United States Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center
Marine Mammal Laboratory
7600 Sand Point Way NE
Seattle WA 98115

7 February 2022

Memorandum To: The Record

From: Kathryn Sweeney, Burlyn Birkemeier, Katie Luxa, and Thomas Gelatt

Subject: Results of Steller Sea Lion Surveys in Alaska, June-July 2021

The Marine Mammal Laboratory (MML) conducted aerial surveys to photograph and count Steller sea lion (*Eumetopias jubatus*) pups (~1 month old) and non-pups (adults and juveniles ≥ 1 year old) hauled out on known terrestrial rookery and haulout sites (AFSC/MML/AEP 2016) in Alaska in June-July 2021. On odd years, MML surveys in the Gulf of Alaska (Southeast Alaska towards the western Gulf of Alaska) portion of the Steller sea lion range in Alaska. On even years, MML surveys the Aleutian Islands regions (and sometimes into the western Gulf of Alaska if sites were missed in the previous year). Surveys scheduled for 2020 were cancelled because of the COVID-19 pandemic. Additionally, there was no ship-based (or uncrewed aircraft system) effort in the Aleutian Islands in 2020 or 2021.

During the summer of 2021 there was a coordinated effort to survey the entire eastern DPS among the MML, Washington Department of Fish and Wildlife, Oregon department of Fish and Wildlife, and Fisheries of Oceans Canada. Once all counts are finalized, information will be shared in a NOAA Fisheries Stock Assessment Report. There was also a collaboration with the Ecosystem Conservation Office of the Aleut Community of St. Paul Island to survey Walrus Island, a rookery in the Pribilof Islands, which will be reported in our next survey memorandum.

The survey team conducted the 2021 survey from 23 June to 8 July from Southeast Alaska (Dixon Entrance, 132°W) through the western Gulf of Alaska (Sanak Islands, 163°W). These Gulf of Alaska surveys have been essential for obtaining status updates during and after anomalous warming events in the North Pacific Ocean reported in 2014-2016, and in 2018-2019 (Litzow et al. 2020). Subsequently, there were anomalies observed in sea lion counts from 2015 to 2019 in the Gulf of Alaska (Fritz et al. 2016, Sweeney et al. 2016-2019).

METHODS

Objectives in 2021 were to survey all terrestrial rookery and haulout sites throughout the Gulf of Alaska (including Southeast Alaska) for Steller sea lion pups and non-pups. Abundance surveys to count Steller sea lions are conducted in late June through mid-July starting ~10 days after the mean pup birth dates in the survey area (4-14 June) by which time ~95% of all pups have been born (Pitcher et al. 2001; Kuhn et al. 2017). Pup counts are

considered a census as pups do not enter the water until they are >1 month old. However, pups that are born or die after the survey are not accounted.

Steller Sea Lion Raw Counts

The survey team operated from a NOAA Twin Otter fixed-wing aircraft equipped with a three high-resolution digital camera mount (as in 2009-2019; see Fritz et al. 2016). The team captured imagery or conducted visual counts (when less than 10 sea lions were present) from Southeast Alaska through the western Gulf of Alaska region (Fig. 1). MML staff counted sea lions from aerial images as in previous years (see Fritz et al. 2016).

AgTrend Model Estimates

Our method for modeling raw count data (agTrend R package; Johnson and Fritz 2014) produces annual rates of change (i.e., trends) and count estimates for regional aggregations, which NOAA Fisheries uses for monitoring Steller sea lion populations. Modeled counts, like raw counts, do not account for animals at sea. The agTrend model produces two types of count estimates:

- **Predicted counts** are used to estimate trends, and account for both observation and process errors.
- **Realized counts** use the standardized variance of raw counts at each site throughout the time series to estimate survey counts we would expect to collect if we had completely surveyed all sites. Therefore, the more complete the survey, the more similar raw counts are to the realized counts, which is evident by smaller credible intervals.

The year with the lowest (nadir) non-pup and pup counts in the western distinct population segment (DPS) in Alaska was recorded in 2002 and in previous annual survey memoranda, we have reported trends since 2002. However, in the "Recovery Plan for the Steller Sea Lion: 5-year Review," (hereafter referred to as the "Review") trends over a 15-year period (2002 – 2017) were evaluated as one of the down-listing criteria (NMFS 2020). Therefore, as it relates to management purposes, in this year's memorandum we have estimated trends for the 15-year period 2006 - 2021for those areas we surveyed in 2021.

In the western DPS, we used raw count data from 1978 to 2021 and modeled counts and trends (2006-2021) for the areas that we surveyed in 2021: east of Samalga Pass; eastern (E-), central (C-), and western (W-) Gulf of Alaska (GULF) regions; E and C GULF regions combined (E+C GULF); and for the total western DPS in Alaska. We do not have any count updates for areas we have not surveyed since 2018 (eastern, central, and western Aleutian Islands regions, west of Samalga Pass). For reference, we only reported trends (2002-2018) from the 2018 survey memorandum for these Aleutian Islands areas (Sweeney et al. 2018). See Sweeney et al. 2018 for more information on the Aleutian Islands.

In Southeast Alaska (SE AK; eastern DPS) we modeled counts and trends for a 30-year period (1991-2021) with raw count data from 1971 to 2021.

RESULTS

The survey team completely surveyed 126 sites (of 134) in the E-, C-, and W GULF regions (Table 1) and 81 sites (of 84) in SEAK (Table 2). The team surveyed White Sisters Island (SE AK); however, due to fog impacting image quality, the pup count was incomplete and not included in analysis. There was incomplete survey coverage of three sites and therefore they were not included in the analyses (Graves Rock and Yasha in SE AK, and Seal Rocks [Kenai] in the E GULF). The team conducted surveys of 32 sites in the E GULF (no sites missed), 55 sites in the C GULF (four haulout sites missed), and 39 sites in the W GULF (three haulout sites and one rookery site missed). Only one haulout site was missed in SE AK.

During the survey, the team came across four new (to MML) site locations:

- Midway Islands (SE AK): 58.251 N, 136.388 W;
- Valdez Arm (E GULF): 61.0809 N, 146.653 W;
- Kodiak/Izhut Bay (C GULF): 58.2345 N, 152.2628 W;
- And Sandman Reef Rock (W GULF): 54.834 N. 161.741 W.

As with past newly discovered sites, MML will add these to the Steller sea lion site list to include in future surveys.

Steller Sea Lion Raw Counts

In this section, we compared 2021 raw counts with counts we observed in 2019 and hereafter, all 2019 data is cited from Sweeney et al. 2019, unless stated otherwise.

Gulf of Alaska regions' non-pup counts—In the western DPS in 2021, we counted 19,721 live non-pups on 83 sites that had at least one non-pup present (Table 1).

We counted 4,490 non-pups in the E GULF, which is slightly more than what we reported in 2019 (+212). In the C GULF we counted 8,352 non-pups and in the W GULF, we counted 6,879. Because we missed sites in the C- and W GULF regions, we were unable to compare 2021 counts with raw counts from previous years.

Southeast Alaska non-pup counts—We counted 14,133 live non-pups on 37 sites with at least one non-pup present in the Southeast Alaska region (Table 2). The sites we saw the greatest declines in non-pup counts since 2019 were (percentage change since 2019): Biali Rock (-43%), Cape Addington -35%), Forrester Complex (-24%), Hazy (-11), Sea Lion Islands (-48%), The Brothers (-58%), West Rock (-56%), West Rock (-56%), White Sisters (-16%), and Wolf Rock (-38%).

Gulf of Alaska regions' pup counts—We counted 6,629 live pups from aerial images captured at 34 sites that had at least one pup present in the three GULF regions combined (western DPS; Table 1).

In the E GULF region we counted 1,128 pups, 26 fewer than we observed in 2019. We counted 2,793 pups in the C GULF, an increase of 104 animals from 2019. In the W GULF, we missed one rookery but were able to compare to 2019 counts after subtracting the missing rookery's pup count from the 2019 total raw count. We counted 2,708 pups in the W GULF which is 265 fewer animals than we observed in 2019.

Southeast Alaska pup counts—We counted a total of 5,317 live pups from aerial images on 11 sites in Southeast Alaska (eastern DPS) that had at least one pup present (Table 2). We did not observe significant changes in pup counts except for a 23% increase at Biali Rocks.

AgTrend Model Estimates

We reported agTrend modeled predicted counts as estimates for regional areas and reported changes in realized counts that have not been "smoothed" to highlight fine scale changes in counts from year to year.

We compared the 2006-2021 trends with those reported from 2002-2017 in the Review for the Gulf of Alaska regions and entire western DPS (NMFS 2020). Hereafter, all trend data from the 2002-2017 period from the Review is cited from NMFS 2020, unless otherwise stated. Similarly, all data from the 2019 survey is cited from Sweeney et al. 2019, unless otherwise noted.

Gulf of Alaska regions' modeled non-pup counts and trends—Non-pup counts for the total western DPS in Alaska increased at a rate of 1.69% y^{-1} between 2006 and 2021 (95% credible interval or CI of 0.93-2.43% y^{-1}; Table 3 and Figure 2). This trend is lower than that reported in the Review (2.14% y^{-1} for a period 2002-2017). The agTrend predicted count estimate for the western DPS in Alaska was 40,528 (95% CI 35,867-46,952).

Non-pups east of Samalga Pass increased 2.30% y^{-1} (95% CI 1.43-3.06% y^{-1}) from 2006 to 2021 (Table 3). We observed that the W GULF increased at a rate of 2.07% y^{-1} for the same period, which is lower than what was reported in the Review (3.01% y^{-1}). Similarly, the E- (1.77% y^{-1}) and C- (3.78% y^{-1}) GULF region trends were lower than those reported in the Review (4.21 and 3.90% y^{-1}, respectively), especially in the E GULF.

From 2019 to 2021, in the combined E+C GULF regions, we observed an increase of 1,132 non-pups (realized counts), after a decline of 2,628 non-pups between 2017 (Sweeney et al. 2017) and 2019 (Figure 3). The increase in this E+C GULF combined area was mostly due to a slight increase in the C GULF region (E GULF was similar to 2019). The W GULF declined by 444 non-pups since 2019. Overall, counts in the Gulf of Alaska were similar to what we estimated in 2019; however, counts haven't been this low in the Gulf of Alaska since before 2011 (Figure 4).

Southeast Alaska modeled non-pup counts and trends—Non-pup counts in Southeast Alaska (eastern DPS) increased at 2.12% y^{-1} (95% CI 1.54-2.72% y^{-1}) in the last 30-year period (1991 to 2021) which is a lower positive trend than what we reported in 2019 (2.53% y^{-1} from 1989 to 2019; Table 3 and Figure 5). The predicted non-pup count was estimated to be 20,515 (95% CI 16,530-25,363). Realized counts indicated non-pups declined 19% from 2019 to 2021.

Gulf of Alaska regions' modeled pup counts and trends—Pup counts in the total western DPS in Alaska increased 1.16% y^{-1} (95% CI 0.51-1.89% y^{-1}), which is lower than the trend reported in the Review (1.78% y^{-1}; Table 3 and Figure 6). The total agTrend predicted pup count for the western DPS in Alaska in 2021 was 12,631 (95% CI 11,115-14,216), 50 more pups than we reported in 2019 (Figure 6).

Pup counts east of Samalga Pass between 2006 and 2021 increased at 2.22% y^{-1}, (95% CI 1.41-2.93% y^{-1}; Table 3). Pup counts in each of the GULF regions were relatively similar to 2019, except the W GULF pup count was slightly lower (276 pups, realized count; Figure 7). Overall, counts in the Gulf of Alaska (combined) appeared to remain relatively stable since 2013 with the exception of the decline in pups in 2017 in the E -and C- GULF regions (Figure 8).

Southeast Alaska modeled pup counts and trends—Pup counts in Southeast Alaska (eastern DPS) increased 2.69% y^{-1} from 1991 to 2021, which is a lower rate of increase than in 2019 (2.85% y^{-1}; Table 3 and Figure 9). This is likely because pup counts have been relatively stable since 2009. The predicted pup count was estimated to be 7,510 (95% CI 6,281-8,898).

DISCUSSION

Overall counts of Steller sea lion pups and non-pups within the range of the western DPS in Alaska increased between 2006 and 2021; however, the trends reported for this 15-year period were much lower for the total western DPS and GULF regions (with the exception of W GULF non-pups) than what was reported in the Review. This indicates that the rate of increase is slowing down, which can be attributed to the continued population decline west of Samalga Pass (Sweeney 2018) and the flat trend in the Gulf of Alaska. This is concerning given the Gulf of Alaska regions were increasing between 2002 and 2011.

Non-pups in Southeast Alaska have been relatively stable since 2015, but declined by 19% between 2019 and 2021 (Figure 5). Despite this decline in non-pups, pup counts in Southeast Alaska have remained relatively stable since 2009.

Several factors, or a combination thereof, could account for trends in the Gulf of Alaska. It's possible that environmental changes related to anomalous warming events in the North Pacific Ocean could be a major contributor. The Pacific marine heatwave persisted across the Gulf of Alaska from 2014 to 2016, with more normal temperatures observed in 2017, and warming again from 2018 to 2019 (Litzow et al. 2020). This warming could be impacting pup production, juvenile survival, adult survival, and/or movement of sea lions in or out of the area, although the mechanism is unknown.

Between 2002 and 2015 we saw a fairly steady increase in non-pups throughout the Gulf of Alaska regions (Figures 3 and 4). In 2017 we observed a higher increase non-pups in the C GULF and corresponding decrease in the neighboring E GULF. Additionally, the combined non-pup counts for the E and C GULF did not change between 2015 and 2017. We attributed this shift to an atypical movement of ~1,000 adult females and juveniles from E to C GULF while the W GULF remained stable (Sweeney et al. 2017). In 2019, non-pup counts declined in the E GULF and remained low in 2021 (at approximately 2010 levels) while the C GULF counts returned to 2015 levels. We do not believe that the increased C GULF counts in 2021 are due to movement from the other GULF regions or Southeast Alaska given counts were virtually the same or lower in these neighboring regions.

The decline in non-pups in the E and C GULF regions in 2019 was preceded by a dramatic decline in pups in both regions in 2017. We speculated that those lower counts observed in 2019 may have been related given a smaller cohort of new pups could contribute to a

reduction in non-pups (2-year olds) two years later. However, this does not explain the drop in non-pups seen in the W and E GULF regions in 2021 though we do not have count information for the even years we did not survey (e.g., 2018 and 2020).

The 2015 non-pup and pup counts in Southeast Alaska were the highest reported in over 50 years yet they dropped below these levels after 2015. Non-pup counts in 2021 are now similar to counts we observed a decade earlier, when pup counts remained relatively flat.

In Southeast Alaska we observed a higher proportion of pups to adult females and juveniles (combined) on rookeries; 19-32% higher than we observed in previous years (at least since 2013). Given pup counts were similar from 2017 to 2019 and there were fewer adult female and juveniles (combined) on rookery sites, this could indicate that there was not a marked decline in reproductive females, but rather a decline in juveniles. The absence of non-pups on the rookery could also be due in part to non-breeding sea lions (and potentially their yearling from the previous year) using haulouts instead of rookeries in 2021. We did not find evidence of similar changes in the GULF, making it difficult to understand if juvenile survival could have played a part in stabilizing non-pup counts in the GULF. We are limited in what we can infer from the count data, especially without more complete haulout site coverage in 2019, and further research is necessary to understand the mechanisms behind both the decline in Southeast Alaska non-pups and the stabilizing in Gulf of Alaska region's non-pups.

Overall, the focused surveys in the Gulf of Alaska in 2021 revealed that non-pup and pup counts of Steller sea lions have continued to be flat (or negative) since 2015 and 2017. Similarly, our counts in Southeast AK revealed a 19% decline in non-pups between 2019 and 2021 while pup counts have remained stable since around 2010.

Researchers have documented a cascade of negative heatwave impacts on numerous species in the Gulf of Alaska from lower to upper trophic levels (Suryan et al. 2021, Von Biela et al. 2019, Yang et al. 2019). For example, in 2017 NOAA Fisheries observed that Pacific cod (*Gadus macrocephalus*) declined 71% in abundance (58% in biomass) in the Gulf of Alaska (Barbeaux et al. 2018) and those declines have continued through 2020 (NMFS 2021). Pacific cod is one of the top four important prey species for sea lions in the GULF region, especially during the winter (~49% frequency of occurrence; Sinclair et al. 2013). Declines in the quantity and quality of other key sea lion prey, including Pacific sand lance (*Ammodytes hexapterus)* and Pacific herring (*Clupea pallasii)*, have also been reported (Suryan et al. 2021, Von Biela et al. 2019). Indeed, following the initial 2014-2016 heatwave, mass mortality and reproductive failure of common murres (*Uria aalge*) in the Gulf of Alaska were thought to be a result of changes in forage fish populations (Piatt et al. 2020).

Warming events are predicted to be the "new normal" in the Gulf of Alaska and long-term impacts on marine communities are not yet known. These changes highlight the importance of regular surveys to monitor species, especially long-lived marine mammals for whom observable, population-level effects may be delayed.

ACKNOWLEDGMENTS

B. Hou, K. Luxa (MML), and B. Birkemeier (University of Washington Cooperative Institute for Climate, Ocean, and Ecosystem Studies and MML) conducted the Twin Otter survey. B. Birkemeier and K. Sweeney analyzed and counted sea lions from imagery. We thank K. Cosentino, C. Licitra, C. O'Toole, and the entire NOAA Aircraft Operations Center for conducting the crewed aircraft survey, and Captain John Faris and the crew of the USFWS *R/V Tiĝlâx* for their continued support of our Aleutian Islands Steller sea lion research project. Each survey presents a unique set of logistical, mechanical, and weather-related challenges, and because of their dedication, we are able to complete as much as possible. Thank you to NOAA AOC's UAS Division for their part in our continued successful implementation of UAS. MML also greatly appreciates the commitment of Morgan Lynn, Jim Gilpatrick and Wayne Perryman (SWFSC), and Don LeRoi (Aerial Imaging Solutions, LLC) to making aerial surveys possible, and the Bureau of Land Management (DOI) for being the "eye in the sky" for the crewed aircraft flights. We thank M. McCormley for her review and comments to improve this manuscript. Research was conducted under authority of U.S. Marine Mammal Protection Act/Endangered Species Act Permit 22289, and NMFS IACUC Protocol NWAK 18-03.

LITERATURE CITED

AFSC / MML / Alaska Ecosystems Program. 2016. Steller sea lion haulout and rookery locations in the United States for 2016-05-14 (NCEI Accession 0129877). NOAA National Centers for Environmental Information. Dataset. Doi: 10.7289/V58C9T7V

Barbeaux, S., Aydin, K., Fissel, B., Holsman, K., Laurel, B., Palsson, W. … Zador, S. 2018. Chapter 2: Assessment of the Pacific cod stock in the Gulf of Alaska in Assessment of Pacific cod stock in the Gulf of Alaska. U.S. Dep. Commer., NOAA Fisheries, December 2018. 160 p.

Fritz L.W., Towell, R., Gelatt, T.S., Johnson, D.S., and Loughlin, T. R. 2014. Recent increases in survival of western Steller sea lions in Alaska and implications for recovery. End. Species Research 26(1):13-24.

Fritz, L., Sweeney, K., Towell, R., and Gelatt, T. 2016. Aerial and ship-based surveys of Steller sea lions (*Eumetopias jubatus*) conducted in Alaska in June-July 2013 through 2015, and an update on the status and trend of the western distinct population segment in Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-321, 72 p

Johnson, D. S., and Fritz, L. W. 2014. agTrend: A Bayesian approach for estimating trends of aggregated abundance. Methods in Ecology and Evolution 5(10): 1110-1115.

Kuhn C. E., Chumbley, K., Johnson, D., and Fritz, L. 2017. A re-examination of the timing of pupping for Steller sea lions *Eumetopias jubatus* breeding on two islands in Alaska. Endang Species Res 32:213-222. https://doi.org/10.3354/esr00796

Litzow, M., Hunsicker, M., Ward, E., Anderson, S., Gao, J., Zador, S. … O'Mallely, R. 2020. Evaluating ecosystem change as Gulf of Alaska temperature exceeds the limits of preindustrial variability. Prog in Ocean 186:1-15.

National Marine Fisheries Service (NMFS). 2021. Stock SMART data records. Retrieved from ww.st.nmfs.noaa.gov/stocksmart. 12/22/2021.

National Marine Fisheries Service (NMFS). 2020. Western Distinct Population Segment Steller sea lion *Eumetopias jubatus* 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Protected Resources Division, Juneau, AK

National Marine Fisheries Service (NMFS). 2008. Recovery Plan for the Steller Sea Lion (*Eumetopias jubatus*). Revision. National Marine Fisheries Service, Silver Spring, MD. 325 pages.

Pitcher, K. W., Burkanov, V. N., Calkins, D. G., LeBoeuf, B. J., Mamaev, E. G., Merrick, R. L., and Pendleton, G. W. 2001. Spatial and temporal variation in the timing of births of Steller sea lions. J. Mammalogy 82(4): 1047-1053.

Sinclair, E. H., Johnson, D. S., Zeppelin, T. K., and Gelatt, T. S. 2013. Decadal variation in the diet of Western Stock Steller sea lions (*Eumetopias jubatus*). U.S. Dep. Commer., NOAA Tech. Memo. NMFSAFSC-248, 67 p.

Suryan, R.M., Arimitsu, M.L., Coletti, H.A., Hopcroft, R.R., Lindeberg, M.R., Barbeaux, S.J. …Zador, S. 2021. Ecosystem response persists after a prolonged marine heatwave. Nature Sci Rept 11(6235), 17 p.

Sweeney, K. L., Fritz, L., Towell, R., and Gelatt, T. 2016. Results of Steller sea lion surveys in Alaska, June-July 2016. Memorandum to D. DeMaster, J. Bengtson, J. Balsiger, J. Kurland, and L. Rotterman, December 5, 2016. https://www.afsc.noaa.gov/NMML/PDF/SSL_Aerial_Survey_2016.pdf.

Sweeney, K. L., Fritz, L., Towell, R., and Gelatt, T. 2017. Results of Steller Sea Lion Surveys in Alaska, June-July 2017. Memorandum to The Record. November 29,

2017. https://www.fisheries.noaa.gov/resource/data/2017-results-steller-sea-lion-surveys-alaska

Sweeney, K. L., Towell, R., and Gelatt, T. 2018. Results of Steller Sea Lion Surveys in Alaska, June-July 2018. Memorandum to The Record. December 4, 2018. https://www.fisheries.noaa.gov/resource/data/2018-results-steller-sea-lion-surveys-alaska

Sweeney, K. L., Birkemeier, B., Luxa, K., and Gelatt, T. 2019. Results of Steller Sea Lion Surveys in Alaska, June-July 2019. Memorandum to The Record. December 6, 2019. https://www.fisheries.noaa.gov/resource/data/2019-results-steller-sea-lion-surveys-alaska

Von Biela, V. R., Arimitsu, M. L., Piatt, J. F., Heflin, B., Schoen, S., Trowbridge, J., and Clawson, C. 2019. Extreme reduction in nutritional value of a key forage fish during the Pacific marine heatwave of 2014-2016. Mar. Ecol. Prog. Series 21(613):171-82

Yang, Q., Cokelet, E. D., Stabeno, P. J., Li, L., Hollowed, A. B., Palsson, W. A., Bond, N. A., and Barbeaux, S. 2018. How "The Blob" affected groundfish distributions in the Gulf of Alaska. Fish. Oceanography 1-20, 20 p.

TABLES & FIGURES

Table 1—Counts of live Steller sea lion non-pups and pups on sites surveyed in the eastern (E-), central (C-), and western Gulf of Alaska (W GULF) regions (western DPS) in 2021 by the survey team. In the ROOK column, rookery sites are noted as "1" (≥ 50 pups in any year since 1970). In the COUNT TYPE column, "image" indicates the count is a mean of two independent counters from aerial imagery while "visual" indicates a visual observation by one or two observers on the aircraft. We indicated those sites that were new by adding "- NEW SITE" to the SITE name.

SITE	REGION	ROOK	DATE	NON-PUP	PUP	COUNT TYPE
AIALIK CAPE	E GULF	0	29-Jun	1		VISUAL
CAPE FAIRFIELD	E GULF	0	3-Jul	1		VISUAL
CAPE HINCHINBROOK	E GULF	0	3-Jul	46	0	IMAGE
CAPE JUNKEN	E GULF	0	3-Jul	0		VISUAL
CAPE PUGET	E GULF	0	3-Jul	0		VISUAL
CAPE RESURRECTION	E GULF	0	3-Jul	68	0	IMAGE
CAPE ST. ELIAS	E GULF	0	3-Jul	990	58	IMAGE
CHISWELL ISLANDS	E GULF	1	29-Jun	118	62	IMAGE
DANGER	E GULF	0	3-Jul	111	0	IMAGE
DUTCH GROUP	E GULF	0	3-Jul	243	4	IMAGE
FOX	E GULF	0	3-Jul	164	0	IMAGE
GLACIER	E GULF	0	3-Jul	508	30	IMAGE
GRANITE CAPE	E GULF	0	29-Jun	62	0	IMAGE
HOOK POINT	E GULF	0	3-Jul	34	0	IMAGE
MIDDLETON	E GULF	0	3-Jul	78	0	IMAGE
NATOA (GROTTO)	E GULF	0	29-Jun	26	0	IMAGE
NO NAME	E GULF	0	29-Jun	48	0	IMAGE
PERRY	E GULF	0	3-Jul	14	0	IMAGE
PILOT ROCK	E GULF	0	29-Jun	1		VISUAL
PLEIADES	E GULF	0	3-Jul	0		VISUAL
POINT ELEANOR	E GULF	0	3-Jul	0		VISUAL
POINT ELRINGTON	E GULF	0	3-Jul	70	0	IMAGE
POINT LaTOUCHE	E GULF	0	3-Jul	0		VISUAL
PROCESSION ROCKS	E GULF	0	3-Jul	120	4	IMAGE
RABBIT	E GULF	0	29-Jun	0		VISUAL
RAGGED/HOOF POINT	E GULF	0	29-Jun	95	1	IMAGE
RUGGED	E GULF	0	3-Jul	8	0	IMAGE
SEAL ROCKS	E GULF	1	3-Jul	920	642	IMAGE
STEEP POINT	E GULF	0	29-Jun	0		VISUAL
THE NEEDLE	E GULF	0	3-Jul	104	19	IMAGE
VALDEZ ARM - NEW SITE	E GULF	0	3-Jul	34	0	IMAGE
WOODED (FISH)	E GULF	1	3-Jul	626	308	IMAGE
AFOGNAK/TONKI CAPE	C GULF	0	29-Jun	2		VISUAL
AGHIYUK	C GULF	0	8-Jul	113	0	IMAGE
AIUGNAK COLUMNS	C GULF	0	7-Jul	4	0	IMAGE

SITE	REGION	ROOK	DATE	NON-PUP	PUP	COUNT TYPE
CAPE GULL	C GULF	0	6-Jul	0		VISUAL
CAPE KULIAK	C GULF	0	6-Jul	206	0	IMAGE
CAPE NUKSHAK	C GULF	0	6-Jul	0		VISUAL
CAPE UGYAK	C GULF	0	6-Jul	0		VISUAL
CHIRIKOF	C GULF	1	8-Jul	631	162	IMAGE
CHOWIET	C GULF	1	8-Jul	1003	620	IMAGE
EAST CHUGACH	C GULF	0	3-Jul	0		VISUAL
GORE POINT	C GULF	0	29-Jun	1		VISUAL
KILOKAK ROCKS	C GULF	0	7-Jul	88	0	IMAGE
KODIAK/BIRD ROCK	C GULF	0	6-Jul	0		VISUAL
KODIAK/CAPE ALITAK	C GULF	0	6-Jul	0		VISUAL
KODIAK/CAPE BARNABAS	C GULF	0	6-Jul	172	1	IMAGE
KODIAK/CAPE CHINIAK	C GULF	0	29-Jun	100	0	IMAGE
KODIAK/CAPE IKOLIK	C GULF	0	6-Jul	176	0	IMAGE
KODIAK/CAPE KULIUK	C GULF	0	6-Jul	0		VISUAL
KODIAK/CAPE PARAMANOF	C GULF	0	6-Jul	0		VISUAL
KODIAK/CAPE UGAT	C GULF	0	6-Jul	288	6	IMAGE
KODIAK/CAPE UYAK	C GULF	0	6-Jul	0		VISUAL
KODIAK/GULL POINT	C GULF	0	6-Jul	7	0	IMAGE
KODIAK/IZHUT BAY - NEW SITE	C GULF	0	3-Jul	48	0	IMAGE
KODIAK/MALINA POINT	C GULF	0	6-Jul	0		VISUAL
KODIAK/STEEP CAPE	C GULF	0	6-Jul	36	0	IMAGE
KODIAK/STURGEON HEAD	C GULF	0	6-Jul	0		VISUAL
KODIAK/SUNDSTROM	C GULF	0	6-Jul	0		VISUAL
KODIAK/TOMBSTONE ROCKS	C GULF	0	6-Jul	0		VISUAL
LATAX ROCKS	C GULF	0	3-Jul	352	42	IMAGE
LONG ISLAND	C GULF	0	29-Jun	130	0	IMAGE
MARMOT	C GULF	1	29-Jun	959	685	IMAGE
NAGAHUT ROCKS	C GULF	0	3-Jul	3	0	IMAGE
NAGAI ROCKS	C GULF	0	8-Jul	211	3	IMAGE
NOISY	C GULF	0	6-Jul	0		VISUAL
NUKA POINT	C GULF	0	29-Jun	0		VISUAL
OUTER (PYE)	C GULF	1	29-Jun	291	108	IMAGE
PERL	C GULF	0	3-Jul	410	0	IMAGE
PERL ROCKS	C GULF	0	3-Jul	0		VISUAL
PUALE BAY	C GULF	0	6-Jul	304	1	IMAGE
SEA LION ROCKS (MARMOT)	C GULF	0	29-Jun	37	0	IMAGE
SEA OTTER	C GULF	0	29-Jun	114	14	IMAGE
SEA OTTER/RK NEAR	C GULF	0	29-Jun	0		VISUAL
SHAKUN ROCKS	C GULF	0	6-Jul	184	6	IMAGE
SITKINAK/CAPE SITKINAK	C GULF	0	6-Jul	292	1	IMAGE
SUD	C GULF	0	3-Jul	0		VISUAL
SUGARLOAF	C GULF	1	3-Jul	1093	914	IMAGE
SUTWIK	C GULF	0	7-Jul	269	22	IMAGE

SITE	REGION	ROOK	DATE	NON-PUP	PUP	COUNT TYPE
TAKLI	C GULF	0	6-Jul	0		VISUAL
TWOHEADED	C GULF	1	6-Jul	370	80	IMAGE
UGAIUSHAK	C GULF	0	7-Jul	0		VISUAL
UGAK	C GULF	0	6-Jul	0		VISUAL
USHAGAT/NW	C GULF	0	3-Jul	0		VISUAL
USHAGAT/ROCKS SOUTH	C GULF	0	3-Jul	76	0	IMAGE
USHAGAT/SW	C GULF	1	3-Jul	382	128	IMAGE
WEST AMATULI	C GULF	0	3-Jul	0		VISUAL
ATKINS	W GULF	1	7-Jul	768	325	IMAGE
ATKULIK	W GULF	0	7-Jul	0		VISUAL
BIG KONIUJI	W GULF	0	7-Jul	0		VISUAL
BIRD (SHUMAGINS)	W GULF	0	7-Jul	16	0	IMAGE
CASTLE ROCK	W GULF	0	7-Jul	4		VISUAL
CHANKLIUT	W GULF	0	7-Jul	0		VISUAL
CHERNABURA	W GULF	1	7-Jul	1032	351	IMAGE
CHERNI	W GULF	0	7-Jul	0		VISUAL
CLUBBING ROCKS NORTH	W GULF	1	7-Jul	52	0	IMAGE
CLUBBING ROCKS SOUTH	W GULF	1	7-Jul	1011	883	IMAGE
EGG (SAND POINT)	W GULF	0	7-Jul	28	0	IMAGE
HAGUE ROCK	W GULF	0	7-Jul	0		VISUAL
HUNT	W GULF	0	7-Jul	0		VISUAL
JUDE	W GULF	1	7-Jul	768	352	IMAGE
KAK	W GULF	0	7-Jul	152	0	IMAGE
KUPREANOF POINT	W GULF	0	7-Jul	162	0	IMAGE
LIGHTHOUSE ROCKS	W GULF	1	7-Jul	248	10	IMAGE
MITROFANIA	W GULF	0	7-Jul	228	0	IMAGE
NAGAI/MOUNTAIN POINT	W GULF	0	7-Jul	192	0	IMAGE
NAGAI/RK W OF CAPE WEDGE	W GULF	0	7-Jul	0		VISUAL
OLGA ROCKS NE	W GULF	0	7-Jul	30	0	IMAGE
OLGA ROCKS SW	W GULF	0	7-Jul	222	2	IMAGE
OMEGA	W GULF	0	7-Jul	0		VISUAL
PAUL	W GULF	0	7-Jul	0		VISUAL
PINNACLE ROCK	W GULF	1	7-Jul	920	656	IMAGE
SANDMAN REEF ROCK – NEW SITE	W GULF	0	7-Jul	18	0	IMAGE
SEA LION ROCKS (SHUMAGINS)	W GULF	0	7-Jul	88	0	IMAGE
SEAL CAPE	W GULF	0	7-Jul	15	0	IMAGE
SIMEONOF	W GULF	0	7-Jul	125	0	IMAGE
SOZAVARIKA	W GULF	0	7-Jul	0		VISUAL
SPITZ	W GULF	0	7-Jul	87	0	IMAGE
SUSHILNOI ROCKS	W GULF	1	7-Jul	321	63	IMAGE
THE HAYSTACKS	W GULF	0	7-Jul	31	0	IMAGE
THE WHALEBACK	W GULF	1	7-Jul	126	66	IMAGE
TWINS	W GULF	0	7-Jul	0		VISUAL
UMGA	W GULF	0	7-Jul	0		VISUAL

SITE	REGION	ROOK	DATE	NON-PUP	PUP	COUNT TYPE
UNGA/ACHEREDIN POINT	W GULF	0	7-Jul	174	0	IMAGE
UNGA/CAPE UNGA	W GULF	0	7-Jul	0		VISUAL
WOSNESENSKI	W GULF	0	7-Jul	61	0	IMAGE

Table 2—Counts of live Steller sea lion non-pups and pups on sites surveyed in the Southeast Alaska region (eastern DPS) in 2021 by the survey team. Rookery sites are noted with a "1" (≥ 50 pups in any year since 1970) in the ROOK column. In the COUNT TYPE column, "image" indicates the count is a mean of two independent counters from aerial imagery while "visual" indicates a visual observation by one or two observers on the aircraft. We indicated those sites that were new by adding "- NEW SITE" to the SITE name.

SITE	ROOK	DATE	NON-PUP	PUP	COUNT TYPE
AKWE	0	28-Jun	0		VISUAL
ALSEK	0	28-Jun	0		VISUAL
BENJAMIN	0	27-Jun	30	0	IMAGE
BERNERS BAY	0	27-Jun	0		VISUAL
BIALI ROCK	1	23-Jun	661	274	IMAGE
BLACK ROCK	0	27-Jun	0		VISUAL
CAPE ADDINGTON	0	23-Jun	489	2	IMAGE
CAPE BARTOLOME	0	26-Jun	0		VISUAL
CAPE BINGHAM	0	28-Jun	182	0	IMAGE
CAPE CROSS	0	28-Jun	0		VISUAL
CAPE FAIRWEATHER	0	28-Jun	0		VISUAL
CAPE OMMANEY	0	26-Jun	114	0	IMAGE
CAPE OMMANEY/S	0	26-Jun	3		VISUAL
CASE (TLINGIT) POINT	0	27-Jun	0		VISUAL
CIRCLE POINT	0	27-Jun	0		VISUAL
CORONATION	0	26-Jun	0		VISUAL
DOROTHY	0	27-Jun	0		VISUAL
EASTERLY	0	26-Jun	190	0	IMAGE
ELDRED ROCK	0	27-Jun	0		VISUAL
EMMONS	0	27-Jun	0		VISUAL
ETOLIN	0	26-Jun	0		VISUAL
FALSE POINT PYBUS	0	27-Jun	0		VISUAL
FORRESTER/C HORN RK	1	23-Jun	355	346	IMAGE
FORRESTER/EAST RK	1	23-Jun	167	183	IMAGE
FORRESTER/FORRESTER ISLAND	1	23-Jun	37	0	IMAGE
FORRESTER/LOWRIE	1	23-Jun	1466	1568	IMAGE
FORRESTER/NORTH RK	1	23-Jun	830	916	IMAGE
FORRESTER/SEA LION RK	1	23-Jun	544	562	IMAGE
FUNTER BAY	0	27-Jun	0		VISUAL
GAFF ROCK	0	27-Jun	0		VISUAL
GLOOMY KNOB	0	27-Jun	0		VISUAL
GRAN (LEDGE) POINT	0	27-Jun	175	0	IMAGE
GRINDALL	0	26-Jun	238	0	IMAGE
HAENKE	0	28-Jun	12	0	IMAGE
HARBOR POINT	0	28-Jun	222	0	IMAGE
HAZY	1	26-Jun	1750	1431	IMAGE
HORN CLIFF	0	26-Jun	0		VISUAL

SITE	ROOK	DATE	NON-PUP	PUP	COUNT TYPE
INIAN	0	27-Jun	2		VISUAL
JACOB ROCK	0	27-Jun	244	0	IMAGE
KAIUCHALI (BIORKA)	0	27-Jun	8	0	IMAGE
LARCH BAY	0	26-Jun	0		VISUAL
LIBBY ISLAND	0	27-Jun	325	0	IMAGE
LISENOI	0	26-Jun	0		VISUAL
LITTLE ISLAND	0	27-Jun	0		VISUAL
MET POINT	0	27-Jun	0		VISUAL
MIDDLE PASS ROCK	0	27-Jun	131	0	IMAGE
MIDWAY ISLANDS - NEW SITE	0	27-Jun	205	0	IMAGE
MIST	0	27-Jun	0		VISUAL
NOSE POINT	0	26-Jun	0		VISUAL
PATTERSON POINT	0	26-Jun	0		VISUAL
PINTA ROCKS	0	27-Jun	0		VISUAL
POINT CAROLUS	0	27-Jun	1	0	IMAGE
POINT LEAGUE (STEVENS PASSAGE)	0	27-Jun	0		VISUAL
POINT LULL	0	27-Jun	28	0	IMAGE
POINT MARSDEN	0	27-Jun	0		VISUAL
POINT MARSH	0	26-Jun	0		VISUAL
ROCKY ISLAND	0	27-Jun	298	0	IMAGE
ROUND ROCK	0	27-Jun	0		VISUAL
SAIL	0	27-Jun	204	0	IMAGE
SAKIE POINT	0	26-Jun	0		VISUAL
SEA LION ISLANDS	0	27-Jun	376	0	IMAGE
SEA LION ROCK (PUFFIN BAY)	0	23-Jun	140	0	IMAGE
SITKAGI BLUFFS	0	28-Jun	0		VISUAL
SITUK	0	28-Jun	0		VISUAL
SOUTH MARBLE	0	27-Jun	1392	26	IMAGE
ST. LAZARIA	0	27-Jun	0		VISUAL
SUKOI ISLETS	0	26-Jun	0		VISUAL
SUNSET	0	27-Jun	552	6	IMAGE
SUNSET POINT	0	27-Jun	0		VISUAL
TARR INLET	0	27-Jun	0		VISUAL
TENAKEE CANNERY POINT	0	27-Jun	0		VISUAL
THE BROTHERS/SW	0	27-Jun	216	0	IMAGE
THE BROTHERS/W+E	0	27-Jun	0		VISUAL
THE SISTERS	0	27-Jun	0		VISUAL
TIMBERED	0	23-Jun	458	3	IMAGE
TURNABOUT	0	27-Jun	0		VISUAL
VENISA	0	27-Jun	0		VISUAL
WALTER (PORT HOUGHTON)	0	27-Jun	0		VISUAL
WEST ROCK	0	26-Jun	483	0	IMAGE
WHITE SISTERS	1	27-Jun	1309		IMAGE
WOLF ROCK	0	23-Jun	296	0	IMAGE

Table 3—Annual rates of change (% y^{-1} with ± 95% credible intervals) of Steller sea lion non-pup and pup counts modeled with agTrend predicted counts, listed from west to east. The western (W-), central (C-), and eastern Aleutian Islands (E ALEU) regions and west of Samalga Pass were modeled for the period 2002-2018 (Sweeney et al. 2018). We modeled the total western DPS (US) and the following regional areas therein that were largely surveyed in 2021 for the period 2006-2021: western (W-), central (C-), and eastern Gulf of Alaska (E GULF) regions; eastern and central Gulf regions combined (E+C GULF); and east of Samalga Pass. Southeast Alaska (SE AK; eastern DPS) was modeled for the 30-year period 1991-2021.

	NON-PUP			PUP		
REGION	**RATE**	**-95% CI**	**+95% CI**	**RATE**	**-95% CI**	**+95% CI**
Aleutian Islands annual rates of change for the period 2002-2018						
W ALEU (RCA 1)	-6.47	-7.81	-5.21	-6.47	-7.42	-5.57
C ALEU	-0.53	-1.64	0.50	-1.60	-2.75	-0.21
RCA 2	-4.16	-6.19	-2.03	-4.43	-6.50	-2.25
RCA 3	-3.05	-4.19	-1.73	-3.44	-4.66	-2.15
RCA 4	-0.23	-2.17	1.96	-0.84	-2.31	2.92
RCA 5	2.41	0.14	4.78	0.19	-2.19	2.51
West of Samalga Pass	-1.22	-2.20	-0.25	-2.08	-3.13	-0.79
E ALEU	1.76	0.50	3.07	2.54	1.67	3.46
Gulf of Alaska annual rates of change for the period 2006-2021						
W GULF	2.07	0.52	3.55	2.47	1.17	3.83
E+C GULF (combined)	2.92	1.82	4.01	2.65	1.45	3.84
C GULF	3.78	2.71	4.82	3.01	1.56	4.53
E GULF	1.77	-0.42	3.92	1.84	0.01	3.70
East of Samalga Pass	2.30	1.43	3.06	2.22	1.41	2.93
All western DPS (US)	**1.69**	**0.93**	**2.43**	**1.16**	**0.51**	**1.89**
Southeast Alaska (eastern DPS) annual rates of change for the period 1991-2021						
SE AK	2.12	1.54	2.72	2.69	2.26	3.17

Figure 1—Steller sea lion terrestrial rookeries and haulouts surveyed in June-July 2021. Survey regions, rookery cluster areas (RCAs), and the boundary between the eastern and western distinct population segments (DPS) in Alaska are also shown.

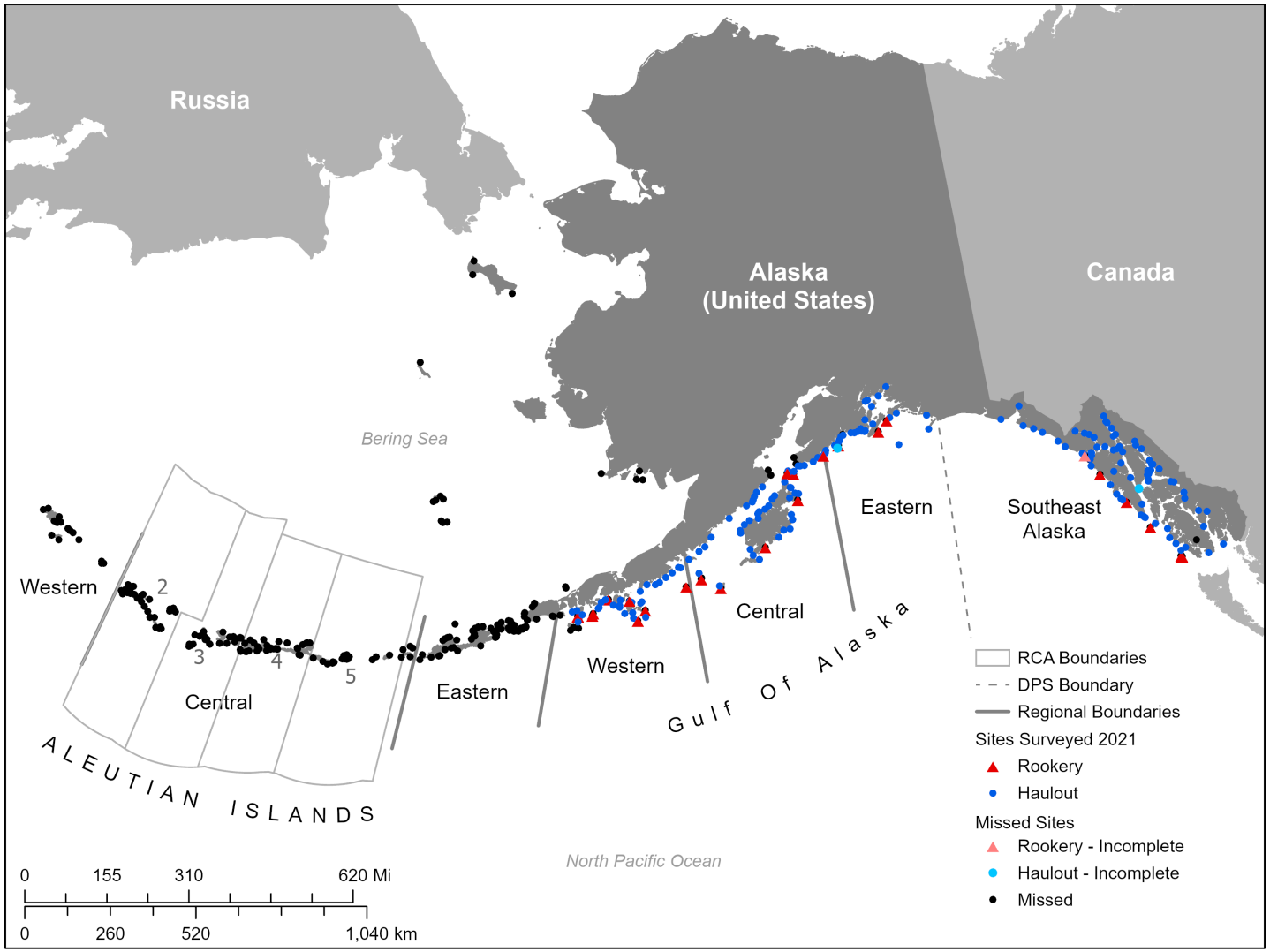

Figure 2—Realized and predicted counts of western DPS Steller sea lion non-pups in Alaska, 2002-2021. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

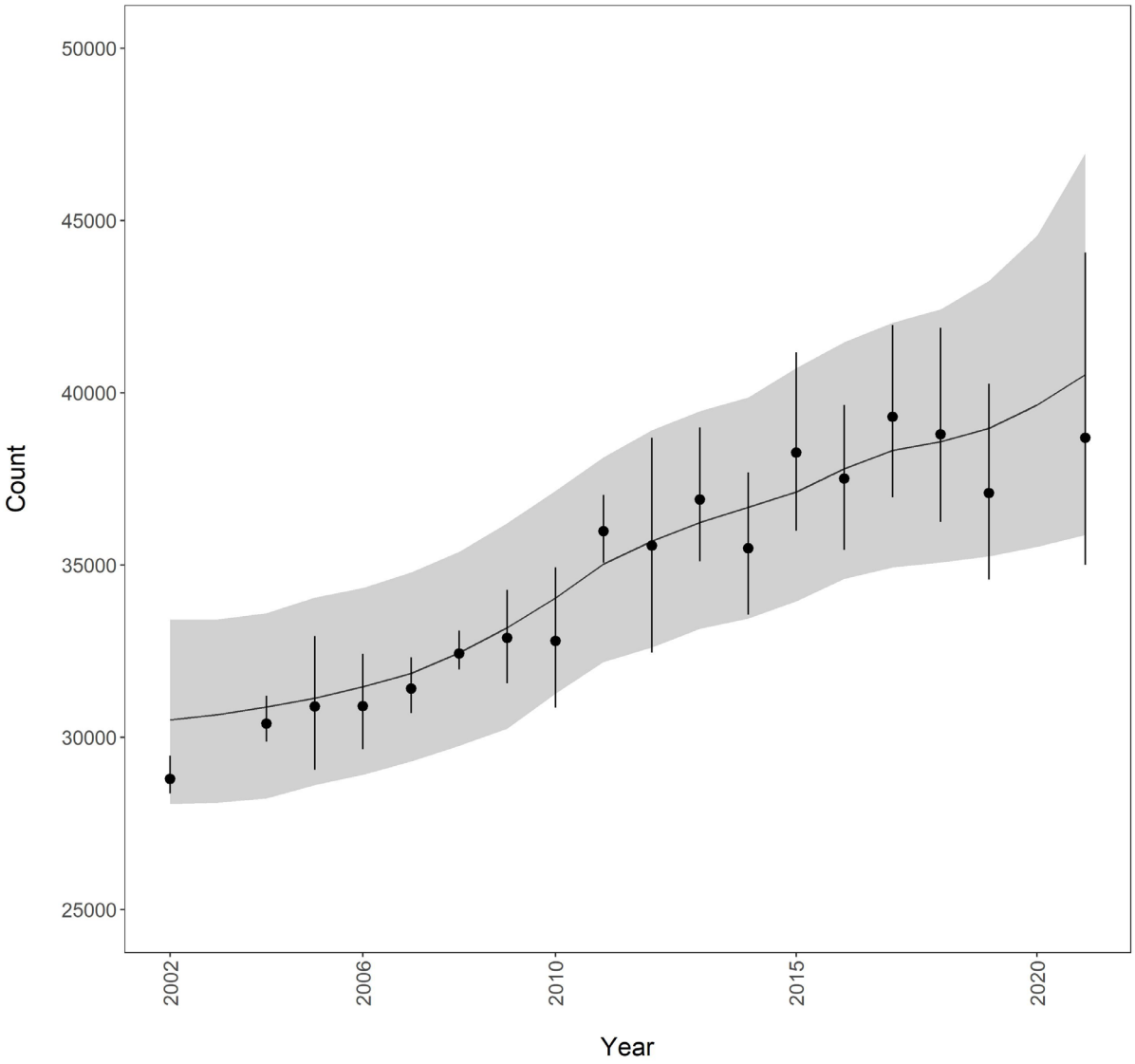

Figure 3—Realized and predicted counts of western DPS Steller sea lion non-pups in the western (W-), central (C-), and eastern Gulf of Alaska (E GULF) regions, 2002-2021. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

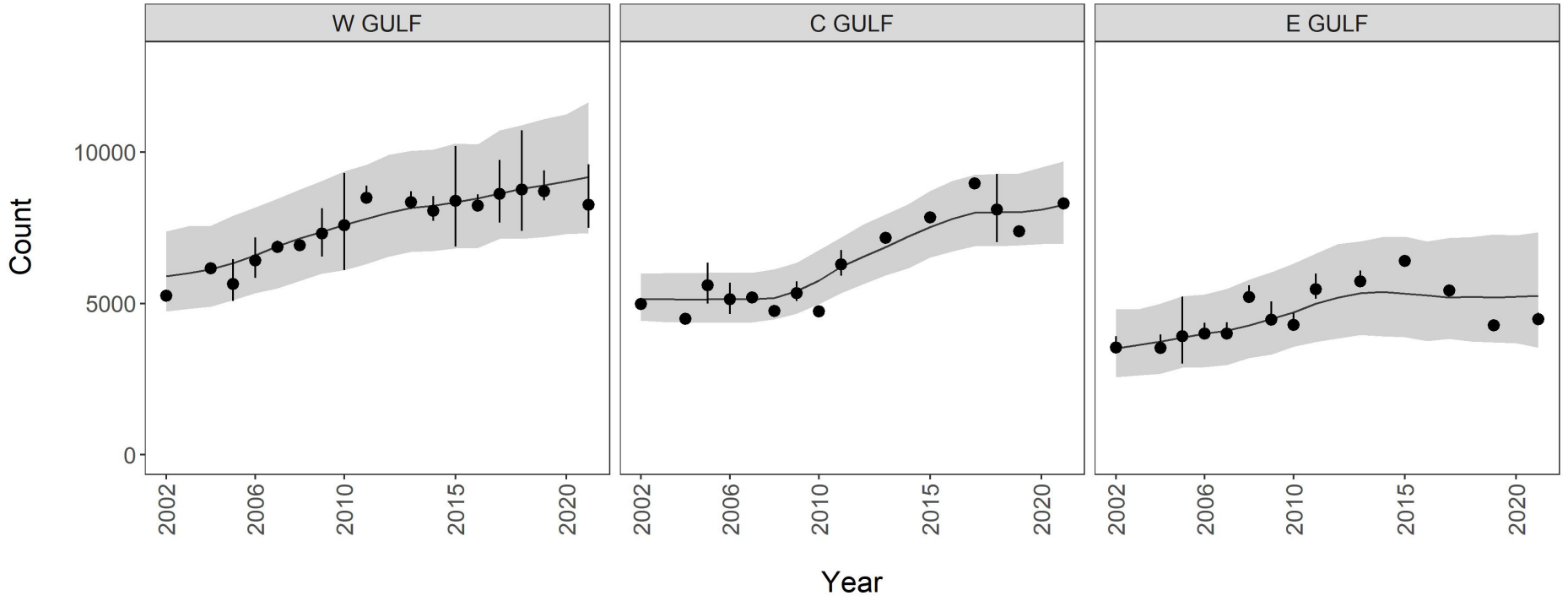

Figure 4—Realized and predicted counts of western DPS Steller sea lion non-pups in the combined regions of the Gulf of Alaska, 2002-2021. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

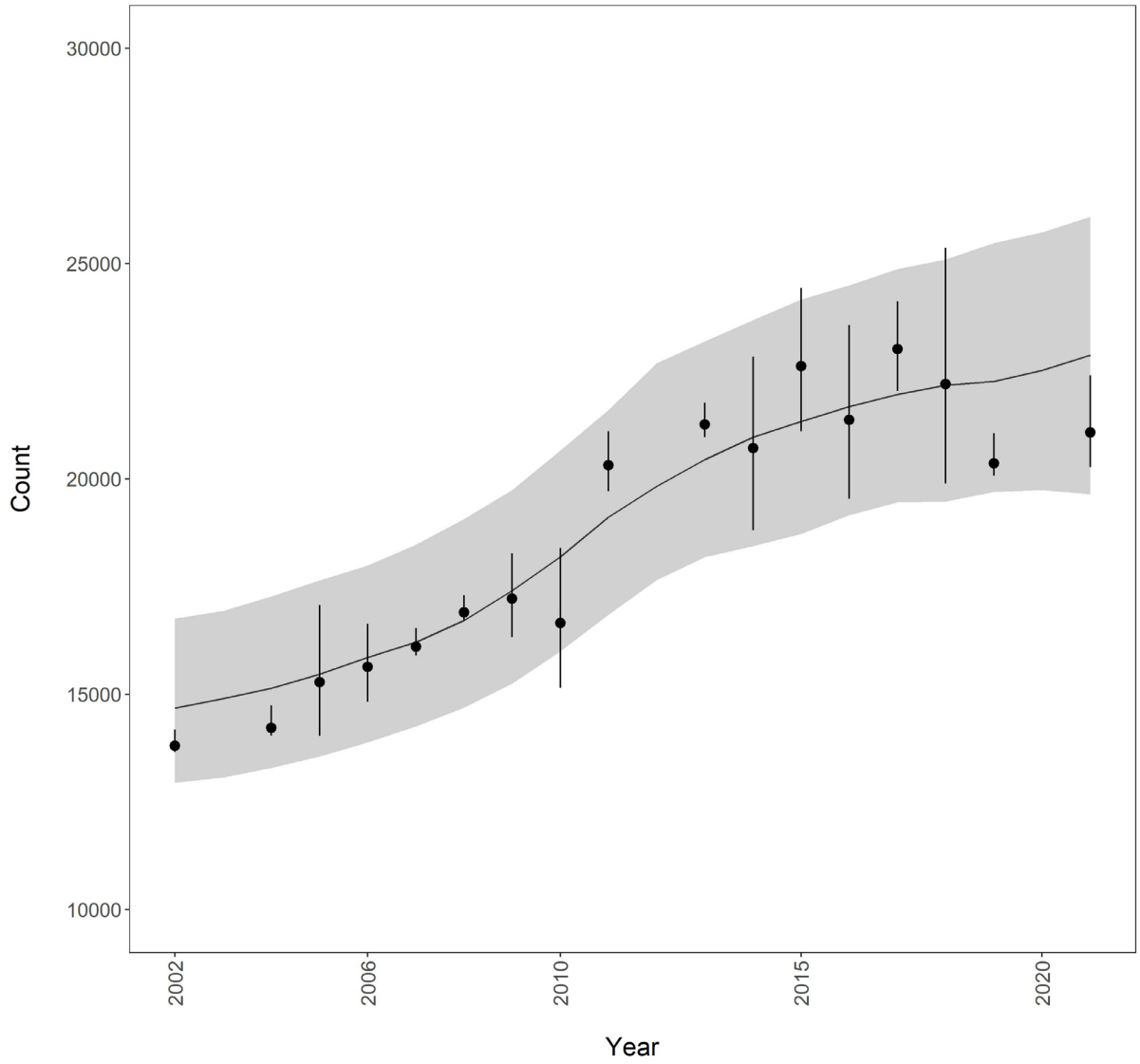

Figure 5—Realized and predicted counts of eastern DPS Steller sea lion non-pups in the Southeast Alaska region, 1991-2021. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

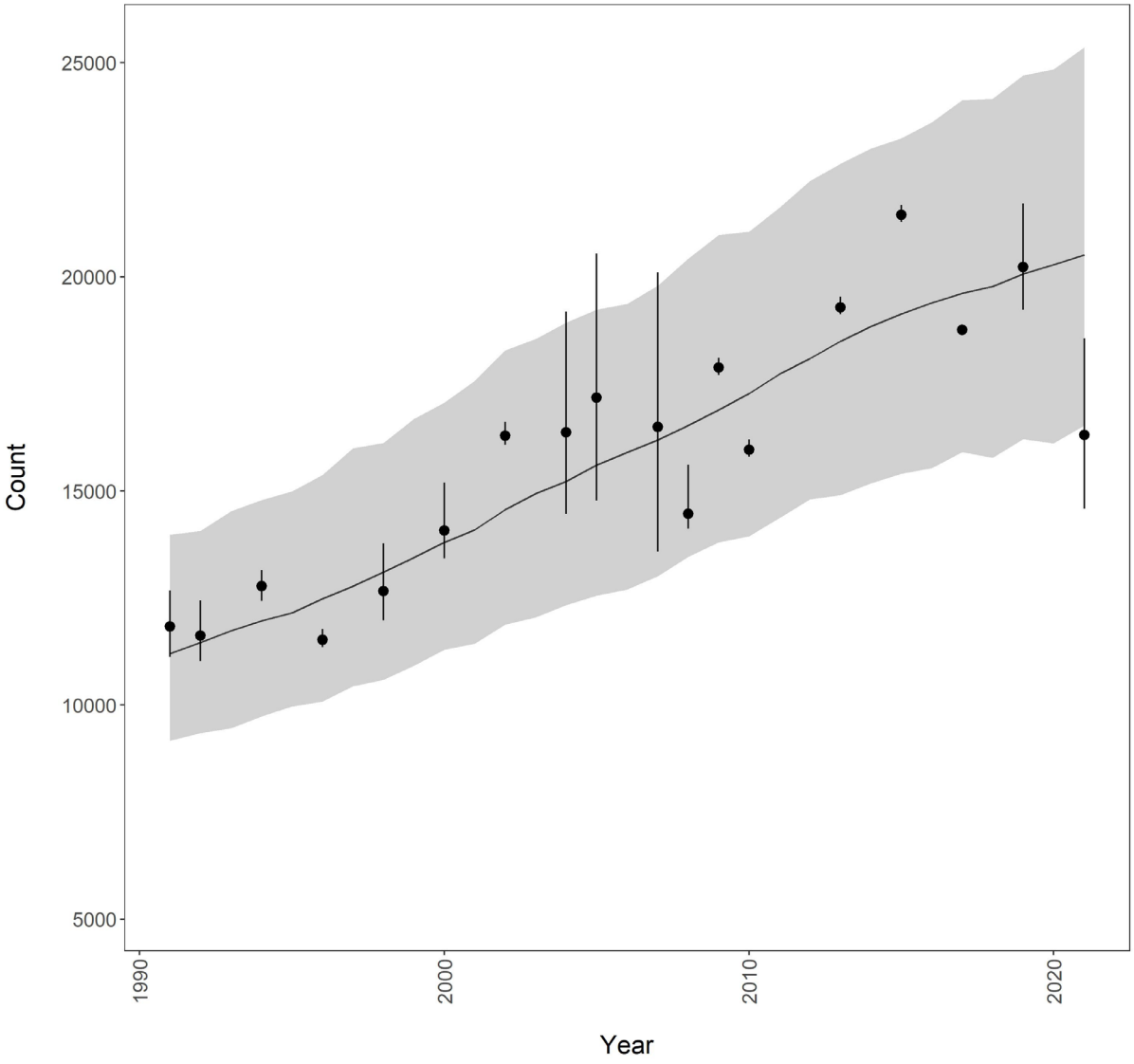

Figure 6—Realized and predicted counts of western DPS Steller sea lion pups in Alaska, 2002-2021. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

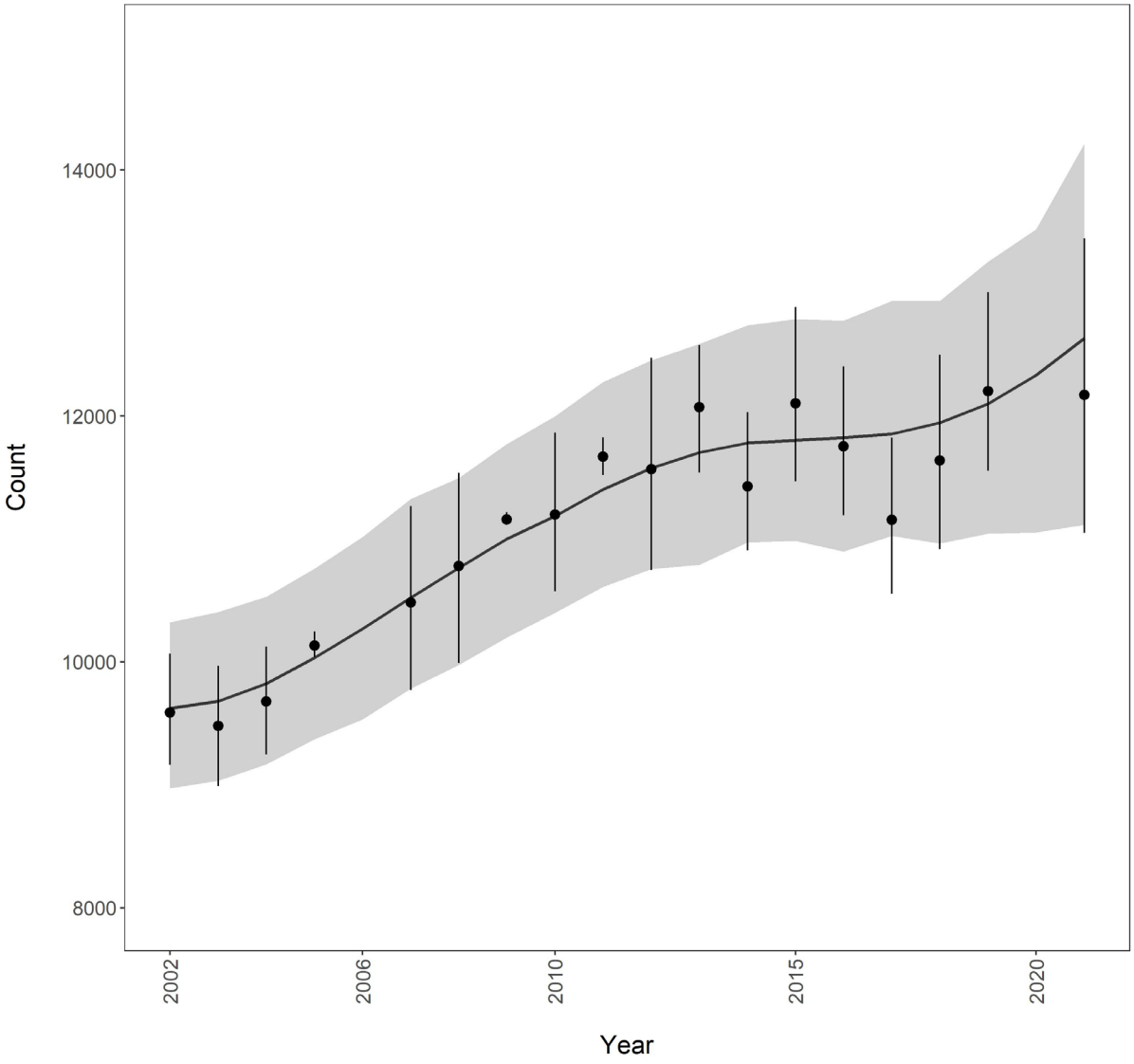

Figure 7—Realized and predicted counts of western DPS Steller sea lion pups in the western (W-), central (C-), and eastern Gulf of Alaska (E GULF) regions, 2002-2021. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

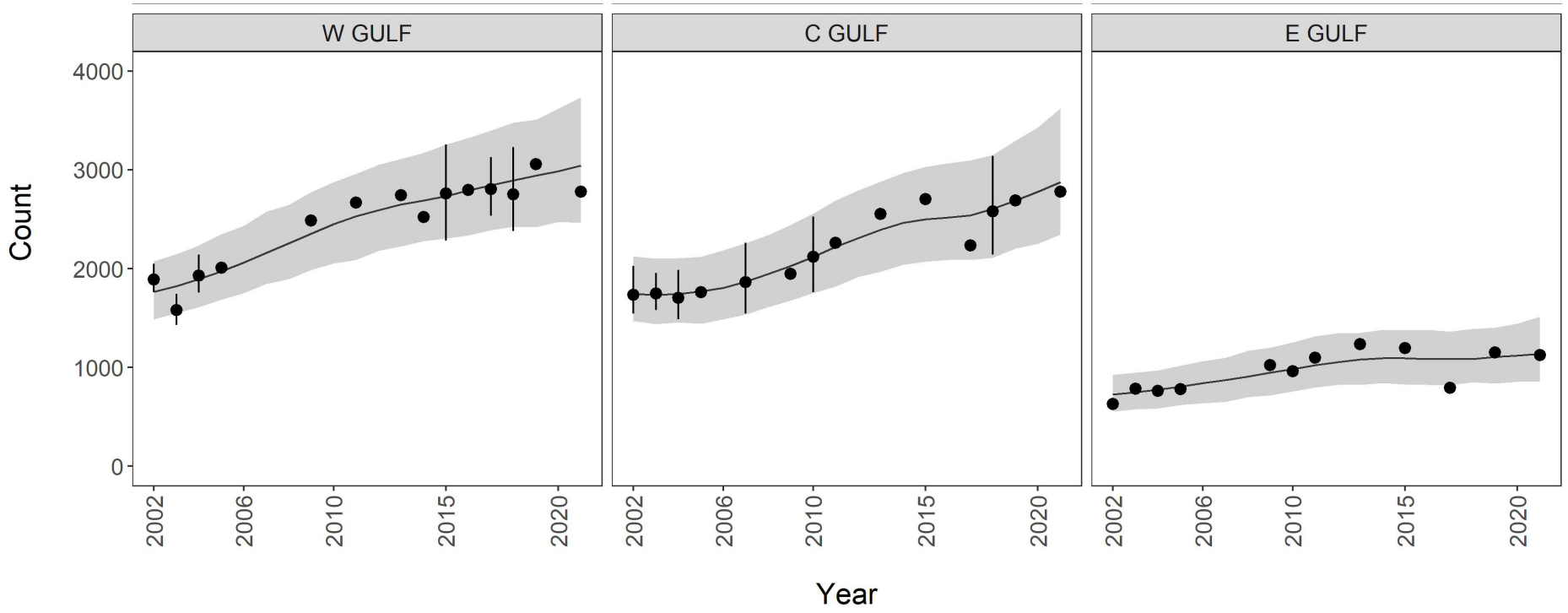

Figure 8—Realized and predicted counts of western DPS Steller sea lion pups in the combined regions of the Gulf of Alaska, 2002-2021. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

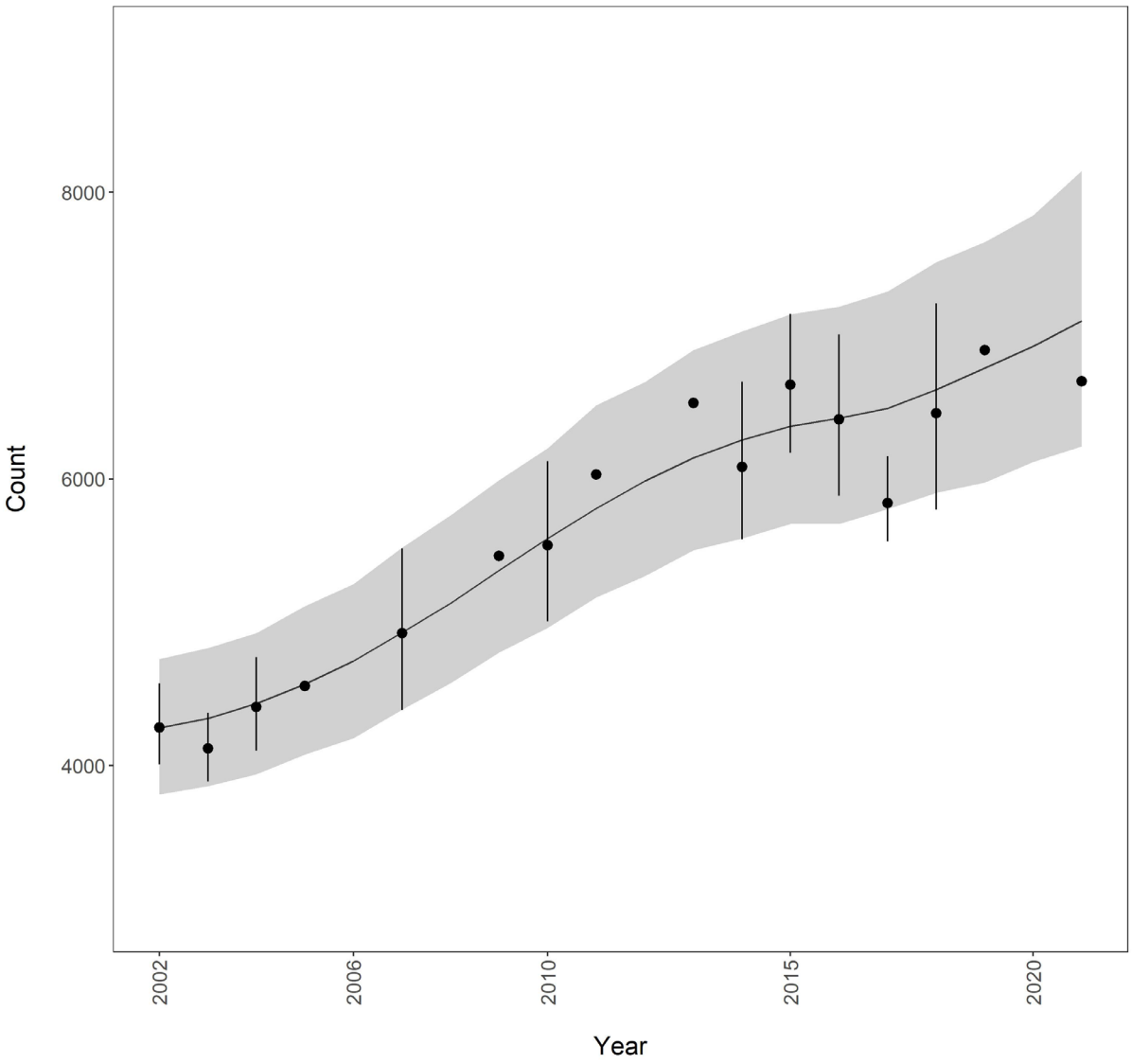

Figure 9—Realized and predicted counts of eastern DPS Steller sea lion pups in the Southeast Alaska region, 1991-2021. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.