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B.C.S., México**

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2021 GRAY WHALE ABUNDANCE IN LAGUNA SAN IGNACIO AND BAHÍA MAGDALENA COMPLEX, B.C.S., MÉXICO

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ABSTRACT

The winter gray whale occupation of Laguna San Ignacio (LSI) and Bahía Magdalena (BM) in 2021 was characterized, similar to the three previous years (2018-2020), by the delayed arrival at the lagoon and the low numbers of calves-of-the-year. In LSI The highest count of single adult whales was 162 whales on 27 February, similar to those observed in previous winters, with maximum counts ranging from 100 to 200 whales counted. Counts of females with calves remained low throughout the 2021 winter season, with the highest number of 19 pairs on 18 March 2021. The highest BM counts were on 26 February in the most southerly aggregation area of Bahía Almejas with 166 adult whales and one female-calf pair. In central Bahía Magdalena, counts were greatest on 27 February with 41 adult whales and no calves. In Canal de Santo Domingo, 49 single whales and six female-calf pairs were counted on 7 February.

Key words: gray whales, calves, skinny whales, low reproduction, carrying capacity, Unusual Mortality Event (UME) Laguna San Ignacio, Bahía Magdalena.

INTRODUCTION

The 2021 winter gray whale abundance in LSI and BM was the fourth consecutive breeding season (2018-2021) characterized by 1) an approximate two-week delayed arrival of the whales to the lagoons; 2) very low numbers of calves-of-the-year (Urbán *et al.* 2018, 2019, 2020); 3) increased adult mortality in the lagoons (Martinez *et al.* 2020), and 4) an increase in the percent of "skinny, poor condition" adult whales (Ronzón *et al.* 2020, 2021).

Low numbers of gray whale female-calf pairs observed in LSI and BM from 2018 to 2021 is similar to the decreased calf abundances observed during the winter breeding seasons from 2007 to 2010 following the range-wide "unusual mortality event" (UME) of 1999 to 2000 (LeBoeuf *et al.* 2000, Gulland *et al.* 2005). A similar observation in 2018, 2019, and 2020 preceded the gray whale UME of 2019-2021 (NOAA 2021). Changing environmental conditions in the gray whales' northern feeding areas may be reducing the availability of food during the summer months, necessitating additional searching time to find food, and resulting in similar conditions leading up to the previous mortality event. While insufficient prey could contribute to the reduced reproduction and apparent decline in the body condition of some gray whales, disease and environmental stressors (*e.g.*, climate change) cannot be ruled out (Christiansen *et al.*, 2021)

METHODS

Boat Surveys for Abundance Estimation: Boat surveys are conducted to estimate the minimum number of gray whales within the primary gray whale winter aggregation and breeding lagoons along the Pacific coast of Baja California the winter breeding season (Urbán *et al.* 2003, Fig. 1). Each survey utilizes a hand-held Global Position System (GPS) device to follow a predetermined survey tracking line that passes through the deepwater areas (i.e., > 2-m deep) utilized by gray whales in each lagoon. Observer and sighting protocols are specified for each lagoon's unique characteristics and are used to obtain and record whales' counts along with each trackline. This method allows duplication of survey effort to compare within-year survey counts along identical survey tracks in each lagoon area and compares with historical counts from previous years (Jones and Swartz 1984, Urbán *et al.*, 2003).

Boat surveys are conducted from 7-m long outboard-powered boats (Pangas), which follow each predetermined survey trackline at a speed of 11-km/hr during the whale counts. Speed and course along the trackline are continuously verified using a hand-held GPS. This survey speed minimized the likelihood that whales (which typically travel at 7 to 9-km/hr) do not move ahead of the survey boat and counted more than once. It allows observers sufficient time to detect surfacing whales (Jones and Swartz 1984).

For each survey, two pairs of observers (one pair searching to the left and one pair searching to the right sides of the boat) note the number of whales seen they pass abeam of the survey boat, thereby documenting the distribution of whale sightings along the trackline. A fifth person records each sighting on printed survey forms, noting: the time of each sighting, the number of whales in each group, their direction of movement, and whether they are single whales or female-calf pairs. The recorder also notes for each portion of the survey the prevailing environmental conditions (i.e., visibility, Beaufort sea state, wind direction, cloud cover, surface water temperature, and depth. Surveys were not conducted or in progress aborted when wind and sea state conditions exceeded Beaufort 3 sea state (winds greater than 18 km/hr with consistent white caps).

By convention, "female-calf pairs" (*i.e.*, female whales with calves of the year) are counted as a single unit, and these pairs are equivalent to calf counts. "Single whales" refer to non-parturient females, adult males, and immature or juvenile animals. Counts of "adult whales" are the sum of all non-calf whales observed (*i.e.*, single whales and female-calf pairs).

Laguna San Ignacio: Boat surveys in LSI follow a 30-km long trackline that begins at the north end of Isla Garzas in the northernmost end of the lagoon (North End Basin) to the west end of Isla Ana at Punta Holcombe at the lagoon entrance (Fig. 2). The survey trackline is divided into five "zones" or segments to record the whales' distribution within the lagoon. Surveys require approximately three hours to complete. The maximum distance from the survey trackline to the 2-m depth contour along the shore is 2.5 km. The minimum distance is 0.8 km; thus, water sufficiently deep to be inhabited by whales and both shorelines are visible to the observers at all points along the trackline. Whales in the "North End Basin" (north of the survey trackline) are

counted from the center of this area by observers searching in 360-degrees around the stationary boat.

Bahía Magdalena: Boat surveys of gray whales in the BM lagoon complex duplicated surveys conducted in previous winters from 2016-2020. The surveys included three different areas where gray whales aggregate within the larger BM lagoon complex: Canal de Santo Domingo in the north from Boca la Soledad south to La Florida; in Bahía Magdalena's center, west and southwest areas; and in Bahía Almejas in the south from a point in the center of the bay south of Puerto el Dátil north to the north-east of Puerto Cortés on Isla Santa Margarita (Fig. 3).

RESULTS

Lguna San Ignacio: In LSI, 11 surveys of gray whales were completed in 2020 to monitor the seasonal abundance and habitat use. Surveys began on 21 January and continued until 4 April (Table 1). The arrival of adult (non-calf) gray whales occurred in mid-January, approximately two weeks later than was observed during 2011-2017 winters, but similar to the last three winters from 2018 to 2020. Departure times were similar to previous years. Maximum adult whale abundance was approximately 175 individuals, higher than those seen in 2020 (Fig. 4).

The highest count of single adult whales (breeding males and females without calves) was 162 whales obtained on the 27 February survey (Fig. 5, Table 1). The numbers of these whales were similar to those observed in previous winters, with maximum counts ranging from 100 to 200 whales counted. These whale counts suggest a possible, increasing trend in abundance for the single whales seen in 2020.

Counts of females with calves remained low throughout the entire 2021 winter season, with the highest number of 19 pairs counted on 18 March 2021; the end of the season increase of female-calf pair counts historically seen in LSI did not occur in 2021 or during the previous three winters (Fig. 6, Table 1). The number of female-calf pairs seen in 2021 was less than 50% of the abundance observed between 2011 to 2017 when female-calf pair counts in March ranged from 50 to 60 pairs to just under 130 pairs (Fig. 6).

Bahía Magdalena: The 2021 gray whale surveys in the Bahía Magdalena lagoon complex were conducted in three different areas during six different periods: 18-22 January, 6-8 February, 26-28 February, and on 5 March (10-surveys in all) (Table 2). The highest counts of gray whales were obtained on 26 February in the most southerly aggregation area of Bahía Almejas with 166 adult whales and one female-calf pair. In central Bahía Magdalena, counts were greatest on 27 February with 41 adult whales and no calves. In Canal de Santo Domingo, 49 single whales and 6 female-calf pairs were counted on 7 February. Gray whale abundance then declined in all areas, with 154 single whales and one female-calf pair were counted in Bahía Almejas during the last survey on 5 March (Table 2, Fig. 7).

As seen in previous winters, the 2021 distribution of gray whales was concentrated in the areas along the north-eastern shore of Isla Creciente, off of the south-eastern shore of Isla Santa Margarita in Bahía Almejas. Along the outer western coasts of Isla Margarita and from the pass

between Isla Margarita and Punta Estrada to the north as far as Bahía Santa Maria. The northernmost concentrations of whales were observed in the Canal de Santo Domingo (Fig. 8). Few gray whales remained in the BM complex by early March, so abundance surveys were discontinued.

DISCUSSION

Since January 2019 and continuing into 2021, an increase of dead gray whale strandings occurred along the west coast of North America from Mexico through Alaska, resulting in the declaration of an "Unusual Mortality Event" (UME) for gray whales (NOAA 2021).

Observations of gray whales in LSI and BM detected an impending UME as early as 2018, 2019, and again in 2020. Specifically, long-term abundance monitoring (15-years) in these gray whale winter aggregation areas and photographic-identification data confirmed significant declines in calf counts, increasing percentages of "skinny" and "emaciated" whales, and the late arrival of the whales each winter. Unfortunately, these trends continued for a fourth winter during 2021. The number of mother-calf pairs in LSI was less than 20-pairs during the entire winter, and the count of females with calves observed in BM was only 11-pairs in all ten surveys; the arrival of the single whales in both lagoons was one to two weeks later than expected. The increases in the low calf production suggest nutrition stress (e.g., lack of prey/food), environmental stress (e.g., climate and oceanographic change), and possible disease in the population.

Similar low calf counts were observed from 2007-2010 following the 1998-2000 range-wide UME when an estimated 33% of the NE Pacific population was lost (LeBoeuf *et al.* 2000, Gulland *et al.* 2005). In the winters following 2011, the numbers of female-calf pairs observed in LSI have increased following the low female-calf counts in the years immediately following the mortality event, suggesting that there has been a continuing recovery of breeding female gray whales (Urbán *et al.* 2011, 2015, 2016, 2017). However, while the counts of females and calves observed in LSI and BM in 2018, 2019, and 2020 were low, the few mothers and calves appeared to be in good (50%) to fair (50%) condition. Indications of nutritional stress or poor condition of these gray whales and calves were not evident.

Several factors may have contributed to the low counts of female-calf pairs of gray whales observed in LSI and BM from 2018 to 2021. The timing and length of the gray whale migration along the Pacific coast of Baja California, the permanency of the whales in Mexican waters during the winter, and their abundance in the primary aggregation areas and breeding lagoons, are influenced by several factors, including Sea Surface Temperature (SST) (Salvadeo *et al.* 2015, Urbán *et al.* 1999). In cold winters, fewer whales utilize the northern areas, and more whales are migrating further south, presumably to find warmer temperatures.

The reduction in the number of calves-of-the-year could result from a reduction in the food-prey available to the whales in their summer feeding areas and that the "carrying capacity" (K) of the population (Moore *et al.*, 2001; Laake *et al.* 2009, Punt and Wade 2010). It is also possible that disease or other factors have compromised the whales' ability to maintain sufficient energy reserves to support their annual migrations from the

summer feeding grounds to their winter breeding aggregations along Baja California's Pacific coast and its coastal lagoons.

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TABLES AND FIGURES

Table 1. Boat survey counts of gray whales: Female-calf pairs, Singles (whales without calves), and total Adults in Laguna San Ignacio during the 2021 winter breeding and calving season. Number of female-calf pairs equals the number of calves observed.

Survey	Date	Female-calf Pairs	Singles	Total Adults
1	21-Jan-21	2	5	7
2	28-Jan-21	2	10	12
3	02-Feb-21	9	32	41
4	08-Feb-21	9	29	38
5	15-Feb-21	13	65	78
6	20-Feb-21	8	98	106
7	27-Feb-21	13	162	175
8	7-Mar-21	16	101	117
9	18-Mar-21	19	89	108
10	26-Mar-21	17	31	48
11	04-Apr-21	11	8	19

Table 2. Boat survey counts of gray whales (Female-calf pairs, Singles (whales without calves), and total Adults) in three areas within the Bahía Magdalena complex during the 2021 winter breeding and calving season. Number of female-calf pairs equals the number of calves observed.

	Area	Date	Female-Calf Pairs	Singles	Total Adults
2021 Gray Whale Survey Counts	Bahía Almejas	18-Jan-21	0	19	19
		06-Feb-21	1	190	191
		26-Feb-21	1	165	166
		05-Mar-21	1	154	155
	Bahía Magdalena	22-Jan-21	0	4	4
		08-Feb-21	0	33	33
		27-Feb-21	0	41	41
	Canal de Santo Domingo	21-Jan-21	0	0	0
		07-Feb-21	6	49	55
		28-Feb-21	2	30	32

Figure 1. Primary gray whale winter aggregation areas and lagoons along the Pacific coast of Baja California, Mexico: Ojo de Liebre (Scammon's Lagoon); Laguna San Ignacio; and the Bahía Magdalena complex.

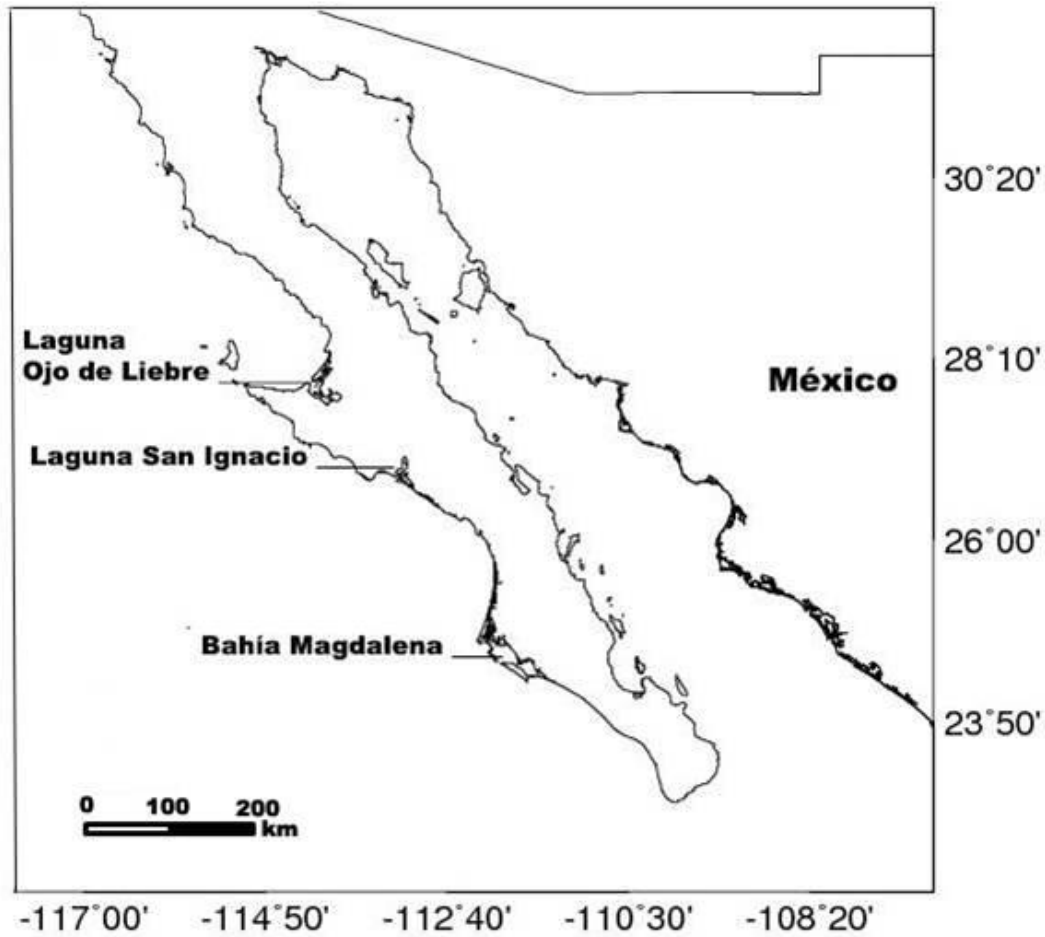


Figure 2. Boat survey track-line for estimating abundance of gray whales in Laguna San Ignacio. Counts of gray whales in the "North End Basin" portion of the lagoon are obtained from a 360° scan of the area. The survey track line continues 30 km south from Isla Garzas (Zone 1) over the deepest portions of the lagoon to Punta Holcombe on the west end of Isla Ana at the entrance of the lagoon (Zone 5).

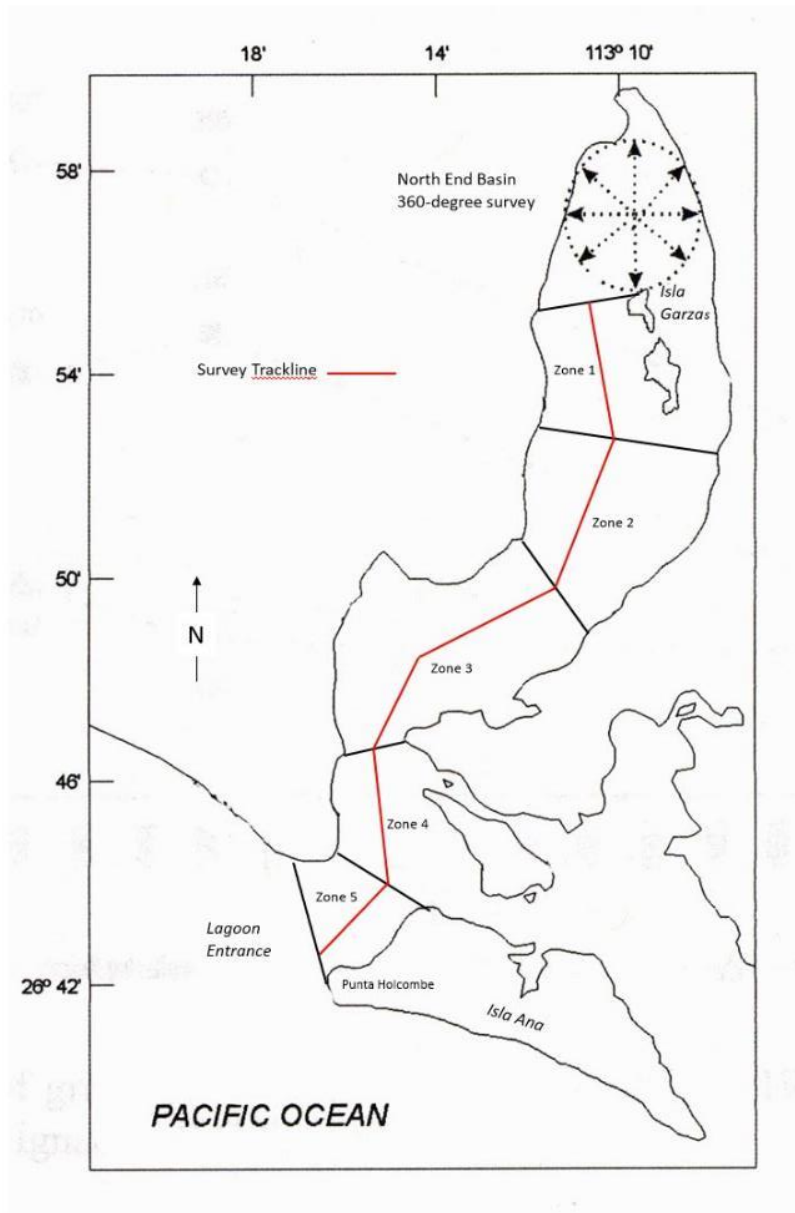


Figure 3. Boat survey track-lines for estimating gray whale abundance in the Bahía Magdalena lagoon complex in three areas where gray whales aggregate: Canal de Santo Domingo in the north; Bahía Magdalena's center, west and southwest areas; and in Bahía Almejas in the south.

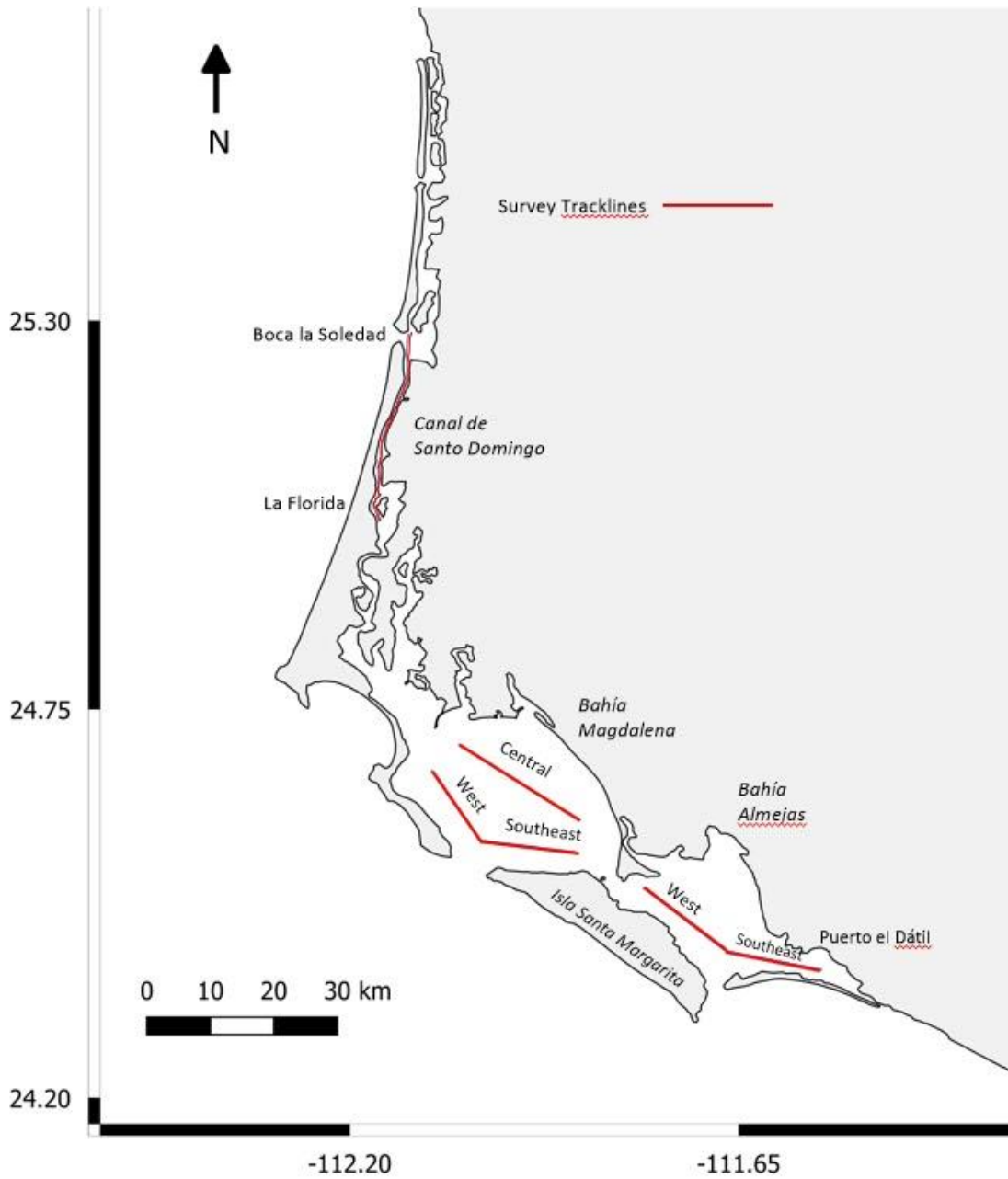


Figure. 4. Numbers of total adult whales (Adult males, females, and females with calves) counted in Laguna San Ignacio during the winter seasons: 2016-2021.

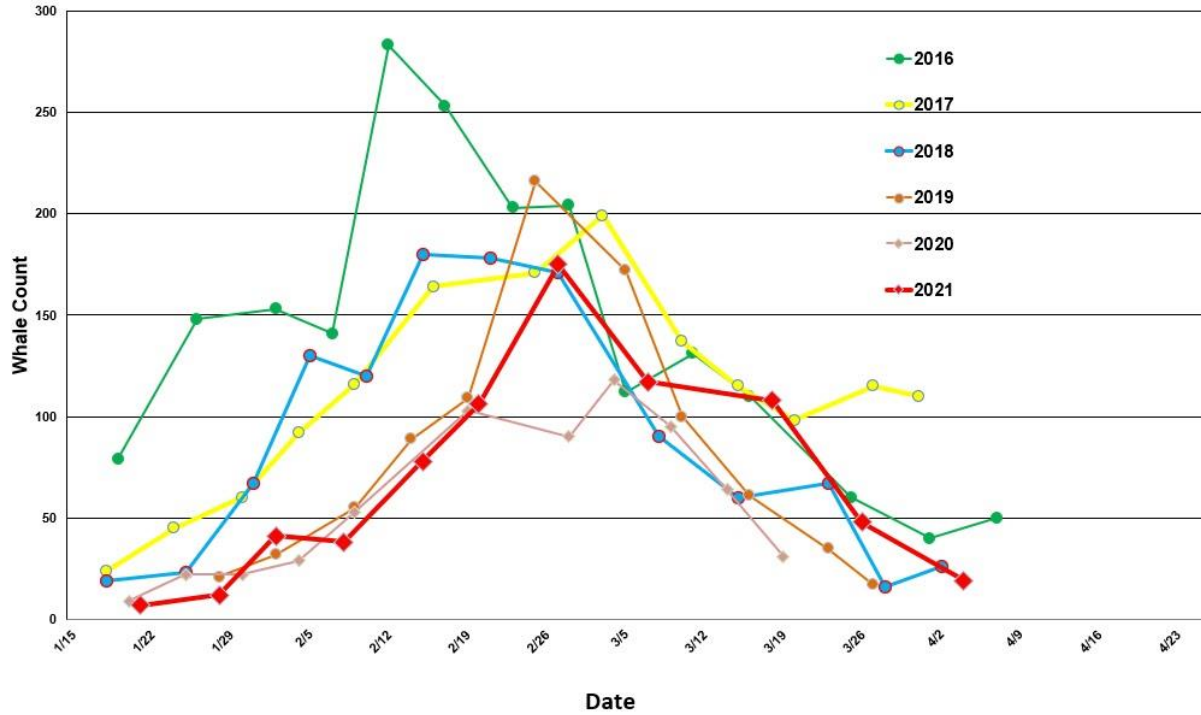
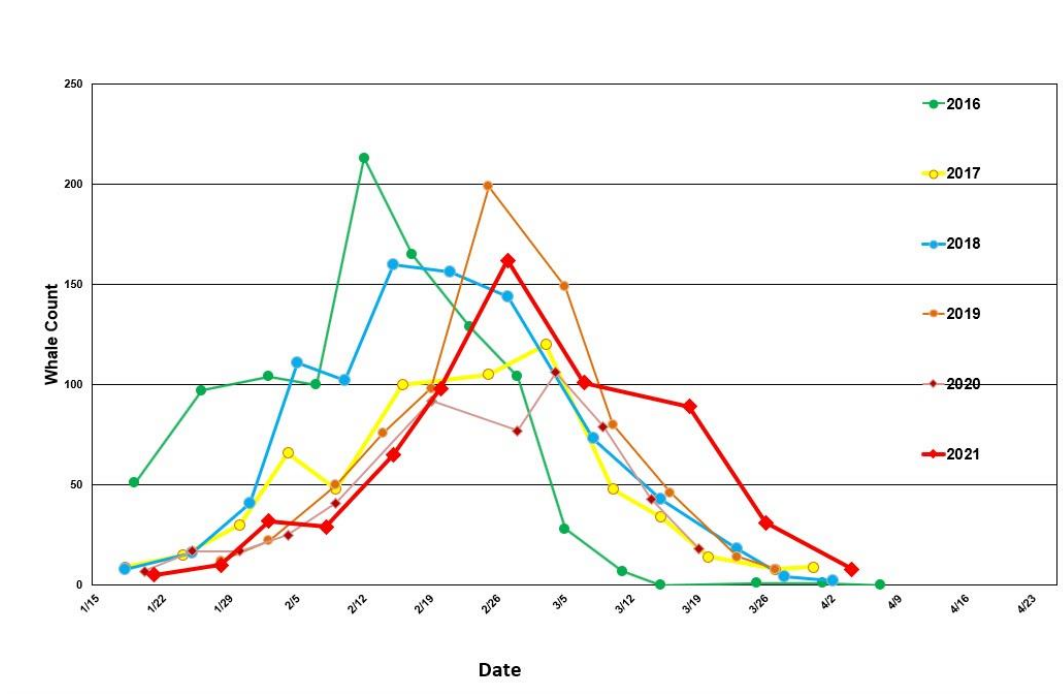


Figure. 5. Numbers of single whales (adult males and females without calves) counted in Laguna San Ignacio during the winter seasons: 2016-2021.



6. Numbers of female-calf pairs (females with young of the year) counted in Laguna San Ignacio during the winter seasons: 2016-2021.

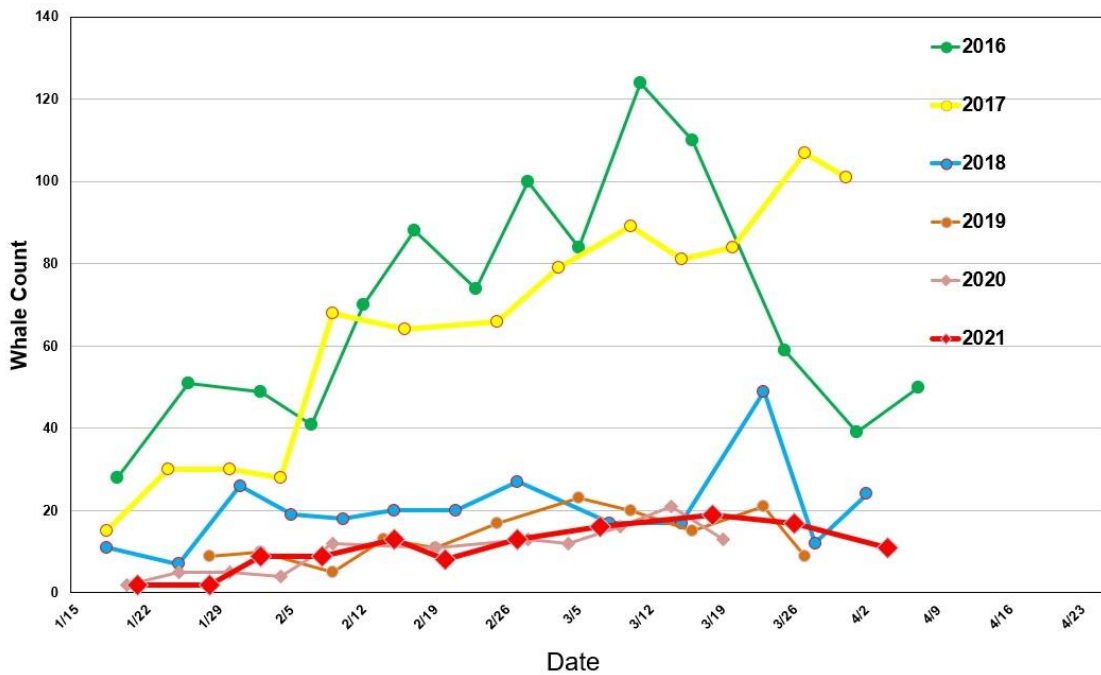


Figure 7. Boat survey counts of gray whales in three areas within the Bahía Magdalena complex during the 2021 winter breeding and calving season. Number of adult whales (Singles) without calves; female-calf pairs equals the number of calves observed. Total equals all adult whales with or without calves.

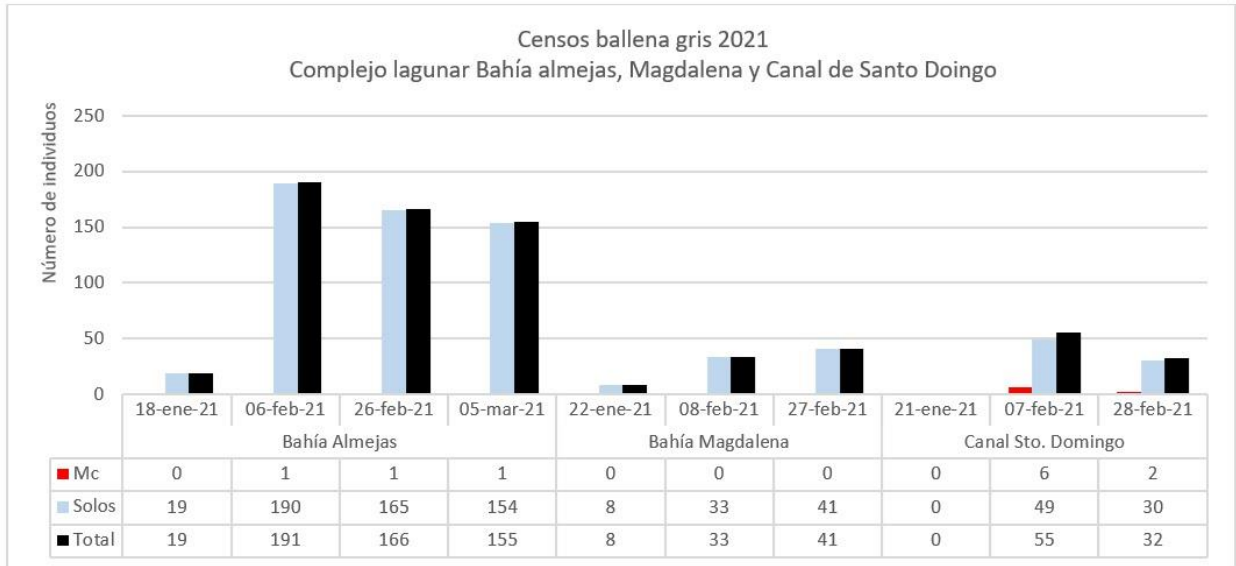


Figure 8. All gray whale sightings in the Bahía Magdalena lagoon complex and surrounded waters in the 2021 winter: Bahía Almejas (BA), Bahía Magdalena (BM) and Lopez Mateos (LM). green circles = gray whale single animals; red circles = gray whale female-calf pairs.

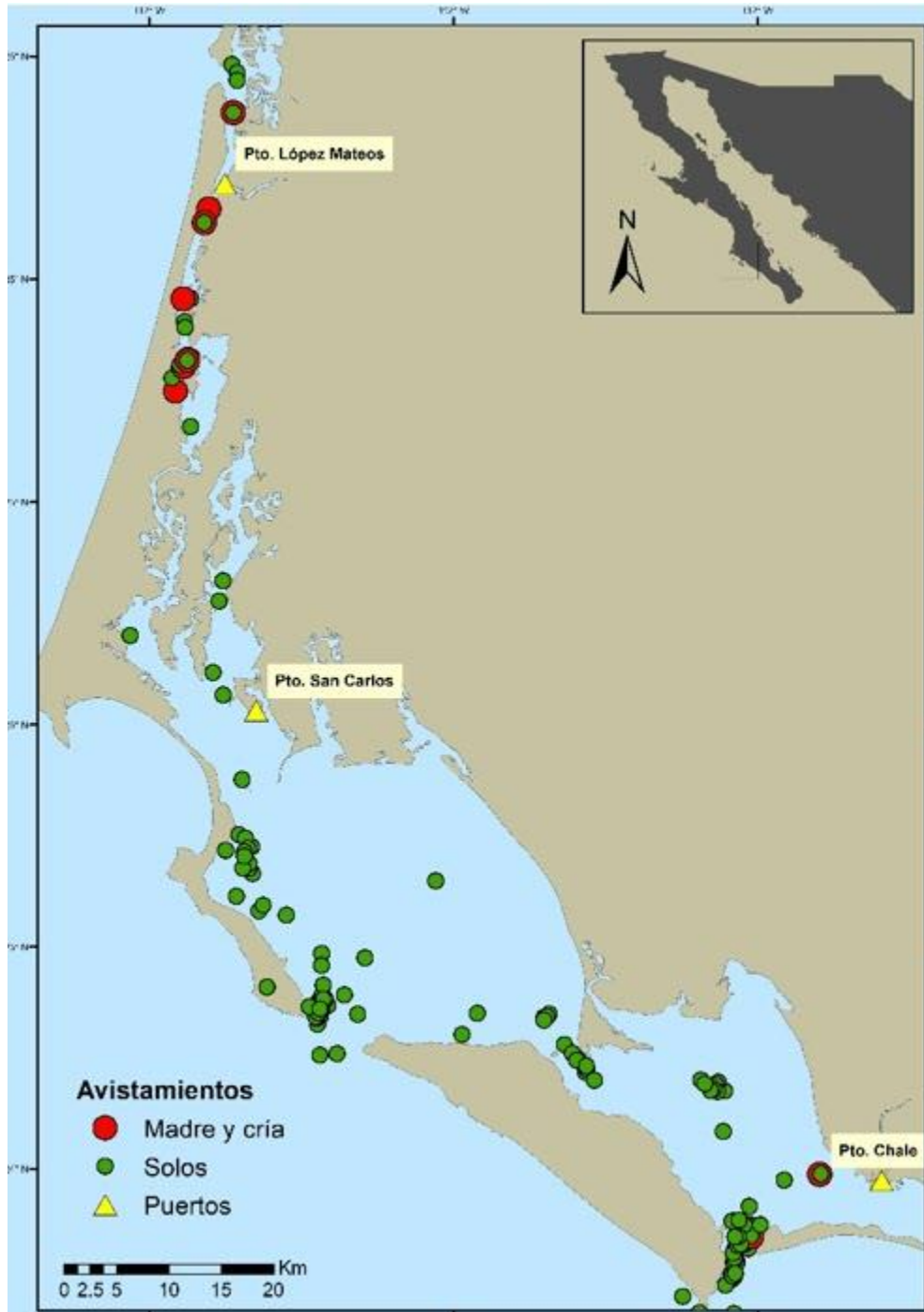


Figure 9A. Boat survey counts of gray whales in the Bahía Almejas portion of the Bahía Magdalena Lagoon complex during 2016, 2017, 2018, 2019, 2020, and 2021 winter breeding calving season. The number of female-calf pairs equals the number of calves observed.

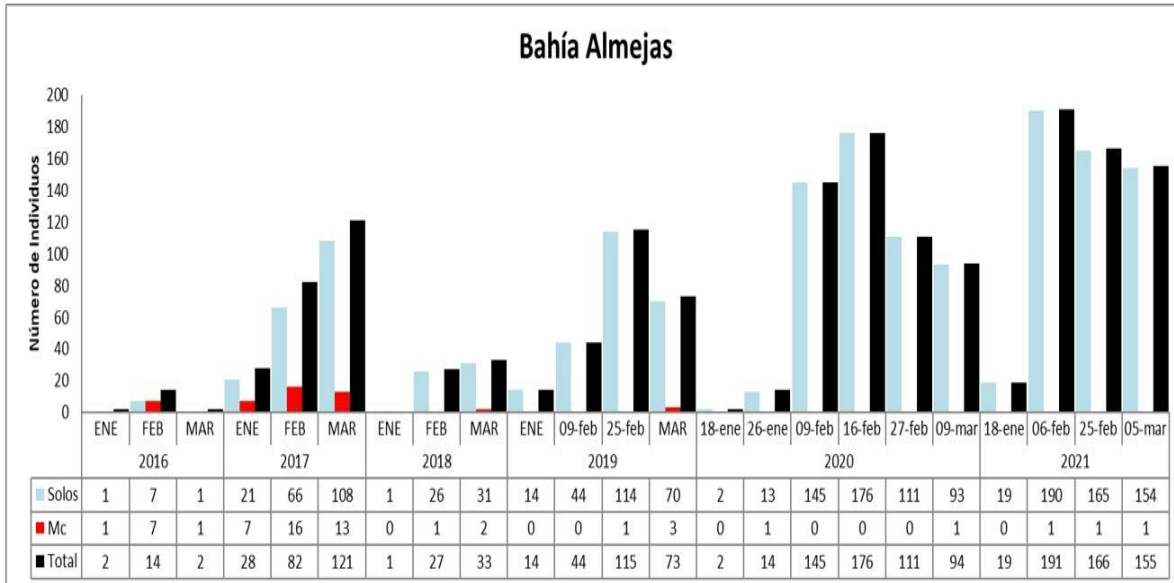


Figure 9B. Boat survey counts of gray whales in the Bahía Magdalena portion of the Bahía Magdalena Lagoon complex during 2016, 2017, 2018, 2019, 2020, and 2021 winter breeding calving season. The number of female-calf pairs equals the number of calves observed.

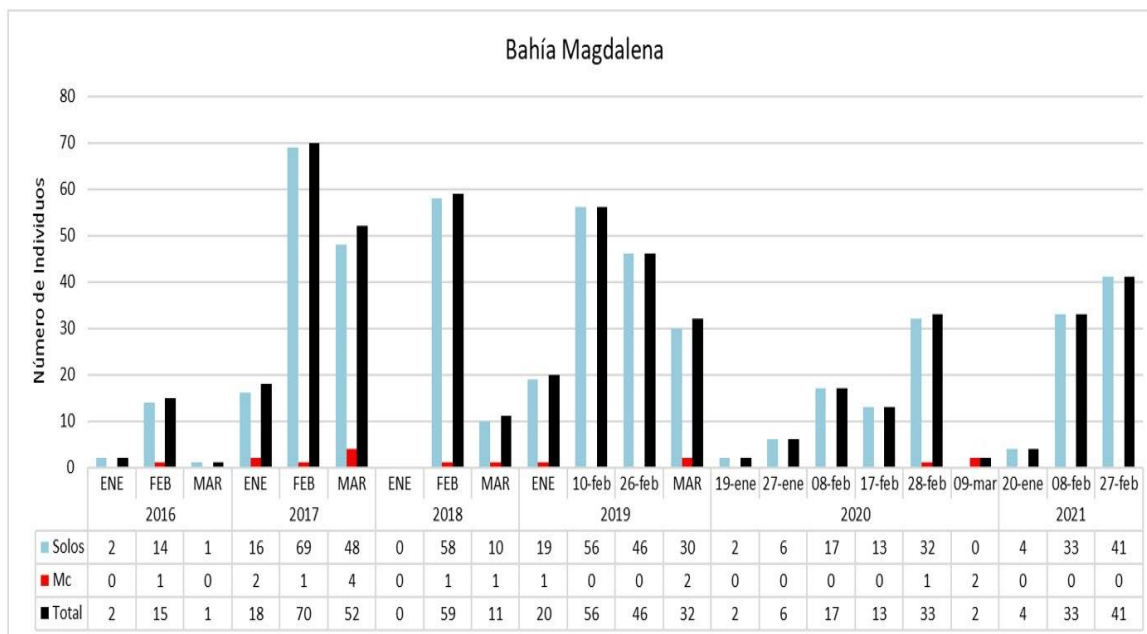


Figure 9C. Boat survey counts of gray whales in the Canal de Santo Domingo portion of the Bahía Magdalena Lagoon complex during 2016, 2017, 2018, 2019, 2020, and 2021 winter breeding calving season.

