Photo-Identification of Beluga Whales in Cook Inlet, Alaska:

Inclusion of Biopsy and Hexacopter Photographs from 2017

Prepared by:

Prepared for:

National Marine Fisheries Service

Marine Mammal Laboratory

June 2018

Photo-Identification of Beluga Whales in Cook Inlet, Alaska: Inclusion of Biopsy and Hexacopter Photographs from 2017

Prepared by:

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Contract Number: WE133F17SE1266

Contract Title: Professional services to provide beluga photographic identifications for 2017 CIBW biopsy, hexacopter, and stock assessment models

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Project Period: September 1, 2017-June 1, 2018.

Final Report Submission Date: June 1, 2018

Prepared for: National Marine Fisheries Service, Marine Mammal Laboratory

Keywords: beluga whale, Cook Inlet, photo-identification, catalog, sighting histories, biopsy, hexacopter

Citation:

McGuire, T., A. Stephens, and J. McClung. 2018. Photo-identification of Beluga Whales in Cook Inlet, Alaska: Inclusion of Biopsy and Hexacopter Photographs from 2017. Report prepared by The Cook Inlet Beluga Whale Photo-ID Project, Anchorage, AK, for National Marine Fisheries Service, Marine Mammal Laboratory. 91 p.

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LIST OF ACRONYMS

AKR	Alaska Region
AOOS	Alaska Ocean Observing System
CIBW	Cook Inlet Beluga Whale
ESA	Endangered Species Act
JBER	Joint Base Elmendorf Richardson
MML	Marine Mammal Laboratory
NMFS	National Marine Fisheries Service

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INTRODUCTION

The Cook Inlet beluga whale (CIBW) population has declined significantly in the last four decades, from an estimated high of 1,300 in the late 1970s to fewer than 400 currently. This decline led the National Marine Fisheries Service (NMFS) to list the CIBWs as endangered under the Endangered Species Act (NMFS 2008). In February 2016, NMFS released the five-year "Species in the Spotlight" Action Plan for CIBWs with the goal of promoting effective research and management actions that would result in recovery. The Action Plan recommended coupling biopsy and photo-identification research as a means of gaining a better understanding of population characteristics.

In 2016 and 2017, the NMFS Marine Mammal Laboratory (MML) implemented a biopsy study of CIBWs. Part of the study included photographing biopsied whales and comparing these photographs to those of the over 350 individually identified whales in the photo-catalog that has been developed and maintained by the Cook Inlet Beluga Whale Photo-ID Project since 2005. Photo-id results of the 2016 biopsy study are presented in McGuire et al. 2017 a, b.

In 2017, the CIBW Photo-ID Project was contracted by NMFS to provide beluga photo-identification services to MML in the following ways : 1) accompany MML staff on the first three field days of the 2017 biopsy survey to ensure that identification photographs were collected in a consistent manner with the 2016 study, 2) review the results of MML's processing of photographs from individual encounters to ascertain if individuals photographed were identified in the CIBW Photo-ID Project catalog, 3) compare the photographs of the identifiable whales to the existing CIBW Photo-ID catalog and incorporate them into the CIBW Photo-ID Project dataset, and 4) provide the individual histories of whales identified during the biopsy survey using the information available from the CIBW Photo-ID Project dataset. An amendment was later made to the contract to allow for the comparison of a select group of photographs taken by NMFS during their 2017 hexacopter surveys with individuals in the CIBW Photo-ID Project catalog.

METHODS

Fieldwork was conducted during August and September of 2017 in Upper Cook Inlet, Alaska (Figure 1). All survey activities were conducted under MML's NMFS Scientific Research Permit #20465. Details about the methods and results of the 2017 biopsy and hexacopter studies, including biopsy and hexacopter survey effort and groups encountered, disposition of biopsy samples, and initial processing of photographs from hexacopter studies may be obtained by contacting the biopsy and hexacopter project lead, Dr. Paul Wade, MML, at Paul.wade@noaa.gov.

Methods of biopsy sample collection, photo-id during biopsy, and identification of biopsied whales from photographs were similar to those described in McGuire et al. (2017 a). Biopsy photos taken in 2017 were provided by MML to the CIBW Photo-ID Project for comparison

with the 2005-2017 catalog, with direction to identify only those individuals from which biopsy samples had been obtained.

MML provided the CIBW Photo-ID Project with a sub-set of photos from the hexacopter studies conducted in 2017. These photos were organized into folders, and each folder contained two types of photographs of individual CIBWs; those taken obliquely by a photographer on a survey vessel, and those taken from a remotely operated hexacopter drone flown by operators on the survey vessel. MML staff selected the subset of photographs they judged useful for photo-id and also made the determination if the oblique photos of an individual matched the aerial photos of the same individual.

RESULTS

Identification of Whales Photographed during Biopsy Studies

Twenty-eight CIBWs were targeted for biopsy (i.e., 28 shots were taken). Fourteen of these shots resulted in strikes. Twelve biopsy samples were collected (Table 1). Samples were not collected from two strikes because one dart remained in the whale without being retrieved, and one sample was lost during retrieval. One individual was successfully biopsied then targeted again later the same day, although the second shot fell short and a second biopsy sample was not collected.

Eight of the biopsied whales with samples were matched to individuals in the CIBW photo-id catalog (Table 1), as was one of the whales from which the sample was not retrieved. The sighting histories of the nine biopsied CIBWs that were identified as individuals in the CIBW Photo-ID Catalog are presented in Appendix A. Three individuals were first photographed in 2005 (the first year of the photo-id catalog), and two were first photographed as recently as 2016. None of the whales biopsied in 2017 were matched to photographs of whales biopsied in 2016, or to whales that had been satellite-tagged by NMFS 1999-2002 (McGuire and Stephens 2016).

Two of the nine identified biopsied whales had photographs of accompanying calves in their previous photo-id histories that suggest they are reproductive females (Table 1). Information from NMFS about genetic sex determined from biopsy skin samples, as well as levels of reproductive hormones in the blubber was not available at the time of this report.

One of the whales biopsied in 2017**,** D2379, had a pronounced concavity behind the dorsal crest (Figure A3). This individual was first photographed as a large calf in 2005, was not photographed in 2006 or 2007, but was seen to have a slight sway in the back in photos from 2008 that appeared to become more pronounced with each year.

Identification of Whales Photographed during Hexacopter Studies

There were 122 folders of individuals photographed from a hexacopter in 2017 that were reviewed for matches to the CIBW Photo-ID Project catalog; 62 of these folders were matched (Table 2). However, six of these folders were of whales that had been photographed during

multiple encounters during the 2017 hexacopter survey, resulting in a total of 56 unique individual whales photographed from a hexacopter that were matched to individuals in the catalog. Table 3 summarizes the reasons that some folders could not be matched to the catalog.

Forty-four percent of the 56 matched individuals were first photographed in 2005 (Table 2), and one whale, D109, had been photographed by MML 19 years earlier, in 1998 (Figure B8). Of the 56 identified individuals, 63% had been identified as reproductive females based on the close accompaniment of calves at some time in their photographic records (Table 2).

Four of the identified whales photographed from a hexacopter in 2017 had previously been tagged by NMFS 1999-2002 during their satellite tagging study: D103 (a female tagged in 2001; Figure B7); D111 (a female tagged in 2000; Figure B10); D49 (unknown sex and year of tagging; Figure B4), and R6 (unknown sex and year of tagging; Figure B49). None of the whales identified from hexacopter photos in 2017 had been matched to photos of whales biopsied in 2016 or 2017.

One whale, D1032 (Figure B18) had been live-stranded with a calf in Turnagain Arm in 2015. The Alaska Marine Mammal Stranding Network photographed the stranding from a NMFS hexacopter and from a NMFS observer on the mudflats and shared the photos with the CIBW Photo-ID Project. This whale had not been photographed again in 2015 after the stranding or during the 2016 field season, leading researchers to wonder if she had survived the effects of the live-stranding (McGuire et al. 2017 c); photographs from 2017 establish that she did.

Forty-one individuals identified from photographs taken during hexacopter surveys showed images of both sides of each whale that could be matched to the CIBW Photo-ID catalog (i.e., they were "dual-side whales"; McGuire and Stephens 2017). Eleven of these individuals already existed as dual-side whales in the catalog, and an additional 30 individuals were able to be classified as dual-side catalog whales because of the linkages between the right and left sides visible in the photographs taken from the hexacopter (Table 3).

DISCUSSION

Integrating the results from the CIBW Biopsy and Hexacopter Studies with the long-term photographic records contained in the CIBW Photo-ID Project catalog for the 69 identified individual CIBWs (i.e., 5 identified individuals biopsied in 2016, 8 identified individuals biopsied in 2017, and 56 individuals photographed from a hexacopter in 2017) that have been matched to date is useful for the following reasons:

1) It offers insights into which individuals in the population are being sampled by biopsy and hexacopter (i.e., was there bias in the sampling method that favored a particular age class, sex, or subgroup?)
2) It validates and augments information in the photo-id catalog by confirming assumptions or providing new information about the sex of biopsied individuals, the individual

identifications, and the linkages between right- and left-side photos of the same individual.

3) It provides life-history context (e.g., relative age, reproductive history, habitat use, and linkages to individuals already sampled in previous satellite-tagging, stranding, and biopsy studies) from linking up to 13 years of photo-id records to the biological samples obtained from biopsy and the morphometrics obtained by hexacopter.
4) It allows for post-sampling examination of possible injury, infection, or behavioral changes resulting from biopsy sampling, and for rates for growth via repeat hexacopter sampling of the same individuals over time.

Results of analyses of the biopsy samples from 2016 and 2017 (e.g., genetic sex determination, reproductive hormones, cortisol levels, age, diet, and microbiome), as well as the measurements obtained by NMFS from the hexacopter photogrammetry studies, remain to be incorporated into the records of identified individuals in the CIBW Photo-ID catalog, pending results becoming available and being shared with the CIBW Photo-ID Project by NMFS. Genetic sex and reproductive hormone levels from the 2016 biopsy study have already been made available and have been incorporated in the CIBW Photo-ID Catalog (McGuire and Stephens 2017).

Individual sighting histories from the CIBW Photo-ID catalog are being shared with colleagues from NMFS, Alaska Department of Fish and Game, Montana State University, and the University of Washington to develop individual-based models for stock assessment, estimation of reproductive and survival rates, and population viability analysis; the integration of information provided by biopsy and hexacopter studies with that provided by photo-id will only strengthen this dataset.

We anticipate that more individuals photographed during the 2017 biopsy and hexacopter studies will be matched to the 2005-2017 CIBW Photo-ID Catalog upon the completion of the cataloging from the 2017 photo-id field season (this report is due December 2018). Additional information about reproductive histories of whale photographed during the 2017 field season will also be updated upon completion of the cataloging of photos from 2017.

In addition, there are potentially many matches to the CIBW Photo-ID catalog in the photos that were taken during the 2017 biopsy and hexacopter studies but that were not part of this contract's scope of work to catalog (i.e., they were not the biopsied whales or those with hexacopter folders created by MML). Allocating resources to catalog these remaining photos would potentially provide information on survival, reproduction, and habitat use of these individual CIBWs.

We recommend two actions to increase the likelihood of matching photographs obtained during future biopsy and/or hexacopter studies with records of individuals in the CIBW Photo-ID Catalog. The first recommendation is to have the CIBW Photo-ID team meet with the biopsy and hexacopter field teams in Anchorage immediately before the biopsy/hexacopter fieldwork commences to discuss how best to collect and archive photos in a manner that is most compatible with long-term photo-id protocols, while still meeting the needs of the hexacopter/biopsy projects. The second recommendation is that the NMFS and CIBW Photo-ID Project photo processing teams meet for a multi- day, post-field season workshop to discuss details of photo processing, naming, archiving, cropping, and prioritization for cataloging, as

well as how to maintain contextual data (i.e., location, group size, group composition, accompaniment of calves) in a way to ensure no information is lost during photo-processing and that information needs of multiple projects are met.

ACKNOWLEDGMENTS

We would like to acknowledge the collaboration on the biopsy and hexacopter studies with our colleagues from the Alaska Department of Fish and Game, the Alaska Marine Mammal Stranding Network, the Alaska Sea Life Center, Axiom Data Science, the Division of Conservation at Joint Base Elmendorf Richardson, the Group for Research and Education on Marine Mammals, Dave McKay, and NMFS (including MML, AKR, the Permits and Conservation Division, and the Office of Law Enforcement).

Photos in the 2005-2017 CIBW Photo-ID Project catalog were taken under General Authorization Letter of Confirmation No. 481-1759, and MMPA/ESA Research Permits #14210 and #18016 to T. McGuire. Photos in the catalog have also been generously contributed by the public and colleagues. The CIBW Photo-ID Project has received funding from the National Fish and Wildlife Foundation (with non-Federal match from Chevron, ConocoPhillips, Unocal, Donlin Gold, Royal Caribbean Cruise Lines, and Wells Fargo), the North Pacific Research Board, the Department of Defense, the Alaska Department of Fish and Game, the Kenai Peninsula Borough, the National Marine Fisheries Service (Alaska Region and Marine Mammal Laboratory), the US Fish and Wildlife Foundation, and the US Forest Service.

All CIBW Photo-ID Project reports are publicly available on the project website (www.cookinletbelulgas.org). In addition, the CIBW Photo-ID Project has provided their photo-id survey dataset to the public via the "NMFS Cook Inlet Beluga Whale Scientific Sightings Mapper" at https://alaskafisheries.noaa.gov/pr/beluga-research-cook-inlet. These data are also a layer in the publicly available Alaska Ocean Observing System's (AOOS) Cook Inlet Beluga Whale Ecosystem Portal http://portal.aoos.org/cibw.php.

REFERENCES CITED

McGuire, T. and A. Stephens. 2016. Summary report: status of previously satellite- tagged Cook Inlet beluga whales. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for Nat. Mar. Fish. Serv., Alaska Region. 86 p.

McGuire, T. and A. Stephens. 2017. Photo-identification of Beluga Whales in Cook Inlet, Alaska: summary and synthesis of 2005-2015 data. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for National Marine Fisheries Service, Alaska Region. 189 p.

McGuire, T., R. Michaud, M. Moisan, and C. Garner. 2017a. Cook Inlet beluga whale biopsy: field report for 2016 Feasibility Study. Report prepared by LGL Alaska Research Associates, Inc., GREMM, and JBER for NMFS. 67 p. + Appendices.

McGuire, T., A. Stephens, R. Michaud, M. Moisan, C. Garner. 2017b. Cook Inlet beluga whale biopsy: photo-identification of biopsied whales during the 2016 Feasibility Study. Report prepared by LGL Alaska Research Associates, Inc., GREMM, and JBER for NMFS. 33 p.

McGuire, T., A. Stephens, and S. Dufault. 2017c. Photo-identification of beluga whales in Upper Cook Inlet, Alaska. Summary of field activities and whales identified in 2015 and 2016. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for National Fish and Wildlife Foundation. 132 p.

NMFS. 2008. Endangered and threatened species; endangered status of the Cook Inlet beluga whale. Federal Register 73(205):62919-62930.

TABLES

Table 1. Summary of photo-id matches made to the 14 individuals biopsied during the 2017 CIBW biopsy study. All biopsy sampling in 2017 was conducted from a vessel (n/a=not applicable).

Date	Shot #	Strike/Miss	Biopsy ID	Side biopsied	Match to CIBW Photo-ID Catalog	CIBW Photo-ID Catalog ID	Year first identified in CIBW Photo-ID Catalog	Photographed with a calf 2005-2017*	Comments
Sep 2, 2017	1	strike	DL-CIB17-01	left	yes	L18630	2015	no	
Sep 2, 2017	2	strike	DL-CIB17-02	right	yes	D19173	2016	no	
Sep 2, 2017	4	strike	DL-CIB17-03	right	yes	D2379	2005	no	photographed again later the same day and on the following day
Sep 2, 2017	7	strike	DL-CIB17-04	left	no	n/a	n/a	n/a	potentially a match but can't be sure, photos blurry
Sep 2, 2017	8	strike	hit, dart stuck	left	yes	L10517	2011	no	
Sep 3, 2017	9	strike	DL-CIB17-05	right	yes	R1187	2008	yes	this is the same whale as miss #2 on Sep 3
Sep 3, 2017	11	strike	DL-CIB17-06	right	no	n/a	n/a	n/a	only rear half of whale photographed
Sep 4, 2017	14	strike	DL-CIB17-07	left	yes	L2366	2005	no	photographed again later the same day and on the following day
Sep 7, 2017	17	strike	DL-CIB17-08	right	no	n/a	n/a	n/a	only rear half of whale photographed
Sep 8, 2017	20	strike	DL-CIB17-09	left	no	n/a	n/a	n/a	glare on part of body used for photo-ID
Sep 9, 2017	21	strike	DL-CIB17-10	right	yes	R624	2005	yes	
Sep 9, 2017	24	strike	DL-CIB17-11	left	yes	L10344	2011	no	
Sep 9, 2017	26	strike	DL-CIB17-12	right	yes	R18993	2016	no	
Sep 9, 2017	28	strike	hit, sample lost	left	no	n/a	n/a	n/a	good photos, no match

* right-side and left-side photo-id catalog complete 2005-2016; 2017 cataloging in progress at the time of this report.

Table 2. Summary of photo-id matches made to the individuals photographed during the 2017 CIBW hexacopter study.

Hexacopter ID (includes date)	CIBW Photo-ID Catalog ID	Year first identified in CIBW Photo-ID Catalog	Photographed with calf 2005-2017*	Comments
17JR_19-Aug-17_S008_DI0001	D206	2005	yes	
17JR_19-Aug-17_S008_Dl0004	R19115	2016	no	
17JR_19-Aug-17_S008_Dl0005	D20769	2016	yes	repeat individual (photographed on >1 day of 2017 hexacopter survey)
17JR_19-Aug-17_S008_Dl0006	D165	2005	yes	repeat individual (photographed on >1 day of 2017 hexacopter survey)
17JR_19-Aug-17_S008_Dl0012	D25	2005	yes	
17JR_19-Aug-17_S008_Dl0018	D8151	2008	no	
17JR_19-Aug-17_S008_Dl0024	R18109	2011	no	
17JR_19-Aug-17_S008_Dl0027	D14	2005	no	
17JR_19-Aug-17_S008_Dl0028	D465	2005	no	
17JR_19-Aug-17_S008_Dl0032	D4400	2010	yes	
17JR_19-Aug-17_S008_Dl0034	R32	2005	yes	
17JR_19-Aug-17_S008_Dl0049	D3086	2009	no	
17JR_19-Aug-17_S008_Dl0050	D113	2005	yes	
17JR_19-Aug-17_S008_Dl0051	D110	2005	no	
17JR_19-Aug-17_S008_Dl0052	D1032	2008	yes	had live stranded with a calf in 2015
17JR_19-Aug-17_S008_Dl0053	R92	2006	yes	
17JR_19-Aug-17_S008_Dl0057	L2327	2006	yes	
17JR_19-Aug-17_S008_Dl0063	D2052	2005	no	
17JR_19-Aug-17_S008_Dl0065	D111	2005	yes	satellite-tagged by NMFS in 2000; biopsy during tagging determined it is female
17JR_19-Aug-17_S008_Dl0071	D135	2005	no	
17JR_19-Aug-17_S008_Dl0073	D1102	2008	yes	repeat individual (photographed on >1 day of 2017 hexacopter survey)
17JR_19-Aug-17_S008_Dl0075	D2241	2005	no	
17JR_19-Aug-17_S008_Dl0077	D595	2007	no	
17JR_19-Aug-17_S008_Dl0083	D17008	2014	no	
17JR_19-Aug-17_S008_Dl0092	D49	2005	yes	satellite-tagged by NMFS sometime 1999-2002
17JR_19-Aug-17_S008_Dl0115	R6	2005	yes	satellite-tagged by NMFS sometime 1999-2002
17JR_19-Aug-17_S008_Dl0122	L10740	2011	yes	
17JR_19-Aug-17_S008_Dl0127	L8242	2009	yes	
17JR_19-Aug-17_S008_Dl0129	L2175	2007	no	
17JR_19-Aug-17_S008_Dl0152	D2346	2005	no	
17JR_19-Aug-17_S008_Dl0161	L434	2005	yes	repeat individual (photographed on >1 day of 2017 hexacopter survey)
17JR_19-Aug-17_S008_Dl0164	D20396	2014	yes	

17JR_19-Aug-17_S008_Dl0166	D5	2005	yes	
17JR_19-Aug-17_S008_Dl0170	D18499	2014	no	repeat individual (photographed on >1 day of 2017 hexacopter survey)
17JR_19-Aug-17_S008_Dl0187	L384	2005	yes	
17JR_19-Aug-17_S008_Dl0195	D60	2005	yes	
17JR_19-Aug-17_S008_Dl0201	D20531	2014	no	
17JR_19-Aug-17_S008_Dl0205	D109	2005	yes	photographed by NMFS in 1998
17JR_19-Aug-17_S008_Dl0206	D419	2005	no	
17JR_19-Aug-17_S008_Dl0207	D27725	2015	no	repeat individual (photographed on >1 day of 2017 hexacopter survey)
17JR_19-Aug-17_S008_Dl0210	L2339	2007	yes	
17JR_19-Aug-17_S008_Dl0212	D103	2005	yes	satellite-tagged by NMFS in 2001; biopsy during tagging determined it is female
17JR_19-Aug-17_S008_Dl0213	L255	2005	yes	
17JR_19-Aug-17_S008_Dl0222	D10860	2011	no	biopsied by NMFS in 2017
17JR_19-Aug-17_S008_Dl0226	L20628	2014	no	
17JR_22-Aug-17_S010_Dl0004	L20291	2013	yes	
17JR_22-Aug-17_S010_Dl0006	R3354	2009	yes	
17JR_22-Aug-17_S010_Dl0013	R11574	2008	yes	
17JR_22-Aug-17_S011_Dl0006	L434	2005	yes	repeat individual (photographed on >1 day of 2017 hexacopter survey)
17JR_22-Aug-17_S011_Dl0009	L2270	2007	yes	
17JR_24-Aug-17_S018_Dl0001	D8778	2008	yes	
17JR_24-Aug-17_S018_Dl0005	D1391	2005	yes	
17JR_24-Aug-17_S018_Dl0006	D4219	2010	yes	
17JR_24-Aug-17_S018_Dl0008	D84	2005	yes	
17JR_24-Aug-17_S018_Dl0013	D20769	2016	yes	repeat individual (photographed on >1 day of 2017 hexacopter survey)
17JR_24-Aug-17_S018_Dl0015	D165	2005	yes	repeat individual (photographed on >1 day of 2017 hexacopter survey)
17JR_24-Aug-17_S018_Dl0021	D27725	2015	no	repeat individual (photographed on >1 day of 2017 hexacopter survey)
17JR_24-Aug-17_S018_Dl0022	D3833	2010	yes	
17JR_24-Aug-17_S019_Dl0007	D4153	2008	yes	
17JR_24-Aug-17_S019_Dl0011	R21848	2016	no	
17JR_24-Aug-17_S019_Dl0012	D18499	2014	no	repeat individual (photographed on >1 day of 2017 hexacopter survey)
17JR_24-Aug-17_S019_Dl0025	D1102	2008	yes	repeat individual (photographed on >1 day of 2017 hexacopter survey)

* right-side and left-side photo-id catalog complete 2005-2016; 2017 cataloging in progress at the time of this report.

Table 3. Summary of photo-id matching efforts between 2017 hexacopter photos and the 2005-2017* CIBW photo-ID Catalog.

	Number
Total Unique Hexacopter IDs	**122**
Unique Hexacopter IDs Matched to Photo-ID Catalog	**62**
repeat hexacopter individuals matched to photo-id catalog	6
unique hexacopter individuals matched to individuals in photo-id catalog	56
hexacopter IDs with oblique images	62
hexacopter IDs with hexacopter (aerial) images	62
hexacopter/photo-id matches made from oblique images only	23
hexacopter/photo-id matches made from hexacopter images only	1
hexacopter/photo-id matches made from both oblique and hexacopter images	38
dual-side match (i.e., identified right side linked to identified left side)	41
hexacopter image confirmation of a dual side match already made in photo-id catalog	11
new dual-side match established with hexacopter images	30
Unique Hexacopter IDs not Matched to Photo-ID Catalog	**60**
individuals with good photos, but no match to the photo-id (marks too subtle and/or just didn't exist in catalog)	24
hexacopter aerials photos don't match the oblique photos	6
lack full profile of whale needed for photo-id (refer to Figure 2)	9
unusable photo-quality	7
calf (may find aa match in the catalog once 2017 cataloging is done and 2017 calves included: may match in future years as calves age)	14

* right-side and left-side photo-id catalog complete 2005-2016; 2017 cataloging in progress at the time of this report

FIGURES

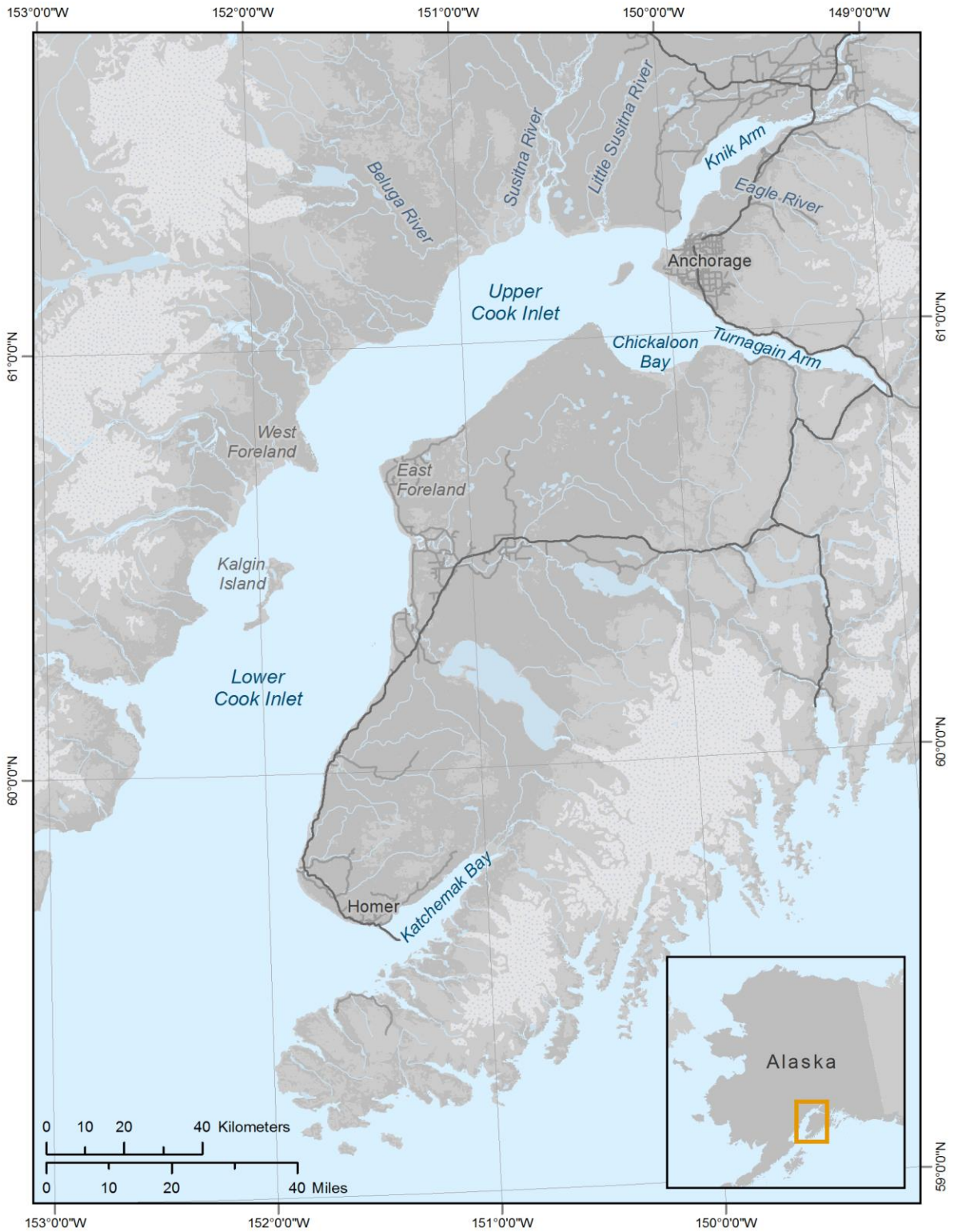

Figure 1. Map of Cook Inlet, Alaska, showing major features discussed in text.

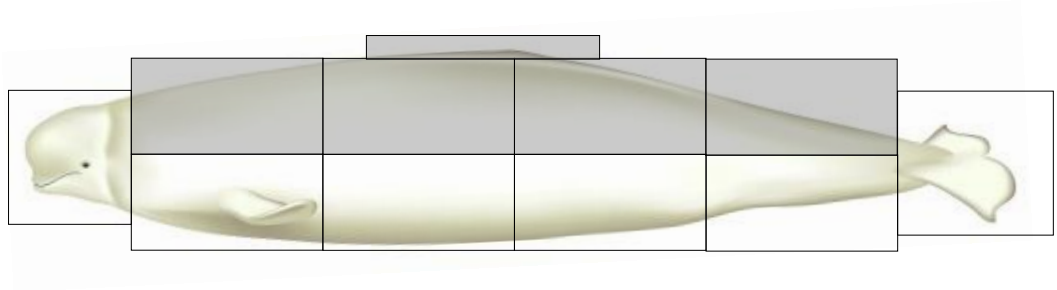

Figure 2. Body segments used to catalog photographs of belugas for photo-id. The five shaded areas are the critical sections used in matching marks. Beluga illustration courtesy of Uko Gorter.

APPENDICES

Appendix A: BELUGAS IDENTIFIED FROM BIOPSY PHOTOGRAPHS

(All photographs taken under NOAA Fisheries MMPA/ESA Scientific Research Permit #20465 to the NMFS Marine Mammal Laboratory.)

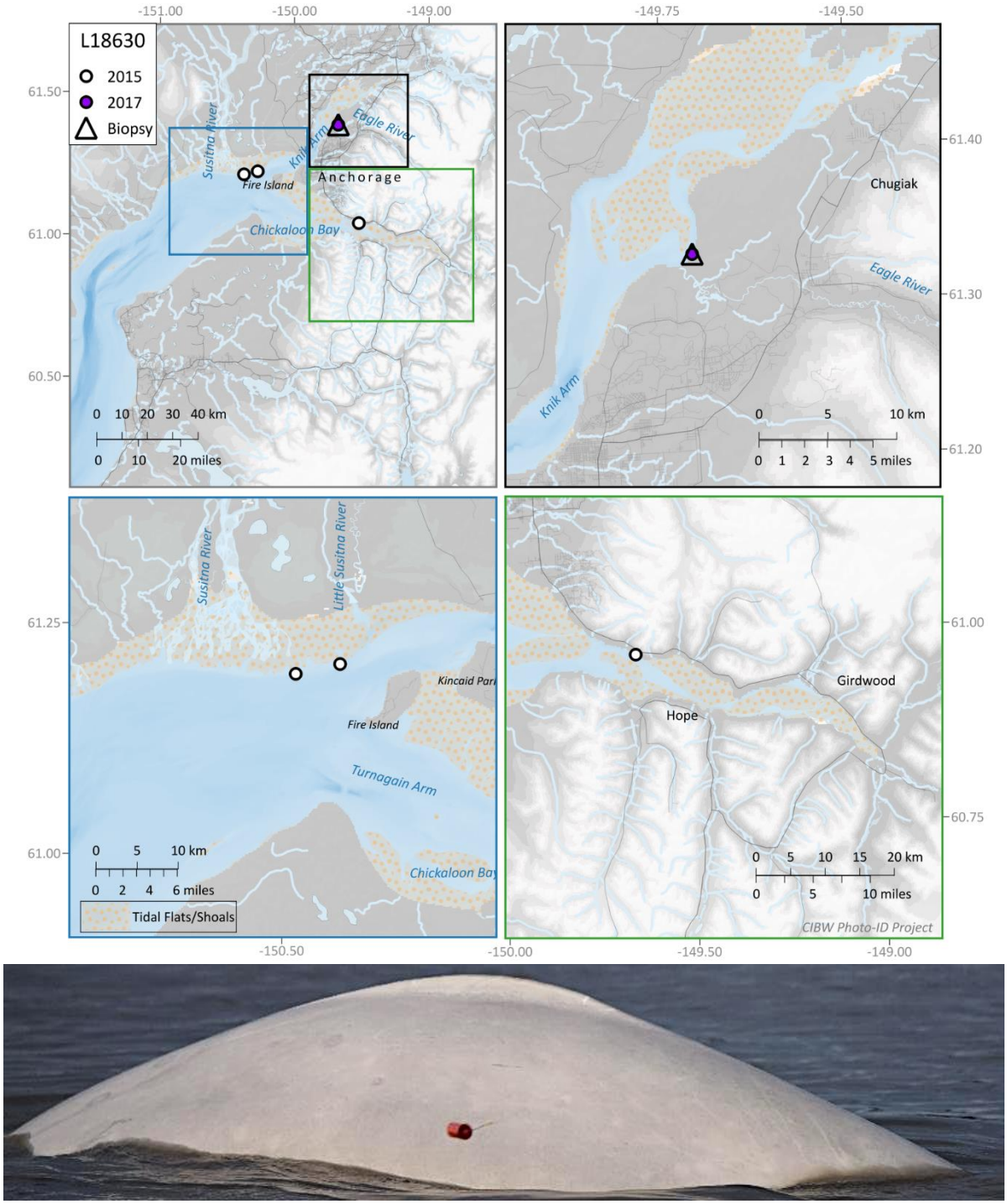

Figure A1. Sighting history of beluga L18630. This whale was biopsied from a vessel on September 2, 2017 and was assigned biopsy ID *DL-CIB17-01*.

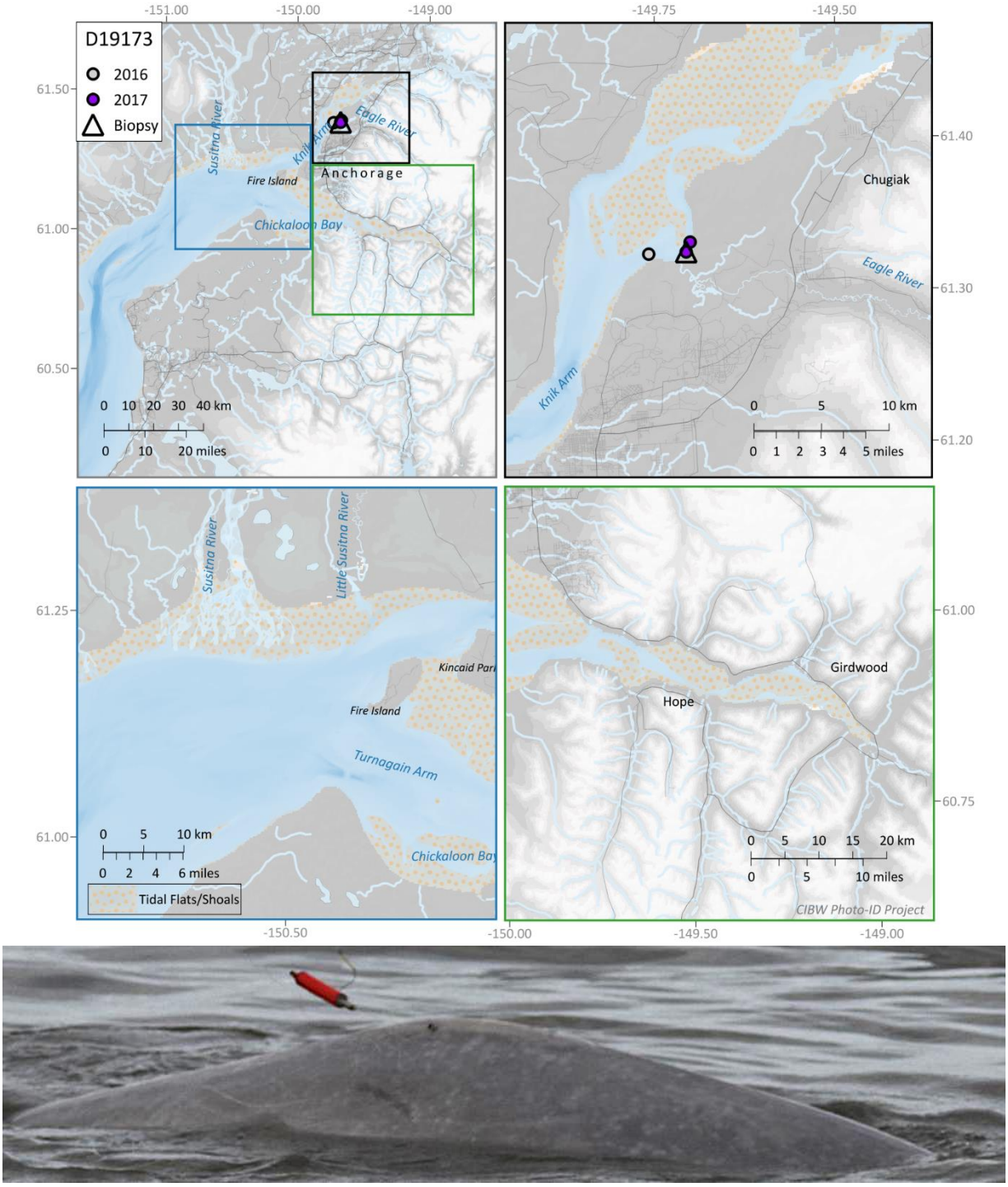

Figure A2. Sighting history of beluga D19173. This whale was biopsied from a vessel on September 2, 2017 and was assigned biopsy ID *DL-CIB17-02*.

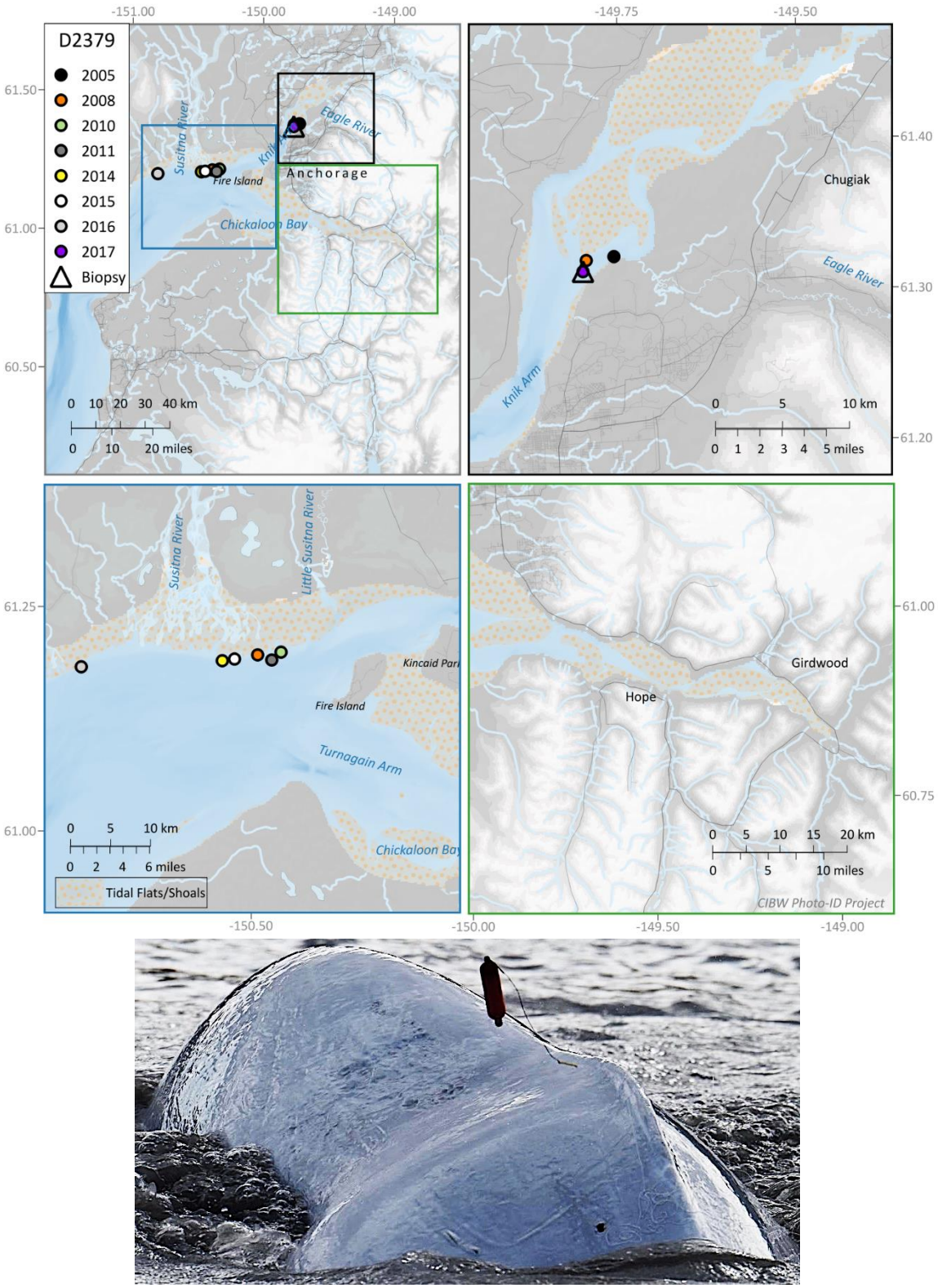

Figure A3. Sighting history of beluga D2379. This whale was biopsied from a vessel on September 2, 2017 and was assigned biopsy ID *DL-CIB17-03.* Photograph is of the right side of the whale, note the concavity behind the dorsal crest.

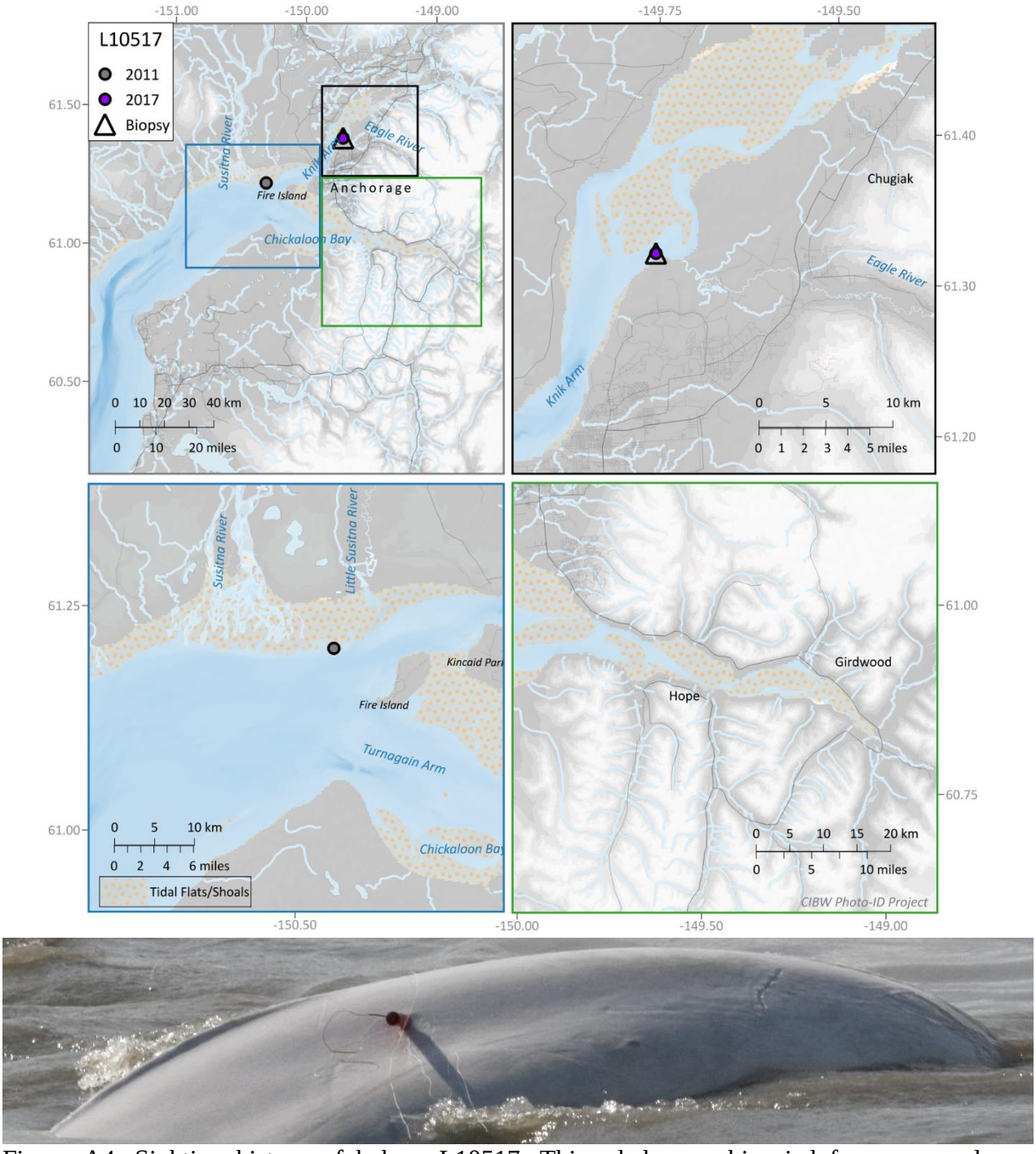

Figure A4. Sighting history of beluga L10517. This whale was biopsied from a vessel on September 2, 2017, however, the dart stuck, preventing the sample from being retrieved.

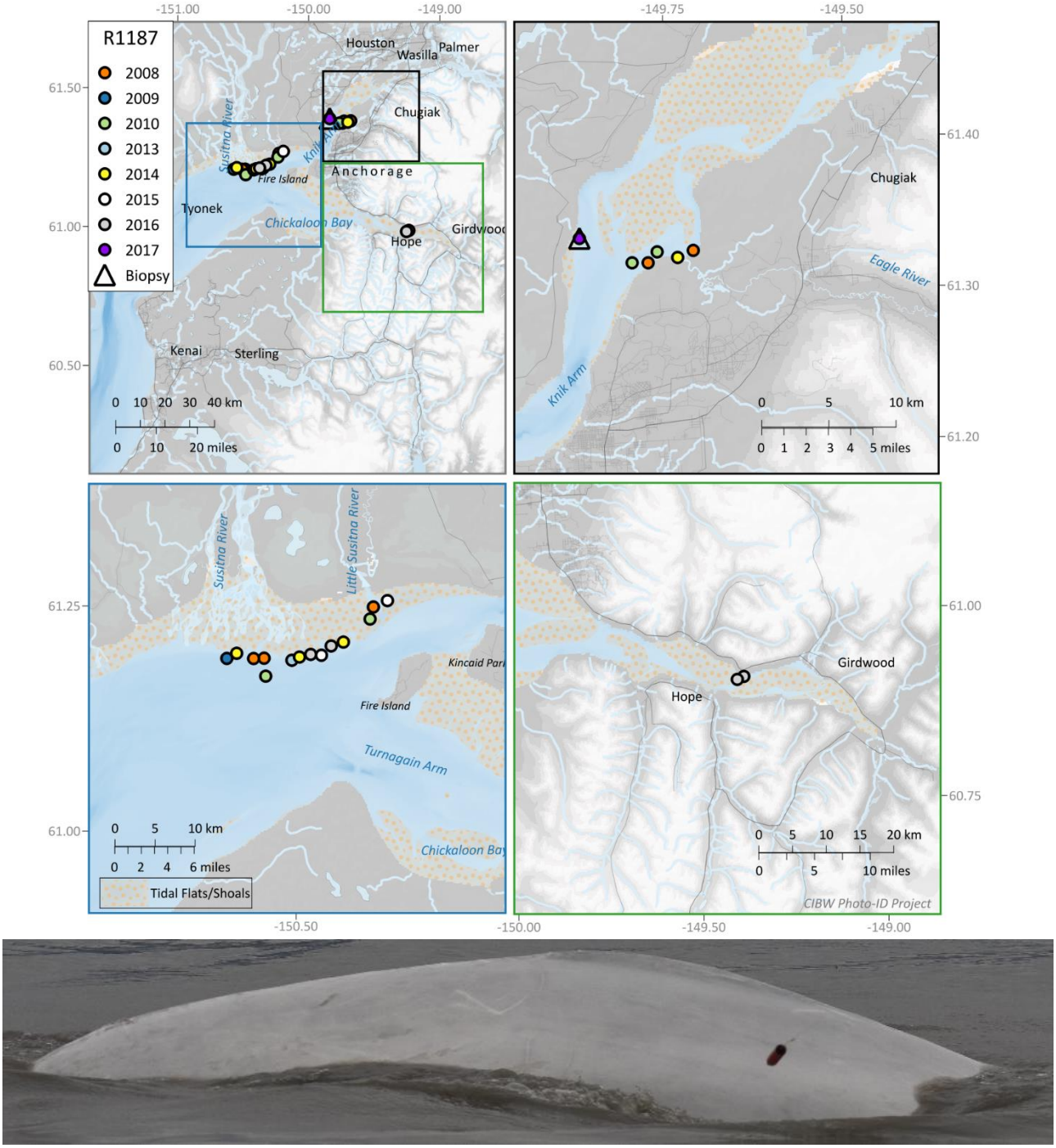

Figure A5. Sighting history of beluga R1187. This whale was biopsied from a vessel on September 3, 2017 and was assigned biopsy ID *DL-CIB17-05*.

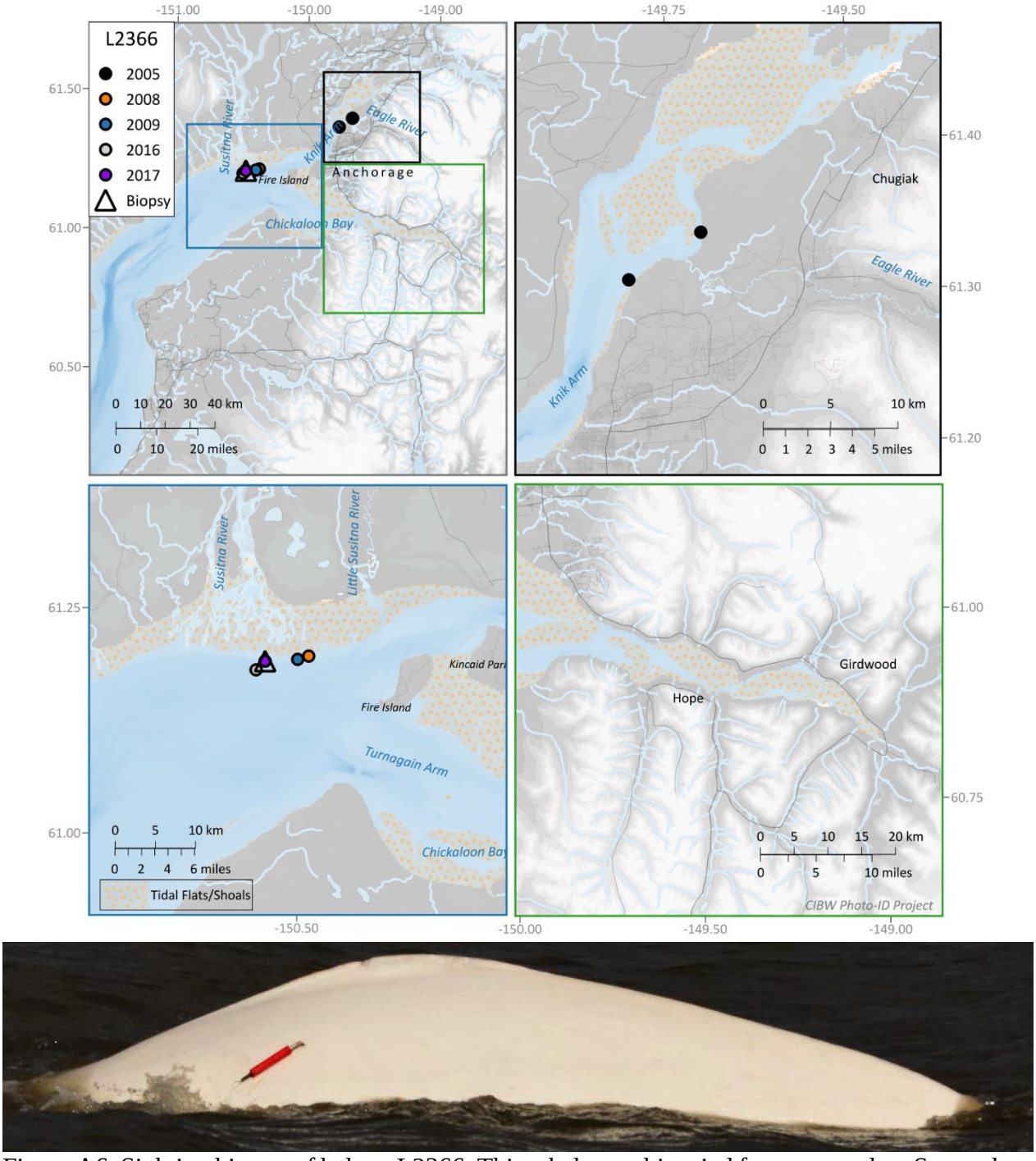

Figure A6. Sighting history of beluga L2366. This whale was biopsied from a vessel on September 4, 2017 and was assigned biopsy ID *DL-CIB17-07*.

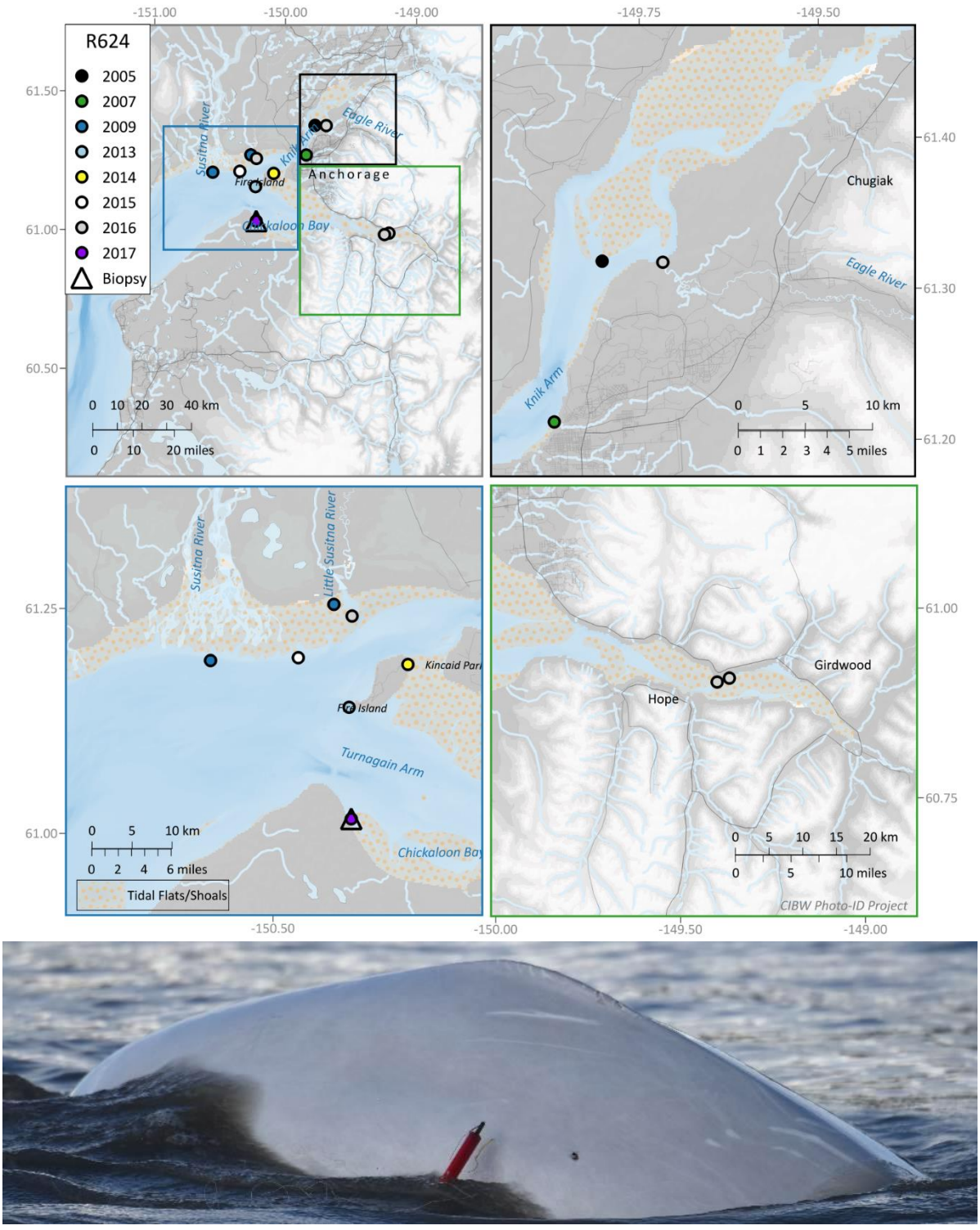

Figure A7. Sighting history of beluga R624. This whale was biopsied from a vessel on September 9, 2017 and was assigned biopsy ID *DL-CIB17-10*.

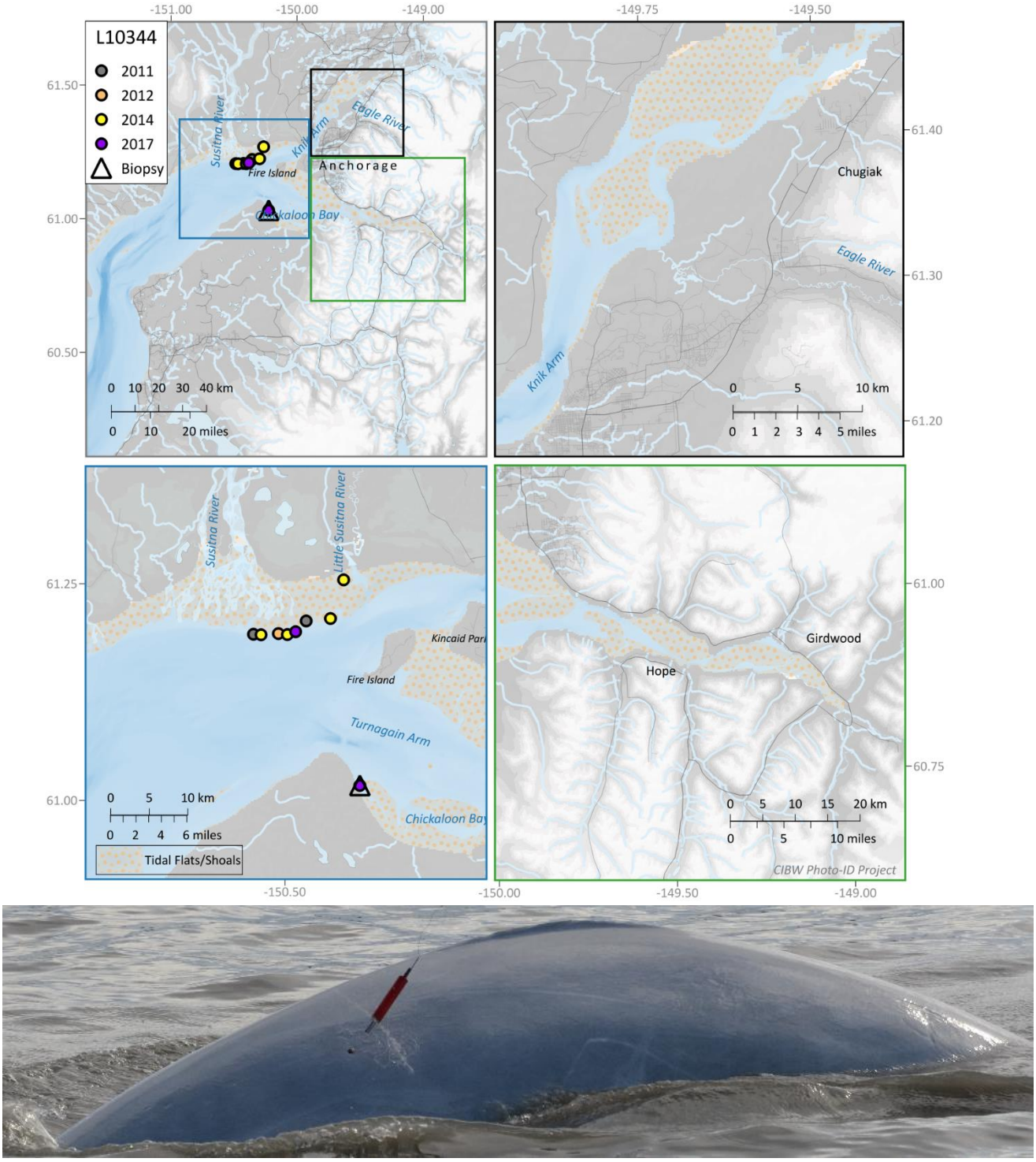

Figure A8. Sighting history of beluga L10344. This whale was biopsied from a vessel on September 9, 2017 and was assigned biopsy ID *DL-CIB17-11*.

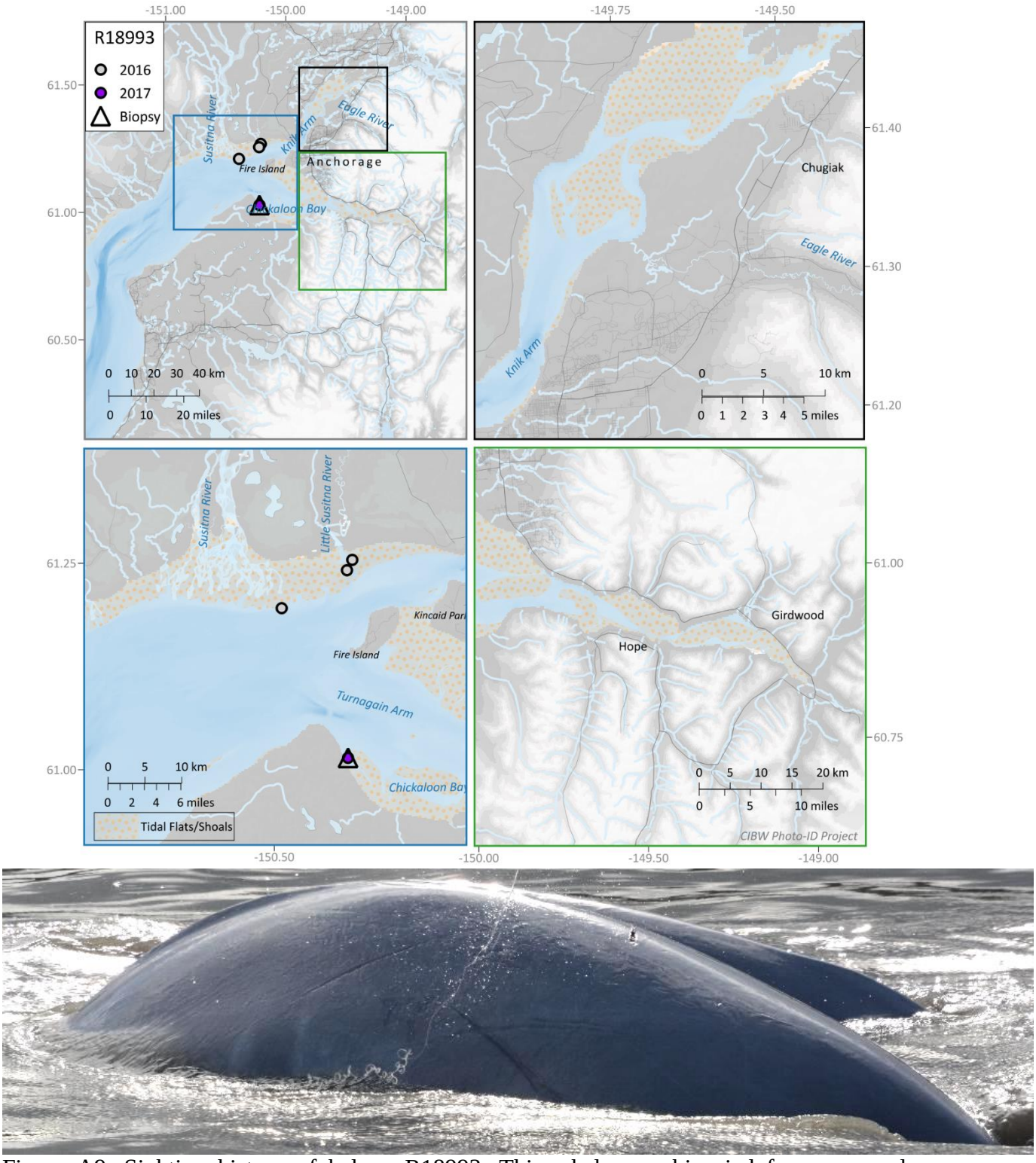

Figure A9. Sighting history of beluga R18993. This whale was biopsied from a vessel on September 9, 2017 and was assigned biopsy ID *DL-CIB17-12*.

Appendix B. Belugas Identified from Hexacopter Photos

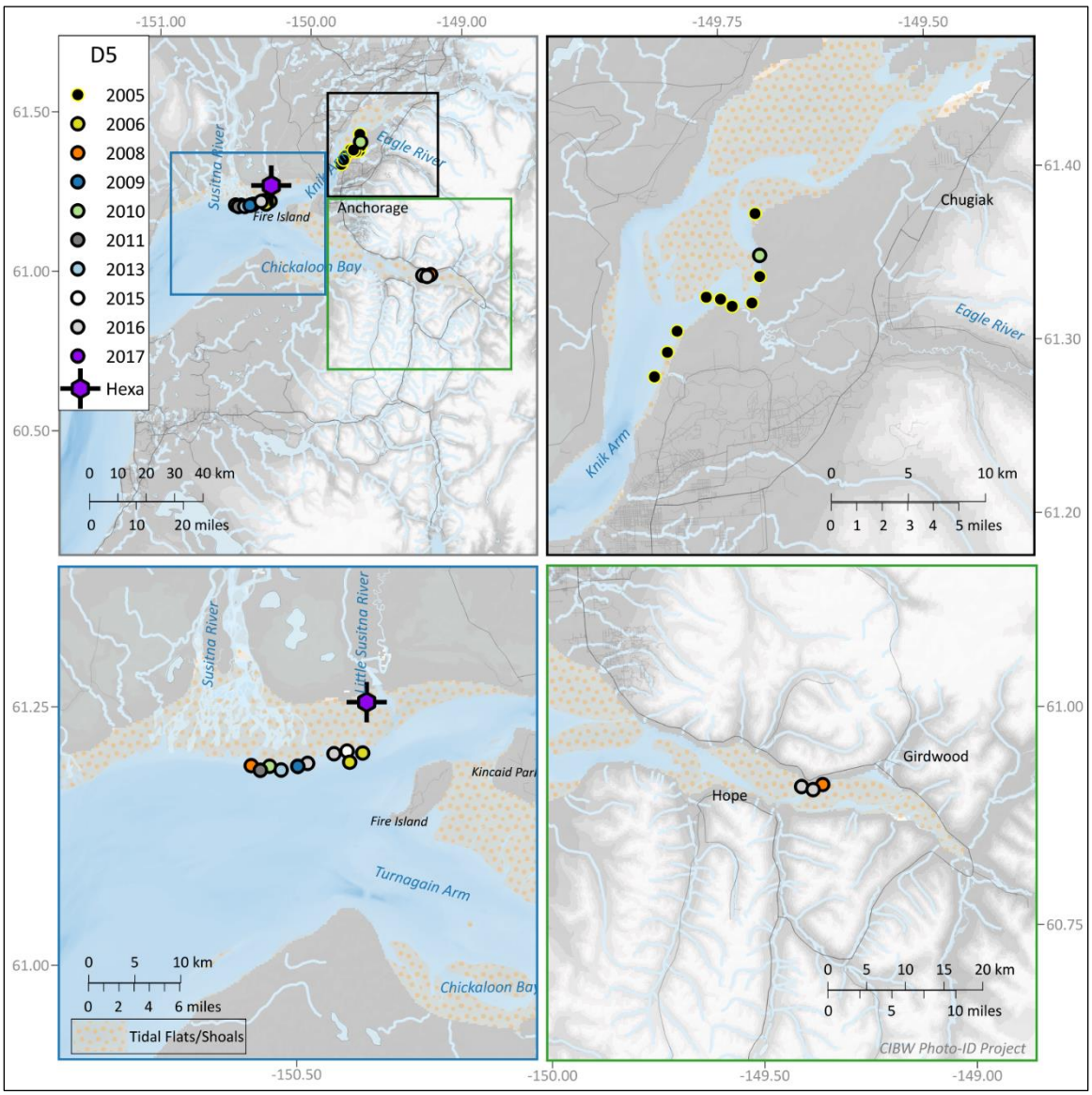

Figure B1. Sighting history of beluga D5. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0166.*

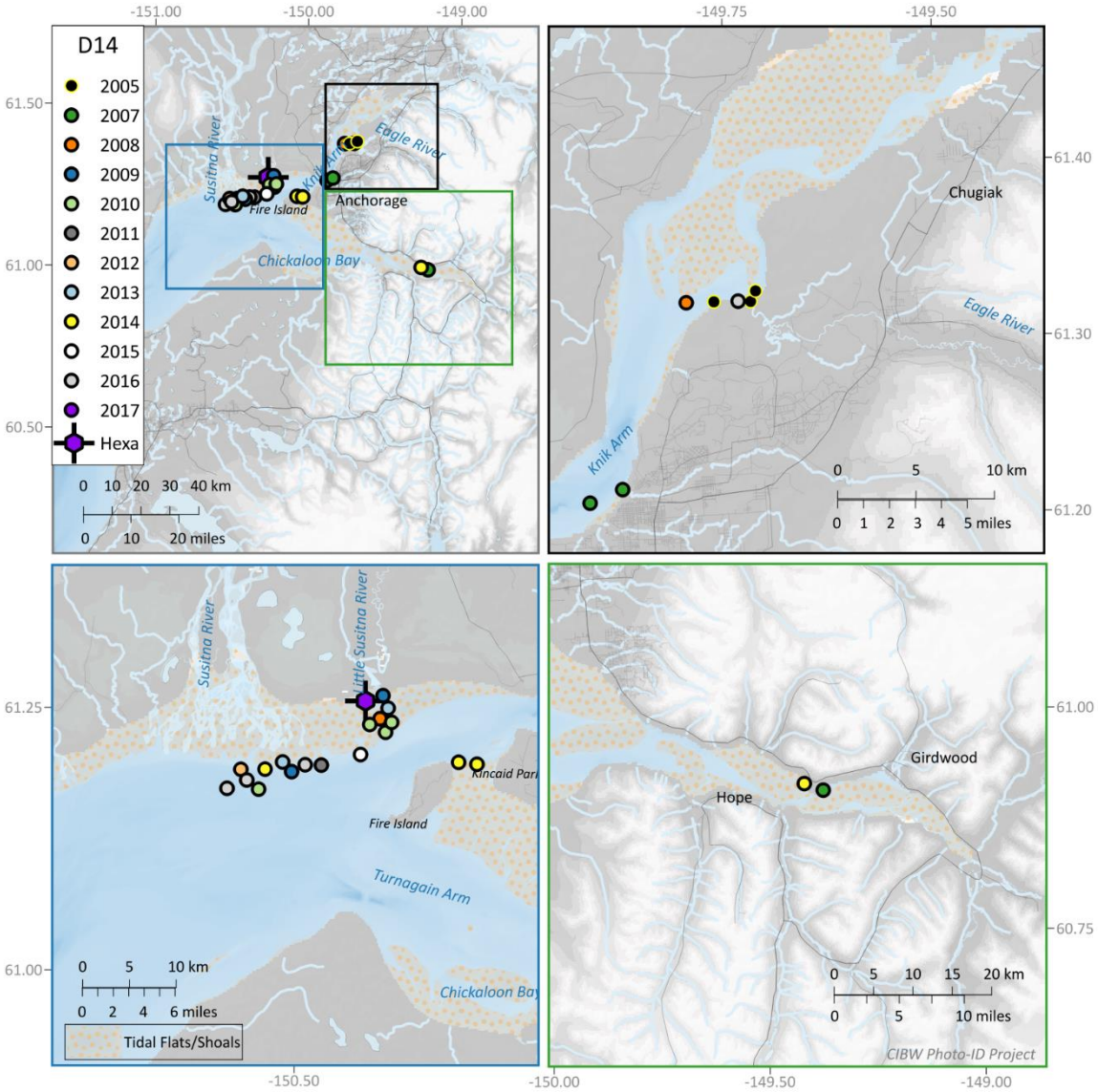

Figure B2. Sighting history of beluga D14. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0027*.

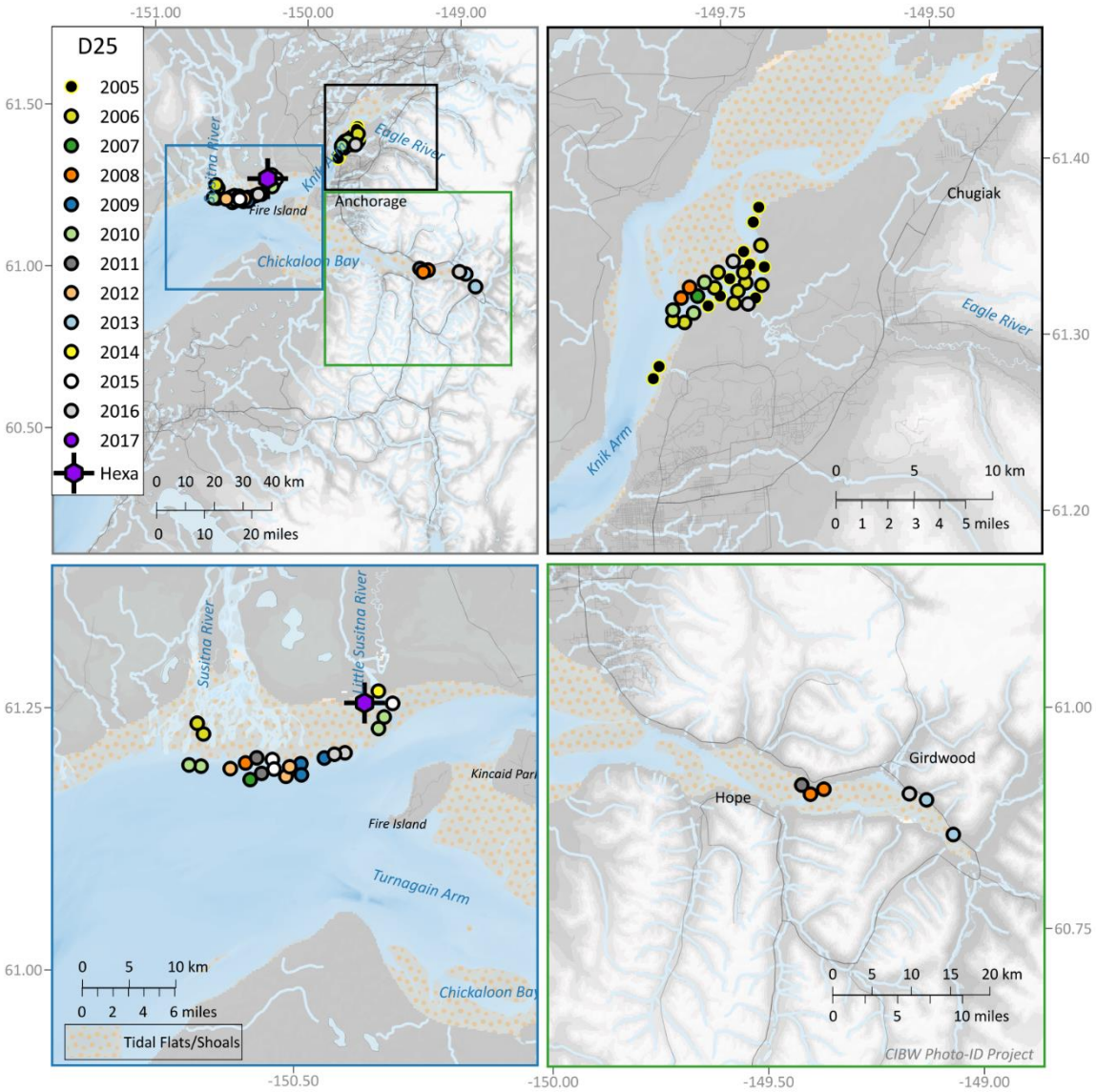

Figure B3. Sighting history of beluga D25. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0012*.

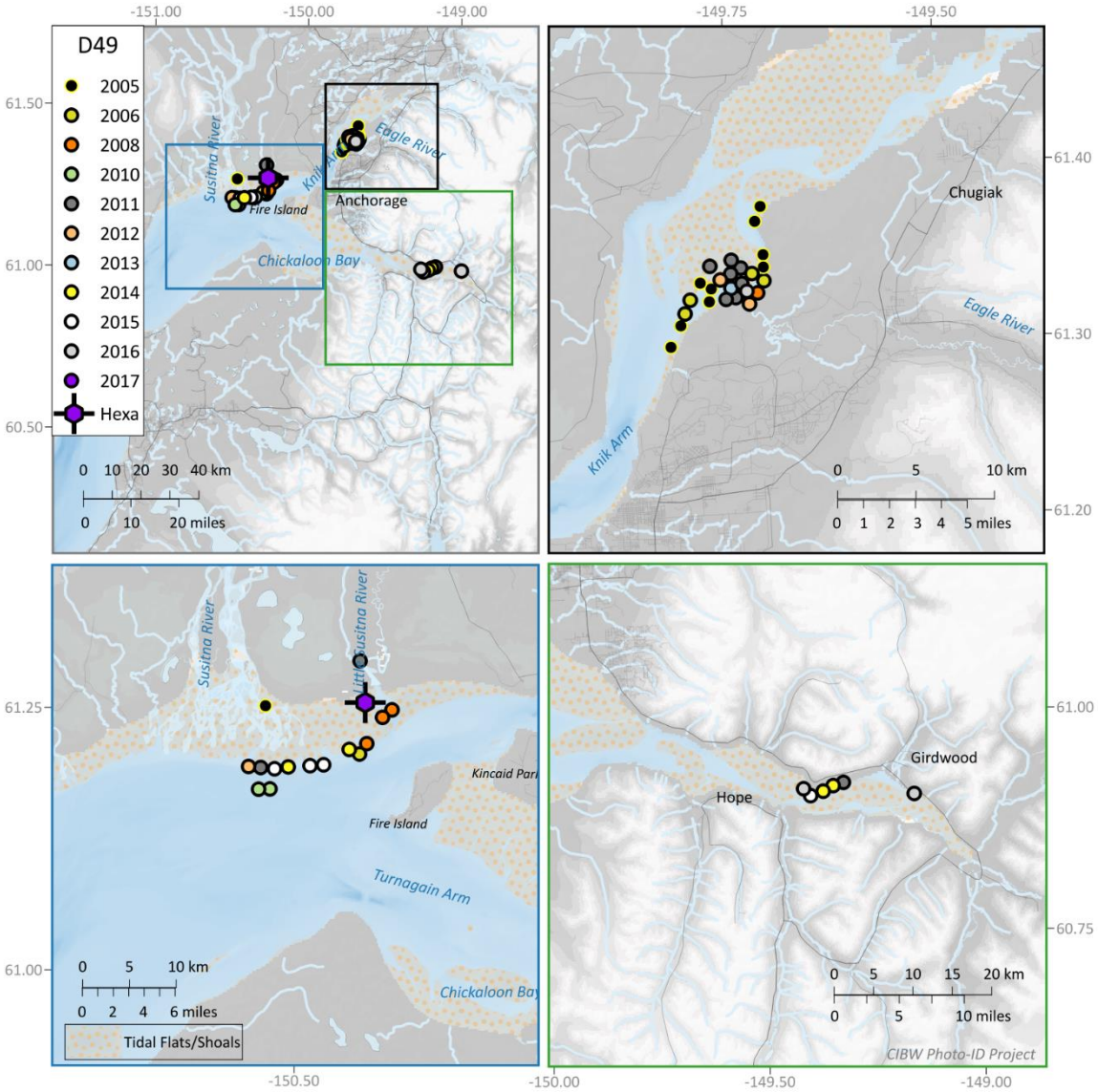

Figure B4. Sighting history of beluga D49. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0092*.

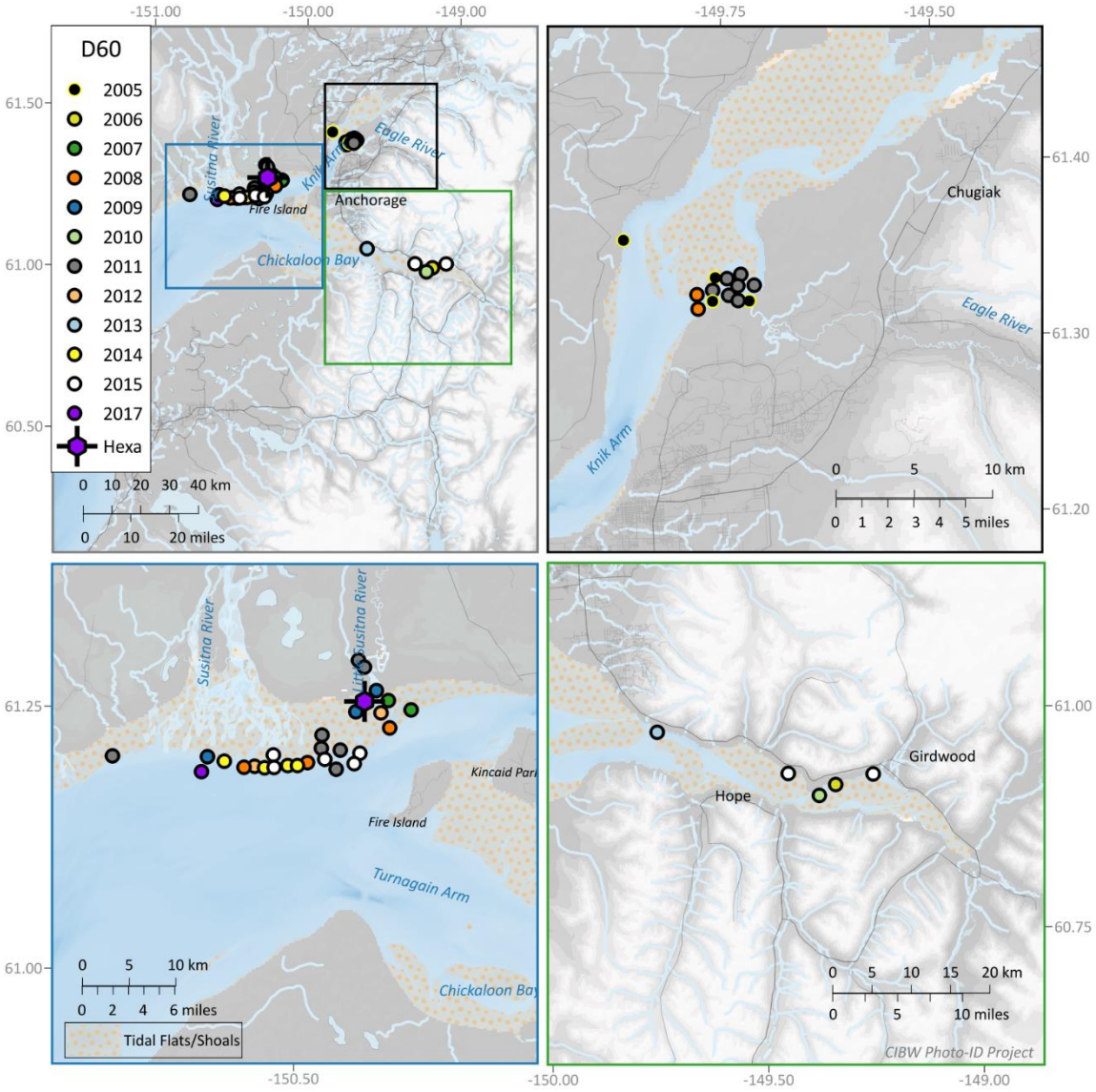

Figure B5. Sighting history of beluga D60. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0195*.

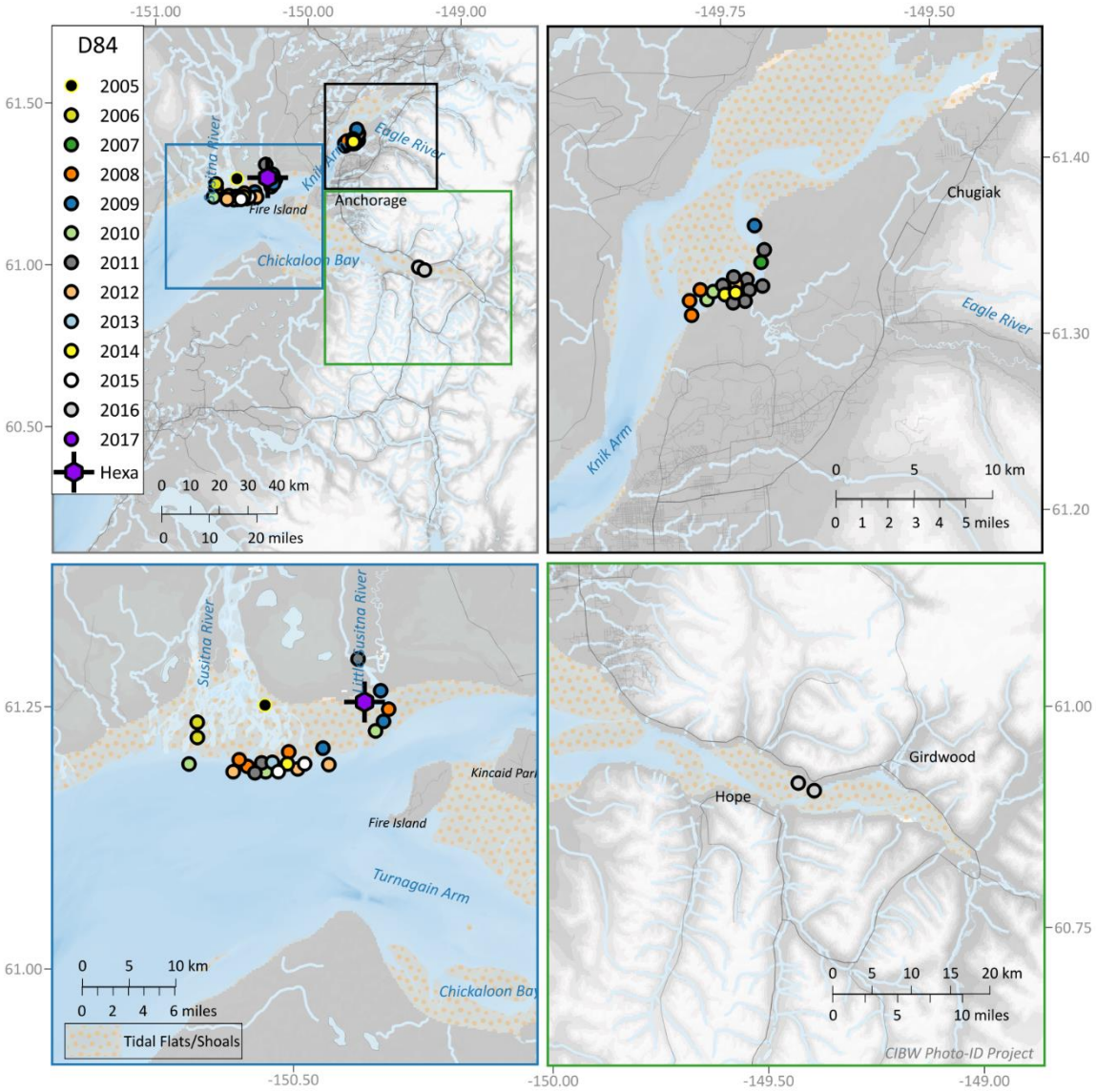

Figure B6. Sighting history of beluga D84. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_24-Aug-17_S018_DI0008*.

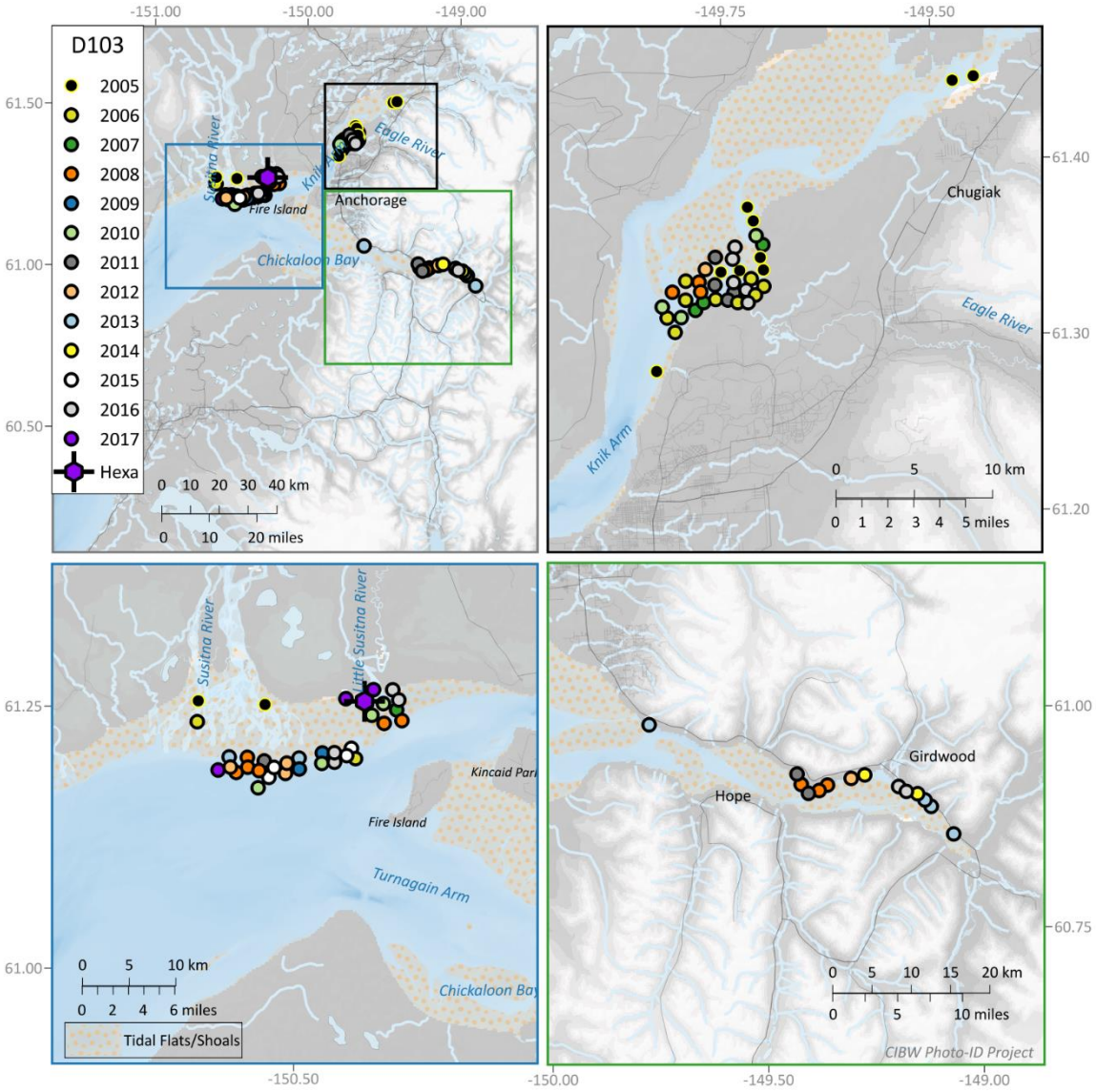

Figure B7. Sighting history of beluga D103. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0212*.

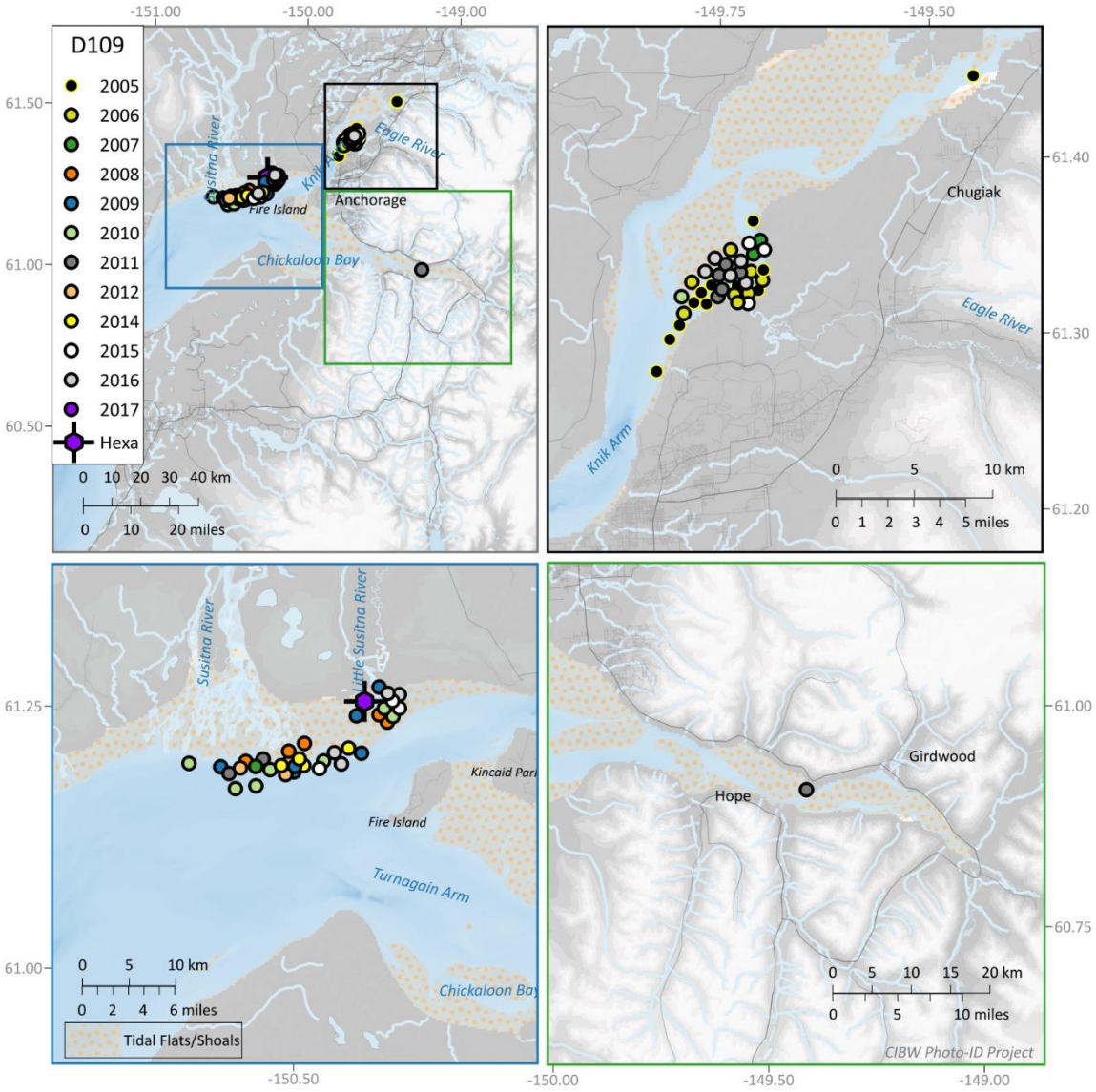

Figure B8. Sighting history of beluga D109. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0205*.

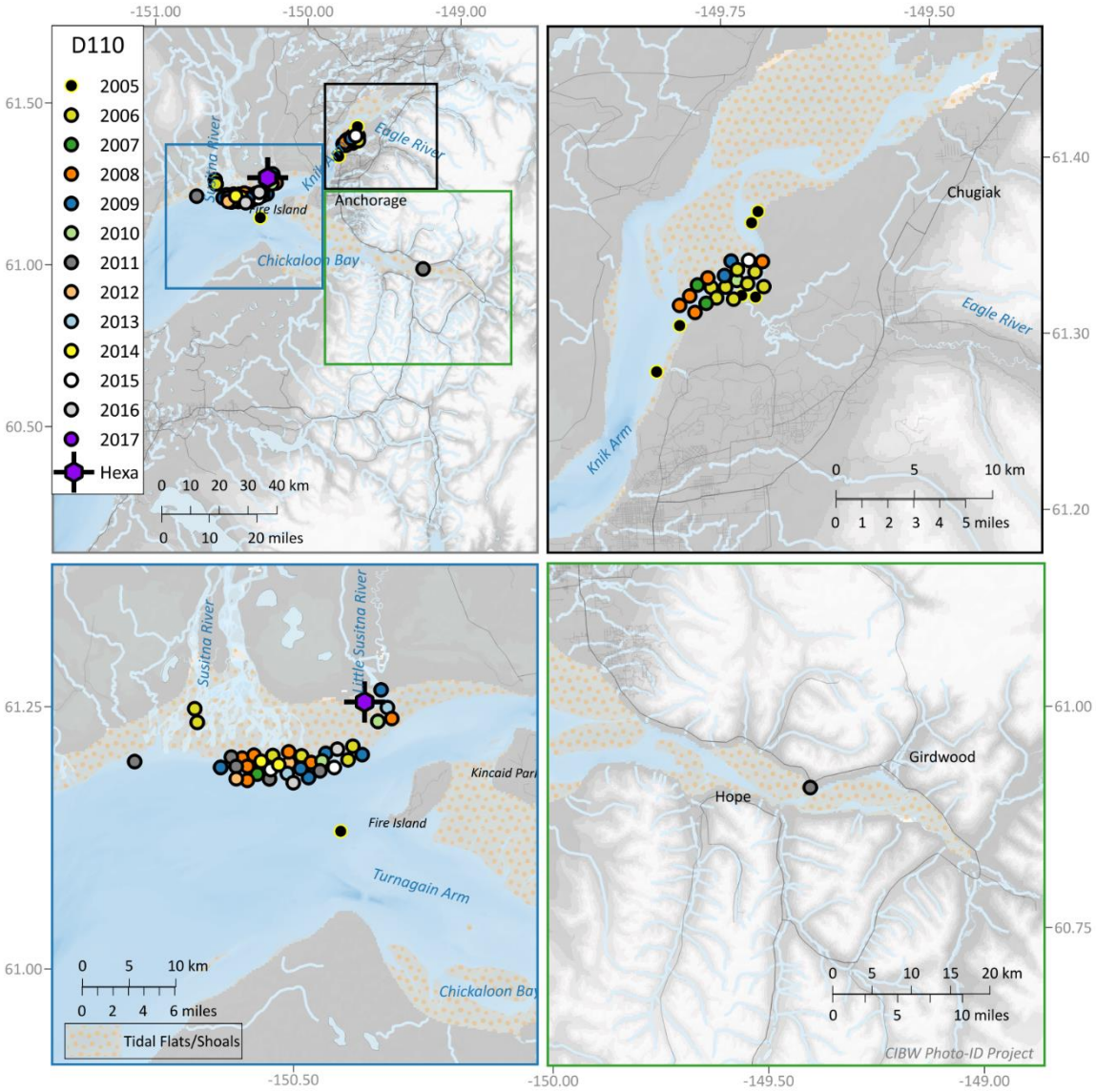

Figure B9. Sighting history of beluga D110. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0051*.

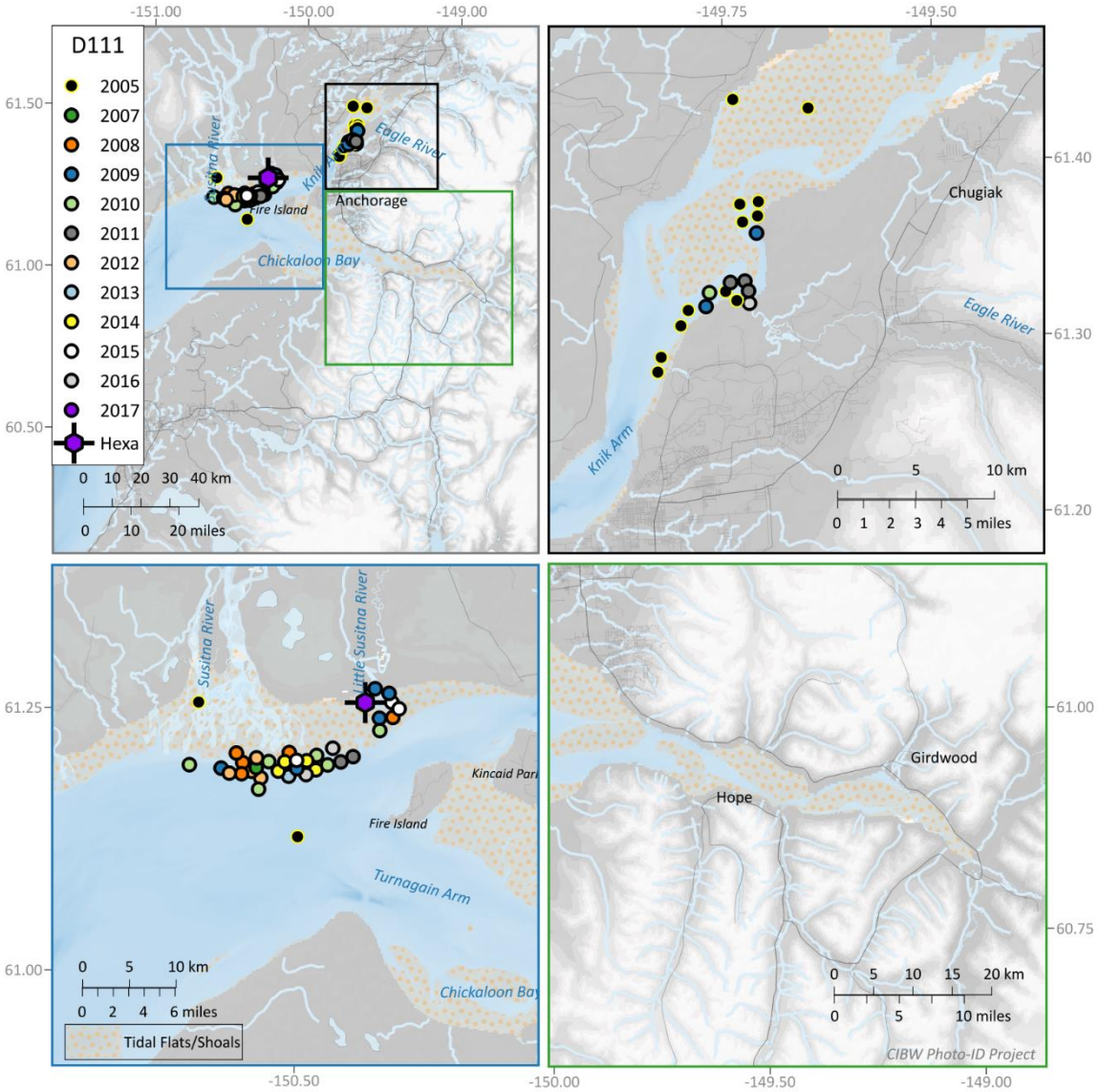

Figure B10. Sighting history of beluga D111. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0065*.

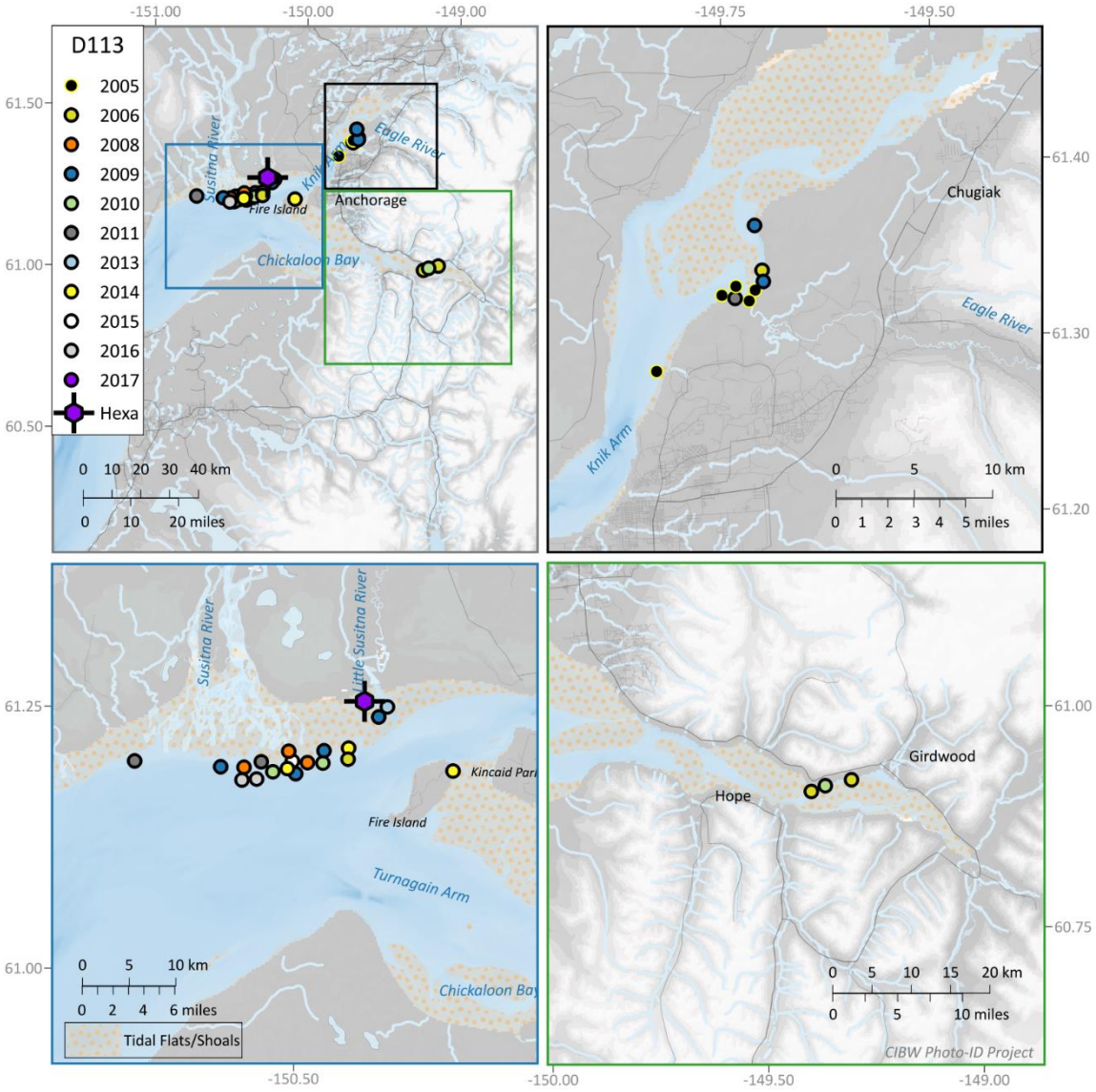

Figure B11. Sighting history of beluga D113. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0050*.

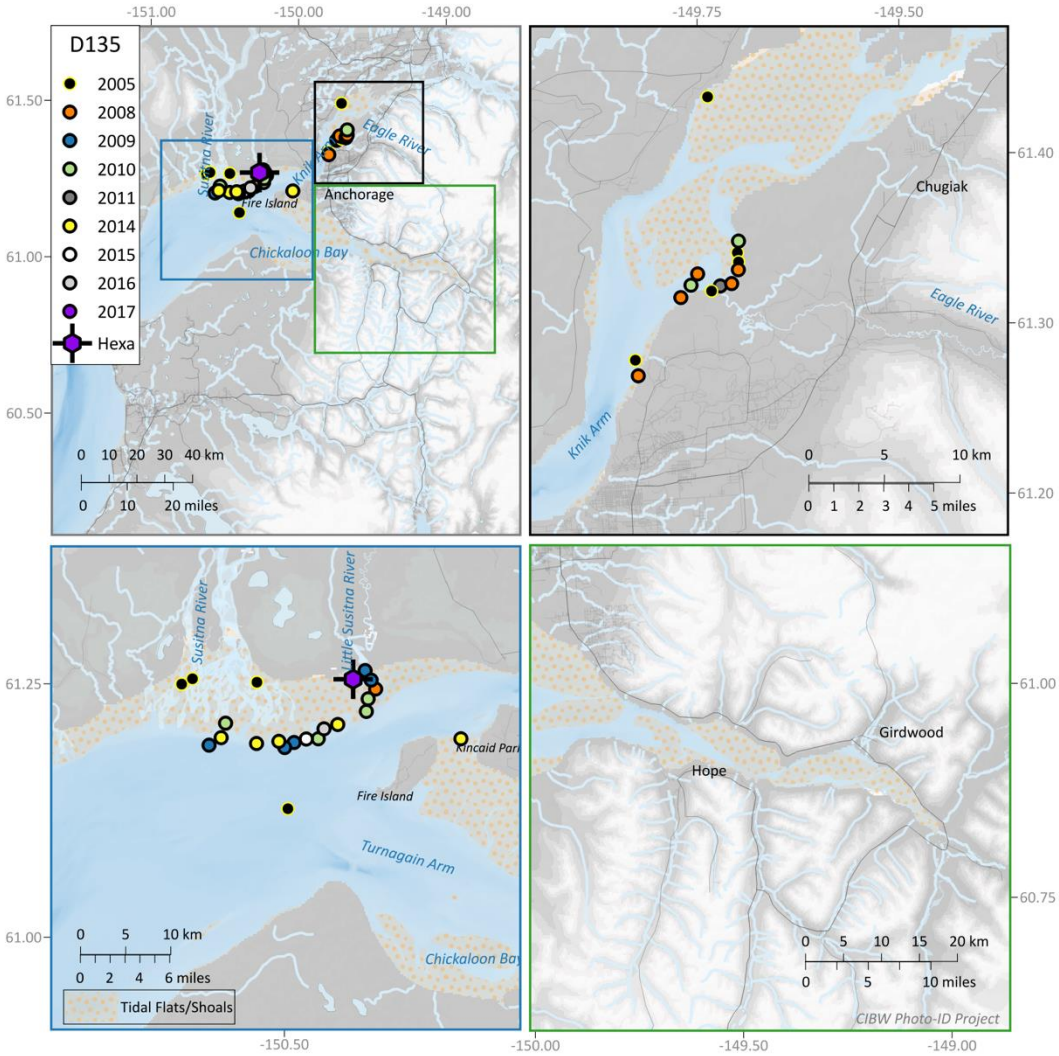

Figure B12. Sighting history of beluga D135. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0071*.

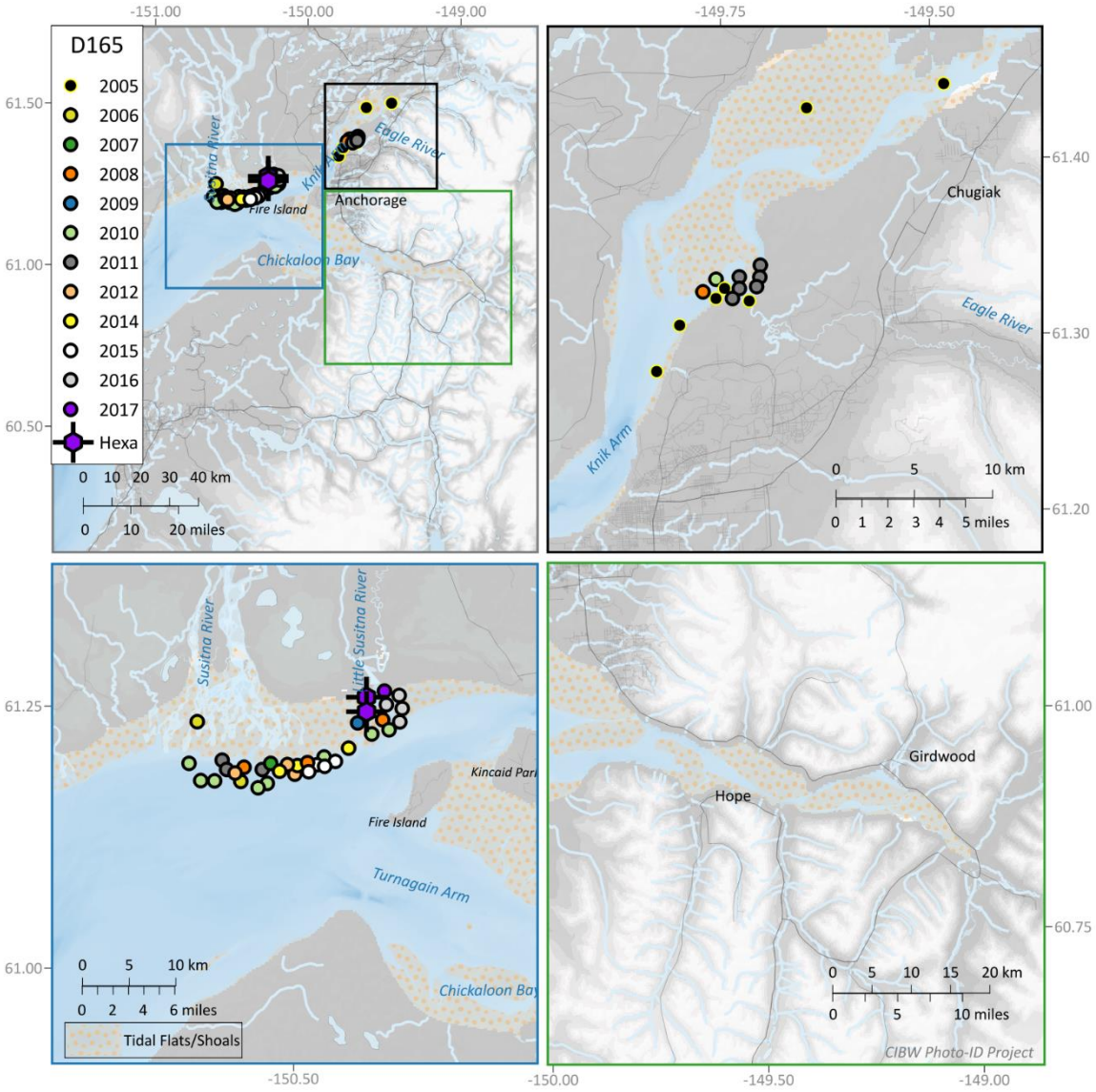

Figure B13. Sighting history of beluga D165. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0006* and ID *17JR_24-Aug-17_S018_DI0015*.

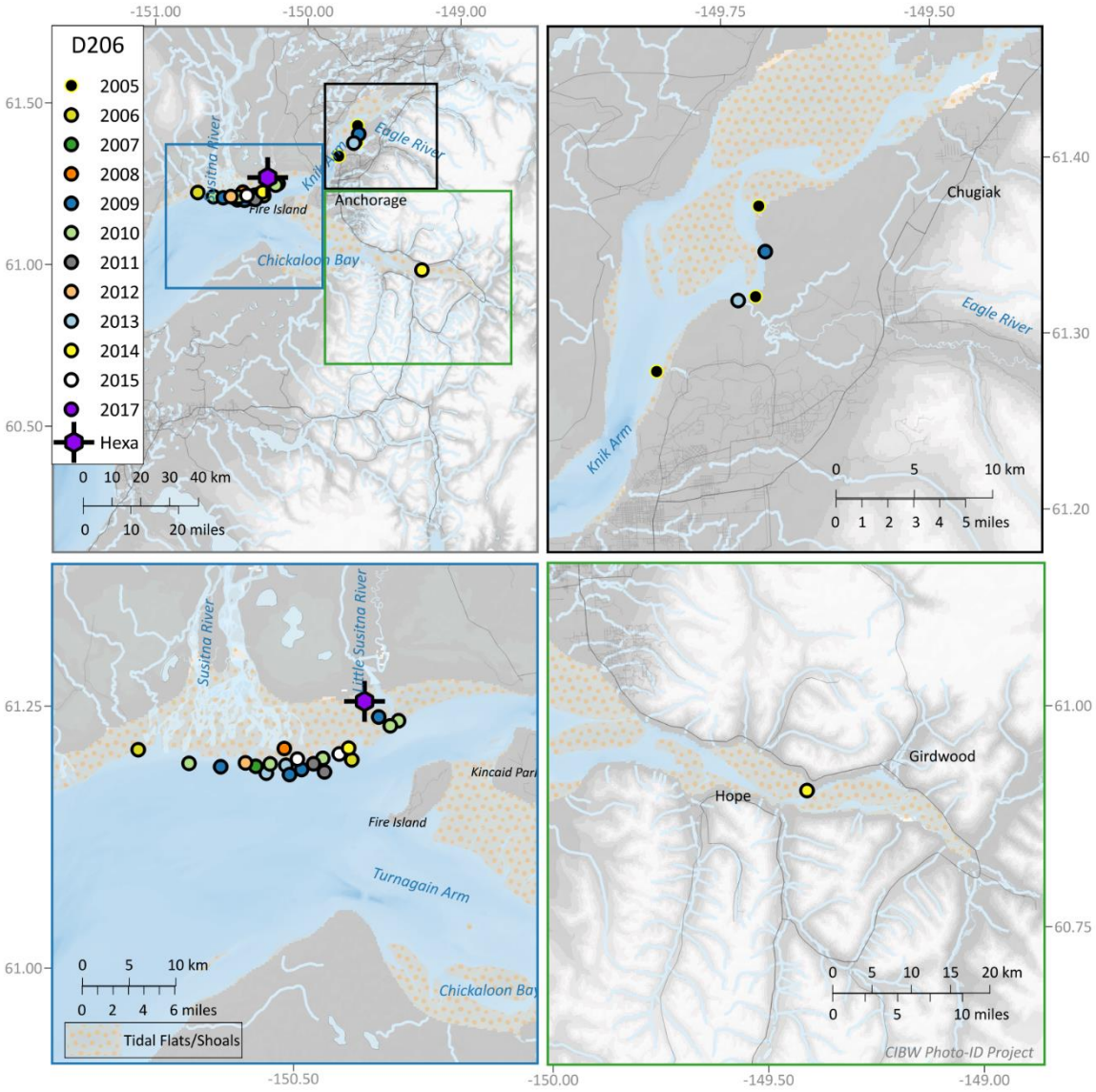

Figure B14. Sighting history of beluga D206. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0001*.

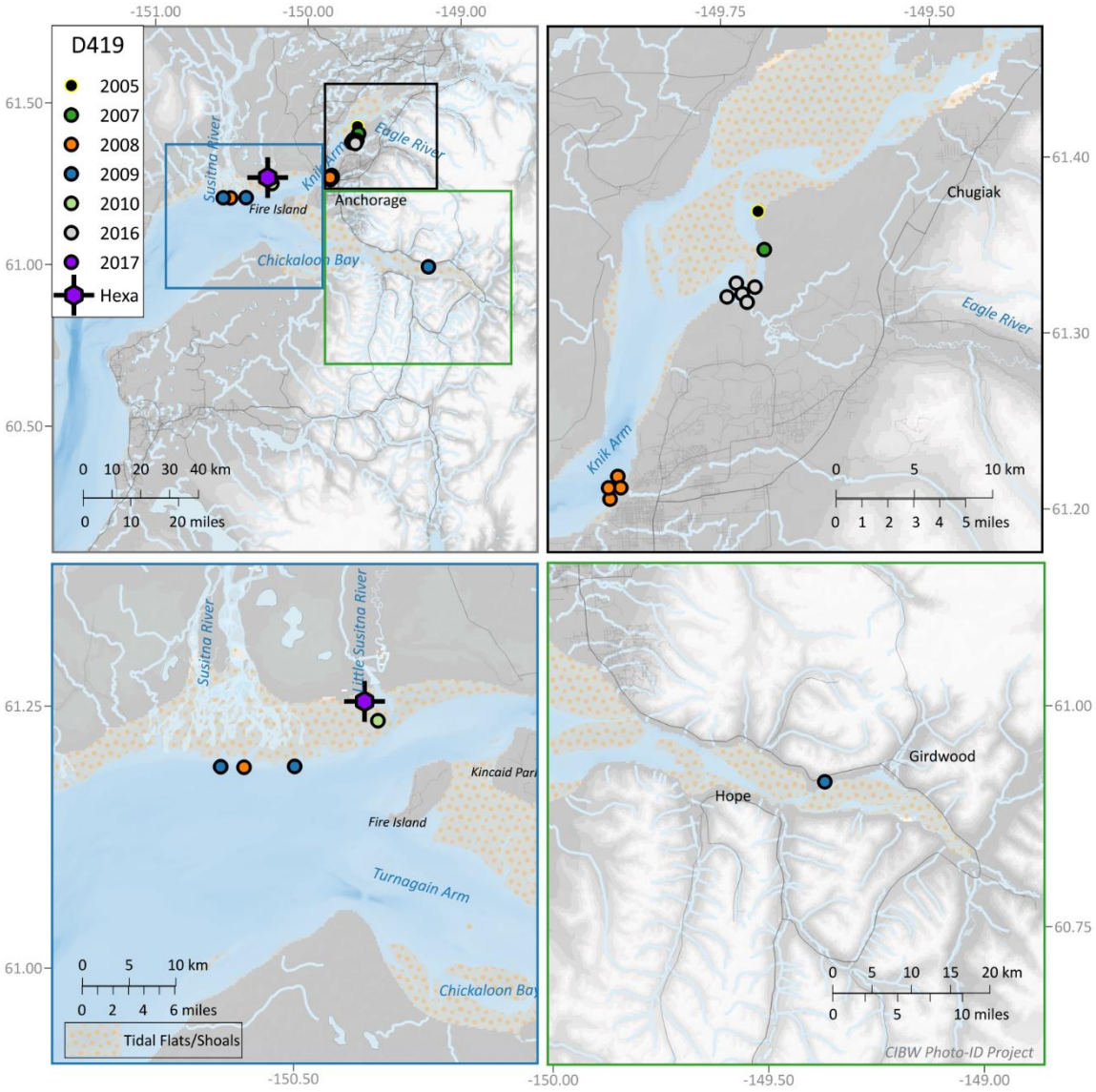

Figure B15. Sighting history of beluga D419. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0206*.

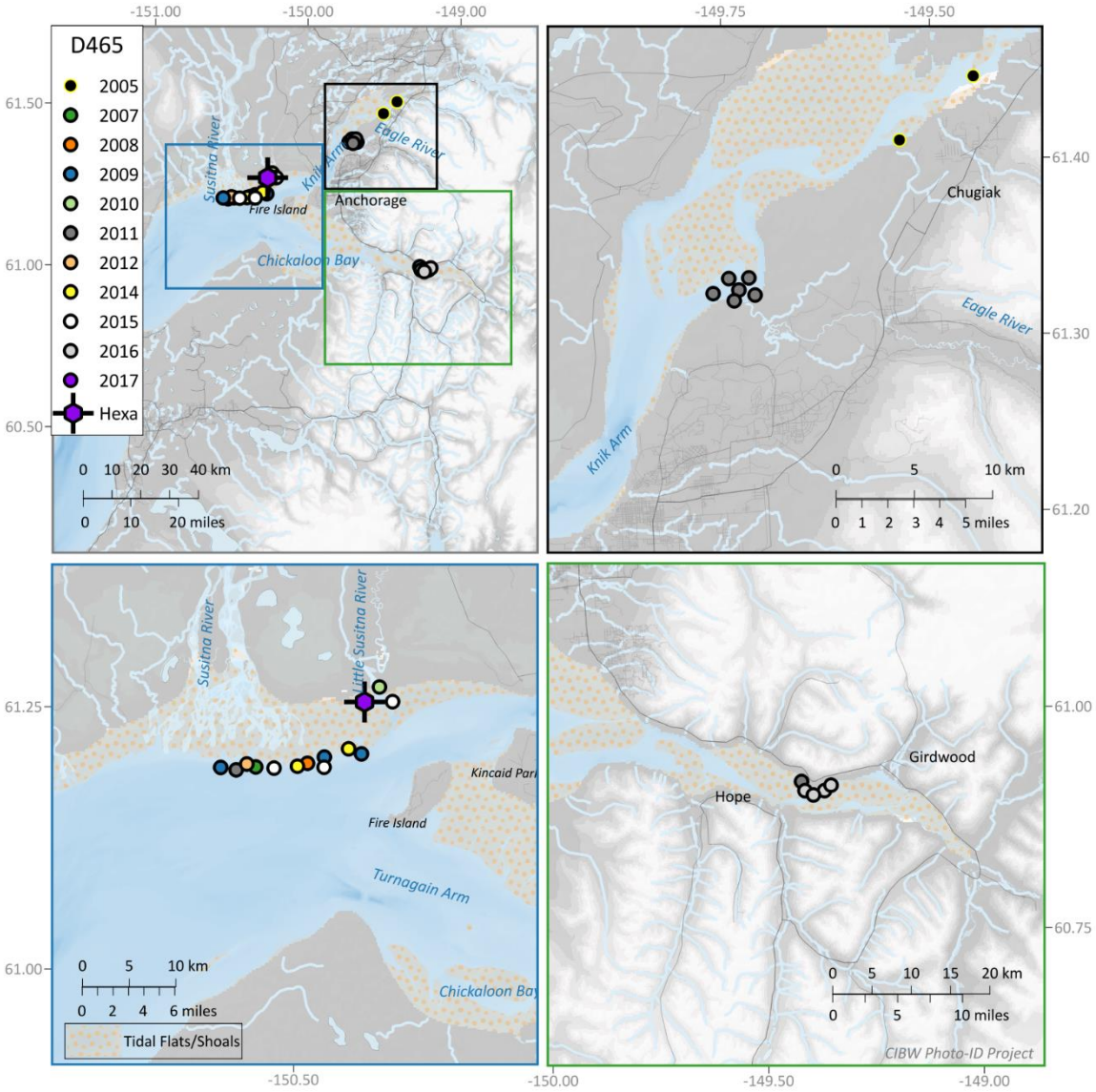

Figure B16. Sighting history of beluga D465. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0028*.

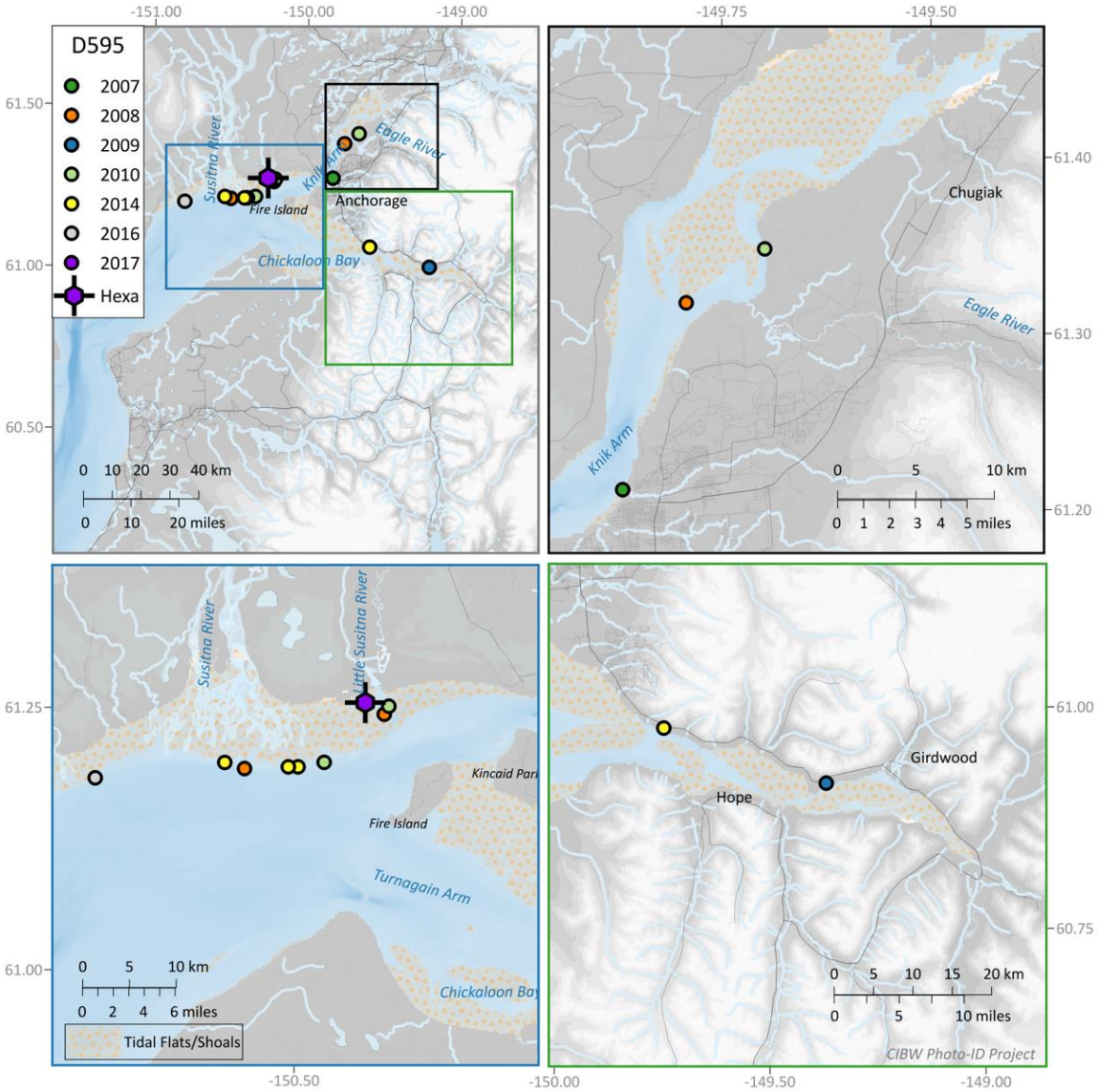

Figure B17. Sighting history of beluga D595. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0077*.

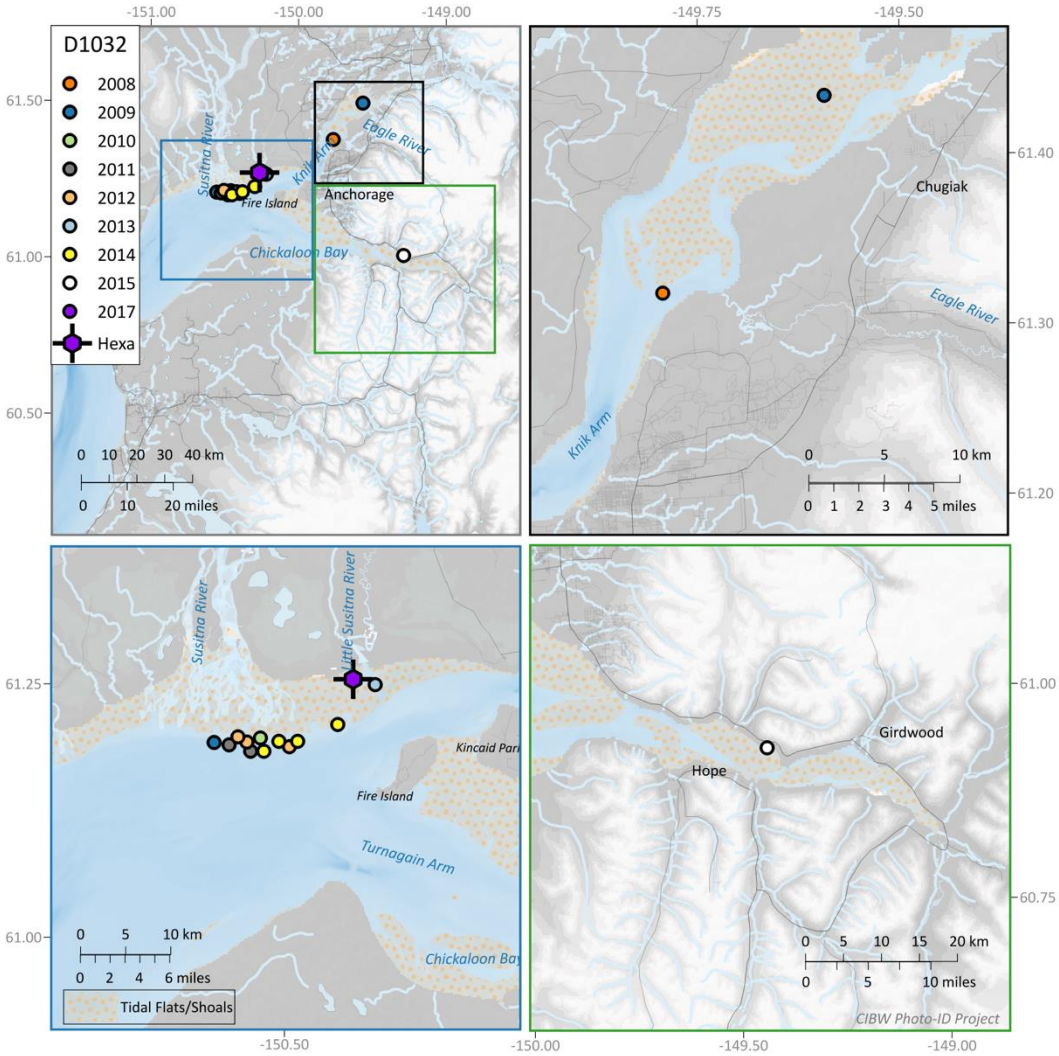

Figure B18. Sighting history of beluga D1032. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0052*.

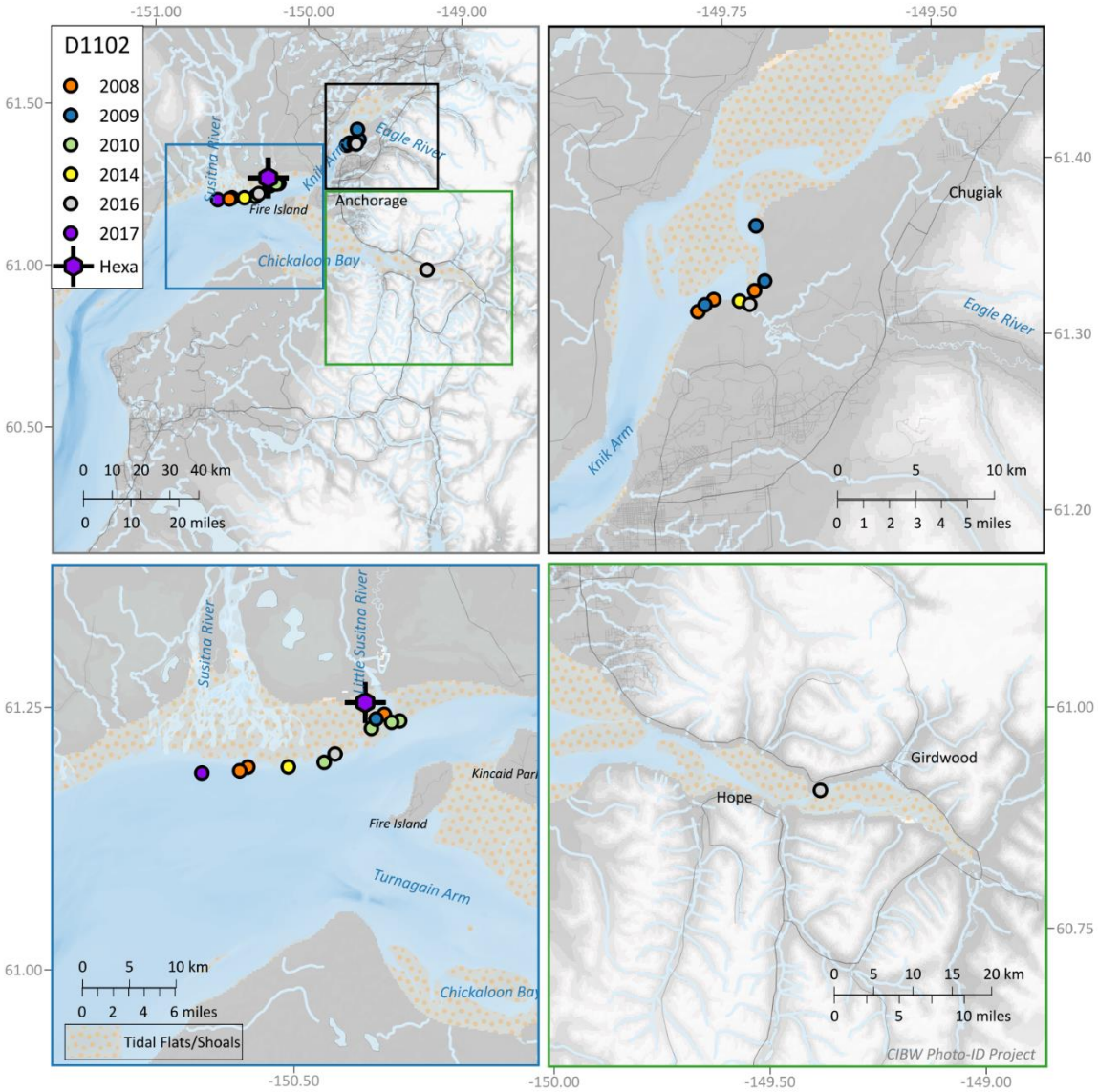

Figure B19. Sighting history of beluga D1102. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0073* and ID *17JR_24-Aug-17_S008_DI0025*.

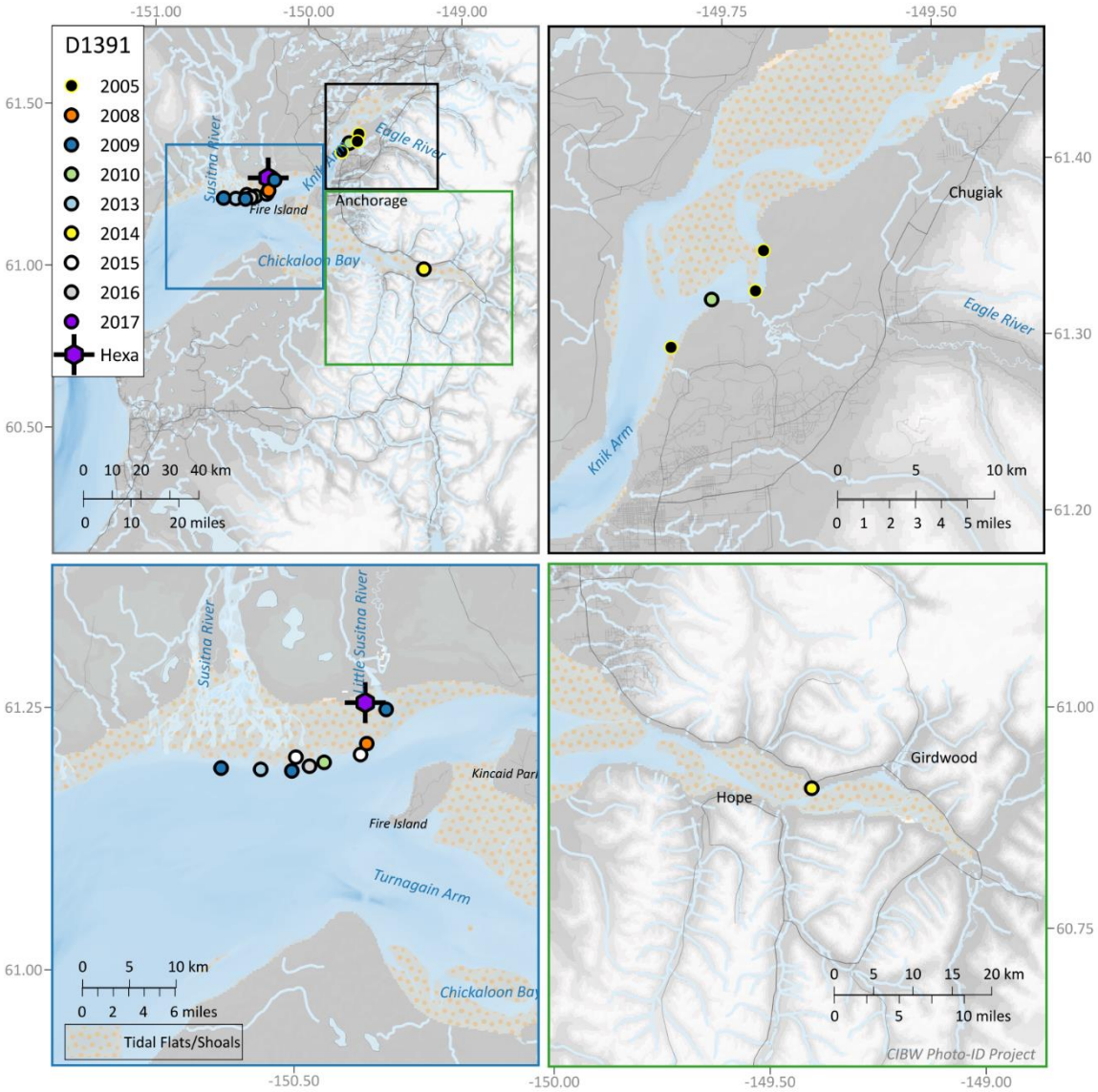

Figure B20. Sighting history of beluga D1391. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_24-Aug-17_S018_DI0005*.

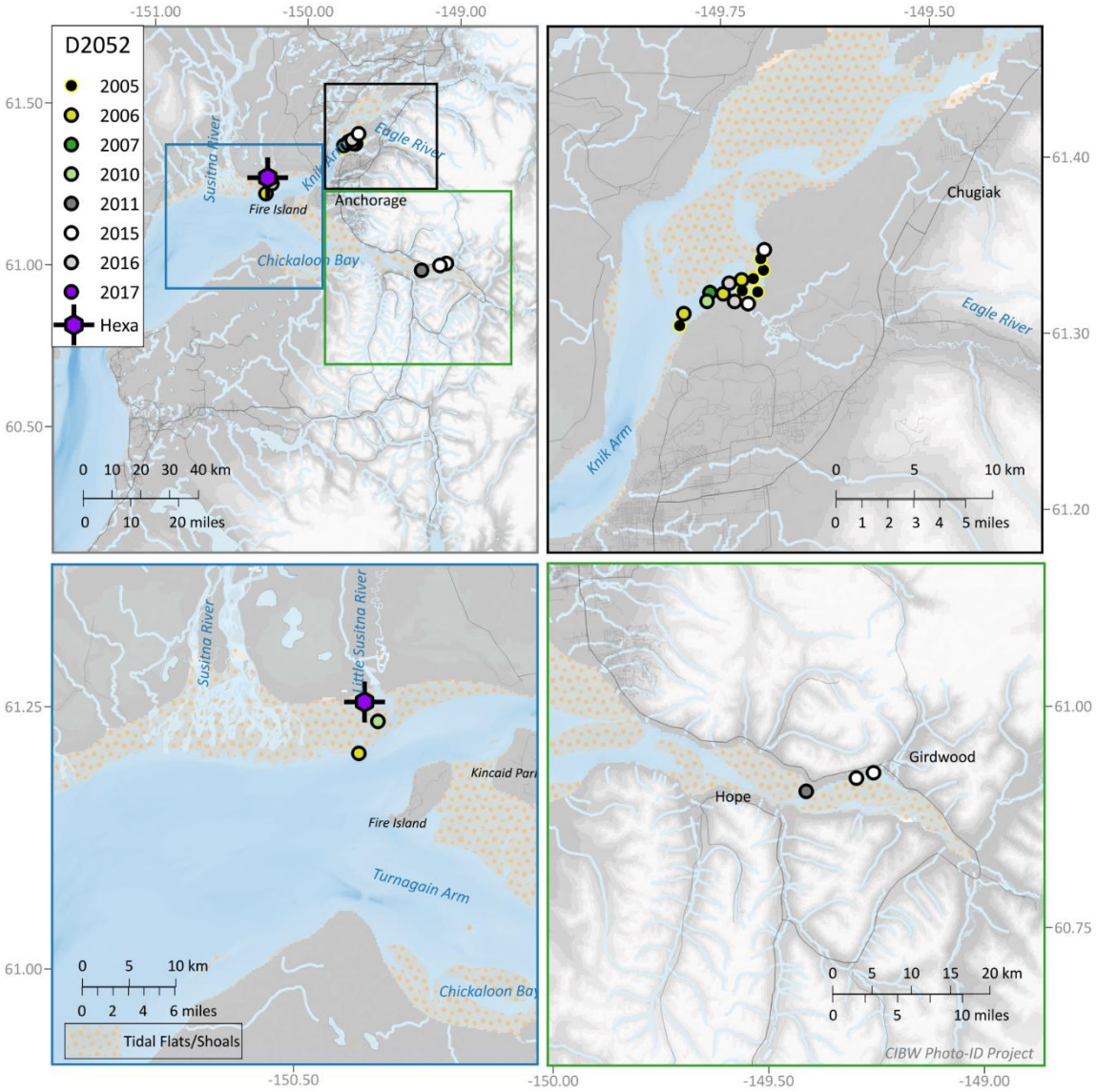

Figure B21. Sighting history of beluga D2052. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0063*.

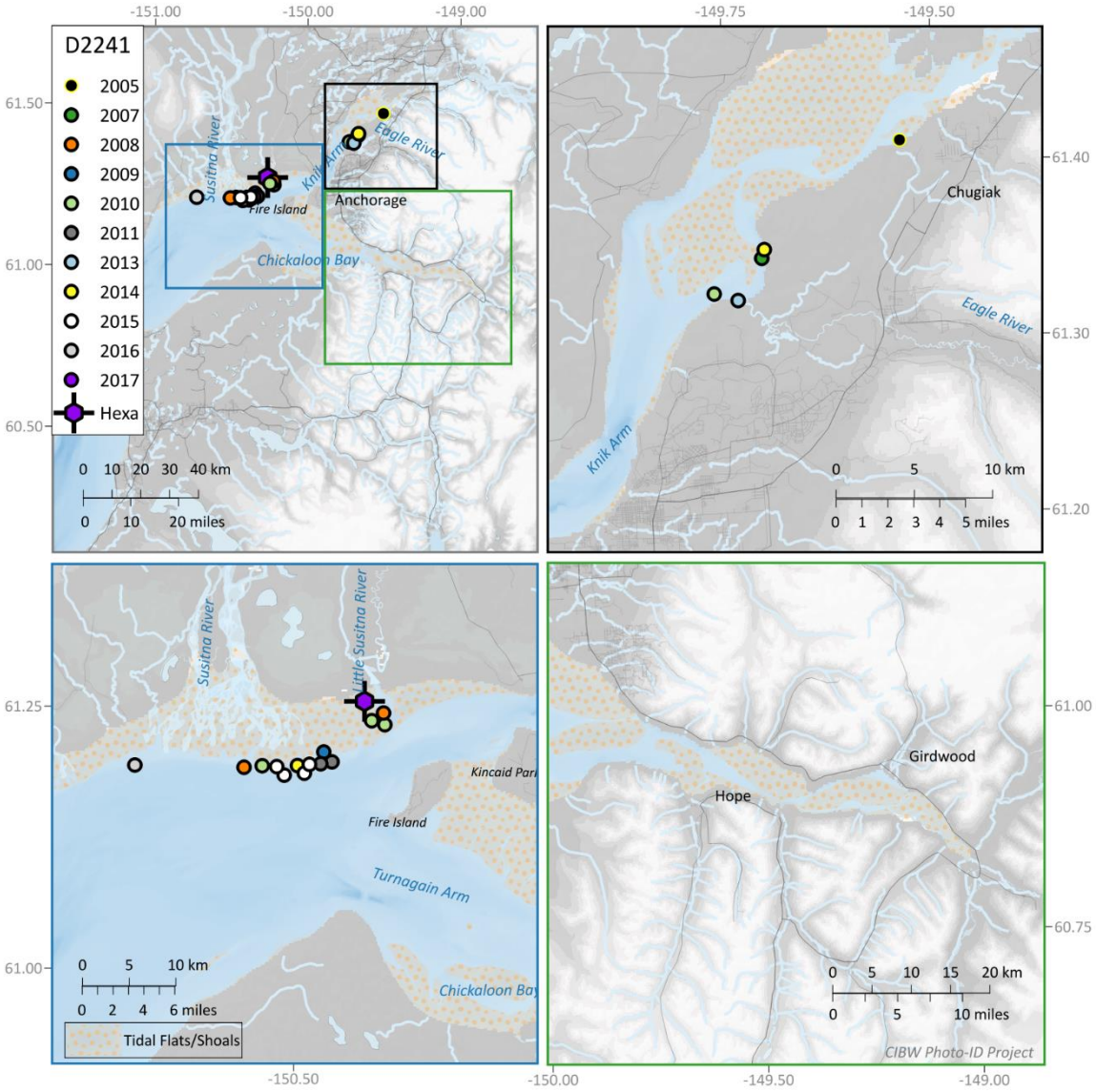

Figure B22. Sighting history of beluga D2241. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0075*.

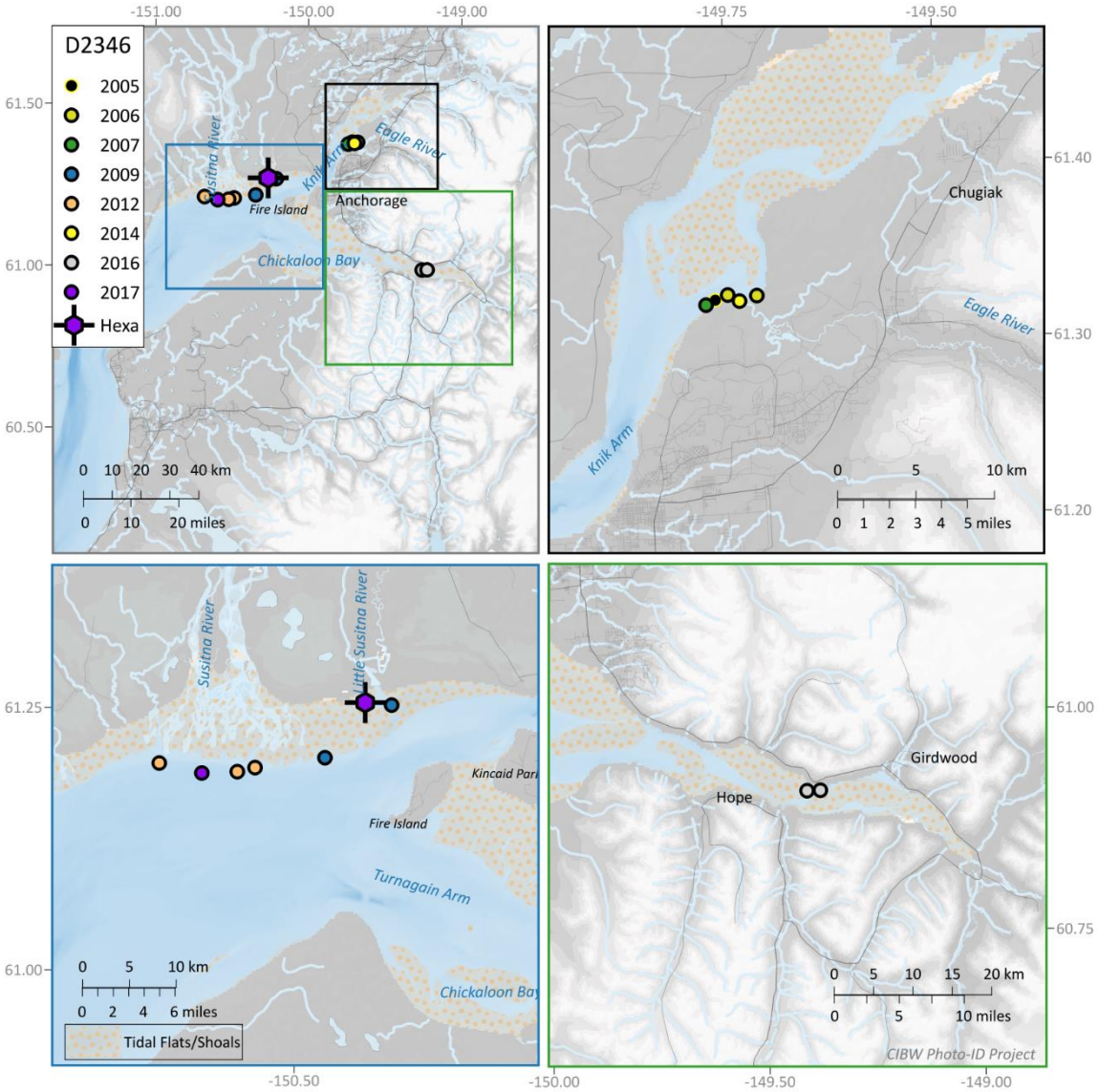

Figure B23. Sighting history of beluga D2346. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0152*.

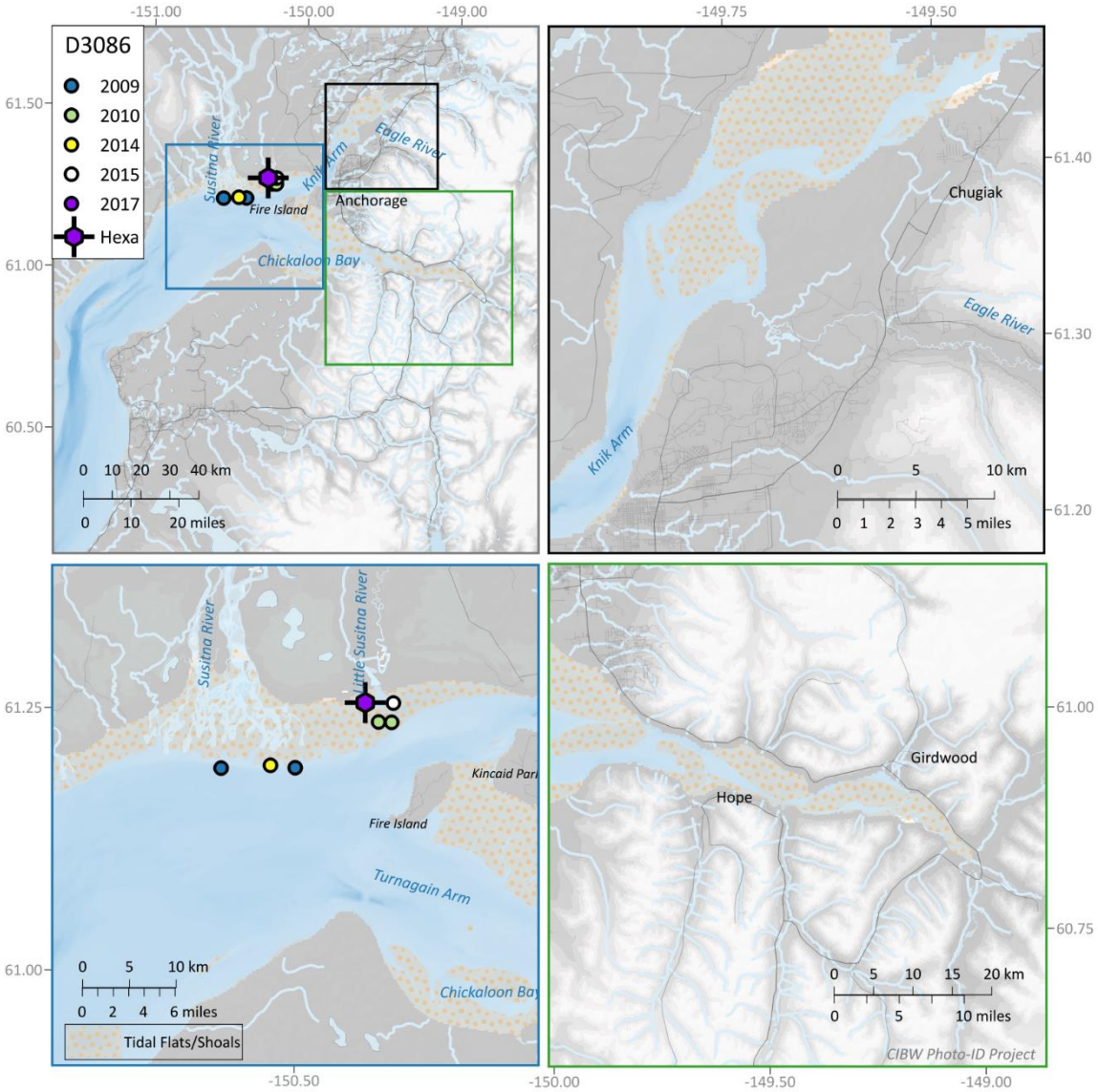

Figure B24. Sighting history of beluga D3086. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0049*.

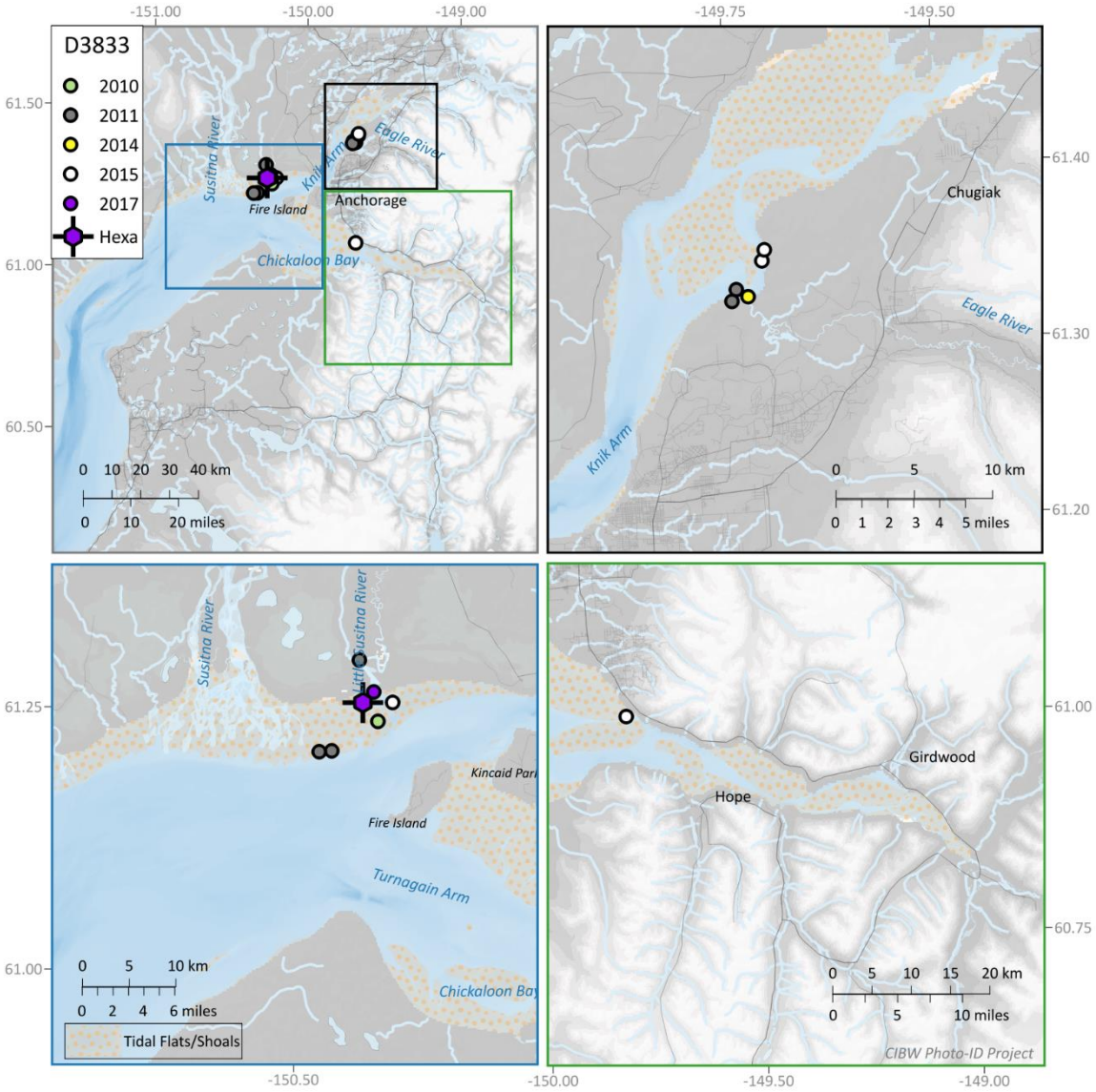

Figure B25. Sighting history of beluga D3833. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_24-Aug-17_S018_DI0022*.

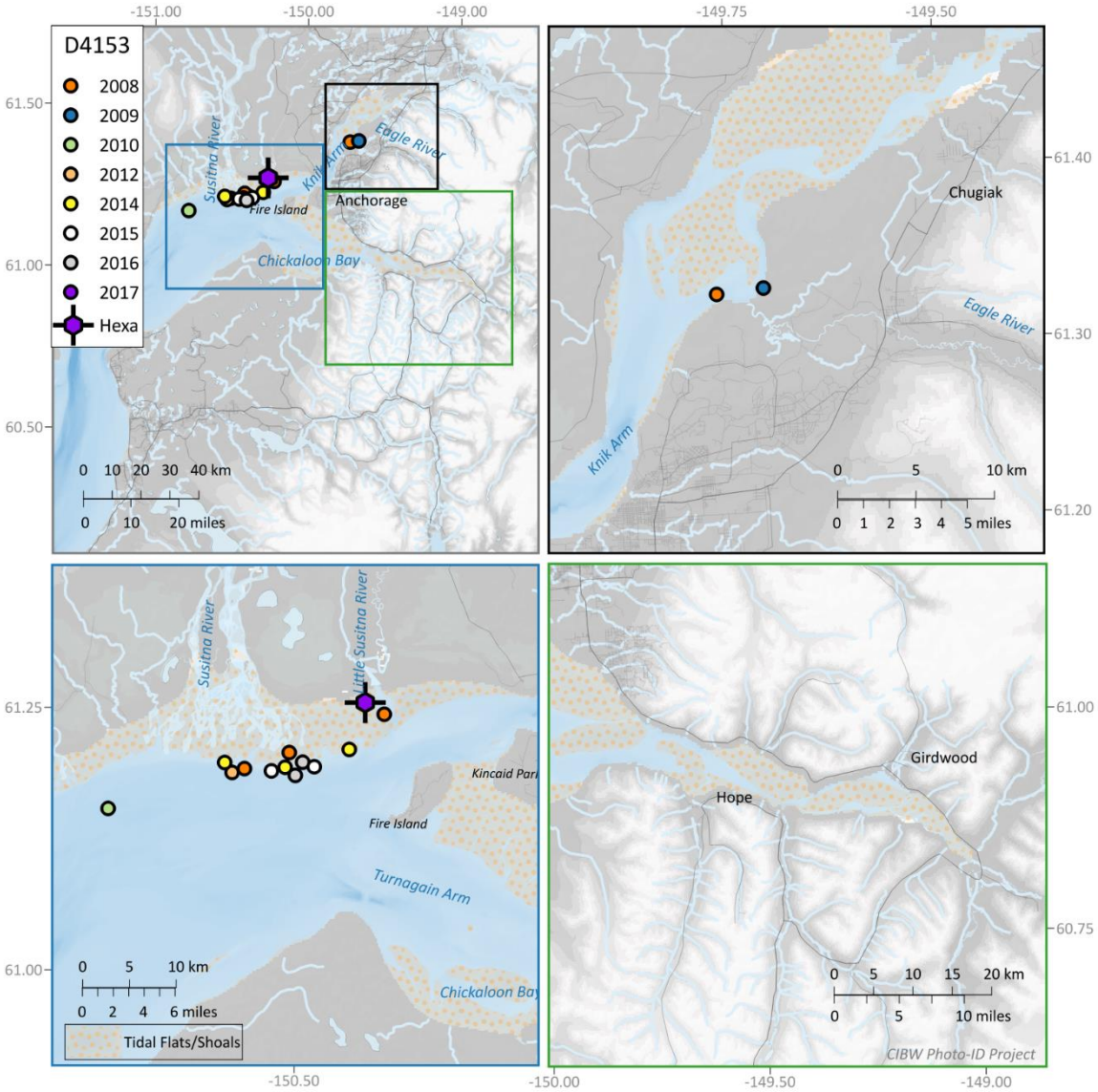

Figure B26. Sighting history of beluga D4153. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_24-Aug-17_S019_DI0007*.

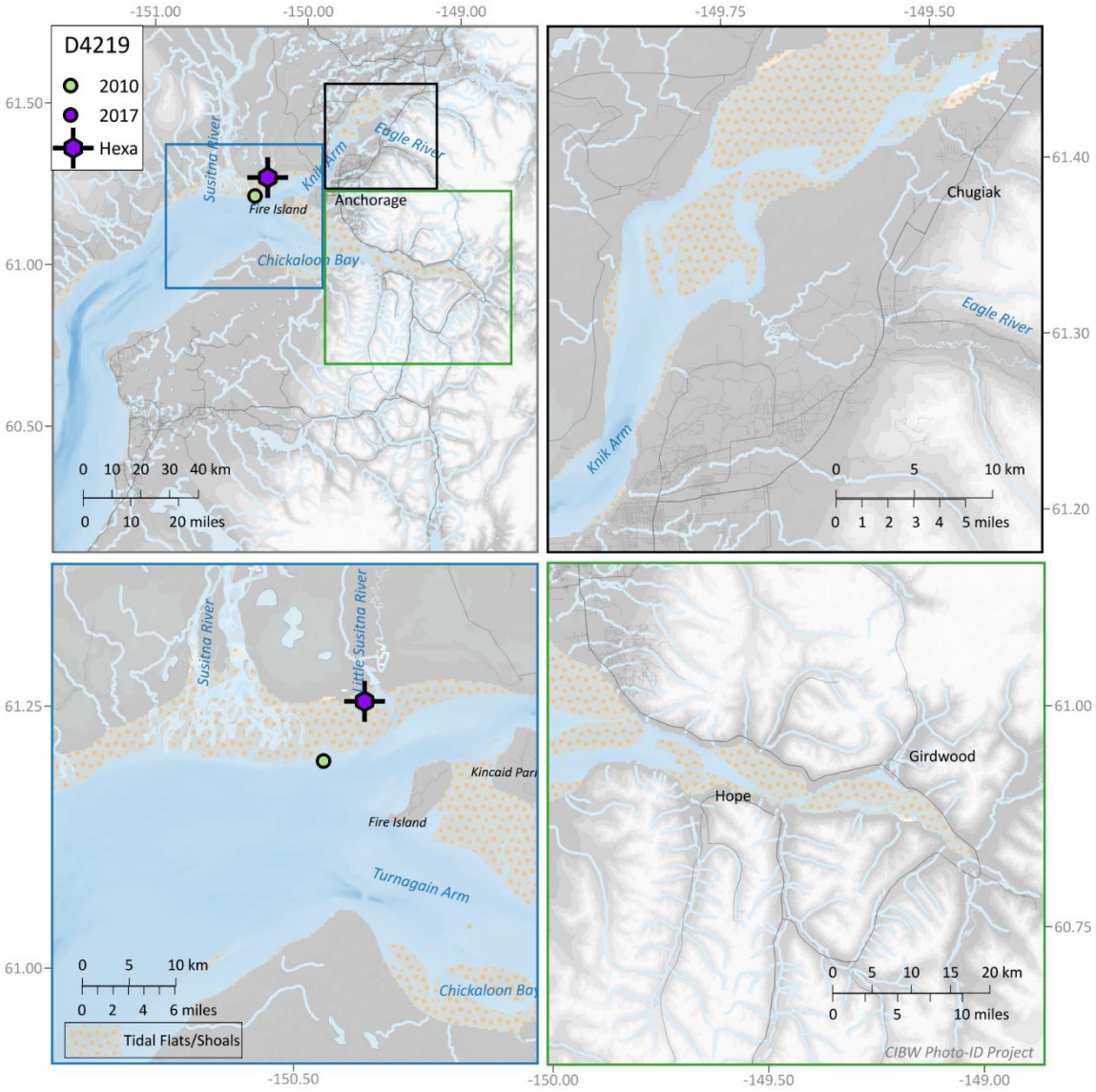

Figure B27. Sighting history of beluga D4219. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_24-Aug-17_S018_DI0006*.

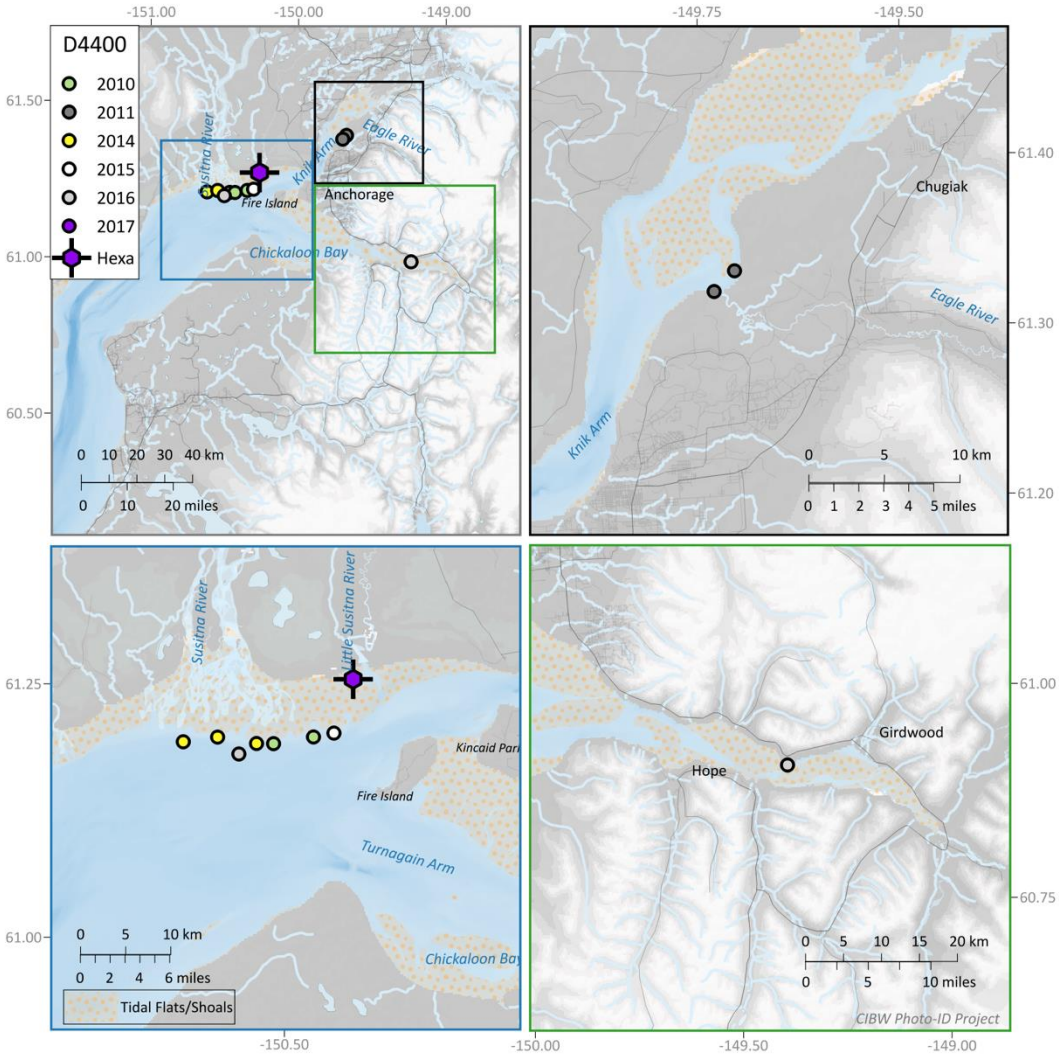

Figure B28. Sighting history of beluga D4400. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0032*.

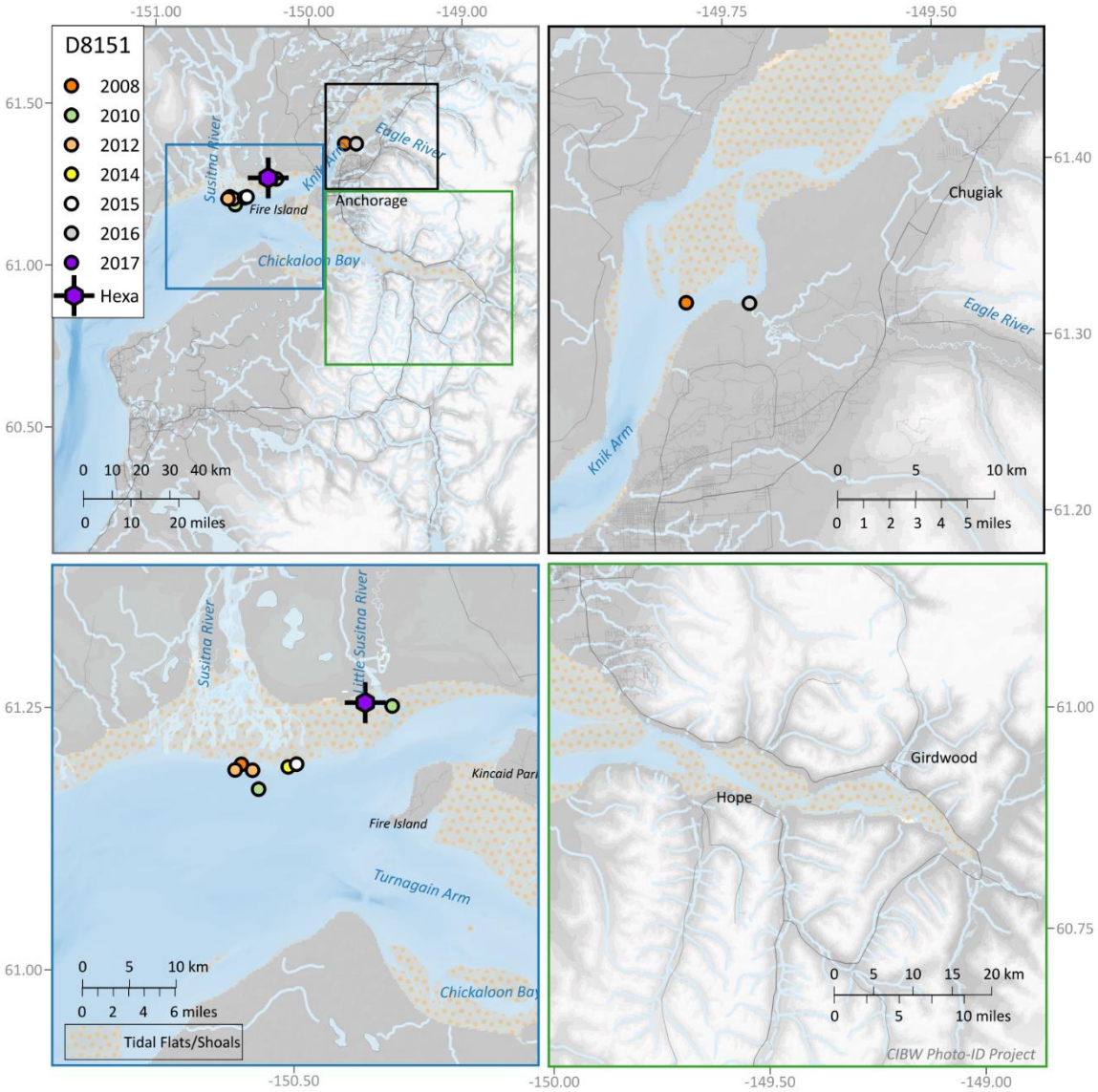

Figure B29. Sighting history of beluga D8151. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0018*.

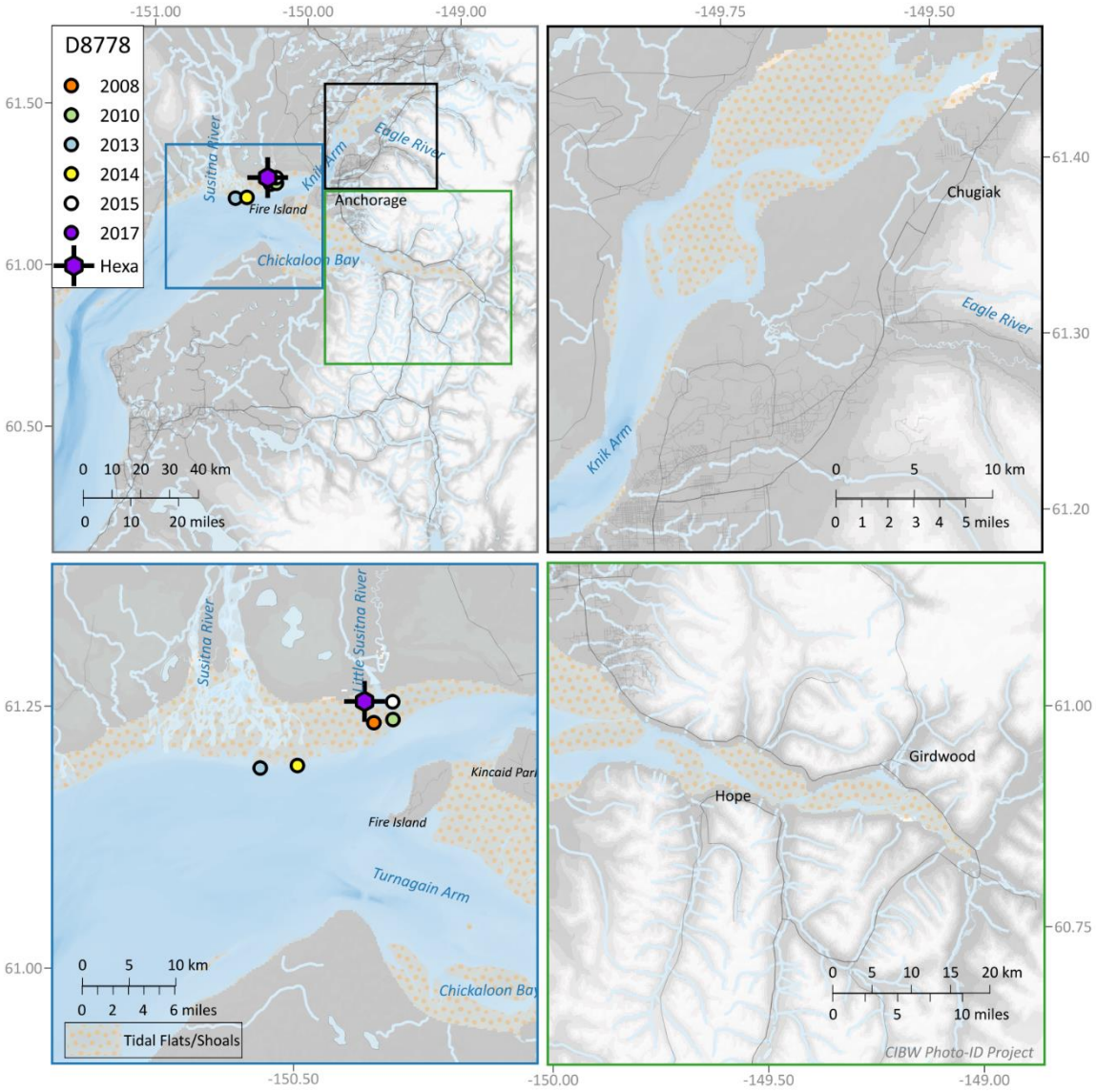

Figure B30. Sighting history of beluga D8778. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_24-Aug-17_S018_DI0001*.

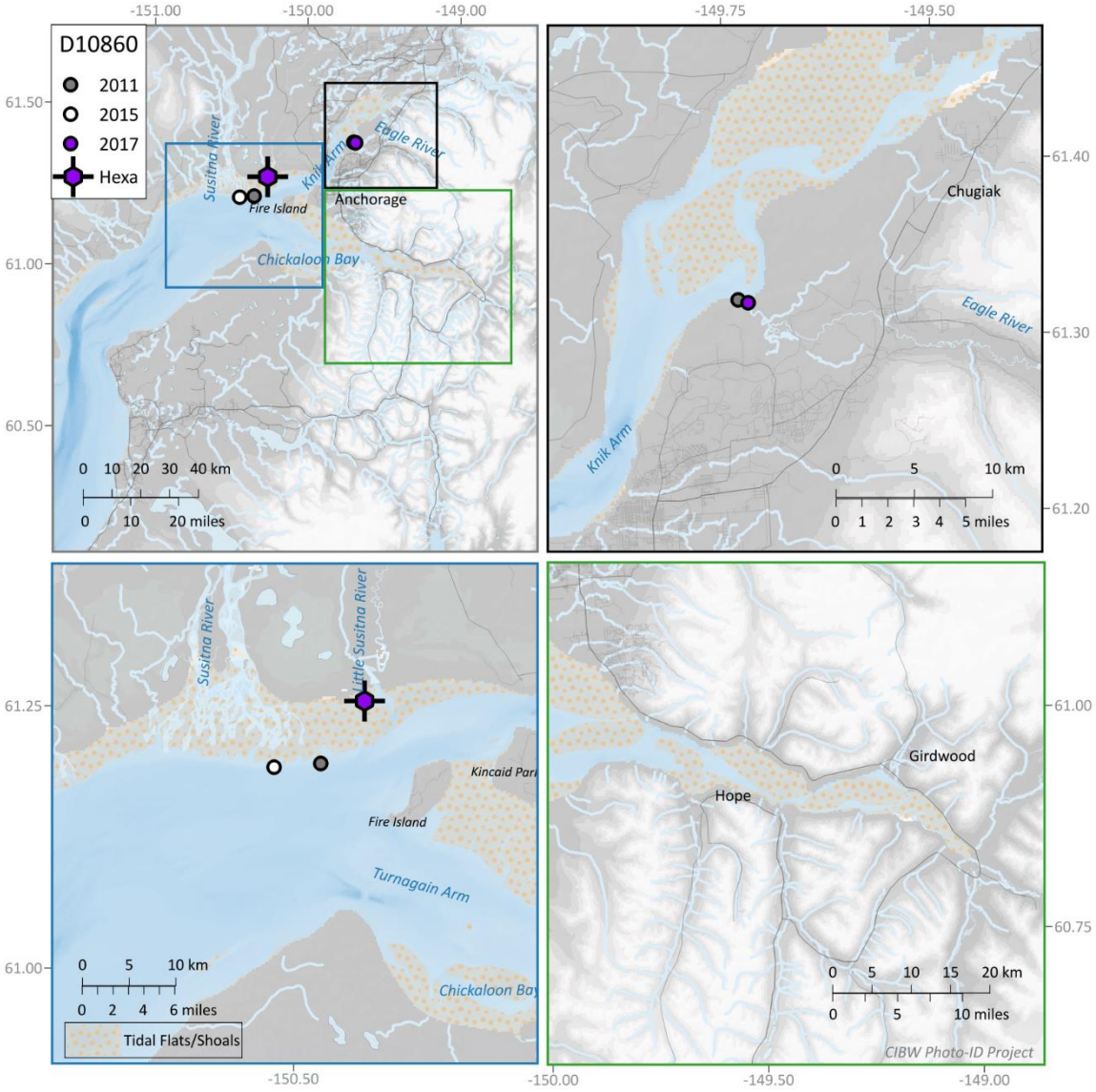

Figure B31. Sighting history of beluga D10860. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0222*.

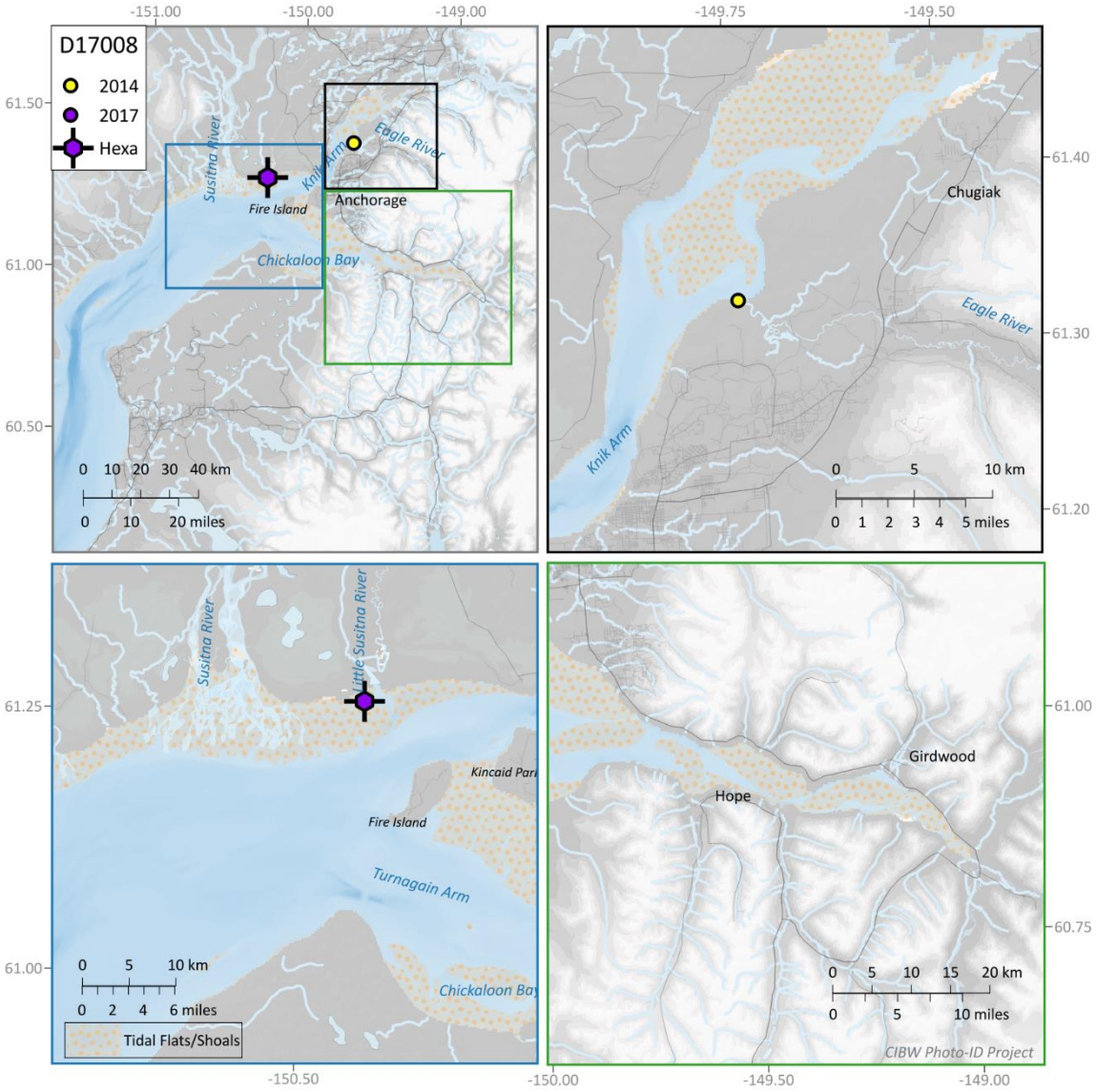

Figure B32. Sighting history of beluga D17008. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0083*.

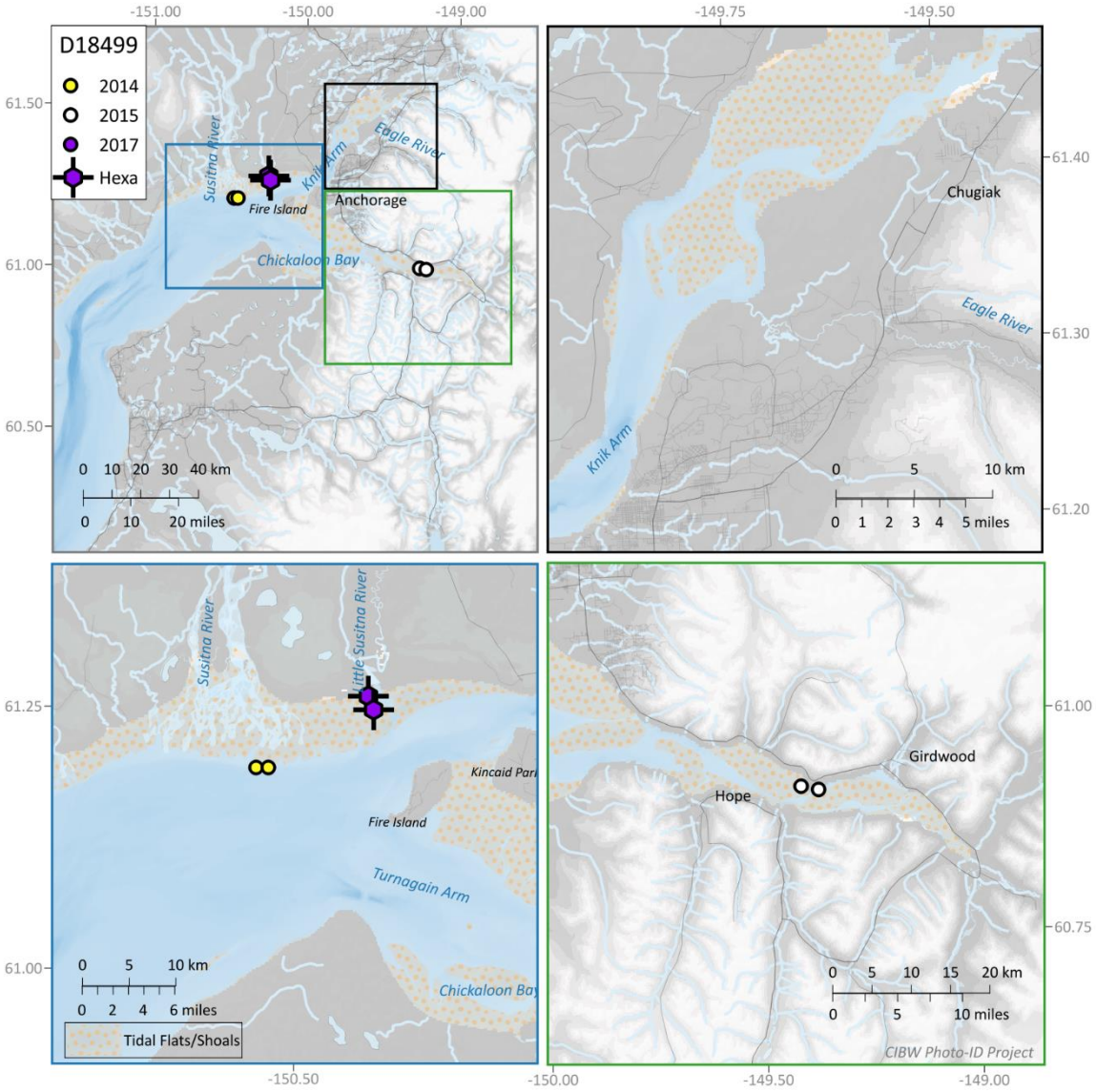

Figure B33. Sighting history of beluga D18499. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_Dl0170* and ID *17JR_24-Aug-17_S008_DI0012*.

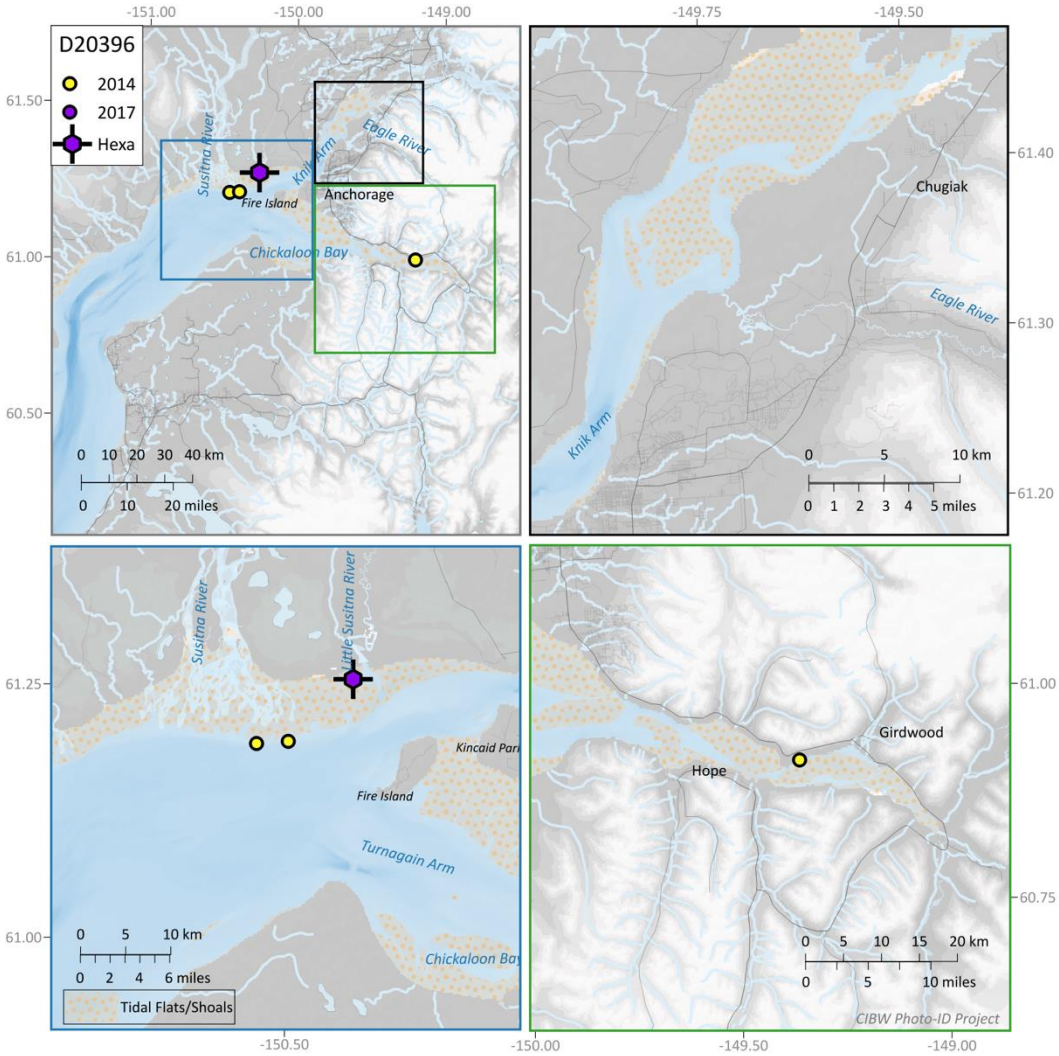

Figure B34. Sighting history of beluga D20396. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0164*.

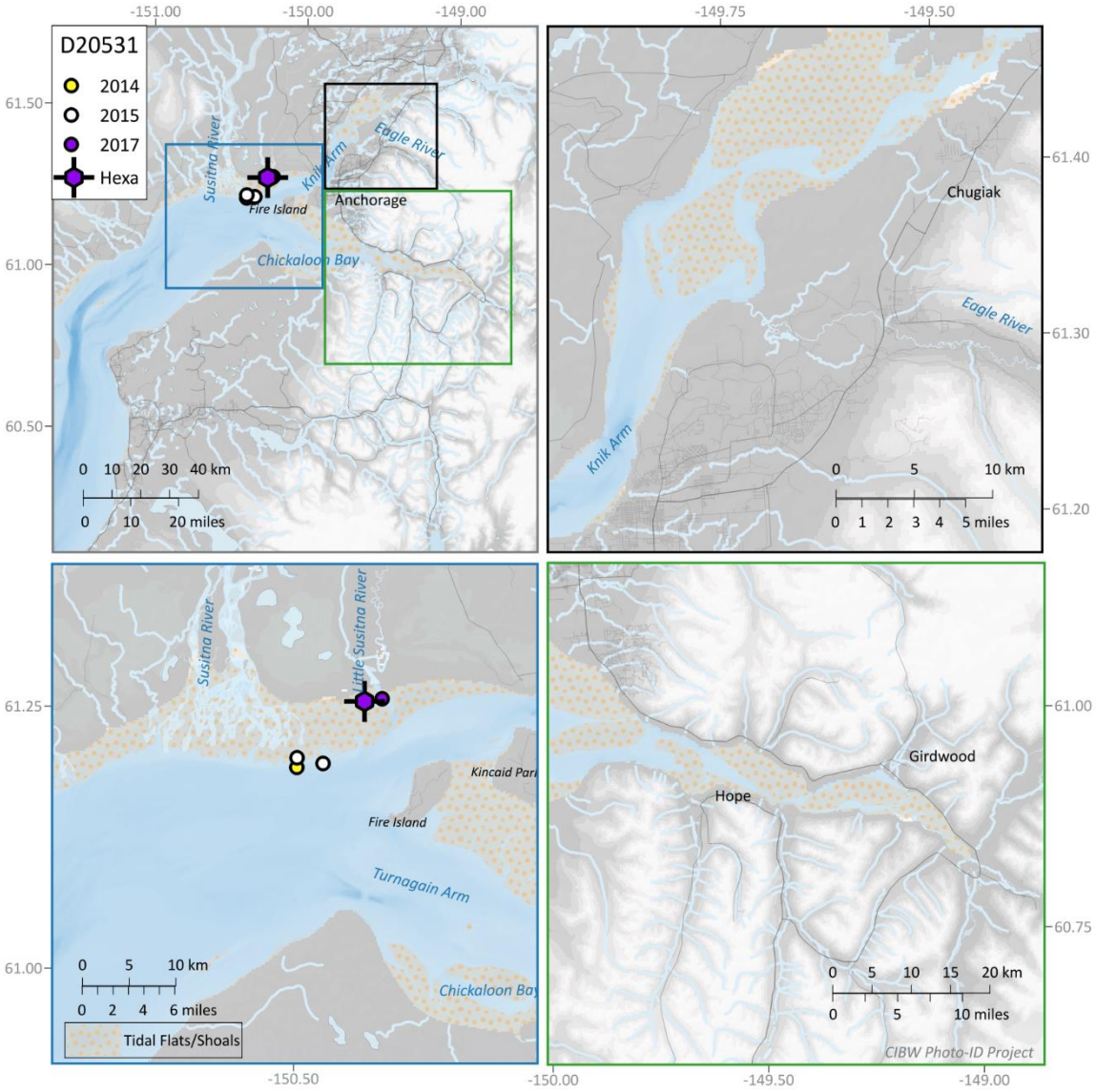

Figure B35. Sighting history of beluga D20531. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0201*.

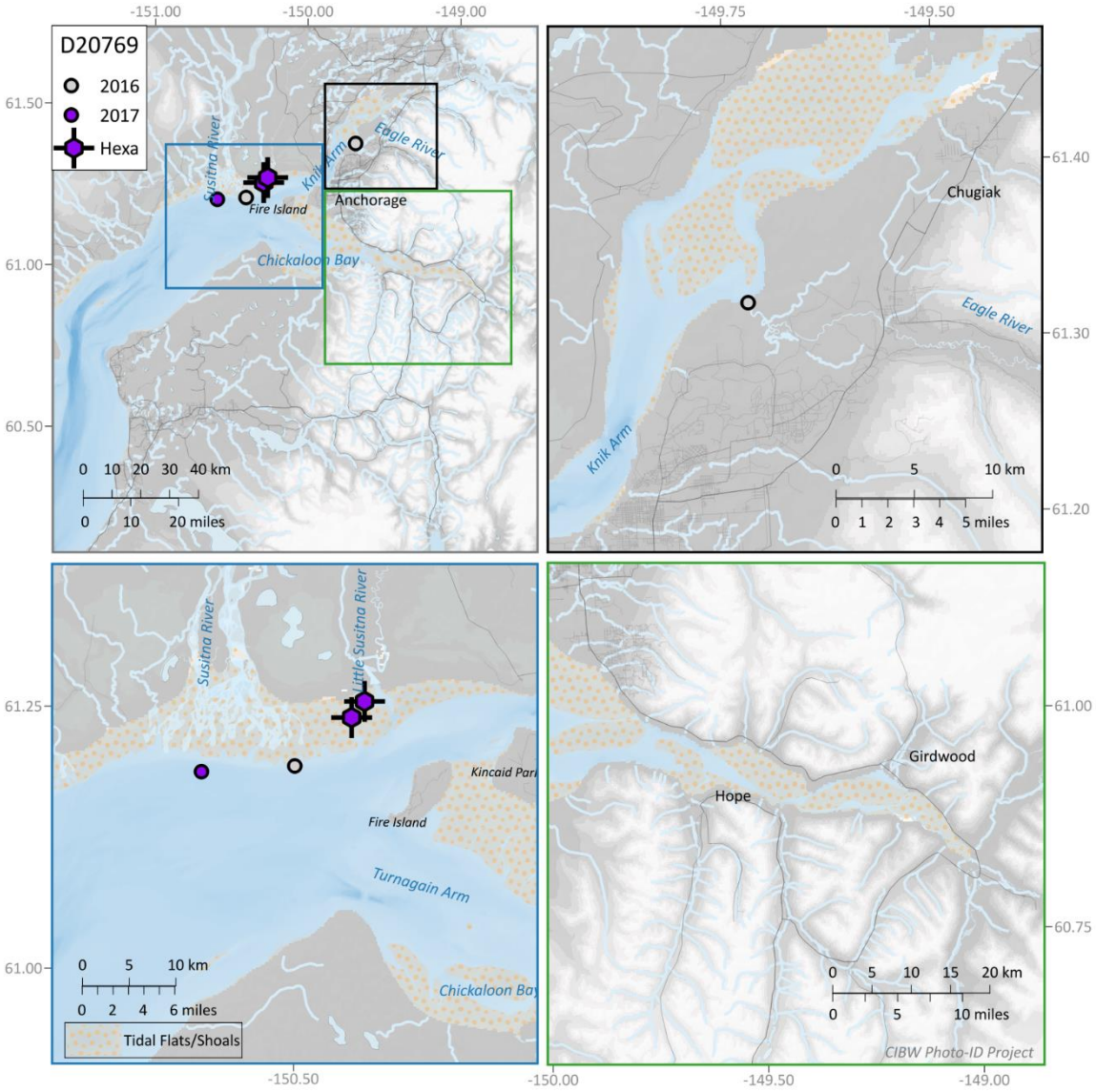

Figure B36. Sighting history of beluga D20769. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0005* and ID *17JR_24-Aug-17_S018_DI0013*.

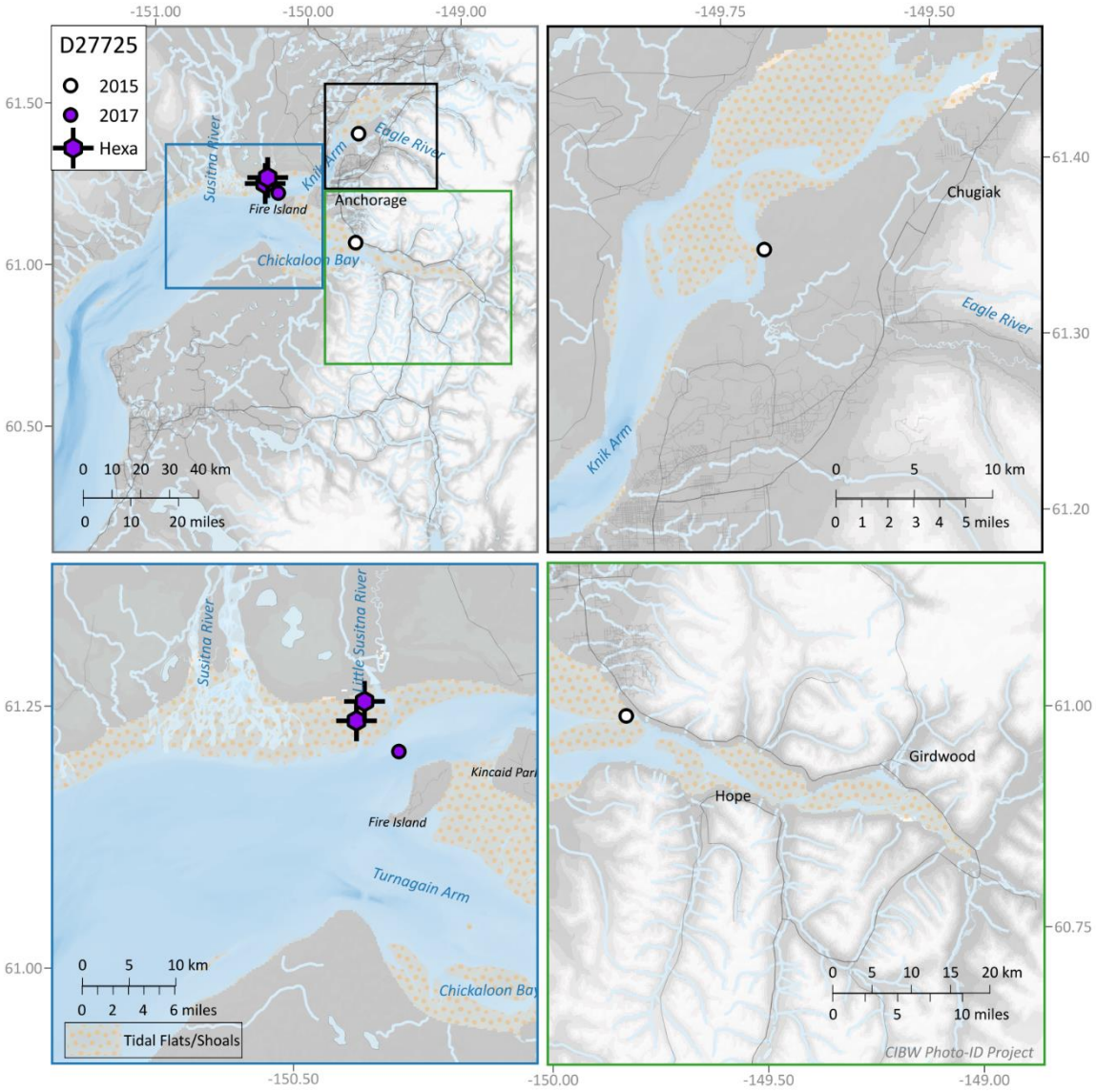

Figure B37. Sighting history of beluga D27725. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0207* and ID *17JR_24-Aug-17_DI0021*.

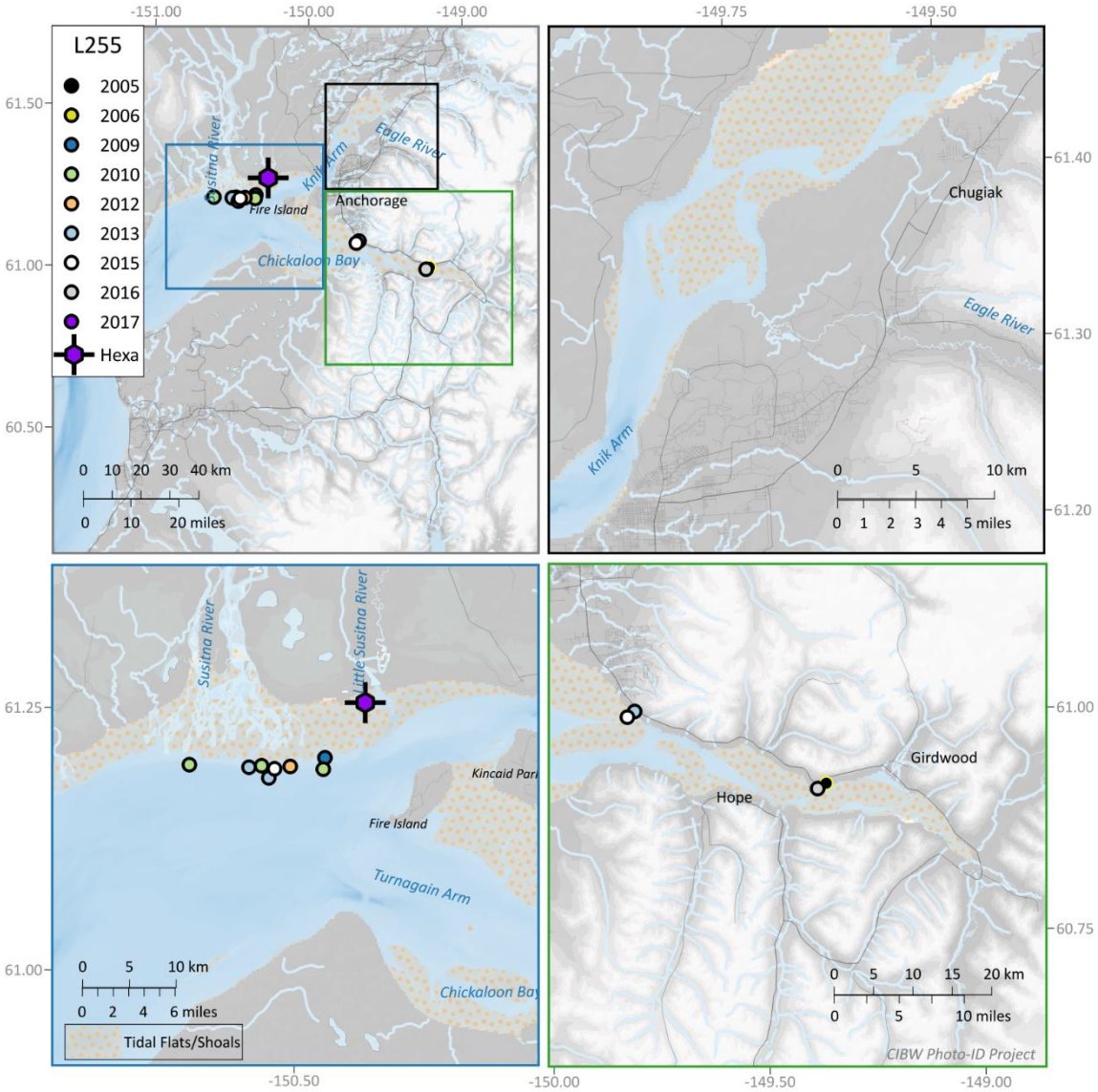

Figure B38. Sighting history of beluga L255. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0213*.

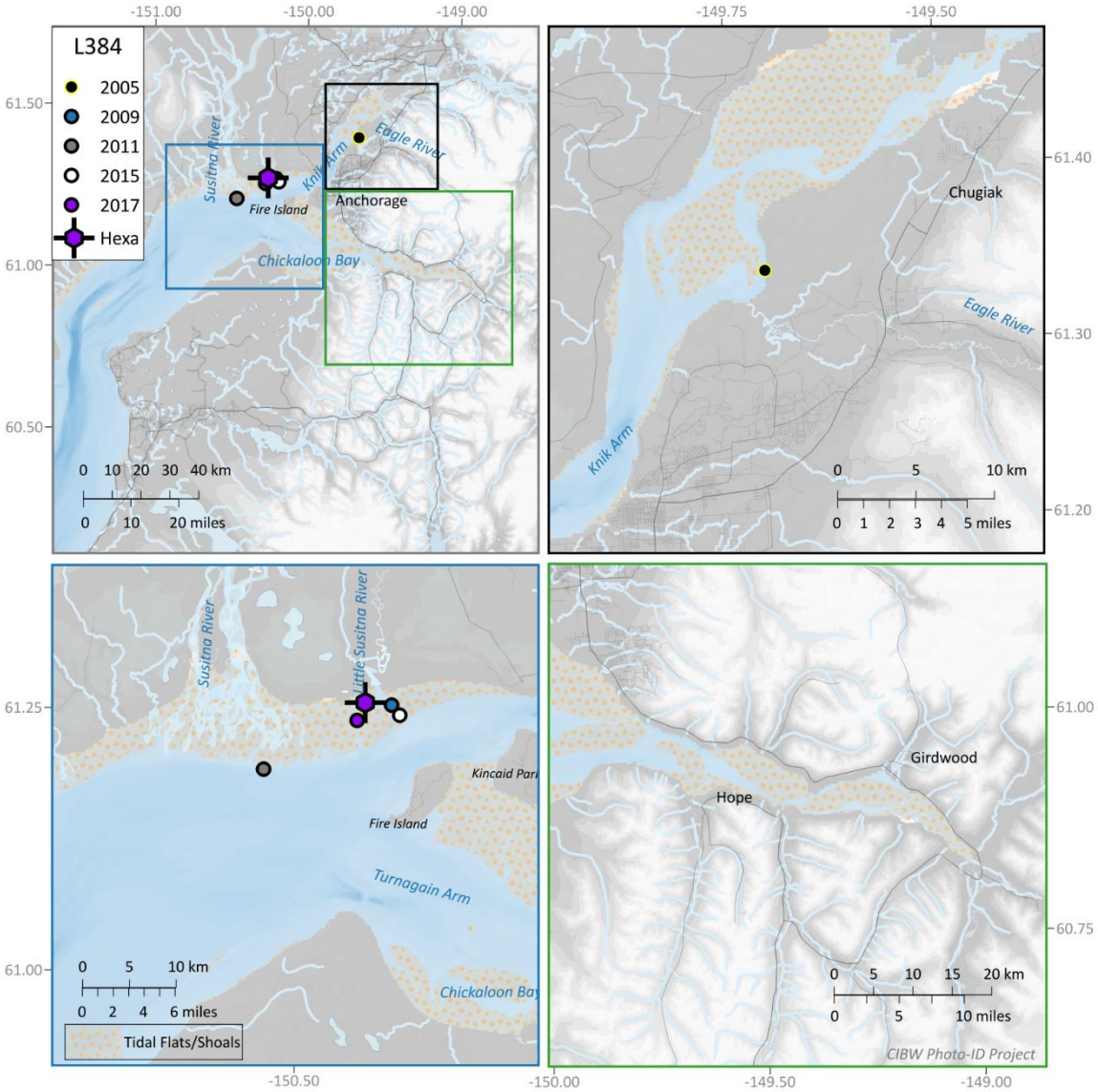

Figure B39. Sighting history of beluga L384. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0187*.

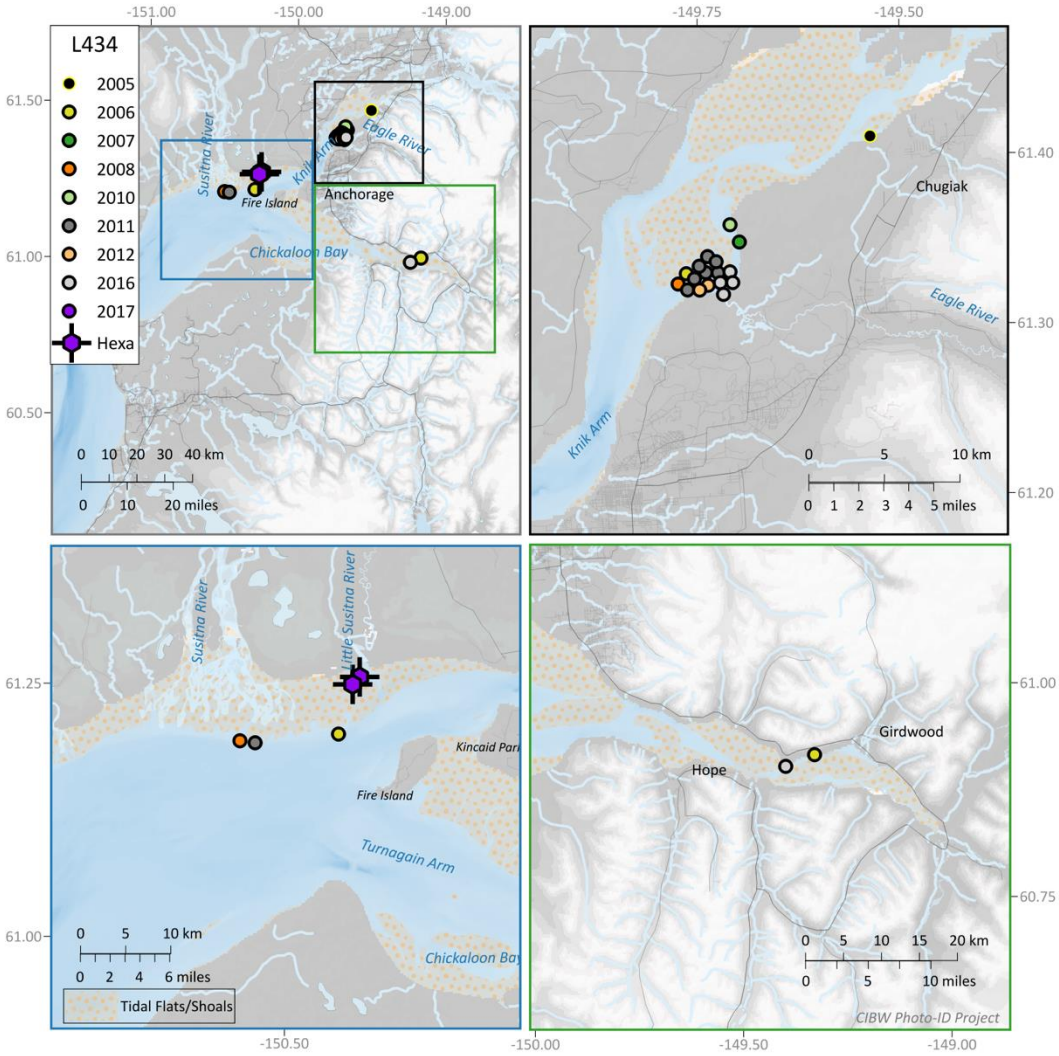

Figure B40. Sighting history of beluga L434. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0161* and ID *17JR_22-Aug-17_S011_DI0006*.

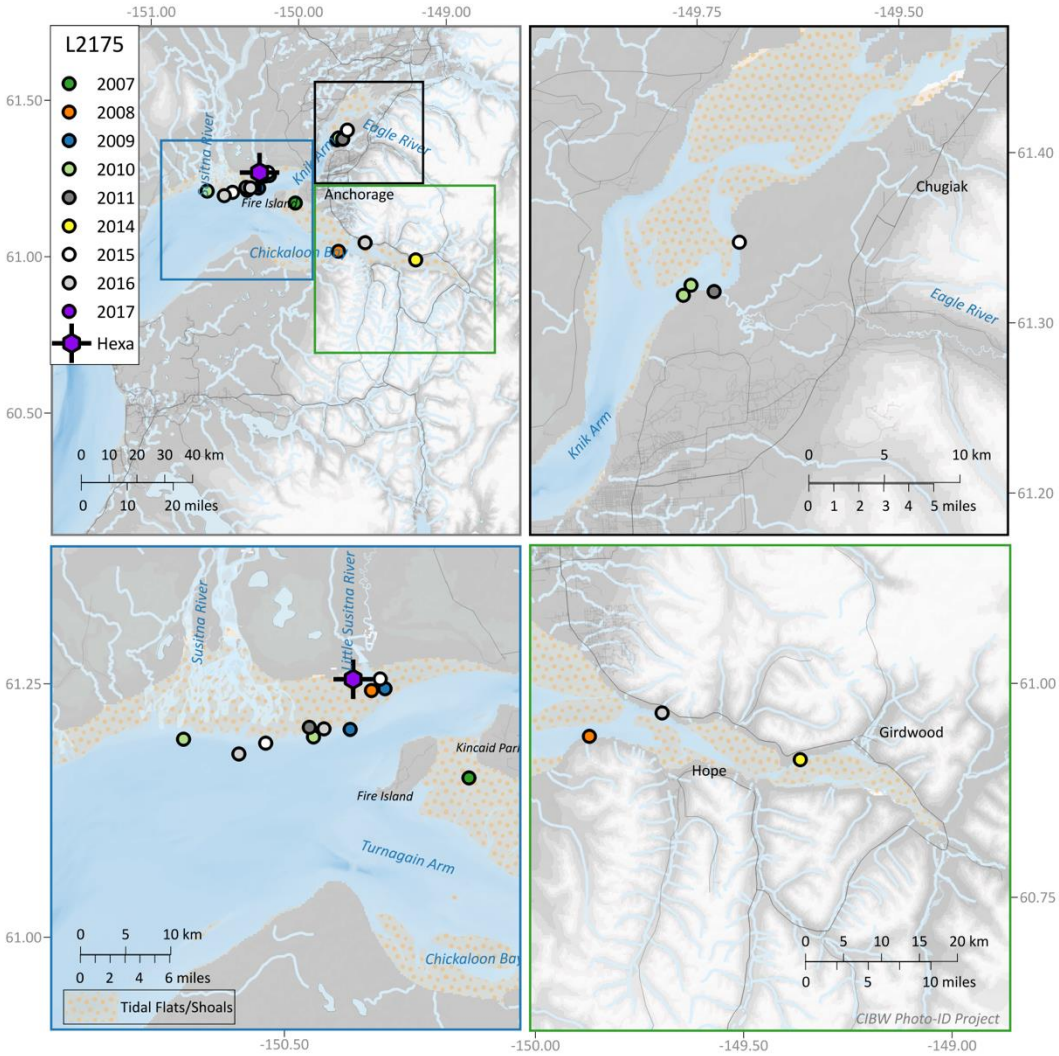

Figure B41. Sighting history of beluga L2175. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0129*.

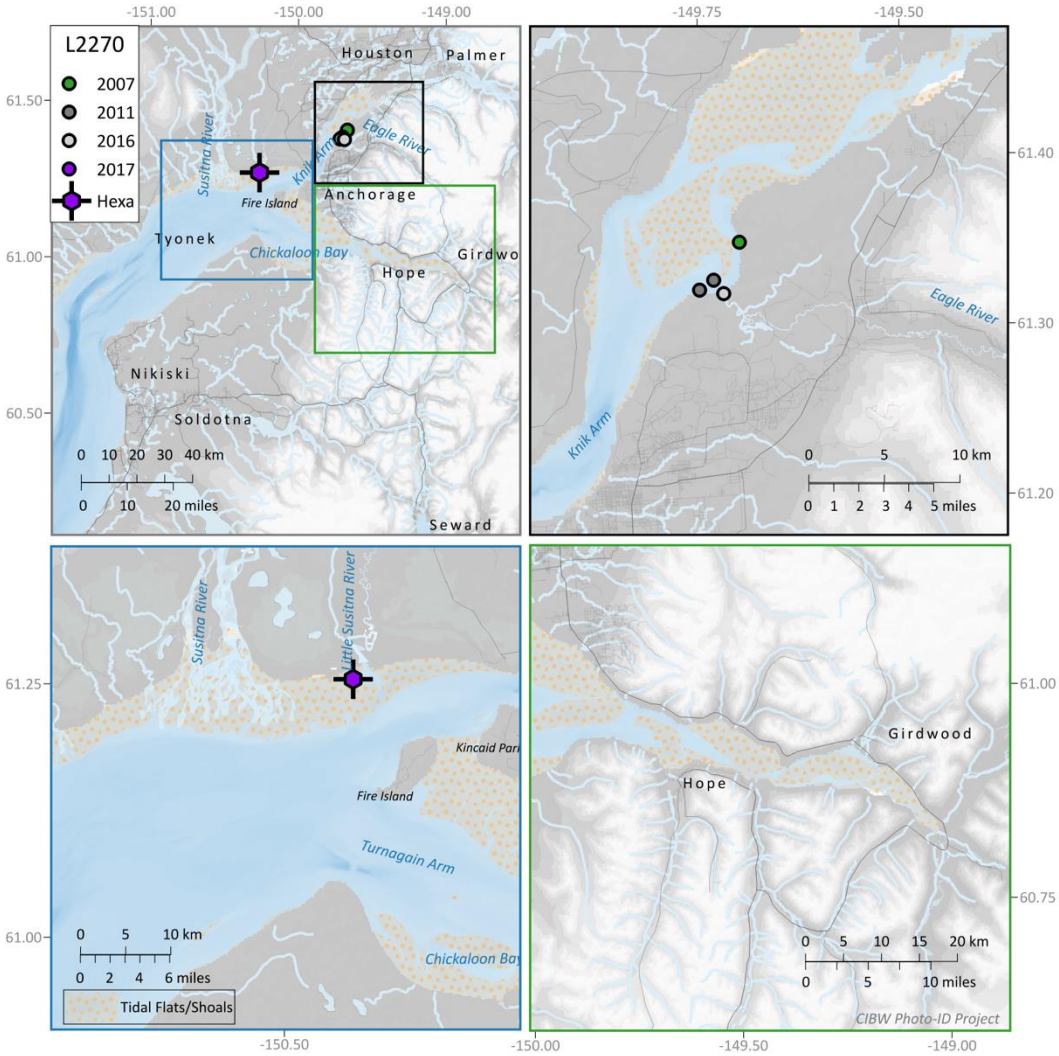

Figure B42. Sighting history of beluga L2270. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_22-Aug-17_S011_DI0009*.

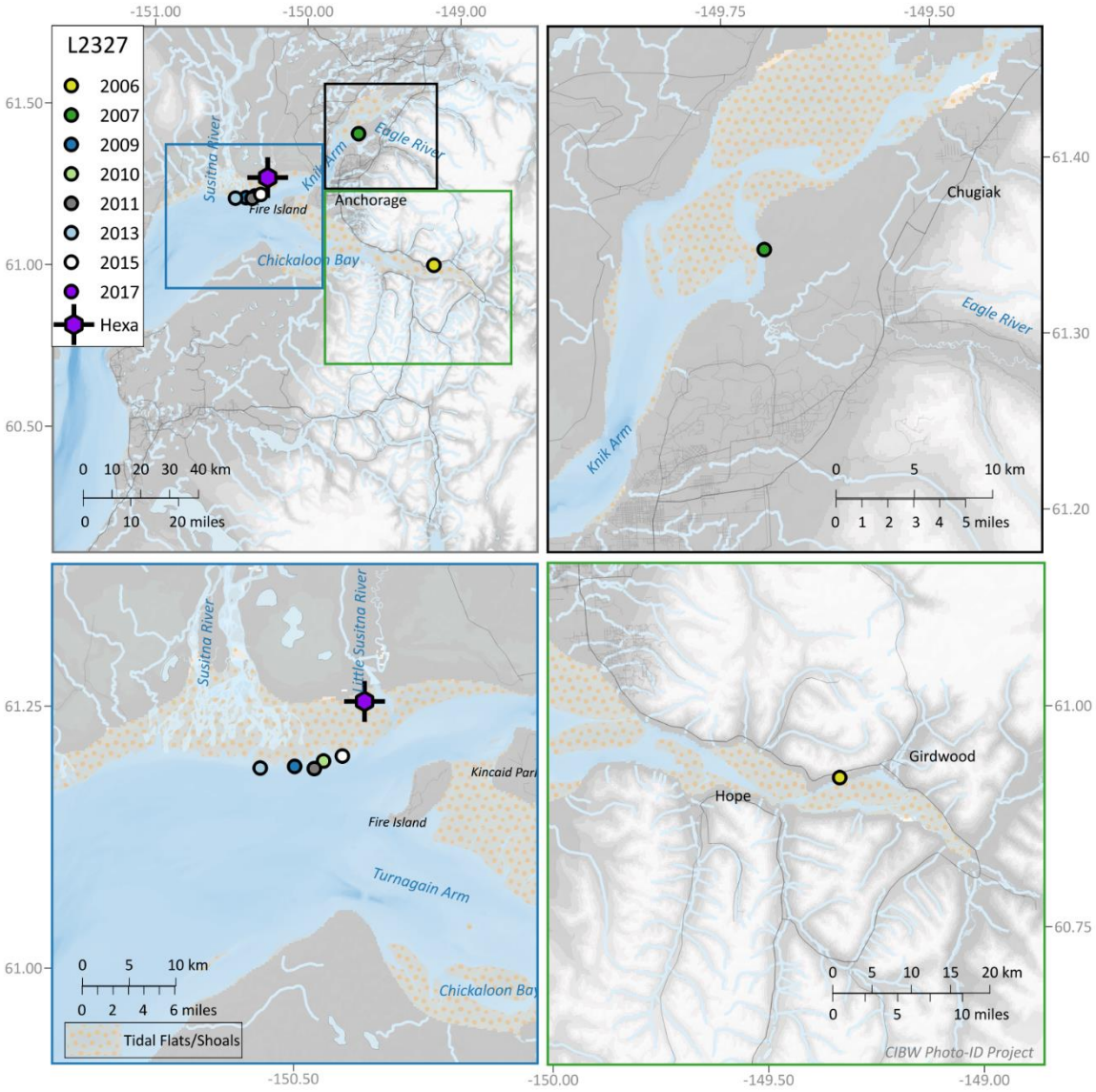

Figure B43. Sighting history of beluga L2327. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0057*.

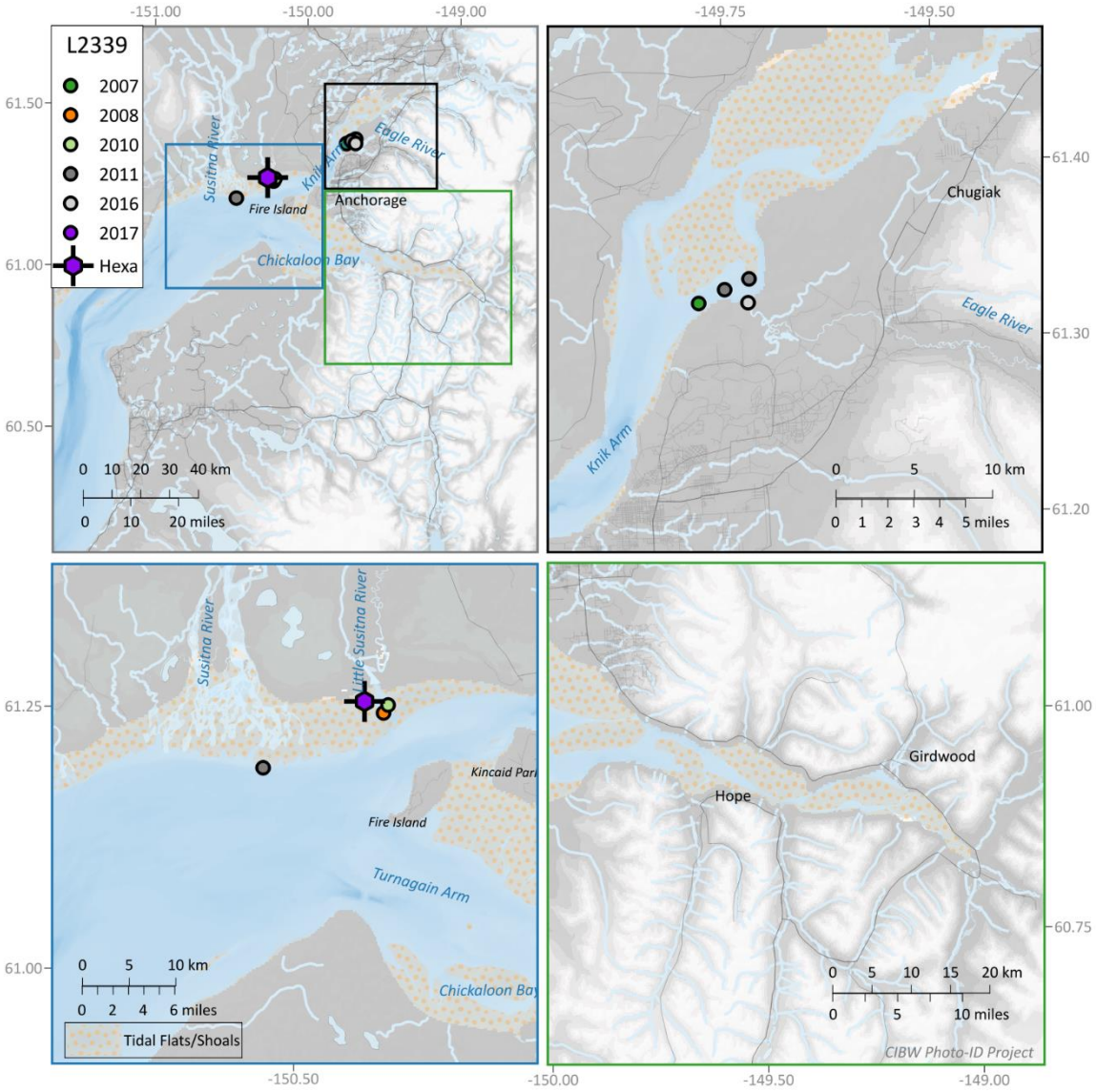

Figure B44. Sighting history of beluga L2339. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0210*.

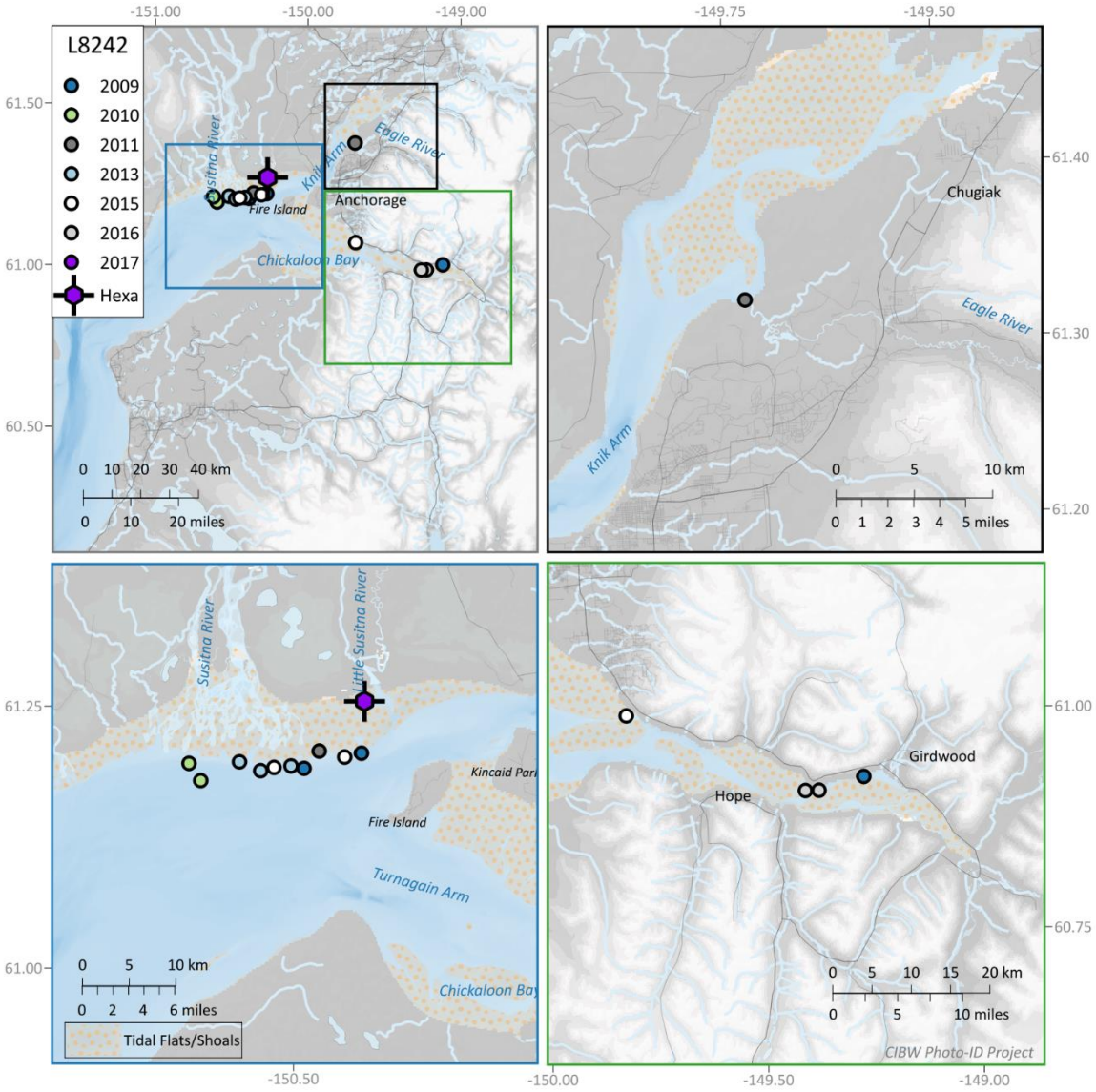

Figure B45. Sighting history of beluga L8242. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0127*.

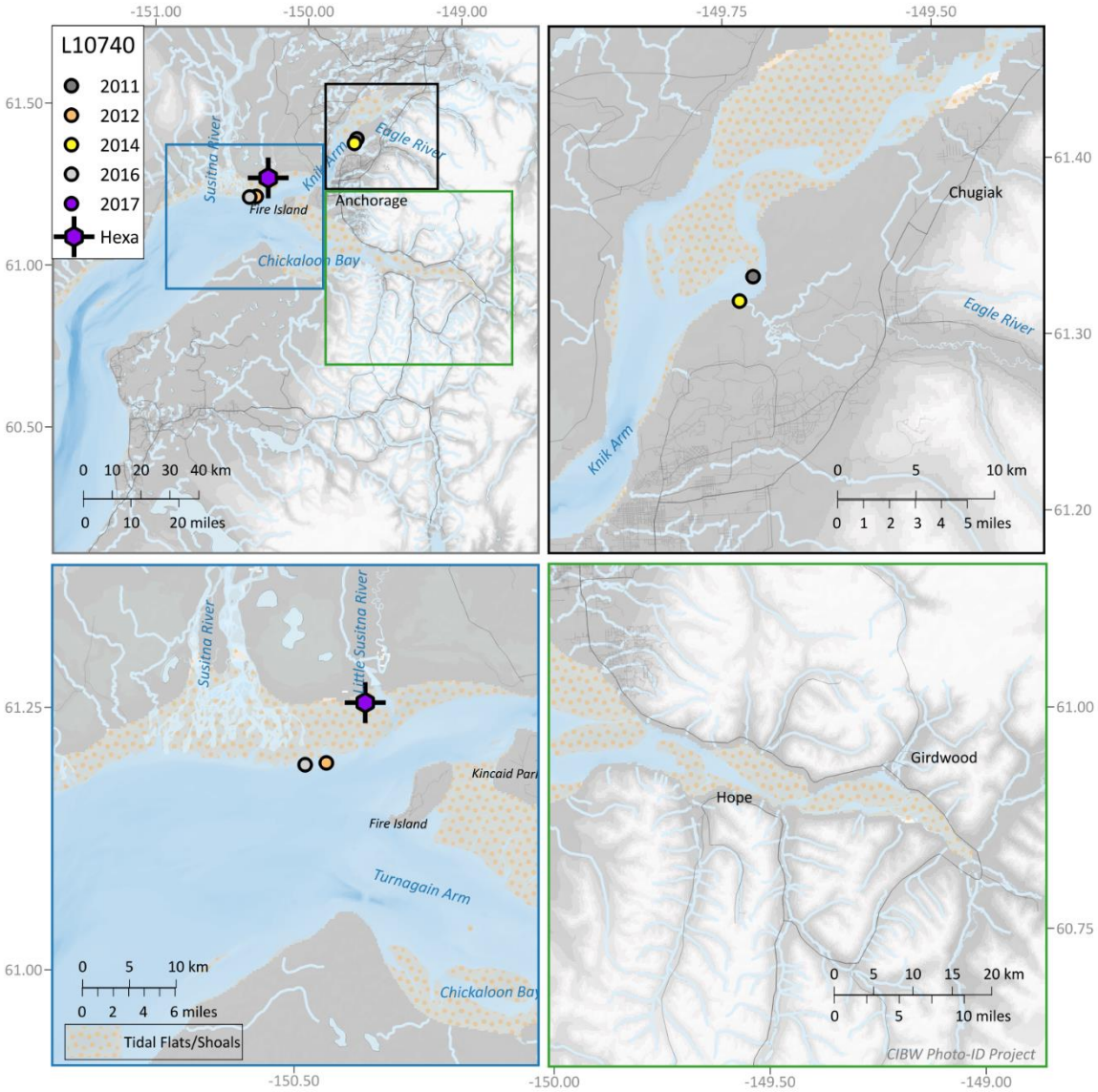

Figure B46. Sighting history of beluga L10740. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0122*.

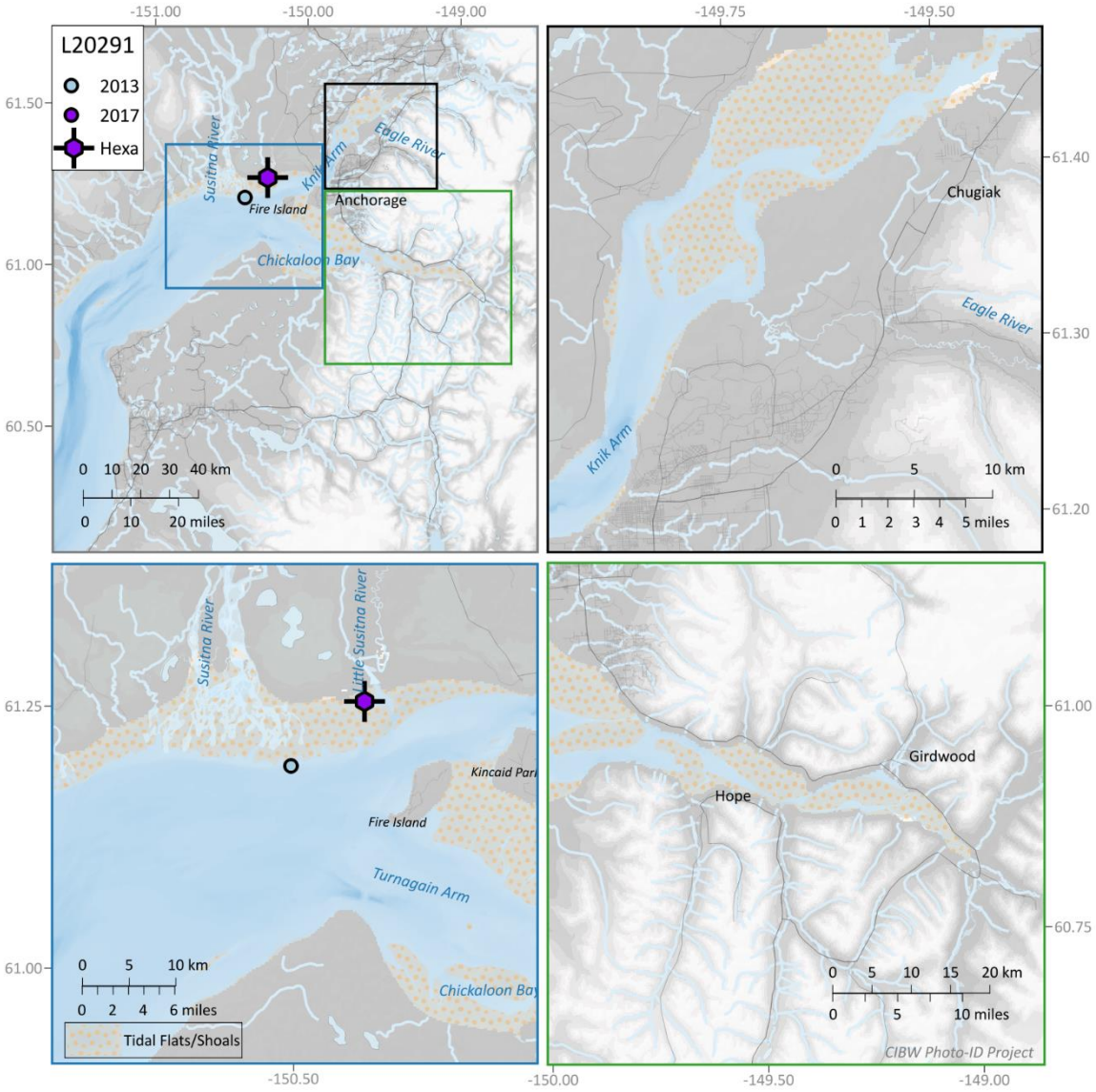

Figure B47. Sighting history of beluga L20291. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_22-Aug-17_S010_DI0004*.

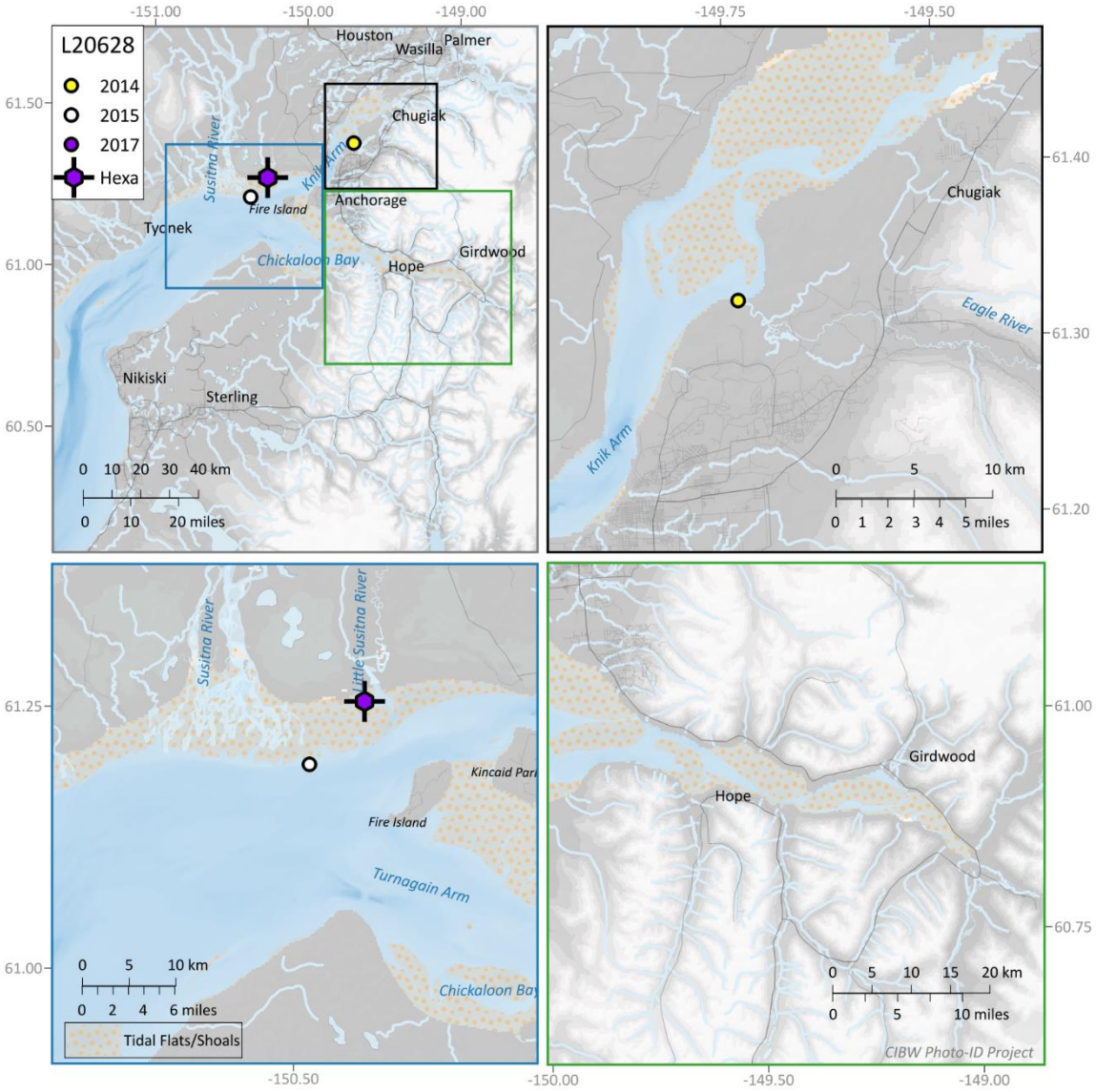

Figure B48. Sighting history of beluga L20628. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0226*.

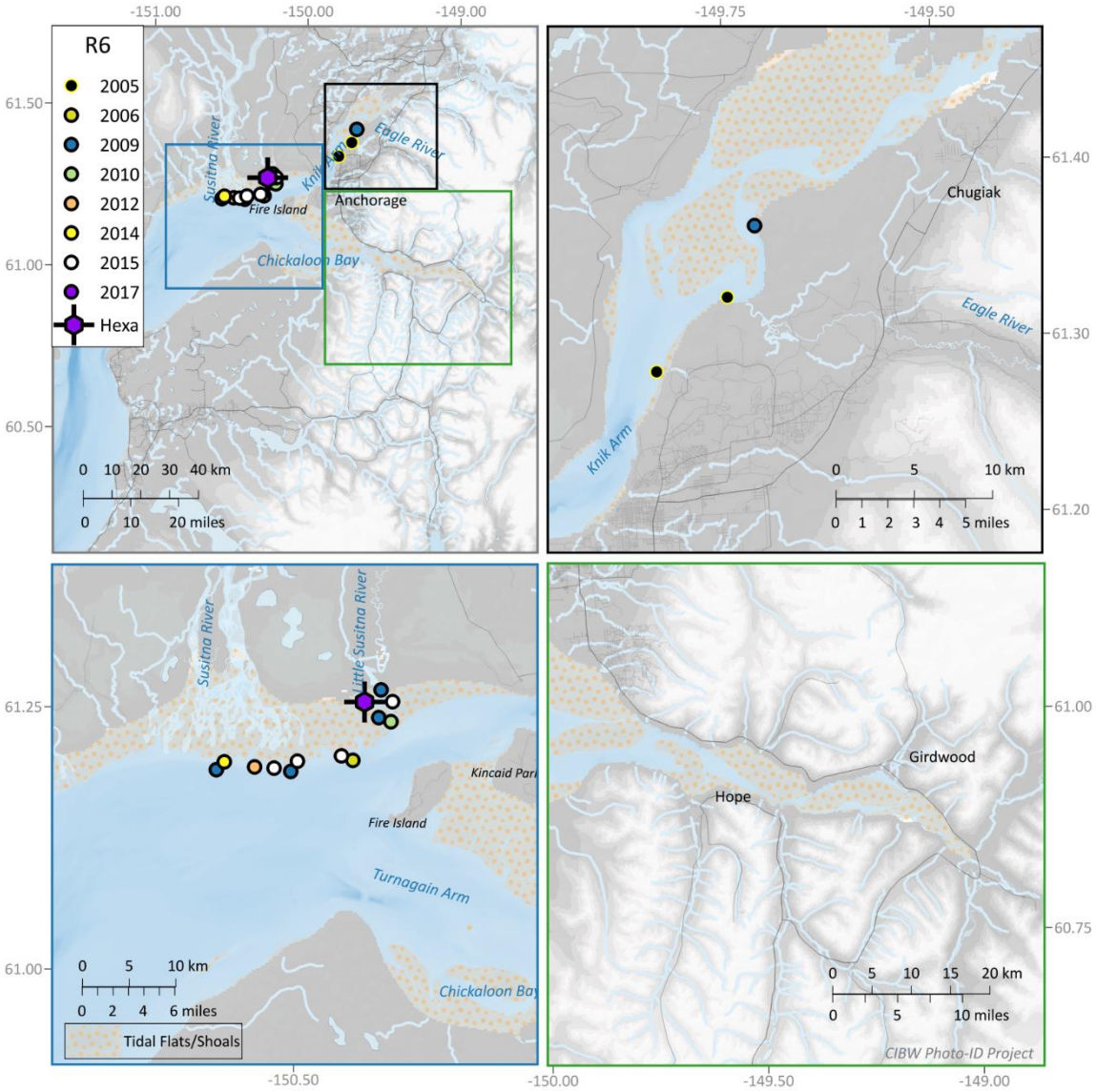

Figure B49. Sighting history of beluga R6. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0115*.

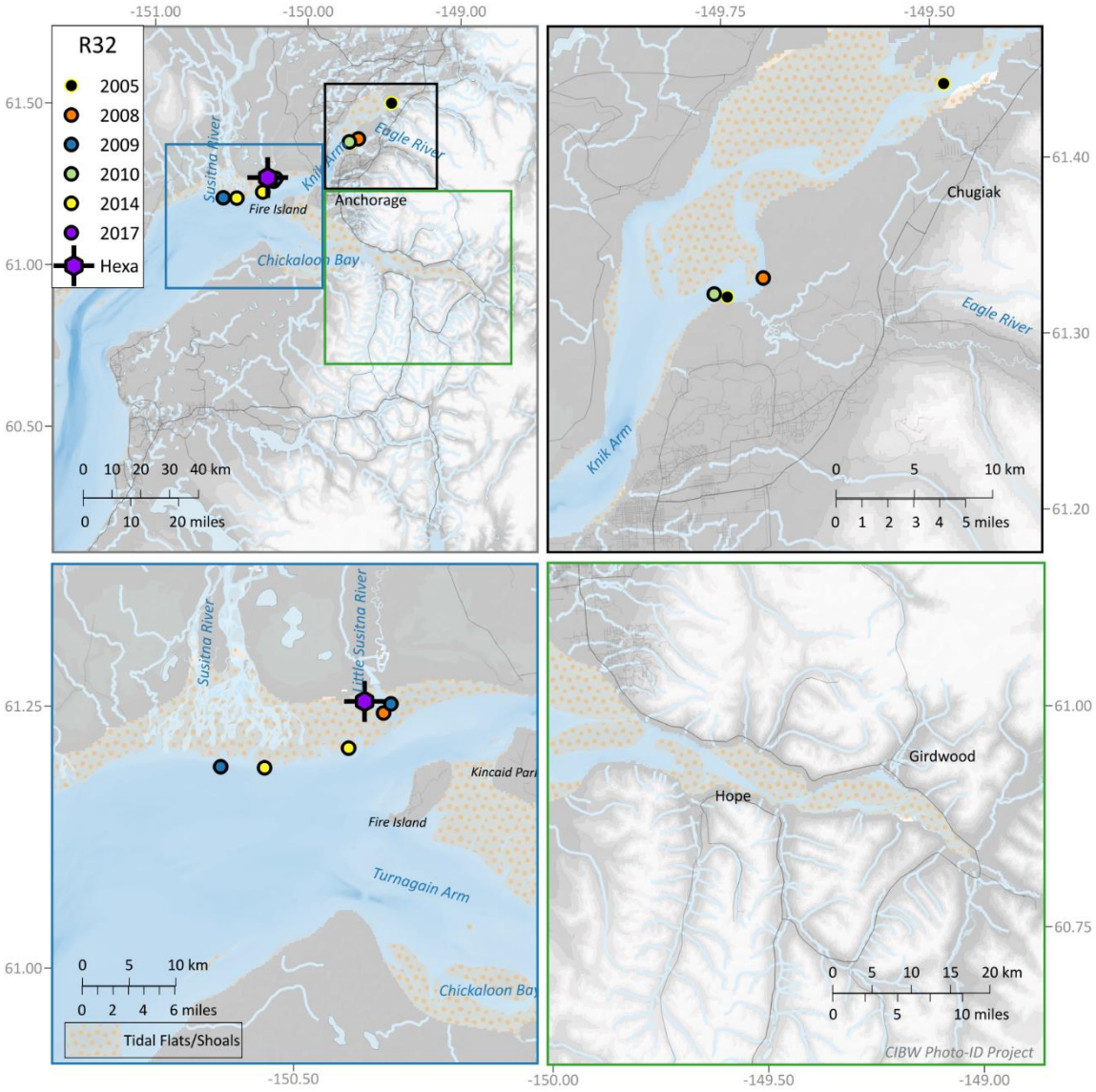

Figure B50. Sighting history of beluga R32. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0034.*

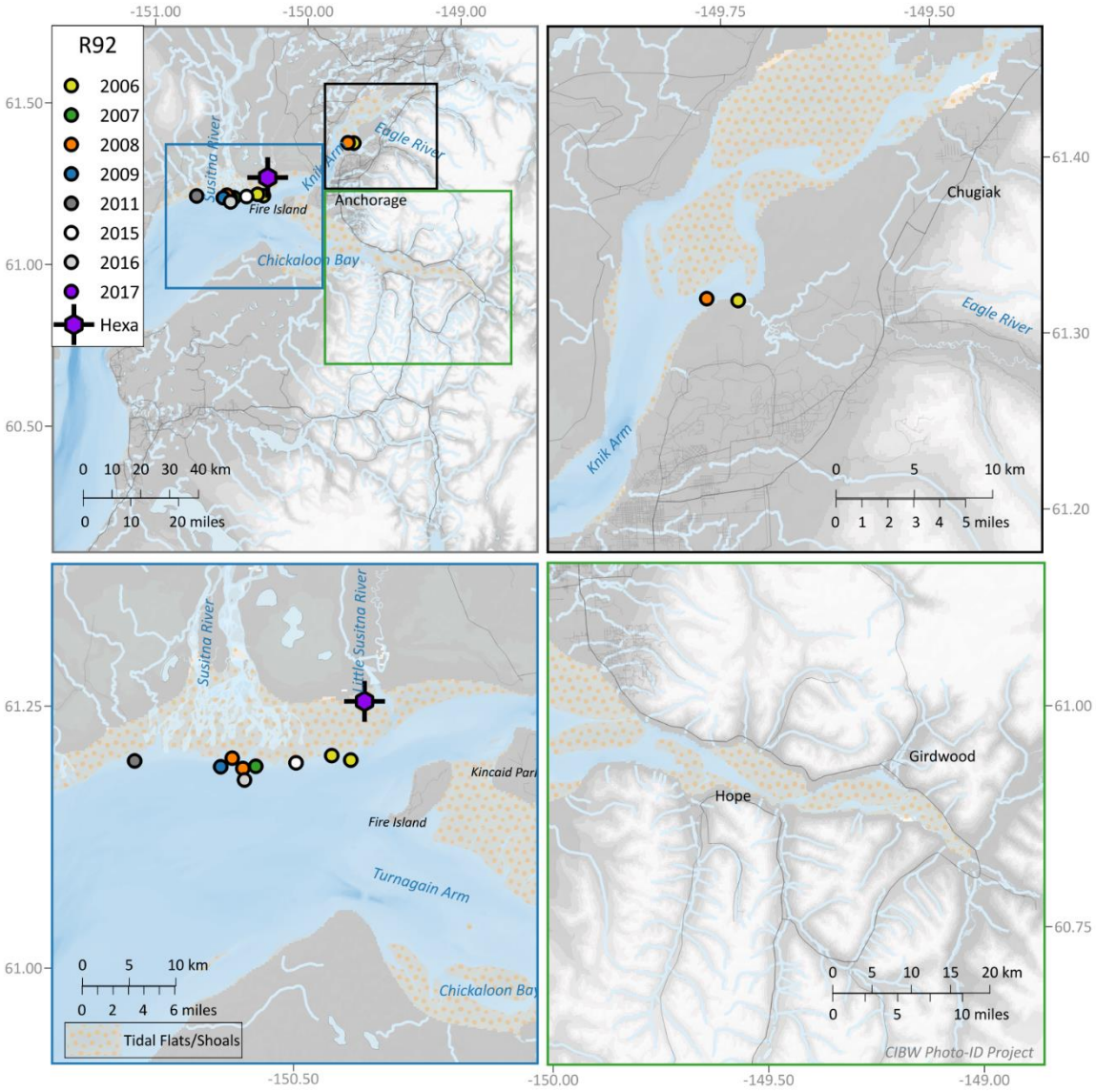

Figure B51. Sighting history of beluga R92. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0053*.

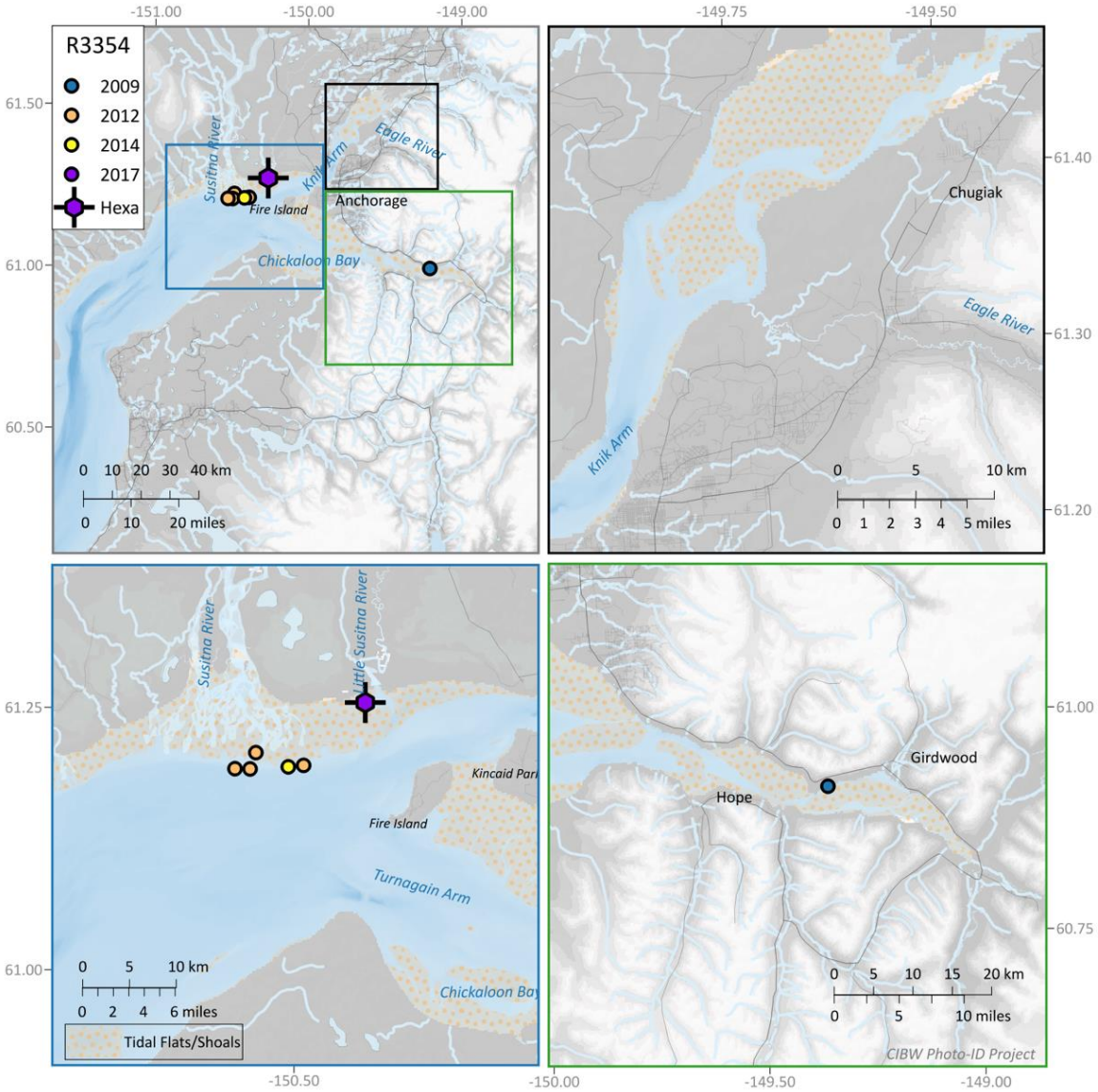

Figure B52. Sighting history of beluga R3354. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_22-Aug-17_S010_DI0006*.

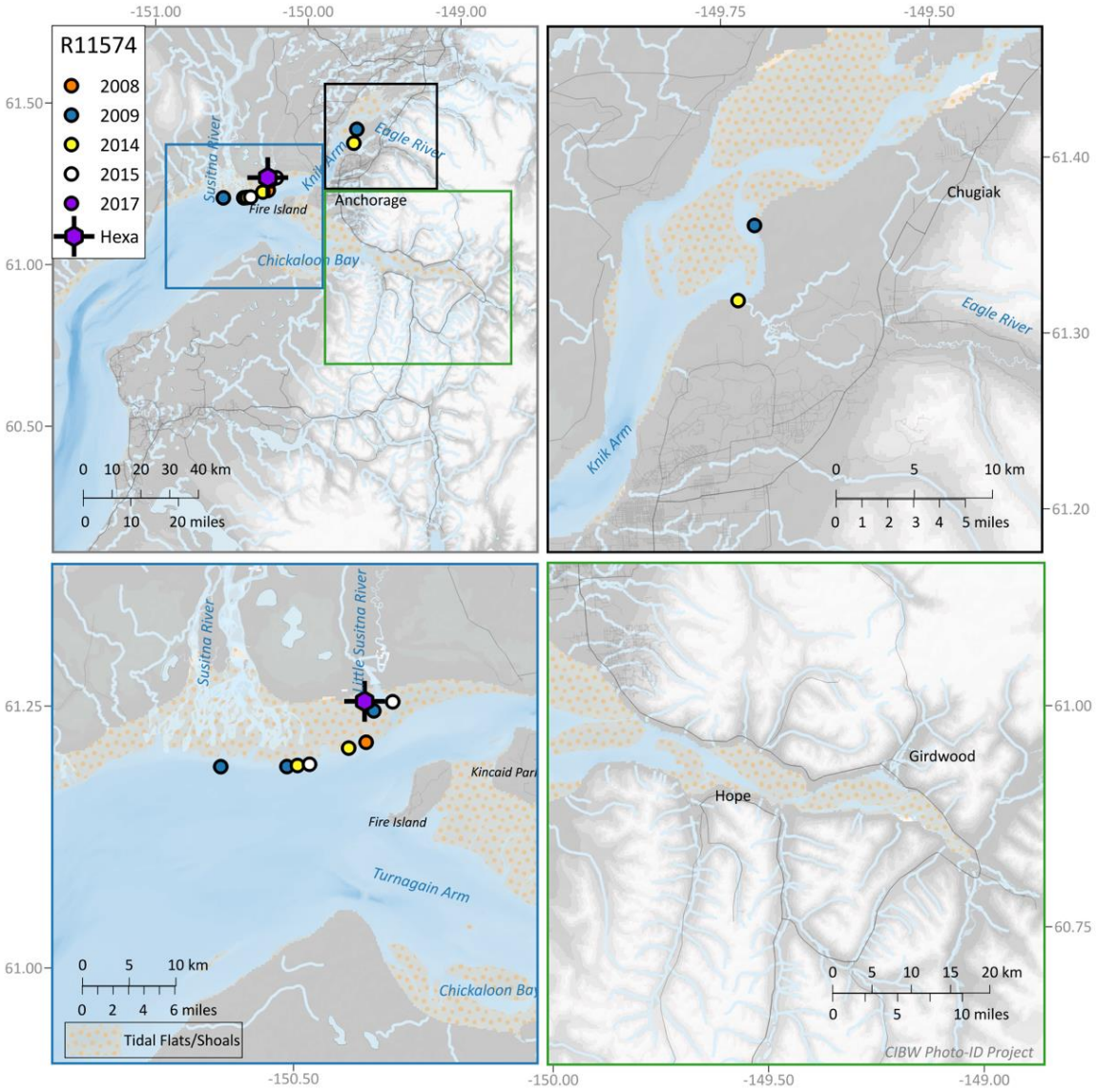

Figure B53. Sighting history of beluga R11574. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_22-Aug-17_S010_DI0013*.

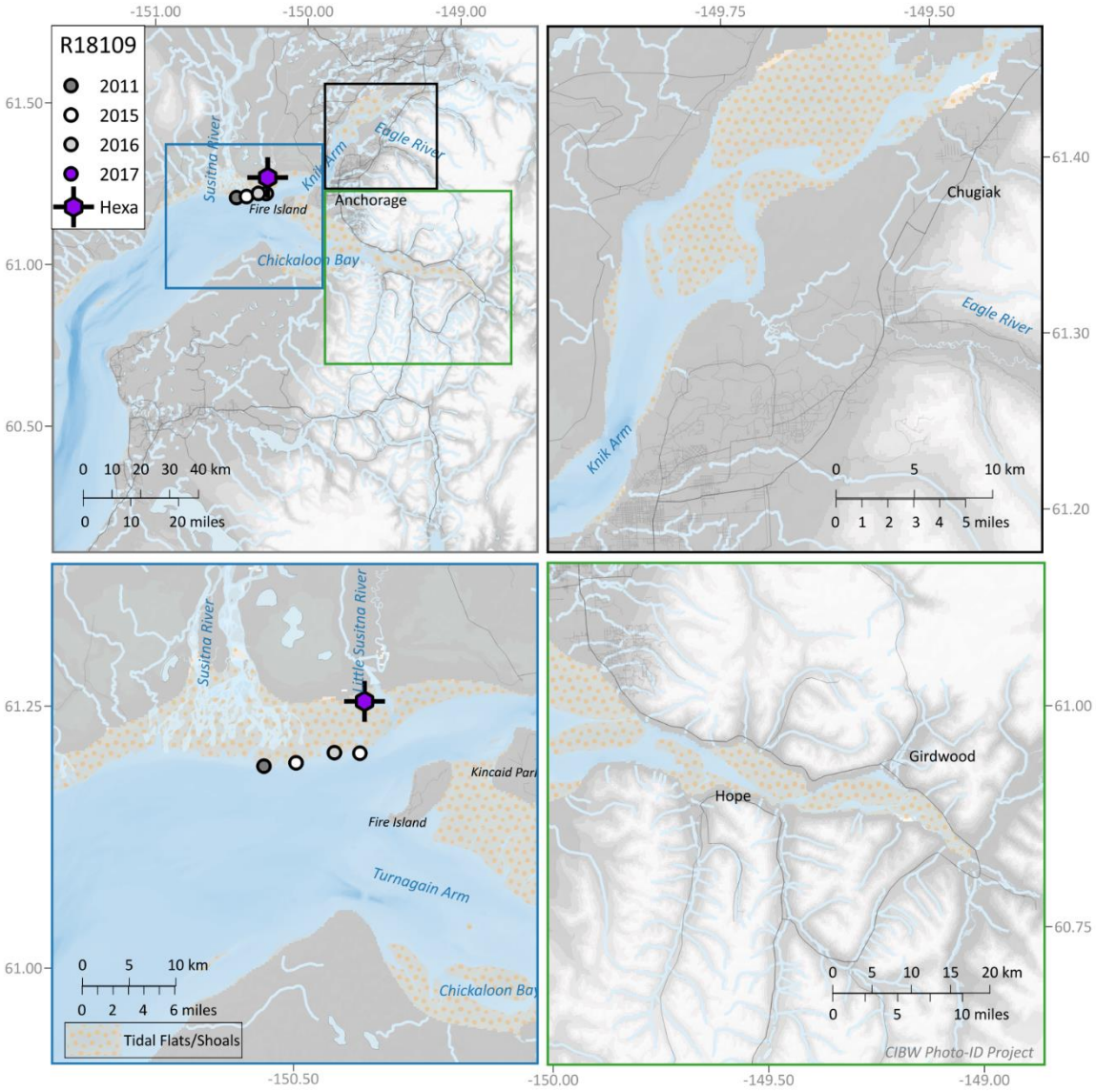

Figure B54. Sighting history of beluga R18109. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0024*.

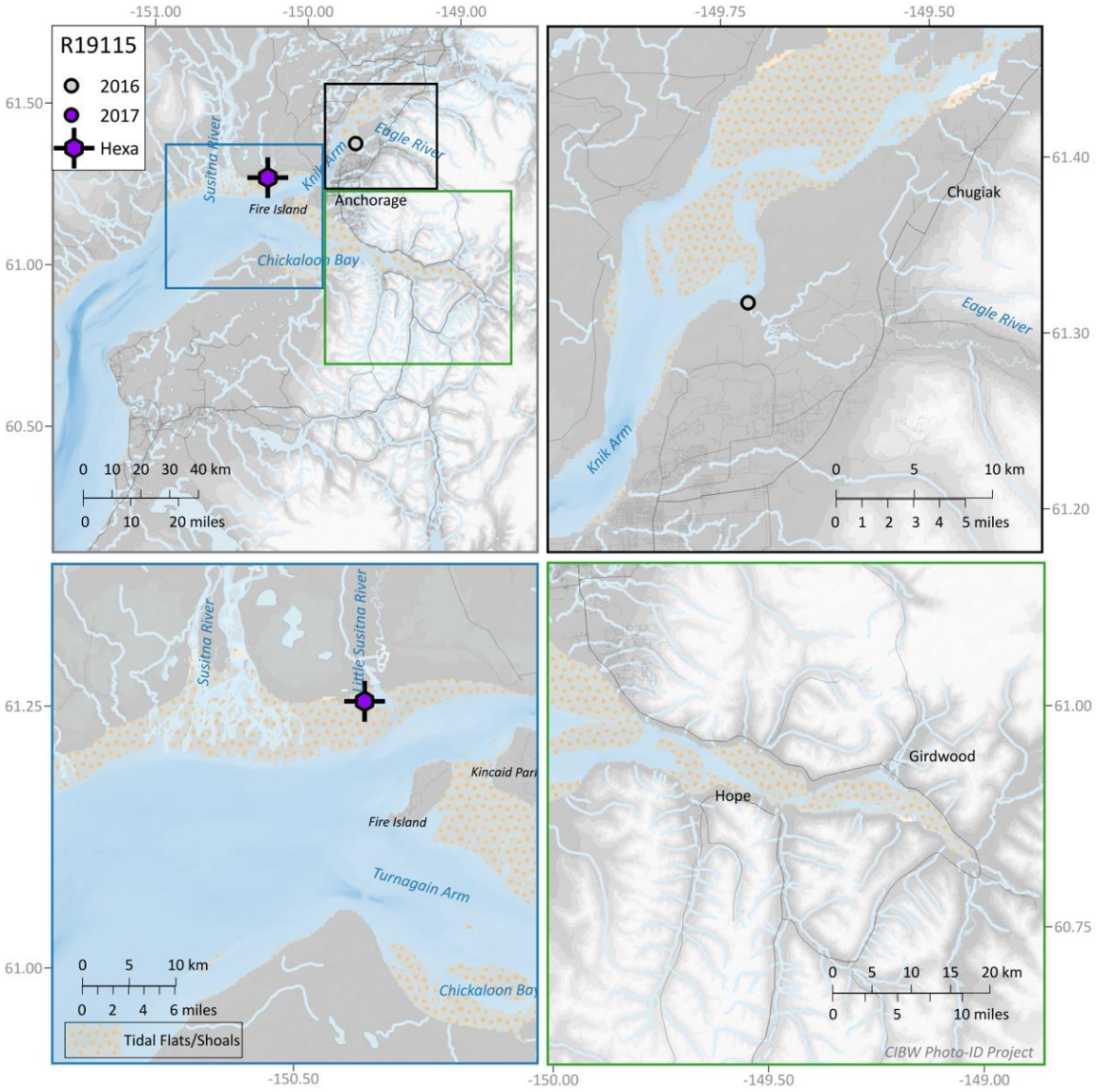

Figure B55. Sighting history of beluga R19915. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_19-Aug-17_S008_DI0004*.

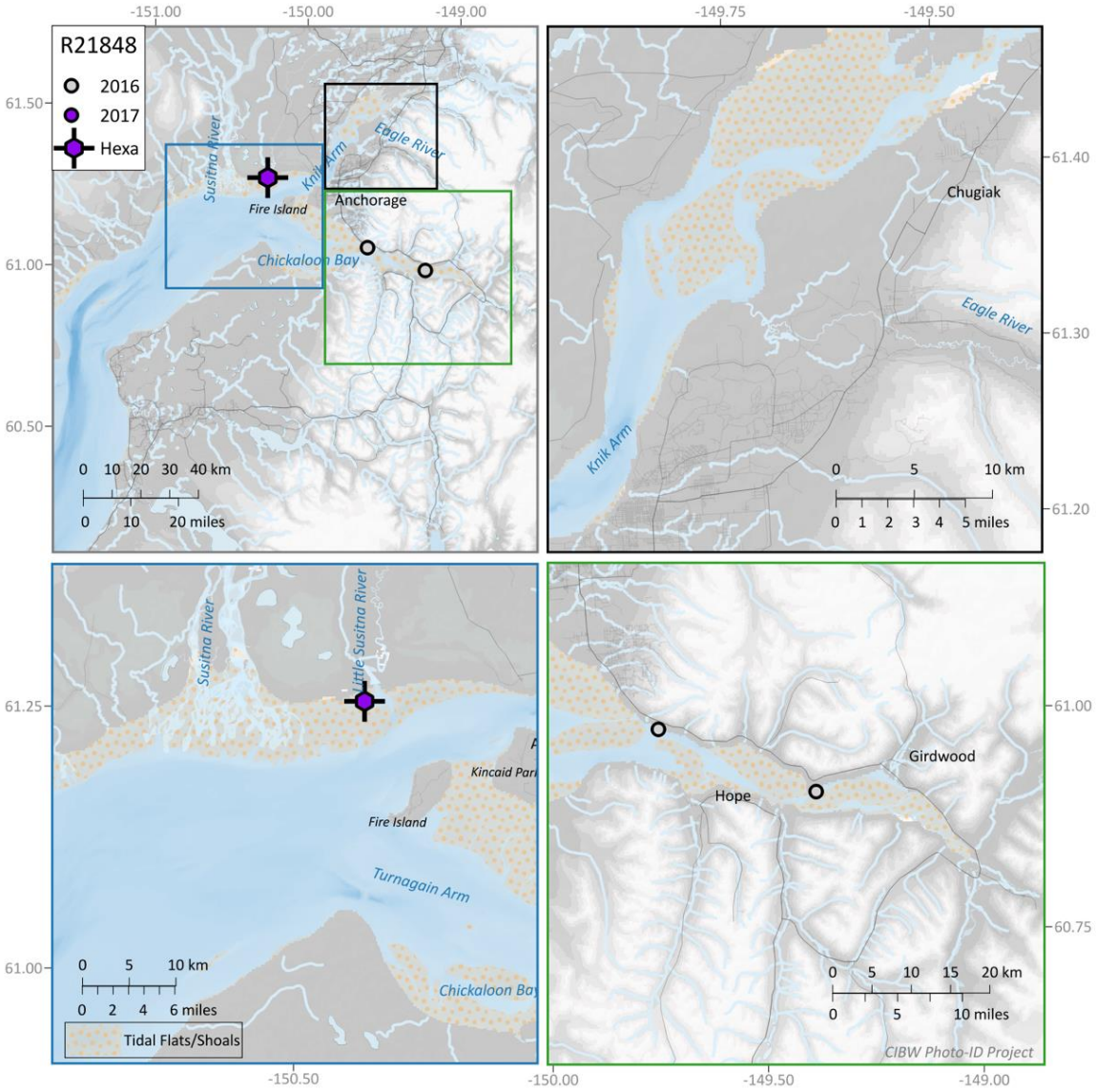

Figure B56. Sighting history of beluga R21848. This whale was photographed from a hexacopter in August of 2017 and was assigned hexacopter ID *17JR_24-Aug-17_S019_DI0011*.