# REPORT OF THE 2007 GRAY WHALE STUDIES AT LAGUNA SAN IGNACIO B.C.S. MEXICO

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# ABSTRACT

Laguna San Ignacio is located in the west coast of Mexico's Baja California Peninsula and it is one of the four main calving-breeding lagoons of the eastern North Pacific gray whale (*Eschrichtius robustus*). Preliminary results are presented for the 2007 gray whale winter research season, and include: abundance estimates, density and distribution of the whales within this lagoon, photographic identification studies, estimation of calving interval, and observations of "skinny" whales. Twelve complete census surveys of the lagoon were conducted from February 5 to March 30, 2007. These boat surveys followed a standard transect and methodology to determine minimum whale abundance and distribution, and to allow comparisons with historical surveys conducted during the periods of peak whale abundance in February between 1978 to 2006. The maximum count of adult whales was 217 on 22 February (197 "single" whales and 20 cows with calves). The highest count of single whales was 197 and occurred on 22 February, and the highest cow-calf pairs count was 37 on 17 February. The high count of adult whales was 46% less than the highest recorded count of 407 adult whales on 14 February 1982, and occurred later in the season than 10 of the previous February highest count surveys suggesting a continuing decline in the number of whales utilizing this lagoon and a delay and shortening of the winter occupation of the lagoon by whales. Counts of female calf pairs also demonstrated declines from 137 pairs counted on 14 February 1982 to 37 pairs on 17 February 2007, or a decline of 73%. These findings could reflect the overall decline in the eastern North Pacific population and/or a differential use of the San Ignacio lagoon compared to other breeding lagoons and coastal areas during the winter. The distribution of whales within the lagoon at the time of the maximum adult whale count was: 63% in the lower zone nearest the entrance, 30% in the middle zone and 7% in the upper zone furthest from the entrance. This represents a change in the utilization of the lagoon since the highest historical count in 1982 when 50% of the whale utilized the lower zone, 16% used the middle zone, and 34% utilized the upper zone. This change in distribution is largely the result of fewer females with calves observed in the lagoon at the peak of the season. From 615 photo-identified whales, 453 were single whales, 137 cows with calves, and 25 undetermined; there were 200 recaptured whales, 111 of cows with calves and only 80 of single whales. The longest period between re-captures was 37 days from a cow with calve.The average calving interval for female whales was estimated at 2.48 years (95% CI 1.65-3.67) for the period 1996-2000. Of those 615 individual whales photographed, 12.35% showed evidence of the "skinny whale" syndrome.

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# I. INTRODUCTION

Laguna San Ignacio is located in the west coast of the Baja California Peninsula in Mexico and it is currently the only one of the four calving-breeding lagoons of the Eastern Pacific gray whale (*Eschrichtius robustus*) that remains mostly undeveloped. San Ignacio lagoon has a long history of commercial fishing by several fishing cooperatives, and since the mid-1990s a significant eco-tourism industry that focuses on winter whale-watching has developed in the lagoon (Dedina and Young, 1995). The lagoon lies within the Vizcaino Desert Biosphere Reserve, Mexico's largest refuge administrated by Secretaria de Medio Ambiente, Recursos Naturales y Pesca (SEMARNAT) (Fig. 1). This is a popular destination for recreational whale watching which began in the mid-1970s. Beginning in the mid-1990's and continuing to the present, seven land-based "eco- tourism" camps operate whale watching tours throughout the winter gray whale occupation of the lagoon (January through April), and a few boat-based "natural history" tours from the United States also conduct whale-watching tours in Laguna San Ignacio (Dedina and Young, 1995).

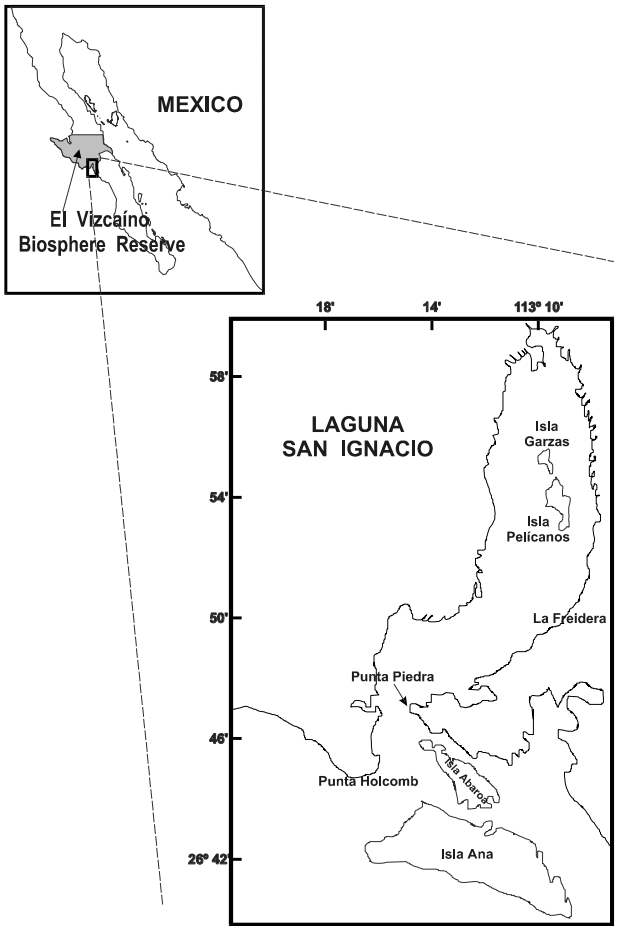


Figure 1. Study site: San Ignacio Lagoon and El Vizcaino Biosphere Reserve

Detailed studies of demography and phenology of gray whales were conducted during the winter in Laguna San Ignacio from 1978 to 1982 (Jones and Swartz, 1984), and resumed from 1996 to 2000 (Urban *et al*. 2002), 2003, and 2005 and 2006 (Urbán unpublished data).

The intent of the 2007 studies was to describe and evaluate the current use of Laguna San Ignacio by the gray whales in the context of the last 25-years, and to evaluate the overall health of the lagoon ecosystem as a habitat for breeding whales. Here, we report preliminary results of the 2007 gray whale winter research program on abundance, density and distribution of the whales, photographic-identification studies, and observations on the apparent health of some whales exhibiting evidence of the "skinny whale" syndrome.

# II. METHODS

## Boat Surveys (census)

Twelve complete census surveys of the lagoon to determine whale abundance and distribution were conducted during the period February 5 and March 30, 2007. The surveys were conducted by following a standard survey transect (Fig. 2) and observer methodology to allow comparison with previous survey counts from 1978-1982 (Jones and Swartz 1984) and 1996-2006 (Urban *et al*. 2002, and unpublished). No complete whale surveys were conducted in the years 1983-1995, or in 2001-2002, or 2004.

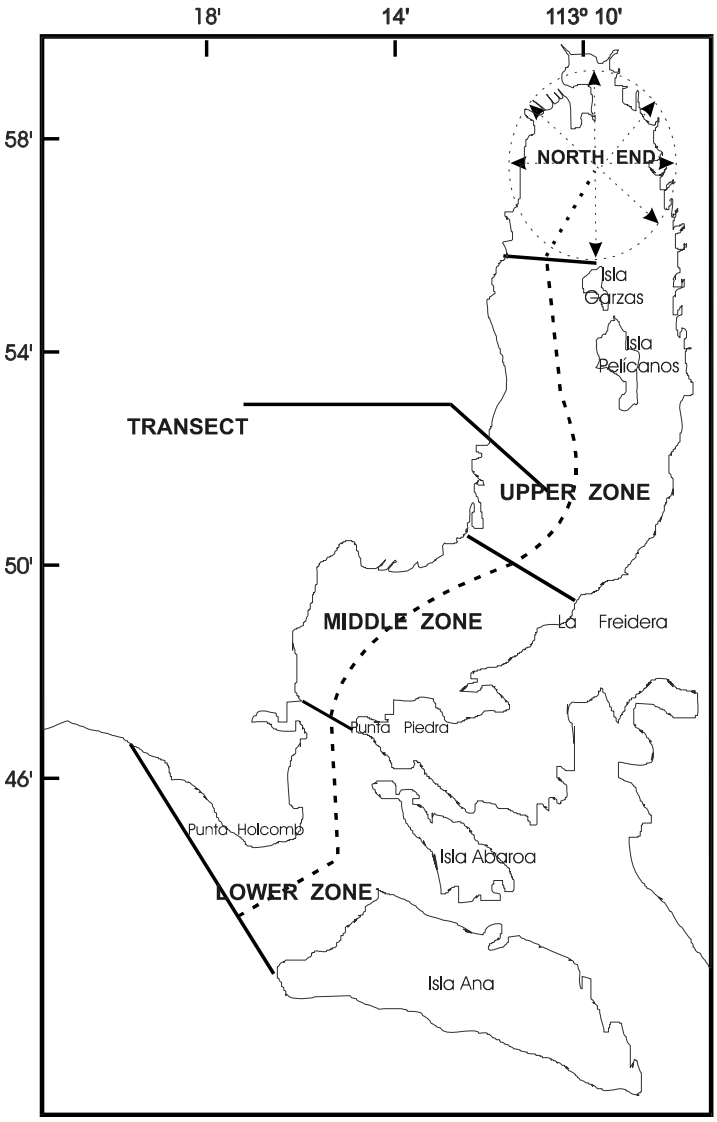


Figure 2. Boat survey transect for counting gray whales in Laguna San Ignacio

For each survey a standard transect line was followed using a 7-m boats powered by an outboard motor, travelling at an estimated speed of 11 km/hr. Speed and transect course were verified using 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 to Isla Garzas at the north end of the lagoon.

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 (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 “cow-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 the 2007 winter season were analyzed as total adult (non-calf) whales, single whales, and female-calf pairs counted in the entire lagoon, and as the number counted within each of the three primary zones (*i.e*., the lower, middle, and upper lagoon zones including the north end area) (Fig. 2). The number of whales in each zone and the total for 2007 were compared with counts from previous years.

## Photographic Identification

Gray whales possess individually unique pigmentation and markings that can be used to identify and document the presence of specific individuals in the lagoon. When surveys for abundance and distribution were not being conducted, efforts were directed at obtaining photographs of individual whales. Photographs of the visible portions of the whale´s backs were taken with 35 mm digital SLR cameras with 70-300 mm telephoto zoom lenses. Any unique or outstanding scars or other conspicuous natural markings were also photographed.

Individual whales were distinguished by comparing the natural markings located on the middle of the dorsal back region of the whale. Photographs were taken of both the left

and right sides of the whales, and when possible, photographs of both sides of the same individual were obtained. The best photographs from the right and left sides of each whale (for each sighting) were selected, assigned a unique sequential identification number, and archived into a digital computerized photographic database. Each photograph for an individual whale was coded according to the type of markings and their locations on the body (*e.g*., unique pigmentation of the skin, mottling, scarring, and barnacles, scars, etc.).This database was then searched by the types of markings on individual whales compared with other whales with similar markings to identify photographs of the same whale obtained during the same year or in other years (*i.e*., matches).

## Health Assessment

Whales exhibiting characteristics of mal-nutrition (food resource limitation) and/or disease (i.e., "skinny whales") as described by Weller *et al.* (2000) were observed during the census and photographic identification surveys in 2007. Once recognized, efforts were made to obtain photographs of the entire body of such whales to document and to evaluate their health. "Skinny" symptoms varied among individuals but included at least one or more of the following diagnostic features:

(1) an obvious sub-dermal protrusion of the scapulas from the body with associated thoracic depressions at the posterior and anterior insertion points of the flipper;
(2) the presence of noticeable depressions on concavities around the blowholes and head; and
(3) a pronounced ridge along the neural/dorsal spine of the lumbar and caudal vertebrae resulting in the appearance of a “bulge” along the lateral flank (Weller *et al*. 2000; Brownell and Weller 2001) (Figs. 13-16). The percent of whales exhibiting "skinny" characteristics were estimated from the total number of these whales photographed divided by the total number of distinct individual whales ("skinny" and not "skinny) photographed during the photo identification surveys.

# III. RESULTS

## Abundance

Counts of gray whales from boat surveys are used as an index of the minimum abundance of whales within the lagoon during the winter breeding season.

The maximum count of adult whales was 217 on 22 February (197 "single" whales and 20 cows with calves). The highest count of single whales was 197 and occurred on 22 February, and the highest cow-calf pair count was 37 on 17 February (Table I, Figs. 3-5). A second high count of 30 cow-calf pairs occurred on 22 March, which was consistent with end of the season increases in cow-calf pairs during the period 1978-1982 (Jones and Swartz 1984). The high count of adult whales was 46% less than the highest recorded count of 407 adult whales on 14 February 1982, and occurred from one to 19 days later in the season in 10 of the previous February surveys suggesting a continuing decline in the number of whales utilizing this lagoon along with a delay and shortening of the winter occupation of the lagoon by whales.

Table I. Census survey counts of gray whales in Laguna San Ignacio, B.C.S., during 2007 winter.

| | | Lower Zone | | Middle Zone | | Upper Zone | | Totals | |
|---|---|---|---|---|---|---|---|---|---|
| | | Sing. | Cow-c p. | Sing. | Cow-c p. | Sing. | Cow-c p. | Sing. | Cow-c p. |
| 5 | Feb | 29 | 7 | 9 | 1 | 4 | 4 | 42 | 12 |
| 6 | Feb | 27 | 11 | 27 | 4 | 5 | 2 | 59 | 17 |
| 10 | Feb | 41 | 5 | 24 | 4 | 11 | 4 | 76 | 13 |
| 16 | Feb | 82 | 8 | 21 | 7 | 6 | 1 | 109 | 16 |
| **17** | **Feb** | **69** | **10** | **46** | **12** | **18** | **15** | **133** | **37** |
| **22** | **Feb** | **126** | **10** | **60** | **5** | **11** | **5** | **197** | **20** |
| 2 | Mar | 91 | 16 | 51 | 4 | 4 | 1 | 146 | 21 |
| 10 | Mar | 30 | 9 | 24 | 8 | 4 | 3 | 58 | 20 |
| 17 | Mar | 10 | 6 | 0 | 2 | 0 | 1 | 10 | 9 |
| 22 | Mar | 4 | 19 | 2 | 7 | 0 | 4 | 6 | 30 |
| 26 | Mar | 9 | 18 | 1 | 0 | 0 | 0 | 10 | 18 |
| 30 | Mar | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 3 |

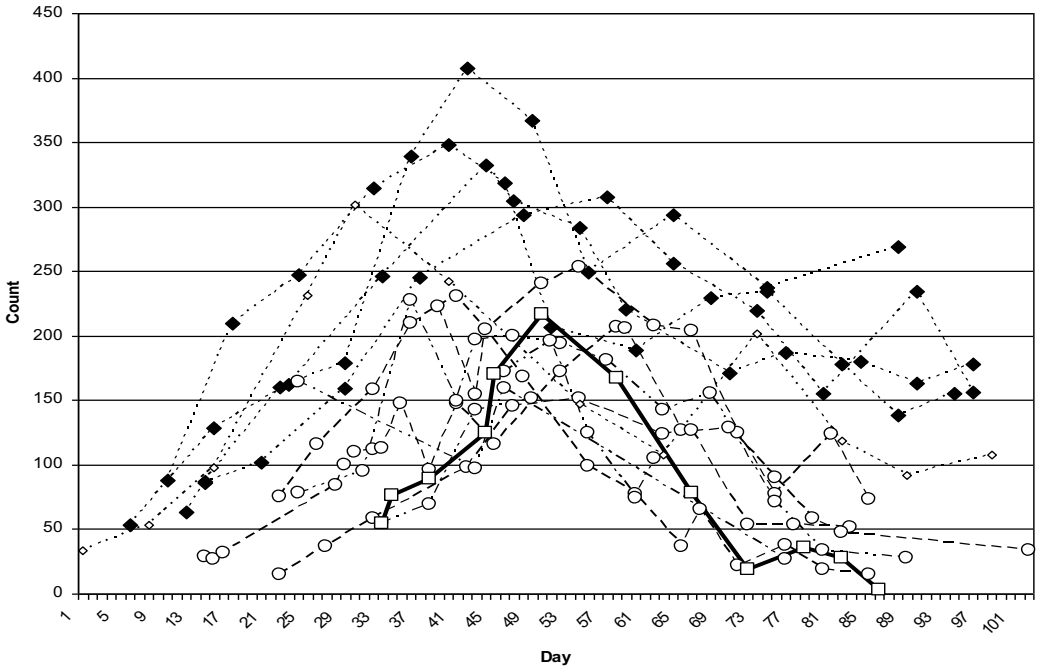


Figure 3. Number of adult whales counted in census surveys of Laguna San Ignacio between 1978 and 2007. Black diamonds = 1978-1982 surveys; White circles = 1996-2006 surveys; White squares = 2007 survey counts. Day 1 = 4 January; day 102 = 15 April.

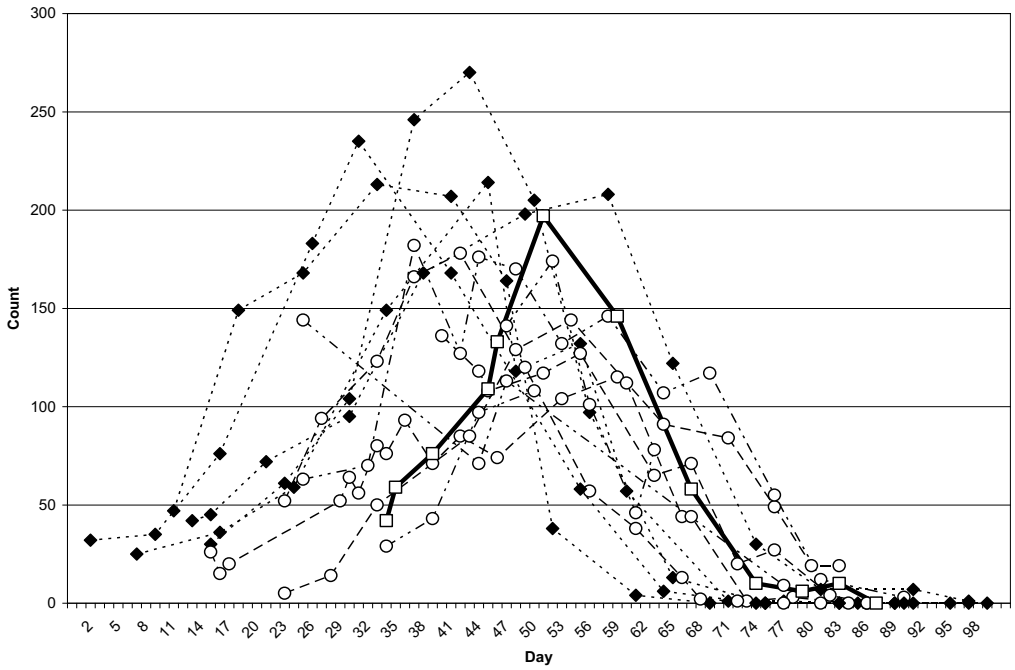


Figure 4. Number of single whales counted in census surveys of Laguna San Ignacio between 1978 and 2007. Black diamonds = 1978-1982 surveys; White circles = 1996-2006 surveys; White squares = 2007 survey counts. Day 1 = 4 January; day 98 = 11 April.

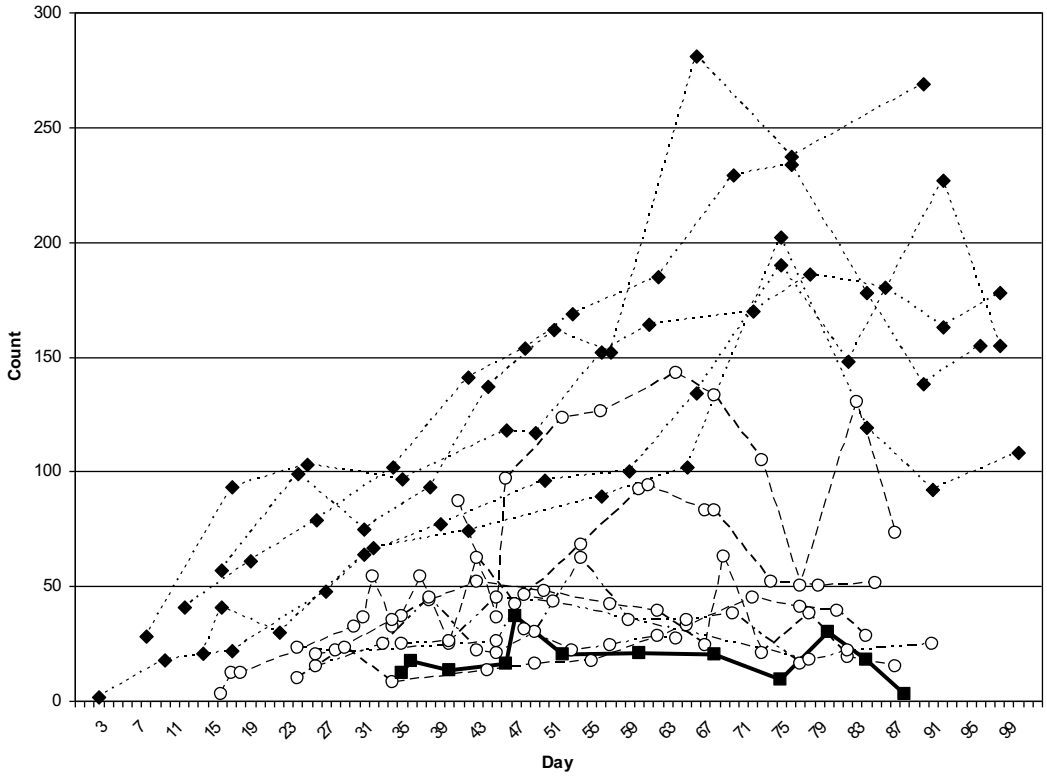


Figure 5. Number of female-calf pairs of gray whales counted in census surveys of Laguna San Ignacio between 1978 and 2007. Black diamonds = 1978-1982 surveys; White circles = 1996-2006 surveys; Black squares = 2007 survey counts. Day 1 = 4 January; day 98 = 11 April.

## Distribution

Whale counts were always greatest in the lower zone nearest the lagoon entrance from the sea and decreased towards the upper zone in the interior of the lagoon. The distribution of whales within the lagoon at the time of the maximum adult whale count on 22 February was: 63% in the lower zone nearest the lagoon entrance, 30% in the middle zone and 7% in the upper zone furthest from the entrance. This represents a change in the utilization of the lagoon since the highest historical count on 14 February 1982 when 50% of the whale utilized the lower zone, 16% used the middle zone, and 34% utilized the upper zone (Jones and Swartz 1984). This change in distribution is largely the result of fewer females with calves observed in the lagoon at the peak of the season (37 cow/calf pairs on 17 February 2007 compared to 137 on 14 February 1982 (Tables I-II, Fig.6).

*Lower zone*

At the time of the maximum adult whale count on 22 February, 63% of the count (126 single whales and 10 cow-calf pairs) occupied the lower zone. As in previous years, the single whales were the principal occupants of the lagoon during February each season. During the first survey on 5 February, 29 single whales and 7 females with calves were counted in the lower zone. From this day on, the counts of single whales in the lower zone increased to a peak of 126 on 22 February, and then their numbers decreased to a low of 9 single whales on 27 March and none were counted during the last survey on 30 March. Counts of females with calves in the lower zone increased from 7 on 5 February to 19 pairs on 22 March. Only one female-calf pair was counted in the lower zone during the last survey on 30 March (Tables I-II, Fig. 6-9).

*Middle zone*

At the maximum adult count, 30% of the count was in the middle zone (60 single whales and 6 female-calf pairs). During the first survey on 5 February 9 single whales and one cow-calf pair was counted in this zone. The counts of single whales increased in this zone to a maximum of 60 on 22 February, after which counts of single whales in this zone declined to one whale on 26 March and none counted during the last survey on 30 March. Counts of female-calf pairs in the middle zone increased from one pair on 5 February to 12 pairs on 17 February, and then decreased to 7 pairs on 22 March and none counted in this zone during the last two surveys on 26 and 30 March (Tables I-II, Fig. 6-9).

*Upper zone*

Seven percent (7%) of the maximum count on 22 February was from the upper zone (5 female-calf pairs and 11 single whales). Historically this zone has been occupied by female-calf pairs, however in 2007 single whales and female-calf pairs were mixed in this zone. The counts during the first survey on 5 February included 4 female-calf pairs and 4 single whales. Counts in this zone increased to 33 adult whales on 17 February (15 female-calf pairs and 18 single whales), and then declined to 2 female-calf pairs on 30 March. Generally speaking, the abundance of whales in the upper zone was the lowest recorded compared to all the historical surveys (Tables I-II, Fig. 6-9).

Table II. Maximum February survey counts and distribution of gray whales from 1982, 1996 and 2007.

| Zone | Cow-calf pairs | | | Singles | | | Total Adult whales | | |
|---|---|---|---|---|---|---|---|---|---|
| | 14 Feb 82 | 2 Mar 96 | 22 Feb 07 | 14 Feb 82 | 2 Mar 96 | 22 Feb 07 | 14 Feb 82 | 2 Mar 96 | 22 Feb 07 |
| Lower | 15 | 33 | 10 | 187 | 84 | 126 | 202 | 117 | 136 |
| Middle | 15 | 31 | 5 | 52 | 25 | 60 | 67 | 56 | 65 |
| Upper | 107 | 28 | 5 | 31 | 6 | 11 | 138 | 34 | 16 |
| TOTAL | 137 | 92 | 20 | 270 | 115 | 197 | 407 | 207 | 217 |

| Lagoon Surface | Whale´s Density | | |
|---|---|---|---|
| Lower 17.5 $Km^2$ | 11.5 | 6.7 | 7.8 |
| Middle 22.9 $Km^2$ | 2.9 | 2.4 | 2.8 |
| Upper 46.6 $Km^2$ | 3.0 | 0.7 | 0.3 |

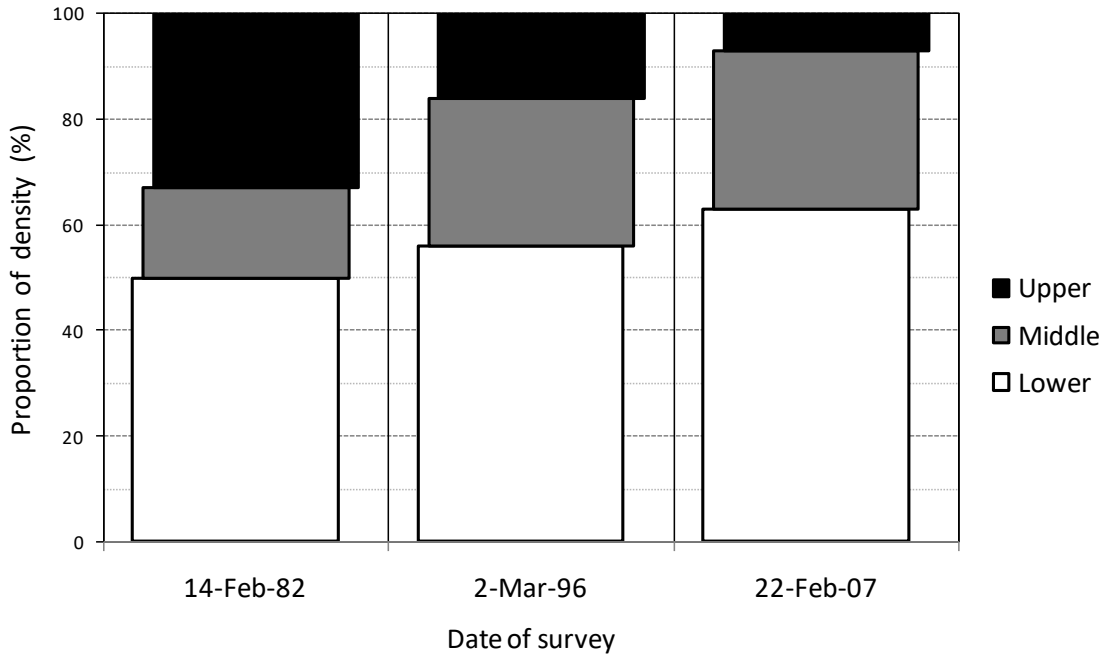


Figure 6. Changes in percent and density (whales/$Km^2$) of adult gray whales counted in February census surveys in 1982, 1996 and 2007.

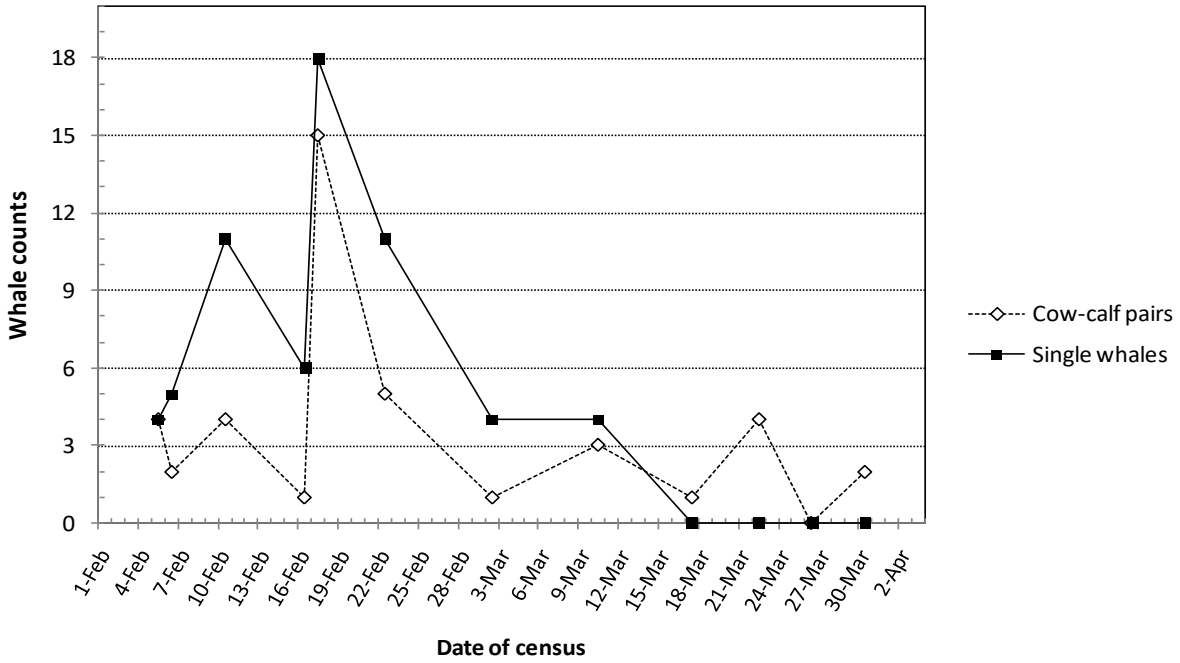


Figure 7. Number of cow-calf pairs (black mark with single line) and single gray whales (white mark with dotted line) counted in census surveys of Laguna San Ignacio in the UPPER ZONE during the 2007 winter season.

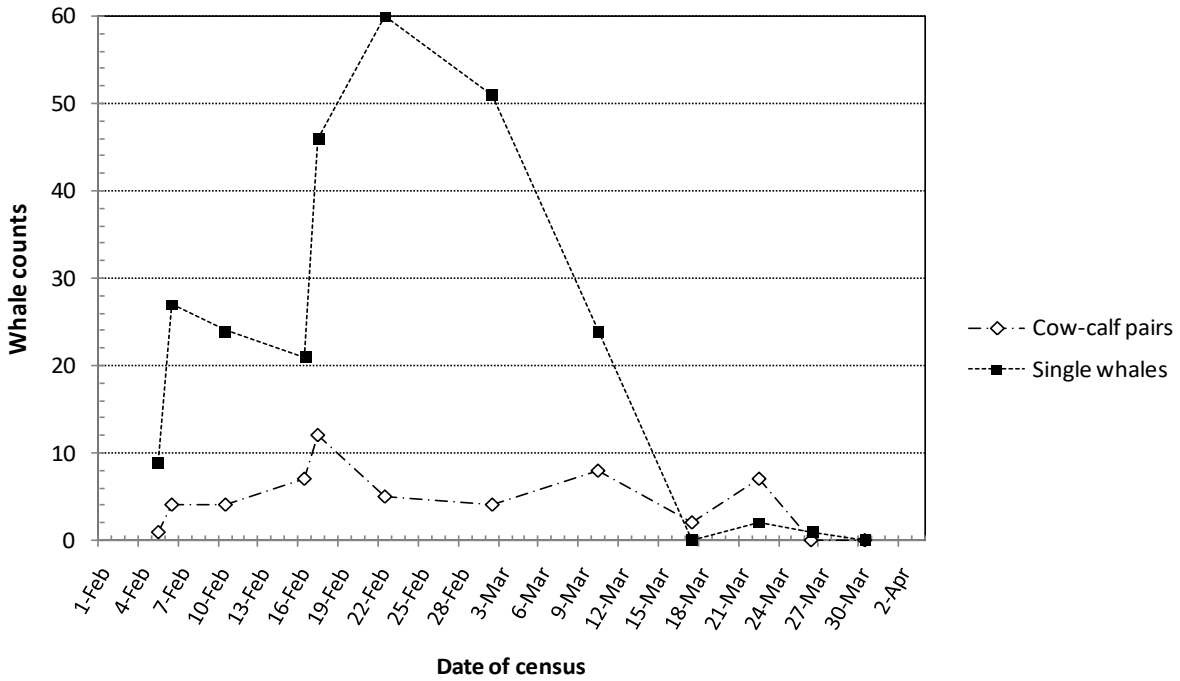


Figure 8. Number of cow-calf pairs (black mark with single line) and single gray whales (white mark with dotted line) counted in census surveys of Laguna San Ignacio in the MIDDLE ZONE during the 2007 winter season.

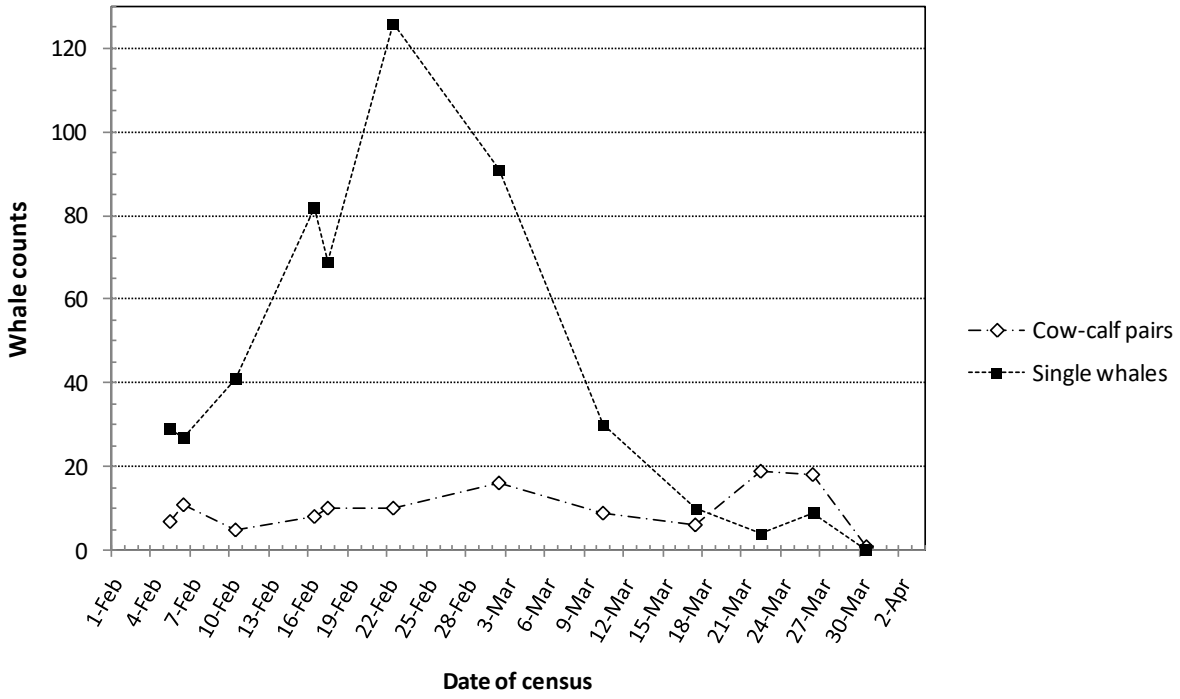


Figure 9. Number of cow-calf pairs (black mark with single line) and single gray whales (white mark with dotted line) counted in census surveys of Laguna San Ignacio in the LOWER ZONE during the 2007 winter season.

## Photographic Identification - Residency

A total of 815 usable photographs of gray whales were obtained from 2428 digital exposures. From these, 615 different individual whales were identified from 1156 right-side photographs and 735 left-side photographs. Only 121 whales were photographed from both sides. The analysis of left-side photographs yielded 181 single whales, 58 females with calves, and 11 unknown whales (individuals that for some reason could not be assigned to one of the previous group classes), or 250 individuals (Table III). The analysis of right-side photographs yielded 272 single whales, 79 females with calves, and 14 unknown whales, for 365 individuals. The minimum number of individual whales (single and females with calves) identified from the photographs is equal to the larger number of individuals identified from the left or right side, or 365 whales identified from the right side photos (this includes the 121 individuals identified from both left and right side photographs). If we assume that the whales identified from only their left side photos are distinct from those identified from right-side photos (none are of the same individual), the maximum number

of identified whales is number of right side identified individuals plus the number of left-side minus the number of both right and left side individuals 365 + (250 - 121) = 494 whales.

There were 200 recaptured whales (whales photographed on more than one occasions during the season). These included 111 cow-calf pairs and 80 single whales. Of these, there were 117 recaptures from the right side photographs; 71 cow-calf pairs and 46 single whales; and 74 recaptures from the left side photographs; 40 cow-calf pairs and 34 single whales (Table III).

Table III. Number of photographs and recaptures in Laguna San Ignacio, B.C.S. February –March 2007.

| GROUP CLASS | Total photographs | Useful photographs | Individuals | Recaptures |
|---|---|---|---|---|
| | LEFT SIDE | | | |
| Singles | 529 | 215 | 181 | 34 |
| Cow-calf | 147 | 98 | 58 | 40 |
| Unknown | 59 | 16 | 11 | 5 |
| Total | 735 | 329 | 250 | 79 |
| | RIGHT SIDE | | | |
| Singles | 855 | 318 | 272 | 46 |
| Cow-calf | 231 | 150 | 79 | 71 |
| Unknown | 70 | 18 | 14 | 4 |
| Total | 1156 | 486 | 365 | 121 |
| | TOTAL | | | |
| Singles | 1384 | 533 | 453 | 80 |
| Cow-calf | 378 | 248 | 137 | 111 |
| Unknown | 129 | 34 | 25 | 9 |
| Total | 1891 | 815 | 615 | 200 |

Different minimum residence intervals were estimated for cow-calf pairs and single whales from the recapture data. Cow-calf pairs stayed in the lagoon for periods ranging from 1 to 37 days with an average of 15.4 ± 3.2 days (C.I. 95%) (Fig. 10). Unlike cow-calf pairs, single whales were recaptured in the lagoon from 1 to 31 days with an average of 8.8 ± 4.5 days (C.I. 95%) (Fig. 11). When these 2007 data are compared with previous years (1996-2000, 2003, 2005 and 2006), the average minimum residence time for cow-calf pairs in 2007 is one of the lowest with the longest of 25.4 ± 5.4 (C.I. 95%) in 1999 and the

shortest of 5.9 ± 2.4 days (C.I. 95%) in 2003. For single whales the 2007 minimum residency time of 8.8 ± 4.5 days (C.I. 95%) s is the second highest of all the years just behind 2005 with 9.5 ± 4.9 days (C.I. 95%) (Table IV).

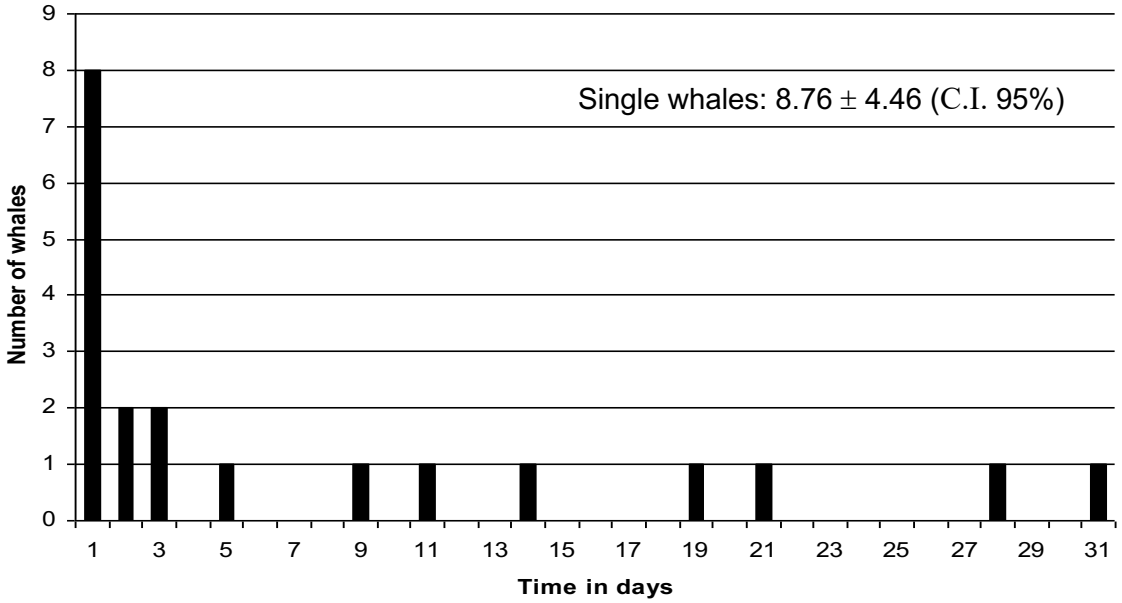


Figure 10. Frequency distribution of recapture times for single whales in San Ignacio lagoon 2007 winter.

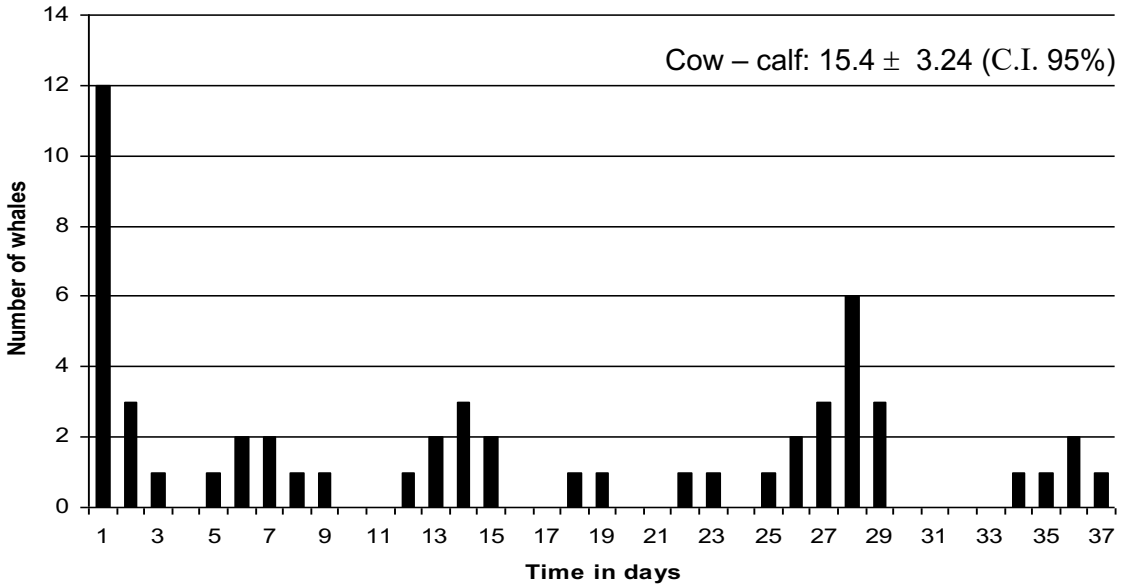


Figure 11. Frequency distribution of recapture times for cow-calf pairs in San Ignacio lagoon 2007 winter.

Table IV. Time of residency averages of gray whales in San Ignacio lagoon, B.C.S. México, 1996-2000, 2003, 2005-2007.

| Year | Group Class | Mean | n | C.I.(95%) | Max | Min |
|---|---|---|---|---|---|---|
| 1996 | cow-calf | 16.7 | 20 | 3.3 | 39 | 3 |
| | singles | 5.9 | 5 | 2.1 | 20 | 1 |
| 1997 | cow-calf | 20.2 | 43 | 4.3 | 43 | 1 |
| | singles | 6.3 | 4 | 4.6 | 10 | 2 |
| 1998 | cow-calf | 20.6 | 43 | 4.1 | 63 | 2 |
| | singles | 5.6 | 5 | 2.0 | 9 | 3 |
| 1999 | cow-calf | 25.4 | 39 | 5.4 | 58 | 1 |
| | singles | 4.3 | 11 | 1.9 | 9 | 1 |
| 2000 | cow-calf | 22.9 | 25 | 6.6 | 55 | 1 |
| | singles | 6.8 | 19 | 3.2 | 23 | 1 |
| 2003 | cow-calf | 5.9 | 9 | 2.4 | 14 | 1 |
| | singles | 3.8 | 11 | 1.9 | 12 | 1 |
| 2005 | cow-calf | 14.8 | 7 | 11.1 | 38 | 1 |
| | singles | 9.5 | 13 | 4.9 | 31 | 1 |
| 2006 | cow-calf | 10.6 | 14 | 3.2 | 21 | 1 |
| | singles | 2.2 | 6 | 1.5 | 5 | 1 |
| 2007 | cow-calf | 15.4 | 55 | 3.2 | 37 | 1 |
| | singles | 8.8 | 21 | 4.5 | 31 | 1 |

Minimum residency times for cow-calf pairs and single whales were compared among years (1996 to 2007) using a Kruskall-Wallis test because the data sets failed a Shapiro-Wilk test statistic for normality ($\partial$ = 0.938650 p-value = 0.000000 for cow-calf pairs, and $\partial$ = 0.700755 p-value = 0.000000 for single whales).

The minimum residence times for females with calves in 2003 and 2006 were significantly shorter than in other years (Kruskal-Wallis Test Statistic = 25.117 p-value=0.001 assuming Chi-square distribution with 8 df) (Fig. 12 top). For single whales there were no significant differences in their minimum residence times across years (Kruskal-Wallis Test Statistic = 10.230, p-value = 0.249 assuming chi-square distribution with 8 df) (Fig. 12 bottom).

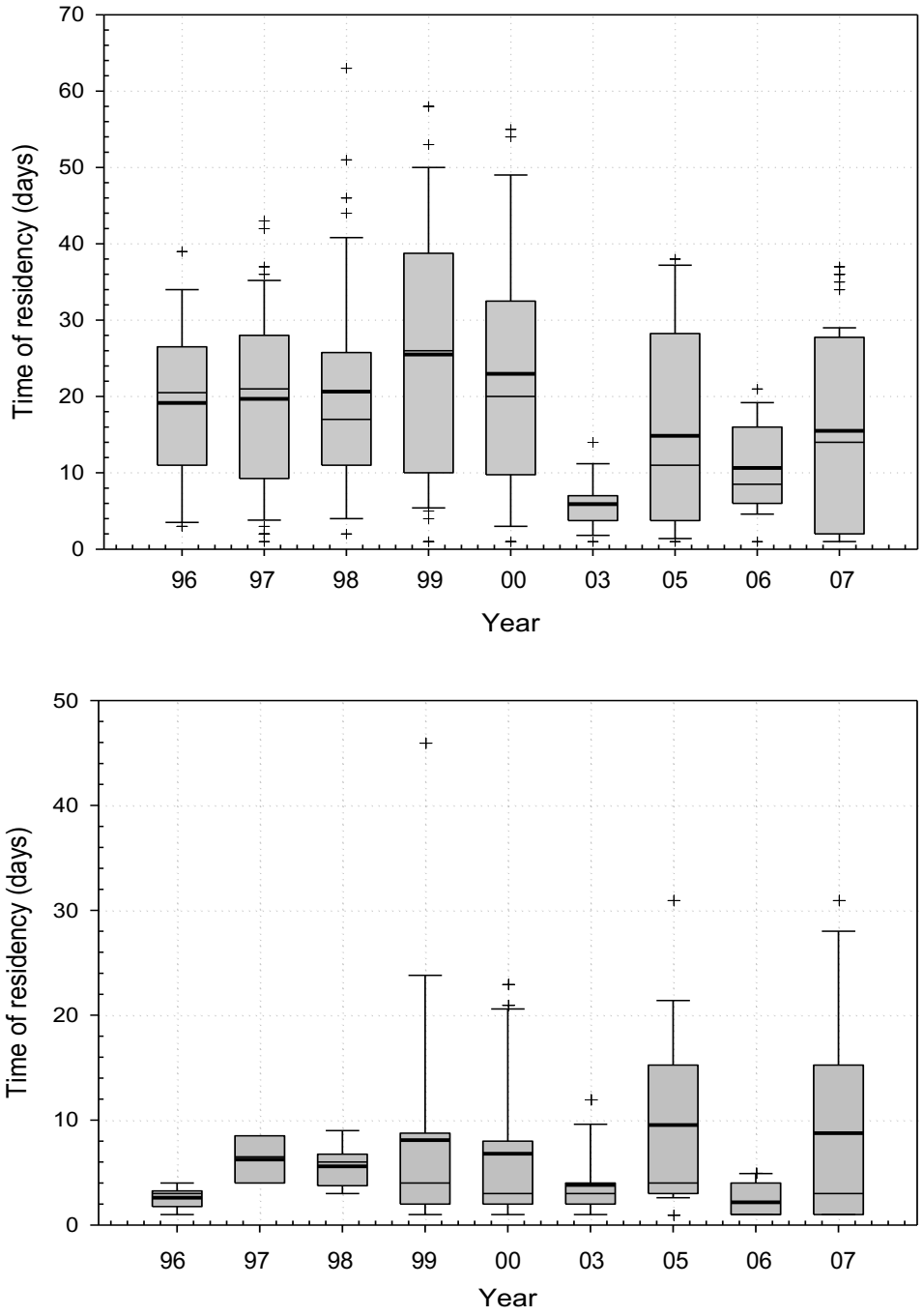


Figure 12. Time of residency comparison of Cow-calf pairs (top) and single whales (bottom) in Laguna San Ignacio throughout study years. Shaded areas represent 25-75% of data, whiskers 10-90%, thin line median, thick line mean and cross-hair the outliers (including maximum and minimum).

## Photographic Identification – Birth Interval

The interval between the birth of calves (*i.e.,* the calving interval) was estimated from photographic recapture data for 50 female gray whales photographed during the 1996 to 2000 winter seasons. These females produced 68 calves during this five year period and produced information on 21 calving intervals (Table V). Periodicity of calving ranged from two (n = 12) to four years (n = 1). The average length of the calving interval during the 5-year period was 2.48 ± SD 0.607 years.

Table V. The reproductive histories of 50 female gray whales observed with two or more calves during the period 1996 to 2000 in Laguna San Ignacio. Solid circles indicate years females were photographed with a different calf, open circles represent years they were seen without a calf, and dashes indicate years they were not photographed.

| Whale ID# | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|
| **LSI-0004** | ● | - | ● | - | - |
| **LSI-0013** | ● | - | - | - | ● |
| **LSI-0015** | ● | - | - | - | - |
| **LSI-0017** | ● | - | - | - | - |
| **LSI-0018** | ● | - | - | ● | - |
| **LSI-0023** | ● | ○ | - | - | - |
| **LSI-0025** | ● | - | - | ● | - |
| **LSI-0034** | ● | - | - | ● | - |
| **LSI-0035** | ● | ○ | ● | - | - |
| **LSI-0039** | ● | - | ○ | - | - |
| **LSI-0046** | ● | - | ○ | - | - |
| **LSI-0051** | ● | - | - | ○ | - |
| **LSI-0055** | ● | - | ● | - | - |
| **LSI-0057** | ● | - | ● | - | - |
| **LSI-0058** | ○ | ● | - | - | - |
| **LSI-0059** | ● | - | - | - | - |
| **LSI-0070** | ● | - | ● | - | - |
| **LSI-0106** | ○ | ● | - | - | - |
| **LSI-0124** | ● | - | - | ● | - |
| **LSI-0142** | ● | - | - | - | - |
| **LSI-0150** | ● | - | ○ | - | - |
| **LSI-0167** | - | ● | - | ● | - |
| **LSI-0171** | ○ | ● | - | ● | - |
| **LSI-0174** | - | ● | ○ | - | - |
| **LSI-0200** | - | ● | - | ● | ○ |

Continue next page

Table V. – Continuation –

| Whale ID# | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|
| **LSI-0202** | - | ● | - | - | ● |
| **LSI-0242** | - | ● | - | - | ● |
| **LSI-0251** | - | ● | - | ● | - |
| **LSI-0298** | - | ● | - | ○ | - |
| **LSI-0318** | - | ● | - | - | ● |
| **LSI-0325** | - | ● | - | - | - |
| **LSI-0347** | - | ● | - | - | ○ |
| **LSI-0359** | - | ● | ○ | - | - |
| **LSI-0370** | - | ○ | ● | - | - |
| **LSI-0378** | - | ● | - | - | ● |
| **LSI-0400** | - | ● | - | ● | - |
| **LSI-0403** | - | ○ | - | ● | - |
| **LSI-0410** | - | ● | - | - | - |
| **LSI-0436** | - | ○ | ● | - | - |
| **LSI-0440** | - | ○ | ● | - | - |
| **LSI-0452** | - | ○ | - | - | - |
| **LSI-0469** | - | - | ● | - | - |
| **LSI-0522** | - | - | ● | - | ● |
| **LSI-0576** | - | - | ○ | ● | - |
| **LSI-0653** | - | - | ● | - | - |
| **LSI-0705** | - | - | ● | - | - |
| **LSI-0750** | - | - | - | ● | - |
| **LSI-0887** | - | - | - | ○ | - |
| **LSI-1390** | - | - | - | - | ● |
| **LSI-1414** | - | - | - | - | ● |

## Health Assessment

A review of the 2007 photographic data indicated that a number of individual whales exhibited obvious signs of mal-nutrition and/or disease that has been termed evidence of the "skinny whale syndrome" (Weller et al. 2000) (Figs. 7-10). A total of 615 unique individual whales were photographed during the 2007 photographic identification surveys. While most gray whales observed within Laguna San Ignacio appeared to be normal, 12.35% exhibited "skinny whale" characteristics (Table VI). These characteristics included post cranial depression (Fig. 13.), hump in the dorsal neck region of the body (Fig. 14) protruding leading edge of the scapula (Fig. 15.) and a concave rather than a convex profile to the dorsal flank area (Fig. 16). Others were observed with protruding leading edges of their scapula, and concave rather than convex profiles to their dorsal flank areas.

Table VI. Proportion of skinny whales in San Ignacio lagoon B.C.S. México, during 2007 winter.

| Group class | Individuals | Skinny whales | Proportion (%) |
|---|---|---|---|
| Cow-calf | 137 | 24 | 17.50 |
| Singles | 453 | 48 | 10.60 |
| Undetermined | 25 | 4 | 16.00 |
| Total | 615 | 76 | 12.35 |

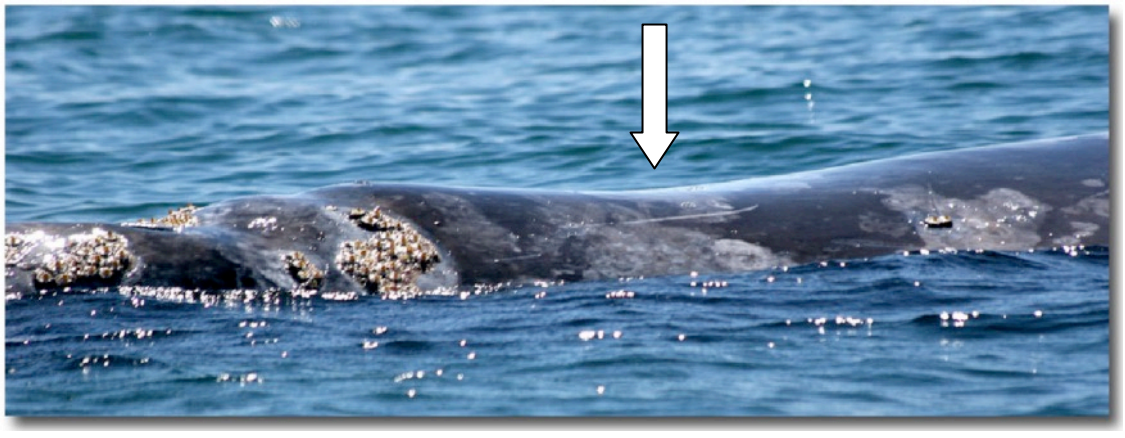

Figure 13. Post cranial depression.

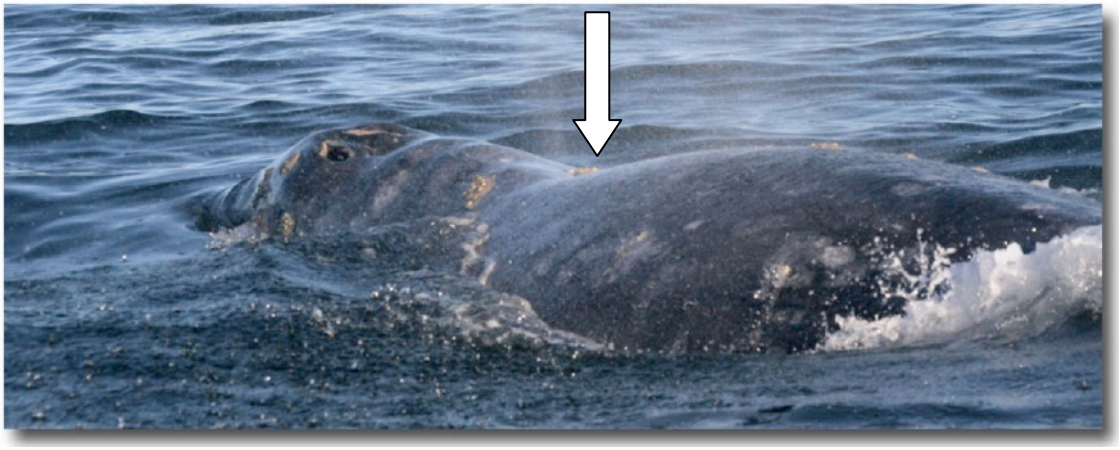

Figure 14. Hump in the dorsal neck region of the body.

Figure 15. Protruding leading edge of the scapula.

Figure 16. Concave profile of the dorsal flank area.

# IV. Laguna San Ignacio Ecosystem Science Program Meeting

On 24 February 2007 a workshop meeting was held at the Kuyima Eco-Tourism campground with the Eco-Tourism Operators, fishermen, and local residents of the lagoon. The purpose of the workshop was to discuss and to explain the "ecosystem science" program at Laguna San Ignacio, and to discuss the primary conservation and management concerns at the lagoon. The workshop was attended by 18 Eco-Tour operators, fishermen and residents and several recommendations for the future of the "ecosystem science" program were received (Fig. 17).

During the meeting the following activities took place:

1. An overview presentation of the Laguna San Ignacio Ecosystem Science Program by Drs. Steve Swartz and Jorge Urbán, Program Coordinators (Figs. 18-19).
2. A question, answer and discussion session involving the program scientists, the Eco-Tourism operators and fishermen.
3. A discussion about the value and contribution of "local knowledge" of Laguna San Ignacio Ecosystem, the whales and marine life.
4. Suggestions and recommendations for the future of the "ecosystem science" program from Eco-Tourism operators and fishermen.

Suggestions and recommendations for the future of the "ecosystem science included:

a. Provide a "Local Knowledge" page on the Laguna San Ignacio Web Site where fishermen and other lagoon residents could share their observations and information.
b. Hold an annual evaluation workshop of the Laguna San Ignacio Ecosystem Science Program in San Ignacio Town so it will be possible for the local residents and community to attend and learn about the science program.
c. Increase the awareness of number of research groups that will be working each year in the lagoon to minimize the number of pangas operating at the same time in the lagoon. It was noted that there is a maximum number of boats permitted at the

same time in the observation area (maximum carrying capacity) and the researchers' pangas contribute to the maximum number allowed under the regulations.

Figure 17. Eighteen participants (eco-tourism and local fishermen attend the Laguna San Ignacio Ecosystem Science Program Meeting on the February 24th 2007 at Kuyima base camp in San Ignacio Lagoon.

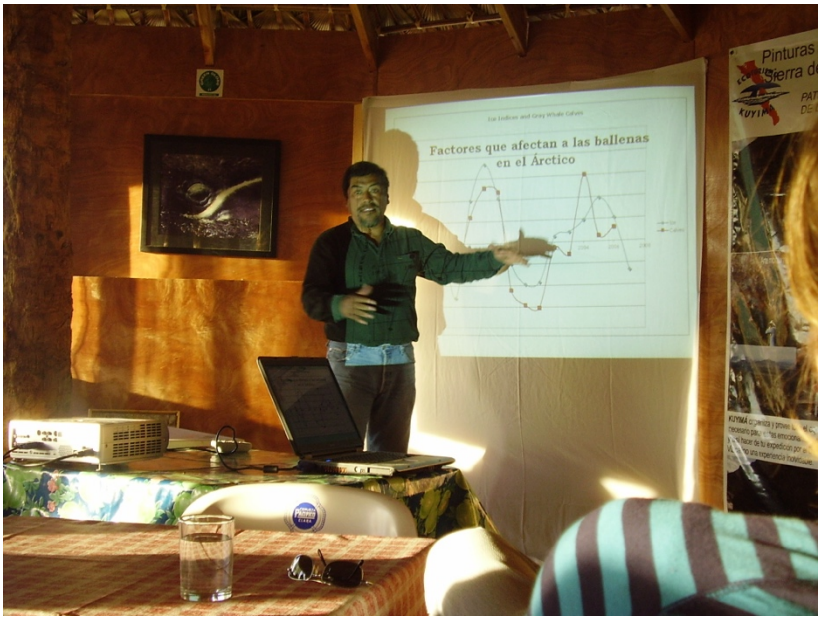


Figure 18. Dr. Jorge Urbán (Marine Mammal Research Program, Autonomous University at Baja California Sur, MÉXICO) talking about past twenty years of scientific research studies in San Ignacio Lagoon.

Figure 19. Dr. Steve Swartz (Cetacean Research Associates, Maryland USA) explaining Laguna San Ignacio Ecosystem Science Program.

# V. DISCUSSION

The counts of gray whales residing within Laguna San Ignacio during the 2007 winter season were noticeably lower than in any previous years counts dating back to 1978, and this was especially true of female-calf pairs (which are equivalent to calf-counts) (Table II). This decreasing trend in the number of whales observed in the lagoon could be a reflection of the overall decline in the Eastern North pacific (ENP) gray whale population since its peak abundance in 1997-1998 (Fig. 20) and/or a shift in the winter distribution of gray whales to areas other than Laguna San Ignacio.

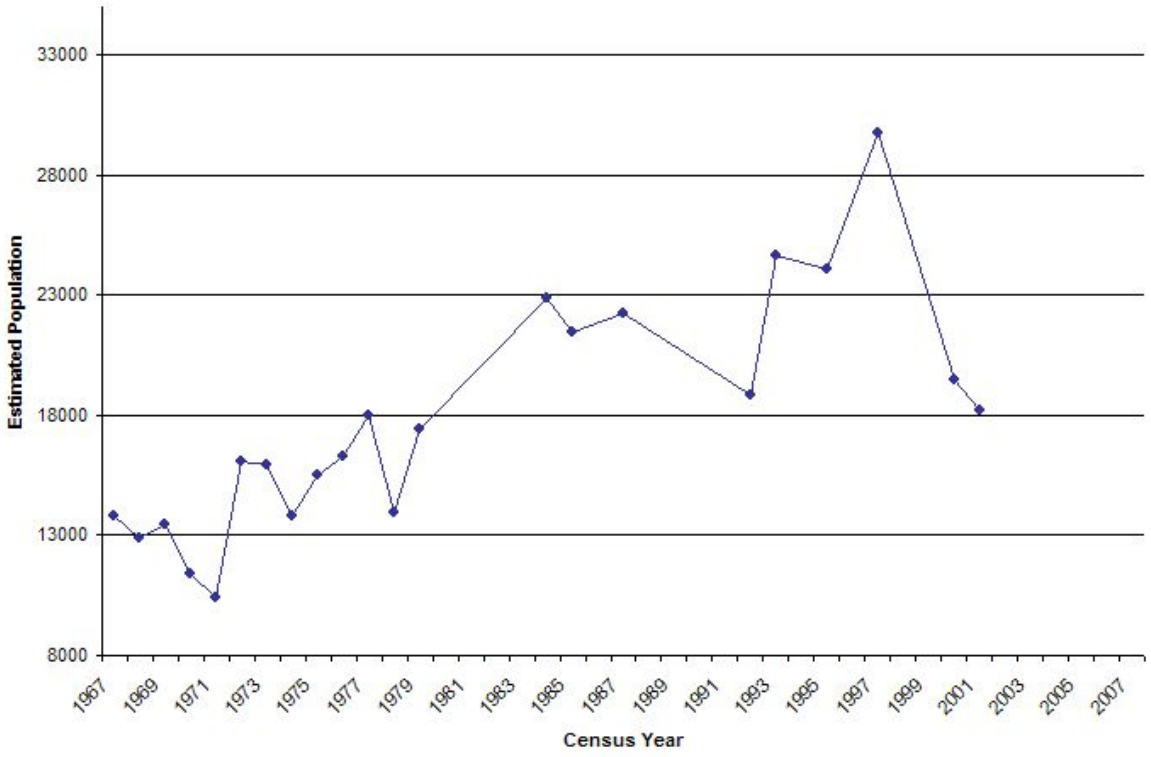


Figure 20. Estimates of the gray whales in the eastern North Pacific population based on visual census of the fall migration past the Granite Canyon, California observation station between 1967/1968 to 2001/2002 (from Rugh *et al.* 2005).

While it is well documented from the central California population census counts

that following a population wide mortality event in 1999-2000 (LeBoeuf *et al.* 2000) the ENP population declined almost one-third from approximately 30,000 to 18,000 individuals by 2001-2002 (Rugh *et al*. 2005). Unfortunately, systematic surveys to count gray whales throughout their winter range and specifically in the breeding lagoons of Baja California have not been conducted since the 1979-1980 winter (Jones and Swartz 1984), and thus it is not possible to determine if gray whales may have shifted their winter distribution from Laguna San Ignacio to other breeding lagoons and coastal areas. Photographic identification studies suggest that, historically, both single adult whales and females with calves of the year can circulate within the Baja California breeding lagoons and coastal areas within the same winter, and that they may visit alternate areas across years (Jones 1990; Jones and Swartz 1984).

Other factors that could affect the number of gray whales observed in Laguna San Ignacio include changes in the phenology of their migrations resulting from changes in the distribution and availability of prey (Highsmith *et al.* 2006; Grebmeier *et al.* 2006), the influence of sea surface temperature on migratory behavior during El Nino/La Nina events (Urbán *et al*. 2003), and/or human activities within the lagoon during the winter whale breeding season (Urbán and Gómez-Gallardo 2000).

Historically the Chukchi Sea and the Chirikov Basin in the northern Bering Sea were known as the ENP gray whales' primary feeding grounds due to high densities of whales observed there during the summer (Kim and Oliver 1989 and Moore *et al*. 2003), and the whales' ampelicid amphipod prey (Grebmeier *et al*. 1989; Highsmith and Coyle 1990). Throughout the 1990s the benthic productivity of the Chirikov basin declined precipitously, due to either overgrazing by the whales (Highsmith *et al.* 2006) or an ecosystem regime shift in the Bering Sea (Grebmeier *et al.* 2006), or some combination of factors. Moore *et al.* (2003) report that only the southern Chukchi Sea supported dense aggregations of gray whales, and that gray whales are now foraging in areas heretofore not considered their primary feeding areas or primary prey species (Moore *et al.* 2007).

Highsmith and Coyle (1992) predicted that the growing gray whale population of the 1990s would not be supportable at its historical primary feeding locations, and that the ENP population may have approached or even exceeded the limits of the available prey

base, or carrying capacity by the turn of the century (LeBoeuf *et al.* 2000; Moore *et al.* 2001; Perryman *et al.* 2002). Disruption of the flow of nutrient rich waters that feed primary and secondary production and support the Arctic benthic communities on which gray whales fed historically could have implications for ENP gray whale calf production and survivorship (Highsmith and Coyle 1990). Dramatic changes in the oceanography of the Arctic associated with global climate change have occurred in recent decades (Green and Pershing 2007) and specifically in the Bering Sea (Grebmeier *et al.* 2006) where marine wildlife populations are apparently responding to the resulting environmental changes. Responses include declines in gray whale abundance on their former primary summer feeding areas in the Chirikov Basin and dispersal to other foraging areas (Moore *et al*. 2007).

Low gray whale calf counts in Laguna San Ignacio and during their northward spring migration are especially troublesome, as they could indicate a reduction in the reproductive potential of the population. Perryman *et al*. (2002) observed that gray whale calf production appears linked to summer ice conditions in the Arctic which may limit pregnant female whales' access to prey resources in some years, and subsequently lower calf survivorship. Their observation suggest that short-term, annual changes in oceanic sea ice conditions along with longer-term basin scale changes may ultimately affect gray whale productivity. Our observations of "skinny" gray whales in Laguna San Ignacio also suggest that prey resource limitation is a factor in the health and status of the population. Vulnerability to parasites and disease associated with prey switching and overall stress could affect gray whale productivity and survivorship (F. Gulland, S.E. Moore and T. Rowles, *pers. Comm*.). Jones (1990) estimated the calving interval for female gray whales at 2.11 + SD 0.403 years during the period 1977 to 1982. The estimated calving interval of 2.48 + SD 0.607 from this study suggests that fewer females are reproducing every other year, which has been typical in the previous decade, and suggests that the reproductive rate of the p ENP population may be slowing. Low calf counts could be indicators that some gray whale females are unable to obtain sufficient energy resources to conceive, or if pregnant to bring calves successfully to term. Brownell and Weller (2002) suggest that resource limitations may result in a three-year rather than the normal two-year reproductive

cycle in western north Pacific gray whales.

Shorter-term oceanic temperature changes may also have an effect on gray whale migration timing, distribution, and production. The Pacific ENSO or Equatorial Northern and Southern Oscillation events result in an anomalous warming of the sea surface temperature during one year, the El Niño, followed by a cooling event the following year, or La Niña (Philander 1985; 1990). These events can influence the phenology, productivity and survivorship of marine animals, including gray whales. Urbán *et al*. (1999) documented a decrease in the number of gray whale females with calves visiting Laguna San Ignacio during the 1997-1998 El Niño and 1998-1999 La Niña events, along with increases in gray whale mortality, and a general shift in the winter distribution of gray whales to the northern areas during the warmer El Niño, and a shift to more southern areas during the cooler La Niña.

Human activities within Laguna San Ignacio could also influence the number and duration of stay of gray whales during the winter months. Whale-watching tourism, fishing, and scientific research all occur within Laguna San Ignacio during the winter breeding season of the gray whales, and all contribute to the underwater noise to the lagoon habitat. In the short-term, the gray whales appear to respond to this boat traffic in one of two ways: they generally ignore the whale-watchers and other boats; or they approach the boats and allow the passengers to pet and massage them in episodes termed "friendly whale behaviour" (Jones and Swartz 1984) which continues to be a popular feature for whale-watchers and eco-tourists to this day.

Beginning in 1978, whale-watching has been regulated by permit in Laguna San Ignacio, and restricted to the lower zone nearest the lagoon entrance (Jones and Swartz 1984). The remaining interior two-thirds of the lagoon remains sanctuary where whale-watching is not permitted. By 1996 Mexico had in place regulations that specified: specific areas where whale-watching activities are permitted (*i.e*., the Lower Zone); the length of the whale-watching season; the number and type of whale-watching boats permitted; and the maximum duration of a single whale-watching trip (*i.e*., 2-hrs) (Urbán and Gómez-Gallardo 2000). In addition to whale-watching in the Lower Zone, fishing and research permits are issued each year which allow these activities throughout the entire lagoon,

however, their numbers are relatively few compared to the number of whale-watching permits issued. The numbers of fishermen have fluctuated annually, although the exact numbers are not well documented. All of these boats do contribute outboard motor noise to the ambient noise levels in the lagoon each winter season.

Jones and Swartz (1984) noted the potential for detrimental consequences to gray whales from human activities within their breeding lagoons, and sought to evaluate the biological considerations that could contribute to such effects during their field studies from 1978 to 1982. They looked at the frequency of commercial whale-watching vessel visitation to the lagoon during this period, and noted that whale-watching vessels and their pangas were active 67% of the time, on average. They detected no changes in the distribution of the whales within the lagoon zones, and no changes in mortality of adult or calves that could be associated with the whale-watching activities. They found no conclusive evidence that gray whales moved out of the areas of whale-watching activities, and they concluded at that time whale-watching activities did not seem to pose a threat to the gray whales' continued use of Laguna San Ignacio.

From 1996 to 2000 eco-tourism based whale-watching increased in Laguna San Ignacio so that there were no days without whale-watching boats operating (Urbán and Gómez-Gallardo 2000), and the number of gray whales utilizing the lagoon also declined by 30% during this period. Gómez-Gallardo (2004) examined the trends of single whale counts and females calf pair counts during the period 1996-1997 and 1978-1982 and suggested that the increase in whale-watching activities that take place in the main areas of the lagoon could have contributed to the decrease of single whales. Urbán and Gómez-Gallardo (2000) suggested the variation in the abundance of whales in the lagoon was due to natural modification in the timing and movements of whale in response to environmental factors and/or human activities such as whale-watching. While they could not demonstrate a direct causal relationship between whale-watching and the fewer number of whales observed in the lagoon, they noted the potential for disturbance and recommended that monitoring programs continue to track the trends in whale-watching activity and trends in the number of whales utilizing the lagoon.

We conclude that following its apparent recovery from depletion, the ENP gray

whale population is now responding in several ways to environmental changes and possible over utilization and decline of its primary food resources. These responses include decreased abundance since the mid-1990s, reduction in the production of calves, changes in the timing of migration and distribution of ENP gray whales on the winter breeding range, and the presence of "skinny" individuals within the population. We concur with our colleagues that, gray whales by nature of their coastal migrations and specific gathering areas in the winter breeding and summer feeding ranges lend themselves to the study and monitoring of changes in their phenology, movements, productivity, and behavior, and these in turn can tell us much about changes in the marine ecosystems gray whales frequent. As such, gray whales are key "indicators" or "sentinel" species that can tell us much about of the health and status of their north Pacific ecosystem.

# VI. ACTIVITIES IN PROGRESS

The following ongoing activities are part of the Laguna San Ignacio gray whale research and monitoring studies.

## Photo-Identification Web-based Database

This web-based photographic identification database and archive is being transitioned from a PC-MS-Access based program to an internet Web-Based program during the summer of 2007. Our goal is to provide a valuable and powerful research tool for gray whale researchers throughout the range of the species. The internet based program will provide access to photographic data sets and the associated searching and sorting software will make the comparison of hundreds or even thousands of gray whale photographs from very different region along it´s migratory route easier and faster. Once the web-based Photo-Id database program is on-line and running, the photographic information from all participating researchers will be accessible via the internet, and researchers may review the database for matches with their photographs. This database and archive will be available for inter-institutional and multinational studies and collaborations. Dr. Steven Swartz is leading this effort with assistance from Dr. Bruce Mate of Oregon State University's Marine Mammal Studies program as a collaborator.

## Eco-tourism Whale-Watching Activities

The information on the historical levels and current levels of whale-watching activities in San Ignacio lagoon from the eco-tourism operators is being archived and analyzed with the assistance of Kuyima Eco-Tourism and the Universidad Autónoma de Baja California Sur. This activity will assemble historical data on the numbers of whale-watching boats that have operated in the lagoon since 2002 to the present, and this database will allow the analysis of levels of whale-watching boat activity (*i.e.*, the number of boats and the time spent at the whale-watching area) for comparison with information

collected during the period 1978 to 1982 (Jones and Swartz 1984). Once this information be in this database, it will be possible to compare the changes in the intensity of whale-watching with changes in the number of gray whales that utilize the lagoon historically and in recent years. This activity is coordinated by MSc. Alejandro Gómez-Gallardo.

# VII. ACKNOWLEDGEMENTS

We gratefully acknowledge of our volunteers Mariela Brito, Loana Mariam Lerch, Katia Galindo, Liliana Paredes, Margarita Aguliar, Klara Jansson for assisting with the field work during the 2007 winter season. The Pacific Life Foundation and The Ocean Foundation provided financial support. Logistic support and field laboratory facilities were provided by Kuyima Eco-Tourismo, the Summer Tree Institute, and Searcher Natural History Tours. The project was conducted under the authorization of Mexican research permit No.00506 from the Subsecretaría de Gestión Para La Protección Ambiental, Dirección General de Vida Silvestre.

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