~~ DRAFT FINAL ~~ DO NOT CITE WITHOUT AUTHOR'S PERMISSION ~~ 2023 GRAY WHALE ABUNDANCE IN LAGUNA SAN IGNACIO AND THE BAHÍA MAGDALENA LAGOON COMPLEX, B.C.S., MÉXICO

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ABSTRACT

Beginning in 2018 observations in Laguna San Ignacio (LSI) and in the Bahía Magdalena (BM) complex were characterized by declining gray whale body condition, low calf counts, and higher mortality rates and were indications of the pending Unusual Mortality Event (UME) which continued from 2019 through 2022. Information gathered in 2023 in these gray whale wintering areas suggests that the UME may be slowing and included: fewer individual whales in "poor" body condition, the first increase in the numbers of calves observed during the previous 5 winters of low counts, and fewer stranded dead whales in these areas.

In LSI he highest number of single adult (non-calf) whales counted in vessel surveys during 2023 was 194 whales on 6 March, which was higher than counts observed in previous five winters. Compared to previous winters from 2018-2022, counts of females with calves increased throughout the winter, with the highest count of 37 pairs observed on 19 March 2023.

The highest gray whale survey count in BM was obtained on 19 February in the most southerly aggregation area of Bahía Almejas and was 295 single adult whales and three female-calf pairs. In central Bahía Magdalena gray whale counts were greatest on 18 February with 97 adult whales and 2 female-calf pairs. In the northern Canal de Santo Domingo, a high count of 14 single whales was observed on 17 March, and a high count of 12 female-calf pairs on 20 February.

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

INTRODUCTION

Beginning in the winter of 2018 observations in Laguna San Ignacio (LSI) of declining gray whale body condition, low calf counts, and higher mortality rates were indications of the pending Unusual Mortality Event (UME) which has continued from 2019 through 2022 (NOAA 2023). Information gathered in LSI in 2023, however suggests that the UME may be slowing and include: fewer individual whales in "poor" body condition (Valerio-Conchas *et al.* 2023), the first increase in the numbers of calves observed during the previous 5 winters of low counts (this report), and fewer stranded dead whales in this lagoon (Martinez-Aguilar *et al.* 2023).

Low numbers of gray whale female-calf pairs observed in LSI and BM from 2018 to 2022 was similar to the decreased calf abundances observed during the winter breeding seasons from 2007 to

2010 following a previous range-wide "unusual mortality event" (UME) from 1999 to 2000 (LeBoeuf *et al.* 2000, Gulland *et al*. 2005). Low calf counts were again observed in in the wintering aggregation areas and lagoons proceeding the gray whale UME of 2019-2023 (NOAA 2023). To date a primary cause of the current gray whale UME has not been conclusively identified. It is likely that this event may have multiple contributors, including mortality linked to killer whale predation, fishing gear entanglements, vessel strikes, and poor body condition possibly associated with diminished prey resources resulting from climate driven ecosystem changes in sub-Arctic and Arctic feeding areas (Christiansen *et al.* 2021, Moore *et al*. 2022).

METHODS

Boat Surveys for Abundance Trend Estimation: Boat surveys are conducted to document seasonal trends in gray whale abundance and 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 during 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 track line that passes through the deep-water areas (i.e., > 3-m deep) utilized by gray whales in each lagoon area. Observer and sighting protocols are specified for each lagoon's unique characteristics and are used to obtain and record whales' counts along each track line. This method allows duplication of survey effort to compare within-year survey counts along identical survey tracks in each lagoon area, and for comparison with historical counts from previous years (Jones and Swartz 1984, Urbán *et al*., 2003).

Boat surveys are conducted from 7-8-m long outboard-powered boats (Pangas), which follow each predetermined survey track line at a speed of 11-km/hr during the whale counts. Speed and course along the track line 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 are counted more than once. It also allows observers sufficient time to detect surfacing whales along the track line (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 track line. A fifth person records each sighting on printed survey forms, noting: the time of each sighing, 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 were 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 the number of these pairs observed 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 adult whales and female-calf pairs).

Laguna San Ignacio: Boat surveys in LSI follow a 30-km long track line 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 track line is divided into five "zones" or segments to record the whales' distribution within the lagoon. The maximum distance from the survey track line to the 2-m depth contour along the shore is 2.5 km, and 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 track line. Whales in the "North End Basin" (north of the survey track line) 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 2016-2022. 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 region, 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 2023 to monitor the seasonal abundance and habitat use. Surveys began on 23 January and continued until 4 April (Table 1). The arrival of adult (non-calf) gray whales began in mid-January and was similar to that seen previous winters from 2018 to 2022. However, departure times in 2023 were approximately two weeks later than in years previous to 2019 suggesting a trend of later departures during the period of the UME. Maximum adult whale abundance count was 224 adult whales on 6 March (Fig. 4).

The highest count of single adult whales (breeding males and females without calves) was 194 whales also obtained on the 6 March survey (Fig. 5, Table 1). The numbers of these whales were similar to those observed in previous winters, with maximum counts ranging from 150 to 200 whales counted, but their departure at the end of the winter season occurred approximately two weeks later than in previous winters.

Counts of females with calves in LSI again remained low throughout the entire 2023 winter season but were slightly higher than the previous 3 winters with the highest number of 37 pairs counted on 19 March 2023. Analysis of photographic identification data indicated that many of the female calf pairs in LSI at the end of the season had previously been in the Bahia Magdalena area. This “end of the season” increase of female-calf pair counts historically occurred in LSI since the 1980’s (Jones and Swartz 1984), however it did not occur during the UME from 2019 to 2022 (Fig. 6, Table 1). The 2023 female-calf pair counts in LSI still continue to remain much lower that the 80 to 120 pairs counted in the years previous to the current UME.

Bahía Magdalena: The 2023 gray whale surveys in the BM lagoon complex were conducted in three different areas during three different periods: 21-23 January, 9-10 February, and 18-20 February (9-surveys in all) (Table 2). The highest counts of gray whales were obtained on 19 February in the most southerly aggregation area of Bahía Almejas with 295 adult whales and three female-calf pairs observed. In central Bahía Magdalena, counts were greatest on 18 February with

97 adult whales and two calves observed. In Canal de Santo Domingo, the highest single whale counts from 10-14 individuals were obtained in February surveys, and 12 female-calf pairs were counted on 20 February. Gray whale abundance then declined in all areas of BM after the first week in March, and further surveys were discontinued due to the paucity of whales. In 2022 and 2023 gray whales departed from the BM complex earlier than in previous winters, as was also observed in LSI in 2022 (Fig.7, Table 2).

When comparing the number of calves observed in 2023, it should be noted that calf numbers declined in the BM complex during the UME but increased from 5 to 40 whales from 2022 to 2023. This increase suggests a possible recovery of the numbers of breeding females, and with that the recovery of the reproductive rate has begun (Fig. 8)

DISCUSSION

Since January 2019 and continuing into 2023, 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 (Fauquier *et al.,* 2023; NOAA 2023).

Observations of gray whales in LSI and BM detected an impending UME as early as 2018, 2019, 2020, 2021 and again in 2022. Specifically, long-term abundance monitoring (18-years) in these gray whale winter aggregation areas and photographic-identification data confirmed significant declines in winter calf counts, increasing percentages of "skinny" and "emaciated" whales (Ronzón-Contreras *et al.* 2020, 2021; Valerio-Conchas, *et al*. 2023), the late arrival of the whales each winter, and the late departure of whales in 2023.

The number of mother-calf pairs in LSI was increased slightly in 2023 with a high count of 37 pairs in mid-March. This late season increase of female-calf pairs was not attributable to additional birth of calves, rather these calves were judged from their size and color to be calves born earlier in the season. Jones and Swartz (1984) previously documented these late season increases in calf counts in March and April, and photographic identification data confirmed that females with calves were entering LSI from other aggregation areas particularly from BM to the south of LSI.

Similar low calf counts were observed from 2007-2010 following the 1998-2000 range wide UME when an estimated 33% of the North Eastern Pacific (NEP) population was lost (LeBoeuf *et al*. 2000, Gulland *et al.* 2005). It is estimated that the size of the ENP gray whale population has declined during the 2019-2023 UME from 27,000 in 2020 to 16,500 whale in 2022 (Eguchi *et al*. 2022). In the winters following The 1999-2000 UME the numbers of female-calf pairs observed in LSI increased, suggesting a continuing recovery of breeding female gray whales (Urbán *et al.* 2011, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022). It is expected that a similar recovery of the reproductive capacity of the population will follow the current UME in the years to come.

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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 counted in Laguna San Ignacio during the 2023 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	23-Jan-23	9	16	25
2	28-Jan-23	14	8	22
3	03Feb-23	23	22	45
4	11-Feb-23	21	57	78
5	17-Feb-23	29	89	118
6	20-Feb-23	28	103	131
7	01-Mar-23	27	138	165
8	06-Mar-23	15	194	209
9	13-Mar-23	20	100	120
10	19-Mar-23	37	40	77
11	04-Apr-23	32	8	40

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 2023 winter breeding and calving season. Number of female-calf pairs equals the number of calves observed.

LOCATION	DATE	FEMALE-CALF PAIRS	SINGLE WHALES	TOTAL ADULTS
Bahía Almejas	22-Jan	0	80	80
	04-Feb	1	180	181
	19-Feb	3	295	298
Bahía Magdalena	21-Jan	0	21	21
	09-Feb	0	79	79
	18-Feb	2	97	99
Canal de Santo Domingo	23-Jan	4	5	9
	10-Feb	9	19	28
	20-Feb	12	10	22

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.

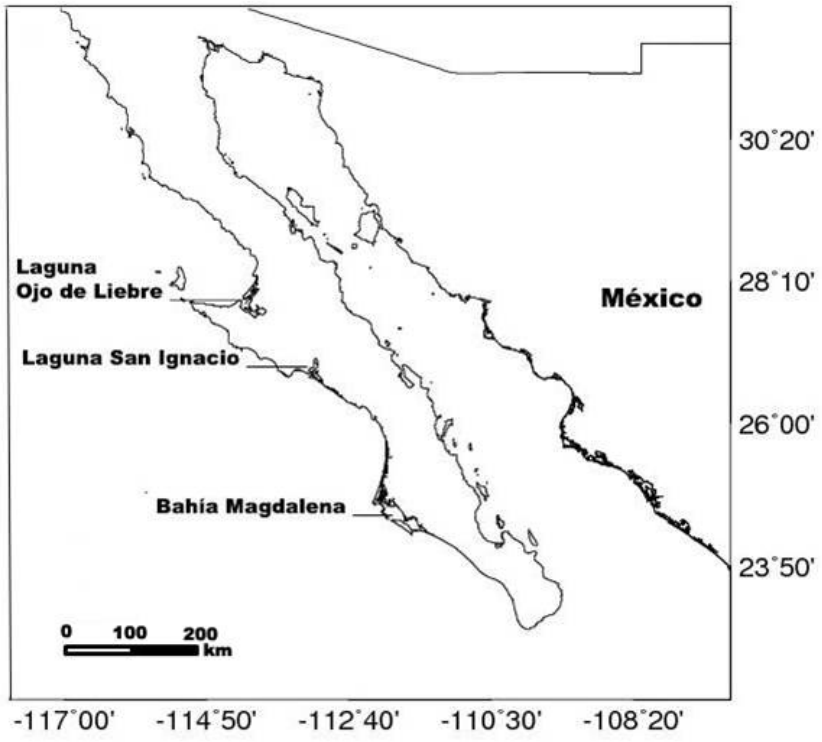

Figure 2. Boat survey track-line for estimating minimum abundance of gray whales in Laguna San Ignacio. Counts of gray whales in the "North End Basin" portion of the lagoon are obtained from a 360^0 scan of the area. The survey track line continues 30 km south from Isla Garzas (Zone 1) over the deepest portions of the lagoon to Punta Holcombe on the west end of Isla Ana at the entrance of the lagoon (Zone 5).

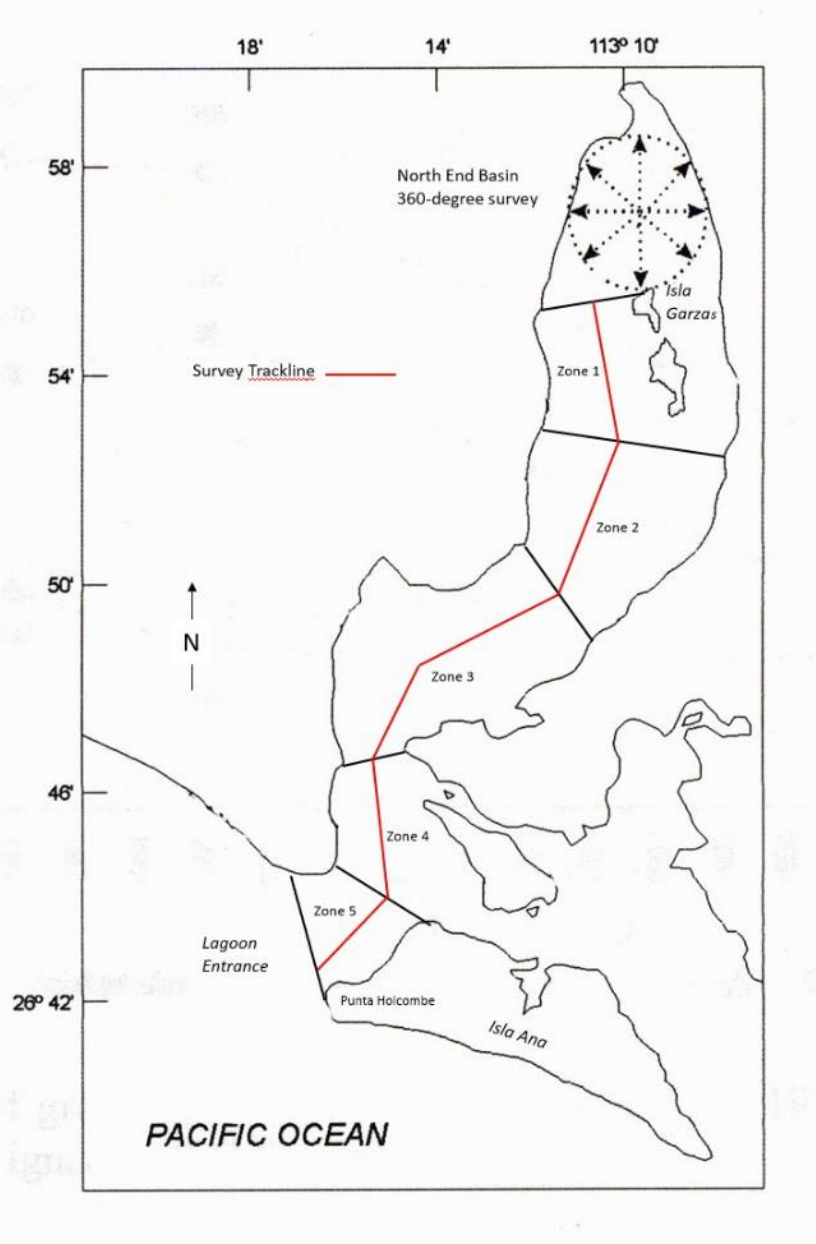

Figure 3. Boat survey track-lines for estimating gray whale abundance in the Bahía Magdalena lagoon complex in three areas where gray whales aggregate: Canal de Santo Domingo in the north; Bahía Magdalena's center, west and southwest areas; and in Bahía Almejas in the south.

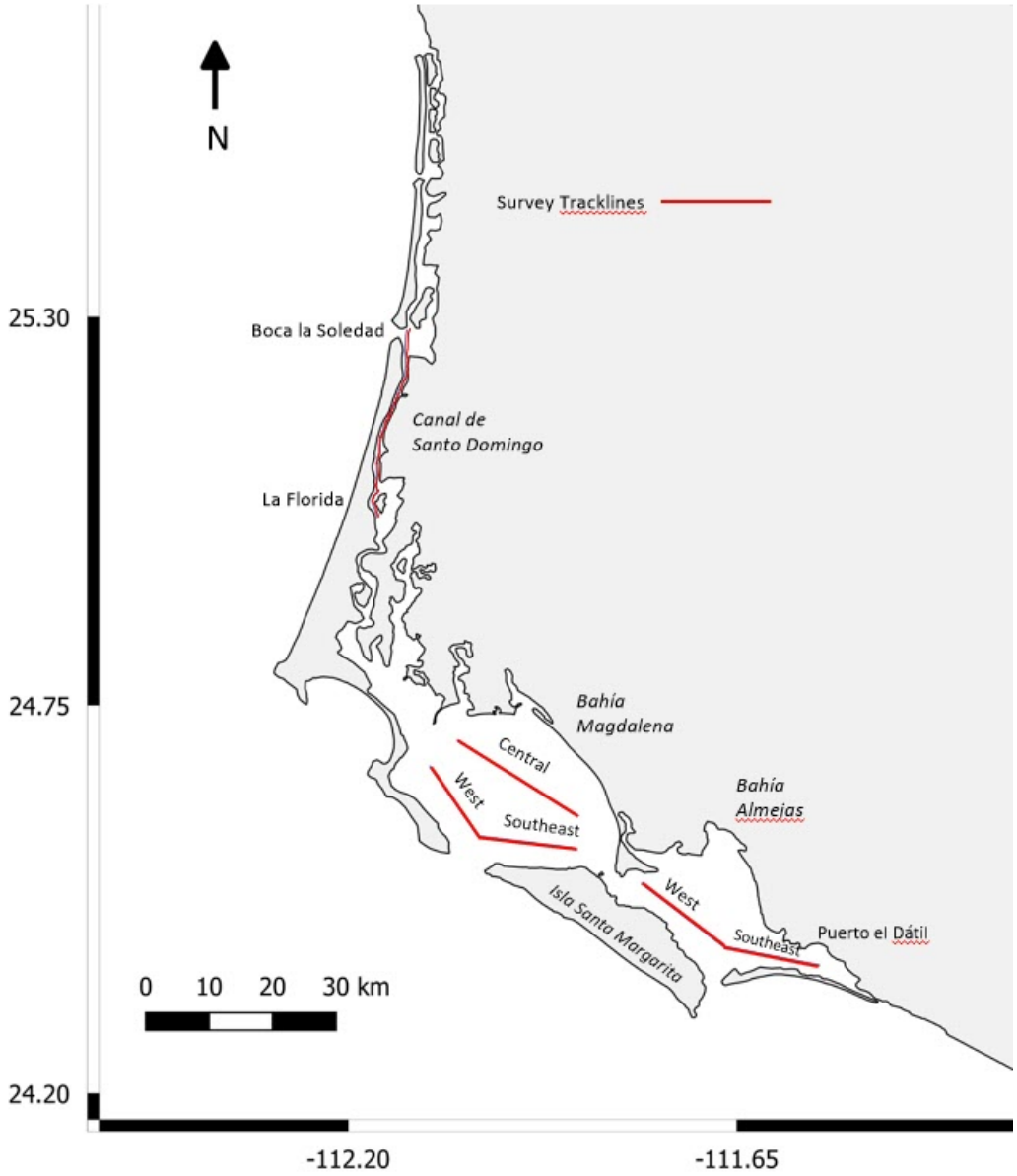

Figure. 4. Numbers of total adult whales (Adult males, females, and females with calves) counted in Laguna San Ignacio during the winter seasons: 2015-2023.

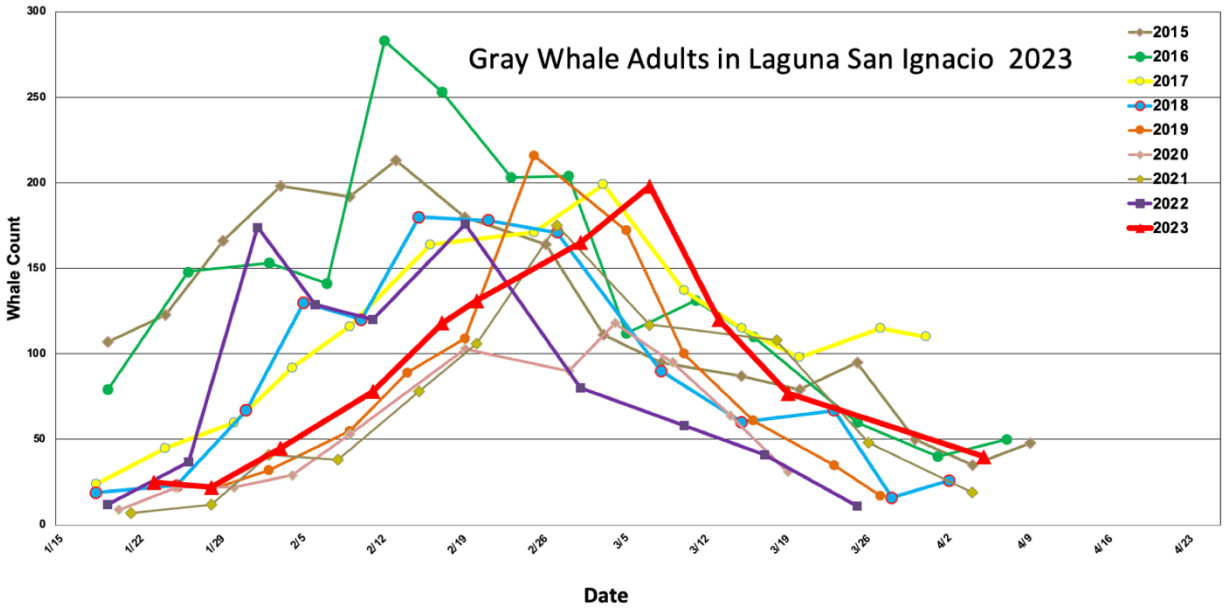

Figure. 5. Numbers of single whales (adult males and females without calves) counted in Laguna San Ignacio during the winter seasons: 2015-2023.

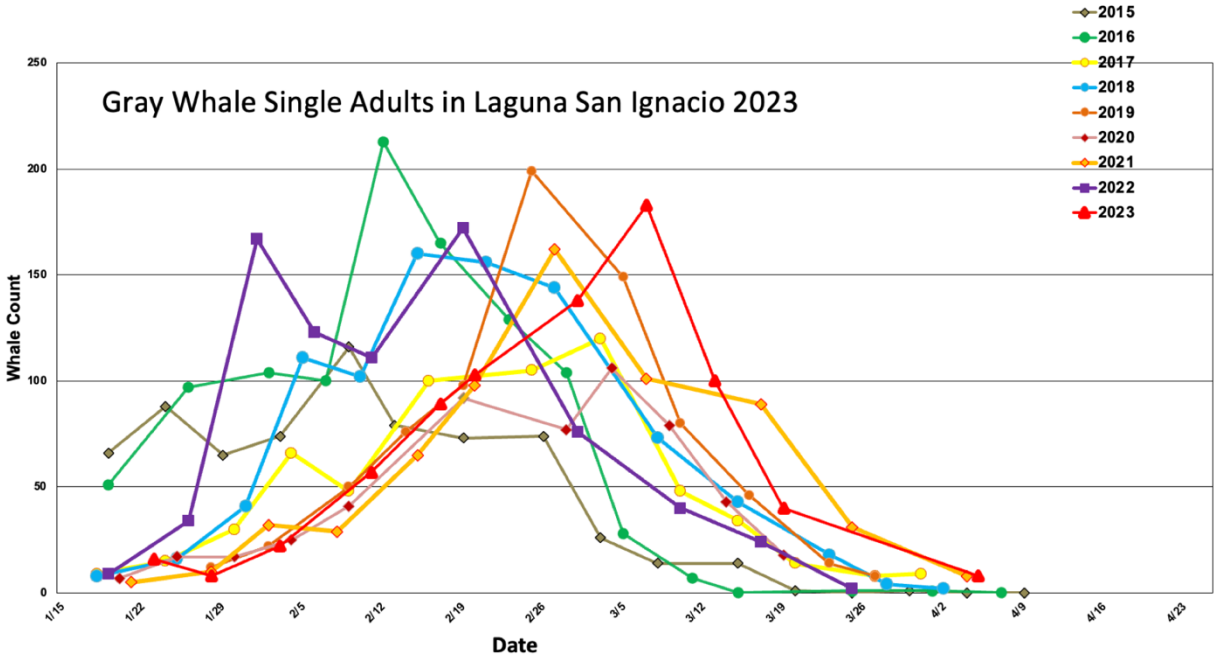

Figure. 6. Numbers of female-calf pairs (females with young of the year) counted in Laguna San Ignacio during the winter seasons: 2015-2023.

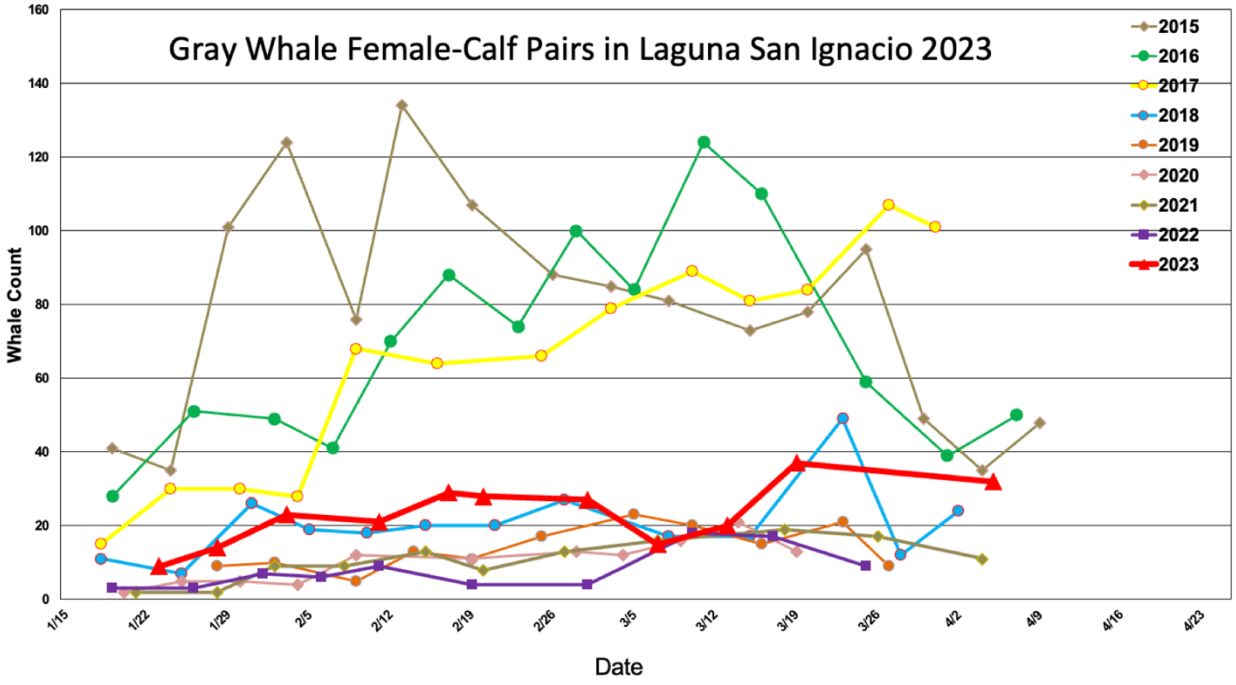

Figure 7. Numbers of single adult gray whales and female-calf pairs (females with young of the year) counted in the Bahía Magdalena (BM) complex during the 2023 winter season.

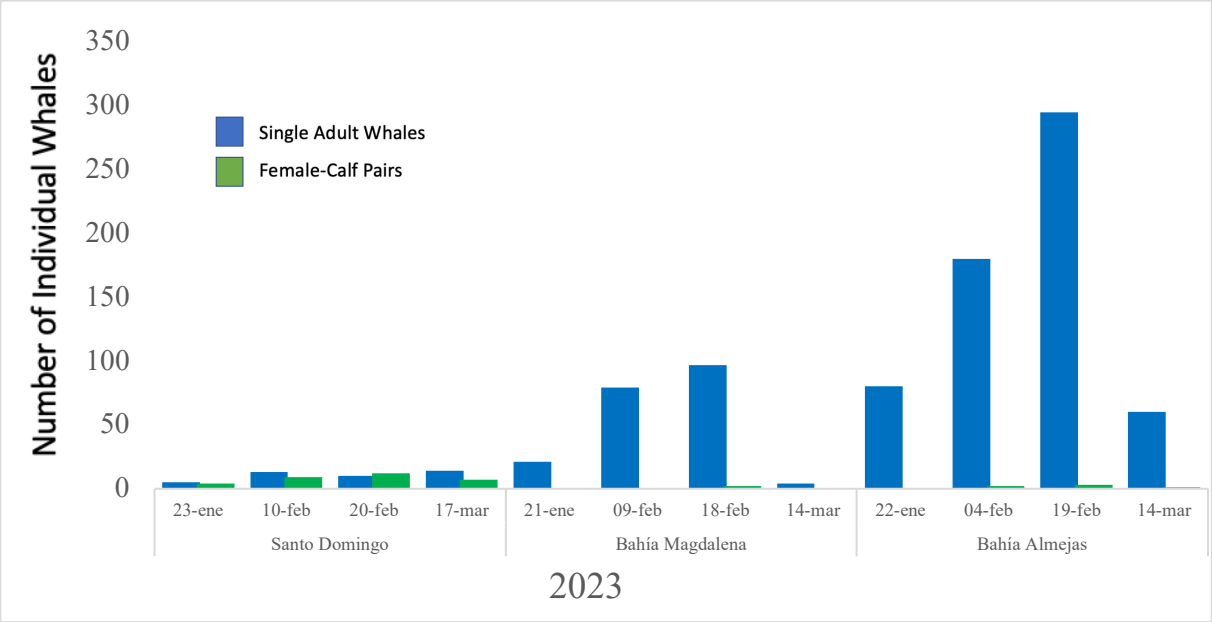

Figure 8. Combined number of female-calf pairs (Mc) in Bahía Almejas, Bahía Magdalena y Canal de Santo Domingo from 2016-2023. The Unusual Mortality Event (UME) began in 2018 and continued through 2022, and the increased count in 2023 suggests reproductive recovery.