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ABSTRACT

The 2019 winter gray whale abundance in Laguna San Ignacio (LSI) was characterized by: an approximate two week delayed arrival of the whales to the lagoon; very low numbers of calves-of-the-year; a greater than expected percent of "skinny" adult whales compared to the previous seven winters. Similarly, in the Bahía Magdalena (BM) lagoon complex to the south, gray whales also arrived late, counts of gray whale calves were lower than observed in recent past winters, however, counts of single whales were greater than the previous (2018) winter. Extreme and frequent winds in 2019 affected the average water temperatures within in LSI which ranged from 15 C° to 18 C°, while in BM water temperatures ranged from 18 C° to 21 C° in January and February, and slightly cooler in March at 16 C° to 20 C°. The cooler water temperatures in the more northerly LSI may have contributed to the observed low abundance of female-calf pairs in that lagoon, however, although warmer water temperatures occurred in BM calf counts there in 2019 were also very low. Reduced prey availability in the gray whales' feeding areas in the N. Pacific and Arctic may have contributed to reduced reproduction (number of calves), and the increase in the percentage of "skinny" whales observed during the 2019 winter breeding/calving season in the whales' aggregation lagoons along the Pacific coast of Baja California, Mexico.

Key words: gray whales, calves, skinny whales, low reproduction, carrying capacity, Laguna San Ignacio, Bahía Magdalena.

INTRODUCTION

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 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 trackline line that passes through the deep water areas (i.e., > 2-m deep) utilized by gray whales in each lagoon. Observer and sighting protocols are specified for the unique characteristics of each lagoon and, are used to obtain and record counts of whales along each trackline. This method allows duplication of survey effort for comparison of within year survey counts along identical survey tracks in each lagoon area, and the comparison with historical counts from previous years (Jones and Swartz 1984, Urbán *et al*., 2003).

Boat surveys are conducted from 7-m long out-board 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 minimizes 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, and 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 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 if 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 counts of 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 northern most 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 distribution of the whales within the lagoon. Surveys require approximately three hours to complete. The maximum distance from the survey trackline to the 2-m depth contour along shore is 2.5 km and the minimum distance is 0.8 km; thus, water sufficiently deep to be inhabitated 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 in 2019 duplicated surveys done in the previous winters of 2016, 2017 and 2018. The surveys included three different areas where gray whales aggregate within the 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 thet north-east of Puerto Cortés on Isla Santa Margarita (Fig. 3).

RESULTS

Lguna San Ignacio: In LSI 11 surveys of gray whales were completed to monitor seasonal abundance and habitat use in 2019. Surveys began on 28 January and continued until 27 March (Table 1). The arrival of adult (non-calf) gray whales occurred in the first week of February, approximately two weeks later than observed during the previous 8 winters, while their departure from the lagoon was similar to previous years; thus their seasonal occupation of the lagoon by adult whales was later and shorter than seen in previous years from 2011 to 2018 (Fig. 4).

The highest count of single adult whales (breeding males and females without calves) was 199 whales obtained on the 25 February survey (Fig. 5, Table 1), which was greater but occurred later in the season than the 160 single whales seen in the lagoon on 15 February 2018, and greater than the 120 single whales

observed on 3 March 2017. These whale counts suggest a trend for an increasing number of single adult whales over the past three winters.

Counts of females with calves remained low throughout the entire 2019 winter season, with the greatest number of calves counted of 23 on 5 March 2019; the typical end of the season increase of female-calf pair counts typically seen in LSI did not occur in 2019, or in the previous winter Fig. 6, Table 1). In 2018, the highest count of females with calves of 49 pairs occurred late in the season on 23 March. The number of female-calf pairs seen in 2019 was far less than that observed between 2011 to 2017, when female-calf counts in March ranged from 50 to 60 pairs to just under 130 pairs (Fig. 6). Female-calf pair counts in 2019 and 2018 were similar to those observed during the winter breeding seasons from 2007 to 2010 following the range wide "mortality event" in the late 1990's (LeBoeuf et al. 2000). Overall, the low number of female-calf pairs observed in 2019 was unexpected, as was their early departure from the lagoon in April.

Bahía Magdalena: The 2019 boat surveys of gray whales in the Bahía Magdalena lagoon complex were conducted in three different areas during four different time periods: 25-27 January, 9-12 February, 25-27 February, and from 6-8 March (12-surveys in all) (Table 2). The highest counts of gray whales were obtained in February in the most southerly aggregation area of Bahía Almejas; 144 adult whales, but only one female-calf pair, when in central Bahía Magdalena counts were 46 adult whales and no calves, and in Canal de Santo Domingo 58 single whales and 7 female-calf pairs were counted. Gray whale abundance then declined in all areas and by early March: 70 single adults and 3 female-calf pairs were counted in Bahía Almejas; 30 single whales and 2 female-calf pairs in central Bahía Magdalena; and 17 single whale and 3 female-calf pairs in Canal de Santo Domingo (Table 2, Fig. 7).

The 2019 distribution of gray whales was concentrated in the area along the north shore of Isla Creciente and off of the eastern shore Isla Santa Margarita in Bahía Almejas, the most southern of the gray whale aggregation areas in the BM complex (Fig. 8). This distribution pattern was also seen during the 2017 winter, but not the 2016 or 2018 winters when fewer gray whales aggregated in this area (Figs. 9a-c). As was observed in LSI, few gray whales remained in the BM complex by mid-March 2019, so abundance surveys were discontinued.

A few gray whales were observed in January and February around Cabo San Lucas at the southern end of Baja California during the winter of 2019, but exact numbers and locations were not reported (pers. Com. Jorge Urbán).

DISCUSSION

In 2019 the late arrival (approximately two weeks) of the gray whales to LSI and BM was unexpected, as were reports of fewer numbers of southbound whale passing Los Angeles and Monterey early in the season (A. Schulman-Janiger and W. Keener per. comn.). Then, the numbers of mother-calf pairs arriving at the lagoons in January was very low and remained low all winter; in the previous years from 2011 to 2017 numbers of mother-calf pairs increase throughout January, but beginning last year (2018) their abundance was lower in both lagoon areas. In addition, the percent of "skinny" single whales observed in the photographic-identification surveys jumped from 4.9%-7.6% during the years 2008-2011, to 23.6% skinny in 2019 (Ronzón and Martínez 2019). This suggests that in recent years the gray whales' are not obtaining sufficient nutrition during their summer feeding in the Arctic and N. Pacific.

Similar low calf counts were observed from 2007-2010 following the 1998-2000 range-wide "mortality event" when an estimated 33% of the N.E. Pacific population was lost (LeBoeuf et al. 2000, Gulland et al. 2005). After 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 and 2019 were low, the female whales and their calves that were present appeared to be in good (50%) to fair (50%) condition, and indications of nutritional stress or poor condition of these gray whale females and calves was not evident.

A number of factors may have contributed to the low counts of female-calf pairs of gray whales observed in LSI and BM in 2019. The timing and length of the gray whale migration along the Pacific coast of Baja California, the period of time the whales reside in Mexican coastal 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 winters with cooler than average sea surface temperatures fewer whales utilize the northern aggregation areas and more whales migrating further south to utilize the more southerly aggregations areas, presumably to find warmer temperatures.

The 2019 winter at LSI experienced cooler water temperatures inside the lagoon; water temperatures ranged from 15 C° to 18 C°. Extreme tidal flows accompanied periods during the new and full moon phases, and extreme prevailing winds in 2019 likely contributed to the cooler water temperatures. In contrast, the warmer water temperatures in the BM complex ranged from 16 C° to 21 C° and this warmer water could account for greater numbers of gray whales in this aggregation area, as the whales generally seek optimum temperatures during their winter breeding and calving season (Salvadeo et.al. 2015, Urbán et al. 1999).

The reduction in the number of calves-of-the-year suggest a slowing of reproduction that could result from a reduction in the food-prey available to the whales in their summer feeding areas, and/or that the current size of the North Eastern Pacific population has exceeded the environmental "carrying capacity" within their current range (Laake et al. 2009, Punt and Wade 2010). With regard to a possible reduction in food/prey resources, currently oceanographers are describing a persistent (2015-present) warmer-than-normal sea temperatures in the North Pacific/Gulf of Alaska and down the coast of North America (Figs. 10 and 11) that has been disrupting the normal seasonal primary production during the summer months in the high latitudes where the gray whales, and other marine life feed (i.e., marine birds, fish and other marine mammals (Belles 2016, Alaska Ocean Observing System 2019, National Geographic Society 2019). This seasonal upwelling and spring freshwater ice-melt from the Arctic normally drives the phytoplankton blooms that are the foundation for food chain that all the marine species (including whales) depend on during the summer to obtain sufficient energy to survive the winter and breed successfully. Skinny gray whales and low calf production suggest that finding sufficient food to support good body condition and reproduction is becoming a problem for the gray whales (and other marine species).

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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 2019 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	28-Jan-19	9	12	21
2	02-Feb-19	10	22	32
3	09-Feb-19	5	50	55
4	14-Feb-19	13	76	89
5	19-Feb-19	11	98	109
6	25-Feb-19	17	199	216
7	05-Mar-19	23	149	172
8	10-Mar-19	20	80	100
9	16-Mar-19	15	46	61
10	23-Mar-19	21	14	35
11	27-Mar-19	9	8	17

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 2019 winter breeding and calving season. Number of female-calf pairs equals the number of calves observed.

	Area	Date	Female-Calf Pairs	Singles	Total Adults
2019	Bahía Almejas	25-Jan-19	0	14	14
		9-Feb-19	0	44	44
		25-Feb-19	1	114	115
		6-Mar-19	3	70	73
	Bahía Magdalena	26-Jan-19	1	19	20
		10-Feb-19	0	56	56
		26-Feb-19	0	46	46
		7-Mar-19	2	30	32
	Canal de Santo Domingo	27-Jan-19	2	7	9
		12-Feb-19	5	52	57
		27-Feb-19	7	58	65
		8-Mar-198	3	17	20

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.

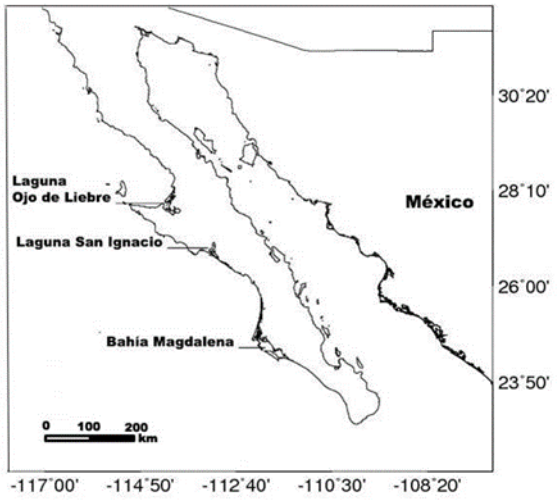


Figure 2. Boat survey trackline in Laguna San Ignacio. Counts in the "North End Basin" portion of the lagoon are obtained from a 360^0 scan of the area. The survey track line continues 30 km south from Isla Garzas (Zone 1) over the deepest portions of the lagoon to Punta Holcombe on the west end of Isla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

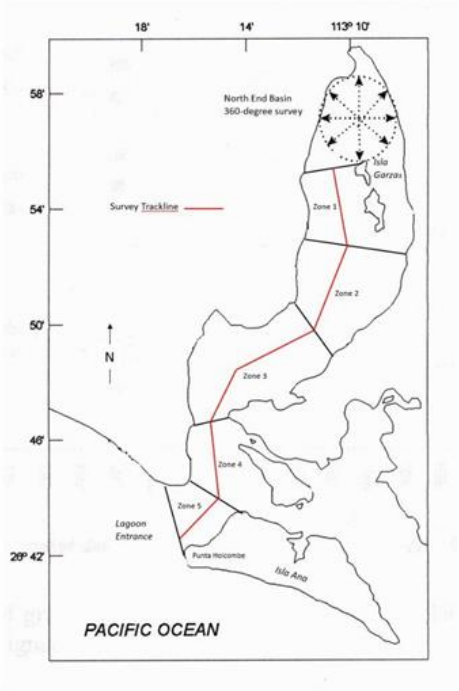


Figure 3. Boat survey tracklines for estimating gray whales in the Bahía Magdalena lagoon complex in three areas where gray whales aggregate: Canal de Santo Domingo in the north; Bahía Magdalena's center, west and southwest areas; and in Bahía Almejas in the south.

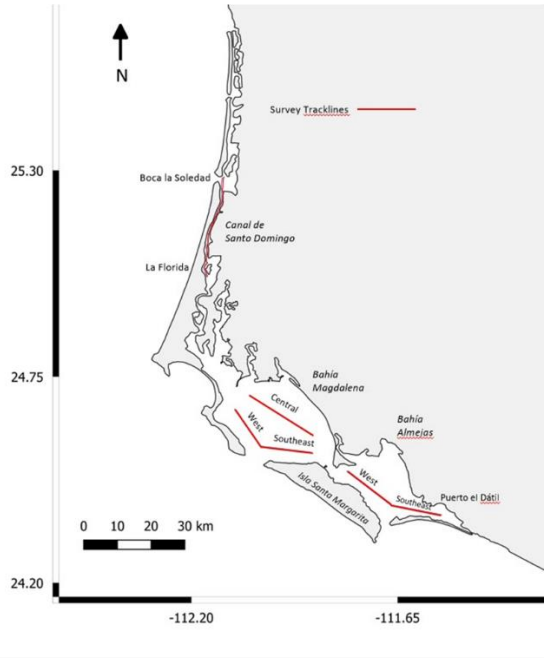


Figure. 4. Numbers of total adult whales (Adult males, females, and females with calves) counted in Laguna San Ignacio during the winter seasons: 2007-2019.

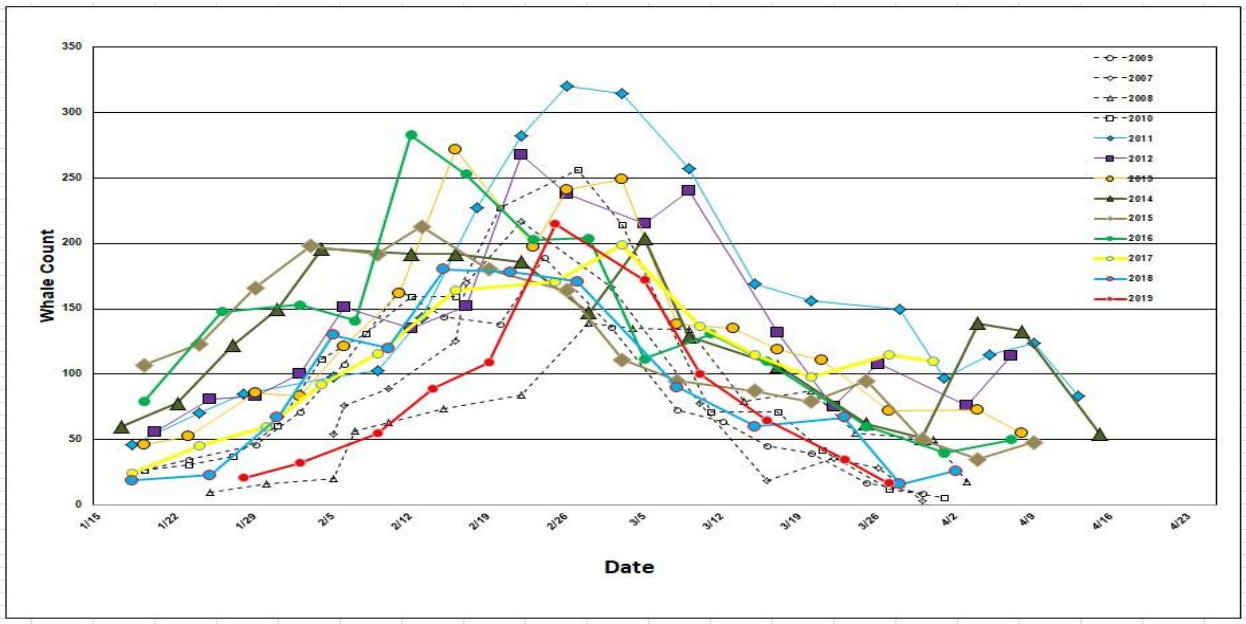


Figure. 5. Numbers of single whales (adult males and females without calves) counted in Laguna San Ignacio during the winter seasons: 2007-2019.

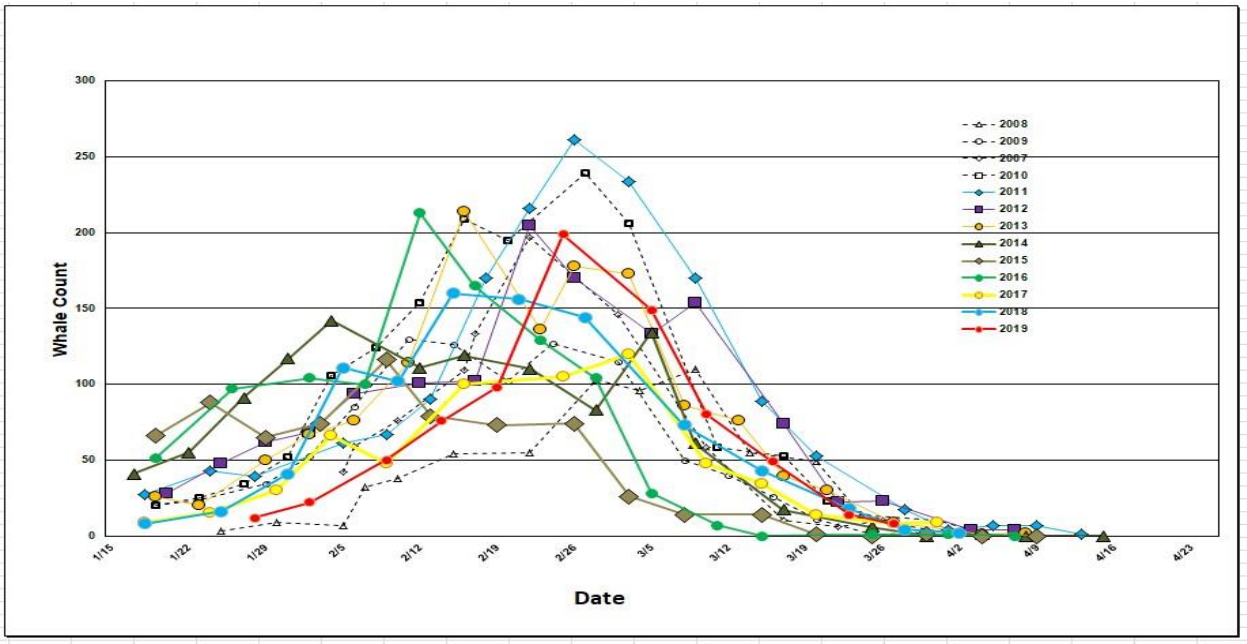


Figure. 6. Numbers of female-calf pairs (females with young of the year) counted in Laguna San Ignacio during the winter seasons: 2007-2019.

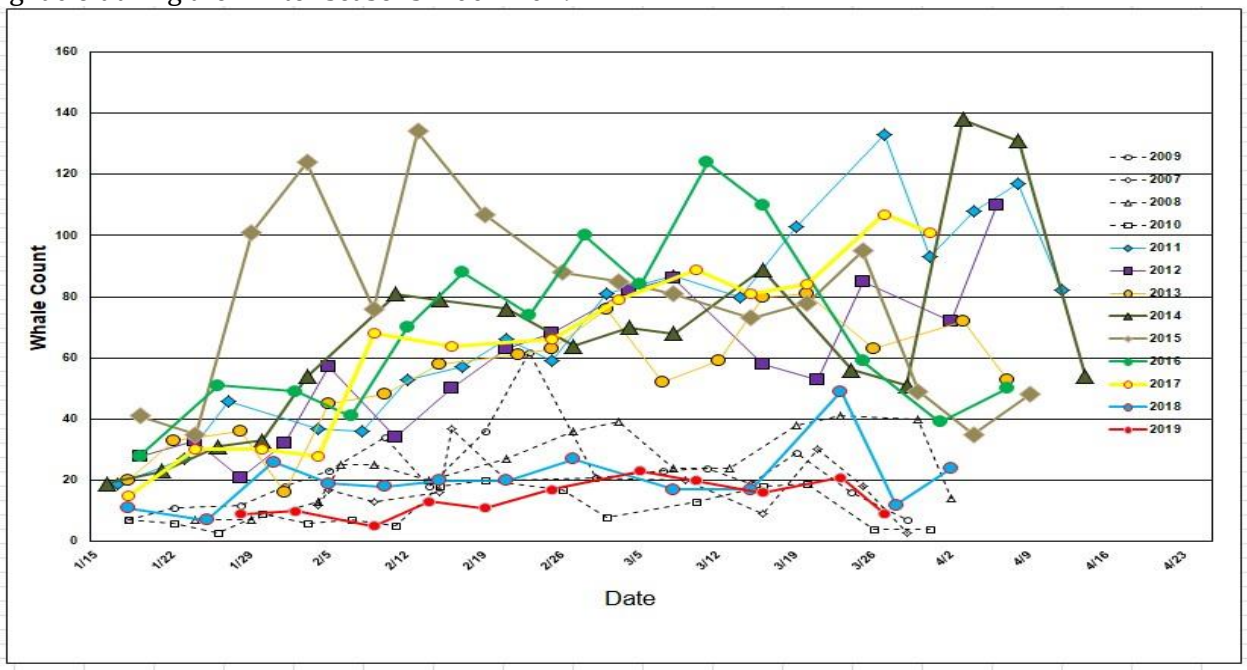
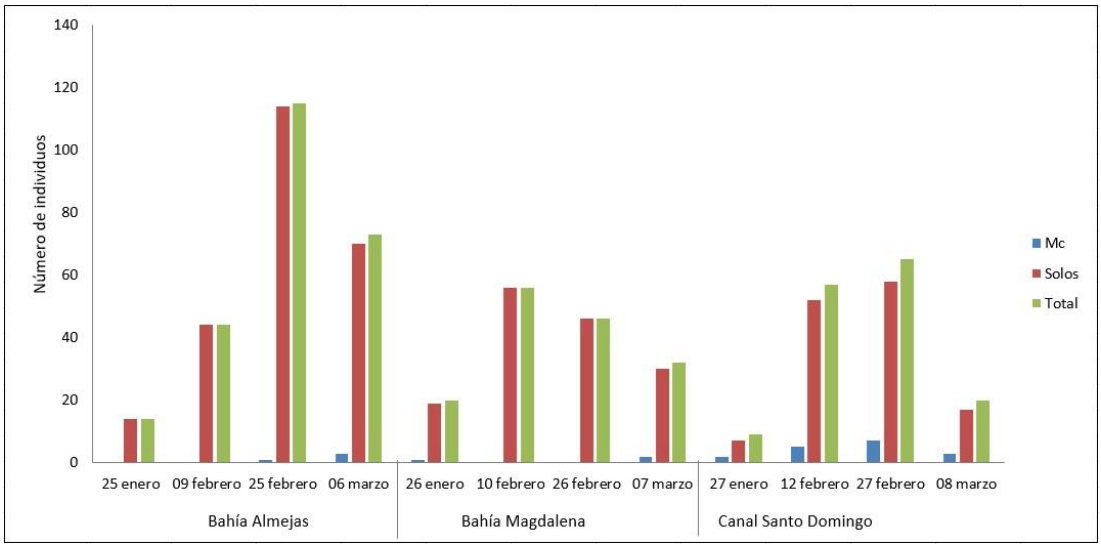


Figure 7. Boat survey counts of gray whales in three areas within the Bahía Magdalena complex during the 2019 winter breeding and calving season. Number of female-calf pairs equals the number of calves observed.



Gray whale sightings in the Bahía Magdalena lagoon complex and surrounded waters in the 2019 winter: Bahía Almejas (BA), Bahía Magdalena (BM) and Lopez Mateos (LM). blue circles = gray whale single animals; red circles = gray whale female-calf pairs.

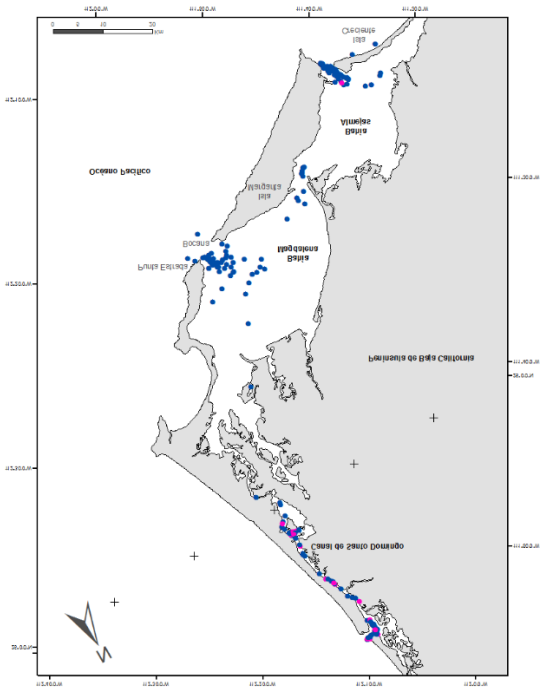
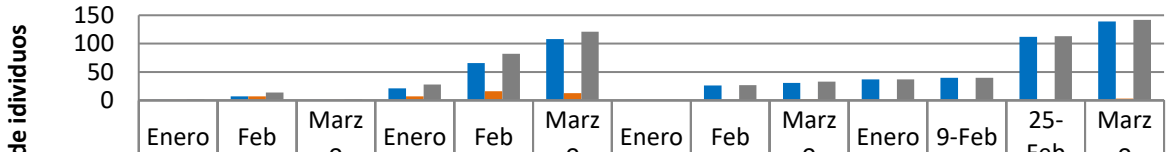


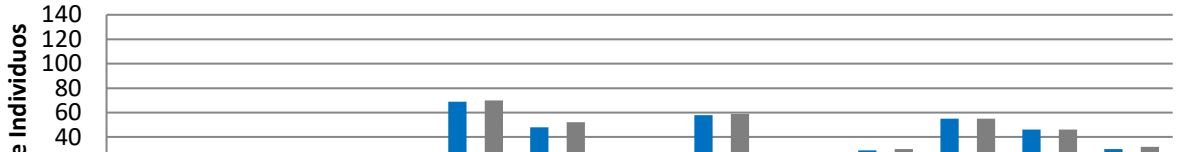
Figure 9a-c. Boat survey counts of gray whales in three areas within the Bahía Magdalena complex during the 2016, 2017, 2018, and 2019 winter breeding and calving season. Number of female-calf pairs equals the number of calves observed.

Figure 9a. Bahía Almejas



	Enero	Feb	Marzo	Enero	Feb	Marzo	Enero	Feb	Marzo	Enero	9-Feb	25-Feb	Marzo
	2016			2017			2018			2019			
Solos	1	7	1	21	66	108	1	26	31	37	40	112	139
Mc	1	7	1	7	16	13	0	1	2	0	0	1	3
Total	2	14	2	28	82	121	1	27	33	37	40	113	142

Figure 9b. Bahía Magdalena



	Enero	Feb	Marzo	Enero	Feb	Marzo	Enero	Feb	Marzo	Enero	10-Feb	26-Feb	Marzo
	2016			2017			2018			2019			
Solos	2	14	1	16	69	48	0	58	10	29	55	46	30
Mc	0	1	0	2	1	4	0	1	1	1	0	0	2
Total	2	15	1	18	70	52	0	59	11	30	55	46	32

Figure 9c. Canal de Santo Domingo

	Enero	Feb	Marzo	Enero	Feb	Marzo	Enero	Feb	Marzo	Enero	12-Feb	27-Feb	Marzo
	2016			2017			2018			2019			
Solos	9	4	0	6	18	13	0	20	8	8	49	58	17
Mc	26	55	4	3	44	34	3	9	16	2	2	7	3
Total	35	59	4	9	62	47	3	29	24	10	51	65	20

Figure 10. Illustration of the anomalous sea temperature in the North Pacific and Gulf of Alaska, referred to as "The North Pacific Blob", and distribution of coastal algal blooms along North America (National Geographic Society website: https://news.nationalgeographic.com/2017/02/space-map-pacific-blob/).

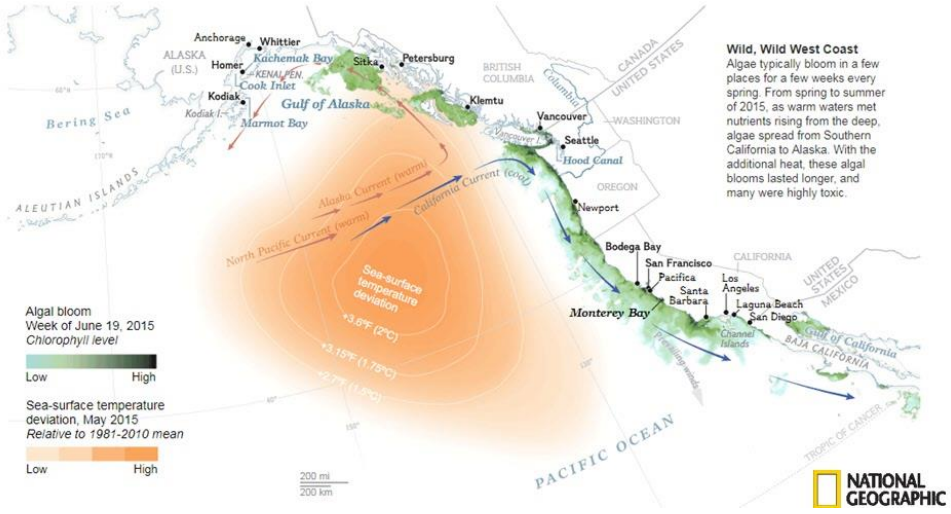


Figure 11. Sea Surface Temperature (SST) forecast for 2018 showing the warmer-than-normal sea temperatures in the North Pacific and Gulf of Alaska (AKA the "North Pacific Blob") that has persisted since 2015.