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ABUNDANCE OF EASTERN NORTH PACIFIC GRAY WHALES 2019/2020

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Overview

The Southwest Fisheries Science Center (SWFSC) regularly conducts shore-based surveys of eastern North Pacific (ENP) gray whales (*Eschrichtius robustus*) to estimate abundance. These estimates are obtained from visual survey data collected off central California between December and February during the gray whale southward migration, and provide regular updates to a time series of estimates that began in 1967 (see Laake *et al*. 2012, Durban *et al*. 2015; 2017). Surveys have recorded a generally increasing trend in ENP gray whale abundance, with the most recent estimate from 2016 of 26,960 whales, indicating that the population has roughly doubled since 1967 when it was estimated at 13,426 whales (Fig. 1). This report presents a new estimate of abundance for ENP gray whales migrating southward off the central California coast between December and February 2019/20[1].

Methods and Results

Data for this updated abundance estimate were collected during the 2019-2020 southward ENP gray whale migration between 3 December 2019 and 14 February 2020. Counts were made from a shore-based watch station at Granite Canyon, California, by teams of observer pairs rotating from a larger pool. Counting and analytical methods followed those described by Durban *et al*. (2015; 2017) for six previous surveys conducted by the SWFSC between 2006/07 and 2015/16 (Fig. 1). These surveys are designed to target the main migration period from late December to mid-February and do not typically cover the early onset or late offset of the migration when few whales are observed. A recent collaborative study between Scripps Institution of Oceanography and SWFSC used passive acoustic receivers deployed off the Granite Canyon study area to monitor gray whale vocalizations during the 2014/15 southward migratory period (Guazzo *et al*. 2017; 2019). The results of that work suggested more whales than previously assumed may be migrating past the survey site during the early onset of the southbound migration in December (Guazzo *et al*. 2019). To further evaluate this possibility, our 2019/20 abundance survey included visual observations during an early monitoring period from 3-20 December, followed by a break in operations between 21-29 December, followed then by the standard monitoring period between 30 December 2019 and 14 February 2020.

From 3 December 2019 through 14 February 2020, 21 trained observers completed 329.2 hours of survey effort over 48 survey days. A total of 1,963 gray whales were counted, with the highest daily count of 169 whales on 17 January 2020. During the early monitoring period (3-20 December) 19 whales were recorded, with 60 out of 75 watch periods[2] reporting zero whales and a maximum of 3 whales reported during a watch period on 19 December 2019.

The estimate of abundance reported here was generated using the N-mixture modeling approach used previously by SWFSC for surveys conducted between 2006 and 2016 (Durban *et al*. 2015; 2017). In this approach, the sighting probability of shore-based observers is estimated by using data from replicate surveys (i.e., data collected simultaneously by two independent observer

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[1] Gray whale southward migration spans two calendar years, starting in the final quarter of one year and extending into the first quarter of the following year. For example, the survey reported here counted whales in December of 2019 and January/February of 2020 and is denoted as 2019/20. This same convention is applied to previous surveys.

[2] A watch period is 90 min in duration unless weather or visibility ends observation effort (see Durban *et al*. 2015).

teams) that were completed in 2009/10 and 2010/11. These sighting probability estimates allow the total number of whales passing through the survey area during a watch period to be estimated from the observed number of whales, even in years when replicate surveys are not conducted.

In the analysis of data, the start date of the southward migration for the Granite Canyon study site is set as 1 December and the end date as 28 February by fixing the number of whales passing the watch station on those two dates to zero. The model fits two possible migration curves based on the observed number of whales, including: (a) a normal distribution where the peak in the number of whales passing daily occurs at the model-estimated midpoint of the migration, and (b) a spline fit that allows the overall migration curve to flexibly match the observed sightings without expectations about the shape of the curve. The model then internally selects which of these two candidate migration curves best matches the daily number of observed whales. The final abundance estimate is the sum of the total number of whales passing the survey area each day (i.e., both observed whales and the estimated number of unobserved whales), with a correction factor applied to account for a small number of whales that may pass too far offshore to be observed by shore-based observers. The modeling approach is described in detail in Durban *et al*. (2015; 2017).

The median estimate of total gray whale abundance for 2019/20 was 20,580 (95% Confidence Interval = 18,700-22,870; Fig. 2). Similar to the observed counts, the model estimated very low numbers of whales migrating past the study area in December 2019, with the majority of whales observed in January and early February 2020. While in some previous years (e.g., 2007/08 and 2009/10) the normal migration curve and the spline migration curve deviated substantially, in 2019/20 the two curves were similar (Fig. 2).

The early monitoring period from 3-20 December 2019 observed few gray whales migrating past the study site. This passage rate was consistent with the rates assumed by the migration curves in earlier years when no shore-based observations were conducted. The results from December 2019/20 support continuation of the current sampling strategy to target the main migration period, from the beginning of January through mid-February, for shore-based visual observations.

Discussion

The most recent abundance estimate for ENP gray whales, as reported here, is 20,580 (95% Confidence Interval = 18,700-22,870). This estimate is lower than the next most recent estimate of 26,960 (95% Confidence Interval = 24,420-29,830) in 2016. Although the time series of abundance estimates for ENP gray whales has recorded generally increasing numbers, this trend has been punctuated by occasional declines such as the one observed between 1997 and 2000 (Fig. 2). In that period, estimated abundance declined from 21,135 in 1997 to 16,033 in 2001 (Laake *et al*. 2012). This decline coincided with an unusual mortality event (UME)[3] that occurred in 1999 and 2000 when higher than usual strandings and mortalities of gray whales were

[3] Under the Marine Mammal Protection Act (MMPA), an unusual mortality event (UME) is defined as "*a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response*"

observed along the west coast of the United States, Mexico and Canada. In total, 651 dead gray whales were reported with 283 observed in 1999 and 368 in 2000 (Gulland *et al*. 2005). While the cause of this UME was not determined, some stranded whales were in poor body condition leading to questions about whether the population of approximately 21,000 ENP gray whales had reached carrying capacity (Moore *et al*. 2001). That being said, the population recovered from decline and in 2016 the abundance was estimated at nearly its all-time high of 27,000 whales. This increase in abundance suggests that carrying capacity had either increased subsequent to the 1999-2000 UME or was never reached earlier and the decline was due to some other, unknown cause(s).

In 2019, NOAA's National Marine Fisheries Service declared the most recent UME for ENP gray whales[4]. As of December 2020, 384 stranded whales were recorded with 214 in 2019 and 170 in 2020. While this UME appears to be at a slightly reduced level compared to the 1999-2000 UME, it overlaps with the observed 23.7% decline in abundance from 2016 to 2020 reported here - 26,960 whales in 2015/16 and 20,580 whales in the 2019/20. Given the increased number of strandings in 2019 that triggered the designation of a UME, it is likely that the majority of this decline occurred in 2019. This decline is comparable to that reported during the 1999-2000 gray whale UME, when abundance declined from 21,135 whales in 1997 to 16,369 whales in 2000, or 22.6% over three years.

The pattern of population growth and decline represented in the time series of abundance estimates for ENP gray whales suggests that large-scale fluctuations of this nature are not rare. The observed declines in abundance appear to represent short-term events that have not resulted in any detectable longer-term impacts on the population. That is, despite occasional declines in abundance since the time-series of data began in 1967, the overall trend has remained positive and neared peak numbers as recently as 2016 when the population was estimated at about 27,000 whales.

While ENP gray whales have shown long-term resilience to population fluctuations for which a direct cause has yet to be determined, NOAA/NMFS continue to closely monitor the population with regular surveys to estimate abundance, calf production and body condition (e.g., Perryman and Lynn 2002, Durban *et al*. 2015; 2017, Perryman *et al*. 2020). The results of these research efforts will continue to provide the best scientific information available regarding the status of the population.

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[4] https://www.fisheries.noaa.gov/national/marine-life-distress/2019-2020-gray-whale-unusual-mortality-event-along-west-coast-and

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Figure 1. Estimated abundance of eastern North Pacific gray whales 1967-2020. Estimates are plotted for January of the survey season (e.g., 2020 corresponds to data collected December 2019 to February 2020). Open circles, with 95% confidence intervals are from Laake *et al*., 2012). Filled circles are medians or best estimates of annual abundance collected by Southwest Fisheries Science Center, vertical black lines are 95% confidence intervals.

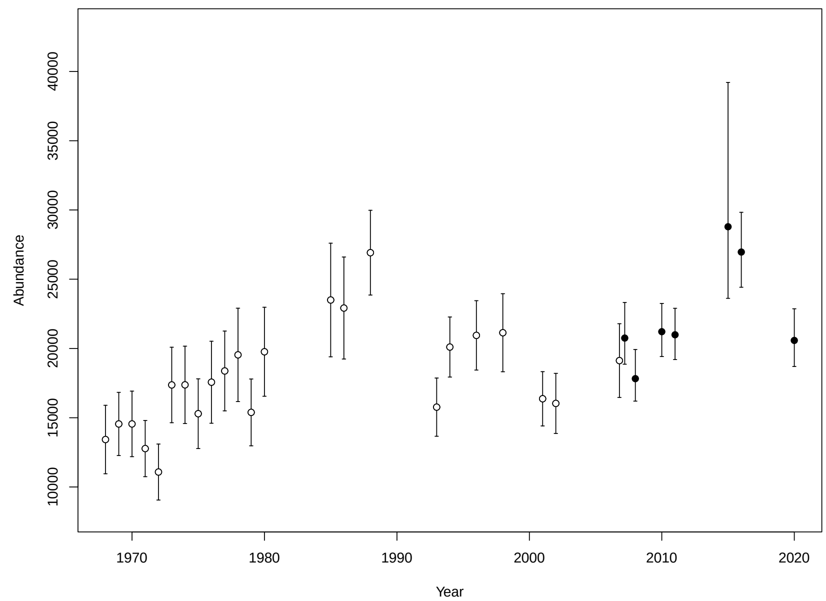

Figure 2. Observed whale passage rates expressed as total counts per day/proportion of day observed (circles) and fitted migration models (lines) for the 2019/20 survey. Broken line represents the median estimates from a hierarchical Normal model for migration. Solid line represents a semi-parametric model of penalized splines (see Durban *et al*. 2015). The abundance estimate for each day (95% confidence intervals shown by vertical lines) is a model averaged compromise between the migration models, and these were summed to estimate overall abundance for the migration.