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ABSTRACT

Gray whale (*Eschrichtius robustus*) population feeds during the summer in the Bering, Chukchi, and Beaufort seas. It migrates to winter breeding and calving grounds along the Pacific coast of Baja California, in Mexico. The assessment of gray whale body condition upon their arrival at the breeding grounds provides an indicator of the whales' "health and reproductive condition." It indirectly is an indicator of the health of the environment. Gray whales were photographed (n=615) to evaluate body condition in Laguna San Ignacio (LSI) in Baja California Sur in 2021. Photographs were sorted into two reproductive-sex categories: Females with calves and Single whales (males and females without a calf). The condition of each whale was scored as "good", "fair", or "poor" using a numerical method developed for the Western North Pacific (WNP) gray whales. In 2021 the proportion of females with calves in “good condition” was 95.3% (n=41); “fair” 4.6% (n=2) and "poor" 0%. The proportion of single whales with “good,” "fair", and "poor" condition was 42.1% (n=259), 33.5% (n=206), and 24.4% (n=150), respectively. Compared to previous years, the proportion of females with calves increase during 2021. For single whales, the body condition is very similar to previous years (2018-2020). However, females' body condition with calves was not reflected in the individuals' photo-identified in 2021 (n=43), compared to the average (n= 226) pairs photo-identified each year from 2011 to 2017. The proportion of single whales with "poor" body condition in 2021 is the second-highest LSI observed. We conclude that all whales' body condition was probably similarly affected; however, comparison and correlation with environmental data from the feeding grounds and others breeding zones is needed to understand the factors that contribute to the whales' body and reproductive condition.

INTRODUCTION

The database of gray whale photographs (2006-2021), maintained by the Laguna San Ignacio Ecosystem Science Program (LSIESP) and the Universidad Autónoma de Baja California Sur (UABCS) allows the assessment of the whales' distribution, abundance, reproductive and body condition during the winter breeding season. Following the Unusual Mortality Event (UME) of 1999-2000 and during 2019-2021, many stranded whales were observed in poor Body Condition in some individuals' whales (e.g., "skinny" whales), and low numbers of female-calf pairs were observed in the breeding lagoons during the period from 2006 to 2010 (Urbán *et al.,* 2011; Martínez-Aguilar *et al.,* 2019). The reduction in the number of gray whale calves in the breeding

lagoons and fewer sightings of female-calf pairs off the Pacific Coast of Baja California is believed to be the outcome of the loss of breeding females during the 1999-2000 UME (LeBoeuf *et al.*, 2000; Urbán *et al.*, 2010; Swartz *et al.*, 2012). The abundance of gray whale female-calf pairs observed in LSI increased during the period from 2011 to 2017 as the population recovered from the 1999-2000 UME (Swartz *et al.*, 2012, Urbán et al., 2016) from mass exploitation during the 19th and early 20th centuries but now, female-calf pair abundance declined again from 2018-2021. Observations of "skinny whales" also increased during this period, suggesting the whales were suffering from poor conditions and nutritional stress from insufficient feeding during the summer months. In 2019, 2020, and continuing into 2021, gray whale strandings increased throughout the whales' range, prompting the U.S. National Oceanic and Atmospheric Administration (NOAA) to declare a second gray whale UME (NOAA 2020).

An analysis of gray whale body condition was conducted using photographic identification (Photo-ID) data for two time periods: 2008-2011 and 2018-2020. Whale photographs were evaluated and body condition scored using a numerical method developed for Western North Pacific (WNP) gray whales (Bradford *et al.*, 2012; Weller *et al.*, 2002). Photographs of single whales and those of females with calves were evaluated as two separate groups, Females with calves (Fc), and Single whales (S) that could be males and females without a calf.

METHODS

The photographs were conducted from a 23-foot-long open boat (Panga) in Laguna San Ignacio (Figure 1) (during the 2018, 2019, 2020, and 2021 gray whale breeding seasons. The information collected with each whale sighting included: weather conditions, geographical position, and characteristics of the gray whale groups (i.e., number of whales and calves).

Photographs were taken with digital SLR cameras (Nikon D7100) equipped with 70-300 mm telephoto lens, a shutter speed of 1/1000 second. For Body condition, we evaluate the photographs of each whale's head, scapula, and lateral flank. Digital images were stored, cataloged, categorized, and archived in high-resolution JPEG format on portable USB-digital computer hard drives, and each whale was assigned an identification number.

Whale's body condition was evaluated and assigned a numerical score following the methodology of Weller *et al.* (2002) and Bradford *et al.*, (2012) (Figure 3). A numerical value (score) was assigned for each of the three principal anatomical areas, the postcranial area, scapular region, and the lateral flanks. The postcranial (head) region was evaluated on the extent of "depression" behind the blowholes and ranked from 1 to 3, with a score of 1 being the worst or "poor" condition, to the score of 3 being the best or "good" condition. The scapular region and the lateral flank were similarly assigned values of 1 or 2; a value of 1 when a subdermal protrusion of the scapula was visible, and a value of 2 when normal, and the flank was assigned a value of 1 when a depression along the dorsal aspect of the lateral flanks was apparent, and a value of 2 when normal (Figure 2) (Brownell and Weller, 2001).

RESULTS

A total of 58 days and 270.17 hours were spent photographing gray whales in LSI. The total of Photo ID whales was 746, of which for body condition evaluation were 658 individuals: 615 single whales and 43 females with calves. Of these females with calves, 95.3% (n=41) had a good body condition, 4.6% (n=2) with a fair body condition, and neither with poor body condition. For single whales with a good body condition were 42.1% (n=259), whales in fair condition were 33.5% (n=206), and finally, the whales with a poor body condition were 24.4% (n=150).

Females with calves increase the good body condition since 2010. However, Single whales observed in the 2021 winter scored the second-highest percentage of "poor" body condition of all whales observed during 2008-2011 and 2018,2019 winters, indicating stability in poor body condition (Table 1).

DISCUSSION

Following the UME of 1999-2000, some gray whales, mainly single whales (without a calf), exhibited a "skinny" appearance and indications of nutritional stress and food resource limitation (Gulland *et al.*, 2005). Previous analysis of the body condition for data obtained from 2008 to 2011 indicated that single whales with "poor" conditions ranged from 7.6% in 2009 to 4.9% in 2011 (Ronzón-Contreras *et al.,* 2020). After 2012, whales with poor body conditions were infrequent, and subsequent analyses of whale body conditions were suspended. However, the reappearance in 2018 of whales in "poor" body condition justified body condition evaluations' resumption. Unfortunately, we could not photograph all the whales (unknown). However, the sample percentage is representative for all sampling years, in 2018 were obtained 35% of single whales (207 of 597), 64% (569 of 888) in 2019, 79% (553 of 696) in 2020 and 88% (658 of 746) in 2021, which is an adequate sample to represent the results of the whales' body condition.

The body condition of Females with calves in "good" condition ranged from 65.8% (n= 52) to 70.5 (n=124) during the period 2008 to 2011, decrease from 43.8% (n=35), (Ronzón-Contreras *et al.,* 2019) and increase to 95.30% (n=41) during the recent period 2018 to 2021 (Figure 4). The fair and poor body condition is stable for both periods, but 2010 was the lowest in fair condition, suggesting an improving trend in breeding female condition in recent years. However, although Fc did not reflect an increase in the poor BC, their abundance in both areas decreased more than 50% compared to previous years, and more than 50%, compared to the average of Fc photo-identified from 2011-2017($\bar{x}$=226) to 2018-2021($\bar{x}$=57).

For single whales with "good" condition ranged from 51.7% (n= 46) to 63.7% (n= 221), during the period 2008 to 2011, (Ronzón-Contreras *et al.,* 2020) and then declined to 43.5% (n=90) to 42.1% (n=259) during the recent period 2018 to 2021. The fair body condition is stable for both periods 41.6 (n=37) to 31.4% (n=109) for 2008 to 2011 and 48.3% (n=100) to 33.5% (n=206) for 2018-2021, however the poor body condition were 6.7% (n=6) to 4.9% (n=17) during the period 2008 to 2011, then increased from 8.2% (n=17) to more than four times to 30% (n= 150) in 2020 and 24.4% for 2021. Overall, the body condition of single whales declined continuously from 2011 to their lowest values in 2020 (Ronzón-Contreras *et al.,* 2020). Therefore, the percent of single

whales with “poor" body condition (24.4%, n=150) during 2021 breeding season in LSI is the second highest observed for this location (Figure 4).

Body condition may influence female calving-interval; if they are in "good" condition at the time that they breed on the winter breeding grounds, they may have sufficient energy to migrate from the breeding grounds to the summer feeding grounds, feed all summer while pregnant, and make the return migration and successfully birth their calves in the following winter (Perryman *et al.*, 2002). However, suppose they do not feed sufficiently during the summer. In that case, the southward fall migration and gestation of a calf may deplete their energy reserves and reduce their body condition sufficiency that may not bring their pregnancy to term and birth a healthy calf. If food resources are limited, reproducing females may not produce a calf every other year as is the gray whales' normal reproductive cycle (Urbán *et al.,* 2019). If food resources are limited, they may skip reproduction for two or more years until they develop sufficient energy/condition reserves to accomplish their Fall and Spring migrations and the birth and nurse of a calf in the winter (Ronzón-Contreras *et al.,* 2019). These possibilities would support the observed departures from the two-year calving cycle for some gray whales (Ronzón-Contreras *et al.,* 2020.

Overall, for the 2021 breeding season, the Females with calves are in good body condition to give a calf next winter year. However, the abundance of Females with calves is low. Therefore reproductive success will be limited. In the case of the single whales, a few recovered from the worst condition recorded for 2020; however, the poor body condition is establishing itself above 20% for the last few years; this could be a restriction to arrive the feeding area not complete their migration.

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TABLES AND FIGURES

Figure 1. Study area, primary gray whale winter aggregation: Laguna San Ignacio.

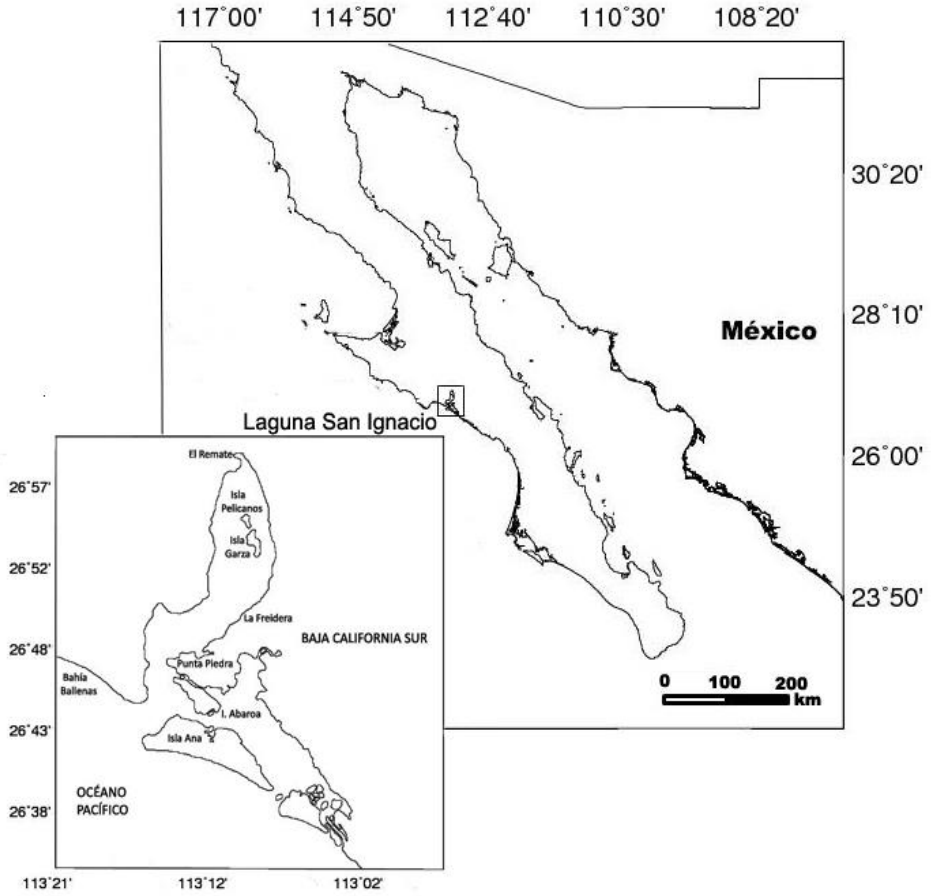
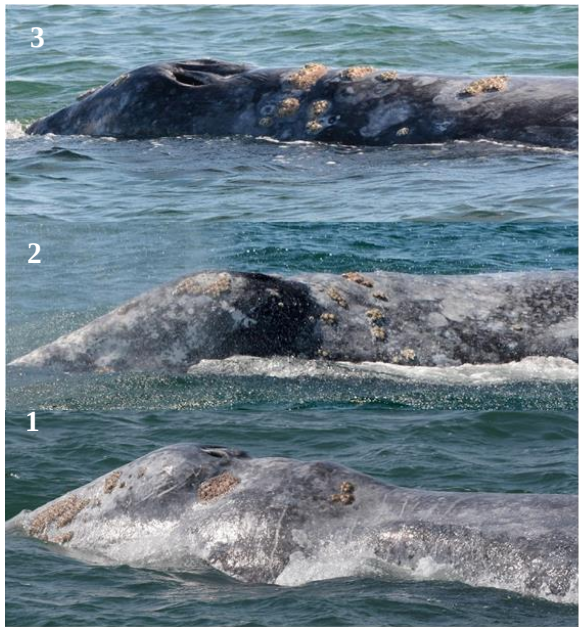


Figure 2. Example of the values assigned to determine body condition for the postcranial area. The value number 3 is for the whales without depression in the postcranial area, 2 is for moderate postcranial depression and 1 is for the significant postcranial depression for the scapular region and dorsal-flank. The value number 2 is for the scapula and dorsal-flank is not visible, and 1 is for whales that see the scapula or depression on the back.

Head/Post-cranial area

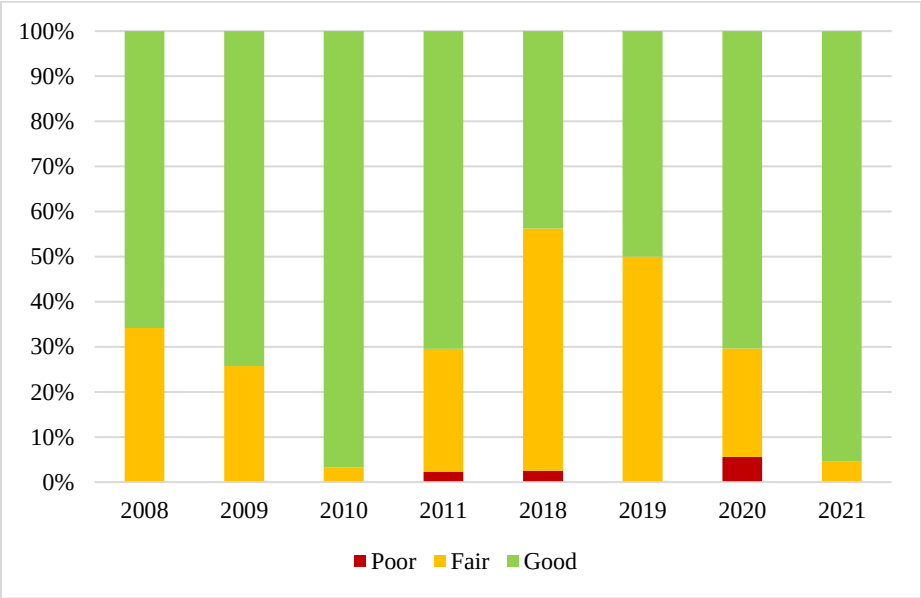


Scapular area

Dorsal-flank area

Figure 3. Categories of the body condition of gray whales: a) good condition/ healthy, b) fair condition, and c) poor condition/skinny (Bradford *et al.*, 2012).

Figure 4. Proportion of body condition gray whales: above the body condition for Females with calves and under the body condition for single whales.



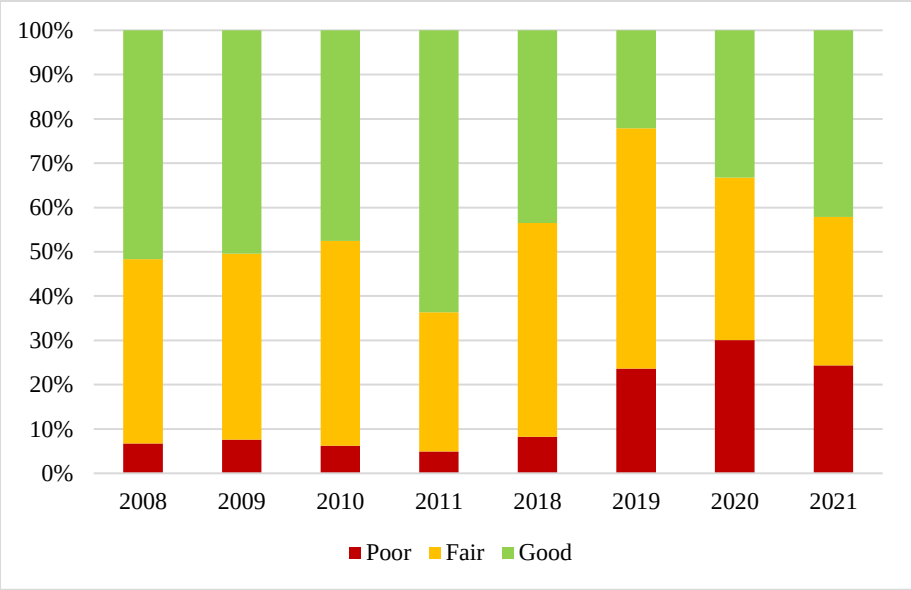


Table 1. Numbers and percentages of gray whale base on their body condition for Laguna San Ignacio, BCS, Mexico (2008-2011 and 2018-2021)

Single whales

Year	2008	2009	2010	2011	2018	2019	2020	2021
No. whales Photo-identified	249	588	718	424	597	847	696	746
No. whales categorized	89	236	433	347	207	529	553	658
Good Condition n (%)	46 (51.7%)	119 (50.4%)	206 (47.6%)	221 (63.7%)	90 (43.5%)	117 (22.1%)	166 (33.3%)	259 (42.1%)
Fair Condition n (%)	37 (41.6%)	99 (41.9%)	200 (46.2%)	109 (31.4%)	100 (48.3%)	287 (54.3%)	183 (36.7%)	206 (33.5%)
Poor Condition n (%)	6 (6.7%)	18 (7.6%)	27 (6.2%)	17 (4.9%)	17 (8.2%)	125 (23.6%)	150 (30%)	150 (24.4%)

Female and calf

Year	2008	2009	2010	2011	2018	2019	2020	2021
No. whales Photo-identified	112	79	38	188	86	41	56	43
No. whales categorized	79	70	31	176	80	40	54	41
Good Condition n (%)	52 (65.8%)	52 (74.3%)	30 (96.8%)	124 (70.5%)	35 (43.8%)	20 (50%)	38 (70.3%)	41 (95.3%)
Fair Condition n (%)	27 (34.2%)	18 (25.7%)	1 (3.2%)	48 (27.3%)	43 (53.8%)	20 (50%)	13 (24.2%)	2 (4.7%)
Poor Condition n (%)	0	0	0	4 (2.3%)	2 (2.5%)	0	3 (5.5%)	0