Anomalous 2012 spring ice cover in the Bering Sea: predicted impacts on eastern North Pacific gray whales

WAYNE L. PERRYMAN AND DAVID W. WELLER

Contact e-mail: wayne.perryman@noaa.gov

Protected Resources Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 3333 North Torrey Pines Court, La Jolla, CA, 92037-1022 USA

ABSTRACT

A linear model relating the average ice cover over the Bering Sea during the first 15 days of May and estimates of northbound gray whale calves the following spring for the years 1994-2010 (ice years 1993-2009) was used to predict calf estimates for 2011 to 2013. Estimates based on the model were compared with preliminary estimates from shore-based calf counts for 2011 and 2012. Anomalous 2012 spring ice cover in the Bering Sea resulted in a prediction of a substantial drop in calf production in 2013 and possibly a reduction in overall physical condition of the population.

KEYWORDS: GRAY WHALE; PACIFIC OCEAN; CALF PRODUCTION; SEA ICE

INTRODUCTION

The primary feeding grounds for the majority of the eastern North Pacific (ENP) population of gray whales are in the Arctic. Over the past 20 years, feeding gray whales have shifted their distribution farther to the north, increasing the potential impact of the timing of the melt of seasonal ice on the total length of the feeding season. Although there has been a well documented negative trend in Arctic ice cover in the summer months (Parkinson *et al.,* 1999), the extent of ice cover in March, when ice is at is maximum, has changed little over the same time period. In addition, the temporal and spatial distribution of seasonal ice is highly variable between years, raising the potential for significant impacts on gray whales during years of exceptionally heavy winter ice.

A negative relationship has been shown between the timing of seasonal ice melt and estimates of northbound gray whale calves counted off central California the following spring (Perryman *et al*., 2002; Perryman *et al*., 2011). It is assumed that ice forms a physical barrier blocking early season access to important feeding areas for pregnant females, the first segment of the ENP gray whale population to migrate north. In heavy ice years, when ice extends far to the south, the temporary lack of access to foraging areas is likely to have a negative impact on the probability that existing pregnancies will be carried to term. It is not clear whether an ice-shortened feeding season has a significant impact on overall population condition or health, however it is interesting that the extent of ice cover over the Bering Sea was anomalously high in 1999 which preceded a second year of high observed mortality of gray whales (Gulland *et al.,* 2005).

Ice cover over the Bering Sea during May 2011was below average while in May 2012 ice cover was the most extensive in the past 20 years (1993-2012). In this report we examine ice-cover data for the Bering Sea between 1993 and 2012 and relate such to (1) estimates of ENP gray whale calf production between 1994 and 2012, (2) a prediction for 2013 calf production and (3) discussion of other potential impacts on the overall condition and health of the ENP population.

METHODS

Seasonal Ice Cover

Gridded sea ice concentrations for the Bering Sea were taken from passive microwave retrievals from the SMMR and SSMI satellite sensors. These data are available online from the National Snow and Ice Data Center (http://nsidc.org/). The data sets for the Bering Sea were extracted from the above source and provided to us by the University of Illinois at Urbana-Champaign Polar Research Group. Daily ice cover values for the period between 1 and 15 May were averaged, and these average values were compared with calf estimates for the following spring. This time period was selected because exploratory analysis of the data for ice cover and calf estimates indicated that May is the time when the two variables are most closely linked.

Shore-Based Surveys

Annual estimates of the number of northbound gray whale calves have been calculated from visual count data collected at the Piedras Blancas Light Station near San Simeon, California. Survey methodologies have been consistent throughout the time series and are reported in Perryman *et al*. (2002). Data presented here include estimates reported by Perryman *et al*. (2011) and unpublished preliminary estimates for surveys conducted in 2011 and 2012. The estimate presented herein for the 2012 gray whale calf survey is based on analysis of unedited data and will change marginally after the final data set is available.

Analysis Techniques

Average ice cover values for the first 15 days of May and calf estimates for the following spring (1994-2010) were used in a linear model to predict estimates of calves for 2011-2013. Although this analysis explains the majority of the observed inter-annual variability in calf production, a Bayesian analysis we have in preparation incorporates life history parameters and other data and is expected to produce a better fit to the data.

RESULTS

There is a clear negative relationship between the area of the Bering Sea covered by seasonal ice during the first two weeks of May and the number of gray whale calves estimated by shore-based counts off central California the following spring (Fig. 1). In 2012, the total extent of ice in May was the highest we have observed since 1993, and the difference between 2011 and 2012 is the largest observed between any two years.

Ice cover data for the Bering Sea between 1993-2009 and calf estimates for the following spring (1994-2010) were used to construct a linear model for the relationship between these data sets (Fig. 2) and predict calf estimates for 2011 through 2013. Preliminary calf estimates for 2011 and 2012 from shore-based counts are presented along with estimates from regression analysis, including a prediction for 2013, in Table 1.

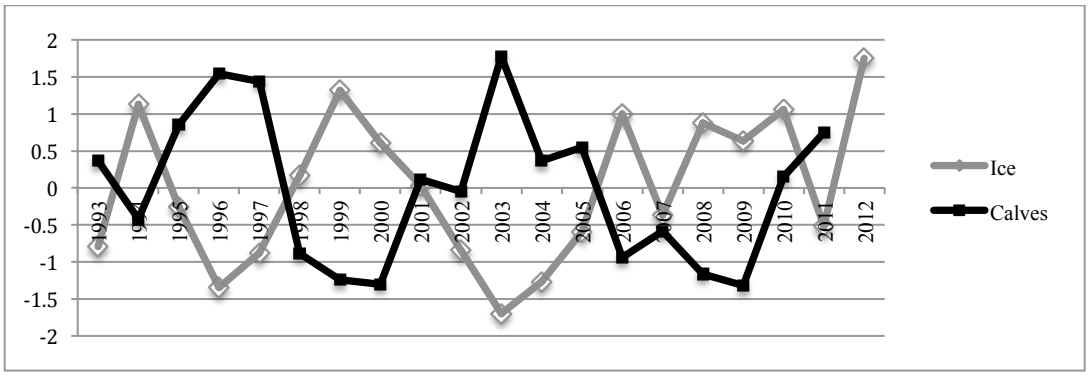

Figure 1 – Standardized values for estimates of northbound calves and average ice extent in the Bering Sea. Years are for ice cover and thus calf estimates are in year -1.

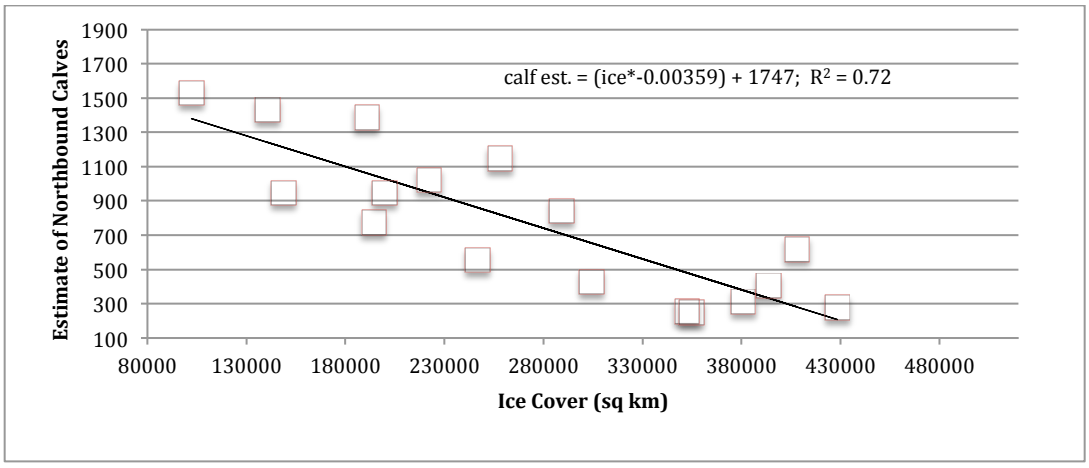

Figure 2 – Linear regression of average ice cover values for the Bering Sea (x) and estimates of northbound gray whale calves passing central California the following spring for the years 1993-2009 (ice years).

Table 1

Estimates of northbound calves from shore-based counts and predicted calf numbers based on the average extent of seasonal ice over the Bering Sea from 1-15 May of the year prior to the calf estimate.

Year	Count-Based Calf Estimate		Ice-Based Calf Estimate (year-1)	
	Estimate	SE	Estimate	SE
2011	854	86.17	305	242.39
2012	1100	115.9	919	241.33
2013			35	244.18

DISCUSSION

May 2012 ice cover over the Bering Sea was the most extensive in our 20-year calf count time series. The high ice extent stemmed from unusually cold winter temperatures and persistent winds that pushed ice southward (NSIDC). Based on these anomalous 2012 ice conditions, we predict a significant drop in ENP gray whale calf production in 2013. It is difficult

to predict how this anomalous winter-spring ice event may impact the overall health and physical condition of the ENP gray whale population as a whole. Given the northward shift of the primary feeding grounds for most of this population, the slow melt of seasonal ice in 2012 will likely delay the beginning of the feeding season, particularly for pregnant females that are the first to arrive to Arctic waters during the northbound migration.

The only year with an average ice cover value that approached what was observed in 2012 was for 1999. This year was followed by the second year of anomalously high gray whale strandings. It is likely that the overall decline in gray whale physical condition observed in 1999 and 2000 was primarily the result of anomalously low primary production in the Bering Sea in 1997 and 1998 (Napp and Hunt, 2001; Overland *et al*., 2001), but it is unclear whether the ice shortened feeding season contributed to the high stranding rates.

Measurements of southbound gray whales in vertical aerial photographs collected in 2012 indicated that overall population condition was comparable to that in previous years when the number of observed strandings was about average. If this sampling is repeated in 2013 we will have an opportunity to compare impacts of seasonal ice on both gray whale reproductive output and population condition. Unfortunately, funding constraints predicted for 2013 will likely preclude this needed sampling from taking place.

REFERENCES

Gulland, F. M. D., Perez-Cortes, H., Urban, J., Rojas-Bracho, L., Ylitalo, G., Weir, J., Norman, S. A., Muto, M. M., Rugh, D. J., Kreuder, C., and Rowles, T. 2005. Eastern North Pacific gray whale (*Eschrichtius robustus*) unusual mortality event, 1999-2000. NOAA Tech. Mem. NMFS-AFSC-150, pp34

Napp, J. A. and Hunt, G. L., Jr. 2001. Anomalous conditions in the south-eastern Bering Sea 1997: linkages among climate, weather, ocean, and biology. *Fish. Oceanogr.* 10:1, 61-68.

Overland, J. W., Vons, N. A., and Adams, J. M. 2001. North Pacific atmospheric and SST anomalies in 1997: links to ENSO? *Fish. Oceanogr.* 10:1, 69-80.

Parkinson, C. L., Cavalieri, D. J., Gloersen, P., Zwally, H. J., and Comiso, J. C. 1999. Arctic sea ice extents, areas, and trends, 1978-1996. *J. Geo. Res.* 104(9)20837-20856.

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

Perryman, W. L., Reilly, S. B., and Rowlett, R. A. 2011. Results of Surveys of Northbound Gray Whale Calves 2001-2010 and Examination of the Full Seventeen Year Series of Estimates from the Piedras Blancas Light Station. Paper SC/M11/AWMP3 presented to the Scientific Committee of the International Whaling Commission.