SC/34/PS4

Gray Whale (*Eschrichtius robustus*) Calf Production and Mortality in the Winter Range

Steven L. Swartz and Mary Lou Jones

Cetacean Research Associates, 1592 Sunset Cliffs Boulevard, San Diego, California 92107

ABSTRACT

Annual gray whale (*Eschrichtius robustus*) calf production and mortality were empirically estimated from data collected in Laguna Guerrero Negro, Laguna Ojo de Liebre, and Laguna San Ignacio, Baja California Sur, Mexico between 1980 and 1982. A gross annual production of 1,185 calves with a 5.4% mortality based on lagoon strandings yielded a net production of 1,121 calves. This represents a 7.0% annual rate of production based on the best estimate of the current population size of 15,942 gray whales. By comparison, the proportion of calves passing Pt. Piedras Blancas, California in 1980 and 1981 was 4.3% (679) and 4.8% (769) respectively, suggesting a 31% calf decrease may occur between the lagoons and central California. Two periods critical to calf survival are postulated; the first period immediately follows birth, and the second corresponds to the calves departure from the lagoons and the beginning of the northward migration.

INTRODUCTION

Empirical data on calf production and mortality are not available for most cetacean species. Recent studies within the breeding and calving lagoons, and along the migratory route of the gray whale (*Eschrichtius robustus*) provide an opportunity to examine newborn calf gross production, mortality, and net calf production during the winter breeding season. This information is useful for analyzing gray whale population growth and recovery from depletion, and it may be useful in understanding other depleted cetacean populations. This paper will:

1. Estimate maximum theoretical calf production based on current gray whale population estimates, proportion of breeding females in the population, and pregnancy rates.
2. Examine empirical data on gray whale calf production and calf mortality in breeding lagoons.
3. Compare observed net calf production within lagoons with calf population estimates from shore counts of the northward spring migration.

ESTIMATED MAXIMUM ANNUAL GRAY WHALE CALF PRODUCTION

Population estimates for gray whales based on shore censuses of the fall migration at Monterey, California between 1968 and 1981 indicated an annual 2.25% rate of increase (Reilly *et al.*, 1980a). The 'best estimate' from a regression of thirteen annual counts was 15,587 for 1980 (Reilly *et al.*, 1980b), and at the above rate of increase would be 15,942 in 1981 and 16,304 in 1982. Additional studies supporting population estimates of this size include an age structured simulation of gray whale population history using Monterey data which yielded a 1980 population of 15,400 (Reilly, 1981), and two years of shore censuses of the northward migration from Pt. Piedras Blancas, California resulting in population estimates of 15,725 for 1980 and 16,140 in 1981 (Poole, 1981). These population size estimates are further supported by earlier independent estimates of 14,400 for 1976 (Hall, 1977), and 15,099 for 1977 (Rugh and Braham, 1979) from fall counts of southward migrating gray whales passing through Unimak Pass, Alaska.

Rice and Wolman (1971) proposed that the maximum theoretical rate of gray whale calf production was 12.8% based on an equal sex ratio (50:50), an adult breeding proportion of 56%, and an annual female pregnancy rate of 46%. Based on the current population estimates given above (Reilly *et al.*, 1980b), the maximum expected number of calves produced assuming a 12.8% rate of increase would be 2,072 for 1981, and 2,119 for 1982.

CALF COUNTS IN THE BREEDING LAGOONS

Gray whales give birth during a 66 day period approximately from 26 December to 1 March (Jones and Swartz, 1983) with a mean birth date of 27 January (Rice *et al.*, 1982). Evidence supporting this proposed calving period comes from studies of the passage of southbound late-pregnant females past San Francisco, California in December and January (Rice and Wolman, 1971), the peak counts of cow/calf pairs in Laguna Ojo de Liebre (Rice *et al.*, 1982) and Laguna Guerrero Negro (Bryant and Lafferty, 1983), and the range of birth dates observed in Laguna San Ignacio (Jones and Swartz, 1983). In Laguna San Ignacio the number of cow/calf pairs counted continued to increase after mid-February. This increase did not include newborn calves; rather, these calves were judged by their size, coloration, and extent of barnacle encrustation to be 1–2 months old and presumably emigrated from areas outside Laguna San Ignacio (Swartz and Jones, 1980; 1981; Jones and Swartz, 1983). Annual calving, then, appears to be near completion by mid-February, and calf counts made during this period would best represent gross calf production in each respective lagoon or coastal area.

Aerial surveys in the breeding lagoons and along the near-shore waters of Baja California, Mexico tend to underestimate abundance of gray whale calves when compared to simultaneous vessel surveys (Fleischer, 1980; Bryant and Lafferty, 1980; Rice *et al.*, 1982; Swartz and Jones, 1981; Storro-Patterson, 1982). Results of aerial

surveys by various researchers, although available, are difficult to compare because of differences in survey dates, aircraft census techniques, and environmental sea state. Vessel surveys utilizing the same techniques were conducted in mid-February for three seasons in Laguna Guerrero Negro (Bryant and Lafferty, 1980, 1983), one season in Laguna Ojo de Liebre (Rice *et al.*, 1982), and for three seasons Laguna San Ignacio (Swartz and Jones, 1980; 1981; Jones and Swartz, 1983); therefore, we have elected to use only the results of vessel surveys in the following analysis. These surveys were limited to lagoon interiors because high surf conditions preclude vessel surveys of lagoon inlets and adjacent near-shore waters even though these areas are utilized by a significant proportion of whales throughout the winter (Swartz and Jones, 1980; Storro-Patterson, 1982; and Norris *et al.*, 1983).

The number of calves counted during vessel surveys, and the number of dead calves discovered in the three breeding lagoons of Laguna Guerrero Negro, Laguna Ojo de Liebre, and Laguna San Ignacio between 1980 and 1982 are summarized in Table 1. The average mid-February calf count in Laguna Guerrero Negro was 129.7. This number of calves, combined with the average of 3.3 dead calves/year, suggests an average annual gross calf production of 133 individuals. Similarly, for Laguna San Ignacio, an average count of 132 calves/year plus four dead calves/year yields an annual gross calf production of 136 animals. Data are available for only one season in Laguna Ojo de Liebre: in 1980 557 calves were counted in mid-February, 12–16 dead calves counted within the lagoon and 23 stranded on the ocean side of the barrier island. This makes an annual gross production at Laguna Ojo de Liebre of 573 if 16 dead calves are added to the 557 living calves counted.

There was no significant difference in the yearly stranded calf and calf counts for Laguna Guerrero Negro, Laguna Ojo de Liebre, and Laguna San Ignacio (chi-square = 0.148, $p = 0.9287$); thus, these data from within the lagoons were combined to yield a grand average mid-February calf count of 818.7, an average stranded calf count of 23.3, which give a combined gross calf production of 842 calves. Because bloated calf carcasses are known to move about and even out of lagoon interiors with the winds and tides (Swartz and Jones, 1978; Rice *et al.*, 1982), we strongly suspect that 23 calves found stranded on the beach between Laguna Guerrero Negro and Laguna Ojo de Liebre belonged to this lagoon system. If these 23 calves are not included, calf mortality and gross production would be underestimated. Adding these calves to the combined totals the gross calf production becomes 842 + 23 = 865 calves for all three lagoons.

LAGOON CALF MORTALITY RATE

Minimum calf mortality may be estimated from the number of dead calves discovered divided by the estimated gross annual calf production. The combined annual mortality for all three lagoons (Laguna Guerrero Negro, Laguna Ojo de Liebre, and Laguna San Ignacio) of 23.3 calves divided by the total estimated gross production of 842 gives an annual lagoon calf mortality rate of 2.8% (Table 1). If the 23 calves found stranded outside of Laguna Guerrero Negro and Laguna Ojo de Liebre are included, the mortality rate becomes 46.3/865 = 5.4%.

ESTIMATED TOTAL ANNUAL CALF PRODUCTION

Aerial surveys by Rice *et al.* (1982) examined major gray whale calving areas and ranked them by the proportion of the total calves counted within each area. These surveys were conducted in mid-February using the same observers and were flown during sea states of Beaufort No. 3 or less, at a constant altitude and air speed. We assume that the bias toward underestimation of calf abundance (as discussed earlier) was uniform during all surveys and the proportions of calves counted in each area are good estimates of actual distributions. The results of these surveys suggest that Laguna Guerrero Negro contained 9%, Laguna Ojo de Liebre 53%, and Laguna San Ignacio 11% of all the calves born that year, or 73% of all the calves produced in a given year. The remaining 27% of the calves were in the Bahia Magdalena lagoon complex and along the Pacific coast of the Baja Peninsula.

If the rates of production and mortality are

Table 1

Gray whale mortality and production in three breeding/calving lagoons between 1980 and 1982.

Lagoon	Year	Stranded calves	Mid-Feb. calf counts	Gross calf production	Mortality rate
Guerrero Negro	1980	4	115	119	0.034
	1981	4	161	165	0.024
	1982	2	113	115	0.017
Average		3.3	129.7	133	0.025
Ojo de Liebre	1980	16	557	573	0.029
Outer Beach LGN & LOL	1980	23	—	—	—
San Ignacio	1980	4	119	123	0.033
	1981	4	140	144	0.028
	1982	4	137	141	0.028
Average		4	132	136	0.029
Grand average (all 3 lagoons)		23.3	818.7	842	0.028
Grand average (including outer beach count)		46.3	818.7	865	0.054

equivalent for all the breeding/calving areas, including Bahia Magdalena and the coastline between lagoons, then the total expected gray whale gross calf production extrapolated from the above proportions would be 865/0.73 = 1.185 calves. The expected total annual calf mortality would be 5.4% of the total gross production, or approximately 64 calves. Thus, the net annual production would be 818.7/0.73 = 1,121 calves.

CALF ABUNDANCE ESTIMATES FROM MIGRATION COUNTS

The 1981 population estimate of 15,942 gray whales (Reilly *et al.*, 1980b) and the estimated net lagoon production of 1,121 calves generated above combine to suggest a 7% annual rate of production, compared with the theoretical maximum rate of 12.8% calculated by Rice and Wolman (1971) (Table 2).

Proportions of calves to adults observed during two short censuses of the spring northward migration are available for comparison with the estimated net annual lagoon production. Poole (1981) utilized Reilly's (1981) model to estimate that 15,725 gray whales passed Pt. Piedras Blancas, California in 1980, and 16,140 passed in 1981; of these 679 (4.3%) in 1980, and 769 (4.8%) in 1981 were calves. The difference between Poole's 1981 calf abundance estimate and the estimated annual net calf production (1,121 − 769 = 352) suggests a calf attrition or loss of up to 31% between the lagoons and central California.

A calf loss of 31% may be the result of an underestimate of northward migrating whales; however, Poole's gray whale population estimates of 15,725 for 1980 and 16,140 for 1981 agree with other independent estimates (Hall, 1977; Rugh and Braham, 1979; Reilly, 1981), and the increase between both years of 415 whales (2.6%) is consistent with the 2.25% annual rate of increase established for gray whales (Reilly *et al.*, 1980a). Unfortunately, estimates of the variance of these calf estimates are not available. Poole states that during the period corresponding to the northward spring migration of cow/calf pairs (from mid-April to the end of May), of 1,790 whales passing Piedras Blancas 264 (15%) were not cow/calf pairs, but may have been postpartum females that had lost their calves. These whales were almost always observed travelling in the presence of a cow/calf pair rather than alone.

If we add 264 to Poole's 1981 estimate of 769 calves to compensate for females that presumably lost their calves, we can account for 1,033 calves which is within 88 calves (8%) of our estimated net annual lagoon production of 1,121. This corroborates our estimated 31% loss rate of calves. If the missing calves do not die but disperse below central California, we would expect approximately 352 gray whales per year to be detected somewhere in the southern range. Except for two verified sightings of gray whale calves unattended by adults off Isla Guadalupe, Baja California, Mexico in April of 1973 and June of 1974 (Leatherwood, pers. comm.), a 13 meter long gray whale in Bahia de San Quintin, Baja California Norte in July 1977 (Aguayo, 1980), and a handful of unsubstantiated reports over the past 15 years, there is no evidence that gray whales in the numbers calculated above remain in the southern range.

DISCUSSION

The best available data suggest approximately 5.4% of the gray whale calves produced annually die within the breeding/calving lagoon areas and that an additional 31% decrease (presumed mortality) of the net lagoon production occurs during the first leg of their northward migration before reaching central California.

The strength of this analysis lies in the accuracy of data from the lagoons and the abundance estimates extrapolated from shore-based migration counts. Estimates of lagoon calf production and mortality are minimum estimates based on counts of cow/calf pairs and of dead calves found within the lagoons during the same time periods. Estimates of calves migrating past central California and estimates of gray whale population size are extrapolated from daytime shore-based counts corrected for whales missed due to poor visibility, whales missed before the first and following the last day of the census, whales that passed during the night time, and whales not sighted as a function of their distance from shore (Reilly *et al.*, 1980b). Although the majority of cow/calf pair sightings are well inshore, we cannot discount the possibility that a few pairs may migrate offshore beyond the sight of coastal census stations. Between 1969 and 1972 Leatherwood (1974) reports five cow/calf pairs migrated northward offshore through the Southern California bight. Similarly, in his 1982 aerial survey off central California, Poole (In Press) observed one cow/calf pair (4%, n = 24) 10.4 km offshore, while all other pairs sighted were within 1.2 km of the beach.

Evidence exists that the tail-end of the cow/calf northward migration may not have passed central California when Poole ceased his observations at the end of May. J. Harvey and B. R. Mate (pers. comm.)[1] reported 25 to 35 cow/calf pairs remained in Laguna San Ignacio and an unknown number were outside the lagoon inlet in the breakers on 26 April 1980. Throughout April and May sportfishing vessel operators sailing between San Diego and Baja California Sur report sightings of gray whale females with their calves moving northerly along kelpbeds and up to a few kilometers offshore (pers. comms)[2]. Storro-Patterson (1982) reports a few females and their calves remain at the lagoon inlets into May, and local

Table 2

Summary of gray whale calf production estimates based on the 1981 population estimate of 15,942 whales (Reilly, 1980b).

		No. calves	Source
Maximum theoretical rate of production	0.128	2,072	Rice & Wolman, 1971
Observed net production in lagoons	0.07	1,121	This paper
Pt. Piedras Blancas estimate	0.043 (1980)	679	Poole, 1982
	0.048 (1981)	769	

Mexican fishermen (pers. comms)[3] indicate gray whales may be found outside the lagoons as late as early June of some years. These observations imply that an unknown number of cow/calf pairs were not included in the central California abundance estimate, and if included they would reduce the disparity between estimated lagoon calf production and estimated calf abundance during the migration.

The frequency of dead gray whale calves found in the lagoons and the apparent loss of calves between the lagoons and central California suggest that two periods critical to the survival of calves occur during the first few months of a gray whale's life. The first period includes birth and the time immediately following birth. The physical appearance and condition of stranded gray whale calves examined in the lagoons indicate some are under-sized and may have been stillborn, while others drowned during birth or died within a few days after birth (Rice and Wolman, 1971; Rice *et al.*, 1981; Jones and Swartz, 1983). Because the gray whale population is recovering from very low levels, we would expect it to include a higher proportion of young females (perhaps first time mothers) than when the population reaches a stable age distribution, and that these females may not be as successful at reproducing as older females that have bred previously. Dead newborn calves are discovered throughout the birthing period (26 December to 1 March), but they are found only infrequently later in the season, suggesting that the probability of dying is greatest just after birth and decreases with time.

The second critical period of calf mortality would correspond to the cow/calf pairs' departure from the lagoon areas and their northward migration. It is reasonable to think some calves are unable to withstand the rigors of coastal migration, fall prey to sharks and killer whales (*Orcinus orca*), or become lost, disoriented, and ultimately separated from their mothers prior to weaning. Killer whale harassment of gray whales is well documented (Rice and Wolman, 1971; Baldridge, 1972; Poole, 1982; Norris, pers. comm.) and probably contributes significantly to the deaths of very young gray whales. Calves of the year comprised 43% of 97 gray whale strandings reported along their migratory route between 1950 and 1981, suggesting that calves die in significantly higher proportion to other gray whale age classes (Jones and Swartz, 1983).

In the present context, caution must be used in drawing strong conclusions about gray whale calf mortality and production in the breeding/calving lagoons because the data are incomplete as follows:

1. Estimates of the variance of the calf estimates from shore censuses, the variance of the population rate of increase, and the variance for the estimated lagoon calf production are not available and are necessary to assess the significance of these numbers.

2. Not all dead whales are discovered; some carcasses strand on beaches not visited by investigators, are lost at sea, or are consumed by scavengers. These data tend to underestimate mortality.

3. Not all calves born each year are detected; census counts represent minimum estimates of annual gross calf production. These data tend to underestimate calf production.

4. Census counts from different sites made at different times and seasons cannot be assumed to be independent; there may be mixing of gray whales (and calves) between lagoons, particularly just prior to northward migration. Census data should be collected simultaneously from all areas to be compared.

5. Lagoon censuses do not include the near-shore waters adjacent to lagoon inlets. These areas are utilized extensively by significant numbers of whales throughout the breeding season (Swartz and Jones, 1980; Norris *et al.*, 1983). Additional cow/calf pairs counted outside the lagoons would decrease the mortality rate but consequently increase the discrepancy between observed net calf production within lagoon areas and calf population estimates from shore counts of the northward migration.

6. Data are not available for all birthing areas; however, we must assume the rate of production and mortality observed in the three lagoons studied is representative of all areas. Additional data from these and other areas is needed.

[1]J. Harvey and B. R. Mate, Oregon State University Marine Science Center, Newport, Oregon.

[2]Fisherman's Landing, and H & M Sportfishing, Inc., San Diego, California.

[3]Abreojos Fishing Cooperative, Punta Abreojos, Baja California Sur, Mexico.

ACKNOWLEDGEMENTS

We are grateful to David Bain, Jeffery M. Breiwick, Steven G. Hoffman, J. Stephen Leatherwood, Edward D. Mitchell, Kenneth S. Norris, Stephen B. Reilly, Dale W. Rice, Dave R. Rugh, and Dave Withrow for their advice, encouragement, and review of this manuscript.

REFERENCES

Aguayo-Lobo, A. 1980. Un ejemplar de ballena gris (*Eschrichtius robustus*) veraneando en Baja California, Mexico en 1977. Abstracts in V Reunion Internacional Sobre Mamiferos Marinos de Baja California, Ensenada, B. C., Mexico. 20–21 February 1980.

Baldridge, A. 1972. Killer whales attack and eat a gray whale. *J. Mammal.* 53: 898–900

Bryant, P. J., and Lafferty, C. M. 1980. The gray whales of Laguna Guerrero Negro. *Whalewatcher*; 14(4): 3–5.

Bryant, P. J., Lafferty, C. M. and Lafferty, S. K. 1983. Re-occupation of Laguna Guerrero Negro, Baja California, Mexico, by gray whales. *In:* M. L. Jones *et al.* (Eds.) *The Gray Whale*. Academic Press, Inc. New York.

Fleischer, L. A. 1980. Aerial surveys of California gray whales in Laguna Ojo de Liebre, Baja California, Mexico, 1980. Technical report to the National Marine Mammal Laboratory, National Marine Fisheries Service, NWAFC, NCAA, Seattle, Washington. 34 pp.

Hall, J. D. 1977. The migration of California gray whales into the Bering Sea. Unpublished manuscript prepared for the U.S. Fish and Wildlife Service. 14 pp.

Leatherwood, J. S. 1974. Aerial observations of migrating gray whales (*Eschrichtius robustus*) off Southern California, 1969–1972. MFR Paper 1055. *Marine Fisheries Review* 36(4): 45–49.

Norris, K. S., Ramirez, B. V., Nichols, G., Wursig, B. and Miller, K. 1983. Lagoon entrance and other aggregations of gray whales (*Eschrichtius robustus*). *In:* R. Payne (Ed.) *Behavior and Communication of Whales*. AAAS Selected Symposia Series, Westview Press, Boulder, CO.

Poole, M. M. In Press. Preliminary assessment of annual calf production of the California gray whale (*Eschrichtius robustus*) from Pt. Piedras Blancas, California. *Rep. int. Whal. Commn* (special issue 6).

Poole, M. M. 1983. Migration corridors of gray whales (*Eschrichtius robustus*) off Southern California, 1980–1982. *In:* M. L. Jones *et al.* (Eds.) *The Gray Whale*. Academic press, New York.

Reilly, S. P. 1981. Gray whale population history: an age structured simulation. Paper SC/33/PS8 presented to the IWC Scientific Committee, Cambridge, June 1981.

Reilly, S. B., Rice, D. W. and Wolman, A. A. 1980a. Preliminary population estimates for the California gray whale based on Monterey shore censuses, 1967/68 to 1978/79. *Rep. int. Whal. Commn* 30: 359–68.

Reilly, S. B., Rice, D. W. and Wolman, A. A. 1980b. Final population estimate for the California gray whale *Eschrichtius robustus* based on Monterey shore censuses, 1967/68–1979/80. Paper SC/32/PS13 presented to the IWC Scientific Committee, Cambridge, June 1980.

Rice, D. W. and Wolman, A. A. 1971. The life history and ecology of the gray whale (*Eschrichtius robustus*). *Am. Soc. Mammal., Spec. Pub.* No. 3. 42 pp.

Rice, D. W., Wolman, A. A. and 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.

Rugh, D. J. and Braham, H. W. 1979. California gray whale (*Eschrichtius robustus*) fall migration through Unimak Pass, Alaska, 1977: a preliminary report. *Rep. int. Whal. Commn* 29: 315–20.

Storro-Patterson, R. 1982. Biological aspects of the eastern Pacific stock of gray whales (*Eschrichtius robustus*) *In:* Background papers for workshop on international cooperation for conservation of gray whales. World Wildlife Fund-U.S. and Int. Union. for Conser. Natur.: 1–165.

Swartz, S. I. and Jones, M. L. 1980. Gray whales (*Eschrichtius robustus*) In Laguna San Ignacio and its near-shore waters during the 1979–80 winter season. Technical report to the World Wildlife Fund–U.S. 37 pp.

Swartz, S. I. and Jones, M. L. 1981. Demographic studies and habitat assessment of gray whales (*Eschrichtius robustus*) in Laguna San Ignacio, Baja California sur, Mexico. U.S. Dept. of Commerce, N.T.I.S. Pub. PB82–123373.

Swartz, S. I. and Jones, M. L. 1983. Demography, behavior, and ecology of gray whales (*Eschrichtius robustus*): 1978 to 1982 in Laguna San Ignacio, Baja California Sur, Mexico. U.S. Dept. of Commerce, N.T.I.S. Publ.