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Update on the Eastern North Pacific Gray Whale (*Eschrichtius robustus*) 2019-2023 Unusual Mortality Event

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ABSTRACT

From 17 December 2018 through 05 April 2023, a total of 638 Eastern North Pacific gray whales (*Eschrichtius robustus*) stranded along the Pacific coast of North America across three countries (Canada, Mexico, and United States). Two hundred and sixteen whales were reported in 2019 (including two whales from December 2018), 172 in 2020, 115 in 2021, 105 in 2022, and 30 as

of 05 April 2023 (Table 1, Figures 1, 2). On the West Coast of the United States, the 122 stranded whales reported in 2019, 79 in 2020, 55 in 2021, and 47 in 2022 exceeded the annual mean stranding rate of 29 ± 10 whales between 2001-2018 (Table 2, Figure 3). Strandings occurred along the entire range of the Eastern North Pacific gray whale, including in the wintering, migratory, and feeding areas (Figure 2, Tables 1, 2), with most whales recorded in U.S waters documented in spring and early summer when gray whales are near the end of their seasonal fast (Figure 3).

Recent abundance estimates of the Eastern North Pacific gray whale population show that it had declined to approximately 20,500 whales by the winter of 2019/2020 and even further to approximately 16,650 whales by the winter of 2021/2022, a period of time that overlaps the Unusual Mortality Event (UME; Stewart and Weller 2021a, Eguchi *et al.* 2022a). Total calf production was estimated at 380 calves (95% CI = 296 – 493) in 2021 and 217 calves (95% CI = 159 – 290) in 2022, and these estimates are among the lowest recorded in the data time-series which began in 1994 (Stewart and Weller 2021b, Eguchi *et al.* 2022b). Three of the four lowest years of calf production during this period coincide with UMEs, the 1999-2000 UME and the current event. Additionally, annual per capita stranding rates were elevated during the 1999-2000 UME and the current event. (Figure 4). This suggests that the factors driving or mediating gray whale fecundity and mortality rates may be similar. Photogrammetry of live gray whales in Mexico from 2017 through 2019 demonstrated significantly lower body condition in whales in 2018 and 2019 compared to 2017 (Christiansen *et al.* 2021). Depending upon the age class of the whales, this lower body condition may have led to delayed reproduction and lower calf counts, and/or reduced survival.

Preliminary results have not identified a primary cause of the gray whale UME. However, the ongoing investigation has identified several likely contributing factors, including ecosystem changes in some sub-Arctic and Arctic feeding areas potentially contributing to malnutrition and compromised body condition (Moore *et al*. 2022); vessel strikes; and to a lesser extent entanglements and killer whale predation. Specifically an evaluation of 61 whales, with partial or complete post-mortem examinations conducted between 2019 and 2021, identified findings that contributed to death in 33 whales (Raverty *et al*. *in prep*). This included 16 whales with emaciation as the only post mortem finding, 11 whales with evidence of vessel strike (including 2 that were also emaciated), 3 whales with pre-mortem killer whale attack (2 probable, 1 suspected), 2 entanglement cases, and 1 entrapment. There were also 28 cases in which cause of death could not be determined. These findings are similar to those reported in a previous review of whales that died in 2019 (Raverty *et al*. 2020).

Between 2019 and 2021, tissue samples from 25 whales tested negative by PCR for morbilliviruses, influenza viruses, and coronaviruses. Additionally, tissue samples from 13 whales were screened by metagenomic viral sequencing and no known or novel viruses were identified in the samples. Nine of these whales also had metagenomic bacterial sequencing performed on tissues, which resulted in sequence fragments from greater than 100+ bacterial genera, many of which may have been present simply due to carcass decomposition. Three whales had *Brucella sp.* sequence fragments amplified by metagenomic sequencing, although no lesions compatible with Brucella infection were identified histologically in any of the three whales.

Samples (*i.e.,* feces, stomach contents, intestinal contents, urine) from 57 whales were tested by ELISA for biotoxins including domoic acid and/or saxitoxin. For domoic acid, 71% of whales (39/55) had detectable concentrations including 5% (3/55) with high (>1000 ng/ml), 2% (1/55) with moderate (164 ng/ml), 64% (35/55) with low (<100 ng/ml) and 29% (16/55) with no detectable concentrations. For saxitoxin, 29% of whales (10/35) had detectable concentrations including 6% (2/35) with moderate (113 & 373 ng/g), 23% (8/35) with low (<100 ng/g) and 71% (25/35) with no detectable concentrations. Currently, the toxic thresholds and kinetics of biotoxins are not well known in cetaceans (Lefebvre *et al.* 2016, Danil *et al*. 2021, Fire *et al*. 2021). Due to carcass decomposition, histologic examination of likely target organs (brain, heart) was not available for these animals, although histologic lesions associated with biotoxin exposure in cetaceans are limited (Broadwater *et al.* 2018).

For current data, please refer to: https://www.fisheries.noaa.gov/national/marine-life-distress/2019-2023-gray-whale-unusual-mortality-event-along-west-coast-and

Table 1: Eastern North Pacific gray whale strandings by country from 17 December 2018, through April 2023.

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

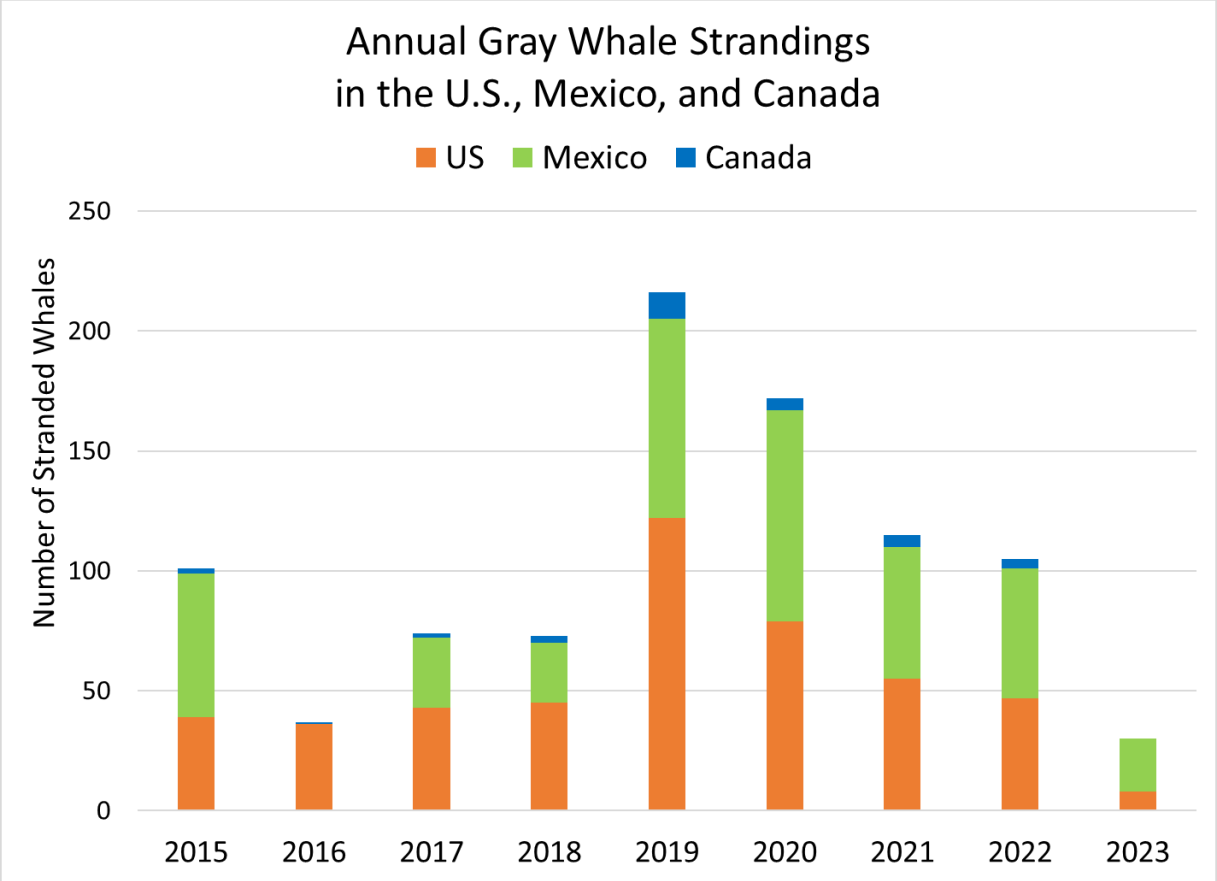

Figure 1: Eastern North Pacific gray whale annual strandings, 2015 to 2023 (as of 05 April 2023) in the U.S., Mexico, and Canada

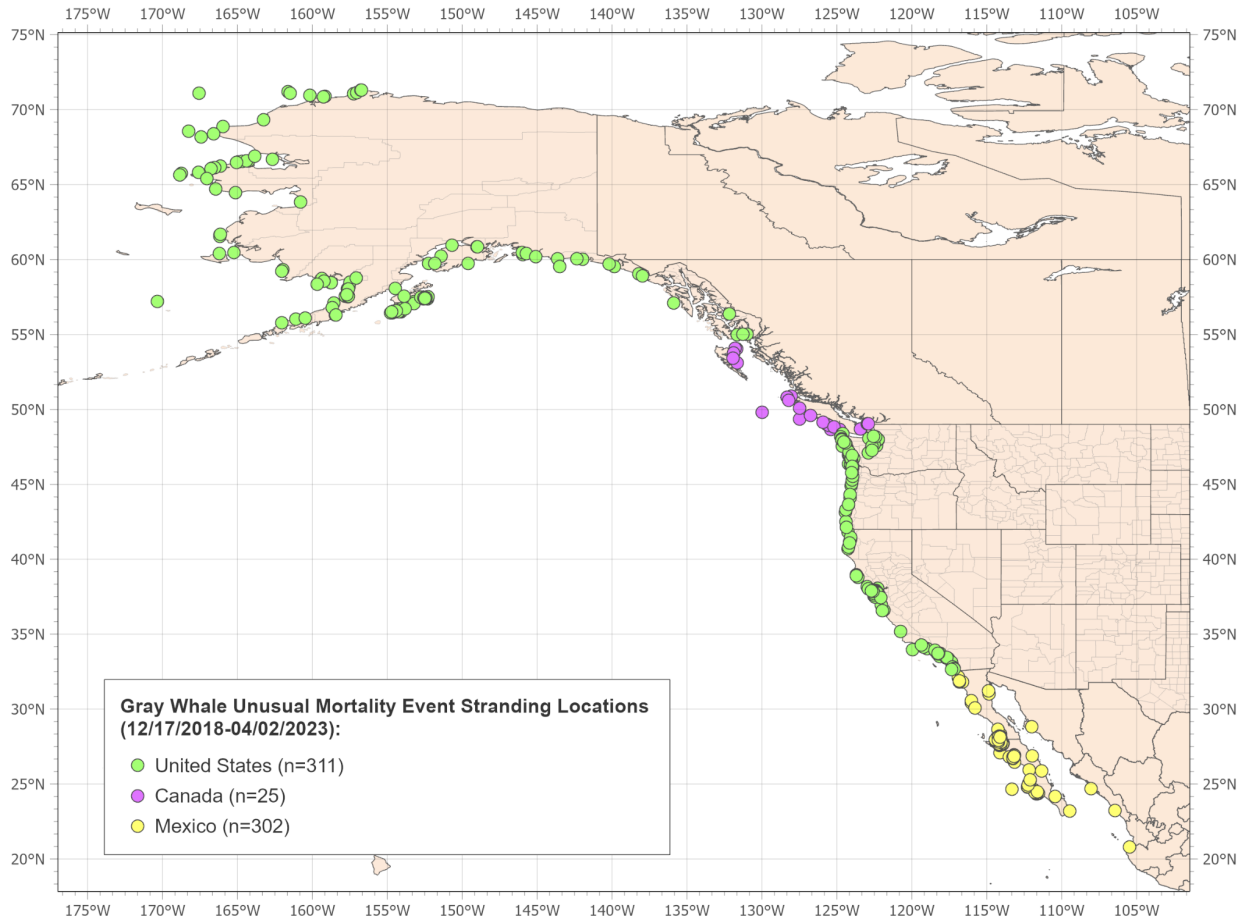

Figure 2: Locations of stranded Eastern North Pacific gray whales from 17 December 2018, through 02 April 2023.

Table 2: Eastern North Pacific gray whale strandings by U.S. state from 01 January 2019, through 05 April 2023.

U.S. State	2019	2020	2021	2022	2023
Alaska	48	45	24	18	0
Washington	34	13	9	15	3
Oregon	6	3	3	4	3
California	34	18	19	10	2
Total	**122**	**79**	**55**	**47**	**8**

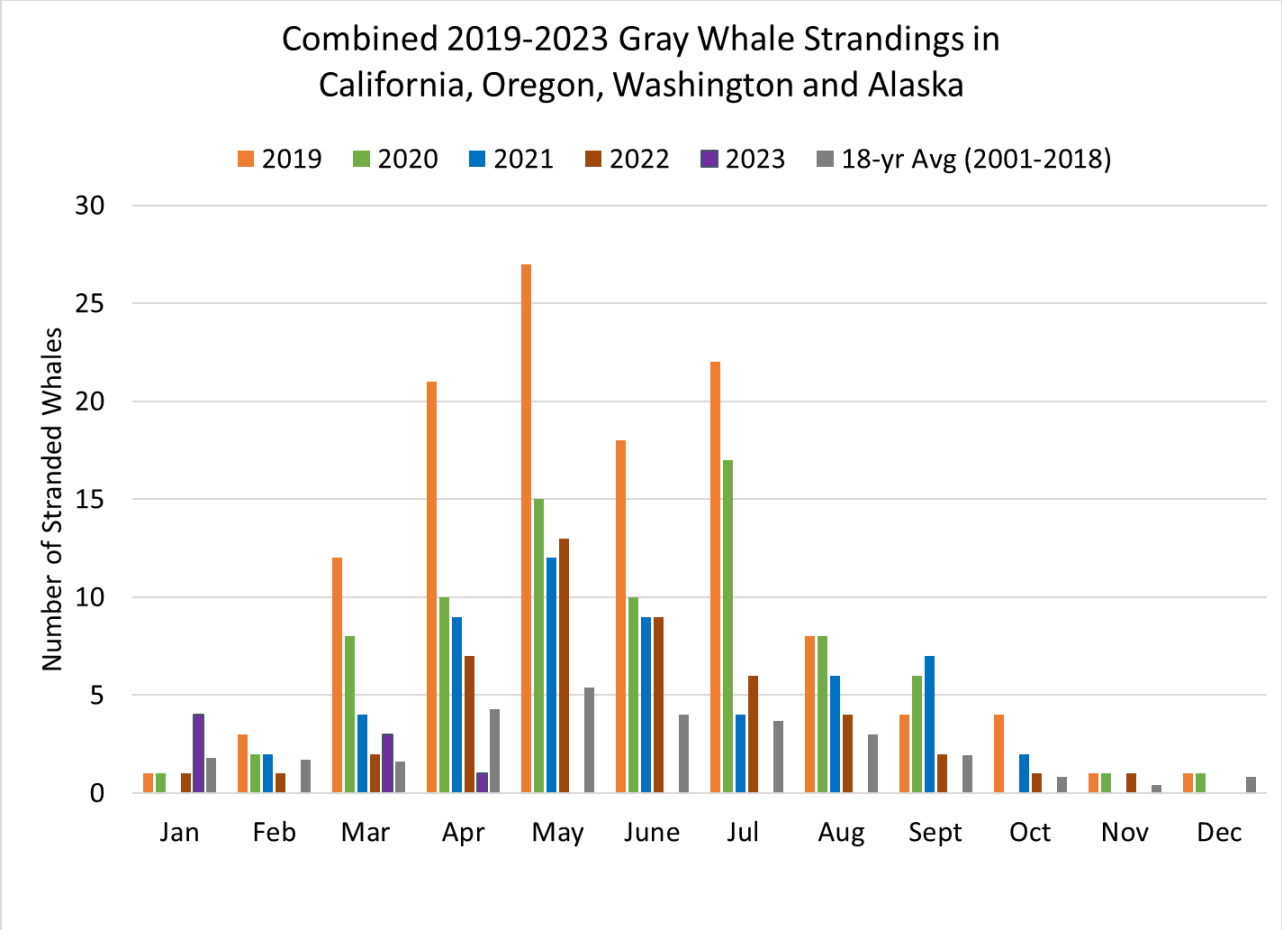

Figure 3: Annual U.S. Eastern North Pacific gray whale strandings from 1 January 2019 through 05 April 2023, compared to 18-year average (2001-2018).

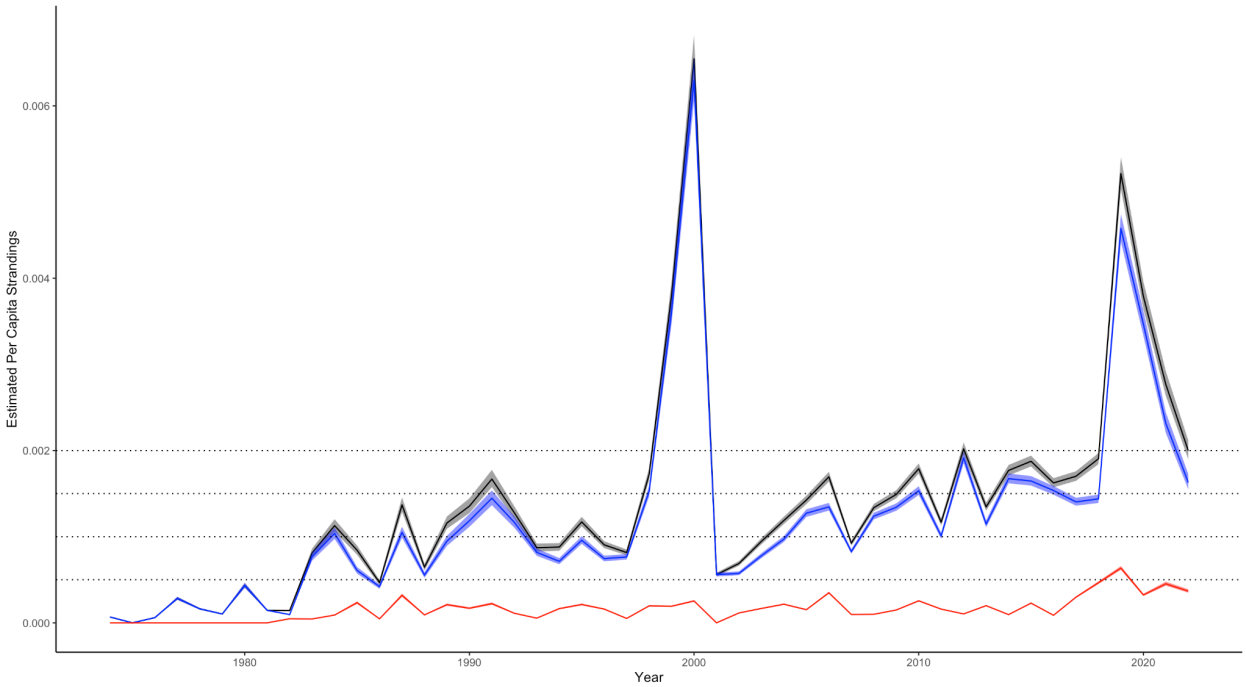

Figure 4: Annual per capita U.S. Eastern North Pacific gray whale strandings from 1970-2022. Red indicates strandings with evidence of human interactions (vessel strike, fishing gear entanglement), blue indicates strandings with no evidence of human interactions, and gray indicates total per capita strandings. Per capita stranding rates were calculated by dividing the number of recorded strandings by the estimated annual abundance from an integrated population dynamics model (Stewart *et al. in prep*). Horizontal dotted lines are reference lines for 0.0005, 0.001, 0.0015, and 0.002 recorded strandings per capita.

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REFERENCES

Broadwater, M.H., Van Dolah, F.M., and Fire, S.E. (2018). Vulnerabilities of marine mammals to harmful algal blooms. In: Shumway SE, Burkholder JM, Morton SL, editors. Harmful Algal Blooms. Chichester, UK: John Wiley & Sons, Ltd, pp. 191–222.

Christiansen, F., Rodríguez-González, F., Martínez-Aguilar, S., Urbán R., J., Swartz, S., Warick, H., Vivier, F. and Bejder, L. (2021). Poor body condition associated with an unusual mortality event in gray whales. Marine Ecology Progress Series 658:237-252.

Danil, K., Berman, M., Frame, E., Preti, A., Fire, S. E., Leighfield, T., Carretta, J., Carter, M. L., and Lefebvre, K. (2021). Marine algal toxins and their vectors in southern California cetaceans. Harmful algae, 103, 102000.

Eguchi, T., Lang, A. R., and Weller, D. W. (2022a). Abundance and migratory phenology of eastern North Pacific gray whales 2021/2022. U. S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-668. https://doi.org/10.25923/x88y-8p07.

Eguchi, T., Lang, A.R., and Weller, D.W. (2022b). Eastern North Pacific gray whale calf production 1994-2022. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-667. https://doi.org/10.25923/4g6h-9129.

Fire, S.E, Bogomolni, A., DiGiovanni, R.A., Jr., Early, G., Leighfield, T.A., Matassa K., *et al*. (2021). An assessment of temporal, spatial and taxonomic trends in harmful algal toxin exposure in stranded marine mammals from the U.S. New England coast. PLoS ONE 16(1): e0243570.

Lefebvre, K.A., Quakenbush, L., Frame E., Burek Huntington, K., Sheffield, G., Stimmelmayr, R., *et al*. (2016). Prevalence of algal toxins in Alaskan marine mammals foraging in a changing arctic and subarctic environment. Harmful Algae, 55: 13–24.

Moore, S.E., Clarke, J.T., Okkonen, S.R., Grebmeier, J.M., Berchok, C.L., and Stafford, K.M. (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.

Raverty, S., Duignan, P., Greig, J., Huggins, J., Burek, K., Garner, M., Calambokidis, J., Cottrell, P., Danil, K., D'Alessandro, D., Duffield, D., Flannery, M., Gulland, F., Halaska, B., King, C., Lambourn, D., Lenhart, T., Urban R., J., Rowles, T., Rice, J., Savage, K. Wilkinson, K. and Fauquier, D. (2020). Post mortem findings of a 2019 gray whale Unusual Mortality Event in the eastern North Pacific. Report to the International Whaling Commission, SC/68B/IST/05.

Raverty *et al*. (2023). In Prep. Gray whale (*Eschrichtius robustus*) post-mortem findings from 2018-2021 during the Unusual Mortality Event in the eastern North Pacific.

Stewart, J.D. and Weller, D.W. (2021a). Abundance of eastern North Pacific gray whales 2-19/2020. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-639.

Stewart, J.D., and Weller, D.W. (2021b). Estimates of eastern North Pacific gray whale calf production 1994-2021. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-653.

Stewart *et al.* (2023). In Prep. Boom-bust cycles in gray whales associated with dynamic and changing Arctic conditions.