SC/68A/CMP/17

Eastern North Pacific gray whale calf production estimates 1994-2018

David W. Weller and Wayne L. Perryman

INTERNATIONAL
WHALING COMMISSION

Eastern North Pacific gray whale calf production estimates 1994-2018

DAVID W. WELLER AND WAYNE L. PERRYMAN

Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, La Jolla, California, USA

Contact e-mail: dave.weller@noaa.gov

ABSTRACT
Shore-based visual counts of eastern North Pacific gray whale calves during their northward migration were conducted between late March and early June each year from 1994-2018 off central California. Estimates of the number of northbound calves showed a high degree of inter-annual variability, ranging from a high of 1,528 in 2004 to a low of 254 in 2010. Calf production was consistently high (exceeding >1,000 calves annually) between 2012-2017, when more than 7,500 calves were estimated. The 2016 estimate of 1,351 calves was about 5% of the most recently reported total abundance of 26,960 (in 2016) for the eastern North Pacific population. In 2018, calf production declined to 867, a level similar to 2011 (858 calves).

KEYWORDS: GRAY WHALE; EASTERN NORTH PACIFIC; CALF PRODUCTION

INTRODUCTION

The majority of eastern North Pacific gray whales *(Eschrichtius robustus)* annually migrate southward from summer feeding grounds in the Pacific Arctic to wintering areas off Baja California, Mexico (Rice and Wolman 1971). Both the southward and northward migration is segregated, to a large extent, by age, sex and reproductive condition. During the northward migration, females with their calves of the year are the last to depart the Baja wintering areas. These mother-calf pairs are observed on the migration route between late March and late May and typically arrive to the summer feeding grounds sometime between May and June. Shore-based counts of northbound gray whale calves have been conducted off central California each spring from 1994 to 2018. This report presents an overview of results from this 25-year time series of estimates for eastern North Pacific gray whale calf production.

METHODS

Shore-based counts of northbound gray whale calves have been conducted from the Piedras Blancas Light Station (north of San Simeon, California) each spring from 1994 to 2018. Data collection methods and analytical techniques have remained consistent each year and follow those reported elsewhere (see Perryman *et al*. 2002; 2017). Briefly, counts were conducted by four observers, with two on effort at any one time, rotating through the following schedule: (a) 90-min on effort as the 'offshore' search area observer, (b) 90-min on effort as the 'inshore' search area observer, (c) 3-hr off effort. Weather permitting, this work was carried out for 12 hours per day; 6 days per week in 1994-2003 and 2005 and 5 days per week in 2004 and 2006-2018. Primary search effort was carried out with unaided eye but 7x50 and 25x150 binoculars were also used when needed.

Based on night/day migration rate data derived from thermal sensors (1994-1996) and aerial surveys (1994-1995) to determine offshore distribution (Perryman *et al*. 2002), it was assumed that: (a) the number of gray whale calves passing the survey site far enough offshore to be undetectable by visual observers was negligible, and (b) day and night passage rates were equivalent. Detection probabilities were also assumed to be the same across acceptable sighting conditions (see Reilly *et al.* 1983; Reilly 1992). To account for imperfect probability of detection of calves by the visual observers, estimates were corrected by the average detection probability obtained from seven consecutive years (1994-2000) of independent replicate counts (mean = 0.89; SE = 0.064).

Each day of survey effort was divided into four 3-hr periods and passage rates during these periods were calculated from the observed counts multiplied by the inverse of the detection function. To correct for periods when observers were not on watch (e.g. poor weather, night time, days off), we embedded the estimators in a finite population model that was stratified by week to account for varying passage rates (Cochran 1977). A Taylor series expansion (Seber 1982) was used to calculate the variance of the estimates.

RESULTS

Estimates of the number of northbound calves showed a high degree of inter-annual variability, ranging from a high of 1,528 in 2004 to a low of 254 in 2010. (Table 1). Calf production was consistently high (exceeding >1,000 calves annually) between 2012-2017 (Fig. 1), when more than 7,500 calves were estimated. The 2016 estimate of 1,351 calves was about 5% of the most recently reported total abundance of 26,960 (in 2016) for the eastern North Pacific population (Durban *et al*. 2017). In 2018, calf production declined to 867, a level similar to 2011 (858 calves) prior to the aforementioned higher levels recorded between 2012 and 2017.

DISCUSSION

During the 25-year time series reported here, estimates of gray whale calves displayed a high degree of inter-annual variability. Based on data from 1994 to 2000, Perryman *et al*. (2002) suggested that the reliance of female gray whales on stored fat resources during pregnancy combined with sea ice regulated access to food during the beginning of a feeding season may impact their ability to carry existing pregnancies to term. When these estimates were examined in the context of environmental data from the northern Bering Sea, a relationship was found between the timing of seasonal ice melt and estimates of northbound gray whale calves counted the following spring. In heavy ice years, when ice extends far to the south, the temporary lack of access to foraging areas appears to have a negative impact on calf production.

The particularly high calf production observed during the 2012-2017 period suggests that gray whales have been experiencing a period of favorable feeding conditions in the Arctic, possibly related to the combination of expanding ice-free habitat (Moore *et al*. 2014), increased primary production (Arrigo and Dijken 2015) and increased flow of nutrient-rich waters through the Bering Strait (Woodgate *et al*. 2012). This hypothesis is further supported by the recent increase in abundance (26,960 in 2016) of the eastern North Pacific gray whale population (Durban *et al*. 2017).

While the impacts of climate change in the Arctic environment are far from being understood, gray whale calf production and abundance may represent a 'boom time', at least in the short-term, for baleen whales in the Pacific Arctic region as has been suggested by Moore (2016).

ACKNOWLEDGEMENTS

The NOAA gray whale calf production surveys conducted from the Piedras Blancas Light Station would not be possible without the support and hospitality provided by U.S. Department of Interior and more recently the Bureau of Land Management. We are particularly indebted to site managers John Bogacki, Jim Boucher and Ryan Cooper. A long list of talented field biologists contributed to this study but the contribution of Richard Rowlett, Susan Chivers and Morgan Lynn stand out as exceptional.

REFERENCES

Arrigo, K. R. and Dijken, G. L. 2015. Continued increases in the Arctic Ocean primary production. Progress in Oceanography 136:60-70.

Cochran, W.G. 1977. Sampling Techniques, Third Edition. Wiley and Sons. New York.

Durban, J.W., Weller, D.W. and Perryman, W.L. 2017. Gray whale abundance estimates from shore-based counts off California in 2014/2015 and 2015/2016. Paper SC/A17/GW/06 presented to the Scientific Committee of the International Whaling Commission, May 2017.

Moore, S. E. 2016. Is it "boom time" for baleen whales in the Pacific Arctic region? Biol. Lett. 12: 20160251.

Moore, S.E., Logerwell, E., Eisner, L., Farley, Jr. E.V., Harwood, L.A., Kuletz, K.,Lovvorn, J., Murphy, J.R., Quakenbush, L.T., 2014. Marine fishes, birds and mammals as sentinels of ecosystem variability and reorganization in the Pacific Arctic region. Pages 337–392, In: J.M. Grebmeier and W. Maslowsik (Eds.) The Pacific Arctic Region: Ecosystem Status and Trends in a Rapidly Changing Environment. doihttp://dx.doi.org/10.1007/978-17-2_11.

Perryman, W. L. and Lynn, M. S. 2002. Evaluation of nutritive condition and reproductive status of migrating gray whales (*Eschrichtius robustus*) based on analysis of photogrammetric data. Journal of Cetacean Research and Management 4(2):155-164.

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? Marine Mammal Science 18(1):121-144.

Perryman, W.L., Weller, D.W. and Durban, J.W. 2017. Estimates of eastern North Pacific gray whale calf production 1994-2016. Paper SC/67a/GW/07 presented to the Scientific Committee of the International Whaling Commission.

Reilly, S.B., Rice, D.W. and Wolman, A.A. 1983. Population assessment of the gray whale, *Eschrichtius robustus*, from California shore censuses, 1967-80. Fishery Bulletin, U.S. 81:267-281.

Reilly, S.B. 1992. Population biology and status of the eastern Pacific gray whales: Recent developments. Pages 1062-1074, In: D. R. McCullough and R. H. Barrett (Eds.) Wildlife 2001: Populations. Elsevier Press, London.

Rice, D. W. and Wolman, A. A. 1971. Life history and ecology of the gray whale (*Eschrichtius robustus*). The American Society of Mammalogists (special issue) 3:1-142.

Rugh, D. J., Shelden, K. E. W., Schulman-Janiger, A. 2001. Timing of the gray whale southbound migration. Journal of Cetacean Research and Management 3(1):31-394.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters (second edition). C. Griffin & Co., Ltd., London.

Woodgate, R. A., Weingartner, T. J., and Lindsay, R. 2012. Observed increases in Bering Strait oceanic fluxes from the Pacific to the Arctic from 2001 to 2012 and their impacts on the Arctic Ocean water column. Geophysical Research Letters 39: L24603. Doi:10.1029/2012GL054092.

Table 1

Annual survey information and eastern North Pacific gray whale calf production estimates 1994-2018.

Year	Effort Hours	Calf Count	Calf Estimate	SE
1994	671	325	945	68.21
1995	610	194	619	37.19
1996	694	407	1146	70.67
1997	709	501	1431	82.02
1998	554	440	1388	94.84
1999	737	141	427	41.10
2000	704	96	279	34.79
2001	722	87	256	28.56
2002	711	302	842	78.60
2003	686	269	774	73.56
2004	562	456	1528	96.00
2005	669	343	945	86.90
2006	531	285	1020	103.30
2007	469	117	404	51.20
2008	498	171	553	53.11
2009	476	86	312	41.93
2010	487	71	254	33.94
2011	500	246	858	86.17
2012	435	330	1167	120.29
2013	483	311	1122	104.14
2014	529	429	1487	133.35
2015	522	404	1436	131.01
2016	436	367	1351	121.38
2017	406	267	1054	101.10
2018	468	243	867	82.37

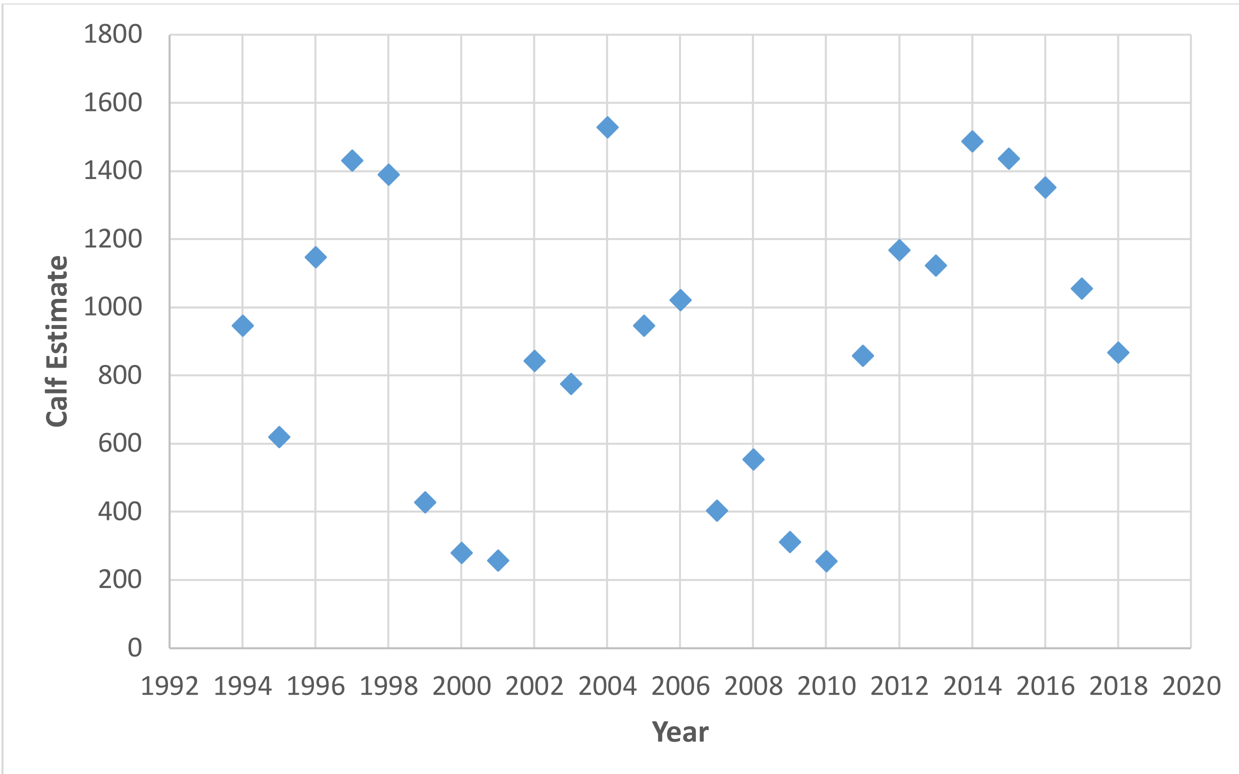

Fig. 1. Estimates of eastern North Pacific gray whale calf production 1994-2018.