

**NUMBERS OF GRAY WHALES (*Eschrichtius robustus*)
UTILIZING LAGUNA SAN IGNACIO AND LAGUNA OJO DE LIEBRE,
BAJA CALIFORNIA SUR, MEXICO
DURING THE WINTER BREEDING SEASONS: 2007-2013**

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ABSTRACT

The date of the overall highest wintertime counts of adult gray whales (*Eschrichtius robustus*) in Laguna San Ignacio, Baja California Sur, Mexico occurred as early as 16 February (2013) and as late as 28 February (2008) during the years 2007 to 2013. The earliest date of the highest counts of gray whales in Laguna Ojo de Liebre occurred on 15 February (2010) and as late as 5 March (2007 and 2012). The number of gray whales utilizing Laguna San Ignacio increased during the 2011 to 2013 winter breeding seasons compared to lower and declining counts of whales observed in this lagoon from 2007 to 2010. The highest counts of adult gray whales (i.e., single adults and female-calf pairs combined) were 320 adult whales in 2011, 268 adult whales in 2012, and 272 adult whales in 2013. The highest counts of single whales were 261 single whales in 2011, 205 single whales in 2012, and 214 single whales in 2013. The highest counts of female-calf pairs were 133 female-calf pairs in 2011, 110 female-calf pairs in 2012, and 81 female-calf pairs in 2013. The increase in seasonal high counts of female-calf pairs during the 2011 to 2013 winters suggests that more female whales are utilizing the Laguna San Ignacio region as a winter aggregation area than during the 2007 to 2010 period. Additionally, these late season increases occurring in late-March and early-April after the end of the birthing period in mid-February suggests that female-calf pairs from other winter aggregating areas (e.g., Laguna Ojo de Liebre and Bahía Magdalena) are moving into Laguna San Ignacio late in the winter breeding season. In contrast, in Laguna Ojo de Liebre no late season increase in the counts of female-calf pairs was observed in 2013 as was seen in Laguna San Ignacio.

Key words: gray whales, Baja California, Laguna San Ignacio, Laguna Ojo de Liebre, Scammon's Lagoon, breeding lagoons, abundance counts, female-calf pairs, birth rate, calf production

INTRODUCTION

Laguna San Ignacio and Laguna Ojo de Liebre (also known as Scammon's lagoon) are two of the three primary calving-breeding lagoons and winter aggregation areas of the Eastern North Pacific gray whale (*Eschrichtius robustus*) along the Pacific coast of Baja California Sur, Mexico. These lagoons are located on the west coast of the Baja California Peninsula, and lie within the El Vizcaino Biosphere Reserve (Fig. 1). Boat surveys utilizing a standardized methodology were used in each area to obtain comparable counts of the number of gray whales in these lagoons during the winters from 2007 to 2013. Here we present the 2007 to 2013 gray whale counts and timing of their occupation of Laguna San Ignacio, and compare the dates of the highest whale counts with those

recorded during the same years in Laguna Ojo de Liebre by the Subsecretaría de Gestión Para La Protección Ambiental, Dirección General de Vida Silvestre, of Mexico .

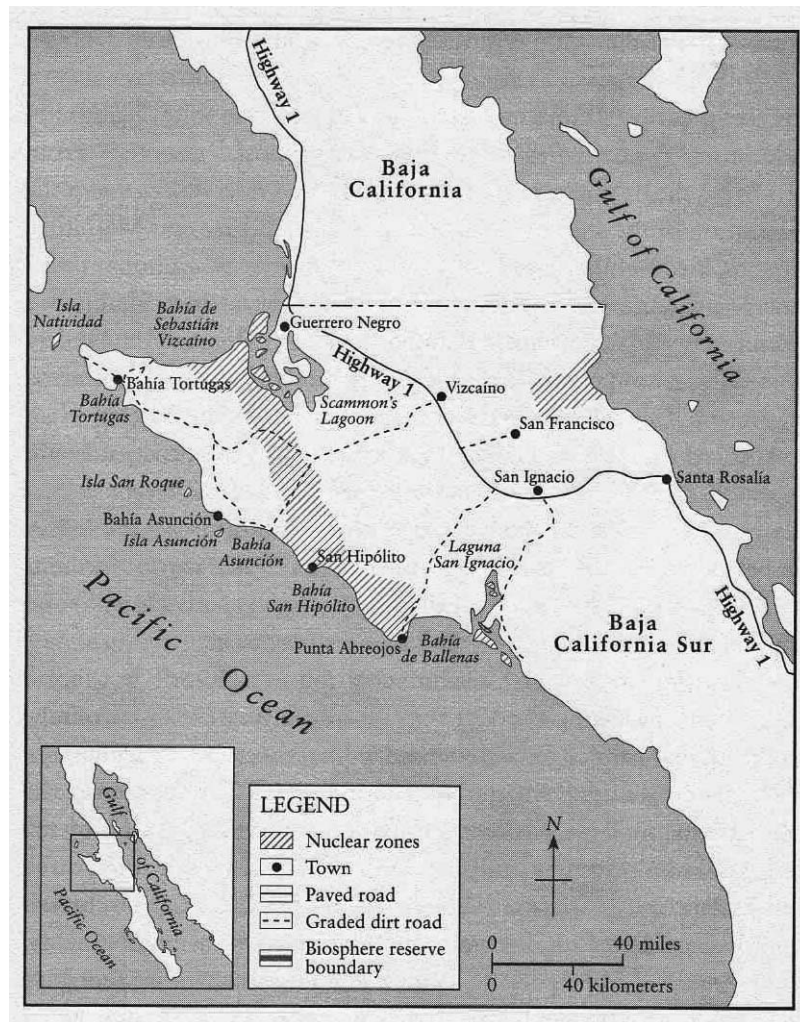


Figure 1. Locations of Laguna San Ignacio and Laguna Ojo de Liebre (Scammon’s Lagoon) within the Vizcaíno Biosphere Reserve of Baja California Sur, Mexico.

METHODS

Boat Surveys (Laguna San Ignacio counts)

Standardized boat surveys have been utilized to count gray whales in Laguna San Ignacio since 1977, and the same methodology continues to be utilized to the present (Jones and Swartz 1984; Urban et al. 2002, 2003, 2010, and 2011; Swartz et al. 2012). Between 2007 and 2013 surveys were conducted from a 7-m outboard powered boat (Panga) which followed a standard transect line at a speed of 11 km/hr during the whale counts (Fig. 2). Speed and transect course were verified using visual landmarks and with a hand-held GPS (Global Position System) device. 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 thus be counted more than once, and allows observers sufficient time to detect surfacing whales (Jones and Swartz 1984). The transect course ran along an imaginary line drawn through the lagoons deep water areas (i.e., > 2.0 m deep) from Isla Garzas at the northern most end of the lagoon

(North End) to the breaker line at the lagoon entrance in the Lower Zone. Each survey required approximately three hours to complete. The maximum distance from the transect line to the 2 m depth contour along shore was 2.5 km and the minimum was 0.8 km. Thus, waters inhabitable by whales and both shorelines were visible at all times within the lagoon, and it was assumed that all whales within 2.5 km of the survey line were seen. Whales in the "North End" of the upper lagoon zone (north of the transect termination) were counted from a stationary location located at the center of the upper portion of the lagoon by observers searching in 360-degrees around the stationary boat (Fig. 2). Surveys were aborted when sea conditions exceeded Beaufort 3 sea state (winds greater than 18 km/hr and consistent white caps).

By convention, we considered "female-calf pairs" (*i.e.*, female whales with calves of the year) 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 animals. Counts of "adult whales" are the sum of all non-calf whales (*i.e.*, single whales and female-calf pairs).

Analysis Procedure

Counts of gray whales in Laguna San Ignacio during each winter season were analyzed and compared across years from 2007-2013 as total adult (non-calf) whales, single whales, and female-calf pairs counted within each of the four lagoon zones: the Lower, Middle, Upper, and North End zones (Fig. 2). The dates and magnitude of the highest gray whale counts in both Laguna San Ignacio and Laguna Ojo de Liebre were compared to evaluate the numbers of whales utilizing each lagoon, and seasonal timing of the occupation of both lagoons by gray whales.

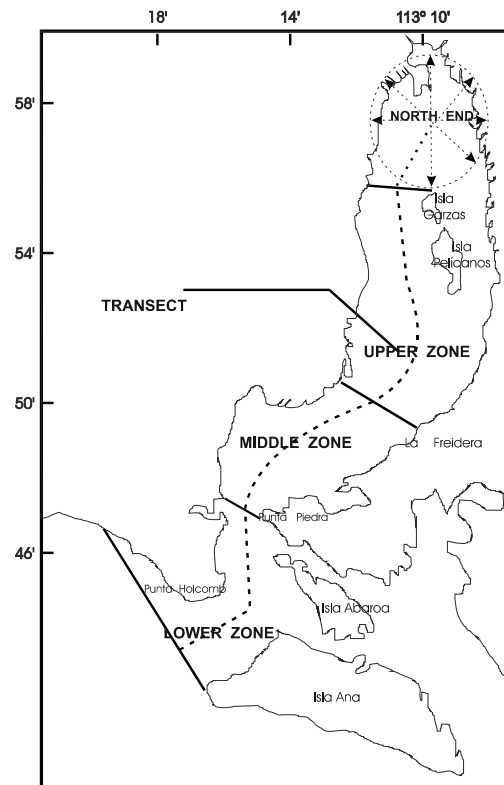


Figure 2. Boat survey track line used to count gray whales in Laguna San Ignacio, Baja California Sur, Mexico between 2007 and 2013.

RESULTS

Gray whale counts in Laguna San Ignacio during 2007-2013:

One-hundred-seven (107) boat surveys to count gray whales were conducted in Laguna San Ignacio from 2007 to 2013 (Figs. 3-5). Surveys typically began in mid-January and the last surveys were conducted the first or second week in April each year.

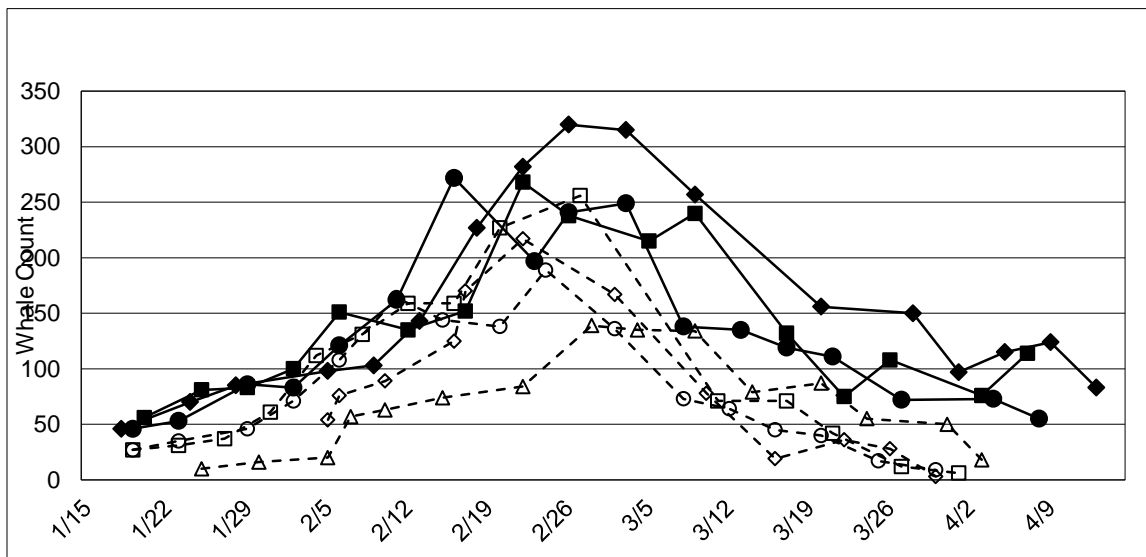


Figure 3. Adult whale counts in Laguna San Ignacio from 2007 to 2013. Black circles = 2013; Black squares = 2012; Black diamonds = 2011; Open squares = 2010; Open circles = 2009; Open triangles = 2008; and Open diamonds = 2007.

The counts of gray whales utilizing Laguna San Ignacio, Baja California Sur, Mexico during the 2011 to 2013 winter breeding seasons were larger compared to counts of whales observed in this lagoon from 2007 to 2010 (Table 1). Seasonal high counts of gray whales occurred as early as 16 February in 2013 (272 whales), and as late as 28 February in 2008 (139 whales). Between 2007 and 2013 gray whales arrived at Laguna San Ignacio at the same time and their counts increased at the same rates (Fig. 3). However, the departure of single whales during the 2007-2010 occurred 1-2 weeks earlier than during the period 2011 and 2013 (Fig 4). Counts of female calf pairs in Laguna San Ignacio increased during January and February to their highest numbers in March and April during the 2011 to 2013 winters, and averaged 108 pairs in those years. In contrast, female-calf pair counts averaged only 40 pairs during the 2007 to 2010 winters. Female-calf pairs were basically absent from the lagoon by April during the 2007-2010 winters, but during 2011 to 2013 winters counts of these whales continued to increase throughout the winter season and between 81 pairs (2013) and 133 pairs (2011) remained in the lagoon at the end of the season in April (Fig. 5).

Table 1. Dates of highest counts of adult gray whales (single adults, and female-calf pairs combined) in Laguna San Ignacio from 2007-2013.

DATE	ADULTS	SINGLE ADULTS	FEMALE-CALF-PAIRS
22-Feb-2007	217	197	20
28-Feb-2008	139	103	36
24-Feb-2009	189	127	62
27-Feb-2010	256	239	17
26-Feb-2011	320	261	59
22-Feb-2012	268	205	63
16-Feb-2013	272	214	58

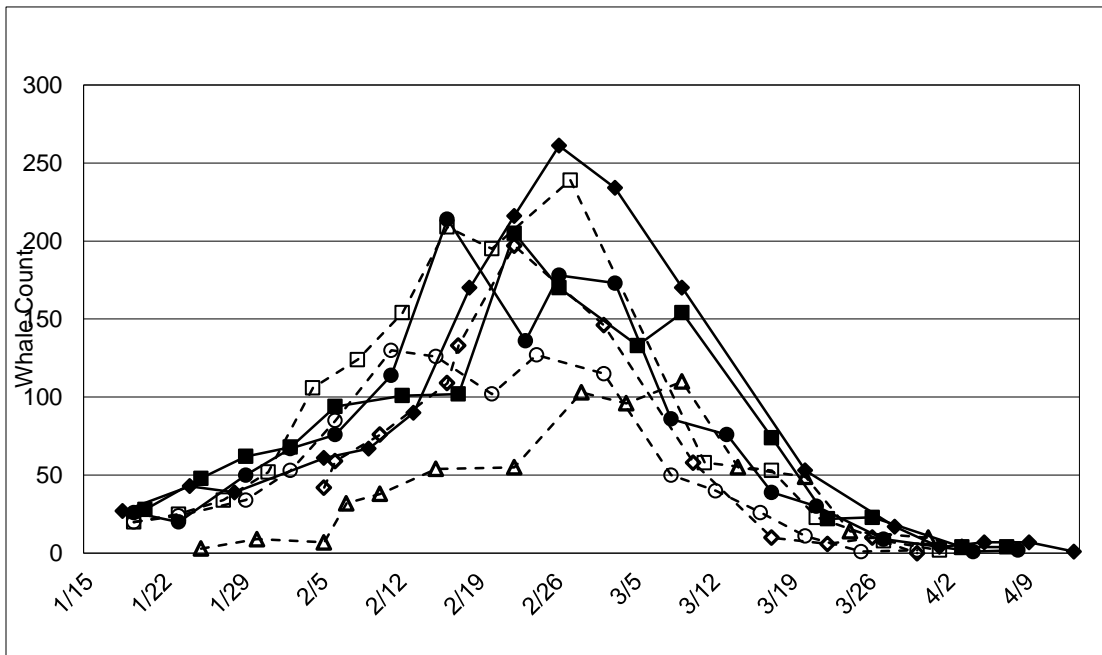


Figure 4. Single whales counted in Laguna San Ignacio from 2007 to 2013. Black circles = 2013; Black squares = 2012; Black diamonds = 2011; Open squares = 2010; Open circles = 2009; Open triangles = 2008; and Open diamonds = 2007.

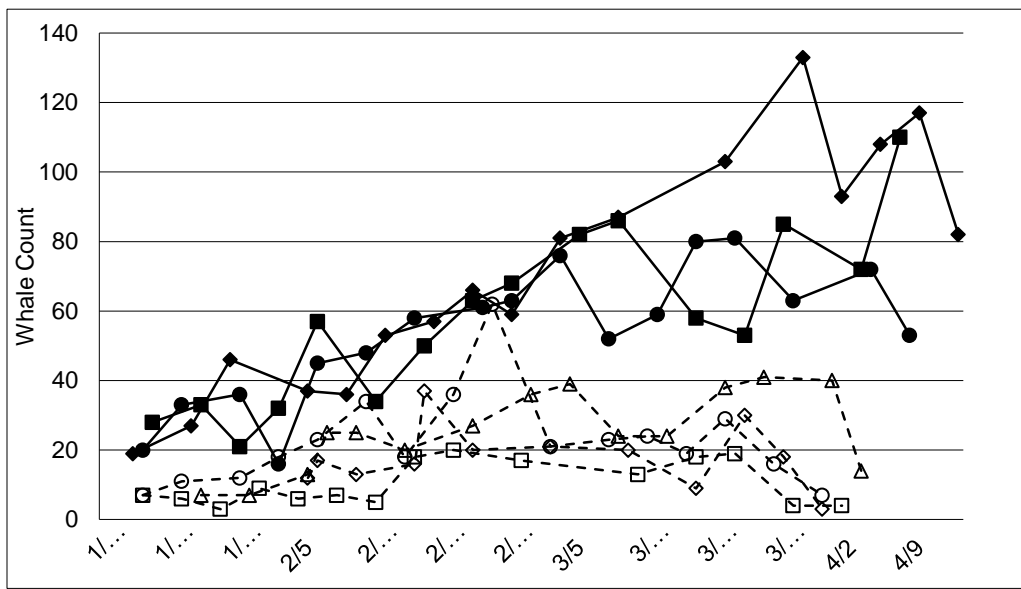


Figure 5. Female-calf pairs counted in Laguna San Ignacio from 2007-2013. Black circles = 2013; Black squares = 2012; Black diamonds = 2011; Open squares = 2010; Open circles = 2009; Open triangles = 2008; and Open diamonds = 2007.

The average highest count of adult gray whales (i.e., non-calf whales) during the period 2007 to 2010 was 200 whales, compared to high counts of 320 adult whales in 2011, 268 adult whales in 2012, and 272 adult whales in 2013 (Table 2). The average highest count of single adult whales (non-female-calf pairs) during the period 2007-2010 was 169 whales, compared to the high counts 261 single whales in 2011, 205 single whales in 2012, and 214 in 2013. The average highest count of female-calf pairs during the period 2007 to 2010 was 40 pairs compared to the highest counts of 133 female-calf pairs in 2011, 110 female-calf pairs in 2012, and 81 female-calf pairs in 2013.

The dates of highest counts of adult whales occurred between 16 February (2013) and 28 February (2008) during the period 2007 to 2013 (Table 2). The highest counts of single whales occurred between 16 February (2013) and 9 March (2008) during the 2007 to 2013 period. The highest counts of female-calf pairs were observed as early as 17 February (2007) and as late as 7 April (2012).

Table 2. Dates and maximum counts of gray whale, adults (non-calf whales), single whales (non-female-calf pairs), and female-calf pairs in Laguna San Ignacio from 2007 to 2013.

ADULT WHALES		SINGLE ADULTS		FEMALE-CALF PAIRS	
DATE	NUMBER	DATE	NUMBER	DATE	NUMBER
22-Feb-2007	217	22-Feb-2007	197	17-Feb-2007	37
28-Feb-2008	139	9-Mar-2008	110	24-Mar-2008	41
24-Feb-2009	189	11-Feb-2009	130	24-Feb-2009	62
27-Feb-2010	256	27-Feb-2010	239	20-Feb-2010	20
26-Feb-2011	320	26-Feb-2011	261	28-Mar-2011	133
22-Feb-2012	268	22-Feb-2012	205	7-Apr-2012	110
16-Feb-2013	272	16-Feb-2013	214	21-Mar-2013	81

Gray whale counts in Laguna Ojo de Liebre 2007-2013:

Twelve surveys to count gray whales in Laguna Ojo de Liebre were conducted during the 2013 winter by the Subsecretaría de Gestión Para La Protección Ambiental, Dirección General de Vida Silvestre, of Mexico. Surveys began on 9 January 2013, and continued until 12 April 2013 (Table 3). As seen in Laguna San Ignacio, survey counts for all whales increased during January and reached their highest number (729 adult whales) in late February (25 February 2013). Afterword survey counts for adult whales declined to their lowest count by mid-April (Fig. 6). Unlike Laguna San Ignacio, there was no late season increase in gray whale counts during the last month of the winter.

The 2013 survey counts of single whales in Ojo de Liebre increased through January to a maximum of 181 single whales on 31 January 2013 (Table 3). Single whale counts then declined during February and March to their lowest numbers (3 single whales) on the final survey day on 12 April 2013. Counts of female-calf pairs increased during January and February to a maximum count of 592 female-calf pairs on 25 February 2013. Counts of female-calf pairs then declined during March and April to a low of 78 pairs on 12 April 2013 (Fig. 6).

The dates of highest adult whale counts (i.e., non-calf whales) in Ojo de Liebre during the period 2007 to 2013 occurred as early as 15 February (573 adult whales in 2010) and as late as 5 March (924 adult whales in 2007 and 2,721 adult whales in 2012) (Table 4).

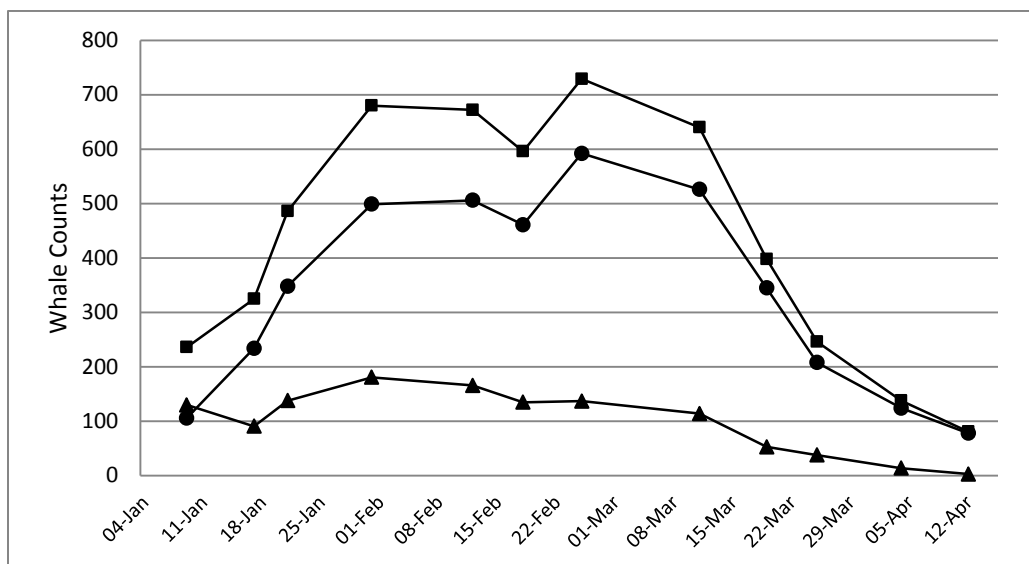


Figure 6. Survey counts of gray whales in Laguna Ojo de Liebre during the 2013 winter. Black squares = Adult whales; Black circles = Female-calf pairs; Black triangles = Single whales (data provided by the Subsecretaría de Gestión Para La Protección Ambiental, Dirección General de Vida Silvestre, of Mexico).

Table 3. Counts of gray whales in Laguna Ojo de Liebre in 2013 (data provided by the Subsecretaría de Gestión Para La Protección Ambiental, Dirección General de Vida Silvestre, of Mexico).

DATE	ADULTS	SINGLE ADULTS	FEMALE-CALF-PAIRS
9-Jan-2013	236	130	106
17-Jan-2013	325	91	234
21-Jan-2013	486	138	348
31-Jan-2013	680	181	499
12-Feb-2013	672	166	506
18-Feb-2013	596	135	461
25-Feb-2013	729	137	592
11-Mar-2013	640	114	526
19-Mar-2013	398	53	345
25-Mar-2013	246	38	208
4-Apr-2013	138	14	124
12-Apr-2013	81	3	78

Table 4. Dates of highest counts of gray whales (total adults = single adults + and female-calf pairs) in Laguna Ojo de Liebre from 2007 to 2013 (data provided by the Subsecretaría de Gestión Para La Protección Ambiental, Dirección General de Vida Silvestre, of Mexico).

DATE	TOTAL ADULTS	SINGLE ADULTS	FEMALE-CALF-PAIRS
5-Mar-2007	924	565	359
3-Mar-2008	1192	720	472
23-Feb-2009	929	607	322
15-Feb-2010	573	390	183
2-Mar-2011	1482	883	599
5-Mar-2012	2721	1523	1198
25-Feb-2013	729	137	592

DISCUSSION

In Laguna San Ignacio the maximum counts of 320 adult whales on 26 February 2011, 268 whales on 22 February 2012, and 272 whales on 16 February 2013 represents a 43% increase above the mean high count of 200 adult whales during 2007-2010 (Table 2). The maximum counts of single whales (non-female-calf pairs) of 261 whales on 26 February 2011, 205 whales on 22 February 2012, and 214 single whales on 16 February 2013 represents a 34% increase over the mean high count of 169 single whales during the 2007-2010 period (Table 2). The maximum counts of female-calf pairs were 133 pairs on 28 March 2011, 110 pairs on 7 April 2012, and 81 pairs on 16 February 2013, representing an increase of 169% over the mean high count of 40 female-calf pairs during 2007-2010 (Table 2).

The principal contributor to the increase in the number of whales utilizing Laguna San Ignacio during the period from 2011 to 2013 was the increase in the number of female-calf pairs, which increased from an average of 40-pairs during the period 2007-2010 to maximum count of 133-pairs in 2011, 110-pairs in 2012, and 81 pairs in 2013. These increases in seasonal high counts of female-calf pairs observed in the 2011-2013 winters suggests that more female whales are utilizing the Laguna San Ignacio region as a winter aggregation area than during the 2007-2010 period. Additionally, these late season increases in occurring in late-March and early-April after the end of the birthing period in mid-February. During the 2011, 2012 and 2013 winters the female-calf pairs entering Laguna San Ignacio at the end of the season included calves that were judged by their size to be 1-2 months old, and not newborn individuals. The gray whale calf birthing period begins in January and is completed by mid-February each year (Rice and Wolman 1971, Jones and Swartz 1984). Thus, these female-calf pairs arriving after the birthing period likely include females that gave birth and resided with their calves in other gray whale winter aggregation areas before coming to Laguna San Ignacio.

The size and estimated age of these calves suggests that female-calf pairs from other winter aggregating areas (e.g., Laguna Ojo de Liebre and Bahia Magdalena) are moving into Laguna San Ignacio late in the winter breeding season. This pattern of lagoon occupation by female-calf pairs was seen during the 1977-1982 winters in Laguna San Ignacio (Jones and Swartz 1984), but not during the 2007 to 2010 surveys. Photographic identification data obtained in Bahia Magdalena during the 2012 and 2013 winters confirm the movements of female-calf pairs from this area into Laguna San Ignacio (*unpublished results*). Similarly, Jones and Swartz (1984) confirmed from photographic identification analysis that female-calf pairs from the Magdalena Bay region to the south and from the Guerrero Negro and Ojo de Liebre region from the north were gathering in Laguna San Ignacio prior to beginning their northward migration to their summer feeding grounds. Other whales first photographed in Laguna San Ignacio were later photographed in other aggregation areas, indicating that gray whales circulate among the breeding lagoons in winter.

The 2013 survey counts for Laguna Ojo de Liebre did not suggest a late season increase in female-calf pairs as was documented in Laguna San Ignacio. This suggests that once their calves are of sufficient age, females leave Laguna Ojo de Liebre with their calves and begin their northward spring migration, or perhaps visit Laguna San Ignacio or other winter aggregation areas in Baja California before their northward migration. The 2013 survey counts for Laguna Ojo de Liebre show a pattern similar to that reported by Jones and Swartz (1984) during the 1980 winter: overall counts were the highest in mid-February, with a high count of 829 adult whales on 1 February 1980; the highest count of single whales was 438 single whales on 1 February 1980; and counts of female-calf pairs were greater than counts of single whales, reaching a high count of 571 female-calf pairs on 4 February 1980; all whale counts declined in March and there were few whales in Laguna Ojo de Liebre by April 1980. The most striking difference between the two lagoons is that there does not appear to be a late season increase in the numbers of female-calf pairs in Laguna Ojo de Liebre as was seen in Laguna San Ignacio during the 1978 to 1982 winters (Jones and Swartz 1984), and during the 2011-2013 winters (*this report*).

A number of factors may contribute to the increase in female-calf pairs seen in Laguna San Ignacio during the 2011 to 2013 winters. Between 1998 and 2000 the Eastern North Pacific gray whale population suffered a range-wide mortality event where annual mortalities exceeded the previous ten year averages by up to ten-fold. Dead whales examined from Alaska to Mexico appeared emaciated, undernourished, and the majority of the dead animals were females (LeBoeuf et al. 2000, Gulland et al. 2005). Following the die-off, estimates of the Eastern North Pacific gray whale population decreased 23% from 21,135 in 1997-1998 to 16,369 in 2000-2001 (Laake et al. 2009), which implies that up to one-third or more breeding females may have been lost from the population, as breeding females would be more susceptible to nutritional stress due to recurring pregnancies and lactations. Loss of breeding females would result in lower calf production following the die-off, as noted by LeBoeuf et al. (2000) and Urban et al. (2003), and fewer sightings of female-calf pairs in the breeding areas off Baja California's Pacific coast following the die-off (Urban et al. 2010). If the impact of this mortality event was most severe on breeding females, it is possible that new cohorts of females have reached sexual maturity and replaced mature breeding females that were lost as a result of the range-wide die-off of gray whales during 1998-2000.

It has been 13-years since the die-off event, and gray whales reach reproductive maturity on average at 8-years of age (range from 5-11 years) (Rice and Wolman 1971). During this post-die-off period, cohorts of young female gray whales would be expected to increase each year, maturing and beginning to reproduce successfully. We would then expect to see increasing numbers of females-with calves as these new breeders replace those that were lost during the die-off event. The increase in the number of female-calf pairs observed in Laguna San Ignacio during the 2011-2013 winters lends support to this hypothesis.

There have been few observations of "skinny" adult whales in Laguna San Ignacio in since the 2007-2010 winters; rather, photographic identification data obtained during the 2011 to 2013 winters indicate that females and calves are in good condition, suggesting that gray whale females are finding adequate nutritional prey resources during the summer, either from traditional feeding areas that have recovered from the oceanographic regime shifts of the 1980's, or in new areas where traditional prey have become established in combination with alternative feeding sites with reliable sources of food, and in novel areas where alternative prey are now available, or some combination of these (Moore, et al. 2007).

Finally, water temperature apparently influences the winter distribution of gray whales along the Baja California coast, and particularly the distribution of females with calves. Urban et al. (2003) noted that during warmer El Niño events fewer gray whale females and calves are seen in the breeding aggregation areas around the lagoons of Baja California, and the opposite is seen during colder water conditions of the La Niña events when females and calves are seen in more southerly latitudes including the Gulf of California and coastal areas of mainland Mexico. The sea temperatures in Laguna San Ignacio during the 2010-2013 winters were colder than usual (unpublished data), a mild La Niña condition, and this may have also contributed to the increase in the number of gray whale female-calf pairs seen in Laguna San Ignacio and their longer duration of stay in the area.

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