

PRELIMINARY COMPARISON OF WINTER COUNTS OF GRAY WHALE IN LAGUNA SAN IGNACIO, B.C.S., MEXICO FROM 1978 TO 2008

Steven L. Swartz¹, Jorge Urbán R²., Alejandro Gómez-Gallardo U.²,
Sergio González C.², Benjamín Troyo V.², and Mauricio Nájera C.²

¹*Cetacean Research Associates
14700 Springfield Road, Darnestown, Maryland 20874 USA*

²*Departamento de Biología Marina. Universidad Autónoma de Baja California Sur
Ap.Post 19-B. La Paz, B.C.S. 23081 MEXICO*

ABSTRACT

Laguna San Ignacio (LSI) 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*). Boat surveys utilizing standardized methodology to count the number of gray whale visiting LSI during the winter were conducted from 1978-1982 (Jones and Swartz 1984), 1996-2000 (Urban et al. 2000), 2003 and 2005 (Urban unpublished), 2006-2007 (Swartz et al. 2007) and 2008 (this paper). Counts from these surveys were compared as four distinct time series that corresponded to specific periods and events in the population's recent history: 1978-1982 the baseline period; 1995-1997 the pre-die-off period; 1998-2000 the period of the range-wide die-off; and 2003 to 2008 the post die-off period. Counts of the total number of adult whales, female-calf pairs, and single non-calf whales were greatest during the baseline period from 1978-1982. Counts of adult whales decreased during the pre-die-off and die-off periods to approximately two-thirds those seen during the baseline period and continued to decline during the post-die-off period. This post-die-off decline included counts of single non-calf whales and mother-calf pairs. Mother-calf pair counts declined during each time period and were the lowest recorded during the post-die-off period from 2003-2008. Overall counts in 2008 were the lowest ever recorded in LSI during winter. The length of the winter season of lagoon occupation also shortened approximately two weeks following the baseline period (1995-2008) as gray whales arrived later and departed sooner from the lagoon. There was also a general shift in the timing of the maximum counts of whales of approximately 7-12 days later than during the baseline period. The 2008 arrival and occupation of LSI was the latest and shortest ever recorded for gray whales this lagoon. Comparison of these trends with other breeding lagoons is needed to determine if these decreasing counts, shortening and shift in the timing of the winter lagoon occupation by gray whales reflect actual population declines or changes in gray whale distribution to other areas within their winter range.

KEY WORDS: GRAY WHALE, BREEDING LAGOONS, ABUNDANCE COUNTS, MOTHER-CALF PAIRS, CARRYING CAPACITY, MORTLAITY, ABUNDANCE DECLINE

INTRODUCTION

The eastern North Pacific gray whale population increased to its historical maximum in 1998 of approximately 29,758 (95% LN CI 24,241-36,531) whales and, following an unusual range-wide mortality event during 1999-2000, the population estimate declined to approximately 18,178 (95% LN CI 15,010-22,015) whales by 2002 (Rugh et al. 2005).

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 (Urban, et al. 2002). 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).

Boat surveys utilizing standardized methodology were used to count the number of gray whale residing within LSI during the winter were conducted from 1978-1982 (Jones and Swartz 1984), 1996-2000 (Urban et al. 2000), 2003 and 2005 (Urban unpublished), 2006-2007 (Swartz et al. 2007) and 2008 (this paper). Counts from these surveys were compared as four distinct time series that corresponded to specific periods and events in the population's recent history: 1978-1982 the baseline period; 1995-1997 the pre-die-off period; 1998-2000 the period of the die-off; and 2003 to 2008 the post die-off period.

METHODS

Boat Surveys (census)

One hundred and seventy-three (173) complete census surveys to determine whale abundance and distribution within the lagoon were conducted during the periods from January 4 to 15 April each year (Tables I-III). 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 1995-2006 (Urban *et al.* 2002, and unpublished), 2007 (Swartz et al. 2007) and in 2008. No complete whale surveys were conducted in the years 1983-1995, or in 2001-2002, or 2004.

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 visual landmarks (1978-1982 surveys) and with a hand-held GPS (Global Position System) device (1996-2008 surveys). 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 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 zones including the north end area) (Fig. 2). Survey counts were compared as four distinct time series that corresponded to specific periods and events in the population's recent history: 1978-1982 the baseline period; 1995-1997 the pre-die-off period; 1998-2000 the period of the range-wide die-off; and 2003 to 2008 the post die-off period.

RESULTS

Counts of gray whales from boat surveys are used as an index of the minimum abundance of whales within the lagoon each survey day during the winter breeding season and do not represent estimates of total abundance or the total number of whales that visit the lagoon during a winter season.

2008 Survey Counts:

Fourteen surveys were conducted to count gray whales between 25 January and 21 March 2008. The maximum count of adult whales was 139 on 28 February (103 "single" whales and 36 cows with calves). The highest count of single whales was 110 and occurred on 9 March, and the highest cow-calf pair count was 39 on 4 and 21 March (Tables I-III). The high count of 139 adult whales was 66% less than the highest recorded count of 407 adult whales on 14 February 1982, and occurred from two to 31 days later in the season than in 12 of the previous 15 winter 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 (Figs. 3-5).

Comparison with Previous Years:

Adult Whale Counts: Counts of adult whales in Laguna San Ignacio were greatest during the baseline period from 1978 to 1982 and reached average maximum numbers of between 400 to 300 whales in mid-February each year (Fig. 3) (Jones and Swartz 1984). Maximum counts of adults during the years from 1995 to 1997 ranged from 200 to 250 whales and occurred from 7 to 10-days later in the season than during the baseline period (Urban et al. 1996 and 1999). Maximum counts during the die-off years from 1998 to 2000 were similar in magnitude and timing as the previous period, but post-die-off maximum counts from 2003 to 2008 were generally lower than previous counts and occurred 5-7 days later in the season (Swartz et al 2007, and this paper).

At the beginning of the season the first counts over 50 whales occurred during the first week of January (4 January) during the 1978-1979 baseline period, and by week 15 (12 April) at the end of the winter season it was not unusual for 100 or more whales (mostly females with calves) to remain in the lagoon (Fig. 6). By the 1990's counts of 50 whales or more were not obtained until the third or fifth week of the winter season (January 18 to February 8), and the end of the season counts below 50 whales occurred as early as week 11 (March 15). In 2008 the first count over 50 whales occurred at week 5 (8 February) and the last count of 50 whales occurred after week 12 (29 March). Overall, these counts of adult whales suggest a continual decline in the number of adult whales counted in Laguna San Ignacio over three decades, a shortening of the winter season of lagoon occupation from 15+ weeks to 9-10 weeks, and a shift of the timing of the migration to the lagoon of up to two weeks from mid-February during the baseline period to late February or early March in recent years.

Single whale counts: Counts of single adult whales in Laguna San Ignacio were also greatest during the baseline period from 1978 to 1982 and reached average maximum numbers of between 200 to 250 single whales in mid-February each year (Fig. 4) (Jones and Swartz 1984). Maximum counts of single whales during the years from 1995 to 2008 ranged from approximately 140 to 175 whales and occurred approximately two weeks later later in the season than during the baseline period (Fig 7). Maximum counts during the die-off years from 1998 to 2000 were similar in magnitude and timing, but post-die-off maximum counts from 2003 to 2008 occurred later in the season than in previous years (Swartz et al 2007, and this paper). The lowest single whales counts signalling their departure from the lagoon was similar in all years and occurred from mid-March to early April. It was noted that the arrival of single whales in 2008 was 7-10 days later than in previous years, although their departure was similar to all other years.

Mother-calf counts: Counts of mothers with calves in Laguna San Ignacio were greatest during last weeks of each season during the baseline period from 1978 to 1982. As noted by Jones and Swartz (1984), mother-calf counts reached peak numbers in March each survey years and ranged from around 175 to over 250 mother-calf pairs (Fig. 5). They attributed this

late season increase to mother-calf pairs that were migrating northward from areas south of Laguna San Ignacio and entering the lagoon during the last weeks of the winter breeding season. This seasonal trend in mother-calf pair counts changed drastically with fewer mother-calf pairs counted in the lagoon (less than 100 pairs compared to 200), and their reduction to fewer than 20 pairs (rather than an increase) by early April during the years from 1995 to 2008 (Fig. 8). Maximum counts of approximately 100 mother-calf pairs occurred in late-February to early-March during the 1995 to 1997 surveys. Counts of mother-calf pairs then declined to less than 60 pairs during the post-die-off years from 1998 to 2008. These counts suggest that fewer gray whale calves were being born during and after the die-off, that fewer mother-calf pairs were utilizing Laguna San Ignacio as a winter nursery area, or both. The 2008 mother-calf-pair counts were the lowest recorded in this lagoon since surveys began in 1978.

DISCUSSION

It is well documented from the central California census of the NEP gray whale population that following a population wide mortality event in 1999-2000 (LeBoeuf et al., 1999) the population declined almost one-third from approximately 30,000 to 18,000 individuals by 2001-2002 (Rugh et al. 2005). It is possible that this decline was in part due to the population increasing beyond the carrying capacity (K) of the environment (Moore et al. 2001).

The counts of gray whales residing within Laguna San Ignacio during the 2008 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 III, Fig. 8). This decreasing trend in the number of whales observed in the lagoon could be a reflection of the overall decline in the NEP gray whale population since its peak abundance in 1997-1998 (Fig. 9) and/or a shift in the winter distribution of gray whales to areas other than Laguna San Ignacio.

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 areas along the pacific coast of Baja California, Mexico. 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).

Gray whales are sensitive to some underwater noise created by human activities such as oil and gas exploration and development (Malme et al. 1984) and the playback of industrial and novel underwater noise in a breeding lagoon (Jones et al. 1985). It is possible that the development of whale-watching within Laguna San Ignacio during the 1990's and early 2000's is contributing to the gray whales shifting to other areas for their winter breeding and calving activities (Swartz et al. 2007). Similar time series of gray whales counts from other lagoon areas and from the coastal shorelines of Baja California are, unfortunately, not available to test this hypothesis. Overall trends in the numbers of whales seen in Laguna San Ignacio do track the estimated one-third decline in the ENP population following the 1998-2000 range wide die-off (Le Boeuf et al. 2000, Rugh et al. 2005), and this suggests that counts of gray whales in Laguna San Ignacio may serve as a reliable index of the status of the overall population.

Counts of gray whales during any one year can be affected by physical factors such as sea temperature. For example, in 1999 and 2008 the sea temperature was unusually colder than normal, what is referred to as a "La Nina" event (Urban et al. 1999 and this paper). 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 Nino and 1998-1999 La Nina 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 Nino, and a shift to more southern areas during the cooler La Nina. During the first half of the 2008 winter the sea temperature in Laguna San Ignacio was 15° C and counts of gray whales were lower than expected compared to previous years. Gray whales were reported by vessel captains gathering in groups around the bays and points along the Baja California's Pacific coast, and they were seen migrating south around the southern tip of Baja California and into the Gulf of California as far north as Loreto (J. Urban pers com). Presumably the whales were seeking the warmer water temperatures generally encountered in lower latitudes. By mid-February the sea temperature within Laguna San Ignacio had increased to 19° C and counts of whales in the lagoon had also increased to numbers comparable with recent years (S. Swartz, pers. com and this paper). Counts of females with calves also increased late in the 2008 season in March, presumably as whales that had migrated south of Laguna San Ignacio earlier

in the season where now returning to begin their northward spring migration to the summer feeding areas.

Changes in the phenology of ENP gray whale migrations may also result from changes in the distribution and availability of prey in the Arctic and elsewhere (Highsmith et al. 2006; Grebmeier et al. 2006; Moore et al. 2003). 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. Low calf counts could be indicators that some gray whale females are having to range further to obtain sufficient energy resources to conceive, or if pregnant to bring calves successfully to term.

We conclude that 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, and we cannot rule out the potential influence of human activities to contribute to these responses. These responses include decreased abundance since the mid-1990s, reduction in the production of calves, and changes in the timing of migration and distribution of ENP gray whales on the winter breeding range.

ACKNOWLEDGEMENTS

We gratefully acknowledge of our volunteers Anaid Lopez Urban and Angie Sremba for assisting with the field work during the 2008 winter season. The World Wildlife Fund – Mexico, the Pacific Life Foundation and an anonymous donor provided financial support. Pro-Peninsula acted as the fiscal agent and coordinator for the 2008 program. Logistic support and field laboratory facilities were provided by Kuyima Eco-Tourismo, Baja Discovery Eco-Tours, and Searcher Natural History Tours. The project was conducted under the authorization of Mexican research permit No.008160 from the Subsecretaría de Gestión Para La Protección Ambiental, Dirección General de Vida Silvestre.

REFERENCES

- Dedina, Serge. 2000. Saving the Gray whale: People, Politics, and Conservation in Baja California. University of Arizona Press, Tucson, Arizona. 186 pp.
- Grebmeier, J.M., J.E. Overland, S.E. Moore, E.V. Farley, E.C. Carmack, L.W. Cooper, K.E. Frey, J.H. Helle, F.A. McLaughlin, and S.L. McNutt. 2006. A major ecosystem shift in the Northern Bering Sea. *Science*. 311:1461-1464.
- Highsmith, R.C., K.O. Coyle, B.A. Bluhm, and B. Konar. 2006. Gray whales in the Bering and Chukchi Seas. Pp. 303-313. In J.A. Estes, D.P. DeMaster, D.F. Doak, T.M. Williams, and R.L. Brownell, Jr., eds. *Whales, Whaling, and Ocean Ecosystems*. University of California Press, Santa Cruz. 402 pp.
- Jones, M.L., Swartz, S.L., and Dahlheim, M.E. 1994. Census of gray whale abundance in San Ignacio lagoon: A follow-up study in response to low whale counts recorded during an acoustic playback study of noise-effects on gray whales. Rep. For U.S. Marine Mammal Commission, Washington D.C. NTIS PB94-195062, 32 pp.
- Jones, M.L. and Swartz, S.L. 1984. Demography and phenology of gray whales and evaluation of whale-watching activities in Laguna San Ignacio, Baja California Sur, Mexico. In: Jones, M.L., Swartz, S.L. and Leatherwood, S. (eds.) *The gray whale, Eschrichtius robustus*. Academic Press, Inc., Orlando, Florida, pp. 309-374.
- LeBoeuf, B.J., H. Perez-Cortez M., J. Urban R., B.R. Mate, and F. Ollervides U. 2000. High gray whale mortality and low recruitment in 1999: potential causes and implications. *J. Cetacean research and Management* 2(2):85-99.
- Malme, C.I., Miles, P.R., Clark, C.W., Tyack, P., and Bird, J.E. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behaviour/Phase II: January 1984 migration. BBN

- Rep. 5586. Rep. From Bolt Berabek & Newman Inc., Cambridge, MA for U.S. Minerals Management Service, Anchorage, Alaska., NTIS PB86-218385.
- Moore, S.E., R.J. Urban, W.L. Perryman, F. Gulland, M.H. Perez-Cortez, P.R. Wade, L. Rojas-Bracho, and T. Rowles. 2001. Are gray whales hitting "K" hard? *Marine Mammal Science* 17:954-958.
- Moore, S.E., J.M. Grebmeier, and J.R. Davies. 2003. Gray whale distribution relative to forage habitat in the northern Bering Sea: Current conditions and retrospective summary. *Canadian Journal of Zoology* 81:734-742.
- Perryman, W.L., M.A. Donahue, P.C. Perkins, and S.B. Reilly. 2002. Gray whale calf production 1994-2000: Are observed fluctuations related to changes in seasonal ice cover? *Marine Mammal Science* 18:121-144.
- Rugh, D.J., R.C. Hobbs, J.A. Lerczak, and J.M. Breiwick. 2005. Estimates of abundance of the eastern North Pacific stock of gray whales (*Eschrichtius robustus*) 1997-2002. *J. Cetacean Res. Manage.* 7(1):1-12.
- Swartz, S.L., Urbán J., González S., Gómez-Gallardo, A., Troyo, B., Nájera, M., and Rojas-Bracho, L. 2007. Preliminary Report of the 2007 gray whale studies at Laguna San Ignacio, B.C.S., Mexico. Rep. Intl. Whal. Commn. SC/59/BRG39, 15 pp.
- Urbán, J.R., L. Rojas_Bracho, H. Pérez-Cortéz, A. Gómez Gallardo U., S. Swartz, S. Ludwig, and R.L. Brownell Jr. 2002. A review of gray whales on their winter grounds in Mexican waters. Rep. Intl. Whale Commission SC/54/BRG/16.
- Urbán, J.R., A. Gómez Gallardo U., V. Flores S., M. Palmeros R., and S. Ludwig. 1999. Changes in the abundance and distribution of gray whales at Laguna San Ignacio, Mexico during the 1997-98 El Nino and the 1998-1999 La Nina. . Rep. Inter. Whale. Commission SC/51/AS22, 8 pp.
- Urbán, J.R., A. Gómez Gallardo U., V. Flores S., J. Cifuentes L. 1996. Report of the 1996 gray whale studies at Laguna San Ignacio, B.C.S. Mexico. Rep. Inter. Whale. Commission SC/48/AS19, 15 pp.
- Weller, D.W., B. Wursig, A.M. Burdin, S.H. Reeve and A.L. Bradford. 2000. Gray whales off Sakhalin Island, Russia: June-October 1999. A joint U.S. – Russian scientific investigation. Final contract report to Sakhalin Energy Investment Company, 69 pp. Available from Texas A&M University, Marine Mammal Research Program, Galveston TX 77551 U.S.A.

Table I. Survey counts of adult (non-calf) gray whales in Laguna San Ignacio, B.C.S. from 1978 to 2008. Bold numbers are maximum counts during the season.

DAY	1978	1979	1980	1981	1982	1995	1996	1997	1998	1999	2000	2003	2005	2006	2007	2008
4-Jan	34															
5-Jan																
6-Jan																
7-Jan																
8-Jan																
9-Jan			53													
10-Jan																
11-Jan	53															
12-Jan																
13-Jan				88												
14-Jan																
15-Jan		63														
16-Jan																
17-Jan		86			87		29									
18-Jan	98		129				27									
19-Jan							32									
20-Jan				210												
21-Jan						25										
22-Jan																
23-Jan		102														
24-Jan																
25-Jan					160				75	15						10
26-Jan			162													
27-Jan				247							78		164			
28-Jan	231															
29-Jan									116							
30-Jan										37						16
31-Jan							84									
1-Feb		159			179		100									
2-Feb	302						110									
3-Feb											95					
4-Feb				315			112		158	58						
5-Feb			246				113							54	54	20
6-Feb															76	
7-Feb							147									57
8-Feb					339				210		227					
9-Feb		245														
10-Feb							96							69	89	63
11-Feb								223								
12-Feb	242			348		257										
13-Feb							147		230		149					
14-Feb					407					98						
15-Feb								154			197		97	142		74
16-Feb			332					205							125	

17-Feb							116								170	
DAY	1978	1979	1980	1981	1982	1995	1996	1997	1998	1999	2000	2003	2005	2006	2007	2008
18-Feb				318								172	159			
19-Feb			305							145	200					
20-Feb		294							168							
21-Feb					367									151		
22-Feb								240							217	84
23-Feb				207								196				
24-Feb							172				194					
25-Feb																
26-Feb	147		284					253		151						
27-Feb					249				99			125				
28-Feb																139
1-Mar		308									181					
2-Mar							207								167	
3-Mar			221				206									
4-Mar				189					77			74				135
5-Mar						81										
6-Mar								208				105				
7-Mar	108									124	142					
8-Mar		256			294											
9-Mar							127		37							134
10-Mar							127	204							78	
11-Mar									65							
12-Mar				229		27						155				
13-Mar																
14-Mar			171								129					79
15-Mar								125	22							
16-Mar							53								19	
17-Mar	202	220														
18-Mar				234	237											
19-Mar								77		90	71					
20-Mar			187						38				27			87
21-Mar							53									
22-Mar															36	
23-Mar										58						
24-Mar		155							19		34					55
25-Mar								124								
26-Mar	119			178						47					28	
27-Mar							51									
28-Mar			180													
29-Mar								73	15							
30-Mar															3	
31-Mar																50
1-Apr				138	269											
2-Apr	92										28					
3-Apr		234	163													18
4-Apr																

- 25 APRIL 2008 -

5-Apr																
6-Apr																
DAY	1978	1979	1980	1981	1982	1995	1996	1997	1998	1999	2000	2003	2005	2006	2007	2008
7-Apr				155												
8-Apr																
9-Apr		156	178													
10-Apr																
11-Apr	108															
12-Apr																
13-Apr																
14-Apr																
15-Apr										34						

Table II Survey counts of single adult (non-mother-calf pair) gray whales in Laguna San Ignacio, B.C.S. from 1978 to 2008.

DAY	1978	1979	1980	1981	1982	1995	1996	1997	1998	1999	2000	2003	2005	2006	2007	2008
4-Jan	32															
5-Jan																
6-Jan																
7-Jan																
8-Jan																
9-Jan			25													
10-Jan																
11-Jan	35															
12-Jan																
13-Jan				47												
14-Jan																
15-Jan		42														
16-Jan																
17-Jan		45			30		26									
18-Jan	76		36				15									
19-Jan							20									
20-Jan				149												
21-Jan						3										
22-Jan																
23-Jan		72														
24-Jan																
25-Jan					61				52	5						3
26-Jan			59													
27-Jan				168							63		44			
28-Jan	183															
29-Jan									94							
30-Jan										14						9
31-Jan							52									
1-Feb		95			104		64									
2-Feb	235						56									
3-Feb											70					
4-Feb				213			80		123	50						
5-Feb			149				76							29	42	7
6-Feb															59	
7-Feb							93									32
8-Feb					246				166		182					
9-Feb		168														
10-Feb							71							43	76	38
11-Feb								136								
12-Feb	168			207		217										
13-Feb							85		178		127					
14-Feb					270					85						
15-Feb								118			176		71	97		54
16-Feb			214					108							109	

- 25 APRIL 2008 -

17-Feb							74								133	
DAY	1978	1979	1980	1981	1982	1995	1996	1997	1998	1999	2000	2003	2005	2006	2007	2008
18-Feb				164								141	113			
19-Feb			118							129	170					
20-Feb		198							120							
21-Feb					205									108		
22-Feb								117							197	55
23-Feb				38								174				
24-Feb							104				132					
25-Feb										144						
26-Feb	58		132					127								
27-Feb					97				57			101				
28-Feb																103
1-Mar		208									146					
2-Mar							115								146	
3-Mar			57				112									
4-Mar				4					38			46				96
5-Mar						36										
6-Mar								65				78				
7-Mar	6									91	107					
8-Mar		122			13											
9-Mar							44		13							110
10-Mar							44	71							58	
11-Mar									2							
12-Mar				0		8					117					
13-Mar																
14-Mar			1								84					55
15-Mar								20	1							
16-Mar							1									
17-Mar	0	30													10	
18-Mar				0	0											
19-Mar								27		49	55					
20-Mar			1						0				9			49
21-Mar							3									
22-Mar															6	
23-Mar										19						
24-Mar		7							0		12					14
25-Mar								4								
26-Mar	0			0							19				10	
27-Mar							0									
28-Mar			0													
29-Mar								0	0							
30-Mar															0	
31-Mar																10
1-Apr				0	0											
2-Apr	0										3					
3-Apr		7	0													4
4-Apr																

- 25 APRIL 2008 -

5-Apr																
6-Apr																
DAY	1978	1979	1980	1981	1982	1995	1996	1997	1998	1999	2000	2003	2005	2006	2007	2008
7-Apr				0												
8-Apr																
9-Apr		1	0													
10-Apr																
11-Apr	0															
12-Apr																
13-Apr																
14-Apr																
15-Apr										0						

Table III. Survey counts of mother-calf pairs of gray whales in Laguna San Ignacio, B.C.S. from 1978 to 2008.

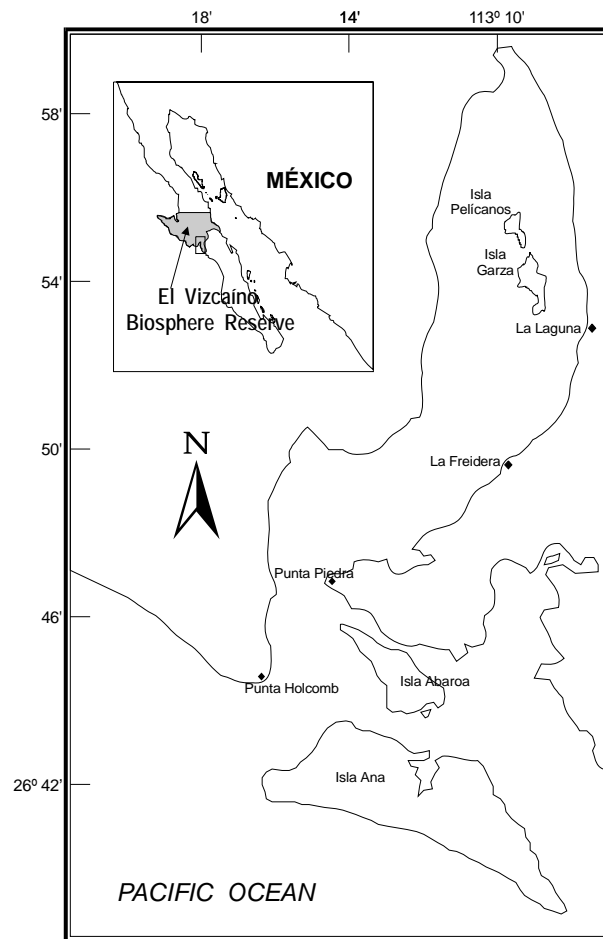
DAY	1978	1979	1980	1981	1982	1995	1996	1997	1998	1999	2000	2003	2005	2006	2007	2008
4-Jan	2															
5-Jan																
6-Jan																
7-Jan																
8-Jan																
9-Jan			28													
10-Jan																
11-Jan	18															
12-Jan																
13-Jan				41												
14-Jan																
15-Jan		21														
16-Jan																
17-Jan		41			57		3									
18-Jan	22		93				12									
19-Jan							12									
20-Jan				61												
21-Jan						23										
22-Jan																
23-Jan		30														
24-Jan																
25-Jan					99				23	10						7
26-Jan			103													
27-Jan				79							15		20			
28-Jan	48															
29-Jan									22							
30-Jan										23						7
31-Jan							32									
1-Feb		64			75		36									
2-Feb	67						54									
3-Feb											25					
4-Feb				102			32		35	8						
5-Feb			97				37							25	12	13
6-Feb															17	
7-Feb							54									25
8-Feb					93				44		45					
9-Feb		77														
10-Feb							25							26	13	25
11-Feb								87								
12-Feb	74			141		40										
13-Feb							62		52		22					
14-Feb					137					13						
15-Feb								36			21		26	45		20
16-Feb			118					97							16	
17-Feb							42								37	

18-Feb				154								31	46			
DAY	1978	1979	1980	1981	1982	1995	1996	1997	1998	1999	2000	2003	2005	2006	2007	2008
19-Feb			117							16	30					
20-Feb		96							48							
21-Feb					162									43		
22-Feb								123							20	27
23-Feb				169								22				
24-Feb							68				62					
25-Feb										17						
26-Feb	89		152					126								
27-Feb					152				42			24				
28-Feb																36
1-Mar		100									35					
2-Mar							92								21	
3-Mar			164				94									
4-Mar				185					39			28				39
5-Mar						45										
6-Mar								143				27				
7-Mar	102									33	35					
8-Mar		134			281											
9-Mar							83		24							24
10-Mar							83	133							20	
11-Mar									63							
12-Mar				229		19						38				
13-Mar																
14-Mar			170							45						24
15-Mar								105	21							
16-Mar							52									
17-Mar	202	190													9	
18-Mar				234	237											
19-Mar								50		41	16					
20-Mar			186						38				18			38
21-Mar							50									
22-Mar															30	
23-Mar										39						
24-Mar		148							19		22					41
25-Mar								130								
26-Mar	119			178						28					18	
27-Mar							51									
28-Mar			180													
29-Mar								73	15							
30-Mar															3	
31-Mar																40
1-Apr				138	269											
2-Apr	92										25					
3-Apr		227	163													14
4-Apr																
5-Apr																

- 25 APRIL 2008 -

6-Apr																
7-Apr				155												
DAY	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1995</u>	<u>1996</u>	<u>1997</u>	<u>1998</u>	<u>1999</u>	<u>2000</u>	<u>2003</u>	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>
8-Apr																
9-Apr		155	178													
10-Apr																
11-Apr	108															
12-Apr																
13-Apr																
14-Apr																
15-Apr										34						

Figure 1. Study site.



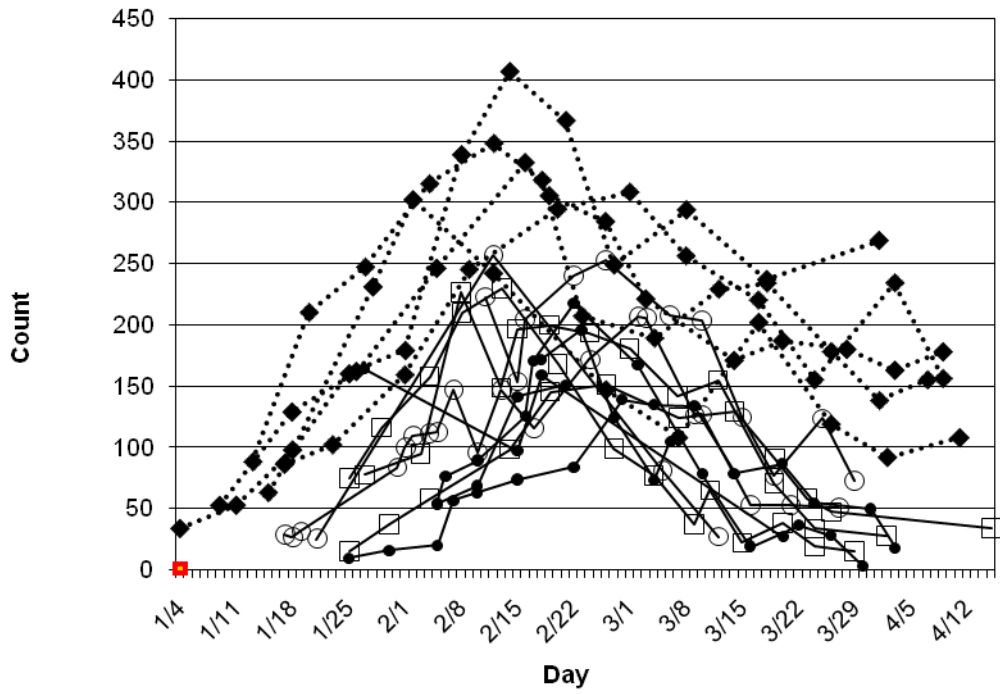


Figure 3. Number of adult whales counted in census surveys of Laguna San Ignacio between 1978 and 2008. Black diamonds = 1978-1982 surveys; White circles = 1995-2007 pre-die off surveys; White squares = 1998-2000 surveys during the die-off; Black Circles = 2003-2008 post die-off surveys.

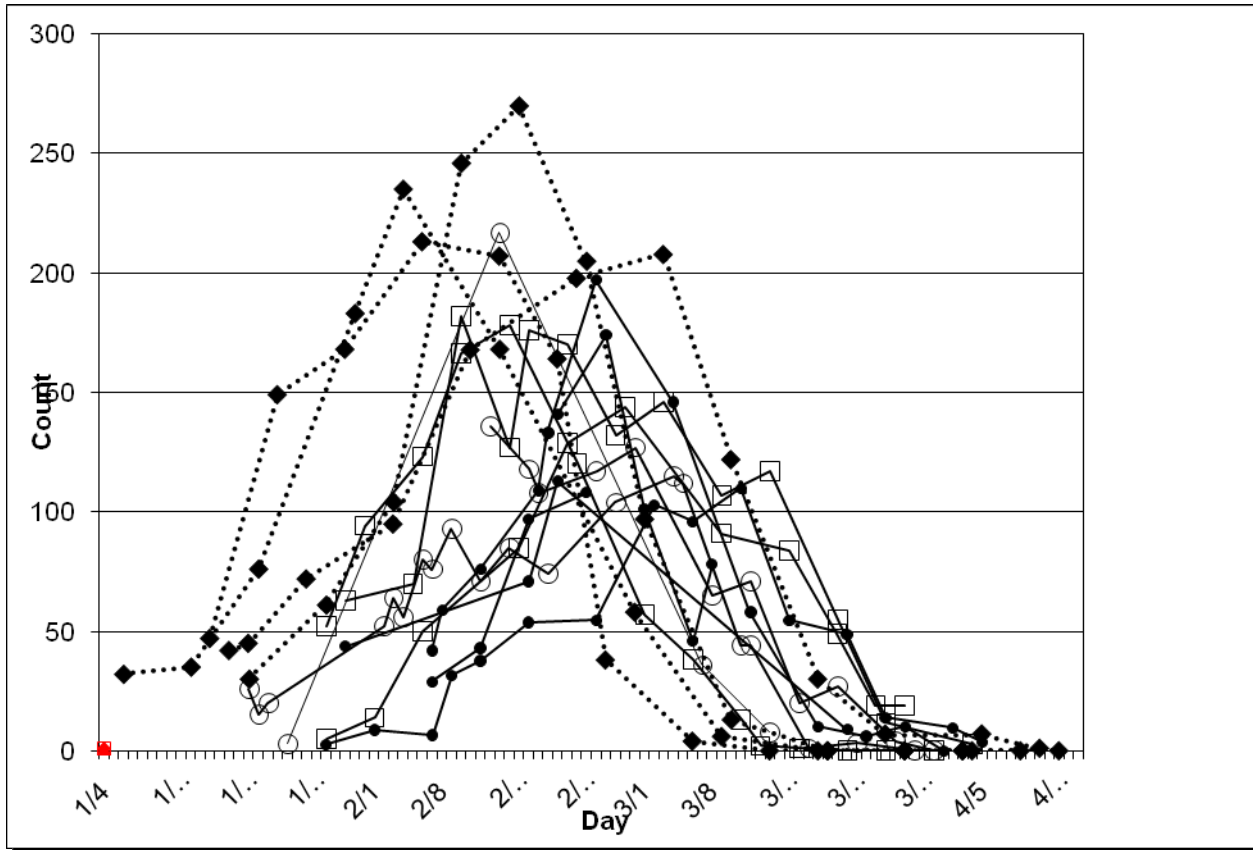


Figure 4. Number of single whales counted in census surveys of Laguna San Ignacio between 1978 and 2007. Black diamonds = 1978-1982 surveys; White circles = 1995-2007 pre-die off surveys; White squares = 1998-2000 surveys during the die-off; Black Circles = 2003-2008 post die-off surveys.

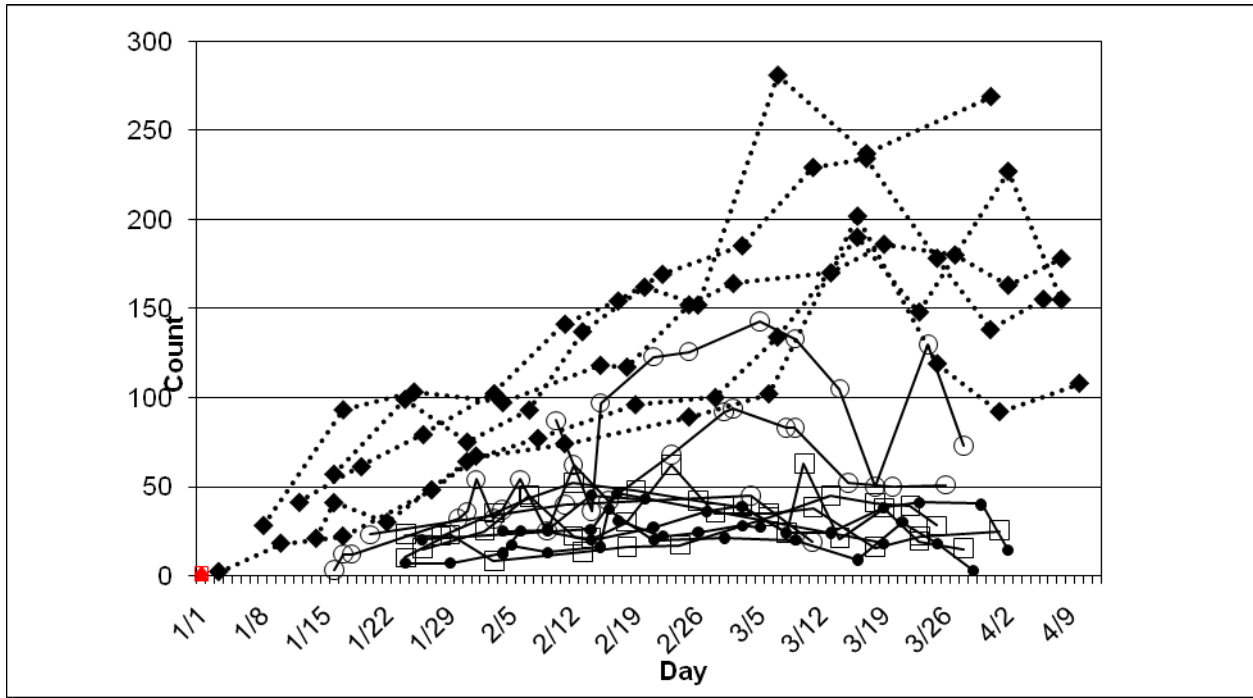


Figure 5. Number of female-calf pairs of gray whales counted in census surveys of Laguna San Ignacio between 1978 and 2007. Black diamonds = 1978-1982 surveys; White circles = 1995-2007 pre-die off surveys; White squares = 1998-2000 surveys during the die-off; Black Circles = 2003-2008 post die-off surveys.

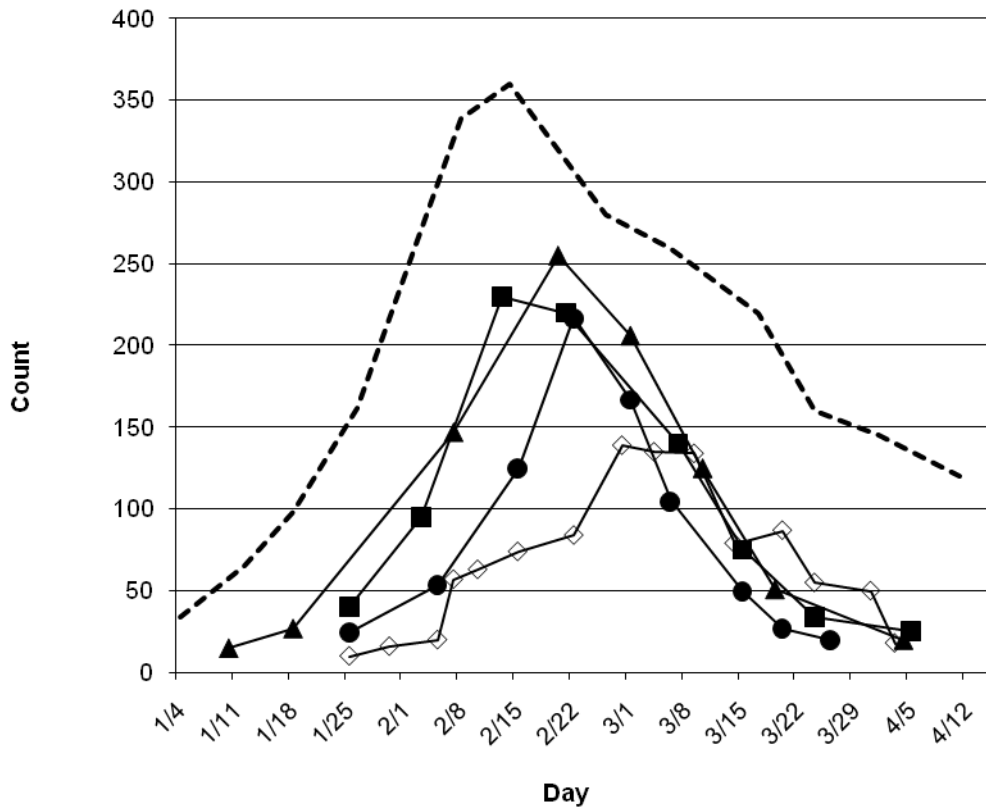


Figure 6. Trends in the number of adult (non-calf) gray whales counted within Laguna San Ignacio between 1978 and 2008. Broken line = 1978-1982; Black triangles = 1995-1997; Black squares = 1998-2000; Black circles = 2003-2008; and White diamonds = 2008 counts.

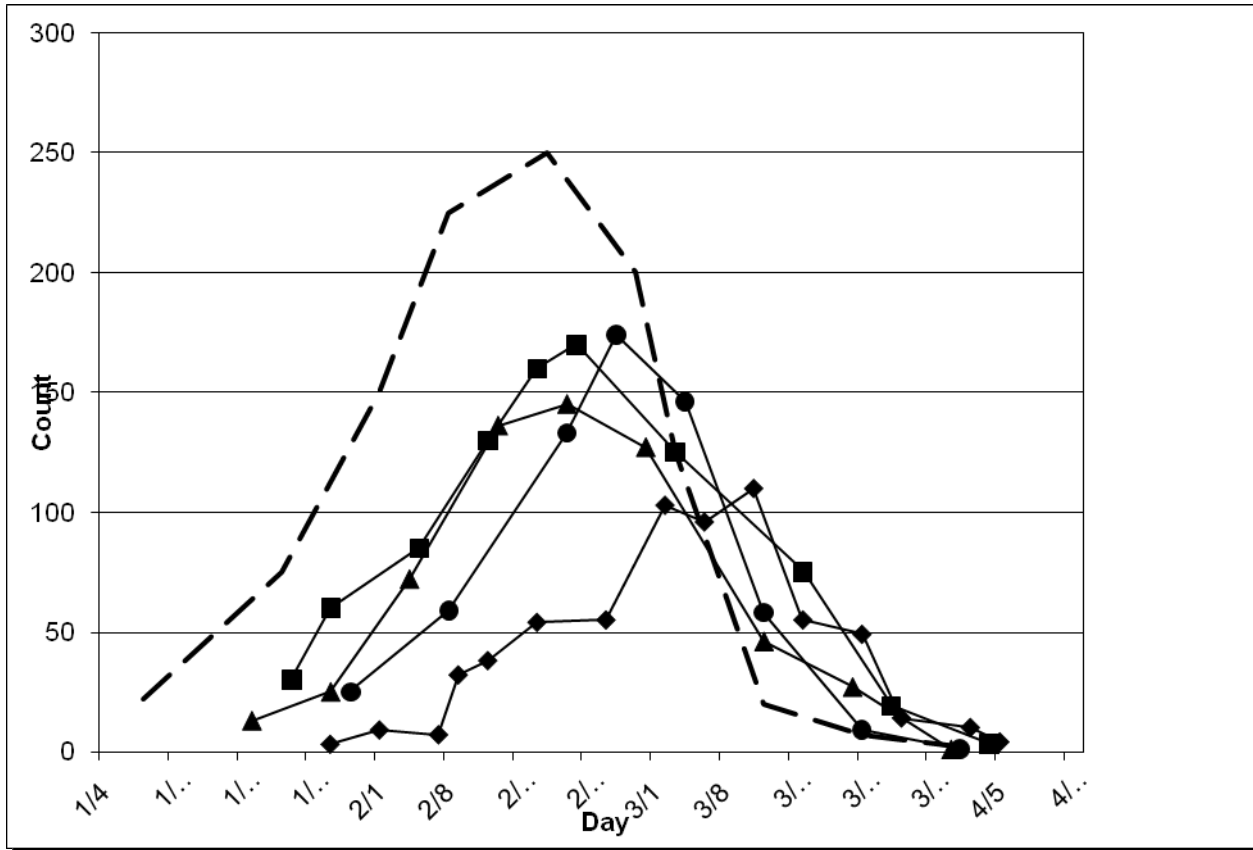


Figure 7. Trends in the number of single (non-mother-calf pair) gray whales counted within Laguna San Ignacio between 1978 and 2008. Broken line = 1978-1982; Black triangles = 1995-1997; Black squares = 1998-2000; Black circles = 2003-2008; and White diamonds = 2008 counts.

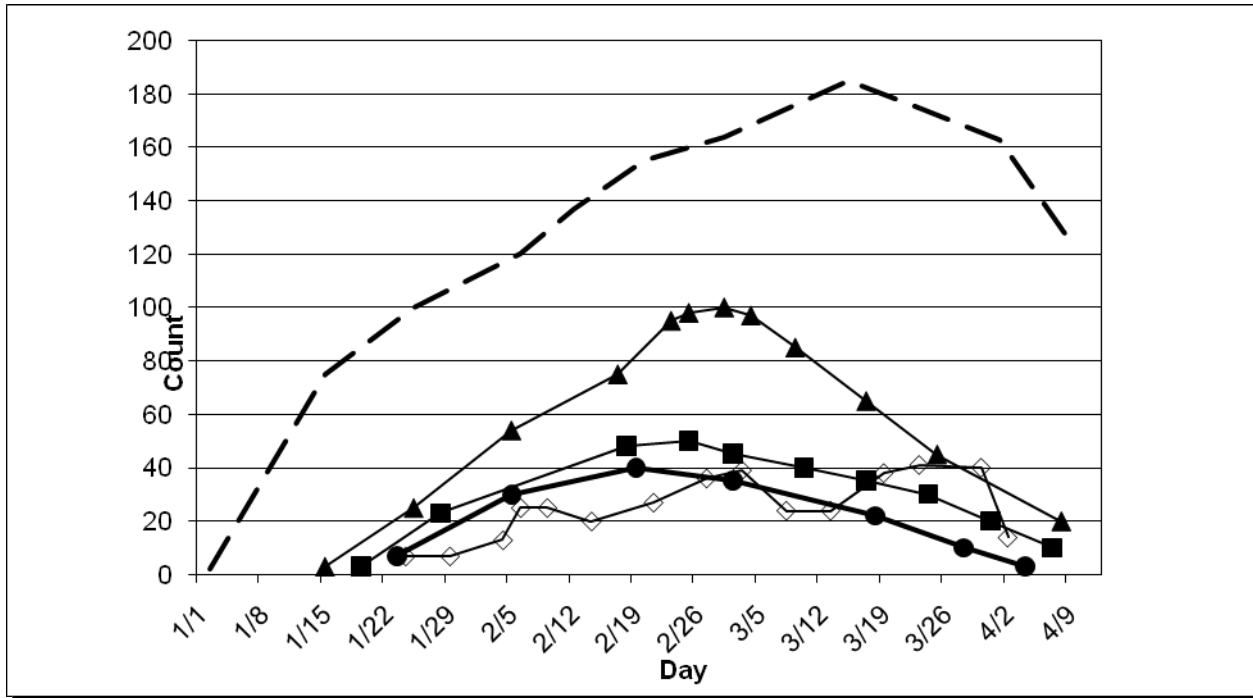


Figure 8. Trends in the number of mother-calf pairs of gray whales counted within Laguna San Ignacio between 1978 and 2008. Broken line = 1978-1982; Black triangles = 1995-1997; Black squares = 1998-2000; Black circles = 2003-2008; and White diamonds = 2008 counts.

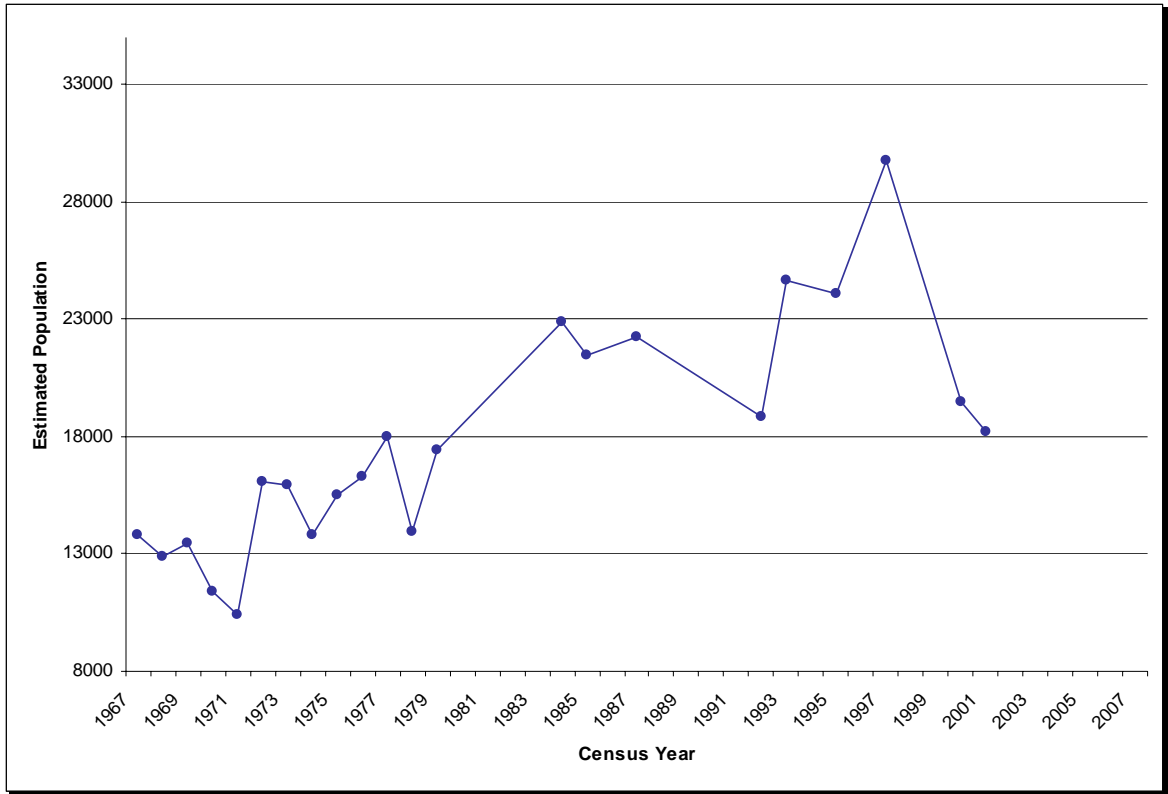


Figure 9. Estimates of the gray whales in the eastern North Pacific population based on visual census of the fall migration past the Granite Canyon, California observation station between 1967/1968 to 2001/2002 (from Rugh *et al.* 2005).

