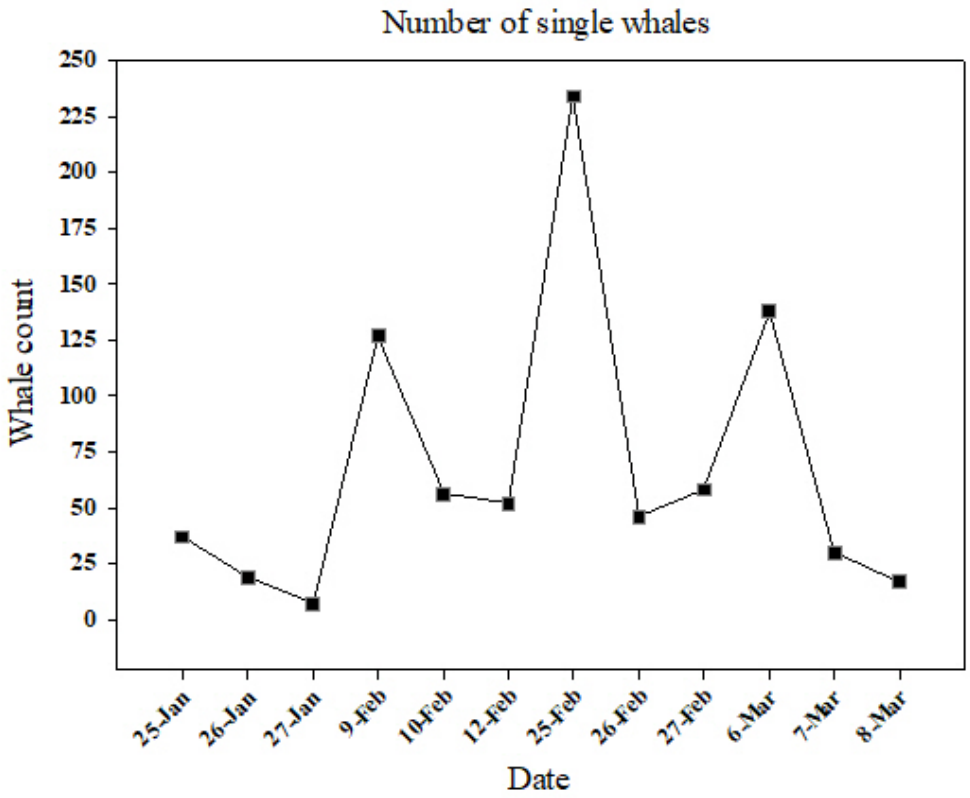

Figure 5.- Results of boat survey counts for single whales. Graphic representation of all the conducted surveys for single adult gray whales (non- female-calf pairs) in Magdalena-Almejas Bay coastal lagoon system in 2019. Source: Authors' own elaboration.

Graphic results for the number of single whales (Figure 5) in our study zone are very analogous to the results for the number of all whales (Figure 4) considering that this year number of mother-calf pairs is rather insignificant to the much larger number of single whales. In Figure 5 we can observe the highest number of adult whales on 25th of February in Almejas Bay with 234 individuals registered.

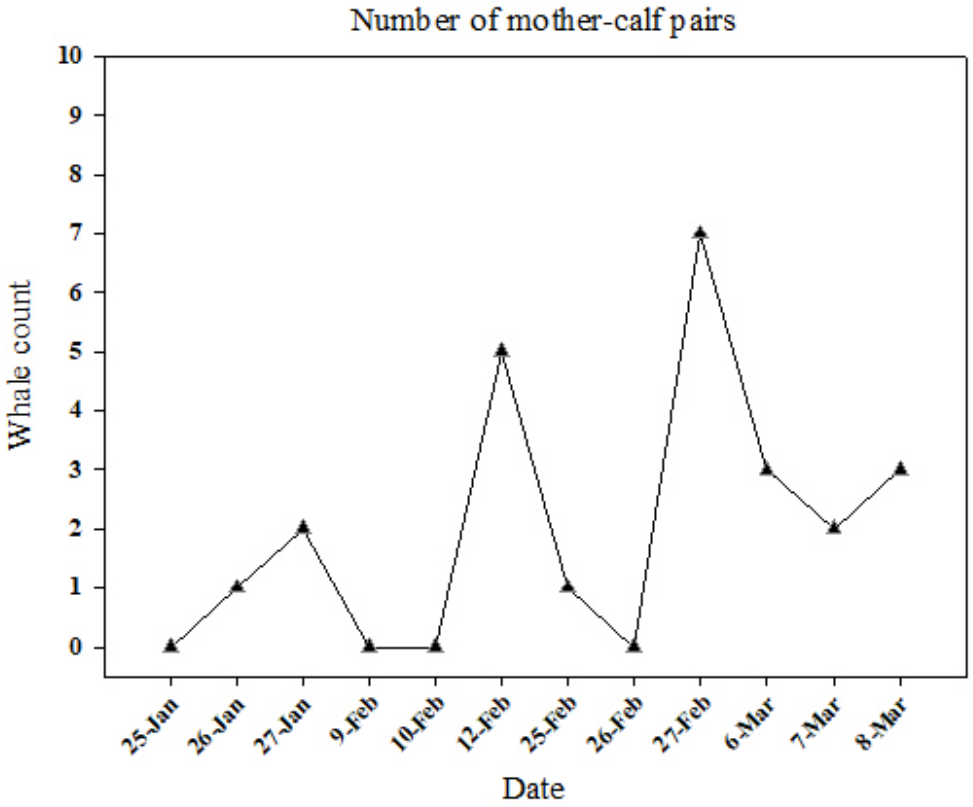

Figure 6.- Results of boat survey counts of female-calf pairs. Graphic representation of all the conducted surveys of female-calf pairs in Magdalena-Almejas Bay coastal lagoon system in 2019. Number of female-calf pairs equals the number of calves observed. Source: Authors' own elaboration.

In the graphic representing boat survey counts of female-calf pairs we notice three peaks, on 27th of January 12th of February and 27th of February (Figure 6). Comparing these results with Table 1 content, we can observe that all the three peaks correspond to The Channel Zone (Santo Domingo Channel). Furthermore, the highest number of female-calf pairs registered this winter was seven pairs, on 27th of February in The Channel Zone.

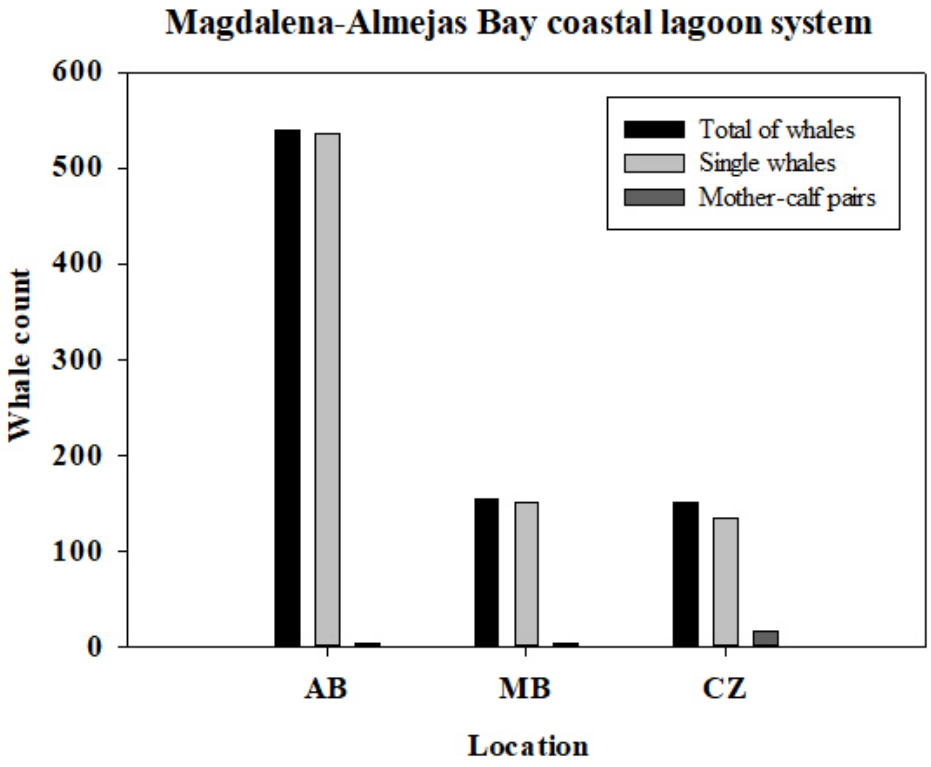

Figure 7.- Results of boat survey counts for every study zone. Number of female-calf pairs equals the number of calves observed. (Key: AB = Almejas Bay; MB = Magdalena Bay and CZ = Channel Zone). Source: Authors' own elaboration.

We can see significantly higher number of the single whales in Almejas Bay (such as the number of total whales considering that the both numbers are similar given that number of mother-calf pairs is much lower than all the other numbers). The number of mother-calf pairs is considerably higher in The Channel Zone (Figure 7) (more than 70% of all the mother-calf pairs registered in winter 2019), whereas in other two parts this number is much lower, below 20% in each of the bays (17% in Almejas Bay and 13% in Magdalena Bay).

3.2 Distribution

Between January and March 2019, 242 sightings (with a group range from one to eight) were made followed by 4650 photographic samples (head, right and left dorsum) of gray whales during 23 days of sea navigation and 230 effort hours (Table 3). After comparing photos and removing recaptured individuals, a total of 319 different whales were identified (308 adults and 11 female-calf pairs).

Table 3.- Photographic identification effort and preliminary results for Bahía Magdalena and surrounding areas. This data includes all three field trips. Effort hours does not considerate lunch time.

Number of Survey Days	23
Number of Effort Hours	230
Number of Images	4650
Number of Sightings	242
Number of All Whales	545
Number of Single Whales	507
Single whales' mean in area per day	23.7
Number of Female-calf Pairs	38
Female-calf pairs' mean in area per day	1.65

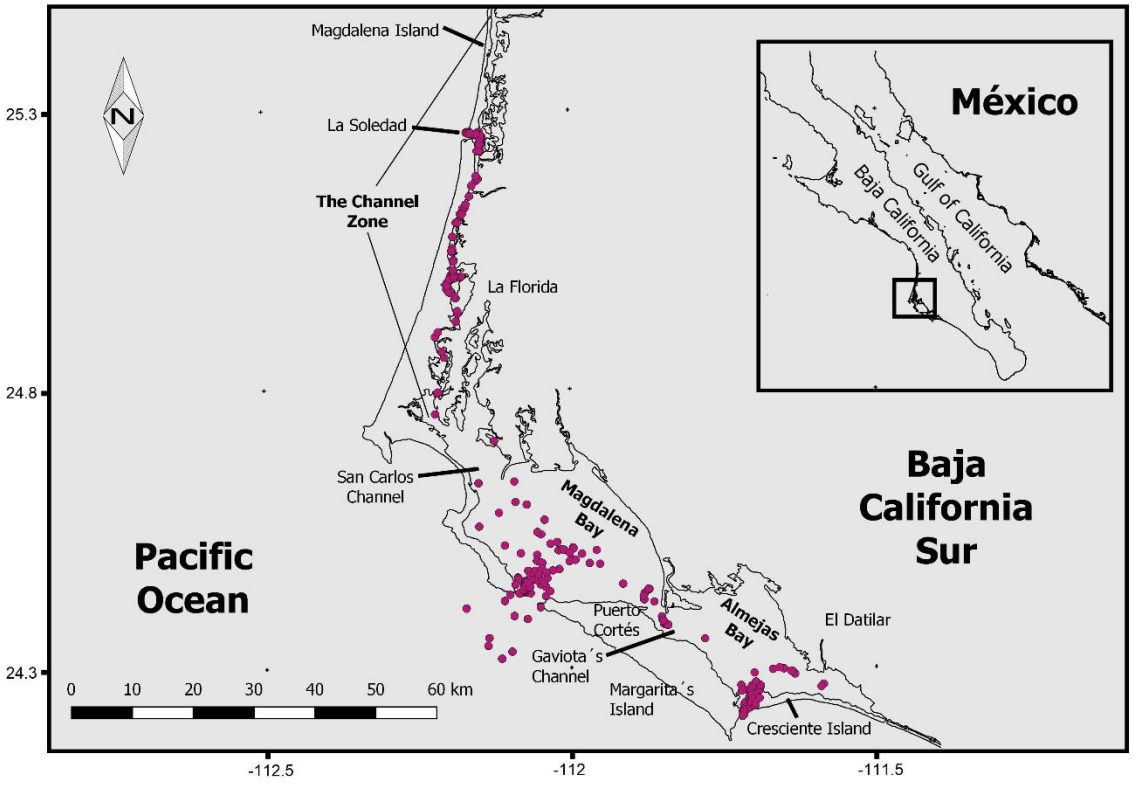

Figure 8.- Distribution of the gray whales in Magdalena-Almejas lagoon complex in 2019. Every point on the map correspond to one individual of the gray whale. Source: Authors' own elaboration.

Distribution of the eastern North Pacific population of gray whales in the Magdalena-Almejas Bay coastal lagoon is presented on the map above (Figure 8). The Channel Zone exhibits almost uniform distribution, from the beginning up north until La Soledad, differing this way from the other two zones. Magdalena Bay and Almejas Bay both show considerable concentration of individuals close

to the entrance to the open ocean and in Gaviota's Channel. In Magdalena Bay we can also observe several whales out in the open ocean.

3.3 Site Fidelity

Photographs of the right dorsum from this year catalog were compared with the 2012-2018 catalog (Figure 9). Approximate number of 32 whales (10%) were re-sighted two or more times in Magdalena-Almejas lagoon complex during the 2019 season (24 single whales and 8 mother-calf pairs). This numbers are approximate considering that comparations were realized by only one person and during many hours, increasing probability of missing a match or falsely identifying some of them.

Figure 9.- Example of site fidelity of single gray whale in Magdalena-Almejas lagoon complex, first seen in 2016 (a) and then, 3 years later, in 2019 (b).

3.4 Nutritional state

As a part of the photo-identification work, photos of gray whale head (with visible scapula) were taken to evaluate their nutritional state and determine the number of whales affected by the nutritional stress. To evaluate this condition, we observe the post cranial region looking for pronounced depression (Figure 10) and a decrease in the volume of the blubber. 32% of all the registered whales presented skinny body condition (32% of adult whales and 37% of female-calf pairs).

Within female-calf pairs, nutritional state was evaluated in both animals separately, but the percentage includes all occurrences, even when only one animal was skinny (skinny mother, skinny calf or both).

Figure 10.- Example of a skinny whale observed in San Ignacio Lagoon in 2007. Source: Swartz *et al.* 2007.

3.5 Other cetaceans

On vessel-based transects there were recorded 249 bottlenose dolphins (*Tursiops truncatus)* (some of them were seen while feeding next to the shore) and 58 unidentified species of common dolphin (*Delphinus sp).* Moreover, there were registered 11 sightings of humpback whale (*Megaptera novaeanlgiae*) with one sighting of female-calf pair inside the Magdalena Bay, 12 sightings of the Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) and 288 bottlenose dolphins during the photo-identification effort.

3.6 SST (Sea Surface Temperature) Registry

The highest temperature registered during daily monitoring in 2019 was 22°C on 28th of January in Magdalena Bay and the lowest was 16.5°C on 5th of March at the same place. Mean temperature of the study area was 19.1°C.

4. Discussion

Photographic identification, also known as photo-identification is a useful method for identifying animals, both marine and terrestrial, from whales and dolphins (Hammond *et al.* 1990) to badgers (Dixon, 2003). Individual identification using natural markings became a very powerful field research tool for ecological and behavioral studies of marine mammals (Würsig and Jefferson, 1990), providing valuable information such as female breeding cycles (e.g. Jones,

1990), population size (e.g. Best and Underhill, 1990), changes in pigment patterns (e.g. Carlson and Mayo, 1990), survival rates (e.g. Buckland, 1990) and many other biological information, as reviewed in IWC (International Whaling Commission, 1990).

This technique involves photographing a body part of the animal, which is visually exceptional (Berta and Sumich, 1999) and mark individual distinctiveness (Friday *et al.* 2000) for its posterior analysis like head (right whale), flukes (humpback whales), dorsal fin (pilot whales) or dorsum (gray whales). It is a reliable and non-invasive capture-recapture method which use natural markings. Images are organized and catalogued in order to compare to the other photographs taken at another time or in different location (Berta and Sumich, 1999). Poor quality of the photo, unfavorable climatic conditions (Agler, 1992; Friday *et al.* 2000) and temporary marks are one of the most challenging issues in the matching process which can provide erroneous results. The most frequent errors are missing a match or falsely identifying a match. To avoid possible errors, comparations should be realized by more than one experienced person and during short sessions should be (no more than 2-3 hours). Both manual and computer-assisted comparations are recommended to raise credibility (IWC, 1990).

In gray whales, photo-identification is based on visible skin characteristics like scars, natural pigmentation, callosities, barnacles and lice (Berta and Sumich, 1999). Due to its inability for developing high velocities and its near-shore habitat, they are more exposed to suffer a boat collision or entangle in fishing nets. Other common scars found on the animal are killer whale's teeth, its one and only predator besides humans (Jefferson *et al.* 2015; Jones and Swartz, 2002; Laist *et al.*2001) (Figure 3).

Magdalena Bay is often mentioned as an important congregation area of gray whales for the breeding season. As reviewed by Urbán and others (2003), there is evidence that this coastal lagoon system possesses separate breeding sites. It appears that The Channel Zone (Santo Domingo Channel) is the most studied of them all and it is also used mainly as a calving and nursing area (Urbán *et al.* 2003) which confirms why more than 70% of all mother-calf pairs were found in this area (Table 2, Figure 6 and 7). The other parts of the study area (Magdalena Bay and Almejas Bay) are probably used mainly for mating and gatherings of young adult whales (Urbán *et al.* 2003) (Figure 5 and 7). It seems that this species is strongly affected by the 21ºC isotherm (which in neutral years is found south of

Magdalena Bay, 24°N), considering that it avoids spreading over areas with SST higher than 22ºC (Martínez, 2016), probably to avoid thermal stress (Martínez, 2016; Rice and Wolman, 1971), so this year distribution was most likely modified by higher temperatures in the lagoon complex. Besides, it was demonstrated that this event also affects depth and shore distance of the wintering whales, making them look for deeper and further waters (Martínez, 2016).

According to the National Oceanic and Atmospheric Administration (NOAA) which tracks El Niño Southern Oscillation (ENSO) evolution status (updated each month, on second Thursday), equatorial sea surface temperatures (SSTs) are above average across most of the Pacific Ocean since June 2018 which indicates the presence of El Niño event (NOAA, 2019a). This warmer water temperatures proved to provoke changes in abundance and distribution of gray whales in previous years in the study area (Gardner and Chavez-Rosales, 2000) and could also be a cause of low numbers of whales this winter breeding season considering that warm waters of El Niño decrease the migration of gray whale to Magdalena-Almejas Bay coastal lagoon system (Jones and Swartz, 2002). Moreover, higher temperatures also produce a drastic decrease in biomass of gray whale primary prey (*Ampelisca macrocephala*) in north pole seas making it harder to survive this fasting period during reproductive season and long migration route (LeBoeuf *et al.* 2000).

In addition, NOAA declared an Unusual Mortality Event (UME) because of the many strandings of gray whales along the West Coast. Since January 1 of 2019 there were reported 155 strandings (73 in Mexico, 47% of all strandings), some of the whales were found emaciated (NOAA, 2019b). This kind of event has already occurred between 1999-2000 (651 strandings or more), but the cause remained undetermined (only 0.5% of stranded whale bodies were examined), although a few possible causes were considered such as starvation, chemical contaminants, biotoxins, infectious diseases, parasites, fisheries interactions and ship strikes. Moreover, many of the corpses were found during winter season in Mexican waters (Gulland *et al.* 2005). During this year daily monitoring we also observed three stranded whales in our study zone (two gray whales and one humpback whale) and one individual of gray whale which seemed to be bottom feeding (because of the visible sediment patch in the water).

Site fidelity results cannot be discussed with details since we can only compare them with 2017 site fidelity results in this area. A total number of re-

sighted whales in 2017 (36 individuals, approximately 10%) was slightly lower than in 2019 gray whale breeding season in Mexican waters.

High number of investigators (Loreto *et al.* 1996; Sánchez, 1997; Heckel *et al. 2001*) tried to evaluate direct influence of whale watching activities to the abundance, distribution and behavior of gray whales, although without obtaining a clear conclusion, so we cannot base on these results. Although one of them suggested that scientific research could be another factor influencing gray whale population changes (Jones *et al.* 1994), along with the local fishing communities. It is important to continue this kind of research in order to identify long-term effects on the population which are more significant for their health than short-term effect (approaching the animal to take a photo) (IWC, 1990). Less than 2% of whales presented visible scars from boat collisions, propeller or other possible injuries.

5. Conclusions

The purpose of this study was to establish seasonal abundance, distribution and side fidelity of the North Pacific eastern gray whales after their arrival to the breeding winter lagoons of Baja California Sur. Additionally, we evaluated nutritional state of the whales.

Decreased abundance of these animals and a high percentage of whales presenting nutritional stress condition (also possible feeding anomalies in the breeding grounds) could be the consequence of El Niño event and climate changes, including higher water temperatures and limited prey in their feeding grounds. The highest number of adult whales (234) was registered February in Magdalena Bay and the highest number of mother-calf pairs (7) in the same month in The Channel Zone.

This year distribution of the North Pacific eastern gray whale corresponds to the normal distribution of the individuals within Magdalena-Almejas Bay coastal lagoon system, that is mother-calf pairs using The Channel Zone (Santo Domingo Channel) as the main calving and nursing site and most of adults (young adults included) are found between Magdalena Bay and Almejas Bay.

The most problematic obstacle of this bachelor's degree thesis was the inability to determine the age and the size of the studied animals which could have been used to include more age groups and compare between the number of young

adults and the number of adults. Furthermore, for better results there should be organized more (or longer) field trips in order to register first whales arriving to the lagoon complex and the last whales leaving the study zone. For more credible site fidelity results, both computer-assisted and manual comparations should be realized and by more than one person. These results demonstrate the importance of the long-term studies on these marine mammals in order to detect any changes in abundance and distribution and its possible causes.

This work will be available for the future program volunteers, students, researchers or any other person who would require information about eastern gray whale population in Magdalena-Almejas Bay coastal lagoon system during winter 2019.

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Memoria del TFG

Durante la realización del trabajo fin de grado, tuve que analizar los datos recogidos durante los censos visuales y la foto-identificación de la ballena gris en el complejo lagunar Bahía Magdalena-Almejas. Con la información de los censos, se recopilaron datos para realizar las tablas, los gráficos y el mapa de la zona de estudio con los transectos marcados para hallar la abundancia de dichos animales. Con los datos recogidos durante el esfuerzo de foto-identificación, tuve que realizar una tabla de resumen (número de fotos, número de avistamientos, días y horas de trabajo, etc.) y un mapa de distribución de las ballenas avistadas. Además, para hallar la fidelidad de la zona (indicar el porcentaje de individuos recurrentes al complejo lagunar) en el año 2019, se compararon las fotografías del dorso derecho de esta temporada con el catálogo que contiene fotos tomadas entre los años 2012 y 2018. Las comparaciones se realizaron con el programa *HotSpotter*. Las fotos de baja calidad, mal centradas o con muchos reflejos del sol se compararon manualmente aparte, para que los resultados sean más fiables. Con las fotografías de la cabeza del animal también se evaluó el estado nutricional de las ballenas.

La formación recibida ha sido a través del personal académico y de la bibliografía utilizada para el desarrollo del trabajo fin de grado. Además, he aprendido a utilizar el programa *QGIS* para realizar mapas de la zona de estudio y el programa *HotSpotter* para realizar las comparaciones de las fotos de esta temporada con las fotos de todo el catálogo del proyecto ballena gris en el complejo lagunar Bahía Magdalena-Almejas (2012-2018).

Mis relaciones con el personal las considero muy buenas, he disfrutado el tiempo que pasé en el laboratorio de mamíferos marinos en la UABCS mientras trabajamos los datos recogidos en salidas de campo y he hecho amigos entre los participantes del proyecto ballena gris y el personal del laboratorio.

El aspecto positivo más significativo ha sido trabajar un tema que me apasiona, que es el tema de los mamíferos marinos. El aspecto negativo era la dificultad para contactar con los tutores para las correcciones de trabajo y la elevada cantidad de datos para procesar durante la realización de las comparaciones de fotos y trabajando los datos recogidos durante los censos.

Personalmente, creo que he aprendido mucho realizando el trabajo, buscando la bibliografía adecuada, analizando los resultados y discutiéndolos, comparando fotos, realizando gráficos, tablas y mapas de la zona de estudio. He adquirido conocimientos sobre ciertos programas necesarios para la realización de mi trabajo fin de grado, la estructura de un artículo científico y la especie de ballena gris, especialmente en aguas mexicanas. Me siento preparada para realizar publicaciones en revistas científicas en un futuro cercano.