



**Laguna San Ignacio
Ecosystem Science Program**
A Project of the Ocean Foundation in Baja California Sur, Mexico



Annual Gray Whale Research Report for Laguna San Ignacio and Bahía Magdalena, B.C.S., México During Winter 2023



Photograph by Sergio Martínez-Agular 2023

May 2023



2023 PROGRAM SUMMARY

Beginning in 2018 observations of declining gray whale body condition, low calf counts, and higher mortality rates in both Laguna San Ignacio and Bahía Magdalena were indications of the pending Unusual Mortality Event (UME) which has continued from 2019 through 2023. However, information gathered in these southernmost gray whale wintering areas this past winter suggests that the UME may be slowing in 2023 and include: fewer individual whales in "poor" body condition, the first increase in the numbers of calves observed during the previous 5 winters of low female-calf counts, and fewer stranded dead whales in these wintering lagoon areas.

In this report we present our initial findings during the 2023 winter concerning the status of gray whales, their condition and reproduction, and our outreach activities from hosting university students on field trips, to introducing the public to a new gray whale research and whale-watching monitoring program in Bahía Magdalena.

Outstanding events and activities in 2023 include:

* 2023 Research Staff and collaborators: [Page 4](#).

* Abundance of single gray whales in both Laguna San Ignacio and Bahía Magdalena wintering areas were greater than that observed in recent years, along with some modest increase in the numbers of female-calf pairs indicating improved overall condition: [Page 5](#).

* Boat-based traditional photo-Identification surveys documented the number and residence times of 1,540 individual whales that visited Laguna San Ignacio and Bahía Magdalena in 2023: [Page 11](#).

* Photographic identification from Unmanned Aerial Vehicles (UAVs) updates historical photo-id data [Page 14](#).

- * Unusual Mortality Event (UME) update: declining number of dead stranded gray whales in the wintering lagoons suggests the 2019-2023 UME may be slowing: [Page 15](#).
- * Boat-based gray whale body condition assessment suggests some improvement in the overall condition of whales wintering in Laguna San Ignacio: [Page 16](#).
- * Unmanned Aerial Vehicles (UAV) assessment of body condition complements the boat-based method for evaluating body condition: [Page 21](#).
- * Gray whale strandings and mortality in Mexico: [Page 24](#).
- * Sightings of additional cetacean species in 2023: [Page 28](#).
- * Outreach and educational activities: [Page 29](#).
- * Reference Documents and Reports: [Page 34](#).

You can read more about each of these and other notable findings from the 2023 winter gray whale research in the following field reports on our website... for LSI and BM

Martínez et.al., 2023. Report on activities to monitor the Gray Whale (*Eschrichtius robustus*) during the 2023 winter in Laguna San Ignacio, B.C.S., Mexico.

Viloria, et.al., 2023. Report of the activities to monitor the Gray Whale (*Eschrichtius robustus*) and public outreach and education programs during the 2023 winter in the Magdalena Bay lagoon complex, Santo Domingo canal and Almejas Bay, B.C.S., Mexico.



RESEARCH STAFF IN 2023

The Laguna San Ignacio Ecosystem Science Program (LSIESP) is a project of The Ocean Foundation in collaboration with the Programa de Investigación de Mamíferos Marinos (PRIMMA) of the Universidad Autónoma de Baja California Sur (UABCS), La Paz, B.C.S., México.



Laguna San Ignacio 2023 gray whale research team.

Drs. Jorge Urbán R., Steven L. Swartz, Sergio Martínez Aguilar (Laguna San Ignacio), and Lorena Viloría Gómora (Bahía Magdalena) directed the 2023 gray whale research. Collaborating researchers in 2023 included: at Laguna San Ignacio: Fabián Missael Rodríguez González, Andrés Gonzáles Cisneros, Minerva Valerio Conchas, Regina Lobo Barrera., Adrián Zamora Zavala, Job Olguin Hernández, and Axel Rosas. In Bahía Magdalena researchers included: Omar García C., María Laura Marcias, Endy Itzayana Ortega Yepes, Flor A. Enríquez Pérez, and Jazmín Julio Romero. In Bahía Magdalena, we collaborated with non-profit organization “Mar Vivo” to provide educational presentations as part of its Community Science Project.

Drs. Fredrik Christiansen, Ph.D. of Denmark’s Aarhus University, Department of Ecoscience, and Lars Bejder of the University of Hawaii at Manoa, Hawaii Institute of Marine Biology, continue to collaborate with our researchers on the application of UAV-drone photogrammetry methodology to measure cetacean growth, body condition, and efficiency of energy conversion/transfer from female whales to their calves.

This research was supported by grants from The Marisla Foundation, The Ocean Foundation, Natural Habitat Adventures Foundation, and private individual donors. In-kind support for logistics was provided by Kuyima Eco-Turismo, Searcher Natural History Eco-Tours, and Baja Discovery Whale-Watching. Field research was conducted under Scientific Research permits SPARN/DGVS/02144/23 from the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), Subsecretaría de Gestión Para La Protección Ambiental, Dirección General De Vida Silvestre, de México.

Our gray whale research teams arrived in Laguna San Ignacio and Bahía Magdalena in mid-January to begin the 2023 gray whale research season. Our field research station at Laguna San Ignacio, the “Francisco ‘Pachico’ Mayoral” laboratory, opened on January 16th and gray whale research activities continued through the first week in April. Gray whale surveys and public outreach and education workshops in Bahía Magdalena were conducted from January 11 to March 26.



Aerial View of our field research station Laboratorio de “Francisco ‘Pachico’ Mayoral” located in the Kuyimita Campground on the south shore of Laguna San Ignacio.

WHALE ABUNDANCE: LAGUNA SAN IGNACIO AND BAHÍA MAGDALENA

Boat surveys were conducted to document seasonal trends in gray whale abundance and photographic identification methods were used to estimate the minimum number of gray whales visiting the primary gray whale winter aggregation and breeding lagoons. For the surveys, hand-held Global Position System (GPS) devices are used to follow a predetermined survey in each lagoon area. Observer and sighting protocols are specified for each lagoon's unique characteristics and are used to obtain and record whale counts along each track line. This method allows duplication of survey effort to compare within-year survey counts along identical survey tracks in each lagoon area, and for comparison with historical counts from previous years to document trends in the whales' use of these areas (Figs. 1 and 4).



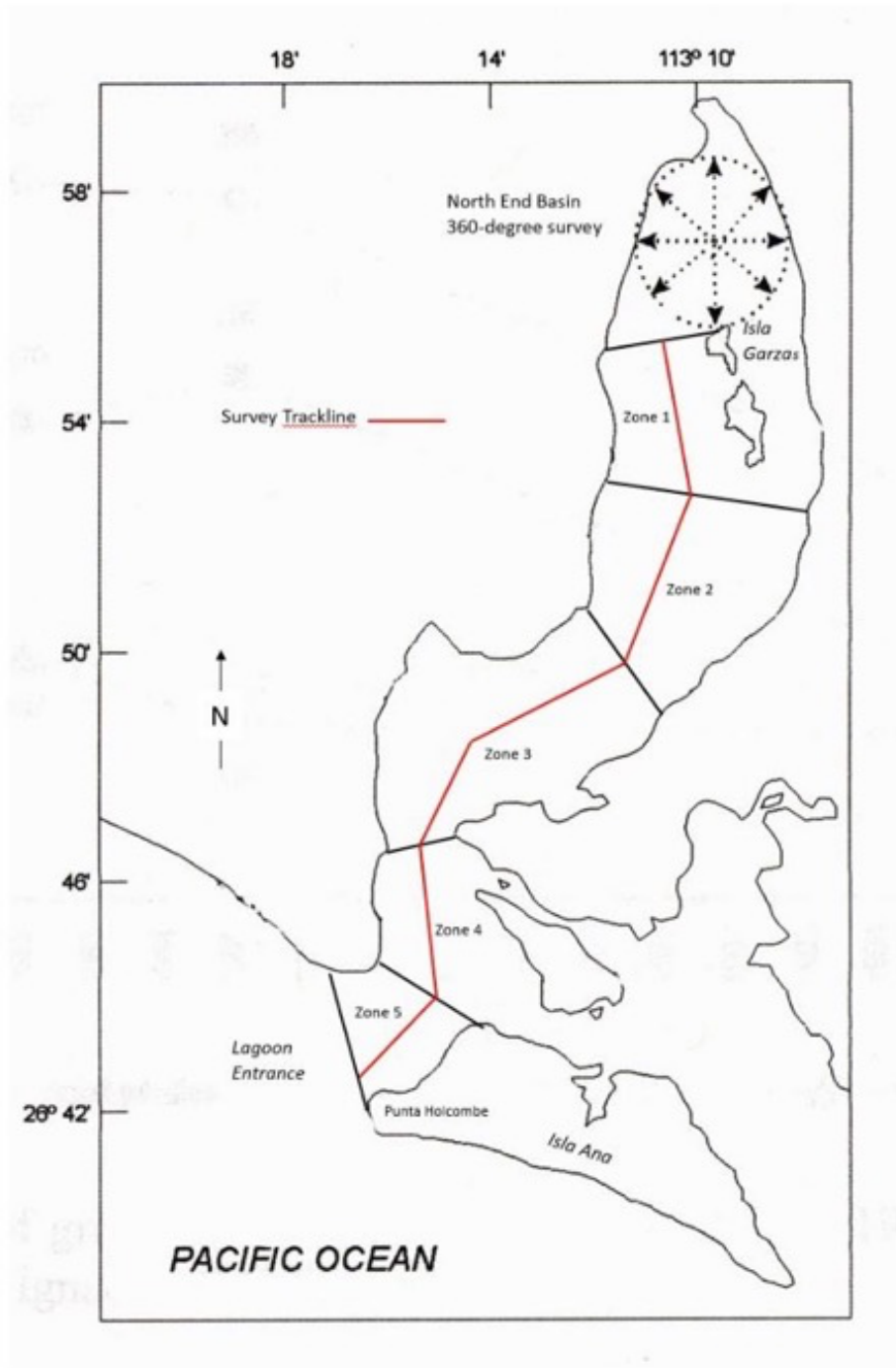


Figure 1. Boat survey track-line for estimating minimum abundance of gray whales in Laguna San Ignacio. Counts of gray whales in the “North End Basin” portion of the lagoon are obtained from a 360° scan of the area. The survey track line continues 30 km south from Isla Garzas (Zone 1) over the deepest portions of the lagoon to Punta Holcombe on the west end of Isla Ana at the entrance of the lagoon (Zone 5).

The 2023 winter occupation of **Laguna San Ignacio** by gray whales was characterized by a slight increase in the numbers of calves-of-the-year compared to recent winters (2018-2022), a reduction in the percentage (8.8 %) of adult whales in “poor” body condition, the lowest since the UME began in 2019. Only 4 adults were discovered stranded compared to 12 in the previous winter. Eleven abundance surveys were completed in Laguna San Ignacio with the highest number of 194 single adult whales counted on 6 March, which was similar to high counts observed in previous winters (Table 1).

Departure times of single adult (non-calf) whales in 2023 were approximately one week later than in previous years (Fig. 2). Compared to previous winters, counts of females with calves continued to be low, but did increase slightly throughout the 2023 winter season, with the highest count of 37 pairs observed on 19 March 2023 (Fig. 3).

Table 1. Boat survey counts of gray whales: Female-calf pairs, Singles (whales without calves), and total Adults in Laguna San Ignacio during the 2023 winter breeding and calving season. Number of female-calf pairs equals the number of calves observed.

Survey	Date	Female-calf Pairs	Singles	Total Adults
1	23-Jan-23	9	16	25
2	28-Jan-23	14	8	22
3	03Feb-23	23	22	45
4	11-Feb-23	21	57	78
5	17-Feb-23	29	89	118
6	20-Feb-23	28	103	131
7	01-Mar-23	27	138	165
8	06-Mar-23	15	194	209
9	13-Mar-23	20	100	120
10	19-Mar-23	37	40	77
11	04-Apr-23	32	8	40

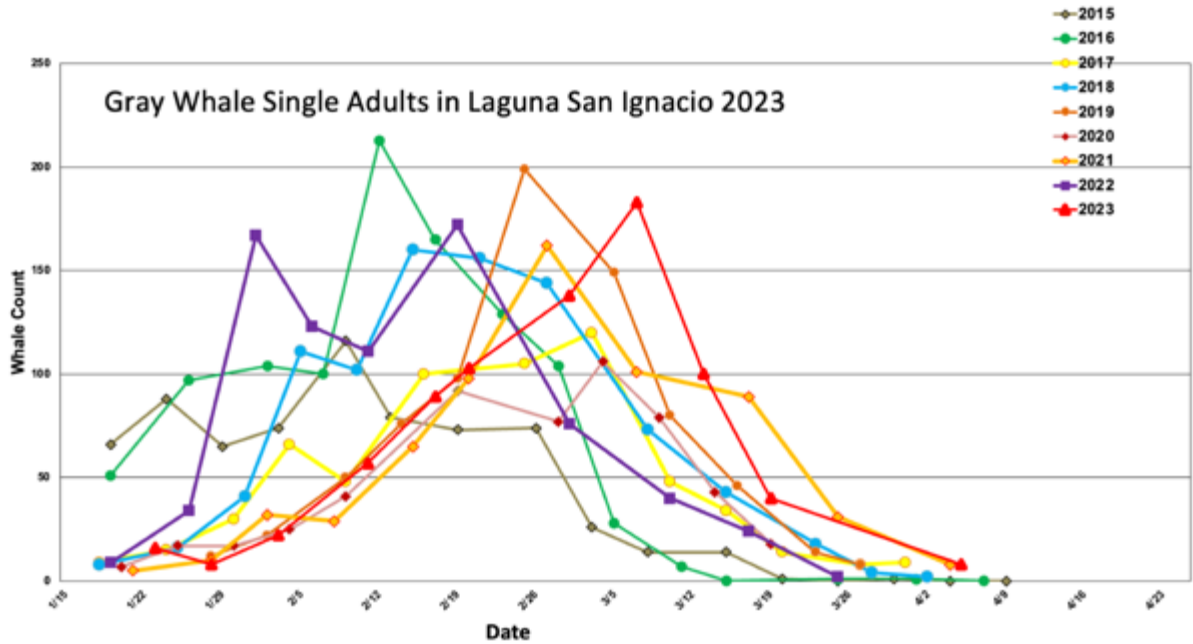


Figure 2. Counts of single adult whales observed in boat surveys in Laguna San Ignacio from 2015 to 2023.

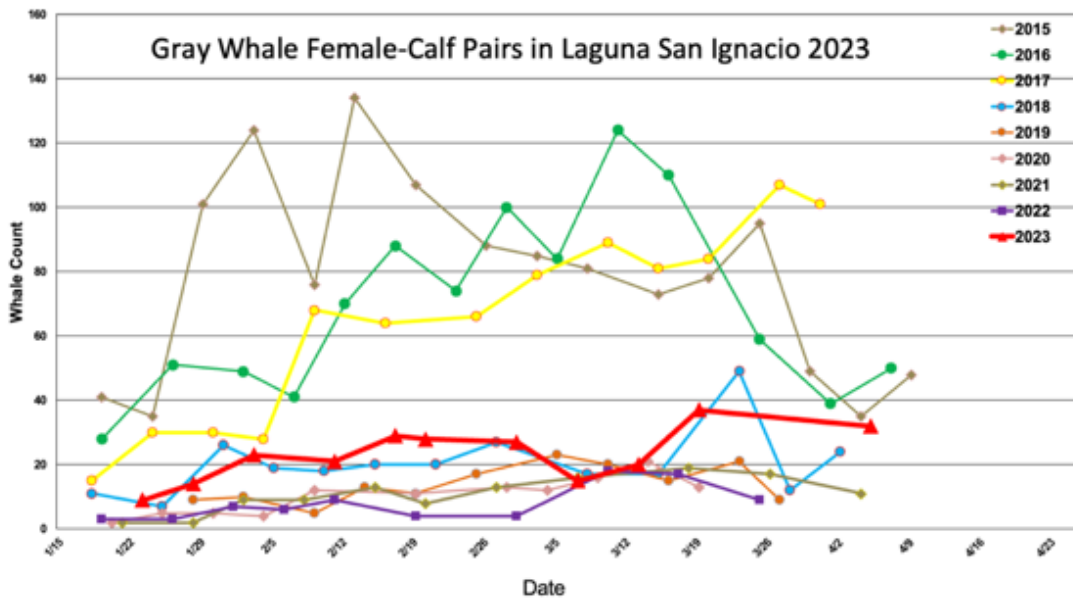


Figure 3. Counts of female-calf pairs observed in boat surveys in Laguna San Ignacio from 2015 to 2023.

Photographic identification data provides another estimate of the total number of individual gray whales that visit a particular aggregation and breeding lagoon during a winter. For example, while the largest number of single adult whales counted during the 2023 boat surveys was 194 whales, 535 distinct individual single adult whales were identified from photographs during the 2023 winter. Similarly, the largest number of female-calf pairs counted in the boat surveys was 37 pairs, while 83 distinct females were photographed in the lagoon during the winter. See the “Photographic Identification” section below for more details.

The 2023 gray whale surveys in the **Bahía Magdalena** lagoon complex were conducted in three different areas (Fig.4). The highest gray whale survey count was obtained on 19 February in the most southerly aggregation area of Bahía Almejas and was 295 single adult whales and three female-calf pairs. In central Bahía Magdalena gray whale counts were greatest on 18 February with 97 adult whales and 2 female-calf pairs. In the northern Canal de Santo Domingo, a high count of 14 single whales was observed on 17 March, and a high count of 12 female-calf pairs on 20 February (Table 2). As in previous winters, gray whale abundance declined in all areas of Bahía Magdalena after the first week in March, and further surveys were discontinued due to the paucity of whales.

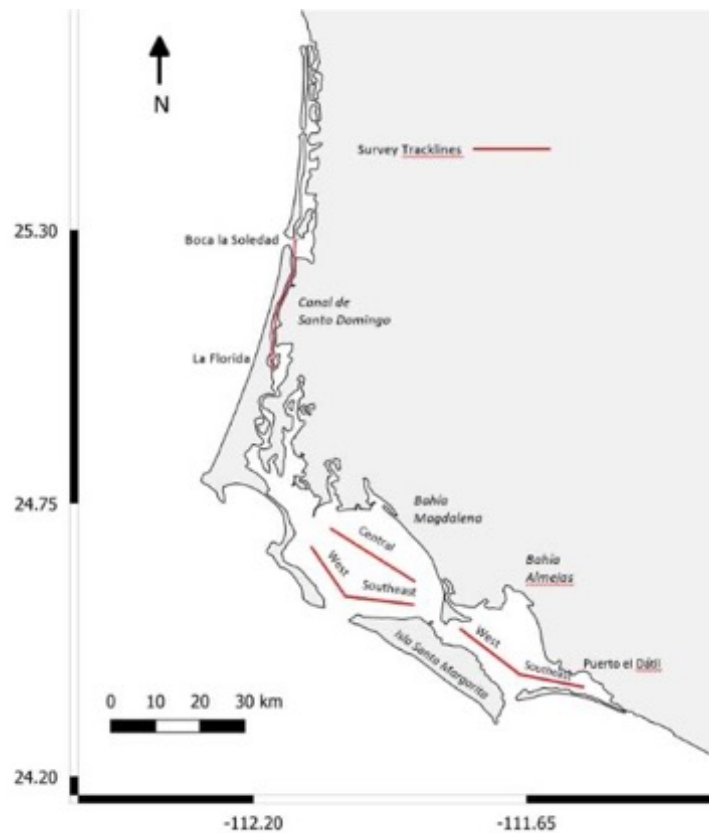


Figure 4. Boat survey track-lines for estimating gray whale abundance in the Bahía Magdalena lagoon complex in three areas where gray whales aggregate: Canal de Santo Domingo in the north; Bahía Magdalena’s center, west and southwest areas; and in Bahía Almejas in the south.

Table 2. Boat survey counts of gray whales (Female-calf pairs, Singles (whales without calves), and total Adults) in three areas within the Bahía Magdalena complex during the 2023 winter breeding and calving season. Number of female-calf pairs equals the number of calves observed.

LOCATION	DATE	FEMALE-CALF PAIRS	SINGLE WHALES	TOTAL ADULTS
Bahía Almejas	22-Jan	0	80	80
	04-Feb	1	180	181
	19-Feb	3	295	298
Bahía Magdalena	21-Jan	0	21	21
	09-Feb	0	79	79
	18-Feb	2	97	99
Canal de Santo Domingo	23-Jan	4	5	9
	10-Feb	9	19	28
	20-Feb	12	10	22

It is important to note that the total number of female-calf pairs observed in the Bahía Magdalena complex increased from 5 in 2022 to 40 pairs in 2023, suggesting a recovery of the reproductive capacity of gray whale population (Fig. 5).

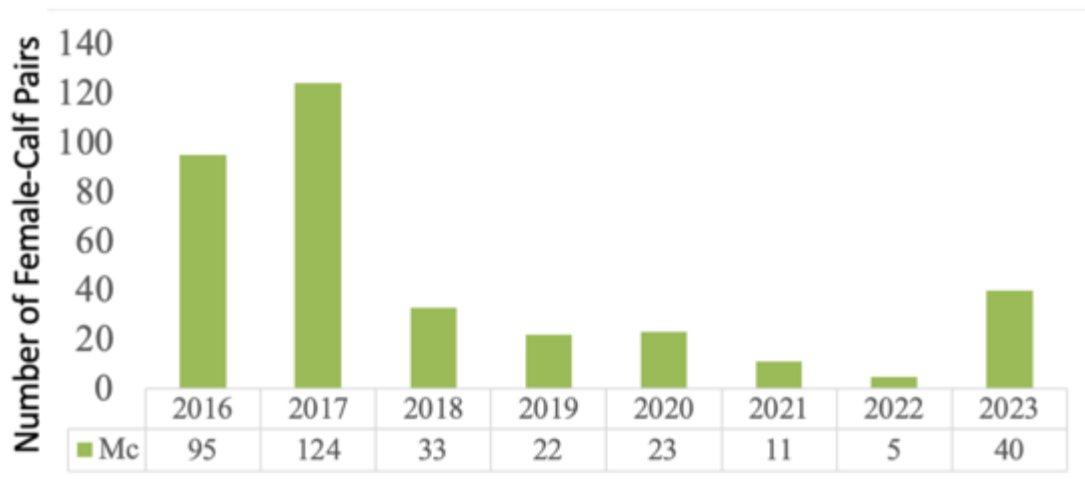


Figure 5. The number of female-calf pairs observed in the Bahía Magdalena complex from 2016 to 2023.

For more details on gray whale abundance in these lagoon areas in 2023, see the following paper:

Urbán R., et al. (2023). 2023 Gray whale abundance in Laguna San Ignacio and Bahía Magdalena lagoon complex, B.C.S., México. Rep. Intl. Whal. Commn. SC/69A/CMP/21.

PHOTOGRAPHIC IDENTIFICATION RESEARCH



The naturally occurring pigmentation patterns, “white” scars, and other markings are characteristic for each individual gray whale and, because these are permanent features, they are used to identify individuals (Fig. 6). During boat-based photo-identification surveys digital photographs were taken of both the left and right sides of individual gray whales with Digital Single Lens Reflex (DSLR) cameras (e.g., Nikon D7500) fitted with Zoom telephoto lenses (e.g., 70mm-300mm). Shutter speeds of 1/1000 second and ISO setting at 400 are used to insure sharp images of the details of the markings on each whale.

All photographs are sorted and catalogued, especially noting those whales that are encountered and photographed multiple times during the winter season. The time periods between the first and last time an individual whale was photographed provides an estimate of the minimum amount of time that individual remained in the area, or a minimum residence time during that winter. Minimum residence times are calculated for single adults (males and females without calves), and for females with calves. Each catalog is then compared with catalogs from previous winters to identify individual whales that have visited an area in multiple years. Interannual sightings of whales are used to evaluate site fidelity to a particular lagoon or winter aggregation area, a calving interval for breeding females. Photographs from both Laguna San Ignacio and Bahía Magdalena are compared to evaluate the exchange and movements of whales between these winter aggregation areas.



Figure 6. Example of the distinctive markings on a gray whale that are used to identify individuals within and among winter breeding seasons.

Laguna San Ignacio Photographic Identification:

In Laguna San Ignacio boat-based photo-identification surveys were conducted on 50 days, for a total effort of 264.5 hours, and yielded 519 sightings of gray whales. All 11,393 images obtained were sorted into catalogs and included 618 individual whales: 83 were females with calves of the year, and 535 were single adult whales (males and females without calves).

In 2023 the estimated average minimum residence time was 34.3 days for females with calves with a maximum residence time of 68 days. The average minimum residence time for single adults was 6.4 days with a maximum residence time of 33 days. Table 3 shows average and maximum residence times for gray whales in Laguna San Ignacio in previous years 2010 to 2023.

Table 3. Average and maximum residence times for gray whales photographed in Laguna San Ignacio: 2010-2023.

Year	Number Mc seen at least in 2 different days		Number of Singles seen at least in 2 different days		
	Average	(Days)	Average	Max	(Days)
2010	(n=33) 31.9	73	(n=77) 6.9	20	
2011	(n=123) 39.1	84	(n=30) 16.3	72	
2012	(n=138) 37.5	81	(n=48) 11.0	67	
2013	(n=118) 35.3	80	(n=46) 9.4	56	
2014	(n=139) 37.6	89	(n=49) 7.6	34	
2015	(n=212) 31.5	82	(n=52) 9.6	68	
2016	(n=171) 29.3	80	(n=42) 8.0	31	
2017	(n=153) 32.7	74	(n=47) 13.2	68	
2018	(n=64) 43.2	80	(n=34) 5.2	22	
2019	(n=37) 31.7	60	(n=108) 6.4	34	
2020	(n=43) 24.5	62	(n=75) 6.7	44	
2021	(n=42) 36.4	71	(n=127) 9.3	62	
2022	(n=35) 32.3	73	(n=120) 7.0	30	
2023	(n=68) 34.3	68	(n=78) 6.4	33	

We can see that between 2010 and 2023 the average residency times for females with calves range from 29.3 days to 43.2 days, with maximum days between the first and last time they

were photographed ranging from 60 days to 89 days. Single adult whales spend much less time in a particular location with their average residency times 5.2 days to 16.3 days, with maximum residency times estimated at 20 days to 72 days. This suggests that single whales move around more than females with calves of the year, which is supported by inter-lagoon photographic matches (re-captures).

Bahía Magdalena Photographic Identification:

In the Bahía Magdalena study area, gray whale photo-identification surveys were conducted in three locations in 2023: central Bahía Magdalena, Bahía Almejas, and in Canal de Santo Domingo. The total effort for the season was 432.3 hours, during these surveys 221 gray whale sightings were made, and 11,058 digital images were obtained. From these images 922 individual whales were identified and include 891 single adults (males and females without calves) and 31 females with calves of the year. Maximum duration of stay in these areas was 26 days for single whales and 42 days for females with calves.

NUMBER OF INDIVIDUAL SINGLE AND FEMALE-CALF PAIRS VISITING LAGUNA SAN IGNACIO FROM 2005 TO 2023 FROM PHOTO-ID DATA		
YEAR	SINGLES	FEMALE-CALF PAIRS
2005	271	114
2006	191	54
2007	272	74
2008	152	88
2009	440	75
2010	515	38
2011	321	187
2012	332	211
2013	292	183
2014	443	195
2015	230	274
2016	350	218
2017	305	195
2018	411	83
2019	575	40
2020	419	54
2021	500	43
2022	532	41
2023	535	83
TOTALS	7086	2250

Photographic identification data provides an additional method for estimating the total number of individual gray whales that visit a particular breeding lagoon and aggregation area during a winter. Table 4 lists the numbers of individual whales that visited and were photographed at least once in Laguna San Ignacio during each 3-month winter breeding season from 2005 to 2023. The number of single adult whales (males and females without calves) have remained relatively constant between 2009 (n=440) and 2023 (n=535). In comparison, the number of females with calves ranged about 200 pairs from 2011 to 2017, but then declined significantly beginning in 2018 and continued to remain low with less than approximately 50 pairs photographed in the lagoon from 2019 through 2022, and then their numbers began to increase in 2023. This decline in reproduction is presumed to be related to the Unusual Mortality Event that began in 2019 which included a range-wide increase in mortalities of adult female whales (see section on the Unusual Mortality Event for more details).

Table 4. Number of individual gray whales that visited Laguna San Ignacio between 2005 and 2023 estimated from photographic identification data.

PHOTO-IDENTIFICATION FROM UNMANNED AERIAL VEHICLES (UAVS)



While similar to boat-based photo-identification, aerial photography from UAVs (drones) is another non-invasive method to photographically identify individual animals from their unique naturally occurring markings. Beginning in 2017 UAVs with high-definition video cameras were in Laguna San Ignacio to simultaneously observe and record both sides of the dorsal region of gray whales in a single image for comparison with traditional boat-based photo-identification methods where only one side of the whale is observed at a time. Whale photographs from both the UAVs and boat-based methods taken from 2017 to 2023 were compared. These included 2,875 right and 4,648 left sides from traditional boat-based photo-ids versus 285 aerial UAV photo-ids of the entire dorsal regions of the whales. Computer assisted software (“Hotspotter”) and visual examination were used to confirm matches of 611 right side and 718 left side photographs among the traditional single-side photo-identification images and the UAV aerial images. The UAV method

confirmed 928 additional whales that were not previously identified by the traditional boat-based method. This UAV aerial photo-identification methodology contributes new information that will complement and allow correction previous interpretations of photo-id data and improve our understanding of the life history of individuals gray whales in Mexico, and potentially throughout the entire range of this species.



Photograph by Fabián Missael Rodríguez González

GRAY WHALE UNUSUAL MORTALITY EVENT (UME): UPDATE 2019-2023



During the last two decades, the North Eastern Pacific gray whale population has experienced two range-wide Unusual Mortality Events: the first occurred from 1999-2000, with at least 319 stranded dead whales discovered in the breeding and calving areas in Mexico, and the second UME during the period from 2019 to 2023.

Since January 2019 the increase of dead gray whale strandings occurring along the west coast of North America from Mexico through Alaska prompted U.S. National Oceanic and Atmospheric Administration to declare a second "Unusual Mortality Event" for gray whales. From 17 December 2018 through 5 April 2023 a total of 638 ENP gray whales stranded along the Pacific coast of North America across Canada, the United States, and Mexico (Table 5).

Table 5: Eastern North Pacific gray whale strandings by country from 17 December 2018 through April 2023 (From NOAA, Fauquier et al., 2023 and Martínez-Aguilar et al., 2023, and this report).

Country	2019	2020	2021	2022	2023	Total
Canada	11	5	5	4	0	25
US	122	79	55	47	8	311
Mexico	83	88	55	54	33	313
Total	216	172	115	105	41	649

*includes 2 whales that stranded in Mexico in December 2018

Some of the stranded whales appeared to be "skinny", suggesting that they were suffering from nutritional stress. Analysis of the possible causes of the 1999-2000 Unusual Mortality Event, suggested that the increase in gray whale mortality was a result of the population increasing to an abundance level that exceeded the "carrying capacity" of the gray whales' feeding grounds. After the 2019 Unusual Mortality Event was declared, renewed efforts to monitor and report gray whale strandings throughout their range in Mexico were undertaken.

Low numbers of gray whale female-calf pairs observed in Laguna San Ignacio and in Bahía Magdalena from 2018 to 2022 is similar to the decreased calf abundance observed in the wintertime aggregation and breeding areas in Baja California Sur from 2007 to 2010 following the previous range-wide Unusual Mortality Event of 1999 to 2000. Low calf counts were again observed in the Baja California lagoons beginning in 2018 and continuing into the 2023 winter, a period that overlaps the Unusual Mortality Event of 2019-2022. To date a primary cause of the current gray whale UME has not been identified. It is likely that this event may have multiple contributors, including mortality linked to killer whale predation, fishing gear entanglements, vessel strikes, and poor body condition possibly associated with ecosystem changes in sub-Arctic and Arctic feeding areas.

Changing environmental conditions in the gray whales' northern feeding areas may be reducing the availability of food during the summer months, necessitating additional searching time to find food (Moore *et al.*, 2023). While insufficient prey could contribute to the reduced reproduction and apparent decline in the body condition of some gray whales, disease and environmental stressors (*e.g.*, climate change) cannot be ruled out.

More information on the gray whale UME and probable contributing causes, is available in the following articles:

Christiansen, F., et al. 2021. Poor body condition associated with an unusual mortality event in gray whales. Marine Ecology Progress Series Vol. 658: 237-252.

(<https://www.sanignaciograywhales.org/wp-content/uploads/2021/01/Christiansen-et-al.-GW-Condition-FINAL-21-Jan-2021.pdf>)

Fauquier, D., et al. 2023. Update on the Eastern North Pacific Gray Whale (*Eschrichtius robustus*) 2019-2023 Unusual Mortality Event. International Whaling Commission Scientific Committee Annual Meeting 2022 Paper Submission – Conservation Management Plans.

Moore, S.E. et al. 2022. Changes in gray whale phenology and distribution related to prey variability and ocean biophysics in the northern Bering and eastern Chukchi seas. PLoS ONE 17(4): e0265934, doi:10.1371/journal.pone.0265934. 26pp.

GRAY WHALE BODY CONDITION

Gray whale body condition is an indication of the whales' success at seasonal foraging, which in turn is indicative of reproductive trends of individuals and of the population. Two different methods were used to assess gray whale body condition in Laguna San Ignacio: First, digital photographic images taken from a boat were used to evaluate the amount of body fat present and the condition of three body areas (the head, scapula, and flank). Each were assigned a numerical score and classified as “good”, “fair” or “poor” condition depending on the amount of body fat-tissue in these regions (Fig. 7a-c).

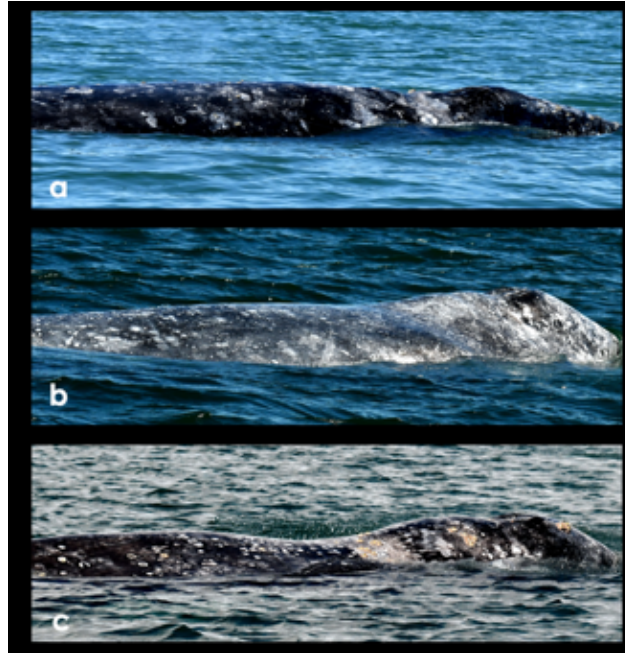


Figure 7a-c. Body condition evaluation classifications: (a) = good; (b) = fair; and (c)= poor.

The second method utilizes UAV-drone photogrammetry with video cameras to photograph gray whales as they surface to breathe. Digital images of the backs of each whale were selected from the videos and were catalogued by age and sex of the whales as females with calves and single adults without calves (Fig. 8). Body condition was then evaluated based on the measurements of the width and length ratios of each photographed whale compared to measurements of known healthy individuals. All drone photographs were sorted into reproductive class categories based on total body length (*e.g.*, calves, juveniles, and adults).



Figure 8. A UAV-drone photograph of a “skinny” or “flaca” gray whale used for condition evaluation.

Boat-Based Condition Analysis:

In 2023 the percentage of single adult whales observed in Laguna San Ignacio with good body condition was 70%, an increase and improvement compared to the 2019-2021 period, and has been the highest percent since the beginning of the Unusual Mortality Event (Table 6). Similarly, single whales in “fair” and “poor” conditions (21.2% and 8.8% respectively) decreased in 2023 and are the lowest percentages observed during the last five winters. (Fig. 9). This suggests that a slow recovery has been progressing since 2021, but this recovery could be due to the combined influence of multiple factors, including: the deaths of whales suffered from fatal nutritional stress; the Eastern North Pacific population suffered a reduction from 27,000 to 16,650 whales during the current UME between 2020 and 2022 (Eguchi *et al.*, 2022); and/or that the food resources have been reduced and the available resources (the present carrying capacity “K”) is not sufficient to support the current size of the North Eastern Pacific gray whale population. Additional wintering and summer feeding areas need to be investigated to understand if this trend is local or is occurring throughout the range of Eastern North Pacific population.

Table 6. Number and percentage of gray whales by body condition category and group type (Mc and Single whales) photographed by boat in Laguna San Ignacio, B.C.S. Mexico from 2019 to 2023.

Singles / Year	2019	2020	2021	2022	2023
No. whales Photo-identified	847	696	746	746	618
No. whales categorized	529	553	658	626	526
Good Condition	117 22.1%	166 33.3%	259 42.1%	269 43%	311 70%
Fair Condition	287 54.3%	183 36.7%	206 33.5%	235 37.5%	94 21.2%
Poor Condition	125 23.6%	150 30%	150 24.4%	122 19.5%	39 8.8%
Mc / Year	2019	2020	2021	2022	2023
No. whales Photo-identified	41	56	43	42	83
No. whales categorized	40	54	41	42	82
Good Condition	20 50%	38 70.3%	41 95.3%	38 90.5%	68 82.9%
Fair Condition	20 50%	13 24.2%	2 4.7%	4 9.5%	11 13.5%
Poor Condition	0 0%	3 5.5%	0 0%	0 0%	3 3.6%

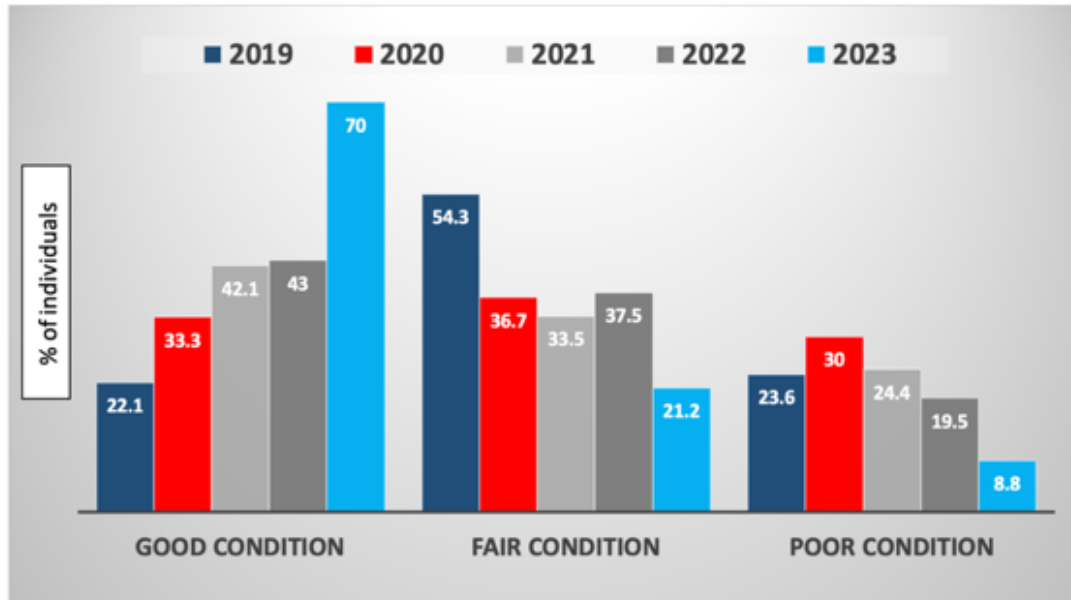


Figure 9. Percentage of single whales’ body condition from boat-based photographs in Laguna San Ignacio from the 2019 to 2023 winters.

Observations of female whales with calves in Laguna San Ignacio in 2023 reflected a high percentage of whales in “good” body condition (82.9%, n= 68), but not the highest in the previous five winters and ranged from 70% to 90% (Fig. 10, Table 6). In addition, the percentage of females with calves in “fair” condition is the highest during the last 3 years, and some mothers with calves appeared in “poor” condition, suggesting that the body condition of breeding females may be declining. This could be due to the high numbers of mothers with calves observed in 2023 (twice than 2022), that may not be in the best condition, but their energetic reserves were sufficient to bring a new calf to term and successfully give birth. It is not known if these females will have sufficient energy reserves post-partum to complete the spring northward migration to the summer feeding areas.

Changes in environmental conditions are likely to affect whale body condition through a direct impact on seasonal production of whale prey resources sources throughout the whales’ range. Additional research on the correlation between environmental changes and gray whale prey production in relation to the body condition will aid our understanding of the effect of these changes on the ENP gray whale population during 2023 and in the future. Additional analysis will focus on identifying known breeding age females with known reproductive histories, to determine when they are expected to have calves during a winter but are not seen with calves.

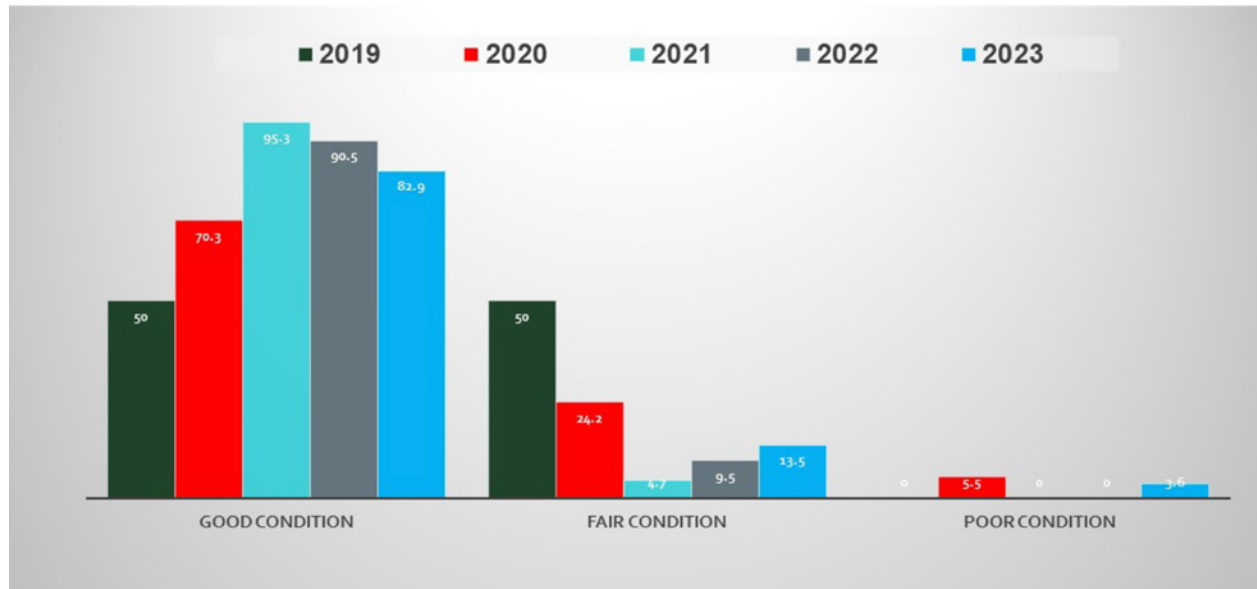


Figure 10. Body condition of females with calves evaluated from boat-based photographs in Laguna San Ignacio from the 2019 to 2022 winters.



Photograph by Sergio Martínez-Agular 2023

UNMANNED AERIAL VEHICLE (UAV) ASSESSMENT OF BODY CONDITION



Unmanned Aerial Vehicles (UAVs) or drones have been used to obtain digital images of gray whales in Laguna San Ignacio from 2017 to 2023, and this information used to evaluate and track trends in gray whale body and reproductive condition. To assess body condition images of the whales on the surface with their body contours perfectly visible in width and length and their bodies completely straight (Fig. 11).



Figure 11. Examples of high-resolution aerial photos from UAV (drones) used to evaluate body condition. Normal condition (top), and "skinny" or poor condition (bottom).

The dorsal surfaces of a gray whale are used to measure body length and width every 5% of the whale's length from the tip of the rostrum to the notch of the tail flukes. For lateral images, height (dorso-ventral distance) was measured along the same 5% measurements (Figs. 12 A and B).

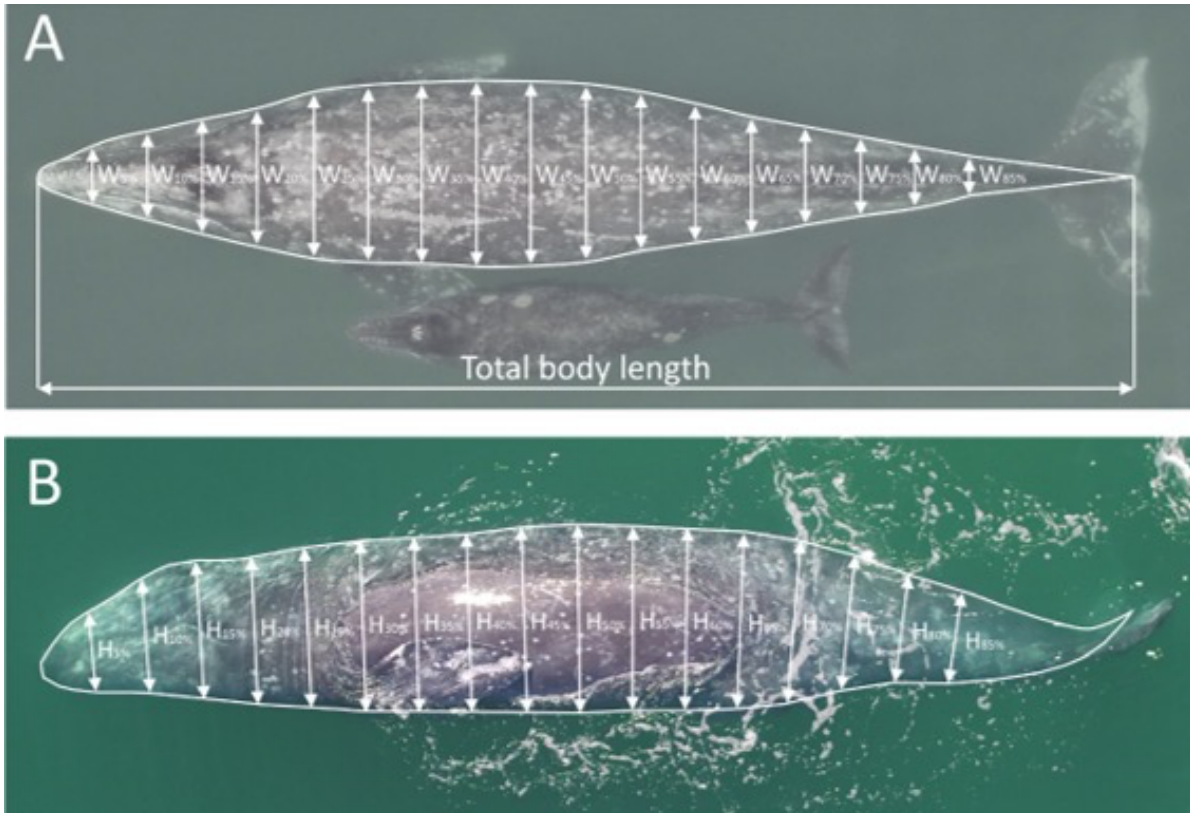


Figure 12. (A) The dorsal surfaces of a gray whale used to measure body length and width every 5% from the tip of the face to the notch of the flukes. (B) Gray whale in lateral position to measure the height (dorso-ventral distance) along the same measurement sites (from Christiansen et al., 2021).

All measurements are scaled (converted from pixels to meters) using the known altitude of the UAV (measured using a laser range finder), the camera sensor size, focal length and image resolution. Each whale was classified into a specific reproductive class according to published lengths as a calf, juvenile, adult including lactating females. These scaled measurements were used to estimate the volume of each 5% section, and these summed to estimate body mass (Fig. 13). This process was repeated with multiple photographs of the same individual whales obtained over the winter for comparison of volume/mass gain or loss over the duration of their stay in the lagoon.

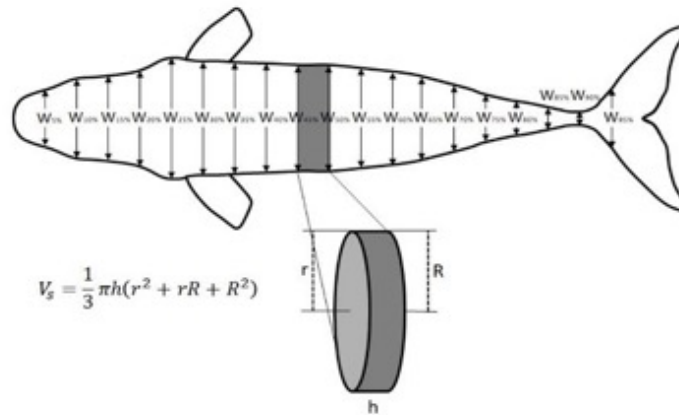


Figure 13. Illustration of the method used to estimate gray whale volume and mass (from Christiansen et al., 2018).

Changes in body condition over the winter for each reproductive class were then plotted as “early” in the season (mostly January) against “late” in the season (mostly late-March to early-April). Average body condition was calculated from the sum of data for all whales sampled for each length class (i.e., calf, juvenile, adult, and lactating females). A positive or good body condition means that an individual was in relatively better condition than the average individual of the same body length, whereas a negative body condition indicated that the individual was in relatively poorer condition. Every reproductive class except calves showed a declining trend in condition (volume/mass) over the winters from 2017 to 2020 (Fig. 14). This would be expected as all gray whales, except calves, are not feeding during the winter reproductive season and their body mass would decrease as they metabolize their body fat. Calves on the other hand are obtaining nourishment from the fat rich milk they nurse from their mothers, and their condition increased as they grew and put on weight during the winter. An emaciation threshold was derived from similar measurements of stranded, dead, emaciated whales (see red broken lines in Fig. 14).

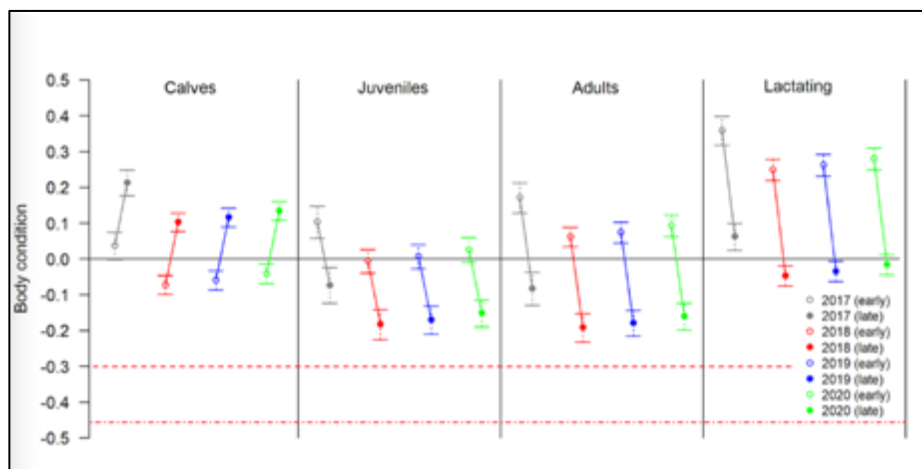


Figure 14. Seasonal trends in gray whale body condition during the winters of 2017 to 2020. Horizontal black line is average condition of all gray whales sampled, positive values are “good” condition, negative values are “poor” condition, and the broken red lines indicate the threshold for “emaciated” condition measured from stranded dead emaciated whales.

These trends of declining body condition suggest that if breeding females were unable to obtain sufficient food during the summer of their pregnancy, their condition may continue to decline to a low level after the birth of their calves. A long-term consequence of this strategy is that post-weaning females would require more time to recover sufficient fat reserves to breed again and reduce calving rates. This could account for the low calving rates observed in the wintering breeding lagoons during the Unusual Mortality Event from 2019 to 2022. In addition, the majority of stranded dead gray whale discovered in Mexico at the beginning of the Unusual Mortality Event were adult females (see stranding section below for more detail). This UAV drone assisted photogrammetry is proving to be a valuable source of information to evaluate the health of individuals whales and their population as they recover from this extreme mortality event.

To learn more of the details of our investigations of gray whale body condition, see the following papes on the LSIESP websiter:

Valerio-Conchas, et al. 2023. *Gray whales' body condition in Laguna San Ignacio, Baja California Sur, México during the Unusual Mortality Event of 2019-2022: 2023 Update. Rep. Intl. Whal. Commn. SC/69A/CMP/16.*

Christiansen, et al. 2021. *Poor body condition associated with an unusual mortality event in gray whales. Marine Ecology Progress Series Vol. 658: 237-252.*

GRAY WHALE STRANDINGS AND MORTALITIES IN MEXICO



Stranded whale data was collected in the gray whale wintering areas in Baja California from 2019 to 2023 included Laguna Ojo de Liebre, Laguna Guerrero Negro, Manuela lagoon, Laguna San Ignacio, the Bahía Magdalena-Bahía Almejas complex, and those reported by the media of gray whales stranded along the Pacific coast of the Baja California Peninsula (Fig. 15). The number of stranded gray whales (n=33) reported in Mexican waters from January 1 to April 11 of 2023 was the lowest since the UME started in 2019.

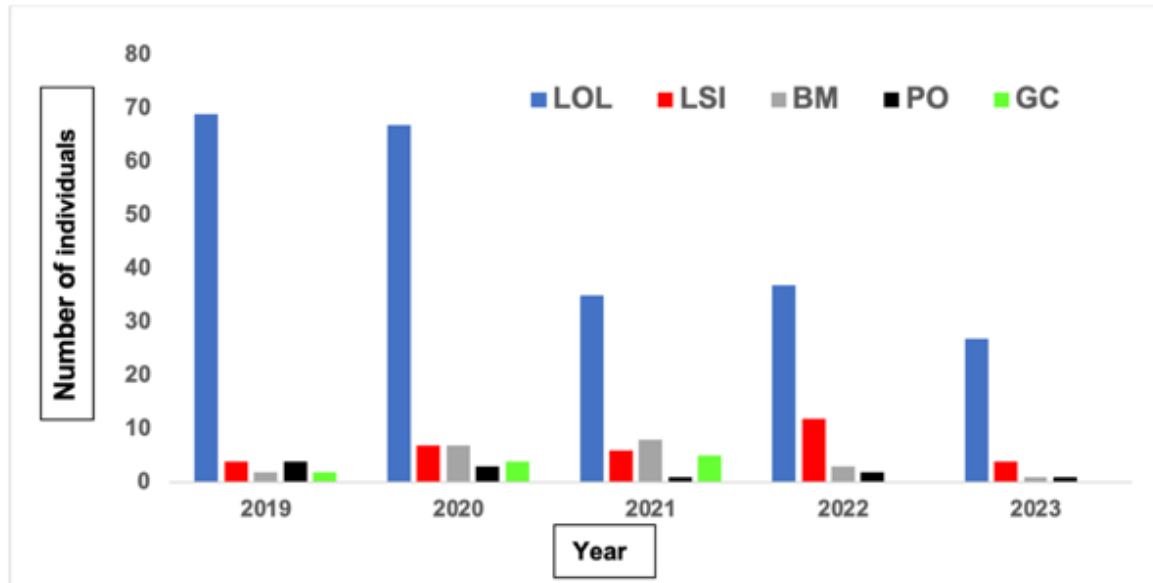


Figure 15. Total number of gray whales stranded in Mexico by area, during (2019-2023) UME. LOL (Ojo de Liebre lagoon), LSI (San Ignacio lagoon), BM (Bahía Magdalena), PO (Pacific Ocean), GC (Gulf of California).

As seen in previous years, the number of strandings in Laguna Ojo de Liebre (n=27) was the highest observed in the three primary wintering areas in Baja California as it is the main breeding and calving lagoon. Due to the long time between surveys to discover strandings in this area, almost all of carcasses examined were in a state of advanced decomposition so their body condition could not be assessed. The number of strandings in Laguna San Ignacio (n=4) was lower than the number of stranded whales discovered in 2022 (n=12). Only one stranded gray whale, a 4.82 m long calf, was discovered in Bahía Magdalena in 2023. Although these whales were in fresh or a moderated state of decomposition, no necropsies were undertaken because the carcasses were floating when they were discovered. Only one of these whales appeared emaciated and it was observed alive five days before it was discovered stranded. Data from 2023 indicated higher stranding rates for females in 2019 and 2023, unlike the period from 2020 to 2022 where stranded males were predominant (Fig. 16).

Calves were the main age category of stranded whales during 2023 in Mexico, as is usually seen in non-Unusual Mortality Event years. Subadult and adult age classes were the most common categories of stranded whales during the 2019-2022 period of the Unusual Mortality Event (Fig. 17). The increase of the number of calves stranded is likely related to higher numbers of calves observed in the wintering lagoons during 2023 (see previous section on abundance).

Unfortunately, in all years the condition of most of the stranded whales could not be determinate due to their advanced state of decomposition when examined. In 2023 only 3 whales observed in Mexico were judged to in good condition, 8 were in moderated decomposition, 6 were in fair condition, and only one was judged to be emaciated.

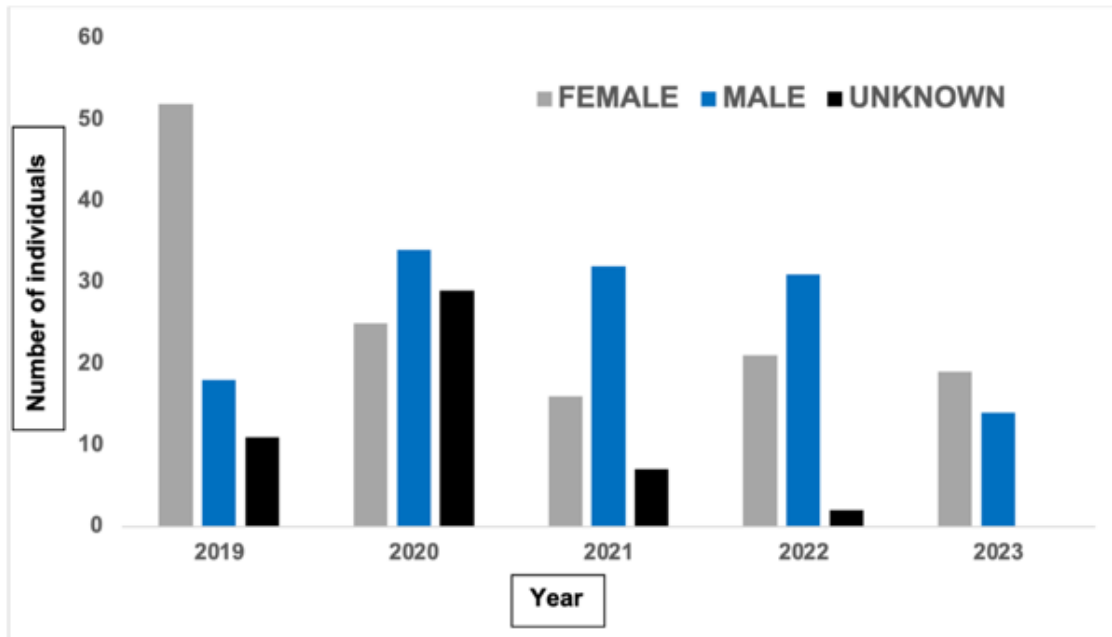


Figure 16 . Total number of gray whales stranded in Mexico by sex during (2019-2023) UME

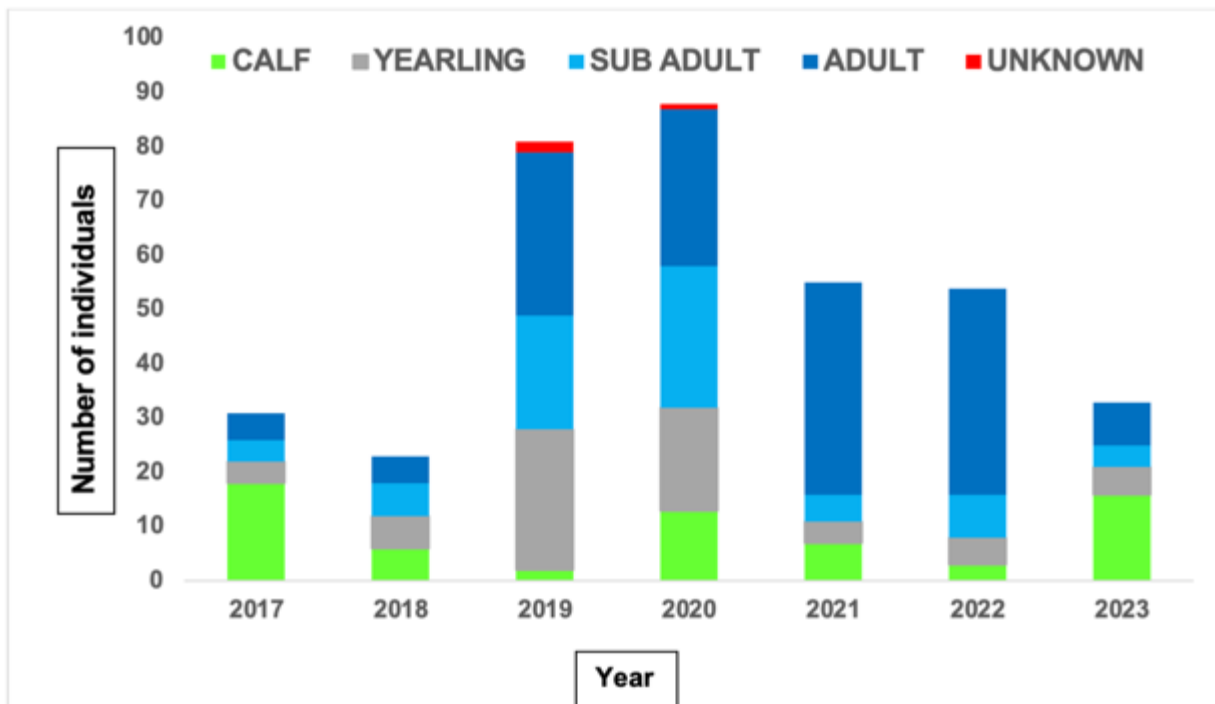


Figure 17 . Age categories of stranded gray whales in Mexico from 2017 to 2023.

As is the case in other portions of the gray whales' range, the number of stranded gray whales reported in Mexico is likely an underestimate of actual mortalities, because of the vast the distances which gray whales are distributed along the Baja California Peninsula. In addition, an undetermined number may drift out to sea and never appear on the coastal beaches, and the differences in search effort conducted in all areas also limits our interpretation of actual mortality rates. Overall, the number of stranded gray whales discovered in Mexico in 2023 is lower than the previous four years, and similar to historical stranding numbers in the years prior to the Unusual Mortality Event, suggesting that the gray whale mortality event may be slowing.

See the NOAA webpage describing the gray whale UME at:

<https://www.fisheries.noaa.gov/national/marine-life-distress/2019-2023-gray-whale-unusual-mortality-event-along-west-coast-and>)

To read more details of the impact of the current UME on gray whales, please see the following papers:

Fauquier *et al.* 2023. Update on the Eastern North Pacific Gray Whale (*Eschrichtius robustus*) 2019-2023 Unusual Mortality Event. *International Whaling Commission Scientific Committee Annual Meeting 2022 Paper Submission – Conservation Management Plans*

Martínez *et al.* 2023. Gray whale stranding records in México, during the 2023 winter breeding season. Rep. Intl. Whal. Commn. SC/69A/CMP/17.



ADDITIONAL SPECIES SIGHTINGS IN 2023



In March of 2023 a rare Dwarf sperm whale (*Kogia sima*) was found stranded inside of Laguna San Ignacio (Fig. 19). While this species is frequently seen and found stranded in the Gulf of California, this is the first discovery of a Pigmy Sperm whale in Laguna San Ignacio.



Figure 19. Dwarf sperm whale (*Kogia sima*) discovered in Laguna San Ignacio.

Additional cetacean species photographed during photo-id surveys and by UAV drones in the Bahía Magdalena lagoon complex in 2023 (Fig. 20). These included: Killer whales (*Orcinus orca*)(n=1), Short-beaked common dolphin (*Delphinus delphis*)(n=5), White sided dolphin (*Lagenorhynchus obliquidens*)(n=3), Humpback whales (*Megaptera novaeangliae*)(n=49), Brydes whale (*Balaenoptera edeni*)(n=1), Blue whales (*Balaenoptera musculus*)(n=10).



Figure 20. Examples of additional cetacean species photographed in the Bahía Magdalena lagoon complex in 2023

OUTREACH ACTIVITIES IN 2023

Laguna San Ignacio: LSIESP researchers made presentations to select eco-tour groups visiting Laguna San Ignacio. We also hosted two classes of undergraduate students from La Universidad Autónoma de Baja California Sur, Mexico (UABCS) that were enrolled in the course “Amniotas Marinos” that visited the lagoon to learn field research and analysis methods for gray whales and other species (Fig. 21). Additional outreach activities included our traditional Community “Reunion” attended by interested public, eco-tourists, naturalists, the local communities, and the public media (*e.g.*, Al Jazeera, El Heraldo, etc.). We continued to use internet social media sites (*e.g.*, website, Facebook and Instagram) to present “virtual” lectures on gray whales and our research.



Figure 21. Aerial View of our field research station Laboratory de “Francisco ‘Pachico’ Mayoral.” The multi-colored tents in the center of this photo belong to a group of undergraduate students from the Universidad Autónoma de Baja California Sur (UABCS) in La Paz that visit the lagoon on field trips to learn gray whale research methods.

Photo-ID Collaboration with Cascadia Research Collective:

In 2022 and 2023 LSIESP researchers collaborated on a photo-ID project with Dr. John Calambokidis of the Cascadia Research Collective and Master’s degree Candidate Anna Blanchard from the University of Exeter, United Kingdom. This project is utilizing the “Flukebook” software platform and matching system to search for and identify female gray whales with calves photographed in Laguna San Ignacio with gray whale mothers photographed by Cascadia researchers off Northern California that are members of the Pacific Coast Feeding Group and the “Sonders”. These matches will provide information on reproductive histories of breeding female whales and calf survivorship between the wintering areas of Mexico and the Pacific Northwest migratory corridor.

Research and Educational Outreach Bahía Magdalena:



In 2023 we conducted our first 3-month winter gray whale research program in the Bahía Magdalena lagoon complex. LSIESP researcher Dra. Lorena Viloría-Gómora from the Universidad Autónoma de Baja California Sur (UABCS) in La Paz, B.C.S., Mexico leads the research team for this expanded program (Fig. 22). This expanded program includes ongoing monitoring of gray whale seasonal abundance and distribution and begins the monitoring of whale-watching activities in three key areas utilized by the whales. These include: Canal de Santo Domingo in the north; Bahía Magdalena’s center, west and southwest areas; and Puerto Chale in Bahía Almejas in the south (Fig. 23).

Figure 22. Dra. Lorena Viloría-Gómora



Figure 23. Bahía Magdalena research team having lunch on the run while surveying gray whales.

The program at Bahía Magdalena includes monthly outreach workshops for Eco-Tourism Offices and providers, the local schools, non-government conservation groups, and community representatives. Discussions include the goals and activities of the gray whale research program, the biology and status of the gray whales during the current UME and longer term climate change impacts, reviewing and interpreting the existing rules and regulations governing whale-watching in this region, and engaging the local people and businesses in a dialogue to support the program (Fig. 24). We are pleased to be hosting these workshops in collaboration with the non-profit “Mar Vivo Community Science Project.”



Figure 24. Presentations were made in 2023 to school and community groups at various education levels in the Bahía Magdalena area.

Scientific and Professional Meetings:

In 2023 LSIESP researchers participated in and presented the results of our gray whale research program at the International Whaling Commission’s Scientific Committee meeting from April 23 to May 5 in Bled, Slovenia, and at the Mexican Society of Marine Mammalogy (SOMEMMA) from May 1-5 at the University of Colima, Manzanillo, Colima, Mexico (Fig. 25). You may view abstracts of their research papers from to these meetings on our website at:

<https://www.sanignaciograywhales.org/research/publications/>



Figure 25. LSIESP and UABCS researchers that attended the May 2023 Mexican Marine Mammal Society (SOMEMMA) meeting at the University of Colima, Manzanillo, Colima, Mexico

ACKNOWLEDGEMENTS

We wish to thank all of the research teams from the Laguna San Ignacio Ecosystem Science Program and the Programa de Investigación de Mamíferos Marinos, Universidad Autónoma de Baja California Sur, La Paz, B.C.S., México that have worked to monitor the gray whales that reside within in Laguna San Ignacio and Bahía Magdalena during the winter months. We thank the “Mar Vivo Community Science Project” in Bahía Magdalena for their collaboration. This research was supported by grants from The Marisla Foundation, the Ocean Foundation, Natural Habitat Adventures Foundation, the Whaleman Foundation, and private individual donors, with in-kind logistic support provided by Kuyima Eco-Tourismo, Inc, and Baja Discovery whale-watching tours. Field research was conducted under Scientific Research permits SPARN/DGVS/02144/23 from the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), Subsecretaría de Gestión Para La Protección Ambiental, Dirección General De Vida Silvestre, de México.

YOU CAN MAKE IT HAPPEN: We are grateful to our family of sponsors whose generous support each year provides the means for the laguna San Ignacio Ecosystem Science Program to conduct research on gray whales and their wintering lagoon aggregation and breeding areas in Baja California.



We urge you to consider becoming a supporter of our program by making a monthly donation through our fiscal sponsor The Ocean Foundation. Setting up your monthly donations is safe and secure at the following link: <https://www.sanignaciograywhales.org/donate/>. Thank You!



Our program is a project of the Washington D.C. based non-profit Ocean Foundation and a collaboration with the Marine Mammal Research Program (PRIMMA) at the Universidad Autónoma de Baja California Sur (UABCS) in La Paz, B.C.S., Mexico.



Please check our website www.sanignaciograywhales.org for additional news updates on our research findings as we prepare for the 2032 winter gray whale research season.

HAVE QUESTIONS OR WANT MORE INFORMATION? Please contact us on our website and we will do our best to address your questions and provide more information on the gray whales and their winter breeding lagoons in Baja California:

<https://www.sanignaciograywhales.org/contact-us/>.



REFERENCE DOCUMENTS AND REPORTS

- Christiansen, F., *et al.* (2021). Poor body condition associated with an unusual mortality event in gray whales. *Marine Ecology Progress Series* Vol. 658: 237-252.
(<https://www.sanignaciograywhales.org/wp-content/uploads/2021/01/Christiansen-et-al.-GW-Condition-FINAL-21-Jan-2021.pdf>)
- Fauquier, D., *et al.* (2023). Update on the Eastern North Pacific Gray Whale (*Eschrichtius robustus*) 2019-2023 Unusual Mortality Event. International Whaling Commission Scientific Committee Annual Meeting 2022 Paper Submission – Conservation Management Plans: SC/69A/CMP/.
(https://www.sanignaciograywhales.org/wp-content/uploads/2023/05/NOAA_IWC-GW-UME_Update2023_11-May-2023.pdf)
- Moore, S.E., *et al.* (2022). Changes in gray whale phenology and distribution related to prey variability and ocean biophysics in the northern Bering and eastern Chukchi seas. *PLoS ONE* 17(4): e0265934, doi:10.1371/journal.pone.0265934. 26pp.
(https://www.sanignaciograywhales.org/wp-content/uploads/2023/05/Moore.etal_.2022.GrayWhaleEcolog-BeringChukchiSeas_PONE-copy.pdf)
- Martínez, *et al.* (2023). Report on activities to monitor the Gray Whale (*Eschrichtius robustus*) during the 2023 winter in Laguna San Ignacio, B.C.S., Mexico. LSIESP Annual Report.
(https://www.sanignaciograywhales.org/wp-content/uploads/2023/05/Laguna-San_Ignacio-Informe-2023-ENGLISH.pdf)
- Martínez, *et al.* (2023). Gray whale stranding records in México, during the 2023 winter breeding season. *Rep. Intl. Whal. Commn.* SC/69A/CMP/17.
(<https://www.sanignaciograywhales.org/wp-content/uploads/2023/05/Gray-whale-stranding-Mexico-2023-11-MAY-2023.pdf>)
- Mexican Marine Mammal Society (SOMEMMA) (2023). Abstracts from LSIESP Researcher's presentations at May 2023 conference.
(<https://www.sanignaciograywhales.org/wp-content/uploads/2023/05/SOMEMMA-ABSTRS-2023.pdf>)
- Rodríguez-González, F.M. and Olguín-Hernández, J.A. (2023). Gray whale aerial monitoring using UAV-drones, season 2023. LSIESP Annual Report.
(https://www.sanignaciograywhales.org/wp-content/uploads/2023/05/LSI_UAV-DRONES_ENGLISH-Abril_2023.pdf)

- Urbán R., *et al.* (2023). 2023 Gray whale abundance in Laguna San Ignacio and Bahía Magdalena lagoon complex, B.C.S., México. Rep. Intl. Whal. Commn. SC/69A/CMP/21.
(<https://www.sanignaciograywhales.org/wp-content/uploads/2023/05/URBAN-ET-AL-2023-GRAY-WHALE-ABUNDANCE-11-MAY-2023.pdf>)
- Valerio-Conchas, *et al.* (2023). Gray whales' body condition in Laguna San Ignacio, Baja California Sur, México during the Unusual Mortality Event of 2019-2022: 2023 Update. Rep. Intl. Whal. Commn. SC/69A/CMP/16.
(<https://www.sanignaciograywhales.org/wp-content/uploads/2023/05/Valerio-Conchas-Body-condition-11-MAY-2023.pdf>)
- Viloria, *et al.* (2023). Report of the activities to monitor the Gray Whale (*Eschrichtius robustus*) and public outreach and education programs during the 2023 winter in the Magdalena Bay lagoon complex, Santo Domingo canal and Almejas Bay, B.C.S., Mexico. LSIESP Annual Report.
(<https://www.sanignaciograywhales.org/wp-content/uploads/2023/05/Bhaia-Magdalena-Ballena-Gris-2023-ENGLISH.pdf>)