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6 December 2019

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 2019

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) on known terrestrial rookery and haulout sites (AFSC/MML/AEP 2016) in Alaska in June-July 2019. On odd years, MML focuses their survey effort on the Gulf of Alaska (southeast Alaska towards the western Gulf of Alaska) portion of the Steller sea lion range in Alaska. The occupied aircraft survey team conducted their survey from 24 June to 4 July from southeast Alaska (Dixon Entrance, 132°W) through the western Gulf of Alaska (Sanak Islands, 163°W). On even years, MML focuses their survey effort in the Aleutian Islands (from the western through the eastern Aleutian Islands regions), and sometimes into the western Gulf of Alaska region if not surveyed the previous year.

The ship-based survey team on board the *R/V Tiĝlâx* did not conduct visual counts or collect aerial imagery using an unoccupied aircraft system (UAS or drone) during the cruise from 20 June to 2 July. The survey team did travel the Aleutian Islands between Adak Island (176°W) and Attu Island (172°E) focusing on other research priorities.

METHODS

MML's objectives for 2019 were to survey all terrestrial rookery and haulout sites throughout the Gulf of Alaska (including southeast Alaska). This survey was of significant importance in order to get a status update after the anomalous pup decline observed in this area in the 2017 survey (Sweeney et al. 2017).

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 are born (Pitcher et al. 2001; Kuhn et al. 2017). Pup counts are essentially a census as pups do not enter the water until they're >1 month old however, pups that are born or die after the survey are not included.

Steller sea lion raw counts

The occupied aircraft survey team operated from a NOAA Twin Otter fixed-wing aircraft equipped with three high-resolution digital cameras (as in 2009-2018; 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 captured with Twin Otter camera array as in previous years (see Fritz et al. 2016).

agTrend modeled estimates

Our method for modeling raw count data (agTrend R package; Johnson and Fritz 2014) produces annual rates of change and count estimates for regional aggregations, which NOAA Fisheries uses for monitoring the Steller sea lion populations. This model produces two types of count estimates: predicted and realized counts. 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 could expect to collect if we had completely surveyed all sites. Therefore, the more complete the survey, the more similar raw counts are to realized counts, which is evident by smaller credible intervals. Modeled counts, like raw counts, do not account for animals at sea.

The year with the lowest non-pup and pup counts for the western DPS in Alaska was 2002. Therefore, we estimated annual rates of change (i.e., trends) from 2002 (Fritz et al. 2016). Using raw count data from 1978 to 2019, we modeled counts and trends (from 2002 to 2019) for the western distinct population segment (DPS) areas that were largely surveyed in 2019: east of Samalga Pass; eastern, central, and western Gulf of Alaska (GULF) regions; eastern and central GULF regions combined (to compare with previous years' analyses); and for the total western DPS in Alaska. For areas that we did not survey in 2019 (west of Samalga Pass; eastern, central, and western Aleutian Islands regions), we reported the annual trend rates (from 2002 to 2018) modeled using raw count data from 1978 to 2018 (Sweeney et al. 2018).

For the eastern DPS, we modeled with raw count data from 1971 to 2019 to calculate trends for a 30-year period (1989-2019).

RESULTS

Before the survey began, the NOAA Aircraft Operations Center flight team had to conduct required maintenance on the Twin Otter aircraft, which changed our survey start location from Sitka to Anchorage, and delayed the start date by one day. Considering these logistical impacts and the importance of conducting a complete survey of the GULF regions to provide an update since the unprecedented pup decline we observed in 2017, we focused survey effort in southeast Alaska on all of the rookeries and major haulouts.

The survey team visited a total 130 sites in the eastern, central, and western GULF regions (western DPS; Table 1) and 26 sites in southeast Alaska (eastern DPS; Table 2). The team surveyed 100% of the eastern GULF sites, 100% of the central GULF, and 90% of the western GULF (missed 3 haulout sites). In the central GULF, the team discovered a 'new' (to MML) site called Suklik (56.0443°N, 156.639°W).

Given the unprecedented favorable weather, the survey team completed the survey in 11 days (9 flight days; typically surveys end on or around 11 July) before reaching the maximum allocated flight hours. The five Bering Sea (eastern Aleutian Islands region) sites were not surveyed because of limited flight hours and the priority to complete as much of the western GULF region as possible.

Throughout this memorandum, we reference raw counts, and modeled (using agTrend) counts and trends that we observed in 2015 and 2017 (the last two GULF survey years). Hereafter, all 2015 and 2017 data is cited from Fritz et al. 2016 and Sweeney et al. 2017 (respectively), unless stated otherwise.

Steller sea lion raw counts

Non-pup counts—We counted 20,129 live non-pups on 86 sites that had at least one non-pup present (Table 1). We counted 4,278 non-pups in the eastern GULF, which is 986 fewer non-pups than we counted in 2017 and 1,956 fewer than 2015. In the central GULF we counted 7,474 non-pups (1,479 fewer than 2017 and 362 fewer than in 2015). In the western GULF, we counted 8,377 non-pups. Since we missed three haulout sites (Bird, Umga, and Nagai/Mountain Point), we are unable to compare raw counts to previous years.

We counted 18,827 live non-pups on 24 sites with at least one non-pup in the southeast Alaska region (eastern DPS; Table 2). We did not survey 57 haulouts.

Pup counts—We counted 6,898 live pups from aerial images captured at 32 sites that had at least one pup present in the three GULF regions (western DPS; Table 1). In the eastern and central GULF regions we counted 1,154 and 2,689 pups, respectively. This is an increase of 359 and 454 pups from 2017 counts (respectively); between 2015 and 2017 we saw a decline of 399 and 472 pups, respectively. In the western GULF we didn't miss any significant pupping sites (we have observed 0-4 pups at Bird since 2011). We counted 3,055 pups in the western GULF however, since past survey years in this region have been incomplete, we cannot compare raw counts.

We counted a total of 6,984 live pups from aerial images on 18 sites in southeast Alaska (eastern DPS) that had at least one pup present (Table 2). Since we surveyed all rookeries and major haulouts where we have historically observed pups, we can compare raw pup counts to previous years. We previously observed a 6% decline in pups from 2015 to 2017. Raw pup counts remained relatively stable from 2017 to 2019.

agTrend modeled estimates

We report the two types of counts that AgTrend is used to estimate: predicted and realized counts. We used realized counts that have not been "smoothed" to report on changes over time.

Non-Pup modeled counts and trends—Non-pup counts for the total western DPS in Alaska increased at a rate of 1.82% y^{-1} between 2002 and 2019 (95% credible interval or CI of 1.29-2.38% y^{-1}; Table 3 and Figure 2). This rate of increase is lower than what we reported in 2018 (2.05% y^{-1}; Sweeney et al. 2018), as well as in the previous three years. The agTrend predicted count estimate for the western DPS in Alaska was 40,351 (95% CI 35,886-44,884) which is 1,431 fewer non-pups than what we reported in 2018.

Non-pups east of Samalga Pass increased 2.71% y^{-1} (95% CI 2.05-3.35) from 2002 to 2019. This rate of increase is lower in magnitude than what we reported in 2018 (3.07% y^{-1}) and 2017 (3.09% y^{-1}). Continuing the pattern of lower magnitudes of annual growth rates, we observed that the western GULF increased at a rate of 2.77% y^{-1} in 2002-2019, which is lower than what we reported in 2017 (3.01% y^{-1}) and in earlier surveys. Similarly, the eastern (3.32% y^{-1}) and central (3.40% y^{-1}) GULF regions increased at lower rates than what we reported in previous survey years.

Previously we reported that between 2015 and 2017, we saw an anomalous decline of ~1,000 non-pups in realized counts in the eastern GULF region and an increase in the central GULF, which was likely caused by an atypical western movement of non-pups. However, in the combined eastern and central GULF regions, non-pup counts remained relatively stable (62 more non-pups in 2017).

From 2017 to 2019, in the combined E+C GULF, we observed a decline of 2,628 non-pups (realized couns) because of declines in non-pups in both the eastern (-1,059) and central (-1,569) GULF regions (Figure 3). The non-pup count for the Gulf of Alaska regions combined has not been this low since 2011 (Figure 4).

Non-pup counts in southeast Alaska (eastern DPS) increased at 2.53% y^{-1} (95% CI 1.91-3.13% y^{-1}) in the last 30-year period (1989 to 2019) which is a higher rate of increase than what we reported in 2017 (2.14% y^{-1} from 1987 to 2017; Table 3 and Figure 5). The predicted non-pup count was estimated to be 22,610 (95% CI 17,727-27,648).

Pup modeled counts and trends—Pups in the total western DPS in Alaska increased at 1.63% y^{-1} (95% CI 1.12-2.16% y^{-1}), which is slightly improved from what we reported in 2018 (1.52% y^{-1}; Sweeney et al. 2018) but not 2017 (1.78% y^{-1}) or 2016 (2.19% y^{-1}; Sweeney et al. 2016) trend estimates. The total agTrend predicted pup count for the western DPS in Alaska in 2019 was 12,581 (95% CI 11,308-12,478), which is 739 more than what we reported in 2018 (Sweeney et al. 2018), and 628 more than in 2017.

Pup counts east of Samalga Pass between 2002 and 2019 increased at 2.90% y^{-1}, (95% CI 1.-3.53) which is the same as what we reported in 2018 (Sweeney et al. 2018), but much lower than what we reported in 2017 (3.18% y^{-1}; Table 3). This is because of the anomalous decline in pups from 2015 to 2017 in the eastern (-33%) and central (-18%) GULF. In these two regions, 2019 pup counts are back up near 2015 levels (Figure 7).

The 2019 realized pup counts in the eastern and central GULF regions increased since the anomalous decline in 2017 and are similar to what we observed in 2015 (-41 and -14 pups, respectively). Despite non-pups remaining relatively stable in the western GULF, pup counts slightly increased from 2017 to 2019 (+241 pups).

Pup counts in southeast Alaska (eastern DPS) increased 2.85% y^{-1} from 1989 to 2019, which is a lower rate of increase than in 2017 (Table 3 and Figure 8). The lower rate of increase for 2019 is likely because observed pup counts have been relatively stable since 2009. The predicted pup count was estimated to be 7,396 (95% CI 6,307-8,782).

DISCUSSION

Overall counts of Steller sea lion pups and non-pups within the range of the western DPS in Alaska increased between 2002 and 2019; however, the annual rate of increase reported was much lower for non-pups than in previous years. This lower magnitude positive trend is attributed to the continued decline west of Samalga Pass and the 2019 decline in non-pups in the Gulf of Alaska. Pup production rebounded from the 2017 anomalous decline and counts are similar to what we observed in 2015.

In 2017 we observed atypical movement of mostly juveniles and adult females from the eastern GULF to the central GULF (though E+C GULF non-pups remained stable), but not into the western GULF. It does not appear that this pattern of movement occurred again in 2019 given that non-pups declined in both the eastern and central GULF regions while the western GULF remained relatively stable. While we could attribute part of the 2017-2019 E+C GULF non-pup decline (2,628) to a reduction in juvenile recruitment (of now 2 year olds), considering the magnitude of the 2015-2017 decline in pup production (-868; 2019 agTrend realized count data) and sea lion survival to years 1 and 2 in these regions (ranging 0.555-0.789 to year 1 and 0.670-0.913 to year 2; Fritz et al. 2014), this could not totally account for the decline. Other likely explanations are reduced juvenile survival during the decreased abundance of available prey, and (or) movement to the east. Interestingly, despite these declines in non-pups, pup production returned to 2015 levels.

After 5 years of relative stability in non-pup counts in southeast Alaska, we observed an increase in non-pups (2,168) between 2017 and 2019. It is possible that this increase could be explained by movement of non-pups from the western DPS E+C GULF regions however, there have not been any sightings of marked sea lions to support this. Despite the 2019 increase in non-pups in southeast Alaska, pup counts remained relatively stable (and have been since 2009). The stability of pup counts despite increases in non-pups is similar to the pattern we observed in the eastern and central GULF regions in 2017: non-pup movement from the eastern to the central GULF with no concomitant pup count increase (in fact, a decline in pup production in both regions).

The Pacific marine heatwave observed from 2014 to 2016 (“The Blob”), which resulted in “extreme reductions” in productivity and groundfish species (Biela et al. 2019, Yang et al. 2019), may have been related to the 2017 anomalous decline in pup production in the E+C GULF. For example, in 2017 NOAA Fisheries observed that Pacific cod declined 71% in abundance (58% in biomass) in the Gulf of Alaska (Barbeaux et al. 2018) Pacific cod is one of the top four important prey species for sea lions, especially during the winter (49% frequency of occurrence; Sinclair et al. 2013). Indeed, prior to 2017, Steller sea lion counts in the Gulf of Alaska had been increasing gradually and consistently since the early 2000s. Recent evidence suggests that this area may be experiencing another prolonged, large-scale warm water event, as, temperatures in the Gulf of Alaska are rising (L’Heureaux 2019).

The 2019 Steller sea lion survey results indicate there may be a continued impact from “The Blob,” with the anomalous decline of non-pups in the E+C GULF. This unprecedented decline in the GULF regions since it began to recover in the early 2000s could be caused by several factors—a decline in juvenile recruitment subsequent to the 2017 pup decline, a decline in juvenile survival due to prey scarcity, and/or movement of non-pups out of the area—however, we cannot know this from survey counts alone.

The phenomenon of increased non-pup counts without a corresponding increase in pup production—as we observed in the central GULF in 2017 and southeast Alaska in 2019—is an important observation.

Given changes in ocean temperatures seem to be becoming more commonplace in the Gulf of Alaska—as well as throughout Alaska and throughout the North Pacific Ocean—the importance of regular surveys to monitor species that play a key role in the ecosystem is evident. In the case of western DPS Steller sea lions, an endangered species, it is especially vital to monitor the continued changes, especially in the Gulf of Alaska since this was an area that prior to 2017, was experiencing relatively gradual and consistent increases in counts (i.e., signs of recovery) since 2002.

ACKNOWLEDGMENTS

We thank L. Norman, C. Maginn, K. Cosentino, R. Pauley, and the entire NOAA Aircraft Operations Center for conducting the occupied 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 Section 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 occupied aircraft flights. B. Hou and K. Luxa (MML), and M. Lynne (SWFSC) conducted the Twin Otter survey. B. Birkemeier and K. Sweeney analyzed and counted sea lions from imagery. 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 18528 and 22289, and NMFS IACUC Protocol A/NW2016-3.

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TABLES & FIGURES

Table 1—Counts of live Steller sea lion non-pups and pups on sites surveyed in the eastern, central, and western Gulf of Alaska regions (western DPS) in 2019 by the occupied aircraft survey team. In the 'rook' column, rookery sites are noted with a '1' (≥ 50 pups in any year since 1970). The count type "image" indicates the count is a mean of two independent counters from aerial imagery while the "visual" indicates a visual observation by one or both of the observers positioned at the aircraft bubble windows.

SITE	REGION	ROOK	DATE	NON-PUP	PUP	COUNT TYPE
AIALIK CAPE	E GULF	0	26-Jun	0		VISUAL
CAPE FAIRFIELD	E GULF	0	27-Jun	22	0	IMAGE
CAPE HINCHINBROOK	E GULF	0	26-Jun	74	0	IMAGE
CAPE JUNKEN	E GULF	0	27-Jun	0		VISUAL
CAPE PUGET	E GULF	0	27-Jun	16	0	IMAGE
CAPE RESURRECTION	E GULF	0	27-Jun	64	0	IMAGE
CAPE ST. ELIAS	E GULF	0	25-Jun	562	47	IMAGE
CHISWELL ISLANDS	E GULF	1	27-Jun	118	78	IMAGE
DANGER	E GULF	0	27-Jun	1		VISUAL
DUTCH GROUP	E GULF	0	26-Jun	9	0	IMAGE
FOX	E GULF	0	25-Jun	158	0	IMAGE
GLACIER	E GULF	0	26-Jun	821	20	IMAGE
GRANITE CAPE	E GULF	0	26-Jun	90	0	IMAGE
HOOK POINT	E GULF	0	26-Jun	70	0	IMAGE
MIDDLETON	E GULF	0	27-Jun	26	0	IMAGE
NATOA (GROTTO)	E GULF	0	27-Jun	153	0	IMAGE
NO NAME	E GULF	0	26-Jun	107	0	IMAGE
PERRY	E GULF	0	26-Jun	0		VISUAL
PILOT ROCK	E GULF	0	26-Jun	0		VISUAL
PLEIADES	E GULF	0	26-Jun	0		VISUAL
POINT ELEANOR	E GULF	0	26-Jun	0		VISUAL
POINT ELRINGTON	E GULF	0	27-Jun	132	0	IMAGE
POINT LaTOUCHE	E GULF	0	27-Jun	0		VISUAL
PROCESSION ROCKS	E GULF	0	26-Jun	102	1	IMAGE
RABBIT	E GULF	0	26-Jun	2		VISUAL
RAGGED/HOOF POINT	E GULF	0	27-Jun	69	1	IMAGE
RUGGED	E GULF	0	27-Jun	6		VISUAL
SEAL ROCKS	E GULF	1	26-Jun	957	697	IMAGE
SEAL ROCKS (KENAI)	E GULF	0	27-Jun	86	0	IMAGE
STEEP POINT	E GULF	0	27-Jun	0		VISUAL
THE NEEDLE	E GULF	0	26-Jun	100	17	IMAGE
WOODED (FISH)	E GULF	1	26-Jun	533	293	IMAGE
AFOGNAK/TONKI CAPE	C GULF	0	28-Jun	0		VISUAL
AGHIYUK	C GULF	0	1-Jul	110	0	IMAGE
AIUGNAK COLUMNS	C GULF	0	3-Jul	11	0	IMAGE
CAPE DOUGLAS	C GULF	0	28-Jun	0		VISUAL

SITE	REGION	ROOK	DATE	NON-PUP	PUP	COUNT TYPE
CAPE GULL	C GULF	0	28-Jun	42	0	IMAGE
CAPE KULIAK	C GULF	0	28-Jun	137	0	IMAGE
CAPE NUKSHAK	C GULF	0	28-Jun	0		VISUAL
CAPE UGYAK	C GULF	0	28-Jun	0		VISUAL
CHIRIKOF	C GULF	1	1-Jul	438	210	IMAGE
CHOWIET	C GULF	1	1-Jul	1059	650	IMAGE
EAST CHUGACH	C GULF	0	26-Jun	0		VISUAL
ELIZABETH/CAPE ELIZABETH	C GULF	0	26-Jun	0		VISUAL
FLAT	C GULF	0	26-Jun	8	0	IMAGE
GORE POINT	C GULF	0	26-Jun	3		VISUAL
KILOKAK ROCKS	C GULF	0	3-Jul	142	0	IMAGE
KODIAK/BIRD ROCK	C GULF	0	29-Jun	0		VISUAL
KODIAK/CAPE ALITAK	C GULF	0	29-Jun	0		VISUAL
KODIAK/CAPE BARNABAS	C GULF	0	29-Jun	184	0	IMAGE
KODIAK/CAPE CHINIAK	C GULF	0	28-Jun	234	0	IMAGE
KODIAK/CAPE IKOLIK	C GULF	0	29-Jun	26	0	IMAGE
KODIAK/CAPE KULIUK	C GULF	0	29-Jun	0		VISUAL
KODIAK/CAPE PARAMANOF	C GULF	0	29-Jun	0		VISUAL
KODIAK/CAPE UGAT	C GULF	0	29-Jun	244	1	IMAGE
KODIAK/CAPE UYAK	C GULF	0	29-Jun	0		VISUAL
KODIAK/GULL POINT	C GULF	0	29-Jun	30	0	IMAGE
KODIAK/MALINA POINT	C GULF	0	29-Jun	0		VISUAL
KODIAK/STEEP CAPE	C GULF	0	29-Jun	42	0	IMAGE
KODIAK/STURGEON HEAD	C GULF	0	29-Jun	0		VISUAL
KODIAK/SUNDSTROM	C GULF	0	29-Jun	0		VISUAL
KODIAK/TOMBSTONE ROCKS	C GULF	0	29-Jun	0		VISUAL
LATAX ROCKS	C GULF	0	29-Jun	232	16	IMAGE
LONG ISLAND	C GULF	0	28-Jun	99	0	IMAGE
MARMOT	C GULF	1	28-Jun	846	628	IMAGE
NAGAHUT ROCKS	C GULF	0	27-Jun	62	0	IMAGE
NAGAI ROCKS	C GULF	0	1-Jul	394	11	IMAGE
NOISY	C GULF	0	29-Jun	0		VISUAL
NUKA POINT	C GULF	0	26-Jun	0		VISUAL
OUTER (PYE)	C GULF	1	26-Jun	180	130	IMAGE
PERL	C GULF	0	26-Jun	210	0	IMAGE
PERL ROCKS	C GULF	0	27-Jun	1		VISUAL
PUALE BAY	C GULF	0	3-Jul	166	0	IMAGE
SEA LION ROCKS (MARMOT)	C GULF	0	28-Jun	3	0	IMAGE
SEA OTTER	C GULF	0	28-Jun	220	0	IMAGE
SEA OTTER/RK NEAR	C GULF	0	28-Jun	3	0	IMAGE
SHAKUN ROCKS	C GULF	0	28-Jun	202	10	IMAGE
SHAW	C GULF	0	28-Jun	0		VISUAL
SITKINAK/CAPE SITKINAK	C GULF	0	29-Jun	223	0	IMAGE
SUD	C GULF	0	26-Jun	0		VISUAL

SITE	REGION	ROOK	DATE	NON-PUP	PUP	COUNT TYPE
SUGARLOAF	C GULF	1	27-Jun	927	852	IMAGE
SUKLIK-NEW SITE	C GULF	0	1-Jul	90	0	IMAGE
SUTWIK	C GULF	0	3-Jul	227	30	IMAGE
TAKLI	C GULF	0	28-Jun	0		VISUAL
TWOHEADED	C GULF	1	29-Jun	460	45	IMAGE
UGAIUSHAK	C GULF	0	3-Jul	0		VISUAL
UGAK	C GULF	0	29-Jun	0		VISUAL
USHAGAT/NW	C GULF	0	27-Jun	0		VISUAL
USHAGAT/ROCKS SOUTH	C GULF	0	26-Jun	67	0	IMAGE
USHAGAT/SW	C GULF	1	27-Jun	152	106	IMAGE
WEST AMATULI	C GULF	0	26-Jun	0		VISUAL
ATKINS	W GULF	1	1-Jul	827	380	IMAGE
ATKULIK	W GULF	0	3-Jul	0		VISUAL
BIG KONIUJI	W GULF	0	1-Jul	0		VISUAL
BIRD (SHUMAGINS)	W GULF	0	4-Jul	7	0	IMAGE
CASTLE ROCK	W GULF	0	1-Jul	71	0	IMAGE
CATON	W GULF	0	1-Jul	372	3	IMAGE
CHANKLIUT	W GULF	0	1-Jul	0		VISUAL
CHERNABURA	W GULF	1	4-Jul	1000	336	IMAGE
CHERNI	W GULF	0	1-Jul	0		VISUAL
CLUBBING ROCKS NORTH	W GULF	1	1-Jul	565	324	IMAGE
CLUBBING ROCKS SOUTH	W GULF	1	1-Jul	841	583	IMAGE
EGG (SAND POINT)	W GULF	0	1-Jul	37	0	IMAGE
HAGUE ROCK	W GULF	0	1-Jul	0		VISUAL
HUNT	W GULF	0	1-Jul	0		VISUAL
JUDE	W GULF	1	1-Jul	762	406	IMAGE
KAK	W GULF	0	3-Jul	93	0	IMAGE
KUPREANOF POINT	W GULF	0	1-Jul	190	0	IMAGE
LIGHTHOUSE ROCKS	W GULF	1	1-Jul	200	15	IMAGE
MITROFANIA	W GULF	0	3-Jul	256	0	IMAGE
NAGAI/RK W OF CAPE WEDGE	W GULF	0	1-Jul	1		VISUAL
OLGA ROCKS NE	W GULF	0	1-Jul	70	0	IMAGE
OLGA ROCKS SW	W GULF	0	1-Jul	246	0	IMAGE
OMEGA	W GULF	0	1-Jul	0		VISUAL
PAUL	W GULF	0	1-Jul	0		VISUAL
PINNACLE ROCK	W GULF	1	1-Jul	1286	803	IMAGE
SANAK	W GULF	0	1-Jul	0		VISUAL
SEA LION ROCKS (SHUMAGINS)	W GULF	0	1-Jul	76	1	IMAGE
SEAL CAPE	W GULF	0	1-Jul	1		VISUAL
SIMEONOF	W GULF	0	1-Jul	26	0	IMAGE
SOUTH ROCKS	W GULF	1	1-Jul	604	82	IMAGE
SOZAVARIKA	W GULF	0	1-Jul	0		VISUAL
SPITZ	W GULF	0	1-Jul	47	0	IMAGE
SUSHILNOI ROCKS	W GULF	1	1-Jul	406	43	IMAGE

SITE	REGION	ROOK	DATE	NON-PUP	PUP	COUNT TYPE
THE HAYSTACKS	W GULF	0	1-Jul	44	0	IMAGE
THE WHALEBACK	W GULF	1	1-Jul	116	79	IMAGE
TWINS	W GULF	0	3-Jul	0		VISUAL
UNGA/ACHEREDIN POINT	W GULF	0	1-Jul	128	0	IMAGE
UNGA/CAPE UNGA	W GULF	0	1-Jul	0		VISUAL
WOSNESENSKI	W GULF	0	1-Jul	105	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 2019 by the occupied aircraft survey team. Rookery sites are noted with a '1' (≥ 50 pups in any year since 1970) in the 'rook' column. The count type "image" indicates the count is a mean of two independent counters from aerial imagery while the "visual" indicates a visual observation by one or both of the observers positioned at the aircraft bubble windows.

SITE	ROOK	DATE	NON-PUP	PUP	COUNT TYPE
BIALI ROCK	1	24-Jun	1161	223	IMAGE
CAPE ADDINGTON	0	24-Jun	755	3	IMAGE
CAPE CROSS	0	24-Jun	0		VISUAL
CAPE OMMANEY	0	24-Jun	124	0	IMAGE
CAPE OMMANEY/S	0	24-Jun	40	2	IMAGE
FORRESTER/C HORN RK	1	24-Jun	533	423	IMAGE
FORRESTER/EAST RK	1	24-Jun	238	160	IMAGE
FORRESTER/FORRESTER ISLAND	1	24-Jun	27	0	IMAGE
FORRESTER/LOWRIE	1	24-Jun	1954	1525	IMAGE
FORRESTER/NORTH RK	1	24-Jun	1232	1004	IMAGE
FORRESTER/SEA LION RK	1	24-Jun	700	541	IMAGE
GRAVES ROCK	1	24-Jun	1796	684	IMAGE
HARBOR POINT	0	24-Jun	384	0	IMAGE
HAZY	1	24-Jun	1976	1432	IMAGE
JACOB ROCK	0	24-Jun	235	0	IMAGE
SEA LION ISLANDS	0	24-Jun	728	7	IMAGE
SEA LION ROCK (PUFFIN BAY)	0	24-Jun	217	0	IMAGE
SOUTH MARBLE	0	25-Jun	1340	16	IMAGE
SUNSET	0	25-Jun	633	12	IMAGE
THE BROTHERS/SW	0	25-Jun	509	0	IMAGE
THE BROTHERS/W+E	0	25-Jun	0		VISUAL
TIMBERED	0	24-Jun	496	10	IMAGE
WEST ROCK	0	24-Jun	1099	2	IMAGE
WHITE SISTERS	1	24-Jun	1564	916	IMAGE
WOLF ROCK	0	24-Jun	477	3	IMAGE
YASHA	0	25-Jun	609	21	IMAGE

Table 3—Annual rates of change (% y^{-1} with ± 95% credible intervals) in counts of Steller sea lion non-pups and pups modeled with agTrend, listed from west to east. The eastern, central and western Aleutian Islands (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 regional areas therein that were largely surveyed in 2019, for the period 2002-2019: western, central, and eastern Gulf of Alaska (GULF) regions; eastern and central Gulf regions combined (E+C GULF); and east of Samalga Pass. Southeast Alaska (eastern DPS) at the bottom of the table are modeled for the 30-year period 1989-2019.

	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 2002-2019						
W GULF	2.77	1.47	4.01	3.37	2.25	4.52
E+C GULF (combined)	3.36	2.43	4.30	2.96	1.91	3.98
C GULF	3.40	2.53	4.32	3.08	1.76	4.35
E GULF	3.32	1.42	5.24	2.68	1.08	4.36
East of Samalga Pass	2.71	2.05	3.35	2.90	2.37	3.53
All western DPS (US)	**1.82**	**1.29**	**2.38**	**1.63**	**1.12**	**2.16**
Southeast Alaska (eastern DPS) annual rates of change for the period 1989-2019						
Southeast Alaska (eastern DPS)	2.53	1.91	3.13	2.85	2.38	3.29

Figure 1—Steller sea lion terrestrial rookeries and haulouts surveyed in June-July 2019. Survey regions, rookery cluster areas (RCAs), and the boundary between the eastern and western distinct population segments (DPS) in Alaska are also shown.

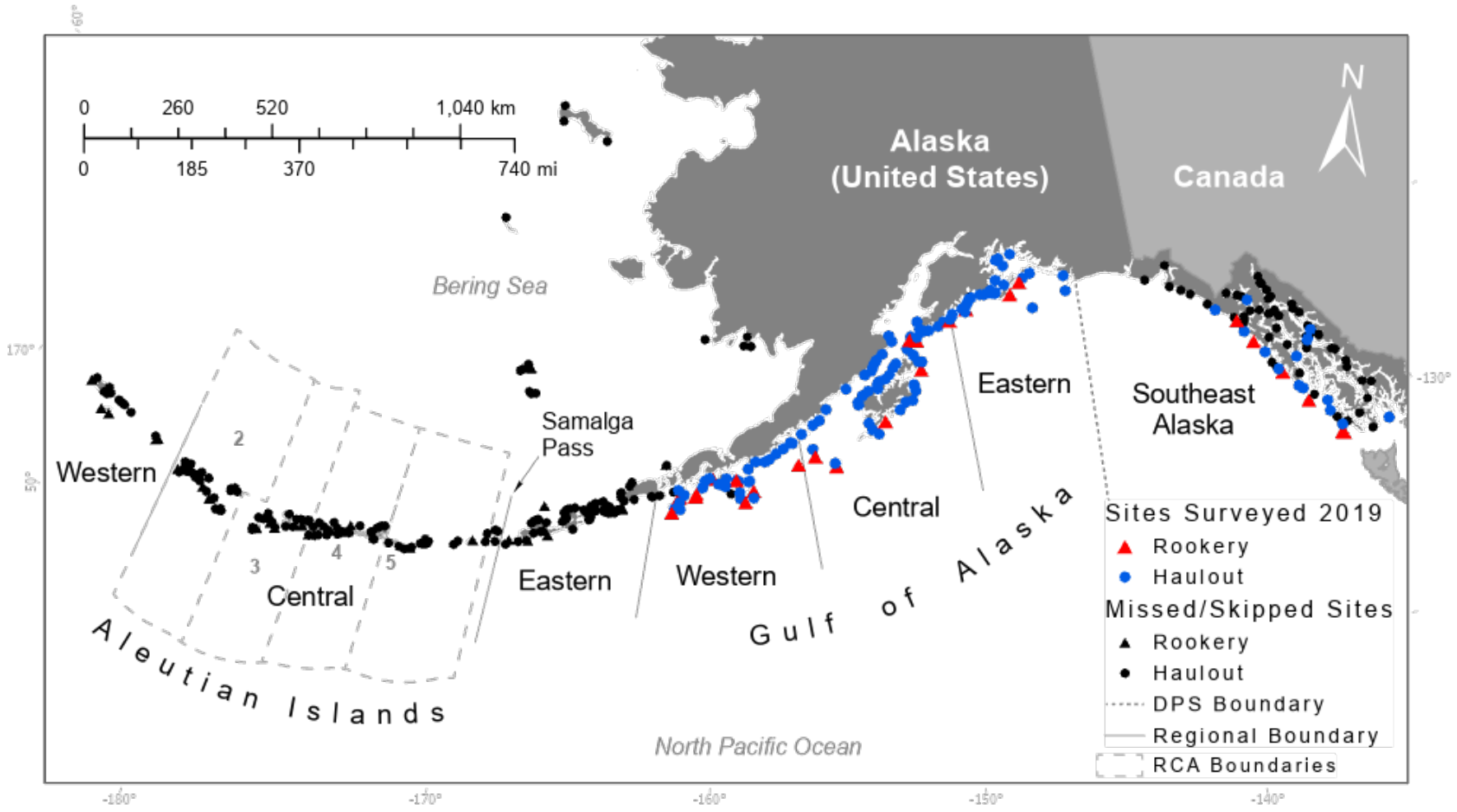

Figure 2—Realized and predicted counts of western DPS Steller sea lion non-pups in Alaska, 2002-2019. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

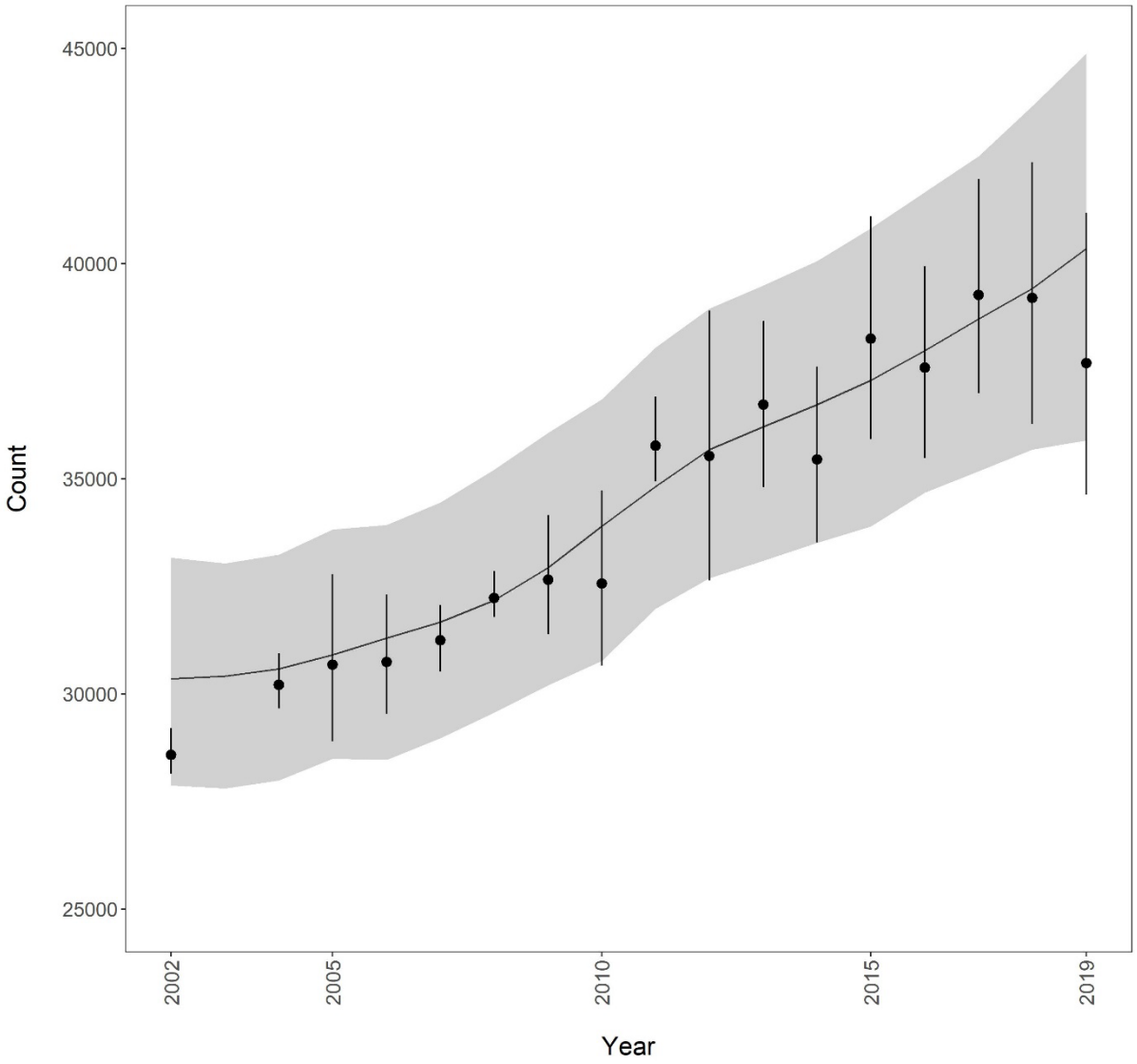

Figure 3—Realized and predicted counts of western DPS Steller sea lion non-pups in the western (W-), central (C-), and eastern Gulf of Alaska (E GULF) regions, 2002-2019. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

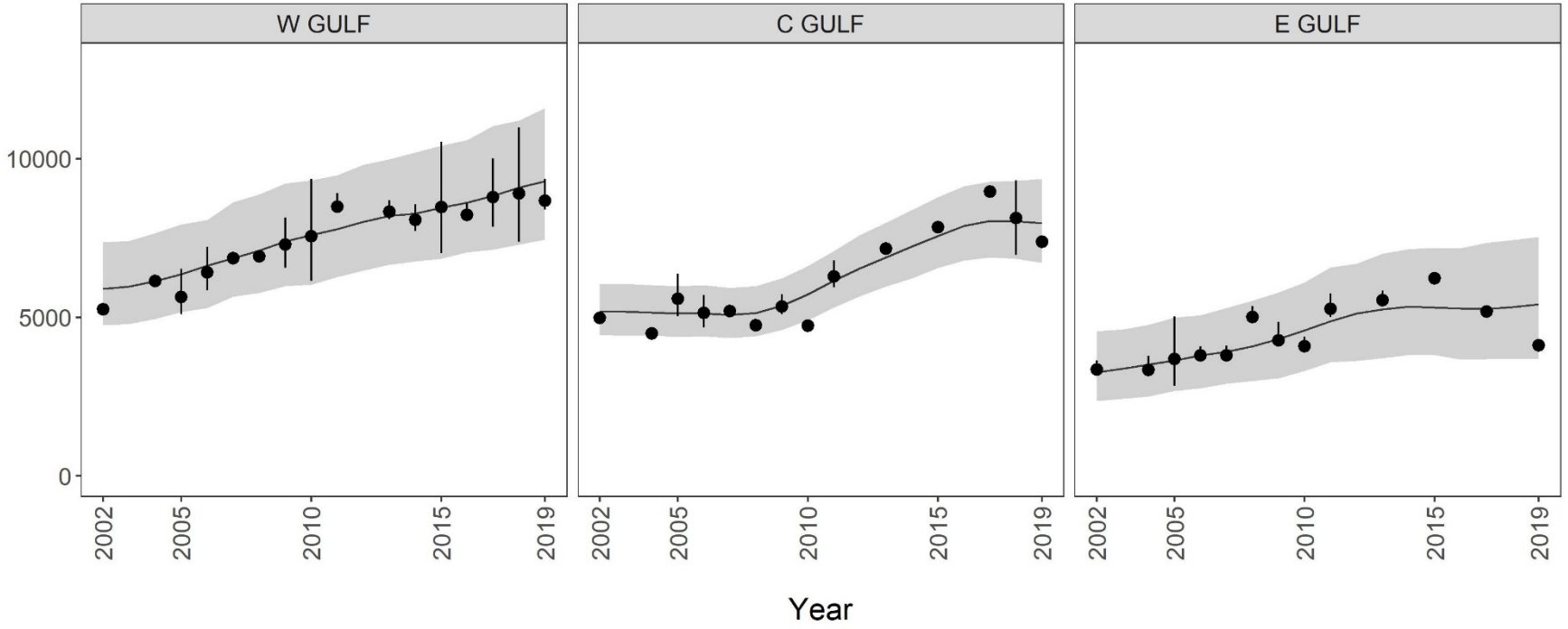

Figure 4—Realized and predicted counts of western DPS Steller sea lion non-pups in the combined regions of the Gulf of Alaska, 2002-2019. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

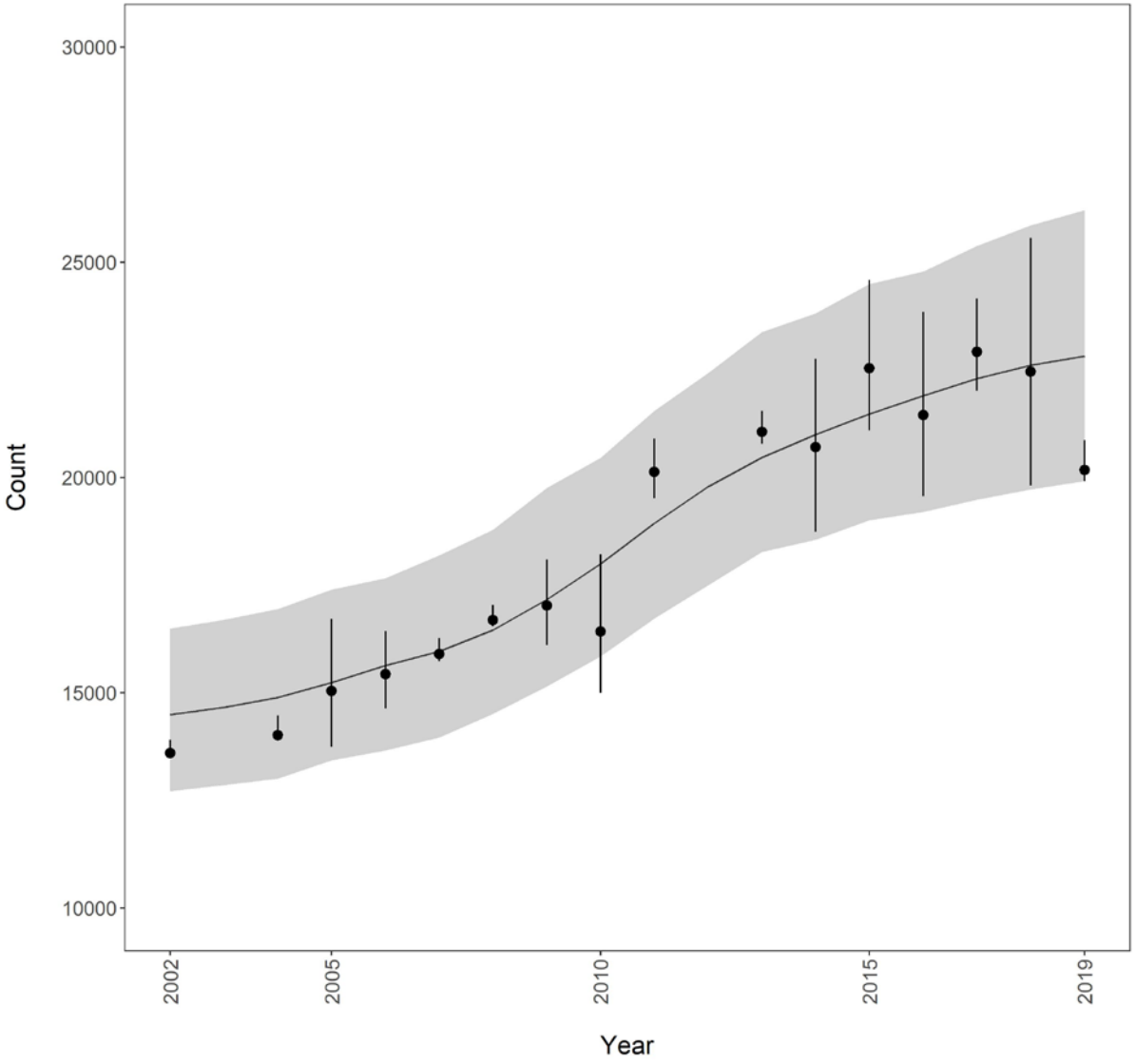

Figure 5—Realized and predicted counts of eastern DPS Steller sea lion non-pups in the southeast Alaska region, 1989-2019. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

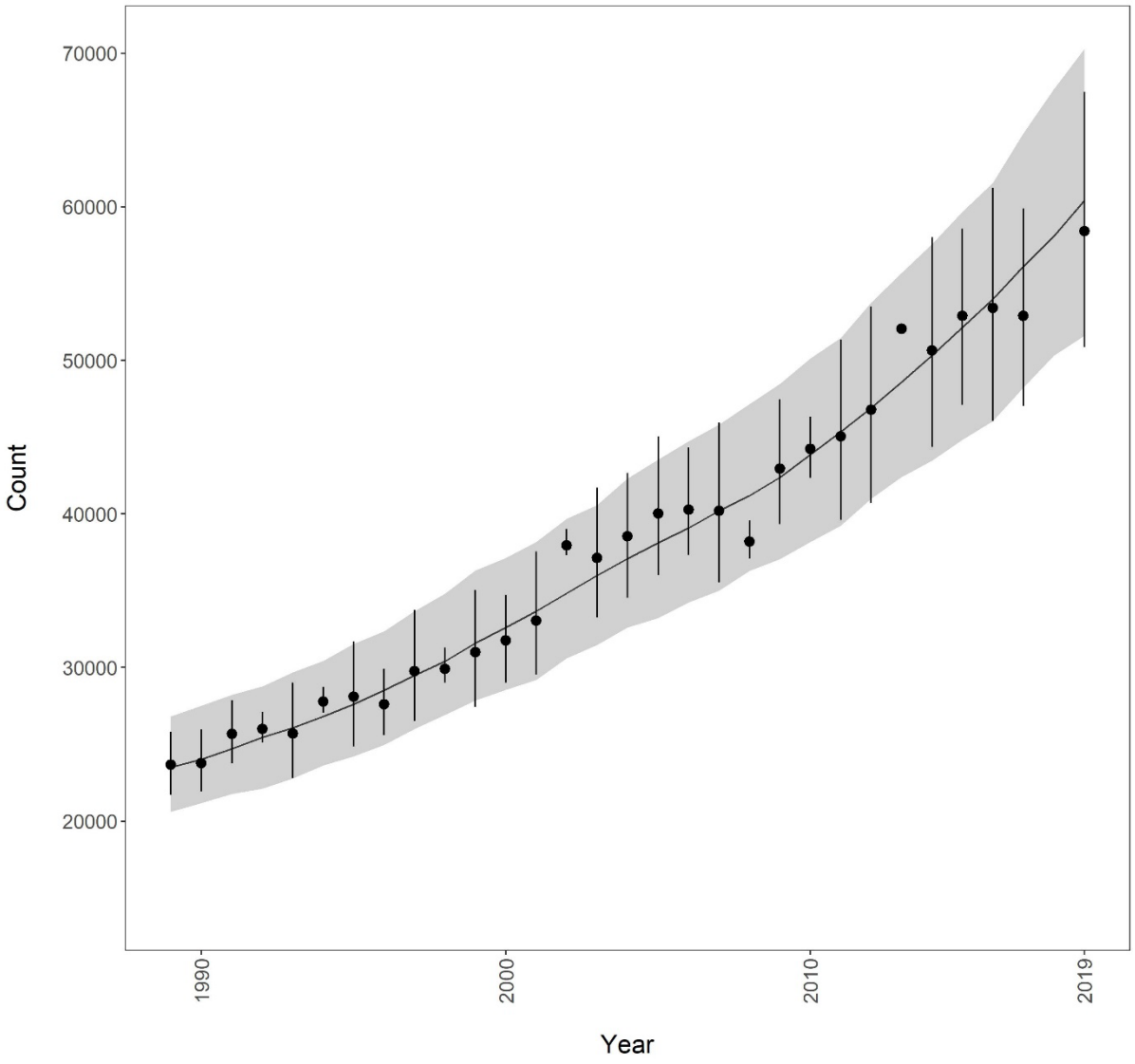

Figure 6—Realized and predicted counts of western DPS Steller sea lion pups in Alaska, 2002-2019. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

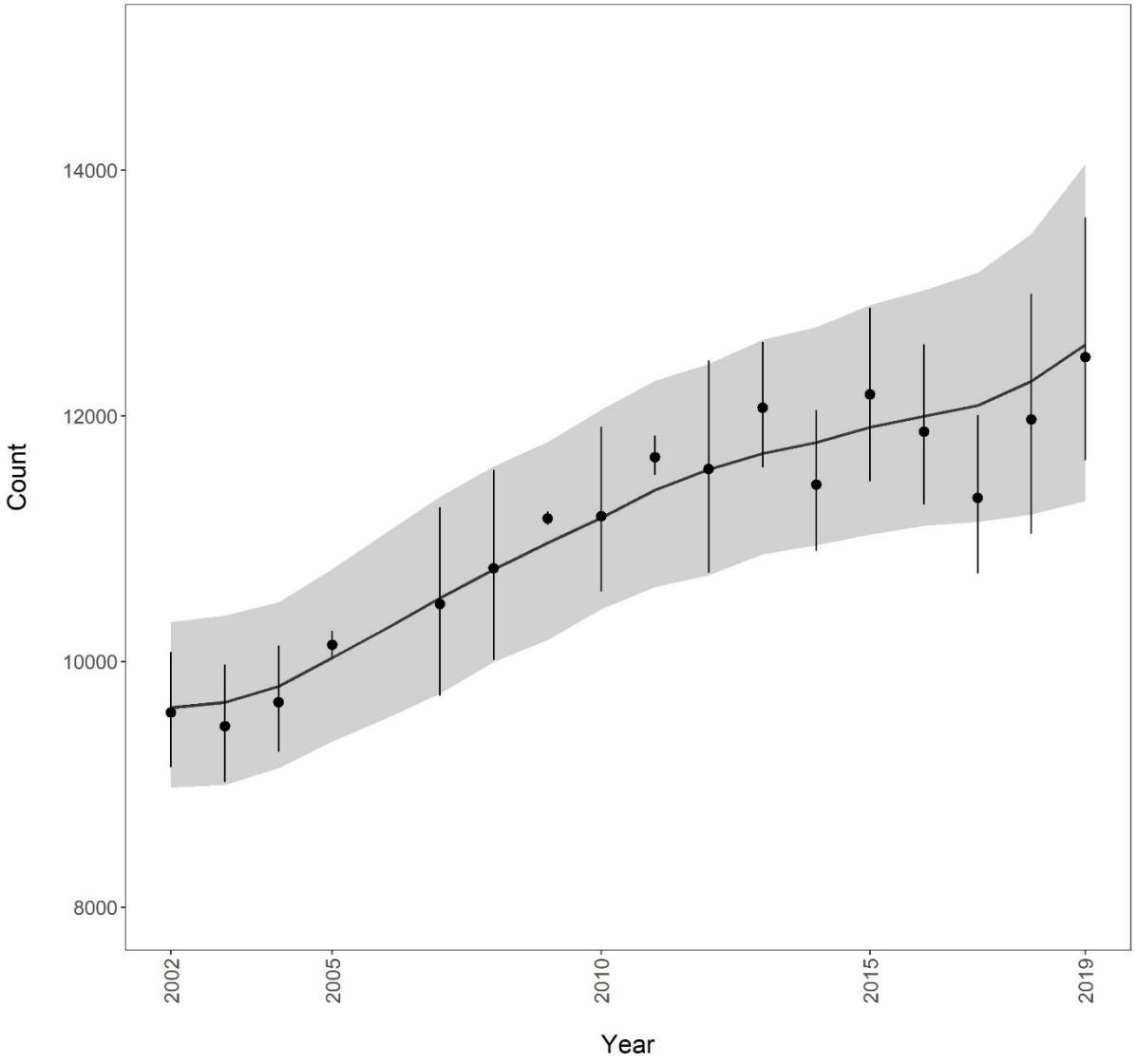

Figure 7—Realized and predicted counts of western DPS Steller sea lion pups in the western (W-), central (C-), and eastern Gulf of Alaska (E GULF) regions, 2002-2019. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

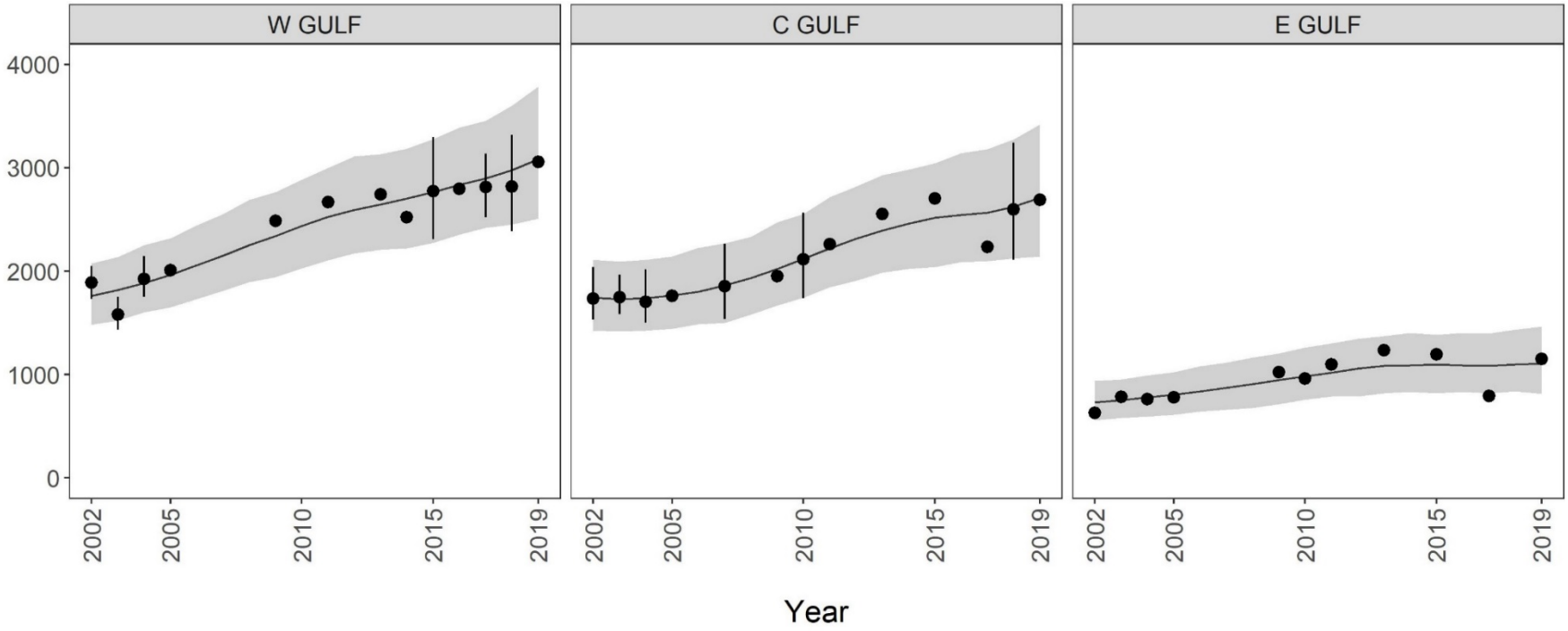

Figure 8—Realized and predicted counts of eastern DPS Steller sea lion pups in the southeast Alaska region, 1989-2019. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.