NUMBERS OF GRAY WHALES (*Eschrichtius robustus*) UTILIZING LAGUNA SAN IGNACIO, BAJA CALIFORNIA SUR, MEXICO DURING THE WINTER BREEDING SEASONS: 2007-2012

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ABSTRACT

The number of Eastern North Pacific gray whales (*Eschrichtius robustus*) utilizing Laguna San Ignacio, Baja California Sur, Mexico increased during the 2011 and 2012 winter breeding seasons compared to declining counts of whales observed from 2007 to 2010. Of particular note were counts of female-calf pairs that continued to increase following the birthing period for calves, suggesting that female-calf pairs were entering this lagoon from other areas. The mean number of adult gray whales (*i.e.*, single adults and female-calf pairs combined) counted during 2007 to 2010 was 200 (SD 49.22) whales, compared to high counts of 320 whales in 2011 and 268 whales in 2012. The mean number of single adult whales (non-female-calf pairs) counted during 2007-2010 was 169 (SD 59.68), compared to the high counts 261 single whales in 2011 and 205 single whales in 2012. The mean number of female-calf pairs counted during 2007 to 2010 was 40 (SD 17.26) compared to the highest counts of 133 female-calf pairs in 2011 and 110 female-calf pairs in 2012. The maximum counts of counts of adult whales of 320 whales on 26 February 2011, and 268 on 22 February 2012, represent a 60% increase in 2011 and a 34% increase in 2012 above the mean high count of 200 adult whales during 2007-2010. The maximum counts of single whales (non-female-calf pairs) of 261 whales on 26 February 2011, and 205 whales on 22 February 2012, represents a 54% increase in 2011 and a 21% increase in 2012 over the mean high count of 169 single whales during 2007-2010. The maximum counts of female-calf pairs were 133 pairs on 28 March 2011, and 110 pairs on 7 April 2012, representing a 232% increase in 2011 and a 175% increase in 2012 over the mean high count of 40 female-calf pairs during 2007-2010. The 2011 and 2012 increase in seasonal high counts of female-calf pairs 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 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 Bahia Magdalena) are moving into Laguna San Ignacio late in the winter breeding season, a pattern not seen since surveys conducted from 1977 to 1982.

Key words: gray whales, Baja California, Laguna San Ignacio, breeding lagoons, abundance counts, female-calf pairs, birth rate, calf production

INTRODUCTION

Laguna San Ignacio (LSI) is one 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. The lagoon is located in the west coast of the Baja California Peninsula (Fig. 1), and lies within the El Vizcaíno Biosphere Reserve. Boat surveys utilizing a standardized methodology to obtain comparable 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 2007-2012 (Urban et al. 2010 and 2011). Historically, counts of gray whales were greatest during the 1977-1982 Series, then counts continually declined between the second and third Series (1996-2010) reaching the lowest counts during the 2010 winter. Survey counts of gray whales, particularly counts of female-calf pairs, then increased during the 2011 winter. The highest counts of female-calf pairs occurred following the birthing period in 2011, 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. This late season increase in female-calf pairs and their numbers exceeding those seen during the 2006-2010 time period was seen again during the 2012 winter. Here we present the 2011 and 2012 gray whale counts and timing of lagoon occupation by gray whales in comparison with counts obtained during the 2007-2010 time period, and we suggest some factors that may have contributed to these increases in the number of gray whale utilizing Laguna San Ignacio as a winter aggregation and breeding area.

METHODS

Boat Surveys (census)

Ninety boat surveys were conducted during the period 2007 to 2012 to estimate the minimum number of gray whales within the Laguna San Ignacio lagoon during the winter breeding season (Apendix 1). 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).

Survey 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. 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 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. 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 during each winter season were analyzed and compared across years from 2007-2012 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).

RESULTS

The number of Eastern North Pacific gray whales (*Eschrichtius robustus*) utilizing Laguna San Ignacio, Baja California Sur, Mexico increased during the 2011 and 2012 winter breeding seasons compared to declining counts of whales observed from 2007 to 2010. Seasonal high counts of gray whales occurred as early as 22 February in 2007 (217 whales) and 2012 (268 whales), and as late as 28 February in 2008 (139 whales) (Table 1).

The mean number of adult gray whales (i.e., non-calf whales) counted during 2007 to 2010 was 200 (SD 49.22) whales, compared to high counts of 320 whales in 2011 and 268 whales in 2012. The mean number of single adult whales (non-female-calf pairs) counted during 2007-2010 was 169 (SD 59.68), compared to the high counts 261 single whales in 2011 and 205 single whales in 2012. The mean number of female-calf pairs counted during 2007 to 2010 was 40 (SD 17.26) compared to the highest counts of 133 female-calf pairs in 2011 and 110 female-calf pairs in 2012 (Table 2).

The maximum counts of 320 adult whales on 26 February 2011, and 268 whales on 22 February 2012, represents a 60% increase in 2011 and a 34% increase in 2012 above the mean high count of 200 adult whales during 2007-2010 (Figure 3). The maximum counts of single whales (non-female-calf pairs) of 261 whales on 26 February 2011, and 205 whales on 22 February 2012, represents a 54% increase in 2011 and a 21% increase in 2012 over the mean high count of 169 single whales during the 2007-2010 period (Figure 4). The maximum counts of female-calf pairs were 133 pairs on 28 March 2011, and 110 pairs on 7 April 2012, representing a 232% increase in 2011 and a 175% increase in 2012 over the mean high count of 40 female-calf pairs during 2007-2010 (Figure 5).

In both 2011 and 2012 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 claves in other gray whale winter aggregation areas before coming to Laguna San Ignacio.

DISCUSSION

The 2011 and 2012 increase in seasonal high counts of female-calf pairs 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 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, a pattern seen during the 1977-1982 survey series, but not during the 1996-2010 surveys.

The principal contributor to the 2011 and 2012 increase in the number of whales utilizing Laguna San Ignacio 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, and 110-pairs in 2012. 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 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. Additional photographic identification comparisons of the 2011 and 2012 female-cal pairs may re-confirm the immigration of whales into Laguna San Ignacio from these other breeding and aggregation areas.

A number of factors may further contribute to the increase in female-calf pairs seen during the 2011 and 2012 winters. 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 12-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 12-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. 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 and 2012 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 coastal areas of mainland Mexico. The sea temperatures during the 2010-2012 winters 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.

ACKNOWLEDGEMENTS

We wish to thank our field researchers and colleagues that assisted with the documentation of the gray whales in Laguna San Ignacio. We also thank The Ocean Foundation, and the World Wildlife Fund-Mexico for their support of the field work and analysis of our results. Thanks to the Eco-Tourism Operators of Laguna San Ignacio, the Association Rural de Interés Colectivo″ (ARIC), to Kuyimeta Eco-Tourismo and Searcher Natural History Tours for logistical support to sustain our field laboratory and field researchers. This research was conducted as part of the Laguna San Ignacio Ecosystem Science Program (LSIESP) under special scientific research permits No.SGPA/DGVS/11560/10 and SGPA/DGVS/00640/12from the Subsecretaría de Gestión Para La Protección Ambiental, Dirección General de Vida Silvestre, de Mexico.

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Table 1. Dates of highest counts of adult gray whales (single adults, and female-calf pairs combined) in Laguna San Ignacio from 2007-2012.

DATE	ADULTS	SINGLE ADULTS	FEMALE-CALF-PAIRS
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
22-Feb-12	268	205	63

Table 2. 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 2012, and the mean and standard deviation for counts during 2007-2010.

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

2007-2010					
MEAN	200		169		40
SD	49.22		59.68		17.26

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

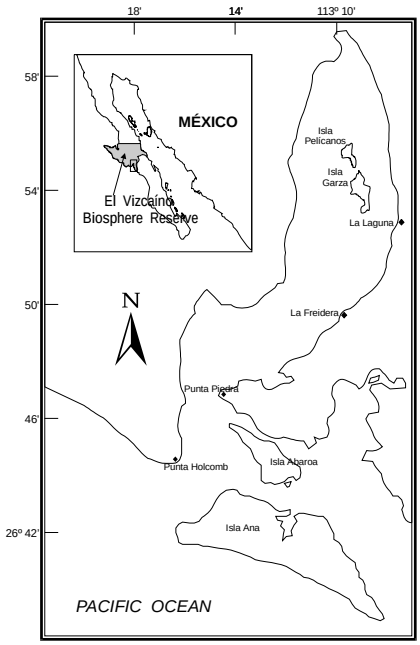

Figure 2. Transect survey line used for all boat counts (census) surveys.

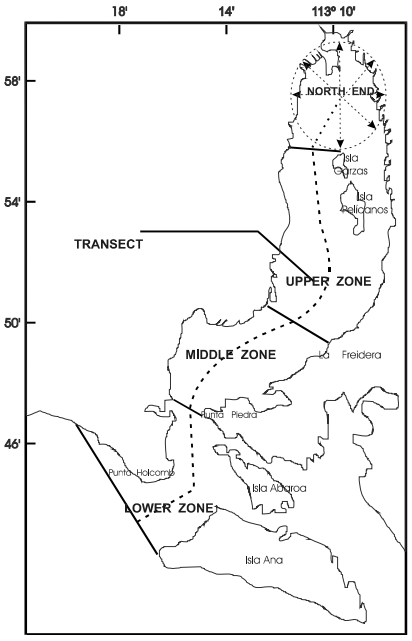

Figure 3. Adult whales counts in Laguna San Ignacio from 2007 to 2012. Dotted lines are counts during 2007-2010; solid lines are counts for 2011 (Diamonds) and 2012 (Circles).

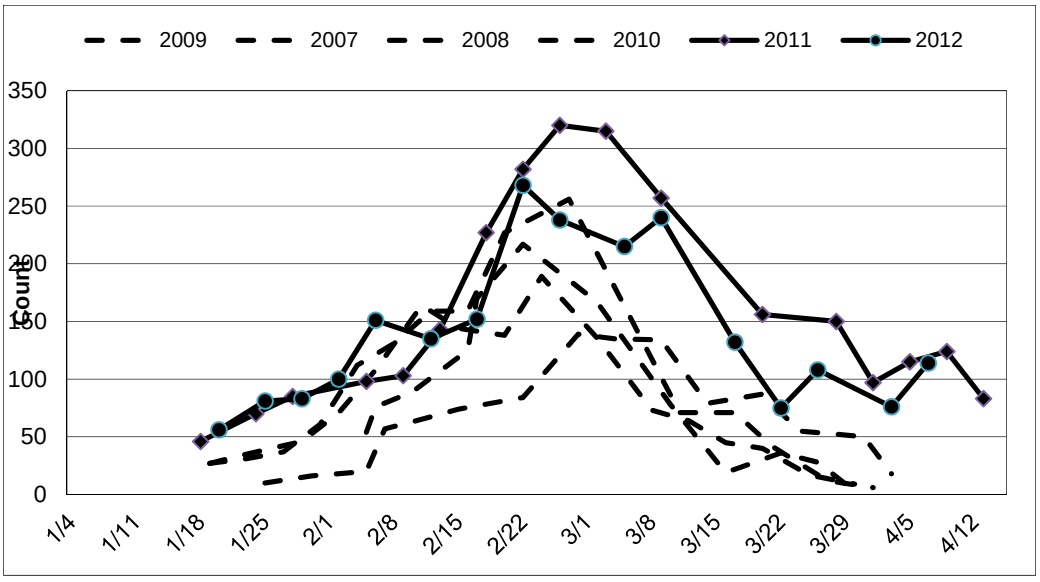

Figure 4. Single whales counted in Laguna San Ignacio from 2007 to 2012. Dotted lines are counts from 2007 to 2010; solid lines are counts for 2011 (Diamonds) and 2012 (Circles).

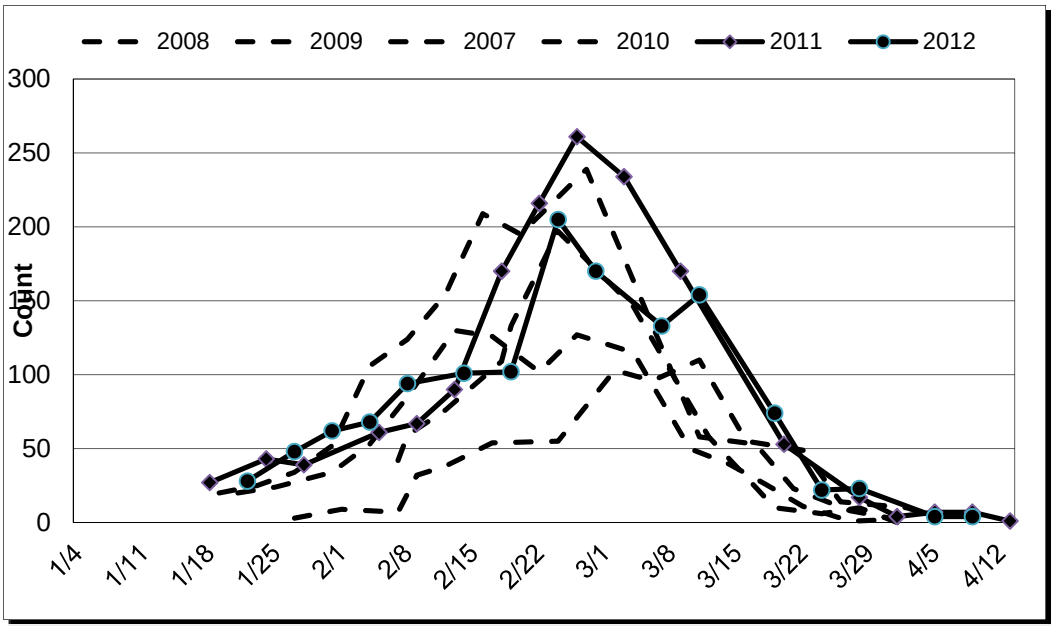

Figure 5. Female-calf pairs counted in Laguna San Ignacio. Dotted lines are counts during 2007 to 2010; solid lines are counts for 2011 (Diamonds) and 2012 Circles).