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A review of gray whales in their wintering grounds in Mexican waters

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ABSTRACT

The Eastern North Pacific gray whale (*Eschrichtius robustus*) is one population of large cetacean that has recovered from depletion resulting from commercial harvest in the mid- to late-1800s. It is believed that this population may be approaching, or possibly exceeding its carrying capacity as suggested by recent increases in mortality of all age and sex classes. Research on the breeding biology and phenology of gray whales that spend the winter in the coastal waters and lagoons of Baja California, Mexico has been conducted for many years. These studies contribute valuable information on the reproductive biology of this species, and the importance of their coastal lagoon habitats to their reproductive success. We review and summarize historical exploitation, conservation measures, the findings of research conducted on gray whales in their winter breeding range, potential natural and anthropogenic threats to this population, and recommendations for future research and monitoring. This review concentrates on the findings of research conducted since the mid-1970s.

KEY WORDS: EXPLOITATION, CONSERVATION, GRAY WHALE, BAJA CALIFORNIA, MORTALITY, BIRTH RATE, GENETIC STUDIES, HABITAT, DISTURBANCE, RESEARCH AND MONITORING

INTRODUCTION

The Eastern North Pacific gray whale population (Eschrichtius robustus) has been the focus of ongoing research and population monitoring as an example of a population of large whales that has successfully recovered from depletion (Jones and Swartz 2002). It is believed that this population may be approaching, or possibly exceeding its carrying capacity, and recent range-wide increases in mortality of all age and sex classes suggest the population may have become food limited (Le Boeuf *et al.* 2000). It is hoped that the scientific study of this population may provide insight into the biological dynamics of this species, and that may be relevant to other recovering populations of large whales. In this regard, research on the breeding biology and phenology of gray whales that spend the winter in the coastal waters and lagoons of Baja California, Mexico has and continues to contribute valuable information on the reproductive biology of this species, and the importance of their coastal lagoon habitats to their reproductive success. In this paper we review and summarize conservation measures, whaling history, and the findings of research conducted on gray whales in their winter breeding range. The review of the biological studies concentrates on the findings of research conducted since the mid-1970s. We conclude with a discussion of natural and anthropogenic threats to grays whales and suggestions for additional research and monitoring that will continue to yield a better understanding of the biology and dynamics of this population.

STUDY SITE.

The winter breeding range of the eastern gray whale population extends from about Point Conception in southern California to Cabo San Lucas, Baja California (Jones and Swartz 2002). Gray whales concentrate in specific areas, particularly outside and within coastal lagoons and bays including: Laguna Guerrero Negro, Laguna San Ojo de Liebre (Scammon's lagoon), Laguna San Ignacio, Santo Domingo Channel, Bahia Magdalena and Bahia Almejas (Figure 1). Some gray whales journey around the cape of the Baja California peninsula, into the Gulf of California, and along the coasts of Sonora, Sinaloa, and Nayarit in mainland Mexico (Berdegué 1956; Gilmore 1960; Henderson 1972; Tershy and Breese 1991). Fleischer and Maravilla C. (1990) concluded that the small number of gray whales present in the Gulf of California on a sporadic basis is not significant to the population. The ecological characteristics of these wintering grounds presumably offer reproductive advantages to gray whales (Fleischer *et al.* 1984; Fleischer and Beddington 1985; Swartz and Jones 1984).

HISTORY OF EXPLOTATION IN BAJA CALIFORNIA

While there are no accounts of gray whale hunts in Mexican waters before the nineteenth century, it is clear that Mexican and Spaniards recognized this species long before the 1800s. It is believed that some indigenous native groups from Baja California occasionally ate meat of gray whales that had died and washed ashore (Russel, 2001). In the following paragraphs we summarize information of gray whale hunting in Baja California and in mainland Mexico presented elsewhere in detail (Rice and Wolman, 1971; Henderson, 1972; 1984; Reeves, 1977; 1984; Reeves and Mitchell, 1988; Dedina, 2000, Russel, 2001; Donahue and Brownell, 2001).

Nineteenth Century

Bahia Magdalena

The first documented catches of gray whales in Baja California are from the winter 1845-46 in Bahia Magdalena with the arrival of the ships United States and Hibernia under Captains Joshua Stevens and James Smith, respectively. During this first season 32 whales were killed (1,440 barrels of oil based on the XIX Century estimate of 35 barrels of oil/gray whales). The boom or peak years of whaling in Bahia Magdalena were from 1845 – 1847 and from 1851 – 1865 when 125 whaling vessels captured between 1950-2000 whales. During the later period 34, 425 barrels of oil brought $516, 375 dollars. The number of whales killed in Bahia Magdalena from 1845-46 through 1873-1874 was estimated at 2145 - 2200.

Laguna Ojo de Liebre and Laguna San Ignacio

In 1855 whaling started in the two lagoons north of Bahia Magdalena: Ojo de Liebre (Scammon's Lagoon) and San Ignacio. In the former, during the 1854-1855 through 1864-1865 winter seasons, whalers on 36 cruises took 553 whales but probably killed 608. From that season until the 1873-1874 season a total of 650 whales were killed and from those 591 were taken. Laguna Guerrero Negro and Manuela, north of Ojo de Liebre, were not important whaling grounds.

The lagoon of San Ignacio and adjacent waters also gave a share of whales to the industry. From 1854-1855 through 1864-65 it is estimated that approximately 350 whales were taken and probably killed 385. By the 1873-1874 season a total of 400 were taken from 440 killed.

Western coast of Baja California and Gulf of California

Additional gray whales were killed and taken along the Pacific coast and Islands of Baja California. Henderson (1984) pinpoints these whaling grounds and indicates that 900 were captured from 1854 – 1865, however it seems that this figure includes whales taken along the coast of California as well. Along the Gulf of California during this same period 150 whales were taken from 165 killed. By 1874 a total of 220 whales were killed (200 taken) in these waters.

Whaling Summary

During the Nineteenth Century an estimated total of 3,296 to 3,351 whales were killed in the bays and lagoons of Baja California (Dedina, 2000). Henderson (1984) reports a similar amount 3235 – 3290 killed with 2941-2991 taken. If we add those from the Gulf of California at least 3465 – 3510 gray whales were killed in Mexican waters in a period of 29 years ranging from 1845 – 1874, or an average of 119 – 121 per year.

The complex of waters of Bahia Magdalena sustained more whaling for a longer period of time than Ojo de Liebre and Laguna San Ignacio. The total kill was probably around 2200 whales during a period of 25 – 30 years. Even though Magdalena remained the most important historical whaling ground, it is interesting to note that surveys conducted in the breeding lagoons in recent years indicate that currently more whales utilize Laguna Ojo de Liebre to the north than utilize Bahia Magdalena and Laguna San Ignacio to the south (Urban *et al.* 2001).

Twenty Century

Bahia Magdalena again became the main focus for commercial whaling in Mexico in the 20th century. Thirty years after the American whalers withdrew, Norwegian whalers started whaling with the factory ship Capella I. Between November 28, 1913 and May 14 of 1914 they took a total of 19 whales. In the next decade the exploitation of gray whales increased with the presence of the Norwegian factory boats Kommanddoren I, Mexico, Ragnhild Bryde I and the Esperanza. The former two took at least 129 whales between mid- November 1924 and February 1926 in Bahia Magdalena. The available data indicate that from 1913 until 1929 Norwegian whalers took 200 whales in Mexican waters. However foreign companies continued to exploit this resource under Mexican permits until 1937 (Dedina, 2000). In the 1960's the gray whale population was considered to be increasing and estimated to be at least 12,000 animals. Whaling companies pressured the Mexican Government to re-open the exploitation of gray whales. In 1965 the Mexican Bureau of Fisheries proposed opening a whaling station in Baja California. Companies would be given a quota of 200 whales per year (Marx 1967, cited by Reeves, 1977; Dedina, 2000).

FORMAL PROTECTION OF GRAY WHALES IN MEXICO

History of gray whale conservation.

The commitment on the part of the Mexican government to the conservation of gray whales and their habitat in Baja California Sur is the result of: 1) the historical legacy of foreign overexploitation of natural resources including gray whales prior to the Mexican Revolution, and the subsequent desire of the federal government to re-establish control over national territory and natural resources; 2) the work of policy makers and environmental advocates to protect two gray whale breeding/calving lagoons as sanctuaries and later as a biosphere reserves; 3) cooperation between Mexican and U.S. scientists and policy-makers interested in the conservation of gray whales and their habitat throughout their migratory range; 4) the enactment of laws that provide government agencies in Mexico with the authorization to protect gray whales and their habitat (Dedina and Young, 1994).

Mexico recognized the Geneva Convention for the Protection of Whales in 1933, and gave its approval to the International Agreement for the Regulation of Whaling in 1938 (Diario Oficial 1938). In 1949 Mexico became a member of the International Whaling Convention (Diario Oficial 1949).

In 1965, the Secretariat of Fisheries (Pesca) proposed the opening of a whaling station to harvest gray whales off the Baja California coast (Bunker 1965). As a result of an international outcry over the proposal, Mexico denied having made plans for resuming whaling (Jones 1965). Pressures for allowing hunting of gray whales continued. In 1970, gray whale researcher Raymond Gilmore argued that keeping the population near 10,000 would provide, "...whales for the whalers and the public and science." He did suggest, however, that Mexico could, ...make more money by having the herd conserved...where (the whales)...will breed unmolested and draw tourists" (Gilmore, 1970 cited by Dedina and Young 1994).

Gray Whale Habitat Conservation

In December 1971, Mexican President Luis Echeverria signed legislation that established Laguna Ojo de Liebre as a whale refuge, the first of its kind in the world (Diario Oficial 1972a; Jones and Swartz 1984). In June, 1972, seven months after creating the Laguna Ojo de Liebre Whale Refuge, Echeverria declared both Laguna Ojo de Liebre and Laguna San Ignacio as Migratory Bird and Wildlife Refuges (Diario Oficial 1972b). In 1979, President Jose Lopez Portillo declared Laguna San Ignacio as a Whale Refuge and Maritime Tourist Attraction Zone. The decree established a permitting mechanism for scientific research and tourism in the area, under the administration of Pesca (Diario Oficial 1979). The vague wording of the 1971 Ojo de Liebre whale refuge decree prompted Lopez Portillo to revise it in 1980, to include reserve status for Laguna Manuela and Laguna Guerrero Negro (Diario Oficial 1980).

In 1984, through the Secretariat of Urban Development and Ecology (SEDUE) a National System of Protected Areas (SINAP) was established. Under SINAP, protected areas were divided into four categories: National Parks, Natural Monuments, Ecological Reserves, and Biosphere Reserves (Diario Oficial 1988; Poder Ejecutivo Federal 1984; SEDUE 1986). In 1988, President Miguel De la Madrid signed legislation creating the Vizcaino Biosphere Reserve to encourage the conservation of endangered plant and animal species, and permit compatible human activities throughout its boundaries (Diario Oficial 1988). In 1993 the Ojo de Liebre and San Ignacio lagoons in the El Vizcaino Biosphere Reserve were added to World Heritage Site list of the United Nations Educational, Scientific, and Cultural Organization (UNESCO).

International Cooperation

An important component of efforts to protect gray whale habitat has been the international cooperation and research that involved sharing information regarding gray whale behaviour, migratory patterns, habitat, and potential conservation needs. In 1977, the Mexican government sponsored the First International Symposium on the Gray Whale in Guerrero Negro. During the meeting researchers and policy-makers from both Mexico and the U.S. discussed the most effective methods of assuring the continued growth of the gray whale population and the successful conservation of the Laguna Ojo de Liebre complex (Aurioles *et al.* 1993).

Beginning in the late 1970s, the U.S. National Oceanographic and Atmospheric Administration (NOAA) sponsored three joint meetings between Mexican and U.S. researchers regarding gray whale research. Conferences on marine mammals held annually since the 1970s by the Mexican Society for the Study of Marine Mammals (SOMEMMA) have brought together researchers from various countries to discuss issues related to gray whale and other marine mammal research (Aurioles *et al.* 1993; Urbán y Rojas, 1999).

Additional Legislation

The General Law of Ecological Balance and Environmental Protection, enacted in 1988 is currently the responsibility of the new Secretariat of the Environment and Natural Resources (SEMARNAT), established in December 2001. Articles 15 through 19 of the law provide SEMARNAT with a broad mandate to formulate policy and planning initiatives, and implement management actions for the protection of the nation's natural resources (Estados Unidos Mexicanos 1993).

The Fisheries Law authorizes Pesca, the Mexican Fisheries Organization, to "Establish measures aimed at the protection of...marine mammals" (Secretaria de Pesca 1992:10). One other piece of legislation, a 1991 addition to the Mexican Penal Code, Article 254 bis, prohibits the unauthorized capture of or injury to marine mammals and sea turtles. A prison term between three to six years is prescribed as the penalty for violating the law (Diario Oficial 1991).

The General Law of Wildlife, under the responsibility of SEMARNAT, was adopted on April 27, 2000 (Diario Oficial 2000a). This is the first wildlife law to confront the challenges of Mexico's mega diversity and socio-economic problems. In January 10, 2002 Article 60 was adopted, which states that: "No marine mammal specimen of any species can be subject of subsistence or commercial use, with the exception of the captures with scientific research and educational purposes" (Diario Oficial 2002a).

The Mexican Official Norm, NOM-59-ECOL-1994, defined those species and subspecies of terrestrial and aquatic wildlife flora and fauna that are in danger of extinction, threatened, rare and those subject to special protection, and established the specific provisions for their protection (Diario Oficial, 1994). This norm was updated on March 6, 2002 (NOM-59-ECOL-2001) (Diario Oficial, 2002b). Since 1994 gray whales are listed under the category of "special protection" which means that this species faces threats that could affect its survivorship.

The Mexican Official Norm, NOM-131-ECOL-1998 also stipulated guidelines and specifications for whale watching activities (Diario Oficial, 2000b). Whale watching activities in Ojo de Liebre and San Ignacio lagoons, Santo Domingo Channel and Bahia Magdalena are included in this norm (Urbán and Gómez-Gallardo, 2000).

Finally, in May 2002 all the Mexican marine territory was established as refuge area for the protection of the large whales (Mysticeti and Odontoceti). (*Diario Oficial*, 2002c).

GRAY WHALE RESEARCH IN MEXICAN WATERS

Laguna Ojo de Liebre-Guerrero Negro

Since the account by Scammon (1874), no studies of gray whales on their winter grounds were conducted until 1952, when Raymond M. Gilmore made the first of a series of field trips to Baja California (Gilmore, 1960a; 1960b; 1976a; 1976b; Gilmore and Ewing, 1954; Gilmore *et al.* 1967). Subsequently, several researchers have visited Laguna Ojo de Liebre, but their observations were mostly brief and opportunistic. These include the studies by Balcomb (1974), Berdegué (1956), Eberhardt (1966), Eberhadt y Evans (1962), Everhardt and Norris (1964), Gard (1974, 1978a, 1978b), Hubbs and Hubbs (1967), Poulter (1968), Samaras (1974), Spencer (1973), White (1975), and White and Griese (1978). In 1978 representatives of Mexico's Departamento de Pesca and the U.S. National Marine Fisheries Service's National marine Mammal Laboratory met to develop a joint program for the study of the gray w for an initial period of five years (1978-1983) (Rice *et al.* 1981). The findings of this joint program are available in published and unpublished papers (Fleischer, 1979; 1980; Fleischer y Beddington, 1985; Rice *et al.* 1981, 1982).

In Laguna Guerrero Negro Bryant and Lafferty (1980, 1983) conducted vessel surveys from 1980 to 1982. In

1988, researchers of the new Biosphere Reserve El Vizcaíno began a monitoring program of gray whales in Laguna San Ignacio and Laguna Ojo de Liebre (Sánchez, 1991; 1998). In 1996 the Universidad Autónoma de Baja California Sur, began a project to document the current abundance, distribution, duration of residency, and mortality of the gray whales in Laguna Ojo de Liebre (Urbán *et al.* 2001).

Laguna San Ignacio.

Aerial surveys to count gray whales wintering in Laguna San Ignacio were conducted between 1947 and 1965 by Gilmore (1960), Hubbs and Hubbs (1967), and Gard (1978a). The first long-term systematic study of gray whales utilizing Laguna San Ignacio was conducted by Jones and Swartz (1984) with the twofold aim of providing baseline information on the demography and phenology of breeding whales, and to evaluate the effects of whale watching activities within the lagoon on the whales. This program continued for five consecutive winters beginning in 1978 and concluding in 1982, and it generated information on: 1) the seasonal timetable of lagoon occupation by whales; 2) the number and distribution of whales utilizing the lagoon interior and inlet area; 3) the proportion of females with calves to whales without calves (singles) that utilize the lagoon throughout each winter season; 4) the location of specific nursery areas and the seasonal abundance of calves in these areas; 5) the seasonal mortality of adult, juvenile, and calves; and 6) the number of whale watching vessels and levels of tourism and other human activities that occur within the lagoon each winter. Between 1996 and 2000 a Mexican research team (Urban *et al.*, 1997, 1998, 1999, 2000, 2001) continued the demographic studies of gray whales in Laguna San Ignacio based on the methods of Jones and Swartz (1984) to provide an update to the historical baseline information for this breeding lagoon and to evaluate the potential effects of building an industrial salt production facility on the northern shore of the lagoon.

Bahia Magdalena-Almejas and Santo Domingo Channel

Studies of gray whales in the Bahia Magdalena area have been conducted principally in the region of la Boca de la Soledad at the end of the Santo Domingo Channel. Hubbs and Hubbs (1967), Gard (1974), Rice *et al.* (1981; 1982) conducted aerial surveys to census gray whales. Fleischer and Contreras (1986) compared censuses from different platforms. Norris *et al.* (1983) reported on the movements of whales in mouth of Bahia Magdalena. Loreto *et al.* (1996) and Sanchez (1997) conducted studies to evaluate the magnitude of whale watching activities in this region, and the effects of those activities on gray whales wintering there. Gardner and Chavez-Rosales (2000) documented changes in the relative abundance of gray whales in Bahia Magdalena during El Niño event (1997-1999). During this time period the whale sightings was inversely related to temperature. Perez-Cortes *et al.* (2000 a) recorded the abundance variations of gray whales in Santo Domingo channel from 1997 to 2000 winter seasons.

Bahía de Todo Santos

Heckel *et al.* (2001) investigated the influence of whale watching boats on the behaviour of gray whales on their migratory route in Bahia Todos Santos, Baja California. They found significant differences in both speed and direction of the transit of gray whales with and without presence of whale watching boats and made recommendations on the whale watching regulations.

BIOLOGY POPULATION KNOWLEDGE

Winter abundance

The various research programs conducted throughout the Pacific coastal waters and coastal lagoons and bays of Baja California provide minimum counts of gray whales that spend the winter breeding season in Mexican waters each year (Table 1). Although coverage has been fragmentary and less than synoptic over the past decades, these counts do provide a rough index of the trends in the population of gray whales that winter in this portion of their breeding range.

Laguna Guerrero Negro

The abundance of gray whales in Guerrero Negro has demonstrated dramatic changes since surveys have been conducted in this lagoon (Fig. 2). Aerial surveys conducted in mid-February during the 1950's and early 1960's indicated that single whales were dominant at that time. The whale count in mid-February 1964 included 120 single whales and 22 mothers with calves (Gard, 1974). Subsequent aerial surveys conducted in 1964 and 1970 detected no whales inside this lagoon. Gray whales were again observed by aerial surveys in 1973 (34 singles and 35 mothers with calves), and in the ensuing three seasons (1974-1976) the numbers fluctuated from 12 to 82 singles and 23 to 34 mothers with calves (Gard, 1978a, b). In 1977 the first boat based counts were made and included one single whale and 57 mothers with calves (Bryant et al, 1984). From 1980 to 1982 Bryant et al (1984) monitoring the gray whale abundance in Guerrero Negro lagoon during the breeding season. Boat based counts during this study indicated a higher predominance of the mothers with calves compared to single whales, with the highest count occurring in 1981 (43 singles and 164 mothers with calves). There were no surveys following this effort until 1997. Boat surveys conducted in 1997, 1998 and 2002 found low numbers (>13) of adult whales inside the lagoon.

Gard (1978a) stated that the decline of whale numbers between 1964 and 1970 was probably caused by the boat activity associated with commercial operation of shipping salt from Laguna Guerrero Negro, which was in operation in that lagoon from 1957 to 1967 (Fig. 2). The constant dredging operation necessary to keep the channel open may have been the main source of disturbance to the whales (Bryant et al, 1984). Unfortunately there is no information on the use of the lagoon by gray whales between 1982 and 1997, but the recent surveys suggest that the seasonal abundance of whales in the lagoon had decrease 90% from the counts obtained in the 1980s. Local fishermen suggested that this decline in abundance could be due to the natural closure of the lagoon entrance resulting from the accumulation of sand in the absence of any dredging operations. At this time there is no conclusive evidence for the cause of the extreme fluctuations of whale abundance in this lagoon over the years.

Laguna Ojo de Liebre

Historical surveys for gray whales indicate that Laguna Ojo de Liebre is the most important breeding and calving lagoon in terms of the number of whales that occupy this lagoon during the winter breeding season. The maximum whale counts since the early 1980's are relatively constant with the exception of two significant declines in recent years (Fig. 3).

During 1988 there was an extreme decline in the counts of mother-calf pairs from 503 in 1987 to 84 in 1988. The cause of this decline remains unknown, however, apparently it was not related with Sea Surface Temperature (SST) anomalies observed during this period; the SST in the lagoon was the same as the year before (17.2 ^{o}C) (Sánchez, 1991). In 1989 low numbers of mothers with calves were observed again along with lower than expected counts of single whales. The SST in the lagoon this year was 15.5 ^{o}C (Sánchez, 1991), and the general winter distribution of gray whales along the Pacific coast of Baja California coast appeared to have shifted further south, with some whales moving into the Gulf of California and up to Bahia de Banderas along the mainland coast (Urbán *et al.* 1990). Unfortunately there were no surveys during the next five years to monitor the trends of gray whale occupancy in the lagoons. Surveys resumed in1996, and winter counts of gray whales had returned to expected levels.

A similar decline in counts occurred in 1999 when the counts of mother-calf pairs decreased from 530 in 1998 to 213. Again, the SST was lower than the average and the general whale distribution appeared to have shifted to the south (Urbán et al in press). The surveys conducted during the 2000 and 2001 winter seasons indicate a slight increase in counts of mothers with calves, but a decrease in counts of single whales. Overall, surveys conducted in 2002 suggest that both classes of whales are utilizing this lagoon in expected numbers.

Laguna San Ignacio

The abundance records for Laguna San Ignacio come from two time series of counts from small boat transects of the lagoon during the peak of the gray whale winter breeding season in February (Fig.4). The first series from 1978 to 1982 conducted by Jones and Swartz (1984) documented that the winter occupation of Laguna San Ignacio by gray whales begins in December and reaches its maximum by mid-February. The seasonal distribution of the overall whale population within the lagoon was bi-modal: the major mode represented the maximum combined counts for each year and was composed of single whales and some mother-calf pairs. Following the February peak, the density of whales utilizing the lagoon decreased as single whales depart and begin their northward migration. During this 5-year period mother-calf pairs increased in numbers during March and slowly declined through April each season. This late season increase in mother calf pairs appeared to be the result of an influx of mothers and calves from other areas, rather than from continuing births of calves. This was confirmed by the estimated length-age of the late season calves indicating that they were not newborns, and by matching photographs of females indicating that some females were coming to Laguna San Ignacio from other lagoon areas during the same winter season. The maximum combined mid-February counts of non-calf gray whales increased significantly 7.3% per year from 300 in 1978 to 407 in 1982 [$F(1,3) = 32.88$, $p < 0.025$, $r2 = 0.916$]. Counts of single whales utilizing Laguna San Ignacio reached a maximum in mid-February each year and averaged 226 whales (range 207-270), but did not show a significant trend [$F(1,3) = 0.52$, $p > 0.50$, $r2 = 0.147$]. Mid-February counts of mothers and calves showed a significant increase each year [$F(1,3) = 16.13$, $p < 0.05$, $r2 = 0.843$] and averaged 112 pairs (range 67-137). The greatest numbers of mother-cal pairs were observed during March following the mid-February maximum total counts, and averaged 225 pairs (range 186-282).

The second time series of whale counts from 1996 to 2000 was conducted by Urban et. al. (2000) using essentially the same survey and counting procedure as Jones and Swartz (1984). This series yielded total combined maximum counts that averaged 204 whales (range 137-253), suggesting an approximate 30% decrease in the mid-February counts of whales in the lagoon since the 1978-1982 time period. This decrease was seen in counts of single whales that averaged 146 whales (range 108-178), and in counts of mother-calf pairs which averaged 58 pairs range (17-126). The late season increase in mother-calf pairs observed in March in the years 1978-1982 was not evident during the 1996-2002 period. Counts of all whales decreased following the 1998 El Nino event, and it is suspected that these decreased counts may be the result of changes in the sea water temperature that persisted during 1999 and 2000 (Urbán et al in press).

Bahía Magdalena Region.

Although Magdalena Bay is frequently mentioned as a winter congregation area for the gray whale, the evidence shows that the different parts of this lagoon complex act as separate breeding sites. Whale counts in this region have been irregular and conducted from different platforms (Table 1). The area most studied has been the Santo Domingo Channel including the entrance, the Boca de la Soledad. Two time series of counts from small boat transects along the channel during the peak of the gray whale winter breeding season in February are available. The first one from 1983 to 1985 conducted by L. Fleischer and colleagues (Fleischer and Beddington, 1985; Fleischer and Contreras, 1986) documented the presence of gray whales from mid January to mid March. Maximum counts were obtained in 1985 and included 173 mothers with calves and 15 single whales (Fig. 5). Perez-Cortes *et al.* (2000; and this paper) conducted the second time series of whale counts from 1997 to 2002. They documented abrupt changes in the abundance of both mothers with calves and single whales, they believed to be related to the influence of ENSO. Abundance decreased from 1997 to 1998, and then gradually recovering until 2002 when the number of mothers with calves was similar to 1997. Surprisingly, the single whales were absent from this area in mid-February (Fig. 5). Thus, it seems that the Santo Domingo Channel area is used mainly as a calving area in opposition to the other parts of the lagoon complex (e.g., main Magdalena Bay and Almejas Bay) that apparently serve as mating areas or sites for congregation of young and immature whales.

Distribution among the breeding lagoons and coastal areas

The core of the winter breeding range of the eastern North Pacific gray whale stock lies along the west coast of the Peninsula de Baja California, from Morro de Santo Domingo (28o 5'N) south to Isla Creciente (24o 20' N). Some whales may be found north of this area all winter, but they are mostly transiting to and from the core winter breeding range. For example, in central California the earliest northbound migrants are seen before the last of the southbound whales have passed this area. In some years, a few whales also continue migrating south past the principal breeding lagoons and travel around Cabo San Lucas, the southern extremity of the peninsula, and enter the Gulf of California (Rice *et al.* 1981). As noted above, the "normal" winter distribution appears to be influenced by periodic SST anomalies; when the SST is higher the distribution shifts to the north (e.g., 1998 breeding season), and when is lower the winter distribution of gray whales shifts to the south (e.g., 1989 and 1999 breeding seasons) (Urbán *et al.* 1990; Gardner and Chavez, 2000; Sanchez-Pacheco *et al.* 2001; Urbán et al in press).

Surveys for gray whales in different winter congregation and breeding areas during the same season were conducted in 1997 and 1998. The 1998 El Niño affected the whale distribution; therefore, the distribution of whales observed in 1997 is believed to best represent the usual distribution of gray whales present in the winter range when no major SST anomalies are occurring.

With regard to the distribution of mothers with calves, Laguna Ojo de Liebre is the most important area followed by Laguna San Ignacio and Santo Domingo Channel (Fig. 6). These three areas included the 91% of the mothers and calves counted in 1997. In comparison, counts of mothers with calves obtained during the 1980 breeding season, indicate that in 1997 their distribution increased in Laguna Ojo de Liebre from 53% to 72%, decreased in Laguna Guerrero Negro from 10% to 1%, and decreased in Bahia Magdalena from 5% to 1% (Table 2) (see Rice *et al.* 1981).

Laguna Ojo de Liebre also contains the greatest proportion of single whales during the winter, followed by Laguna San Ignacio, Bahia Almejas and Bahia Magdalena (Fig. 7). Compared to the distribution of single whales observed during the 1980 breeding season (see Rice *et al.* 1981), the main changes in distribution single whales seen in 1997 include an increase of single whales in Laguna San Ignacio from 12% to 20%, a decrease in Laguna Laguna Guerrero Negro from 7% to 1%, and a decrease in the Santo Domingo Channel from 10% to 3% (Table 3).

Calf production and mortality in the lagoons

Jones and Swartz (1984) estimated the minimum calf mortality rate during the winter breeding seasons between 1978 and 1982 by dividing the number of dead calves discovered each season by the number of living and dead newborn calves counted each season (i.e., the number of dead calves discovered divided by the sum of the total number of living calves at peak of the breeding season + the number of dead calves discovered). The mortality rates from 2.8% in 1980 to 5.8% in 1978, with a five-year average of 3.5%.

Swartz and Jones (1983) estimated annual gray whale calf production and mortality from data collected in Laguna Guerrero Negro, Laguna Ojo de Liebre, and Laguna San Ignacio between 1980 and 1982. A gross annual production of 1185 calves with a 5.4% mortality based on lagoon strandings yielded a net production of 1121 calves. This represented a 7.0% annual rate of production based on the best estimate of the current population size of 15,942 whales. By comparison, the proportion of calves passing Pt. Piedras Blancas, in central California during the spring migration in 1980 and 1981 was 4.3% (679) and 4.8% (769) respectively (Pool 1984), suggesting a 31% calf decrease may occur during the northward spring migration between the breeding lagoons and central California. Based on these results, they postulated two periods critical to calf survival: the first period immediately follows birth, and the second corresponds to the calves' departure from the lagoons and the beginning of the northward migration.

For the winter seasons 1997 to 2002 annual calf production was estimated using the assumption that counts of mother-calf pairs in Laguna Ojo de Liebre, Laguna San Ignacio and Santo Domingo Channel comprise 91 % of the annual calf production in all of the winter breeding areas, based on the percent of counts of mother-calf pairs observed during the 1997 winter season in all areas (Table 2). These estimates ranged from a low of 286 calves in 1999 to a high of 910 calves in 1997. Estimates based on counts of mother-calf pairs suggest a decrease in calf production from the 1997 high (910 calves estimated) to a low in 1999 (286 calves), followed by a gradual increase to 670 calves during the period 2000 to 2002 (Table 4).

Additional estimates of annual calf production are based on counts of northward migrating mother-calf pairs past Piedras Blancas in central California (Perryman, 2001; Perryman and Rowlett, 2002; Perryman *et al.* 2002). These estimated ranges from a high of 1431 in 1997 followed by a gradual decline to 256 calves in 2001. For the years 1997 to 1999 the estimate calf production based on counts of mother-calf pairs in the breeding lagoons was lower, suggesting that counts made within the breeding lagoons were underestimating total calf production. It is possible that in those years additional calves were located outside of the lagoons along the coast of Baja California and not captured by the lagoon surveys. This could also suggest that the areas outside the breeding lagoons constitute an important calving area that is utilized to a greater extent as the population has continued to increase. Estimates of the percent of mothers with calves utilizing areas outside the lagoons ranged from lows of 33% to 36% (1997 and 1999 seasons) to a high of 53% in 1998. This could be explained by the changes in the winter distribution of whales resulting from higher than normal SST in their winter range. During such years, we can expect that a larger percent of gray whales will give birth and rear their newborn calves outside the lagoons and in the northern coastal waters of Baja California and southern California. In contrast, estimates of calf production based on mother-calf pairs migrating past central California in 2000 and 2001 were less than those based on counts within the lagoons (24% and 65% respectively) (Table 4). This suggests that for these years fewer calves were surviving during the northward spring migration from the lagoons to the summer feeding areas to the north. Increases in calf mortality could be consequence of the low body reserves of the adult whales due a decrease in their principal prey in their feeding grounds as suggested by Le Boeuf *et al.* (2001).

Calf mortality inside the lagoons was estimated using the same methodology described by Swartz and Jones (1983), and varied from 2.3% in 1999 to 0.5% in 2001, with an average of 2.0% (Table 5). These rates are lower than the 5.4% estimated by Jones and Swartz (1984). Between the 1999 and 2001 winter seasons the estimated calf mortality declined from 2.2% to 0.005%, and then increased to 1.0%. This trend in mortality may be associated with the suggestion that greater numbers of mother-calf pairs resided outside the breeding lagoons between 1997 and 1999 that year, and thus, fewer dead calves were available to be discovered within the lagoons.

Duration of stay within the breeding lagoons

Laguna San Ignacio

The photographic identification of 975 single whales and 519 mothers with calf obtained during the winter seasons of 1996 to 2000 revealed that the cow-calf pairs remain within the area of Laguna San Ignacio approximately three times longer than single whales. (Urbán *et al.* 1997, 1998) (Table 6; Figure 8). The longest period between first and last sighting for a mother with calf was 61 days during the 1998 winter season. The average time between first and last sightings ranged from 25.5 (95% CI = 20.1-30.9; n = 39) days in 1999 to 19.1 (95% CI = 14.3-23.9; n = 20) days in 1996. In contrast the average time between first and last sightings for single whales ranged from 6.8 (95% CI = 3.6-10.0; n = 19) days in 2000, to 2.6 (95% CI = 1.7-3.5; n = 5) days in 1996.

These results are consistent with findings by Jones and Swartz (1984), Harvey and Mate (1984) and Swartz (1986) who estimated from whale counts that the length of the winter season for mother-calf pairs as 16-18 weeks, whereas the length of the single whale (males and females without calves) season was estimated at 11.5 weeks. It is believed that this difference can be attributed to the need for mothers to remain in the lagoon habitats for longer periods following the birth of their calves, compared to single adults that gather at the lagoons at the period of highest whale densities to obtain mating opportunities. The longest period between the first and the last photographically documented sighting within one season of a mother with calf was 91 days (Swartz 1986).

Laguna Ojo de Liebre

In the 2001 season, a total of 404 gray whales were photo-identified, 219 mothers and 182 single whales. Four of the mothers were first photographed without calf and few days later with the newborn. Similar to Laguna San Ignacio, different residency intervals were documented for each class based on re-sightings and photographs of identified individual whales. The photographic records suggest that mothers with calves stayed in the lagoon area for periods of one to at least 76 days with an average of 22.1 days (95% CI = 18.0-26.2; n = 69). Similarly, single whales stayed in the lagoon area for a period of one to at least 70 days with an average of 13.2 (95% CI = 4.7-21.7; n = 20).

Birth rate

Jones (1990) analyzed approximately 6000 photographs of at least 562 distinctively marked gray whales that were photographed in the breeding lagoons of Baja California. These included 55 mature female gray whales that were seen from 2 to 6 winter breeding seasons from 1977 to 1982. These females produced a total of 115 calves over the 6-yr period. The length of time between birth and consecutive calves was documented for 42 of the females. Calving intervals ranged from 1-4 years but were predominantly 2 years (1 calf every other year). The observed calving intervals were: 1 year (n = 1), 2 years (n = 48), 3 years (n = 6), and 4 years (n = 5). The mean length of the calving interval, or breeding cycle, for the population from 1977 to 1982, was estimated as 2.11 (SD = 0.403) years.

Between 1996 and 2000, 1494 gray whales were identified from photographs in Laguna San Ignacio. From these, 34 females were seen in more than one year, and 18 with calves in different winter seasons. Calving intervals range from 2-4 years: 2 years (n = 11), 3 years (n = 7), 4 years (n = 1). The mean length of the calving interval was estimated as 2.50± 0.29 years (95% CI = 2.21-2.8; n = 19). This interval is significant higher than 2.11 (SD = 0.403) years estimated for the period 1977 to 1982 (H (1, N=78)= 4.165557 p=0.0413) (Urbán and Gómez-Gallardo, 2000) (Figure 9).

It is difficult to conclude if this increasing trend in the calving interval is the consequence of the continued growth of the eastern North Pacific gray whale stock, which could be nearing its carrying capacity (Moore *et al.* 2001), or the 1998-1999 change in SST associated with the ENSO events, which is believed to be the cause of changes in the distribution, abundance and mortality of this population, or some combination of effects.

Mortality

Jones and Swartz (1984) summarized published records of dead gray whales found in the breeding lagoons from 1954 to 1983. They also reported on 194 dead gray whales that were discovered in the breeding lagoons between 1977 and 1982, which included 57 males and 44 females for which the sex could be determined. Calves were the most frequent age-length class of dead whales averaging 91% (range 78%-100%). The percentage of immature whales ranged from 0% to 19.6% among the lagoons, while adults ranged from 0% to 5%.

Le Boeuf et al (2000) summarized records of stranded gray whales in Laguna Ojo de Liebre, Laguna Guerrero Negro, Laguna Manuela and offshore these lagoons from 1984 to 1999. This compilation of gray whale mortality records was base on the mortality review by Sanchez Pacheco (1991; 1998), unpublished records from the Biosphere Reserve El Vizcaíno (1997-1999), and aerial surveys during 1999. Years with the highest mortality were 1991 with 45 stranded whales (37 adults, 2 yearlings and 6 calves); and 1999 with 71 stranded whales (14 adults, 10 yearlings, 5 calves and 42 unknown edge class).

During the winter season of 2000, relatively high numbers of stranded gray whales were again observed throughout the gray whales' distribution. Along the Mexican coast there were 207 stranded whales, 61.8% adults, 3.9% yearlings, 12.6% calves and 21.7% unknown (Table 7). In the following winter (2001) the number of stranded whales discovered within the Mexican breeding range decreased to 10 whales (1 adult, 2 yearlings, 1 calf and 6 unknown); and 13 whales in 2002 (4 adults, 6 calves and 3 unknown).

According to Le Boeuf *et al.* (2000), the high mortality rate of gray whales in 1999 and 2000, the low calf production, shifts in the timing of winter occupation of the lagoons, changes in distribution and behaviour during migration and the reproductive season, are consistent with the hypothesis that the animals are suffering from low reserves of body fat and have insufficient energy to survive the regular period of fasting between feeding seasons. They argue that the cause of this condition was most likely attributable to a decrease in their principal prey on the summer feeding grounds brought about by increased predation and the depressing effect of increasing water temperature over the last decade on amphipod biomass. Moore *et al.* (2001) argue that this event could be and indication that the Eastern gray whale population is reaching environmental carrying capacity.

Movements, telemetry

Harvey and Mate (1984) and Mate and Harvey (1984) utilized VHF-radio tags to monitor the movements and behaviour of 18 gray whales in Laguna San Ignacio between 1979 and 1980. Ten of the whales tagged in February 1980 had mean dive duration from 1.0 to 2.6 min (mean = 1.6 + 0.02 min). Ninety-nine percent of the 11,080 dives recorded were less than 6 min and 49% less than 1 min in duration. The longest dive was 25.9 minutes. Tagged whales averaged 4.4 + 0.6 sec at the surface per surfacing. Eight of the tagged whales averaged less than 2.9% of the time at the surface (range 1.56-16.3%). The tagged whales averaged 35.6 surfacing per hour. Three surfacing patterns were documented: regular-long, regular-short, and clumped. These accounted for approximately one-half of all dive sequences analyzed for two whales. Three radio-tagged whales were monitored for 4, 5, and 11 days, and moved into the ocean on 2, 2, and 7 occasions, respectively. Most oceanic movements were at night and 40% were against the tide. Seven of the tagged whale did not remain in the lagoon for more than 2 days. Those whales that left the lagoon travelled an average of 87 km/day during the northward migration. No differences were found between maximum swimming speeds of single adults and those of mothers with calves. Some tagged whales moved both to the north and south of their tagging site in Laguna San Ignacio to adjacent breeding areas. Some tagged whales lingered around Laguna Ojo de Liebre and one whale was found apparently feeding with up to 60 other whale in an area along the northern coast of Baja California. One whale tagged in 1979 travelled 6680 km from San Ignacio to Unimak Pass, Alaska 94 days following its tagging in Mexico.

Ludwig *et al.* (2001) investigated movements and dive habits in female gray whales in Laguna San Ignacio during the winter seasons of 1999-2001. Twenty-five VHF transmitters were successfully deployed with a crossbow on female gray whales with calves to investigate their preference for specific areas within and around the lagoon. Movements were documented for up to 9 successive days, including night movements. Cow-calf pairs used the entire lagoon interior and periodically exited the lagoon. Most animals preferred the middle and lower lagoon, with mothers with older calves preferring the lower zone nearest the entrance. These data documented that some females with calves stayed outside the lagoon for extended periods of up to 2 to 3 days (i.e., in the Bahia Ballenas). It confirms the assumption that the Bahia Ballenas area is important to the whales, and should be included in any conservation plan for the lagoon area. During winter 1999 and 2001, Multi-Sensor/VHF tags were attached to female gray whales with calves, using suction cups with dissolvable magnesium release mechanisms. Data on depth, duration, tilt, temperature and light intensity were recorded. Tags were deployed successfully on 17 females with calves, recording a total of 40 hours of diving data, representing 1080 dives. Overall mean dive duration was 1.54 min ± 0.27 SD (max. 10.5 min). Two different dive profiles were distinguished, V- and U-shaped dives. Maximum dive depth was 27.4 m. Mother- calf pairs used the whole depth profile of the lagoon. Diving bouts consisting of repetitive extended U-shaped dives. Resting was apparently an important part of the surface-dive characteristics of mother-calf pairs in the breeding grounds.

Site fidelity, genetics

Currently there is ongoing research in gray whale genetics in the breeding grounds. Genetic data are being used to investigate the role of female-directed philopatry in winter habitat-use patterns. Goerlitz e.t al. (in prep.) analyzed 306 base pairs (bp) of mitochondrial DNA (mtDNA) control region for 83 animals sampled from two geographically discrete winter breeding and calving lagoons: Laguna San Ignacio and Laguna Ojo de Liebre. The analysis revealed 28 haplotypes (π, nucleotide diversity = 0.02, h, haplotype diversity = 0.95). Within Laguna San Igancio, significant genetic differentiation was present between mothers (adult females with calves; n = 42) and females (cows without calves, n = 11, AMOVA FST = 0.088, p = 0.038), and between Laguna San Ignacio females and a random sample of females collected from outside of the winter range (non-lagoon females, n = 29, FST = 0.041, p = 0.045). This suggests that females' fidelity to Laguna San Ignacio is restricted to the years that they produce a calf and that it is influenced by female-directed philopatry. No genetic differentiation was evident between Laguna Ojo de Liebre females (n1997=10) and Laguna San Ignacio females (n1997=26, FST = 0.046, p = 0.14; n1996 + 1997= 42, FST = 0.013, p = 0.27) or between Laguna Ojo de Liebre females and non-lagoon females (FST = -0.03, p = 0.82). Certainly these are preliminary results and may be due to reduced analytical power because of the small sample sizes associated with Laguna Ojo de Liebre. Alternatively, due to disturbance by historical whaling operations, philopatry may not be currently associated with Laguna Ojo de Liebre. Additional biopsies will be obtained from the other calving grounds (Bahia Magdalena and Laguna Ojo de Liebre) to increase the sample sizes and to properly test patterns of female-directed winter habitat use.

Environmental and anthropogenic threats

Climate change

Though not a threat in Mexican waters, the major climatic regime shift in the artic region, probably coupled with a shorten feeding season due to extensive seasonal ice, lower overall food availability and El Niño and la Niña phenomenon had an effect on the mass mortalities, the skinny whales and low calf production observed in Mexican waters, and all along the distribution range of gray whales (Le Boeuf et al, 2000; Jones and Swartz, 2002; Perryman *et al.*, 2002). A combination of the factors responsible for these events could be repeated and mortalities could be observed in Mexican lagoons and all along the gray whales range. It's important to have scientific teams prepared to document such events in the future and have the capabilities of obtaining samples from stranded whales.

Mortality in Passive Fishing Gear

Norris and Prescott (1961) documented the first gray whale taken in fishing gear. The whale was caught in April 1959 off the Palos Verdes Peninsula, California in a gill-net used for white sea bass (*Cynoscion nobilis*). Brownell (1971) reported four additional dead gray whales from California fisheries caught during the 1960s. Heyning and Lewis (1990) reported two dead gray whales and 61 more entangled gray whales during the 1980s in California fisheries. Forty of these 61 whales were observed alive but many of them were entangled in fishing gear and their survival was questionable in many cases. Most entangled whales were three years of age or younger. During the 1990s, two gray whales were observed dead in the offshore driftnet fishery off California (J. Carretta, pers. comm.). Thus, the minimum incidental by-catch in California fisheries is 47 whales over the past 43 years.

In Mexico there have been 6 documented incidents of gray whales entangled in passive fishing gear. Two subadults gray whales (11-12 m) were caught in a large nylon rope and steel chain in Playa Palmira, close to San Jose del Cabo in the southern end of Baja California Peninsula; one in 1989 and the other in 2000, both whales were released by local fishermen, divers and scientists with at least superficial injuries in the rostrum and mouth. Two calves had been observed dragging a buoy and line entangled around their peduncle; one in Santo Domingo Channel in 1992, and the other in Laguna San Ignacio in 1999. One gray whale, probably yearling (10-11 m) was caught by a "curvinera" gillnet in Bahia de Ballenas, 15 miles NW of Laguna San Ignacio mouth. This whale was release by students of the UABCS, after four days of the entanglement with injuries in the peduncle. Finally, the only documented fatal incident was a calf found dead in a gill-net used, apparently illegally, for sea turtles in Laguna San Ignacio in 1996 (Nájera et al, in prep.).

Angliss *et al.* (2001) reported additional human-caused mortality in fishing gear from Alaska, British Columbia, Canada and Washington but the data are very limited. Data on gray whales taken in other parts of their range (Russia) are not available.

Ship strikes

Gray whales are commonly hit by ships because of their near shore migration route (Laist *et al.* 2001). Five documented gray whale moralities were caused by ship strikes in Californian waters between 1993 and 1998 and one is known from Alaskan waters in 1997 (Angliss *et al.* 2001). It is believed that many ship strikes and subsequent mortality go unreported because the whale may not die when hit and may not strand when dead.

During the winter season, when the whales are inside the lagoons occasionally small fibber glass fishing boats (pangas) hit some whale in their transit to the fishery areas out side the lagoons. There is no information about the magnitude of this impact on the whales. There is not documentation of strikes by large ships on gray whales in Mexican waters, but based on the Photo-ID catalogue of the UABCS, at least 2% of the whales (n = 1600) show injuries (scars) presumably produced by large keels or propels.

Nautical steps

Currently, in waters of the Baja California Peninsula gray whales are relatively undisturbed due to the absence or almost a lack of military exercises, coastal development and industries. However, there is a chance of potential change if the "Nautical Steps" tourist development proceeds as proposed by the Mexico's Bureau of Tourism. The project consists of a mega-development, which would cover more than 2,500 miles of coast. It is aimed at luring the 1.6 million boat owners in California and other nearby U.S. states into a new system of harbours, wharves, hotels, restaurants, airports and airstrips. Marina's of the Nautical Steps network would link ports beginning in Ensenada, just south of San Diego, to marinas located along the entire western and eastern coasts of the Baja Peninsula. No more than 120 miles apart, some of the marinas would also be along the coasts of Sonora and Sinaloa states, which face Baja across the Gulf of California, on the mainland coast of Mexico. Only five such marinas or harbours currently exist; others would be expanded or built in new areas. If the Nautical steps is not carefully planned to be a low-impact development it could pose a major risk to gray whales and other large cetaceans in the area.

Major potential threats include: 1) increase in whale-watching activities along the Baja California coast and outside the breeding lagoons; 2) increased noise associated with vessel traffic - much man-made noise in the ocean occurs in the lower frequency range and at high levels, which could interfere with or mask the gray whale' sounds or possibly damage their hearings (Jones and Swartz, 2002), 3) other potential sources of risk could come from pollution from vessels and fuel stations network, marinas, golf courses and hotels.

Whale watching

Dr. Raymond Gilmore directed the first long-range marine mammal tourist ventures into Baja California waters in 1970. He stated that the "entry of man with his industrial or recreational activities into the calving and courting lagoons… could have only an adverse effect on the reproduction and survival of the newborn… the damage, if any as of now, has not been measured" (Gilmore, 1976).

Gard (1974) was the first investigator to attempt a systematic documentation of the effects of human activities on the whales in the lagoons. He concluded that the most serious threat to the whales are the San Diego-based excursions boats that come to observe and photographed whales. Rice (1975, in Reeves, 1977), for instance, said that "considerable harassment is caused by commercial cruise boats which take people into the calving lagoons to see the whales", he saw this kind of activity, together with the industrial development, as the "greatest threat" to the whale population.

Kenyon (1973, in Reeves, 1977) detailed the observed effect on gray whales of close approach by outboard skiffs, but Kenyon, like Gard (1974), was unable to demonstrate unequivocally that such disturbances actually harm whales. "It is unknown", he admitted, "what effect this continued large-scale disturbance may have on the habits, behaviour, and population size of the gray whale. Certainly the effect is not beneficial". Villa (1975), who was on the same cruise as Kenyon, wrote that "the hundreds of tourists who want to view whales closely in the lagoons force the animals to seek other quiet areas far from their normal routes.

Jones *et al.* (1984), noted that the primary, more constant sources of potential human disturbance to the gray whales in Laguna San Ignacio from 1977 to 1982 were local fishing cooperatives inside the lagoon, U.S, commercial whale watching excursions (both ocean-going and overland groups), and scientific researchers. During the course of their study they found no statistically significant evidence to substantiate the contention that whale watching had a detrimental effect on the demography of gray whales in Laguna San Ignacio. They concluded, that as of 1982 whale watching activity in the lagoon did not seem to pose a serious threat to gray whales, but its potential for becoming a problem should be acknowledge so that future developments can be monitored carefully for the benefit of whales and humans. Urban *et al.* (1997) detected a decrease in whale density in Laguna San Ignacio compared to earlier studies by Jones and Swartz (1984) and mention that this variation was perhaps due to natural modification in timing and movements of the whales in response to changes in environmental factors or human activities such as whale watching (Urbán and Gómez-Gallardo, 2000). Mosig (1998) founded and inverse relation between the average number of whale-watching boats and the average numbers of gray whales in Laguna San Ignacio in the winter of 1997, but she can not demonstrated a direct effect of the vessels on the whales. Heckel *et al.* (2001) found significant differences in both speed and direction of the transit of migrant gray whales with and without presence of whale watching boats in Bahia de Todos Santos, Baja California.

Noise disturbance

The number of gray whales occupying Laguna San Ignacio declined in 1984 following a series of noise playback studies within the lagoon, but appeared to return the following year when no playback studies were conducted (Jones *et al.* 1988). Similar studies of noise playback during the gray whales' migration past central California documented avoidance and disruption of their migration (Malme *et al.* 1983, 1984). Cetaceans, including gray whales, seem most responsive to noise when the sound levels are increasing or when a noise source first starts up, as during a playback experiment of when migrating whales are swimming toward a noise source. Limited observations also suggest that stationary industrial continuous noise result is less dramatic reactions by cetaceans than to moving sources of sound, particularly from ships (Richardson *et al.* 1995). Familiar noises are similarly habituated by cetaceans.

LGN (Liquid natural gas) Facilities

A number of different energy consortiums have made announcements of their plans to build Liquefied Natural Gas (LNG) terminals at different locations along the northern Baja California coast. Sempra Energy and partner CMS Energy plan to build a $400-million (U.S.) terminal about 60 miles south (probably on Punta Salsipuedes) of the U.S.-Mexico border. Another project with El Paso Corp., Royal Dutch/Shell, Chevron Texaco Corp and Marathon Oil Co. want to build a terminal at in Rosarito (Playas de Tijuana). Both projects plan to re-gasify the super-cooled liquid gas and pipe it to California and other destinations in Mexico. The Sempra project will include a pier of a 1,000 feet or more from shore. Both projects hope to be operational around 2005 (all of the above is from Kraul, 2001a ,b). What is the source of the oil? Huge reservoirs of natural gas exist in the Tarija Province of Bolivia. The plan is to extract the gas and pipe it to a Pacific port, liquefy the gas and transport it by ship to the Mexican LNG terminals (Anon. 2002). First, Bolivia needs to find a port in either Peru or Chile.

The Sempra project, if on Punta Salsipuedes, would be at an important point of the gray whale migration, especially the northbound females with their calves that pass very close to prominent point of land.

FUTURE RESEARCH AND MONITORING NEEDS

Proportion of population utilizing the breeding lagoons

The surveys conducted in the lagoons have utilized counts from aerial and vessel to obtain an index of the density of gray whales in various lagoons and coastal areas of Baja California during the winter breeding season. At best, these counts indicate the beginning, maximum, and end of the breeding season. To establish the importance of the coastal and lagoon areas as breeding habitats in terms of priority of utilization, it is necessary to determine the proportion of the population that utilizes these breeding habitats each winter, and the proportion of those that utilize specific areas. This will require the integration of the survey results with estimates of residency within specific lagoons, and the "turn-over rates" or rate of exchange of whales in those sites. In addition, the timing and duration of the winter breeding season needs to be better documented. Previous surveys have not documented the initial arrival of the first gray whales in Baja California, or the departure of the last whales in the spring. Future surveys should begin early and continue for a sufficient time to document the "tails" of the winter occupation of the lagoons by whales.

Photographic Identification

To address residency times and inter-lagoon movements, individual reproductive rates, and fidelity to specific areas, photographic identification programs should continue in all areas that gray whales congregate during the winter. The analysis of these photographs will provide a permanent record that contributes to numerous research objectives, including the identification of specific components of the population in other portions of their range (e.g., Northwest summer residents, Bearing Sea feeding aggregations, etc.).

Radio Telemetry

Radio tagging, both VHF and satellite based methods, have great potential to improve understanding of gray whale migration paths, rates of travel, and yearly variation in the migration timing and residency rates in the breeding lagoons and coastal areas of Baja California. These data are valuable for addressing questions of the effects of seasonal variations in the gray whales reproductive behaviour that may be the result of changes in environmental conditions.

Genetic Research

The findings of genetic research conducted in recent years suggest that there may be groups of related gray whales within the population that preferentially seek and utilize specific breeding lagoons for calving. Such a structure within the population may have implications for the resiliency of the population to perturbations from natural climate changes, or from disturbance from human development or accidents (e.g., oil spills). Additional genetic sampling of gray whales in all the principal lagoon areas should be undertaken to increase the size of the genetic data base for this population to the extent that it will support statistically meaningful analyses and provide the basis for conclusions concerning the sub-structure of the population, and that portion of the population that resides in the waters of Baja California each winter.

Calf Production

Calf counts during the northbound migration do not coincide with counts in the breeding lagoons. There is a reported loss of about 30% of the calves between the breeding lagoons and the counts in central California (Swartz, 1986). This needs to be investigated. An independent estimate of north migrating cow-calf pairs needs to be considered in northern Baja California. This will allow comparing with those counts from central California. The appropriate site for land surveys needs to be identified in northern Baja California.

Whale watching.

Assessments of long-term effects of whale watching are aimed at measuring changes in population parameters, physical condition of individuals and habituation or tolerance (IFAW, 1995). The population parameters that can be monitored in conjunction with whale watching programs and used to assess the long term status of whale stocks could include:

1. Those related with photo-identification of individual whales like: residency times, philopatry, and fecundity/calving rates.

2. Those related with behaviour of the whales with or without the presence of tourist boats versus land based platforms.

3. Those related to genetic studies using skin samples from living and stranded dead whales, including research on genetic diversity, and relatedness.

4. Mortality including the counting, measuring and determining the sex the dead whales founded in the lagoons.

16. REFERENCES

Anon. 2002. Pipe dreams. *The Economist*, 16 March 2002.

Aurioles-Gamboa, D., Urbán R., J. and Morales V., B. 1993. Programa Nacional de Investigación sobre Mamíferos Marinos. pp 139-159 In *Biodiversidad Marina y Costera de México*. S.I. Salazar-Vallejo y N.E. González (eds.) Comm. Nal. Biodiversidad y CIQRO, México, 865 pp.

Balcomb, K.C., III. 1974. The birth of a gray whale. *Pac. Disc*. 23 (3): 28-31.

Berdegué, J. 1956. Último censo de la Ballena gris, Rhachianectes glaucus Cope, en aguas de Baja California. *Ciencia* 16 (4-6):99-109.

Bryant, P.J., Lafferty, C.M. and Lafferty. S.K. 1984. Reoccupation of Laguna Guerrero Negro, Baja California Sur, Mexico by gray whales. Pp. 375-387 In: Jones, M. L., S.L. Swartz, and J.S. Leatherwood (eds): *The Gray Whale, Eschrichtius robustus*. Academic Press, Orlando 600 p.

Bunker, J. 1965. "Experts Fear End of Gray Whale if Pact's Broken." *San Diego Evening Tribune* 21 June, p. 1.

Dedina, S. 2000. *Saving the gray whale. People, politics and conservation in Baja California*. The University of Arizona Press, Tucson, Arizona, 186 p.

Dedina, S. and Young, E.H. 1995. Conservation and development in the gray whale (*Eschrichtius robustus*) lagoons of Baja California Sur, Mexico. Report to the U.S. Marine Mammal Commission. Contract No. T10155592.

Diario Oficial. 1972a. "Decreto que declara zona de refugio para ballenas y ballenatos, las aguas del área de la Laguna Ojo de Liebre, al sur de la Bahía de Sebastián Vizcaíno, en el Litoral del Océano Pacifico, Territorio de Baja California." *Diario Oficial* 14 January, pp. 4-5.

Diario Oficial. 1972b. "Decreto por el que se declara zona de reserva y refugio de aves migratorias y de la fauna silvestre, la constituida por la laguna Ojo de Liebre y San Ignacio, dentro del área que comprende la Bahía de San Sebastián Vizcaíno, en la costa del Territorio Sur de Baja California". *Diario Oficial* 11 September, pp. 4-5.

Diario Oficial. 1979. "Decreto por el que se declara como refugio para ballenas grávidas y ballenatos y zona de atracción turístico-marítima, las aguas de la zona interior de la Laguna de San Ignacio, en el Estado de Baja California Sur." *Diario Oficial* 16 July, pp. 23-24.

Diario Oficial. 1980. "Decreto por el que se modifica el diverso de 6 de diciembre de 1971, declarándose como zona de refugio para ballenas y ballenatos las aguas del complejo Laguna Ojo de Liebre, ubicados en Baja California Sur." *Diario Oficial* 28 March, pp. 36-37.

Diario Oficial. 1988. "Decreto por el que se declara la Reserva de la Biosfera "El Vizcaíno", Ubicada en el Municipio de Mulegé, BCS." *Diario Oficial* 30 November, pp. 2-26.

Diario Oficial. 1991. "Articulo 254 bis al Codigo Penal." *Diario Oficial* 30 December, p. 9.

Diario Oficial. 1994. Norma Oficial Mexicana NOM-059-ECOL-1994. Que determina las especies y subespecies de flora y fauna silvestres terrestres y acuáticas en peligro de extinción, amenazadas, raras y las sujetas a protección especial y que establece especificaciones para su protección. *Diario Oficial* 16 May.

Diario Oficial 2000a. Ley General de Vida Silvestre. *Diario Oficial* 4 July.

Diario Oficial. 2000b. Norma Oficial Mexicana NOM-131-ECOL-1998. Que establece lineamientos y especificaciones para el desarrollo de actividades de observación de ballenas, relativas a su protección y conservación de su hábitat. *Diario Oficial* 10 January. 11-17

Diario Oficial 2002a. Decreto por el que se reforman diversas disposiciones de la Ley General de Vida Silvestre. *Diario Oficial* 10 January.

Diario Oficial. 2002b. Norma Oficial Mexicana NOM-059-ECOL-2001. Protección ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión 0 cambio-Lista de especies en riesgo. Protección. *Diario Oficial* 6 March.

Donahue, M.A. and Brownell Jr., R.L. 2001. Twentieth Century whaling statistics for Eastern Pacific gray whales. Paper SC/53/BRG16 presented to the IWC Scientific Committee, June 2001 (unpublished). 14pp. [Available from the Office of this Journal]

Eberhardt, R.L. 1966. The population of gray whales (*Eschrichtius robustus*) on the southern coast of Peninsula de Baja California, Mexico. *Bull. So. Acad. Sci*. 65 (4): 202-4.

Eberhardt, R.L. and Evans, W.E. 1962. Sound activity of the California gray whale (*Eschrichtius robustus*). *J. Audio Eng. Soc*. 10:324-8.

Eberhardt, R.L. and Norris, K.S. 1964. Observations on newborn Pacific gray whale *Eschrichtius glaucus* Cope) on Mexican Calving grounds. *J. of Mamm*. 45(1): 88-95

Estados Unidos Mexicanos. 1993. Ley General del Equilibrio Ecológico y la Protección al Ambiente. Ed. Porrua. Mexico City.

Fleischer, L. 1979. Methods of population estimation of breeding California gray whales in Baja California, Mexico. Unpublished Research proposal for a Ph. D. Dissertation presented to the College of Fisheries, University of Washington, Seattle, (Mimeo Rep.):43 pp.

Fleischer, L. 1980. Aerial surveys of California gray whales in Laguna Ojo de Liebre, B.C.S., Mexico. (1980). Paper SC/33/PS18 presented to the IWC Scientific Committee, June 1981 (unpublished). 34pp. [Available from the Office of this Journal]

Fleischer, L.A. and Beddington, J. 1985. Seasonal Abundance, Reproduction and Early Mortality Rates of Gray Whales (Eschrichtius robustus) in Mexican Waters (1980-1985). Paper SC/A90/G29 presented to the IWC Scientific Committee. June 1985. (unpublished). 34pp. [Available from the Office of this Journal]

Fleischer, L.A. and O. Maravilla C. 1990. "Presence of Gray Whales (Eschrichtius robustus) in the Gulf of California." Paper presented to the Scientific Committee of the International Whaling Commission at the Special Meeting for the Comprehensive Assessment of the Gray Whale. Seattle. (unpublished). [Available from the Office of this Journal]

Fleischer, L.A., Contreras, J. and Michel, E. 1984. "La Ballena Gris (*Eschrichtius robustus*) en la Region Norte de Bahia de Magdalena, B.C.S., Mexico." Paper presented at the IX Reunion para el Estudio de los Mamiferos Marinos, 29-30 March, pp. 1-46. (unpublished). La Paz, Mexico.

Fleischer, LA. and Contreras U., J. 1986. Censos de Ballenas Grises (Eschrichtius robustus) en Bahia Magdalena, B.C.S. Mexico. *Ciencia Pesquera* 5:51-62. (2)

Gard, R. 1974. Aerial census of gray whales in Baja California lagoons, 1970 and 1973, with notes on behavior, mortality and conservation. *Calif. Fish Game* 60(3):132-144.

Gard, R. 1978a. Aerial census and population dynamics study of gray whales in Baja California during the 1976 calving and mating season. U.S. Mar. Mamm. Commn., Rep. No. MMC 76/09. 20 pp. Available from NTIS, Springfield, VA; PB-275-297.

Gard, R. 1978b. Aerial census, behavior, and population dynamics study of gray whales in Mexico during the 1974-1975 calving and mating season. U.S. Mar. Mamm. Commn., Rep. No. 75-07. 18pp. Available from:NTIS, Springfield, VA:PB-275-295.

Gardner, S.C. and Chavez-Rosales, S. 2000. Changes in the relative abundance and distribution of gray whales (*Eschrichtius robustus*) in Magdalena Bay, Mexico during El Niño event. *Mar. Mammal Sci.* 16(4): 728-738

Gilmore, R.M. 1960. A census of the California gray whale. *U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish*. 342:1-30.

Gilmore, R.M. 1976. The friendly whales of Laguna San Ignacio. *Terra* 15(1): 24-28

Goerlitz, D.S., Belson, M., Urbán R., J., Rojas-Bracho, L. and Schaeff, C. In prep. Preliminary analysis of mitochondrial DNA variation among Eastern North Pacific gray whales (*Eschrichtius robustus*) on winter breeding grounds in Baja California.. Unpublish maniscript.

Harvey, J.T. and Mate, B.R. 1984. Dive characteristics and movements of radio-tagged gray whales in San Ignacio Lagoon, Baja California Sur, Mexico. Pp. 561-575 In: Jones, M. L., S.L. Swartz, and J.S. Leatherwood (eds): *The Gray Whale, Eschrichtius robustus*. Academic Press, Orlando 600 p.

Heckel, G., Reillt, S.B., Sumich, J.L. and Espejel, I. 2001. The influence of whalewatching on the behaviour of migrating gray whales (*Eschrichtius robustus*) in Todos Santos Bay and surrounding waters, Baja California, Mexico. *J. Cetacean Res. Manage*. 3(3): 227-237.

Henderson, D.A. 1972. *Men and Whales at Scammon's Lagoon*. Dawson's Book Shop, Los Angeles. 313 pp.

Henderson, D.A. 1984. Nineteenth Century Gray Whaling: Grounds, Catches, and Kills, Practices and Depletion of the Whale Population. pp. 159-186. *In*: *The Gray Whale, Eschrichtius robustus*. M.L. Jones, S.L. Swartz, and S. Leatherwood, (eds.) Academic Press. Orlando.

Hubbs, C. L., and Hubbs, L.C. 1967. Gray whale censuses by airplane in Mexico. *Cal. Fish Game* 53(1): 23-7.

Jones, H.Y. 1965. Mexican Denies Whale Hunt Plans. *San Diego Union* 12 September, p. A2.

Jones, M.L. 1990. The reproductive cycle in gray whales based on photographic resightings of females on the breeding grounds from 1977-82. *Rep. int. Whal. Commn* (special issue 13): 177-182

Jones, M.L. and Swartz, S.L. 1984. Demography and Phenology of Gray Whales and Evaluation of Human Activities in Laguna San Ignacio, Baja California Sur, Mexico. *In: The Gray Whale, Eschrichtius robustus*,. M.L. Jones, S.L. Swartz, and S. Leatherwood (eds.) pp. 309-374. Academic Press. Orlando.

Jones, M.L., Swartz, S.L. and Dahlheim, M.E. 1988. Census of gray whale in San Ignacio Lagoon in 1985: a follow-up study in response to low whale counts in 1984. Final Report to U.S. Marine Mammal Commision. Contract MM2911023-0. 35 pp.

Jones, M.L. and Swartz, S.L. 2002. Gray whale, *Eschrichtius robustus*. pp. 524-536 *In*: W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds) Encyclopedia of Marine Mammals. Academic Press, San Diego. 1414 pp.

Kraul, C. 2001a. Sempra plans major energy project in Baja. *Los Angeles Times*, 5 October 2001.

Kraul, C. 2001b. Sempra plan would bring state Bolivian gas via Baja. *Los Angeles Times*, 5 December 2001.

Laist. W.L., Knowlton, A.R., Mead, J.G., Collet, A.S. and M. Podesta. 2001. Collision between ships and whales. *Mar. Mammal Sci.* 17(1):35-75

Le Bœuf, B.J., Pérez-Cortés, H., Urbán R., J., Mate, B.R. and Ollervides U., F. 2000. High gray whale mortality and low recruitment in 1999 : potential causes and implications. *Journal of Ceatcean Research and Management* 2(2): 85-99

Loreto C., P.A., Fleischer, L.A. and Maravilla Ch, M.O. 1996. Actividades turístico-educativas en dos zonas de refugio de la ballena gris *Eschrichtius robustus* (Lilljeborg, 1981) en Baja California Sur, México durante la temporada 1991. *Boletín Pesquero* CRIP-La PAZ, 2: 15-29

Ludwig, S., Culik, B.M., Ludwig, M. and Urbán R., J. 2001. Movements and diving of gray whales (*Eschrichtius robustus*) in a calf nursery, San Ignacio Lagoon, Baja California, Mexico, 1999-2001. Abstracts. 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada November 28-December 3. pag. 129

Malme, C.I., Miles, P.R., Clark, C.W., Tyack, P. and Bird, J.E. 1983. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. BBN report 5366. Rep. From Bolt Beranek & Newman Inc., Cambridge, MA, for U.S. Minerals Management Serv., Anchorage, AK. NTIS PB86-174174.

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 behavior/Phase II: January 1984 migration. BBN report 5586. Rep. From Bolt Beranek & Newman Inc., Cambridge, MA, for U.S. Minerals Management Serv., Anchorage, AK. NTIS PB86-218377.

Mate, B.R. and Harvey, J.T. 1984. Ocean movements of radio tagged gray whales. Pp. 577-589 *In*: Jones, M. L., S.L. Swartz, and J.S. Leatherwood (eds): *The Gray Whale, Eschrichtius robustus*. Academic Press, Orlando 600 p.

Moore, S., Urbán R., J., Perryman, W., Gulland, F., Perez-Cortes, H., Rojas-Bracho, L. and Rowles, T. 2001. Are gray whales hitting 'K' hard?. *Mar. Mamm. Sci.* 17(4):954-958

Mosig R., P. 1998. Efectos del turismo en la abundancia y comportamiento de la ballena gris, *Eschrichtius robustus*, en Laguna San Ignacio, B.C.S., México. Bachelor Thesis. Universidad Nacional Autónoma de México. México. 139 pp. (In Spanish)

Nájera C., M., Urbán R., J., Solís L., I, and Gómez-Gallardo U., A. in prep. Gray whale interactions with fishery gears in Mexican waters.

Norris, K.S., Villa R., B., Nichols, G., Wursig, B. and Miller, K. 1983. Lagoon entrance and other aggregations of gray whales, *Eschrichtius robustus*. *In: Behavior and Communication of Whales*, ed. R. Payne, pp. 259-293. Boulder: Westview Press.

Pérez-Cortes M., H., Maravilla C., O. and Loreto C., P. 2000. Abundance variations of gray whales, *Eschrichtius robustus*, at the northern part of Bahia Magdalena, B.C.S. Mexico. Paper SC/527AS17 presented to the IWC Scientific Committee. May 2000. (unpublished). [Available from the Office of this Journal]

Perryman, W.L. 2001. Northbound gray whale calf survey for 2001- Progress report. Paper SC/53/BRG11 presented to the IWC Scientific Committee. June 2001. (unpublished). [Available from the Office of this Journal]

Perryman, W.L. and Rowlett, R.A. 2002. Preliminary results of a shore-based survey of northbound gray whale calves in 2001. Paper SC/54/BRG3 presented to the IWC Scientific Committee. April 2002. (unpublished). [Available from the Office of this Journal]

Perryman, W.L., Donahue, M.A., Perkins, P.C. and Reilly, S.B. 2002. Gray whale calf production 1994-2000: are observed fluctuations related to changes in seasonal ice cover? *Mar. Mamm. Sci.* 18(1): 121-144.

Pool, M.M. 1984. Migration corridors of gray whales along the central California coast, 1980-1982. Pp. 389-407 In: Jones, M. L., S.L. Swartz, and J.S. Leatherwood (eds): *The Gray Whale*. Academic Press, Orlando 600 p.

Reeves, R and Mitchell, E. 1988. Current status of gray whale, *Eschrichtius robustus*. *Canadian Field-Naturalist* 102(2): 369-390

Reeves, R.R. 1977. The Problem of Gray Whale (*Eschrichtius robustus*) Harassment at the Breeding Lagoons and during Migration. U.S. Dept. of Commerce, N.T.I.S. PB-272-506. 60 pp.

Reeves, R.R. 1984. Modern Commercial Pelagic Whaling for Gray Whales. *In: The Gray Whale, Eschrichtius robustus*,. M.L. Jones, S.L. Swartz, and S. Leatherwood (eds.) pp. 187-202. Academic Press. Orlando.

Rice, D. and Wollman, A. 1971. The life history and Ecology of the Gray Whale (*Eschrichtius robustus*). Special Publications, no.3 *American Society of Mammalogist*. 142 p

Rice, D.W., Wolman, A.A., Withrow, D.E. and Fleischer, L.A. 1981. Gray whales on the winter grounds in Baja California. *Rep. Int. Whal. Commn*. 31:477-489.

Rice, D.W., Wolman, A.A., Withrow D.E. 1982. Distribution and Numbers of Gray Whales on their Baja California winter grounds. Paper SC/34/PS12 presented to the IWC Scientific Committee, June 1982. (Unpublished). [Available from the Office of this Journal]

Richardson, W.J., Green, C.R., Malme, C.I. and Thompson, D.H. 1995. *Marine mammals and noise*. Academic Press, Inc. San Diego. 576 pp.

Russell, D. 2001. *The eye of the whale. Epic passage from Baja to Siberia*. Simon and Schuster, NY. 688p.

Samaras, W. F. .1974. Reproductive behavior of the gray whale, *Eschrichtius robustus*, in Baja California. *Bull. So. Cal. Acad. Sci*. 73(2): 57-64.

Sánchez P., J.A. 1991. Distribución espacio–temporal de la Ballena gris (*Eschrichtius robustus*) en la Laguna Ojo de Liebre, B.C.S., México. Bachelor Thesis. Universidad Autónoma de Baja California Sur. México. 70 pp. (In Spanish)

Sánchez P., J.A. 1998. Gray whale mortality at Ojo de Liebre and Guerrero Negro lagoons, Baja Califonia Sur, Mexico: 1984-1995. *Mar. Mammal Sci*. 14(1):149-155.

Sánchez P. J.A. 1997. Descripción y desarrollo de las actividades turísticas de observación de ballena gris en las lagunas de la Reserva de la Biosfera "El Vizcaíno" y Bahía Magdalena, Baja California Sur, México, temporadas 1996 y 1997. *Boletín Pesquero* CRIP-La PAZ, 7: 1-7 (In Spanish)

Sánchez-Pacheco, J., Vázquez-Hanckin, A., de Silva-Dávila, R. 2001. Gray whales mid spring feeding at Bahía de los Angeles, Gulf of California, México. *Mar. Mammal Sci*. 17(1): 186-191

Sánchez-Pacheco, J., Vázquez-Hanckin, A., de Silva-Dávila, R. 2001. Scammon, C.M. 1874. *The Marine Mammals of the Northwestern Coast of North America*. John H. Carmany & Co. San Francisco, California.

Secretaria de Pesca. 1992. Legal Framework for Fisheries 1992. Mexico City: Secretaria de Pesca.

SEDUE. 1986. Estado del Medio Ambiente en Mexico. Mexico City: Secretaria de Desarrollo Urbano y Ecologia.

Spencer, M.P. 1973. Scientific studies on the gray whales of Laguna Ojo de Liebre (Scammon's Lagoon), in Baja California, Mexico. *Nat. Geogr.. Soc. Res. Rep*. 1966:235-53.

Swartz, S.L. 1986. Gray whale migratory, social and breeding behavior. *Rep. Int. Whal. Commn*. Special Issue 8: 207-229

Swartz, S.L. and Jones, M.L. 1983. Gray whale (*Eschrichtius robustus*) calf production and mortality in the winter range. *Rep. Intl. Whal. Commn.* 33:503-507.

Tershy, B.R. and Breese. D. 1991. Sightings and Feeding of Gray Whales in the Northern Gulf of California. *J. Mammal*. 72:830-831.

Urbán R., J., Bourillón M., l., Claridge, D.E. and Balcomb III, K.C. 1990. The gray whale Eschrichtius robustus in the southern portion of Baja California peninsula during the breeding season 1989-1990. Abstracts. XV Reunión Internacional para el Estudio de los Mamíferos Marinos. La Paz, B.C.S.

Urbán R., J., Gómez-Gallardo U., A., Flores de Sahagún, V., Cifuentes L., J., Ludwig, S. and Palmeros R., M. 1997. Gray whale studies at Laguna San Ignacio, B.C.S., Mexico, 1996. *Rep. int. Whal. Commn* 47: 625-633

Urbán R., J., Gómez-Gallardo U., A. and Palmeros R. M. 1998. A note on the 1997 Gray whale studies at Laguna San Ignacio, B.C.S., México. *Rep. int. Whal. Commn*. 48:513-516

Urbán R., J. and Rojas B., L. 1999. Los programas de conservación de mamíferos marinos p.541-573. *In*: Ma del C. Rodríguez H. and C. Hernández F. (eds). *Océanos ¿Fuente inagotable de recursos?* . Programa Universitario del Medio Ambiente, UNAM-SEMARNAP. 589 pp. (In Spanish)

Urbán R., J., Gómez-Gallardo U., A., Flores de Sahagún, V., Palmeros R., M. and Ludwig, S. 1999. Changes in the abundance and distribution of gray whales at Laguna San Ignacio, México during the 1997-98 El Niño and the 1998-99 La Niña. Paper SC/51/AS31 presented to the IWC Scientific Committee, May 1999. (unpublished). 8pp. [Available from the Office of this Journal]

Urbán R., J., and Gómez-Gallardo U., A. 2000. Whalewatching and gray whales at Laguna San Ignacio, B.C.S., México. Paper SC/52/WW12 presented at the IWC Scientific Committee. June 2000. 17 pp. [Available from the Office of this Journal]

Urbán R., J., Gómez-Gallardo U., A. and Solís L., I. 2001. Report of the 2001 gray whale winter season in Laguna Ojo de Liebre, México. Paper SC/53/BRG18 presented at the IWC Scientific Committee. June 2001. 8pp. [Available from the Office of this Journal]

Urbán R., J., Gómez-Gallardo U., A. and Ludwig, S. In press. Abundance and mortality of gray whales at Laguna San Ignacio, México, during the 1997-98 El Niño and the 1998-99 La Niña. *Geofísica Internacional*

Villa-Ramírez, B. 1975. Las ballenas grises de Baja California. *Bioconservación y supervivencia* 1(1): 8-12

White, S.B., and Griese H.J. 1978. Notes on length, weight, and mortality of gray whale calves. *J. Mamm*. 59(2):440-1.

Table 1. Counts of gray whale mother-calf pairs (MC) and single adult or juvenile whales (S) along the Pacific coast and within the breeding lagoons at the peak of the breeding season in February. (Laguna San Ignacio 1978-1982 from Jones and Swartz 1984; Bahia Almejas, Bahia Magdalena, Ojo de Liebre, and west coast in 1980 from Rice *et al*., 1981; Laguna Guerrero Negro 1980-1982 from Bryant *et al* 1984; Laguna Ojo de Liebre 1980-1983, and Santo Domingo Channel 1982-85 from Fleischer and Beddington 1985 and Fleischer and Contreras, 1986; Laguna Ojo de Liebre 1985-1989 from Sánchez, 1991; All areas from 1996 to 2002 from Urban *et al*., 2002).

YEAR	BA		BM		SDC		LSI		LOL		LGN		C*	
	MC	S	MC	S	MC	S	MC	S	MC	S	MC	S	MC	S
1978							67	235						
1979							100	208						
1980	4	135	25	60			118	214	557	187	115	19	116	326
1981							141	207	525	477	164	43		
1982					106	33	137	270	553	483	101	23		
1983					123	36			463	299				
1984					151	7								
1985					173	15			502	283				
1987									534	336				
1988									95	369				
1989									91	178				
1996							92	115	512	213			21	206
1997	15	94	9	72	83	17	126	127	626	320	7	5		
1998	5	15	1	4	12	7	52	178	530	401	5	3	46	138
1999					32	26	17	144	213	324				
2000					16	21	45	182	256	209				
2001					25	44	29	108	333	133				
2002	44	201			97	0	43	170	475	248	6	2		

BA=Bahia Almejas; BM=Bahia Magdalena; SDC=Santo Domingo Channel; LSI=Laguna San Ignacio; LOL=Laguna Ojo de Liebre; LGN=Laguna Guerrero Negro; C=west coast of Baja California Peninsula.

Table 2. Percent of mothers with calf distribution during 1980 and 1997 winter seasons.

Year	BA	BM	SDC	LSI	LOL	LGN	Total
1980	<1	5	13	13	58	10	100
1997	2	1	10	14	72	1	100

Table 3. Percent of single whales distribution during 1980 and 1997 winter seasons.

Year	BA	BM	SDC	LSI	LOL	LGN	Total
1980	19	8	10	12	44	7	100
1997	15	11	3	20	50	1	100

Table 4. Estimated total annual calf production

Year	SDC	LSI	LOL	Total	Estimate to all breeding areas	Calf estimate in California	Difference	Difference (%)
1997	83	126	626	835	910	1431	521	36%
1998	12	52	530	594	647	1388	741	53%
1999	32	17	213	262	286	427	141	33%
2000	16	45	256	317	345	279	-66	-24%
2001	25	29	333	387	422	256	166	-65%
2002	97	43	475	615	670			

Table 5. Calf mortality rate in the breeding lagoons.

Year	SDC	LSI	LOL	Total	Stranded calves	Gross calf production	Mortality rate
1997	83	126	626	835	17	852	0.020
1998	12	52	530	594	7	601	0.012
1999	32	17	213	262	5	267	0.020
2000	16	45	256	317	7	324	0.022
2001	25	29	333	387	2	387	0.005
2002	97	43	475	615	6	621	0.010

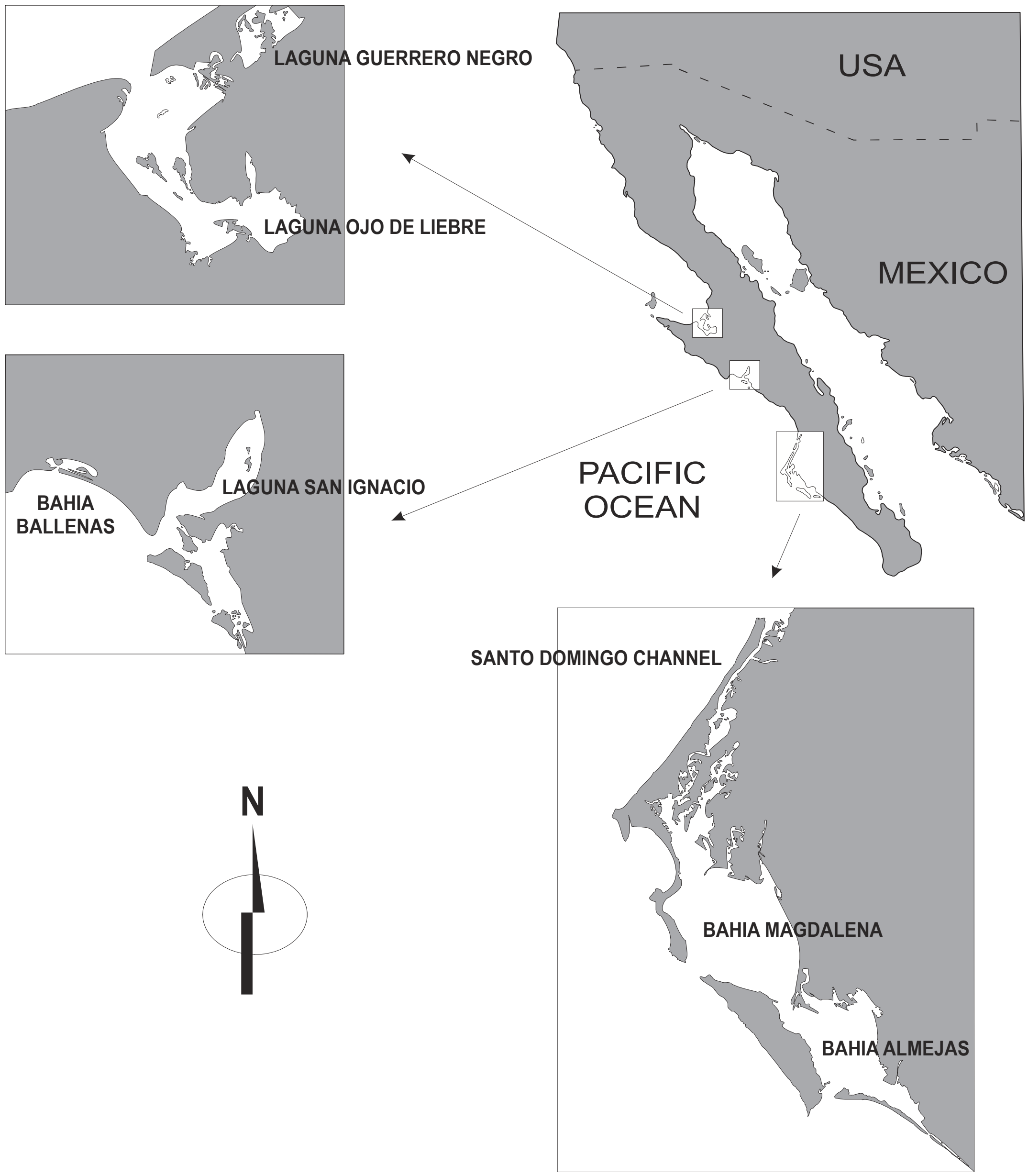
Table 6. Duration of the stay in Laguna San Ignacio 1996-2000.

	1996		1997		1998		1999		2000	
	X	n	*X*	n	*X*	n	*X*	n	*X*	n
Single whales	2.6 ± 0.9	5	6.2 ± 3.2	4	5.6 ± 2	5	4.3 ± 2.0	11	6.8 ± 3.2	19
Mothers with calf	19.1 ± 4.8	20	19.6 ± 3.5	43	20.6 ± 4.1	43	25.5 ± 5.4	39	23.0 ± 6.6	25

Table 7. Gray whales stranded in the Mexican cost during the winter season of 2000.

		Bahia Almejas	Bahia Magdalena	Santo Domingo Channel	Laguna San Ignacio	Laguna Ojo de Liebre	West coast of Baja California	Total	%
Age class	Adults	0	10	2	34	34	48	128	61.84
	Yearlings	0	1	0		7	0	8	3.86
	Calves	1	5	0		1	19	26	12.56
	Unknown	0	3	1			41	45	21.74
	Total	1	19	3	34	42	108	207	100.00
Gender	Males	0	11	1	27	16	23	78	37.68
	Females	1	7	1	6	24	0	39	18.84
	Unknown	0	1	1	1	2	85	90	43.48
	Total	1	19	3	34	42	108	207	100.00

Figure 1. Study site.



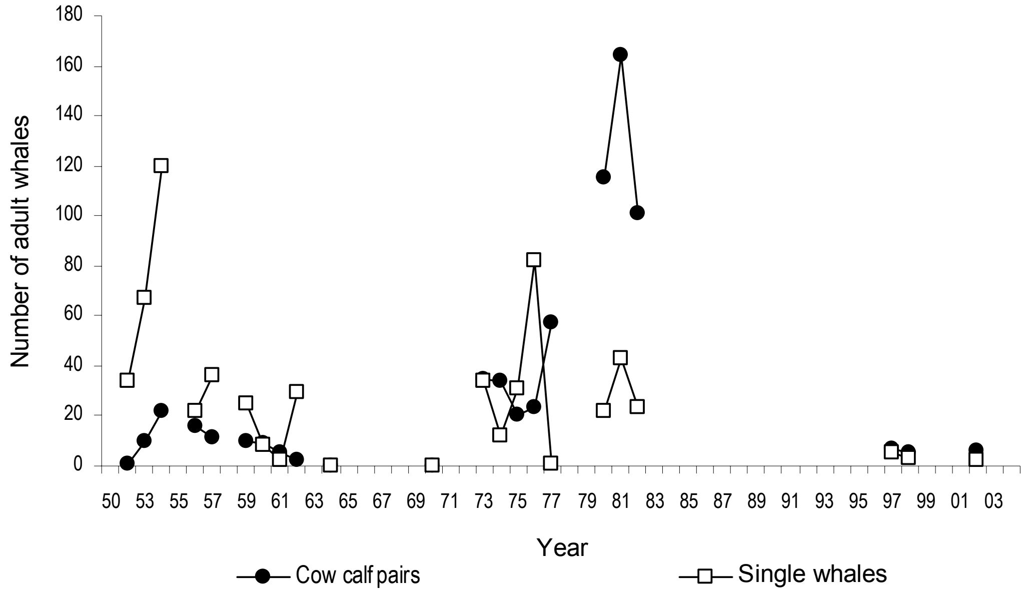


Figure 2. Abundance of gray whales in Laguna Guerrero Negro

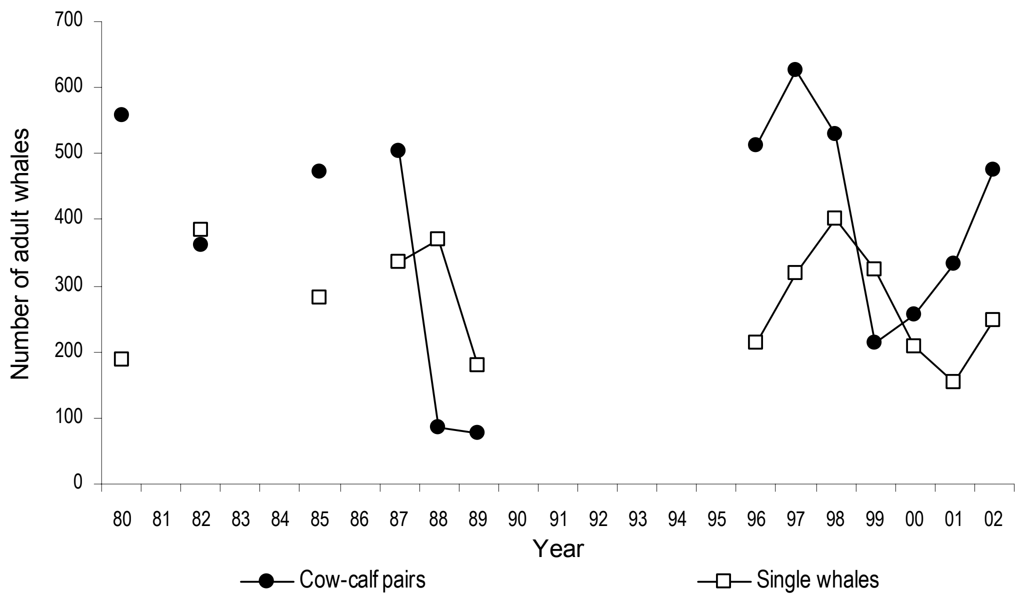


Figure 3. Abundance of gray whales in Laguna Ojo de Liebre.

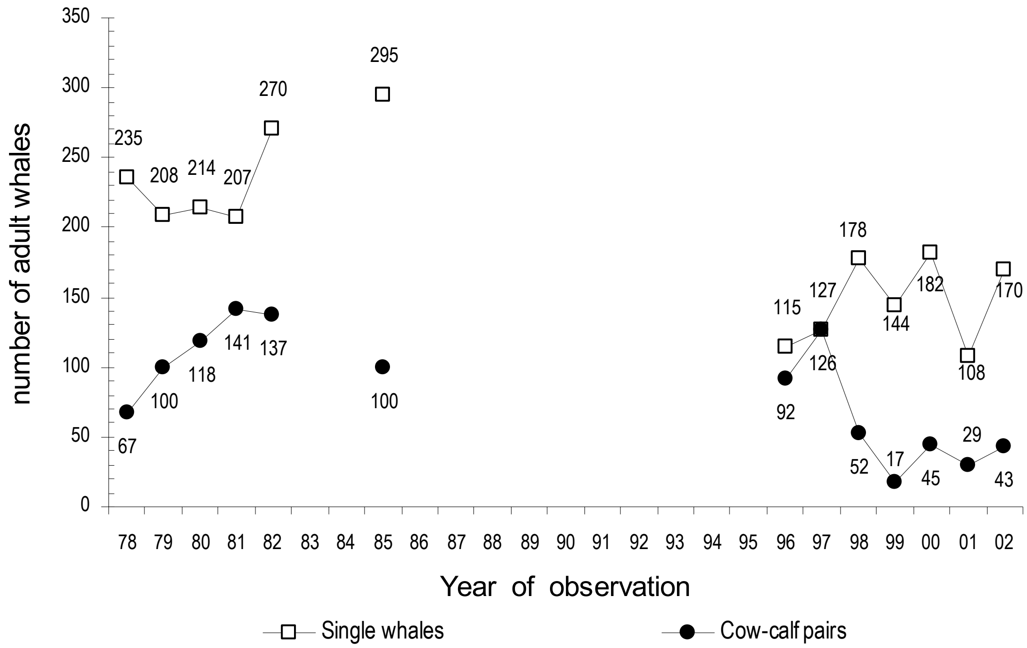


Figure 4. Abundance of gray whales in Laguna San Ignacio.

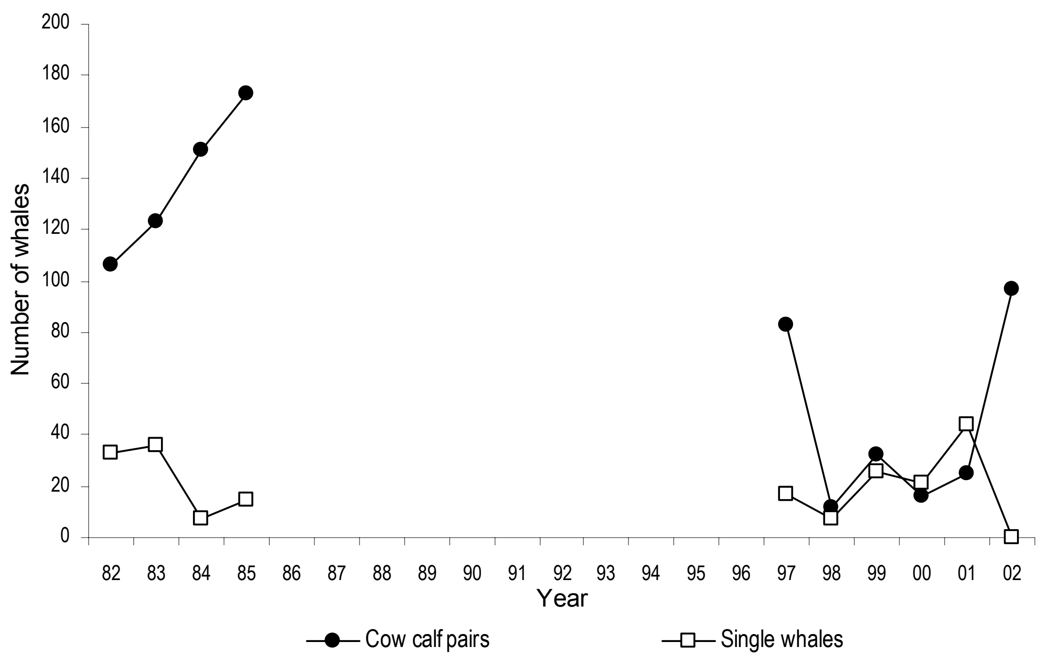


Figure 5. Abundance of gray whales in Santo Domingo Channel.

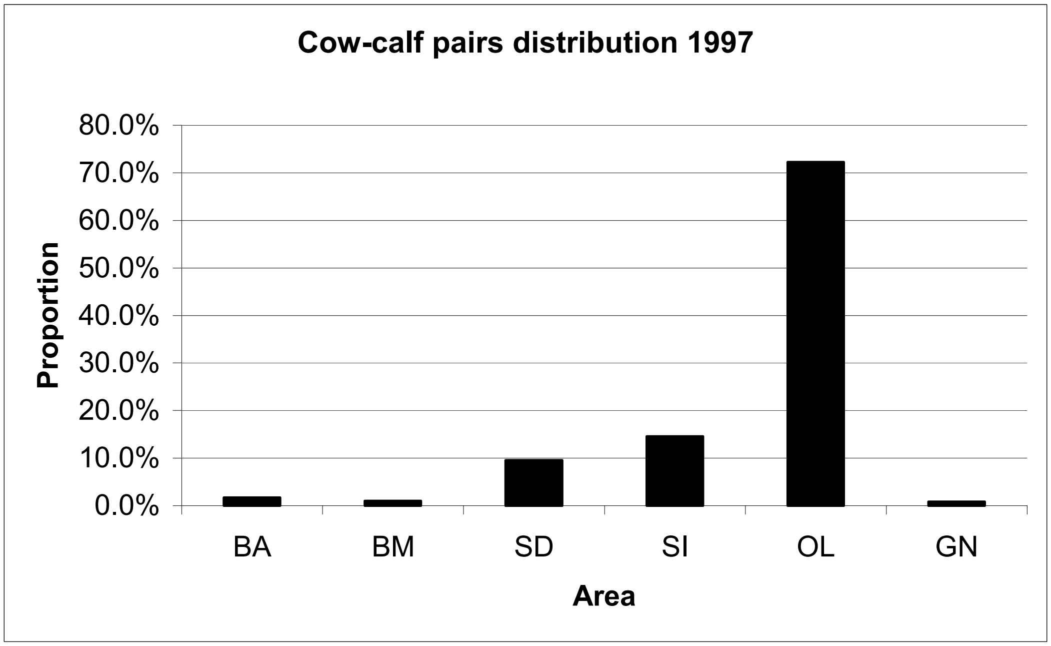


Figure 6. Mothers with calf distribution in the 1997 winter season.

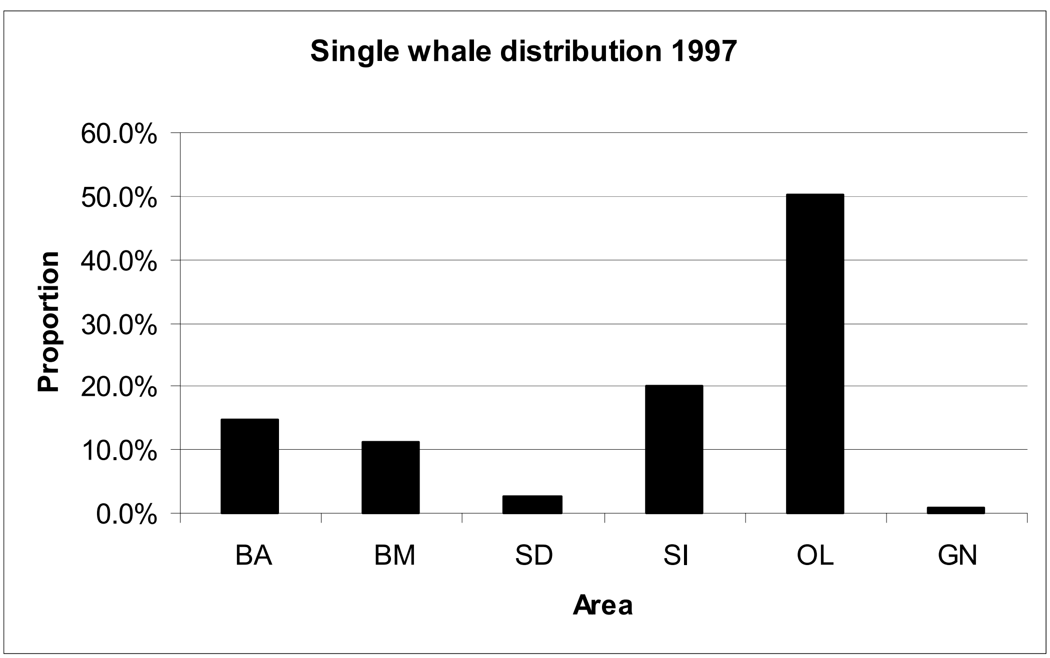


Figure 7. Single whales distribution in the 1997 winter season.

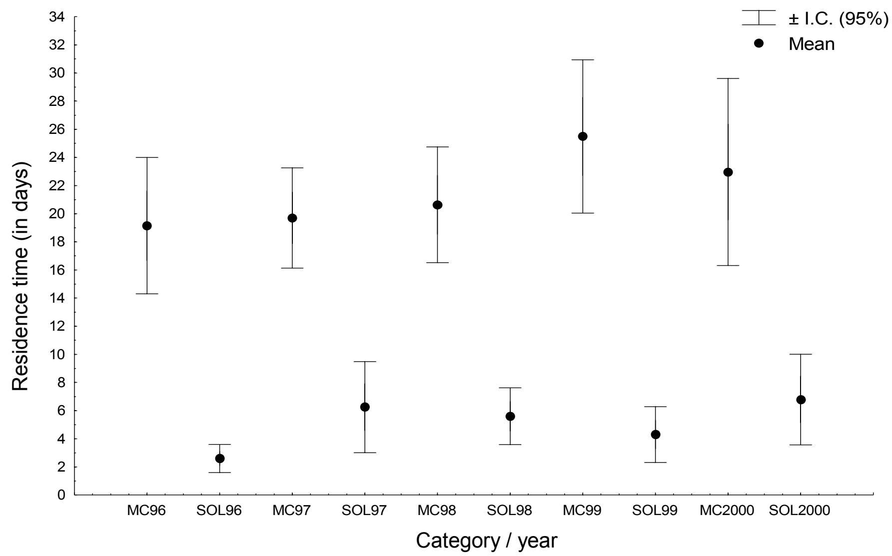


Figura 8. Residency time of gray whales in Laguna San Ignacio Winter seasons 1996-2000. MC = mothers with calf; SOL = single whales.

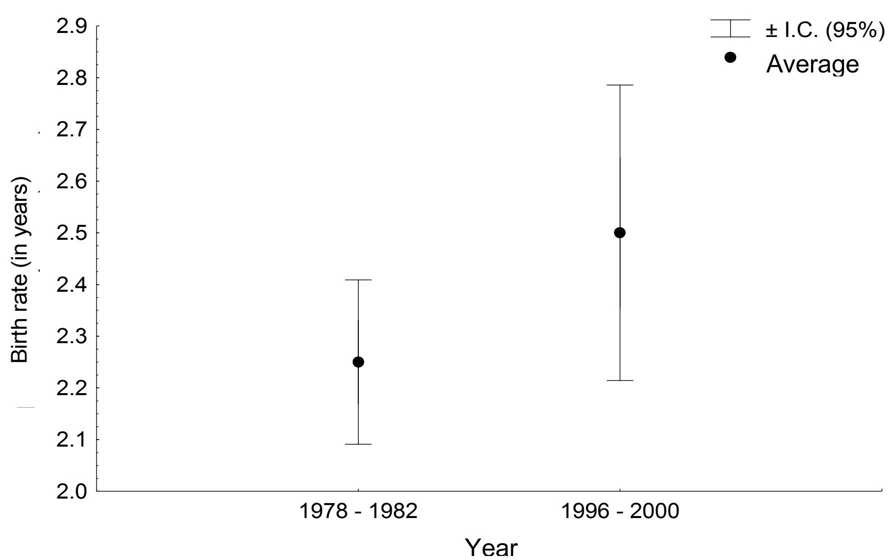


Figure 9. Birth rate estimates in Laguna San Ignacio.