UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Alaska Fisheries Science Center
National Marine Mammal Laboratory
7600 Sand Point Way N.E.
Seattle, Washington 98115
Tel: 206.526.4040 Fax: 206.526.6615
E-mail: tom.gelatt@noaa.gov

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Author: Michelle Lander, Devin Johnson, Brian Fadely, Tom Gelatt

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Summary: Memo submitted to Leadership at the Alaska Science Center for approval of methods and results of analysis requested by the NOAA Fisheries Alaska Regional Office. This report summarizes results of an analysis of satellite tag telemetry data collected from deployments on Steller sea lions (*Eumetopias jubatus*) throughout the western-central Aleutian Islands during 2000-2013. This new quantitative analysis uses output from a continuous-time-random-walk (CTCRW) model and shows proportions of critical habitat use associated with modeled predicted locations stratified by 0-3 nautical miles (nmi), 3-10 nmi, 10-20 nmi and >20 nmi, and inside/outside of the 200 m isobaths (as an indicator of the continental shelf), and grouped by age-class (juvenile vs. adult) and season (winter vs. summer). Use-proportions calculated by animal are combined and compared to indicate inter-animal variability. A total of 29,228 locations from the 45 sea lions were collected, and 24,004 locations were retained after filtering the data. Deployment durations ranged between 8-256 days for all sea lions (juveniles: 8-121 days; adult females: 21-256 days), with most juveniles tracked between the ages of 10-13 months old. Winter movements of juveniles were contained entirely within critical habitat, though the sample size is small (4 animals), young (9-10 months), and limited to February-March. In summer the proportion of trip durations spent within critical habitat was 90.5%. Three adult female sea lions were tracked into the summer months of April-July, and on average 92.3% of their time was spent within critical habitat, mostly within areas bounded by the 200 m isobath. Winter adult females showed a much broader distribution, with on average 26% of their locations beyond the 200 m isobaths and 20% outside of critical habitat. The majority of predicted locations at-sea occurred on the continental shelf (within the 200 m isobath), regardless of age class or season. Offshelf (beyond 200 m isobath) trips were undertaken by juvenile males and adult females. Similar to travel outside of critical habitat, most movements beyond the shelf were performed by juvenile males (13 males versus 5 females) or adult females.
The findings and conclusions in the paper are those of the author(s) and do not necessarily represent the views of the National Marine Fisheries Service.

Division - Laboratory

Alaska Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
Seattle, Washington

SECTION 515 PRE-DISSEMINATION REVIEW & DOCUMENTATION FORM

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Name and Title of Reviewing Official: John Bengtson, Director, National Marine Mammal Lab

(Must be at least one level above person generating the information product) Pursuant to Section 515 of Public Law 106-554 (the Data Quality Act), this product has undergone a pre-dissemination review.

Signature ____________________ Date 26 Nov 13

Name and Title of Reviewer(s): Douglas DeMaster, Director, AFSC

Lowell Fritz, Fisheries Research Biologist. Alaska Ecosystems Program

Signature ____________________ Date 11/26/13

Signature ____________________ Date 26 Nov 2013

At-sea distribution of Steller sea lions in the western-central Aleutian Islands

Prepared by:
Michelle Lander, Devin Johnson, Brian Fadely and Tom Gelatt
National Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 7600 Sand Point Way NE, Seattle, WA 98115-6349

1 August, 2013

<u>Overview</u>

This report summarizes results of an analysis of satellite tag telemetry data collected from deployments on Steller sea lions (*Eumetopias jubatus*) throughout the western-central Aleutian Islands during 2000-2013, and was requested to be completed by the end of July during discussions on 24 April, 2013 between AKR and AKC. This new quantitative analysis uses output from a continuous-time-random-walk model and shows proportions of critical habitat use associated with modeled predicted locations stratified by 0-3 nautical miles (nmi), 3-10 nmi, 10-20 nmi and >20 nmi, and inside/outside of the 200 m isobaths (as an indicator of the continental shelf), and grouped by age-class (juvenile vs. adult) and season (winter vs. summer). Use-proportions calculated by animal are combined and compared statistically to indicate inter-animal variability. Though initially requested for a series of tables to be provided outside of a "white paper" format, some description of the methods used and results is appropriate. This brief overview can be expanded into a larger white paper or other format such as an AFSC Processed Report if that would be desirable or more appropriate.

Previous studies that have published data on juvenile sea lion movements or at-sea behavior in the western-central Aleutian Island areas (Call et al., 2007; Fadely et al., 2005; Lander et al., 2011a; Lander et al., 2011b; Lander et al., 2010; Lander et al., 2009; Rehberg and Burns, 2008) focused on sea lion behavior and ecology and relied on limited numbers of tracked animals mostly specific to the scope of each study. For the purposes of analyzing Steller sea lion habitat use and potential foraging areas relative to critical habitat designations, previous analyses for Section 7 consultations of groundfish fishery effects combined available telemetry data from multiple studies, and initially used raw location data to calculate proportions of locations within critical habitat zones and outside of critical habitat (NMFS 2001). Subsequent analyses added speed and geometric filtering of raw locations, and used only locations associated with diving behavior to >4 m, and with increasing spatial and temporal coverage as deployment sample sizes improved (NMFS 2003, 2010). These subsequent approaches reduced some autocorrelation in the location data, but also limited the extent inferences could be made as to habitat use.

In this study we combined all telemetry deployments during 2000-2013 in the central and western Aleutian Islands, including recent deployments on adult females, and conducted a spatial analysis to identify patterns of use relative to sea lion critical habitat and bathymetry in an area of intense fisheries management measures intended to reduce potential competition. The analytical approach modeled travel paths using the continuous-time correlated random walk model (CTCRW; Johnson et al. 2008). The CTCRW model output was used to show habitat use by individual to indicate intra-animal variation, then aggregated in a by age-class, season, critical habitat zone (<3 nmi, 3-10 nmi, 10-20 nmi, >20 nmi), or occurrence inside/outside of the 200 m isobath contour as possible factors. Though this analysis is novel, data from some of the deployments included in this analysis have also been used in previous published studies (Call et al., 2007; Fadely et al., 2005; Lander et al., 2011a; Lander et al., 2010; Lander et al., 2009; Lander et al., 2007; Loughlin et al., 2003; Pitcher et al., 2005; Rehberg and Burns, 2008).

Methods

During the period February 2000 – October 2012, a total of 45 Steller sea lions were captured and equipped with a satellite-linked transmitters and data loggers from sites within the western and central Aleutian Islands (Table 1). Juvenile sea lions (*n*=39; 17 F, 22 M; 9-23 months old at capture, 10-26 months old at last transmission; Figure 1; Appendix 1) were captured on land using hoop nets (Loughlin et al., 2003), or at sea using an underwater dive capture technique (McAllister et al., 2001). Sea lions were restrained physically, sedated with an intramuscular injection of diazepam (approximately 1.5 mg/kg), or anesthetized with isoflurane delivered with oxygen via a facemask or anesthesia machine (Heath et al., 1996; Johnson et al., 2004). Adult female sea lions (*n*=6) were chemically immobilized using a combination of medetomidine-butorphanol-midazolam (dosage range approximately 0.038-0.044, 0.13-0.15, and 0.19-0.22 mg/kg respectively) via remotely delivered darts (3.0 ml Daninject™ dart syringes) from a CO_2 rifle (Daninject™ Model JM Special). After waiting for sedation to be achieved (~10 minutes) the animal was approached and transferred to inhalable isoflurane anesthesia. While anesthetized, measurements of tooth size (upper canine), body size, and time-of-year were used to infer ages of juvenile sea lions (King et al. 2007), and satellite-linked depth recorders (SDR-T16, 13.5 x 4.5 x 3.7 cm, 330 g; Wildlife Computers Ltd., Redmond, WA), satellite relayed data loggers (SRDL series 9000, 10.5 x 7.0 x 4.0, 370 g, Sea Mammal Research Unit (SMRU), Gatty Marine Laboratory, University of St. Andrews, Scotland), or fast-loc transmitters (SPLASH10-F-400, 10.0 x 5.5 x 2.0 cm, 225 g; Wildlife Computers) were attached to the dorsum of each animal using 5-minute epoxy (Devcon products, Riviera Beach, FL; Table 1). For adult female sea lions attachments were to the top of their head.

All data were obtained through Service Argos, Inc., a satellite-based location and data collection system (Argos 1996) and decoded using a data analysis program (DAP; Wildlife Computers Inc., Redmond, WA). The SDRs, which were equipped with a saltwater switch to assess conductivity readings every 20 minutes, recorded whether those readings were “dry” or “wet.” These data were compiled into timeline messages detailing when the animals were dry (hauled-out) or wet (at sea) for 20-minute increments every 24 hours. In contrast, the SRDLs, which also were equipped with a saltwater switch, reported the start and end times of unbroken periods of dry (hauled-out) or wet (at-sea) readings.

Movements

Locations from all instruments were filtered using a swim speed of 2 m/s with the algorithm described by McConnell et al. (1992) after deleting duplicate and Z (-9) locations (argosfilter-package, R 3.0.1, R Development Core Team 2006). The filtered data were then merged with the haulout data via their time stamp, and we assumed animals were at-sea (i.e. wet) during days for which no timeline data were received. For each animal, the data were processed with a continuous-time correlated random walk (CTCRW) model, which was generalized to account for a dry time covariate as described in Johnson et al. (2008). This model, which allowed for inclusion of measurement error of telemetry locations and parameter estimation using maximum likelihood, was used to predict uniformly-spaced animal locations for 20 minute intervals (Johnson et al. 2008).

All wet, predicted locations that were generated with the CTCRW model were projected to an Albers equal-area conic projection defined for the State of Alaska and data for each individual were plotted within zones of designated critical habitat for Steller sea lions (CFR 223, 226, and 679.22; Steve Lewis, NOAA Fisheries, Alaska Region), including 0-3 nautical miles (nmi), 3-10 nmi, and 10-20 nmi from the nearest major haulout or rookery, three large offshore foraging areas around Shelikof Strait, Bogoslof, and Seguam Pass (i.e. areas > 20 nm within critical habitat), and all of the land areas contained within those buffers because the CTCRW models did not account for land (ArcMap 10.3, ESRI, Redlands, CA). This GIS shape file differed slightly from the shape file (Steller_10_20_Transit_Forage) used for the analysis described in NMFS (2003). The percentages of locations within each critical habitat zone were summarized for each individual and summary statistics (i.e. mean, standard error (SE), and range) were calculated for each age class and season. Similar to NMFS (2010), winter was defined as October through March, whereas summer was defined as April through September. Additionally, data of all individuals were pooled and summarized in a fashion similar to NMFS (2010) for comparison purposes.

To further summarize the percentage of wet, predicted locations that occurred on the continental shelf (i.e. 200 m isobaths) for each individual, a bathymetric raster data set (100 m resolution) of the Aleutian Islands was obtained from (http://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/default.htm). Contours were created for the raster data set, from which the 200 m contour data were extracted. For areas of unknown bathymetry (missing data) north of Atka Is. and around Amlia Is. and western Seguam Pass (Zimmerman et al. 2013), broken contour lines were affixed to the nearest contour in the ETOPO 2′ gridded elevation data set obtained from the AFSC. After creating a closed polygon of the 200 m contour data, all wet, predicted locations that were generated with the CTCRW model were summarized for each individual and the summary statistics detailed above were also calculated for each age class and season. The percentage of wet, predicted locations that occurred within the 200 m polygon was also summarized for the pooled data set.

Results and Discussion

A total of 29,228 locations from the 45 sea lions was collected ($\bar{x}$ = 664 locations per individual, SD = 578, range = 68 to 2,598), and 24,004 locations were retained after filtering the data ($\bar{x}$ = 546, SD = 480, range = 61 to 2,297; Figure 2). Deployment durations ranged between 8-256 days for all sea lions (juveniles: 8-121 days; adult females: 21-256 days), with most juveniles tracked between the ages of 10-13 months old (Figure 1). A total of 142,824 wet, predicted locations was generated using the CTCRW models ($\bar{x}$ = 3,174 locations per individual, SD = 3,133, range = 254 to 14,792; Figure 3), which varied between age classes and seasons (Figure 4). Of the 45 sea lions, locations were received within a single season only for 38 animals; whereas 7 animals (DBID 6295, 6296, 6297, 6298, 14809, 25, and 15135) had data that spanned both seasons, resulting in 52 data sets (Appendices 1 and 2). The data for the three animals tagged on 29 March 2003 were all defined as having summer locations.

Proportions of predicted (wet) locations generated from CTCRW models averaged across individuals by age/sex class and season (Table 2) represent a new presentation of this type of data that reflect inter-individual variability. Previously (NMFS 2003, 2010) locations were pooled within the critical habitat zones, and CTCRW model output pooled following that method is shown by season or age class (Table 3), or by age/season class interaction (Table 4). The pooled values recalculated based on the fewer critical habitat zones (0-10 nmi rather than 0-3 and 3-10 nmi) as used in NMFS (2010) are then compared to the NMFS (2010) values in Table 5. Even in this pooled form there are clear seasonal and age differences in proportions of locations inside and outside of critical habitat.

Winter movements of juveniles were contained entirely within critical habitat (Tables 2, 4 and 5), though the sample size is small (4 animals), young (9-10 months) and limited to February-March). In summer the proportion of trip durations spent within critical habitat was 90.5% (Table 4). Compared to the NMFS (2010) analysis a greater proportion of time occurs within the 10-20 nmi portion of critical habitat (19.5% vs 8.8%; Table 5), with a similar decrease in the proportion of locations outside of critical habitat (21.9% vs 9.5%; Table 5). This shift is largely due to the addition of SMRU-tagged juveniles that remained close to the continental slope. These proportions are similar to those presented by Lander et al. (2011*a*) for central Aleutian Island juveniles.

Three adult female sea lions were tracked into the summer months of April-July, and on average 92.3% of their time was spent within critical habitat (Table 2), mostly within areas bounded by 200 m isobath. This distribution of summer locations is consistent with findings from studies tracking females in the eastern Aleutian Islands and Gulf of Alaska that show most foraging trips during the perinatal and early-pup-rearing periods occur within 20 nm of a rookery (Merrick and Loughlin 1997). Winter adult females overall showed a much broader distribution, with on average 26% of their locations beyond the 200 m isobaths and 20% outside of critical habitat (Table 2).

The majority of wet, predicted locations occurred on the continental shelf (within the 200 m isobath), regardless of age class or season (Tables 2, 3 and 4; Appendix 2). Offshelf (beyond 200 m isobath) trips were undertaken by juvenile males and adult females. Similar to travel outside of critical habitat, most movements beyond the shelf were performed by juvenile males (13 males versus 5 females) or adult females.

In this study habitat use was primarily defined as the proportion of time spent within the various critical habitat zones, to fulfill goals associated with the subsequent evaluation of fisheries management actions. Secondarily the degree of association with on-shelf areas was determined by splitting locations associated with being in waters less or greater than 200 m. Differences in proportions of use within and outside of critical habitat were likely a result of a combination of different filtering techniques, sample sizes (due to the inclusion of additional juvenile sea lion and adult data), and use of a different critical habitat shape file. All of these differences however improve estimates of critical habitat use over previous analyses.

While there were a greater number of sea lions included in this analysis than in previous analyses (NMFS 2003, 2010), coverage relative to the overall age-sex composition of the population remains limited and there are significant gaps. Most juveniles were between 10-13 months old (Figure 1), and the greatest temporal coverage was between April-June (Table 6). No information on juvenile behavior during September-January has been collected in the western-central Aleutian Islands. Though the sample sizes for adult females are low, because of better tag functionality relative to juveniles and season of capture there is much better coverage throughout the year though lacking during the pup-rearing period (Table 6).

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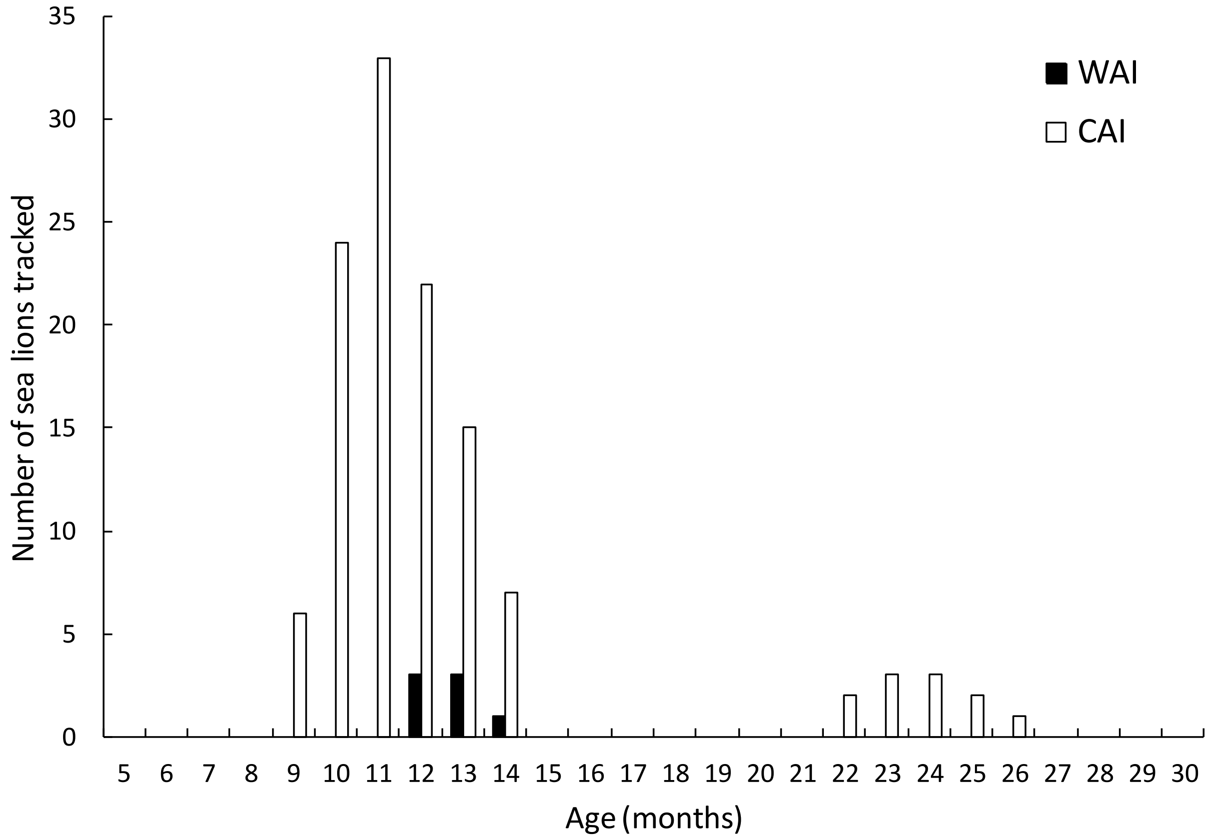

Figure 1. Number of juvenile Steller sea lions tracked by age of sea lion in the western (WAI) and central (CAI) Aleutian Islands during 2000-2005.

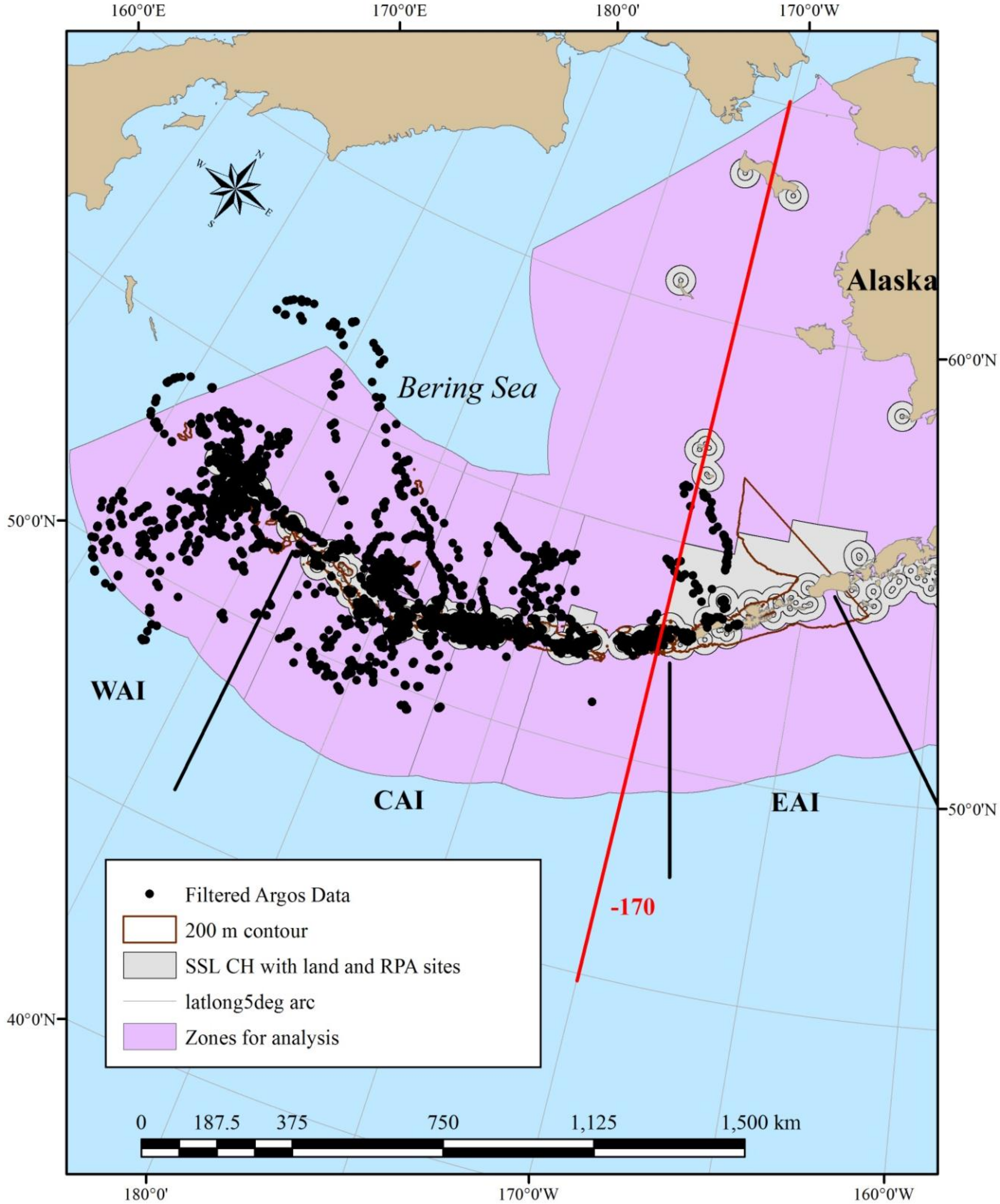

Figure 2. Locations (n = 24,004) of 45 juvenile Steller sea lions after filtering the raw diagnostic Argos data and plotted with respect to designated critical habitat (CFR 223, 226, and 679.22) depicted in gray (0-3 nmi, 3-10 nmi, 10-20 nmi, and foraging areas > 20 nmi from haulouts and rookeries) and the continental shelf (defined as 200 m).

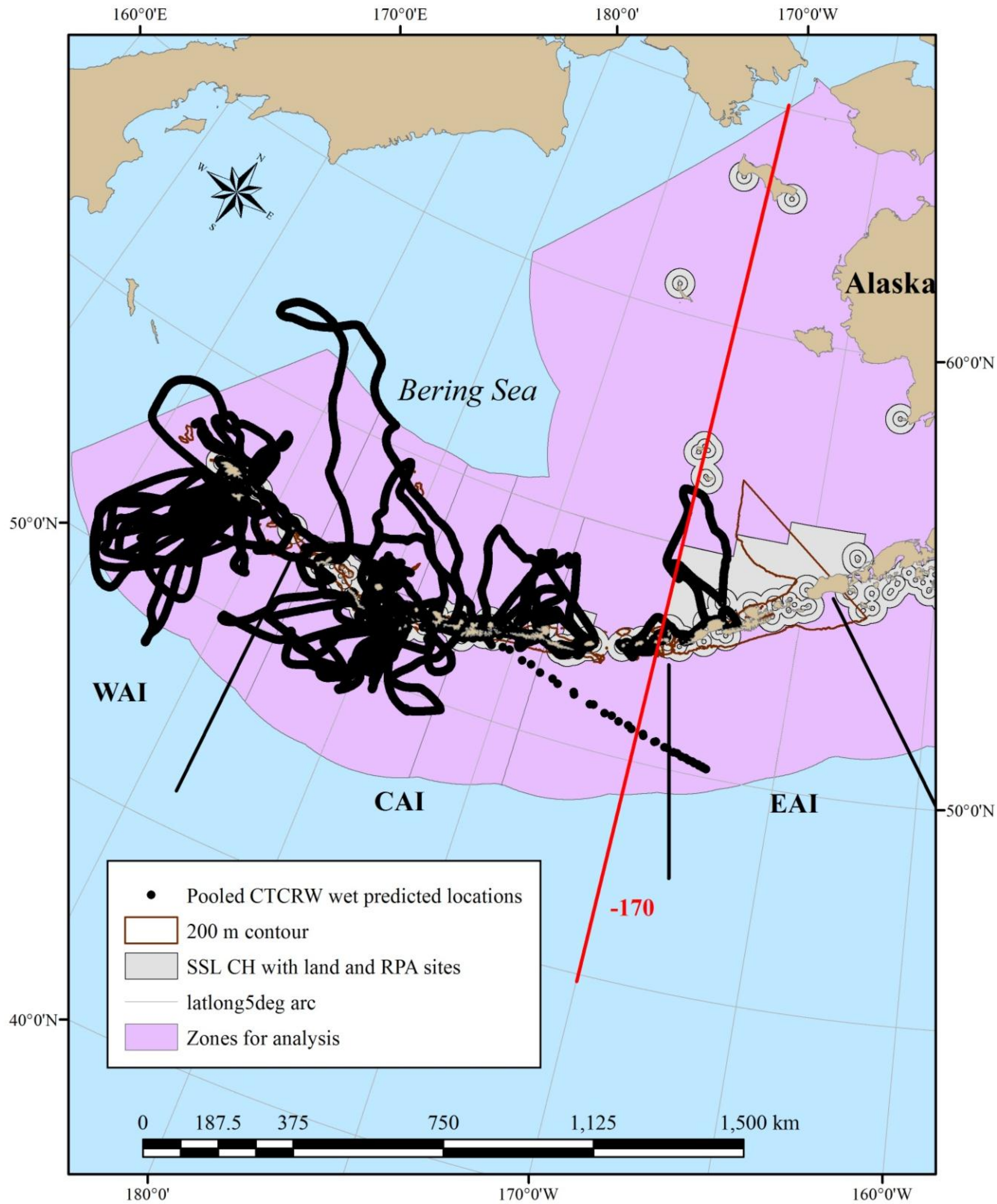

Figure 3. Predicted locations (n = 142,824) that were generated with the CTCRW model, pooled among 45 Steller sea lions, and plotted with respect to designated critical habitat (CFR 223, 226, and 679.22) depicted in gray (0-3 nmi, 3-10 nmi, 10-20 nmi, and foraging areas > 20 nmi from haulouts and rookeries) and the continental shelf (defined as 200 m).

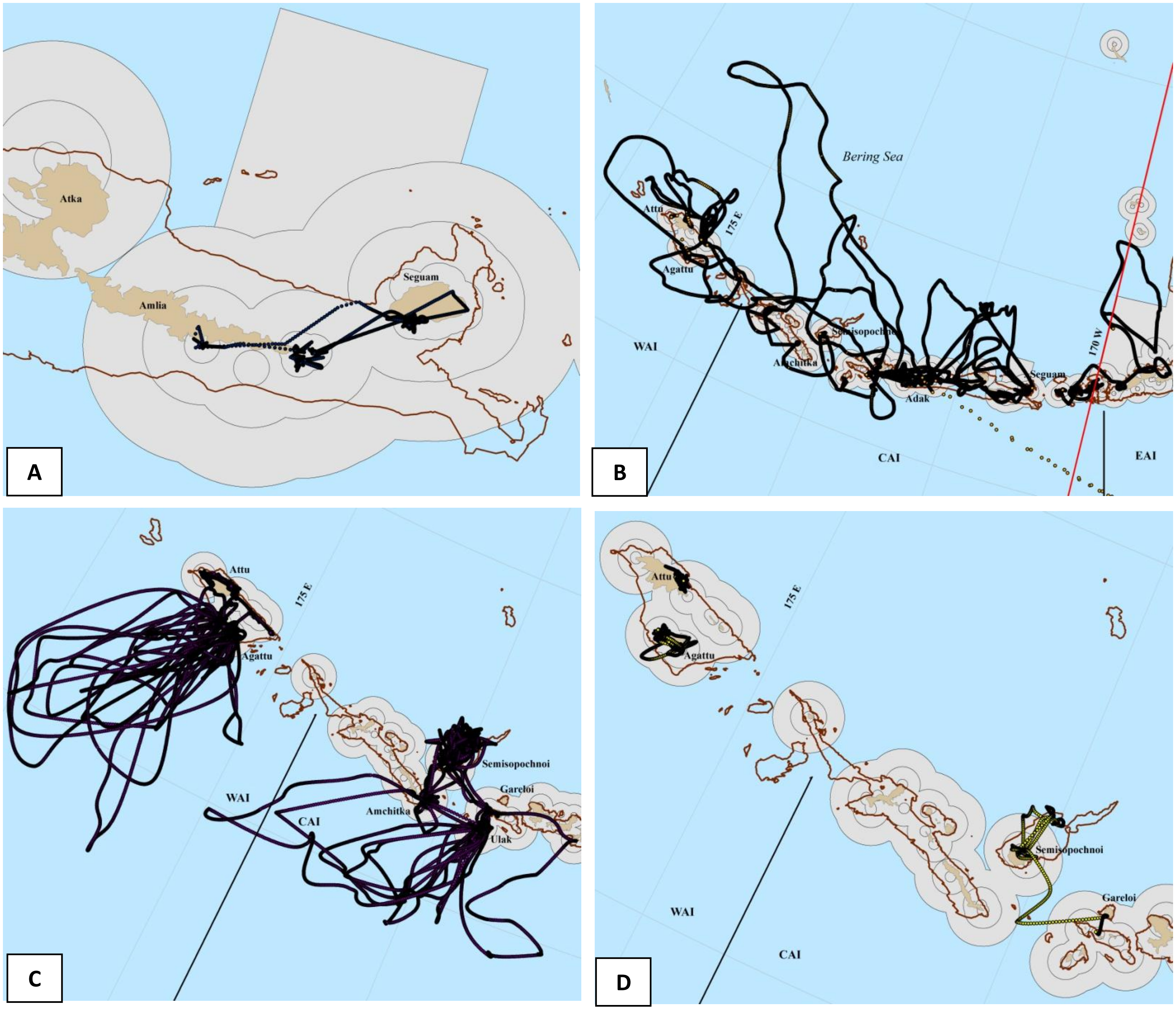

Figure 4. Wet, predicted locations obtained from the CTCRW models for a) four juvenile Steller sea lions (*n* = 5,752 locations) during winter (October-March); b) 39 juvenile Steller sea lions (*n* = 85,010 locations) during summer (April-September); c) six adult female Steller sea lions (*n* = 42,901 locations) during winter, and; d) three adult female Steller sea lions (*n* = 9,161 locations) during summer with respect to designated critical habitat (CFR 223, 226, and 679.22) depicted in gray (0-3 nmi, 3-10 nmi, 10-20 nmi, and foraging areas > 20 nmi from haulouts and rookeries) and the continental shelf (defined as 200 m, depicted as brown lines).

Table 1. Information for juvenile (Juv) and adult (A) Steller sea lions satellite-tagged in the central (CAI) and western Aleutian Islands (WAI) by the National Marine Mammal Laboratory (NMML) and the Alaska Department of Fish and Game (ADFG) from 29 February 2000 to October 2013 (m = months, F = female, M = male, SDR = satellite depth recorder, SRDL = satellite relay data logger, GMT = Greenwich Mean Time).

PTT	DBID	Location	Region	Cap Age (m)	Age Class	Sex	Instrument	Agency	Capture Date (GMT)	Date Last Transmission (GMT)	Season
14111	6295	Turf Pt., Seguam	CAI	9	Juv	F	SDR	NMML	2/29/2000	4/30/2000	both
14114	6296	Turf Pt., Seguam	CAI	9	Juv	F	SDR	NMML	2/29/2000	4/22/2000	both
14116	6297	Turf Pt., Seguam	CAI	9	Juv	F	SDR	NMML	3/1/2000	4/26/2000	both
14163	6298	Turf Pt., Seguam	CAI	9	Juv	M	SDR	NMML	3/1/2000	6/13/2000	both
19414	7620	Bay of Waterfalls, Adak	CAI	9	Juv	M	SDR	ADFG	4/7/2002	7/24/2002	summer
19426	7621	Bay of Waterfalls, Adak	CAI	9	Juv	M	SDR	ADFG	4/7/2002	7/20/2002	summer
14150	7820	Buldir	WAI	12	Juv	M	SRDL	NMML	7/3/2002	8/13/2002	summer
14151	7821	Cape Wrangell, Attu	WAI	12	Juv	F	SRDL	NMML	7/5/2002	8/24/2002	summer
14153	7822	Cape Wrangell, Attu	WAI	12	Juv	F	SRDL	NMML	7/6/2002	7/20/2002	summer
25537	Agnes	Yunaska	CAI	22	Juv	F	SRDL	ADFG	3/29/2003	6/25/2003	summer
25740	Barnes	Yunaska	CAI	10	Juv	M	SRDL	ADFG	3/29/2003	6/23/2003	summer
25741	Chisak	Yunaska	CAI	10	Juv	F	SRDL	ADFG	3/29/2003	6/17/2003	summer
25560	Delarof	Kagalaska	CAI	10	Juv	F	SRDL	ADFG	4/1/2003	6/30/2003	summer
25742	Elwood	Kagalaska	CAI	10	Juv	F	SRDL	ADFG	4/1/2003	5/13/2003	summer
25548	Fenner	Kagalaska	CAI	22	Juv	M	SRDL	ADFG	4/1/2003	7/30/2003	summer
25745	Gramp	Kagalaska	CAI	10	Juv	F	SRDL	ADFG	4/2/2003	6/22/2003	summer
25564	Hidalgo	Kagalaska	CAI	10	Juv	M	SRDL	ADFG	4/3/2003	7/26/2003	summer
14159	10007	Kagalaska	CAI	11	Juv	M	SRDL	NMML	5/7/2004	7/7/2004	summer
14162	10008	Kagalaska	CAI	11	Juv	M	SRDL	NMML	5/7/2004	7/20/2004	summer
14163	10009	Silak Isl.	CAI	11	Juv	M	SRDL	NMML	5/8/2004	7/23/2004	summer
14164	10010	Silak Isl.	CAI	11	Juv	M	SRDL	NMML	5/8/2004	7/31/2004	summer
14170	10011	Silak Isl.	CAI	11	Juv	M	SRDL	NMML	5/8/2004	8/2/2004	summer
14171	10012	Little Tanaga Isl.	CAI	23	Juv	F	SRDL	NMML	5/17/2004	6/22/2004	summer
23441	11246	Silak I.	CAI	10	Juv	F	SDR	NMML	4/20/2005	6/12/2005	summer
23663	11247	Silak I.	CAI	10	Juv	F	SDR	NMML	4/20/2005	5/11/2005	summer
23664	11248	Little Tanaga I.	CAI	10	Juv	M	SDR	NMML	4/21/2005	5/14/2005	summer
23665	11249	Lake Point	CAI	10	Juv	M	SDR	NMML	4/23/2005	6/12/2005	summer
23667	11250	Lake Point	CAI	10	Juv	M	SDR	NMML	4/23/2005	5/21/2005	summer
23671	11251	Lake Point	CAI	10	Juv	M	SDR	NMML	4/23/2005	6/26/2005	summer
24214	11252	Lake Point	CAI	10	Juv	M	SDR	NMML	4/23/2005	5/12/2005	summer

Table 1. Continued.

PTT	DBID	Location	Region	Cap Age (m)	Age Class	Sex	Instrument	Agency	Capture Date (GMT)	Date Last Transmission (GMT)	Season
24829	11253	Lake Point	CAI	10	Juv	F	SDR	NMML	4/23/2005	6/17/2005	summer
24834	11255	Ship Rock	CAI	10	Juv	F	SDR	NMML	4/25/2005	5/7/2005	summer
24835	11256	Ship Rock	CAI	10	Juv	M	SDR	NMML	4/26/2005	7/1/2005	summer
24836	11257	Ogalala Pt.	CAI	10	Juv	M	SDR	NMML	4/26/2005	6/1/2005	summer
24837	11258	Ogalala Pt.	CAI	10	Juv	F	SDR	NMML	4/26/2005	6/27/2005	summer
24838	11259	Lake Point	CAI	11	Juv	M	SDR	NMML	5/2/2005	5/9/2005	summer
24839	11260	Lake Point	CAI	11	Juv	M	SDR	NMML	5/3/2005	7/31/2005	summer
8262	11261	Lake Point	CAI	11	Juv	M	SDR	NMML	5/3/2005	6/19/2005	summer
25923	11262	Semisopochnoi	CAI	11	Juv	F	SDR	NMML	5/3/2005	6/5/2005	summer
35224	14809	Hasgox pt., Ulak	CAI		A	F	SPLASH10	NMML	11/1/2011	4/24/2012	both
14751	25	Cape Wrangell, Attu	WAI		A	F	SPLASH10	NMML	10/18/2012	6/3/2013	winter
61087	15134	Alaid	WAI		A	F	SPLASH10	NMML	10/20/2012	11/9/2012	winter
61142	15135	Cape Sabak, Agattu	WAI		A	F	SPLASH10	NMML	10/23/2012	7/5/2013	winter
61089	15136	East Cape, Amchitka	CAI		A	F	SPLASH10	NMML	10/25/2012	12/11/2012	winter
61080	15137	Hasgox pt., Ulak	CAI		A	F	SPLASH10	NMML	10/26/2012	3/29/2013	winter

Table 2. Mean ± SE and (range) of percentages of wet, predicted locations generated from CTCRW models in zones of designated critical habitat and within/outside the 200 m isobath for season and age class interactions. Sample sizes in parentheses in the header denote number of Steller sea lions. Winter is defined as October through March, whereas summer is defined as April through September.

	Winter Juv (*n*=4)	Summer Juv (*n*=39)	Winter AF (*n*=6)	Summer AF (*n*=3)
Inside Critical Habitat				
0-3 nmi	95.7 ± 1.5 (91.9 – 98.8)	44.6 ± 5.4 (0.0 – 100.0)	34.7 ± 6.0 (19.8 – 55.3)	44.3 ± 22.4 (0.6 – 75.3)
3-10 nmi	4.3 ± 1.5 (1.2 – 8.1)	33.8 ± 5.2 (0.0 – 100.0)	21.6 ± 4.8 (4.3 – 39.7)	34.2 ± 15.8 (13.7 – 65.3)
10-20 nmi	0.0 ± 0.0 (0.0 – 0.0)	15.5 ± 4.0 (0.0 – 91.5)	24.3 ± 9.5 (3.0 – 55.8)	13.9 ± 10.2 (1.2 – 34.0)
> 20 nmi (forage boxes)	0.0 ± 0.0 (0.0 – 0.0)	0.3 ± 0.2 (0.0 – 8.7)	0.0 ± 0.0 (0.0 – 0.0)	0.0 ± 0.0 (0.0 – 0.0)
Outside Critical Habitat	0.0 ± 0.0 (0.0 – 0.0)	5.8 ± 2.1 (0.0 – 47.8)	19.4 ± 8.9 (0.0– 52.4)	7.7 ± 7.7 (0.0 – 23.0)
Bathymetry				
Inside 200 m isobath	100.0 ± 0.0 (100.0 – 100.0)	92.2 ± 2.7 (38.7 – 100.0)	73.9 ± 9.7 (42.0 – 100.0)	92.7 ± 6.5 (79.7 – 99.7)
Outside 200 m isobath	0.0 ± 0.0 (0.0 – 0.0)	7.8 ± 2.7 (0.0 – 61.3)	26.1 ± 9.7 (0.0 – 58.0)	7.3 ± 6.5 (0.3 – 20.3)

Table 3. Percentages of wet, predicted locations generated from CTCRW models in zones of designated critical habitat and within/outside the 200 m isobath for season and age classes. Sample sizes in parentheses denote pooled number of Steller sea lions and number of locations, respectively. Winter is defined as October through March, whereas summer is defined as April through September.

	Winter (n=10; 48653)	Summer (n=42; 94171)	Juvenile (n=43; 90762)	Adult (n=9; 52062)
Critical Habitat				
0-3 nmi	36.9	35.1	38.2	31.4
3-10 nmi	22.0	36.5	34.2	27.0
10-20 nmi	18.1	19.1	18.3	19.6
> 20 nmi (forage boxes)	0.0	0.4	0.4	0.0
Outside CH	23.0	8.9	8.9	22.0
Bathymetry				
Inside 200 m	72.6	88.2	88.1	73.8
Outside 200 m	27.4	11.8	11.9	26.2

Table 4. Percentages of wet, predicted locations generated from CTCRW models in zones of designated critical habitat and within/outside the 200 m isobath for season and age class interactions. Sample sizes in parentheses denote pooled number of Steller sea lions and number of locations, respectively. Winter is defined as October through March, whereas summer is defined as April through September.

	Winter Juv (n=4; 5752)	Summer Juv (n=39; 85010)	Winter AF (n=6; 42901)	Summer AF (n=3; 9161)
Critical Habitat				
0-3 nmi	95.7	34.3	29.0	42.8
3-10 nmi	4.3	36.2	24.4	39.1
10-20 nmi	0.0	19.5	20.5	15.1
> 20 nmi (forage boxes)	0.0	0.5	0.0	0.0
Outside CH	0.0	9.5	26.1	3.0
Bathymetry				
Inside 200 m	100.0	87.3	68.9	96.6
Outside 200 m	0.0	12.7	31.1	3.4

Table 5. Percentages of locations in zones of designated critical habitat reported in Table 3.11 of NMFS (2010) and percentages of wet, predicted locations generated from CTCRW models in designated critical habitat. Data are pooled within season and age class interactions.

	NMFS (2010)		CTCRW model			
	Summer Juv	Winter Juv	Summer Juv	Summer AF	Winter Juv	Winter AF
Inside Critical Habitat						
0-10 nmi*	68.8	100.0	70.5	81.9	100.0	53.4
10-20 nmi	8.8	0.0	19.5	15.1	0.0	20.5
> 20 nmi (forage boxes)	0.5	0.0	0.5	0.0	0.0	0.0
Outside Critical Habitat	21.9	0.0	9.5	3.0	0.0	26.1

* note: 0-3 and 3-10 nmi are combined. Juv = juvenile, AF = adult female age classes

Table 6. Number of Steller sea lions tracked by Aleutian Island area during 2000-2013, by month and age class (Region WAI = western Aleutian Islands, CAI = central Aleutian Islands).

Age class	Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Juvenile	WAI	0	0	0	0	0	0	3	2	0	0	0	0
	CAI	0	2	4	26	35	26	10	1	0	0	0	0
	Total	*0*	*2*	*4*	*26*	*35*	*26*	*13*	*3*	*0*	*0*	*0*	*0*
Adult female	WAI	2	2	2	2	2	2	1	0	0	3	3	2
	CAI	2	2	2	1	0	0	0	0	0	2	3	3
	Total	*4*	*4*	*4*	*3*	*2*	*2*	*1*	*0*	*0*	*5*	*6*	*5*

Appendix 1. Counts and percentages of wet, predicted locations generated from CTCRW models in zones of designated critical habitat for 45 Steller sea lions.

				Count Data						Percentage Data				
PTT	DBID	Age class	Season	0-3 nm	3-10 nm	10-20 nm	> 20 nm	outside CH	Total	0-3 nm	3-10 nm	10-20 nm	> 20 nm	outside CH
14111	6295	Juv	summer	1253	94	0	0	0	1347	93.0	7.0	0.0	0.0	0.0
14111	6295	Juv	winter	1491	49	0	0	0	1540	96.8	3.2	0.0	0.0	0.0
14114	6296	Juv	summer	1126	114	0	0	0	1240	90.8	9.2	0.0	0.0	0.0
14114	6296	Juv	winter	1277	113	0	0	0	1390	91.9	8.1	0.0	0.0	0.0
14116	6297	Juv	summer	1240	0	0	0	0	1240	100.0	0.0	0.0	0.0	0.0
14116	6297	Juv	winter	1355	69	0	0	0	1424	95.2	4.8	0.0	0.0	0.0
14163	6298	Juv	summer	1624	527	241	125	1407	3924	41.4	13.4	6.1	3.2	35.9
14163	6298	Juv	winter	1381	17	0	0	0	1398	98.8	1.2	0.0	0.0	0.0
19414	7620	Juv	summer	1340	868	487	0	2075	4770	28.1	18.2	10.2	0.0	43.5
19426	7621	Juv	summer	989	1017	803	0	1648	4457	22.2	22.8	18.0	0.0	37.0
14150	7820	Juv	summer	1102	144	36	0	205	1487	74.1	9.7	2.4	0.0	13.8
14151	7821	Juv	summer	2093	159	0	0	0	2252	92.9	7.1	0.0	0.0	0.0
14153	7822	Juv	summer	512	1	1	0	0	514	99.6	0.2	0.2	0.0	0.0
25537	Agnes	Juv	summer	207	21	2455	0	0	2683	7.7	0.8	91.5	0.0	0.0
25740	Barnes	Juv	summer	515	426	1530	283	511	3265	15.8	13.0	46.9	8.7	15.7
25741	Chisak	Juv	summer	1525	1111	137	0	5	2778	54.9	40.0	4.9	0.0	0.2
25560	Delarof	Juv	summer	263	58	2202	0	0	2523	10.4	2.3	87.3	0.0	0.0
25742	Elwood	Juv	summer	16	1036	0	0	0	1052	1.5	98.5	0.0	0.0	0.0
25548	Fenner	Juv	summer	1070	2235	1063	0	0	4368	24.5	51.2	24.3	0.0	0.0
25745	Gramp	Juv	summer	859	355	841	0	0	2055	41.8	17.3	40.9	0.0	0.0
25564	Hidalgo	Juv	summer	0	4152	0	0	0	4152	0.0	100.0	0.0	0.0	0.0
14159	10007	Juv	summer	94	1582	20	0	0	1696	5.5	93.3	1.2	0.0	0.0
14162	10008	Juv	summer	42	2548		0	0	2590	1.6	98.4	0.0	0.0	0.0
14163	10009	Juv	summer	630	1969	66	0	0	2665	23.6	73.9	2.5	0.0	0.0
14164	10010	Juv	summer	1293	1118	438	0	533	3382	38.2	33.1	13.0	0.0	15.8
14170	10011	Juv	summer	792	2757	0	0	0	3549	22.3	77.7	0.0	0.0	0.0
14171	10012	Juv	summer	278	901	0	0	0	1179	23.6	76.4	0.0	0.0	0.0
23441	11246	Juv	summer	710	1394	0	0	0	2104	33.7	66.3	0.0	0.0	0.0
23663	11247	Juv	summer	907	0	0	0	0	907	100.0	0.0	0.0	0.0	0.0

Appendix 1. Continued.

				Count Data						Proportion Data				
PTT	DBID	Age class	Season	0-3 nm	3-10 nm	10-20 nm	> 20 nm	outside CH	Total	0-3 nm	3-10 nm	10-20 nm	> 20 nm	outside CH
23664	11248	Juv	summer	123	511	0	0	0	634	19.4	80.6	0.0	0.0	0.0
23665	11249	Juv	summer	593	420	1418	0	0	2431	24.4	17.3	58.3	0.0	0.0
23667	11250	Juv	summer	1106	22	0	0	0	1128	98.0	2.0	0.0	0.0	0.0
23671	11251	Juv	summer	602	993	887	0	0	2482	24.3	40.0	35.7	0.0	0.0
24214	11252	Juv	summer	567	0	0	0	0	567	100.0	0.0	0.0	0.0	0.0
24829	11253	Juv	summer	1250	791	221	0	0	2262	55.3	35.0	9.8	0.0	0.0
24834	11255	Juv	summer	239	51	0	0	0	290	82.4	17.6	0.0	0.0	0.0
24835	11256	Juv	summer	998	1087	546	0	0	2631	37.9	41.3	20.8	0.0	0.0
24836	11257	Juv	summer	384	333	388	0	0	1105	34.8	30.1	35.1	0.0	0.0
24837	11258	Juv	summer	1187	1294	25	0	0	2506	47.4	51.6	1.0	0.0	0.0
24838	11259	Juv	summer	133	121	0	0	0	254	52.4	47.6	0.0	0.0	0.0
24839	11260	Juv	summer	255	280	2124	0	571	3230	7.9	8.7	65.8	0.0	17.7
8262	11261	Juv	summer	405	229	621	0	1149	2404	16.8	9.5	25.8	0.0	47.8
25923	11262	Juv	summer	826	67	14	0	0	907	91.1	7.4	1.5	0.0	0.0
35224	14809	A	summer	676	163	76	0	273	1188	56.9	13.7	6.4	0.0	23.0
35224	14809	A	winter	3834	1468	1014	0	2808	9124	42.0	16.1	11.1	0.0	30.8
14751	25	A	summer	24	2414	1256	0	0	3694	0.6	65.3	34.0	0.0	0.0
14751	25	A	winter	2048	2475	5719	0	0	10242	20.0	24.2	55.8	0.0	0.0
61087	15134	A	winter	466	45	543	0	0	1054	44.2	4.3	51.5	0.0	0.0
61142	15135	A	summer	3220	1006	53	0	0	4279	75.3	23.5	1.2	0.0	0.0
61142	15135	A	winter	2083	2126	793	0	5511	10513	19.8	20.2	7.5	0.0	52.4
61089	15136	A	winter	1533	693	458	0	88	2772	55.3	25.0	16.5	0.0	3.2
61080	15137	A	winter	2481	3648	280	0	2787	9196	27.0	39.7	3.0	0.0	30.3

Appendix 2. Counts and percentages of wet, predicted locations generated from CTCRW models in/outside the 200 m isobath for 45 Steller sea lions.

				Count Data			Percentage Data	
PTT	DBID	Age Class	Season	Inside 200 m	Outside 200 m	Total	Inside 200 m	Outside 200 m
14111	6295	Juv	summer	1347	0	1347	100.0	0.0
14111	6295	Juv	winter	1540	0	1540	100.0	0.0
14114	6296	Juv	summer	1240	0	1240	100.0	0.0
14114	6296	Juv	winter	1390	0	1390	100.0	0.0
14116	6297	Juv	summer	1240	0	1240	100.0	0.0
14116	6297	Juv	winter	1424	0	1424	100.0	0.0
14163	6298	Juv	summer	2158	1766	3924	55.0	45.0
14163	6298	Juv	winter	1398	0	1398	100.0	0.0
19414	7620	Juv	summer	2226	2544	4770	46.7	53.3
19426	7621	Juv	summer	1967	2490	4457	44.1	55.9
14150	7820	Juv	summer	1287	200	1487	86.6	13.4
14151	7821	Juv	summer	2252	0	2252	100.0	0.0
14153	7822	Juv	summer	514	0	514	100.0	0.0
25537	Agnes	Juv	summer	2670	13	2683	99.5	0.5
25740	Barnes	Juv	summer	2190	1075	3265	67.1	32.9
25741	Chisak	Juv	summer	2677	101	2778	96.4	3.6
25560	Delarof	Juv	summer	2523	0	2523	100.0	0.0
25742	Elwood	Juv	summer	1052	0	1052	100.0	0.0
25548	Fenner	Juv	summer	4352	16	4368	99.6	0.4
25745	Gramp	Juv	summer	2008	47	2055	97.7	2.3
25564	Hidalgo	Juv	summer	4152	0	4152	100.0	0.0
14159	10007	Juv	summer	1667	29	1696	98.3	1.7
14162	10008	Juv	summer	2590	0	2590	100.0	0.0
14163	10009	Juv	summer	2665	0	2665	100.0	0.0
14164	10010	Juv	summer	2813	569	3382	83.2	16.8
14170	10011	Juv	summer	3549	0	3549	100.0	0.0
14171	10012	Juv	summer	1179	0	1179	100.0	0.0
23441	11246	Juv	summer	2104	0	2104	100.0	0.0
23663	11247	Juv	summer	907	0	907	100.0	0.0
23664	11248	Juv	summer	634	0	634	100.0	0.0

Appendix 2. Continued.

				Count Data			Percentage Data	
PTT	DBID	Age Class	Season	Inside 200 m	Outside 200 m	Total	Inside 200 m	Outside 200 m
23665	11249	Juv	summer	2415	16	2431	99.3	0.7
23667	11250	Juv	summer	1128	0	1128	100.0	0.0
23671	11251	Juv	summer	2467	15	2482	99.4	0.6
24214	11252	Juv	summer	567	0	567	100.0	0.0
24829	11253	Juv	summer	2177	85	2262	96.2	3.8
24834	11255	Juv	summer	290	0	290	100.0	0.0
24835	11256	Juv	summer	2629	2	2631	99.9	0.1
24836	11257	Juv	summer	1105	0	1105	100.0	0.0
24837	11258	Juv	summer	2506	0	2506	100.0	0.0
24838	11259	Juv	summer	254	0	254	100.0	0.0
24839	11260	Juv	summer	2868	362	3230	88.8	11.2
8262	11261	Juv	summer	931	1473	2404	38.7	61.3
25923	11262	Juv	summer	903	4	907	99.6	0.4
35224	14809	A	summer	947	241	1188	79.7	20.3
35224	14809	A	winter	7020	2104	9124	76.9	23.1
14751	25	A	summer	3684	10	3694	99.7	0.3
14751	25	A	winter	10219	23	10242	99.8	0.2
61087	15134	A	winter	1054	0	1054	100.0	0.0
61142	15135	A	summer	4218	61	4279	98.6	1.4
61142	15135	A	winter	4420	6093	10513	42.0	58.0
61089	15136	A	winter	1984	788	2772	71.6	28.4
61080	15137	A	winter	4858	4338	9196	52.8	47.2