INCREASE IN THE NUMBER OF GRAY WHALES (*Eschrichtius robustus*) UTILIZING LAGUNA SAN IGNACIO, BAJA CALIFORNIA SUR, MEXICO DURING THE 2011 WINTER

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ABSTRACT

Following four years (2007-2010) of declining counts of Eastern North Pacific gray whales within Laguna San Ignacio, Baja California, Sur, Mexico, the number of whales utilizing this lagoon during the 2011 winter breeding season was significantly higher than that seen in recent winters, and counts of female-calf pairs continued to increase following the birthing period for calves, suggesting that female-calf pairs were entering this lagoon from other areas. Weekly census counts began on 18 January 2011 and continued until 13 April 2011 to document the number of whales utilizing the lagoon during the winter. Gray whales continued to enter the lagoon through January and February and counts of adult whales reached a high count of 320 whales on 26 February, representing a 60% increase above the average high counts between 2007-2010 and approaching the number of adult whale counts observed in the 1980's. The number of single whales (whales not accompanied by calves) observed in 2011 reached its maximum of 261 whales on 26 February, and was similar to single whale counts obtained in the 1980's. Counts of female-calf pairs increased throughout the winter and reached a maximum of 133 pairs on 28 March, and 82 pairs were counted on the last census on 13 April. The 2011 high count of female-calf pairs was 233 % increase over the previous four year average count of 40-pairs (2007-2010). The increase in seasonal high counts suggests that more female whales are successfully producing calves following the range-wide die-off of 1998-2000 (LeBoeuf et al. 2000), gray whale females are finding adequate prey in their summer Arctic feeding areas to successfully produce offspring following disruption of their prey species populations in recent decades (Moore et al. 2008), oceanographic conditions and sea temperatures favored gray whales' reproduction and their occupation of the breeding-calving areas off the Baja California coast, or some combination of these and other factors.

Key words: gray whales, Baja California, Laguna San Ignacio, breeding lagoons, abundance counts, birth rate, calf production, die-off, habitat, distribution, research and monitoring

INTRODUCTION

Laguna San Ignacio (LSI) is one of the three calving-breeding lagoons and winter congregation areas of the Eastern North Pacific gray whale (*Eschrichtius robustus*). The lagoon is located in the west coast of the Baja California Peninsula in Mexico (Fig 1), and lies within the El Vizacaino Biosphere Reserve. Standardized counts of the number of gray whales in the lagoon during the winter were conducted during three time periods: Series 1 from 1978-1982 (Jones and Swartz 1984); Series 2 from 1996-2000 (Urban et al. 2010), and Series 3 from 2006-present (Urban et al. 2010 and 2011). Historically, counts of gray whales were greatest during the 1977-1982 Series, then continually declined between the second and third Series (1996-2010) reaching the lowest counts during the 2010 winter. Counts then increased significantly during the 2011 winter, particularly counts of female-calf pairs increased significantly, and approached historical densities and distributions of whales observed in the lagoon during the 1980s. Additionally, numbers of female-calf pairs continued to increase following the birthing period suggesting that female-calf pairs were entering Laguna San Ignacio from other areas, a pattern not observed since the late-1970's and mid-1980's. Here we present the 2011 gray whale counts and timing of lagoon occupation by gray whales in comparison with the previous years, and suggest some factors that may have contributed to this increase.

METHODS

Boat Surveys (census)

Two-hundred twenty-one census surveys to determine whale abundance and distribution within the lagoon were conducted during the period 1978-2011: 60-surveys during the period 1978-1982; 70-surveys from 1996-2000; and 74-surveys from 2006-2011. Surveys followed a standard survey transect (Fig. 2) and whale counts obtained by using standard observer protocol each year to allow comparison with previous survey counts and historical counts from this lagoon (Jones and Swartz 1984, Urbán *et al*., 2002).

Each survey was conducted from a 7-m outboard powered boat (Panga) which followed a standard transect line. Boats travelled at a speed of 11 km/hr during the whale counts. 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. The transect line ran along an imaginary line drawn through the lagoons deep water areas (i.e., > 2.0 m deep) from the breaker line at the lagoon entrance in the lower lagoon zone, to Isla Garzas at the north end of the lagoon in the upper zone. Each survey required about 2.5 to 3.0 hr 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 clearly visible at all times within the lagoon (it was assumed that essentially all animals within 2.5 km of the trackline 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 centre 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.

Analysis Procedure

Counts of gray whales during each winter season were analyzed as total adult (non-calf) whales, single whales, and female-calf pairs counted within each of the three primary zones (*i.e*., the lower, middle, and upper lagoon zone including the north end area) (Fig. 2). The distribution of whales within the lagoon's three zones

were expressed as the percent (%) of the total number of whales counted in each zone during surveys conducted during the period of maximum whales counts in late-February. The three time series compared with the 2011 whale counts were: 1978-1982, 1996-2000, and 2006-2010.

RESULTS

Abundance

Seasonal high counts of gray whales in Laguna San Ignacio occurred as early as 2 February (1978) and as late as 2 March (1996) (Table 1). The maximum whale counts during the 2011 winter season were 320 total adult whales counted on 26 February, 261 single whales counted on 26 February, and 133 female-calf pairs counted on 28 March. These numbers represent substantial increases over the previous four year averages (2007-2010): for adult whales an increase of 60% over the previous 4-year average of 200; for single whales an increase of 54% over the previous 4-year average of 169; and for female-calf pairs an increase of 233% over the previous 4-year average of 40 pairs (Table 2; Figs. 3,4,5).

The arrival of gray whales from Laguna San Ignacio during the 1978-1982 was earlier than during the period 1996-2010, and their departure later in the season (Fig. 3). In recent years whales arrived at the lagoon 10-14 days later in January, and left the lagoon by the last week in March than during the 1980's. Single whales (non-female-calf pairs) arrived in mid- to late-January and departed the lagoon by the end of March (Fig. 4). In 2011 female-calf pairs began arriving in the lagoon in mid-January and their numbers increased to a maximum count of 133 pairs on 28 March, after which they remained in the lagoon and numbered at least 82-pairs at the last census survey on 13 April (Fig. 5). From the 1990's to 2010, counts of female-calf pairs declined to as low as 20 pairs in 2010 and were absent from the lagoon by the end of March. However, rather than decreasing by the end of the season as seen during the 1996-2010 winters, counts of female-calf pairs increased in 2011 and remained high during the first half of April; the final survey on April 13th counted 82 female-calf pairs, and local fishermen (pers. comm..) reported eight female-calf pairs remained in Laguna san Ignacio on May 12th 2011(Fig. 5). In summary, in 2011 female-calf pairs occupied the lagoon in greater numbers than any time during the previous decade and remained longer in the lagoon, a pattern seen during the surveys of the 1970's and1980's (Jones and Swartz 1984), but not seen from 1996-2010.

Distribution

During the 1970's and 1980's gray whale count were the highest ever recorded (i.e., 407 whales on 14 February 1982), and whales were distributed throughout the entire length of Laguna San Ignacio during the winter. Whales segregated into two groups – single breeding whales and female-calf pairs, and each group utilized the lagoon differently at different times. Single whales were most abundant in the areas nearest the entrance of the lagoon, while female-calf pairs utilized the interior middle and upper lagoon areas furthest from the lagoon entrance and breeding groups of single whales (Jones and Swartz 1984).

During the period 1996 to 2010 numbers of whales counted in the lagoon were less than in previous years, and the segregation of single and female-calf groups was less distinct. Also, few whales were observed utilizing the upper portions of the lagoon during this period (Table 3). In contrast, during the 2011 winter the maximum counts of adult whales increased to 320 whales on 26 February compared to 207 whales on 2 March 1996 and 256 whales on 27 February 2010. Most of this increase was due to the high counts of female-calf pairs observed in 2011, which increased from 17-female calf pairs on 27 February 2010 to 59-pairs on 26 February 2011. As was observed during the 1970's and 1980's, female calf pairs utilized the entire lagoon, being almost evenly distributed within the upper, middle, and lower lagoon areas at the time of maximum counts and whale densities within the lagoon (Table 3).

DISCUSSION

Several factors may have contributed to the sudden increase in the number of gray whales that occupied and utilized Laguna San Ignacio during the 2011 winter reproductive season. The number of single whales (i.e., non-female-calf pairs) was relatively unchanged from that observed during the previous four years: the counts of single whales in 2011 were similar to previous years, and the timing of the arrival of single whales and their departure from the lagoon was delayed 7-10 days compared to the occupation of the lagoon by single whales during the period 1978-1982 (Fig 4). This delay was also observed during the census conducted during the southward fall migration off Carmel, Central California, suggesting that gray whales were spending more time in their summer range, presumably feeding (Rugh et al. 2008).

The principal contributor to the increase in the number of whales in the lagoon was attributable to an increase in the number of female-calf pairs: maximum counts of female-calf pairs increased from an average of 40-pairs during the period 2007-2010 to 133-pairs in 2011, a 233% increase. In addition, some female-calf pairs remained in the lagoon following the birthing period and their numbers continued to increase until early-April, suggesting that female-calf pairs were entering Laguna San Ignacio from other areas. This pattern of late-season arrival of female-calf pairs had not been seen since the surveys conducted during the 1970's and 1980's by Jones and Swartz (1984), who confirmed from photographic identification analysis that female-calf pairs were gathering in Laguna San Ignacio from the Magdalena Bay region to the south and from the Guerrero Negro and Ojo de Liebre region from the north.

Previous annual fluctuations of the numbers of female-calf in the lagoons were similar to changes in the estimates of gray whale calves observed during the spring northward migration based on shore-based surveys conducted from the Piedras Blancas Light Station in California (Perryman *et al*. 2002, 2010). Perryman et al. suggest that the numbers of calves that are born each year are influenced by the amount of time pregnant female whales are able to feed in the Arctic, and this is a function of the degree of seasonal ice cover in the areas where the whales find their prey: more calves are seen migrating north in the winter-springs following mild "light ice" Arctic summers, while fewer calves are seen in winters following severe "heavy" ice conditions in the Arctic (Perryman et al., 2010). But this correlation between calf production and ice conditions cannot explain the significant increase in the number of female-calf pairs seen in Laguna San Ignacio in 2011.

It is possible that the Eastern North Pacific gray whale population now includes new cohorts of females that 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. 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). This mortality event was presumably triggered by a decline in biomass of the whale' principal prey, due in part to the combination of increasing sea surface temperatures resulting from a "regime shift" during the previous decade in the North Pacific (Hare and Manuta 2000), the 1997-1998 El Niño event that proceeded the die-off (Gulland et al. 2005), and increased predation from the growing gray whale population (Moore 2008).

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).

It has been 11-years since the die-off event, and gray whales reach reproductive maturity on average at 8-years of age (range from 5-11years) (Rice and Wolman 1971). During the 11-year post-die-off period, cohorts of young female gray whales would be increasing 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. In fact, the increase in the number of female-calf pairs observed in Laguna San Ignacio and in Laguna Ojo de Liebre during the 2011 winter supports this hypothesis (Urban et al. 2011).

Observations of healthy “fat” calves of the year and few “skinny” adult whales in Laguna San Ignacio in 2011 also suggests 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 mainland Mexico. The sea temperature during the 2010-2011 winter was colder than usual, 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 the lagoon and their longer duration of stay in the area.

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Figure 1. Laguna San Ignacio Study site in Baja California Sur, Mexico.

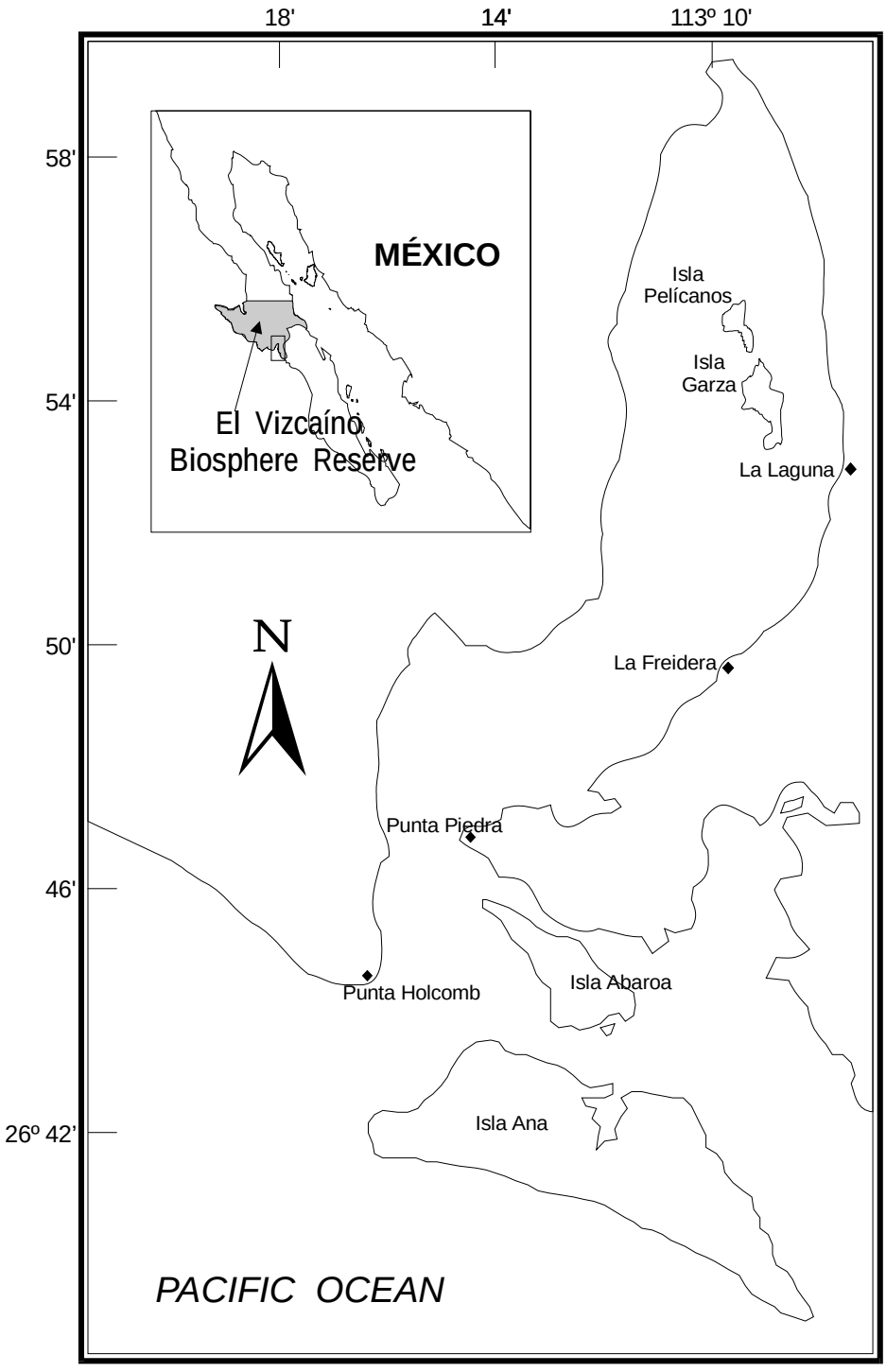

Figure 2. Transect survey line used for all boat counts (census) surveys.

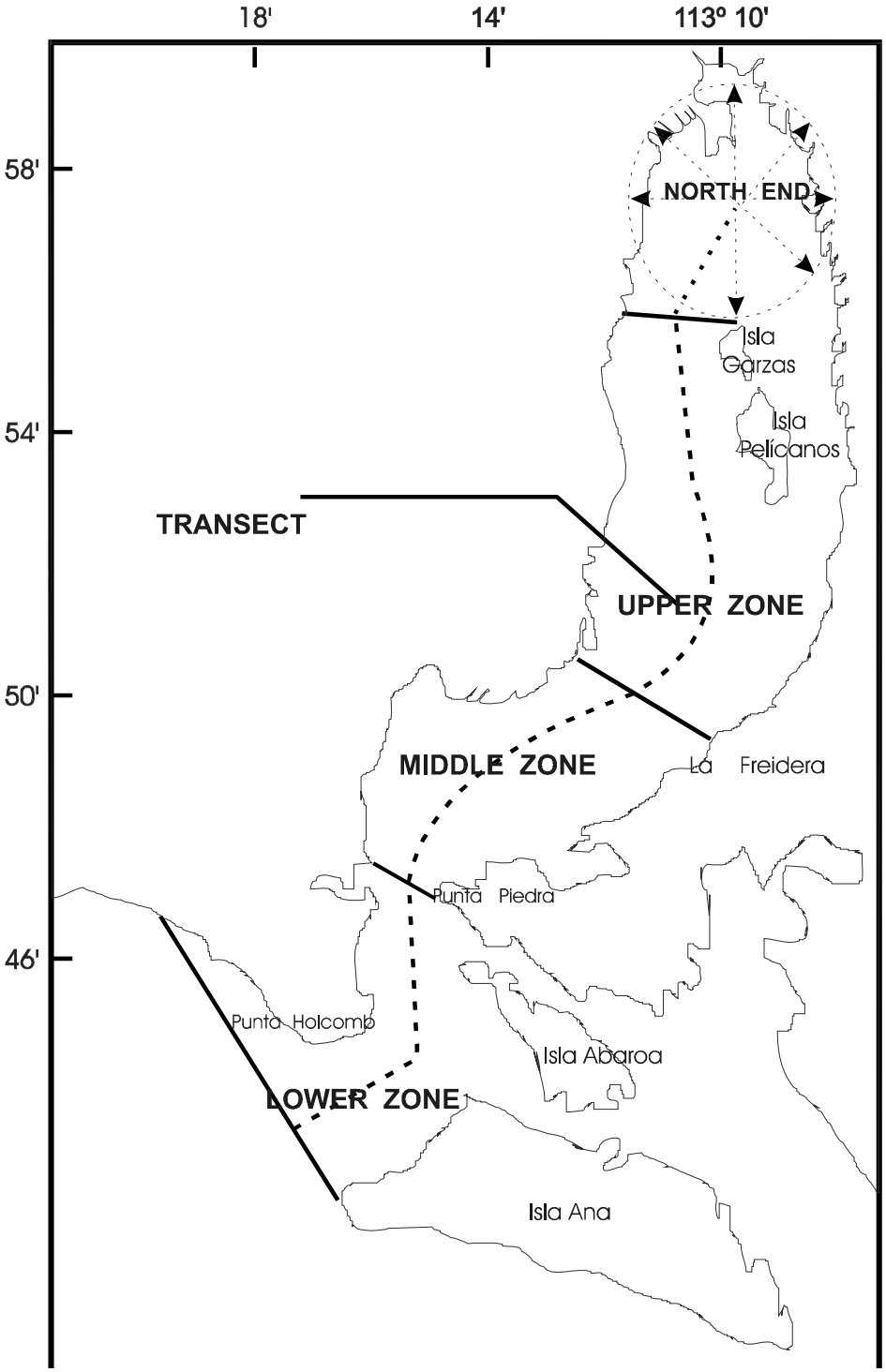

Figure 3. Adult whales counts in Laguna San Ignacio from 1978 to 2011. Dotted lines are counts during 1978-1982; solid lines are counts from 1996-2000; dashed lines are counts from 2007-2010; and solid line with diamonds are counts from 2011.

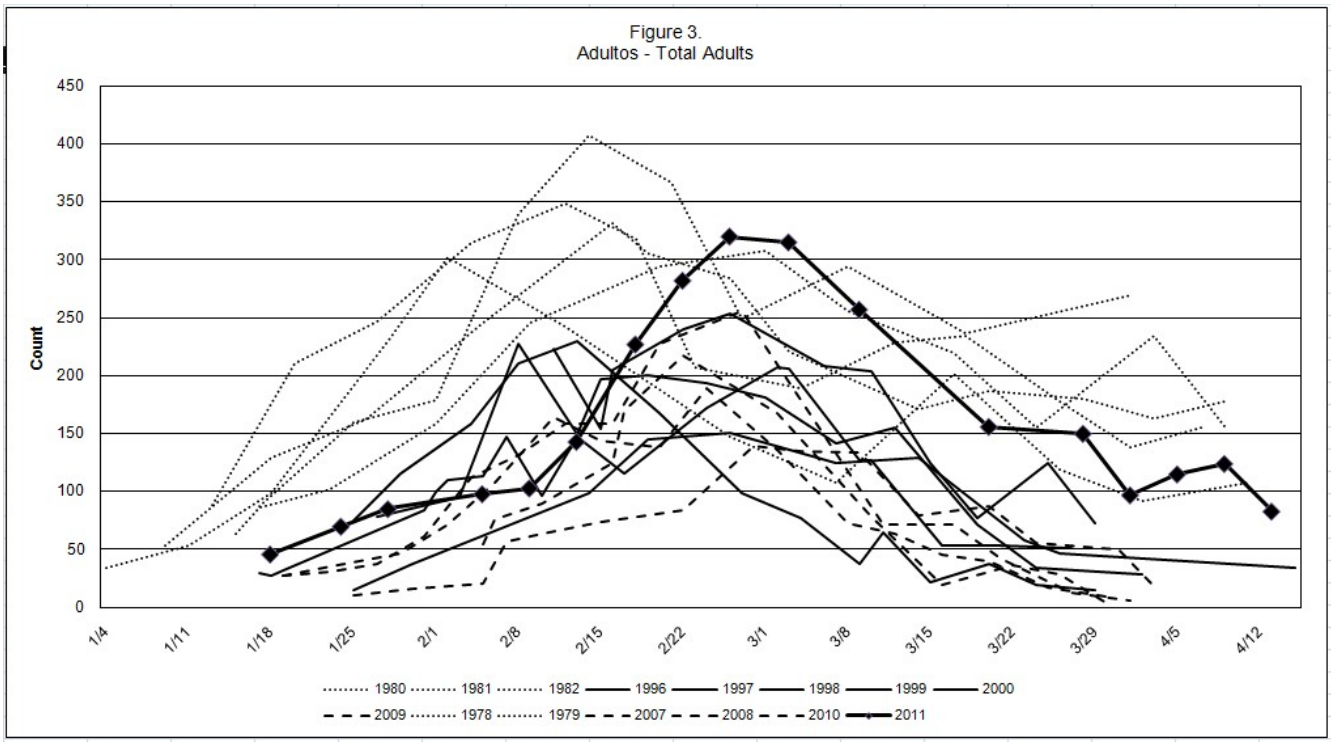

Figure 4. Single whales counted in Laguna San Ignacio from 1978 to 2011. Dotted lines are counts during 1978-1982; solid lines are counts from 1996-2000; dashed lines are counts from 2007-2010; and solid line with diamonds are counts from 2011.

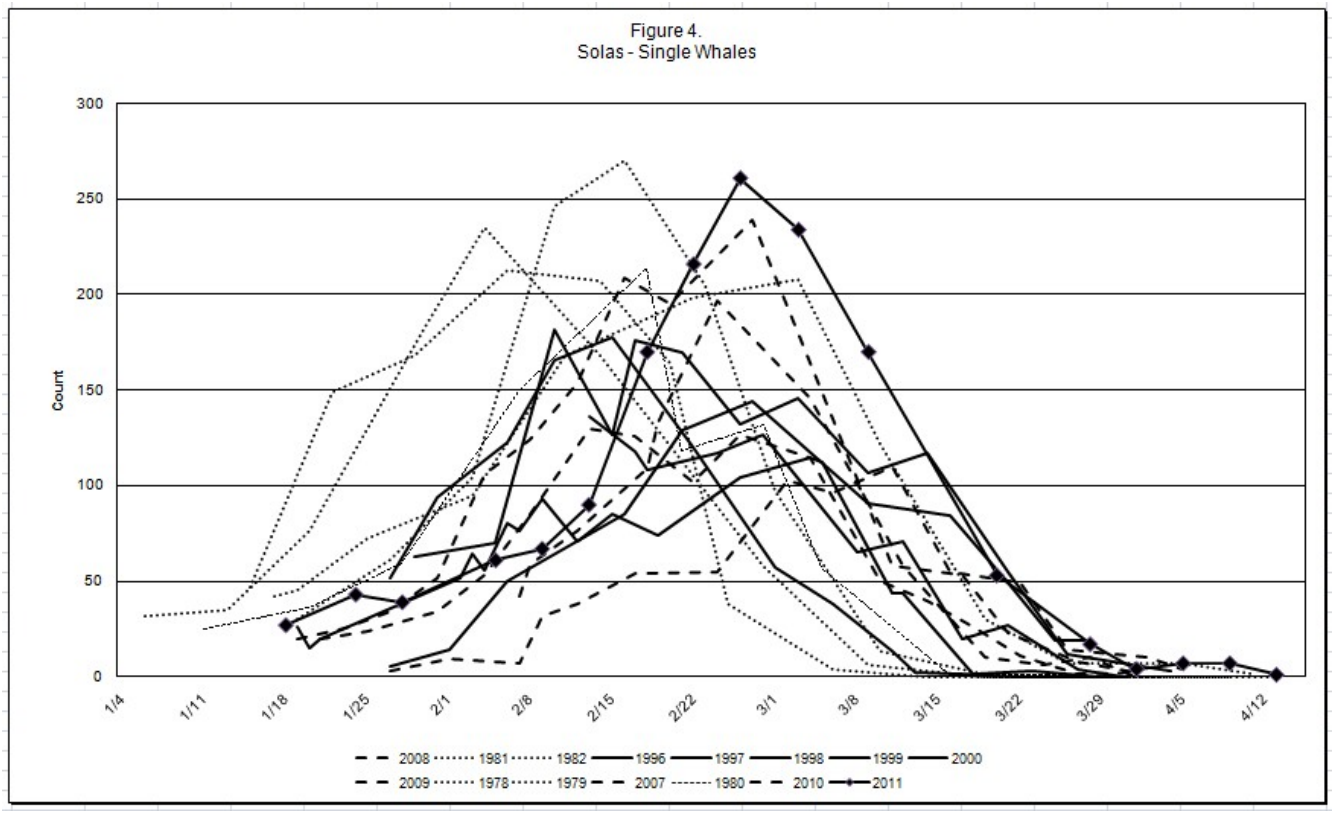

Figure 5. Female-calf pairs counted in Laguna. Dotted lines are counts during 1978-1982; solid lines are counts from 1996-2000; dashed lines are counts from 2007-2010; and solid line with diamonds are counts from 2011.

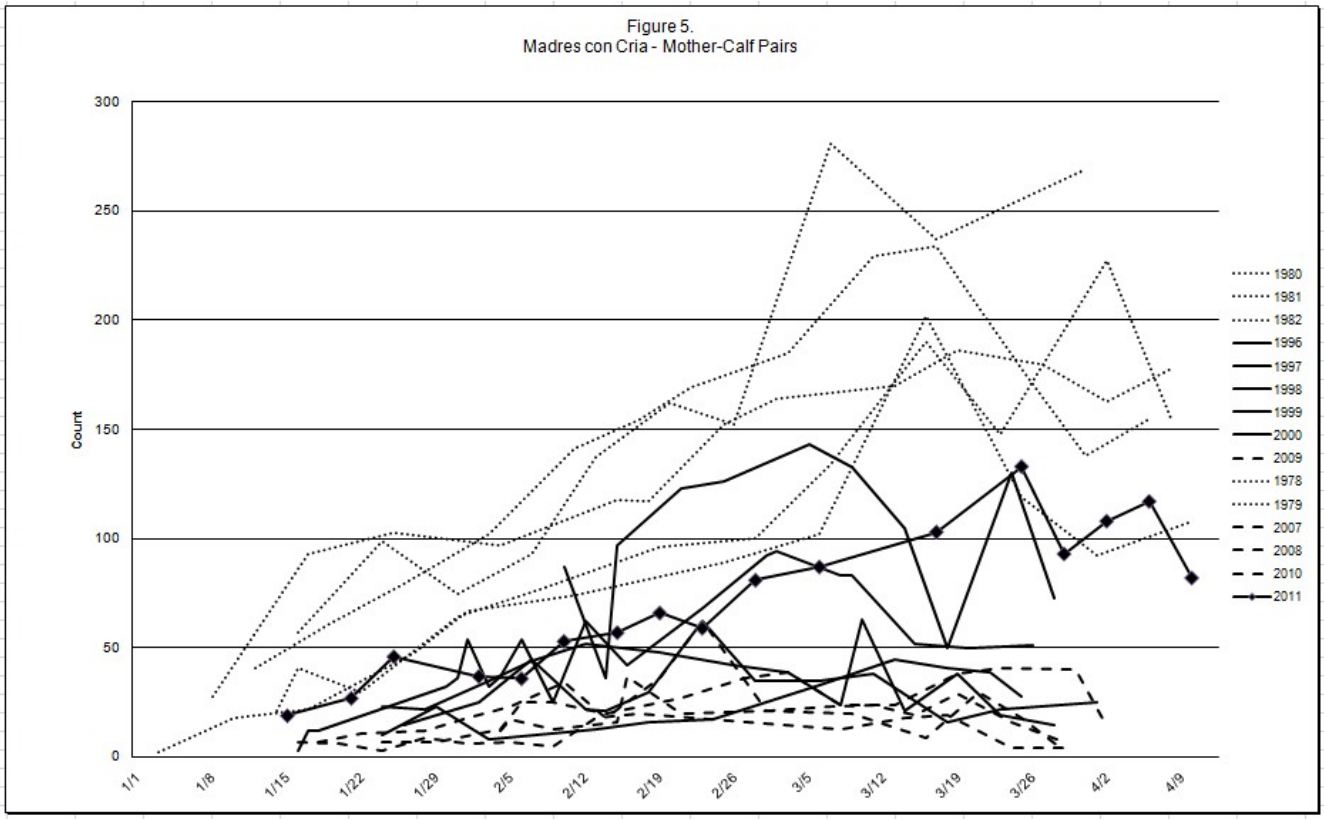

Table 1. High counts of gray whales (adults, singles, and female-calf pairs) in Laguna San Ignacio from 1978-1982, 1996-2000, and 2007-2011.

DATE	ADULTS OBSERVED	SINGLES OBSERVED	CC-PAIRS OBSERVED
2-Feb-78	302	235	202
1-Mar-79	308	208	227
16-Feb-80	332	214	186
12-Feb-81	348	207	234
14-Feb-82	407	270	281
78-82 AVERAGE	339	227	226
2-Mar-96	207	115	94
26-Feb-97	253	127	143
13-Feb-98	230	178	63
26-Feb-99	151	144	45
8-Feb-00	227	182	62
96-00 AVERAGE	214	149	81
22-Feb-07	217	197	37
28-Feb-08	139	103	41
24-Feb-09	189	127	62
27-Feb-10	256	239	20
26-Feb-11	320	261	133
07-11 AVERAGE	224	185	59

Table 2. Maximum counts of gray whales (adults, singles, and female-calf pairs) in Laguna San Ignacio from 1978-1982, 1996-2000, 2007-2010, and 2011.

YEAR	ADULTS OBSERVED	SINGLES OBSERVED	CC-PAIRS OBSERVED
78	302	235	202
79	308	208	227
80	332	214	186
81	348	213	234
82	407	270	281
96	207	115	94
97	253	136	143
98	230	178	63
99	151	144	45
2000	227	176	62
2007	217	197	37
2008	139	110	41
2009	189	130	62
2010	256	239	20
07-10 Average	200	169	40
2011	320	261	133
Increase over 07-10 Average	60%	54%	233%

Table 3. Distribution of gray whales in the upper, middle, and lower portions of Laguna San Ignacio during the seasonal high census counts in 1982, 1996, 2010, and 2011.

	Female-Calf Pairs			
	14-Feb-82	2-Mar-96	27-Feb-10	26-Feb-11
Lagoon Portion				
Upper	107	28	7	22
Middle	15	31	3	18
Lower	15	33	7	19
TOTAL	137	92	17	59

	Single Whales			
	14-Feb-82	2-Mar-96	27-Feb-10	26-Feb-11
Upper	31	6	19	22
Middle	52	25	61	80
Lower	187	84	159	159
TOTAL	270	115	239	261

	Total Adult Whales			
	14-Feb-82	2-Mar-96	27-Feb-10	26-Feb-11
Upper	138	34	26	44
Middle	67	56	64	98
Lower	202	117	166	178
TOTAL	407	207	256	320