AMNWR 2017/08

BIOLOGICAL MONITORING AT EAST AMATULI ISLAND, ALASKA IN 2016

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Key words: Alaska, Barren Islands, black-legged kittiwake, breeding chronology, common murre, East Amatuli Island, fork-tailed storm-petrel, *Fratercula cirrhata,* glaucous-winged gull, Gulf of Alaska, *Larus glaucescens*, *Oceanodroma furcata*, population trend, productivity, *Rissa tridactyla*, tufted puffin, reproductive success, *Uria aalge*

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May 2017

Cite as: Kettle, A.B. 2017. Biological monitoring at East Amatuli Island, Alaska in 2016. U.S. Fish and Wildlife Service Report, AMNWR 2017/08. Homer, Alaska.

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INTRODUCTION

The Alaska Maritime National Wildlife Refuge (AMNWR) conducts annual ecological monitoring at nine sites throughout Alaska (Figure 1). The objective of this long-term monitoring program is to collect baseline status and trend information for a suite of seabird species representing piscivorous and planktivorous trophic guilds, including key species that serve as indicators of ecosystem health. Members of these guilds include surface-feeders and divers feeding in both nearshore and offshore waters. By comparing the data with environmental conditions and information from other sites, ecosystem processes may be better understood. Data also provide a basis for directing management and research actions, and in assessing effects of management.

East Amatuli Island has been a Refuge-funded annual monitoring site since 2000 (except that monitoring did not occur in 2012 and 2015). During 1993-1999, selected seabird species were monitored annually for oil spill damage assessment and recovery by the Refuge with funding from the *Exxon Valdez* Oil Spill Trustee Council (Roseneau et al 1995, 2000).

In 2015 (a year with no field-season monitoring), AMNWR personnel made a two-hour visit to East Amatuli on 2 September, in order to ascertain whether cliff-nesting seabirds had failed to breed, as had occurred in nearby Kachemak Bay (except that kittiwakes nesting near a fish processing discharge pipe in Homer did breed successfully) and at Chowiet Island.

Detailed results of the 2016 East Amatuli Island monitoring field season are contained in this report and archived at the AMNWR headquarters in Homer, Alaska. Summary data are also included in the annual Alaska seabird monitoring report (e.g., Dragoo et al. 2017).

This report also contains previous years' fork-tailed storm-petrel monitoring results from the report, *Fork-tailed Storm-petrel Monitoring at East Amatuli Island, Alaska during 1997-2013* (Kettle 2014) and black-legged kittiwake results from the report, *Black-legged Kittiwake Monitoring at East Amatuli Island, Alaska during 1993-2014* (Kettle 2016). For parameters that were monitored in 2016, earlier results from those multi-year reports are included here.

STUDY AREA

East Amatuli Island (58°55' N, 152°10' W) is one of the seven Barren Islands, located between the Kodiak archipelago and the Kenai Peninsula (Figures 2 and 3). The Barren Islands range in size from 10 to 2,800 ha, totaling about 4,000 ha. Geologically the islands are a continuation of the Kenai Peninsula and are of mixed origin (from a map by Wilson et al. 2009). They are generally steep and tall, ranging to an elevation of 650 m. Among the eighteen species of seabirds that breed on the islands are about 75,000 pairs of fork-tailed storm-petrels (*Oceanodroma furcata*), 25,000 pairs of black-legged kittiwakes (*Rissa tridactyla*), 3,400 pairs of glaucous-winged gulls (*Larus glaucescens*), 60,000 pairs of common murres (*Uria aalge*), and 70,000 pairs of tufted puffins (*Fratercula cirrhata*; Manuwal 1980, Roseneau et al. 2000).

Of the Barren Islands group East Amatuli (Figure 4) contains the highest seabird abundance. The island provides ledges physically suitable for cliff-nesting birds and contains substrate for burrow-nesters. While the North American river otter (*Lontra canadensis*) is common across the island group, the group's other mammalian seabird predators--northern red-backed vole (*Clethrionmys rutilus*, present on West Amatuli and Ushagat) and arctic ground squirrel (*Spermophilus parryii*, present on Ushagat)--are absent from East Amatuli.

Most of East Amatuli Island is comprised of steep slopes, with a spine ranging in elevation to 470 m. Lower elevations are dominated by grasses and sedges; higher elevations by crowberry (*Empetrum nigrum*) and other maritime tundra plants.

High marine productivity around the Barren Islands contributes to the seabird breeding habitat. Steep local bathymetry, the location at the entrance to Cook Inlet with its large tides and strong currents, the surrounding Alaska Coastal Current, and the strong winds of the area are factors that make the Barren Islands prolific for large numbers of breeding seabirds and marine mammals.

METHODS

Personnel

In 2016 the USFWS field crew of three--Arthur Kettle, Georgia Lukas, and Dana Nelson—worked from the East Amatuli field camp for 11 days (25 August-5 September). Aaron Christ, Georgia Lukas, Leslie Slater, and David Martindell earlier helped to deploy or maintain time-lapse cameras. On 15 July, during a half-day visit to the island by the R/V *Tiglax*, Arthur Kettle, Sasha Kitayski, Georgia Lukas, and Leslie Slater conducted a brief circumnavigation by skiff of most of the island, scanning the cliffs for murre adults and for kittiwakes attending nests.

Data Collection and Analysis

Time-lapse cameras: In 2016 all periodic monitoring of murre and kittiwake productivity plots was done with seven time-lapse cameras. They were deployed on 7 May on an eastern headland of the island, with views of productivity/population plots used since 1993. The cameras viewed four black-legged kittiwake plots and eight common murre plots. Another camera was installed overlooking tufted puffin habitat on “Valley Rise”, a short hike from the field camp. Each camera system was programmed to record an image every 90 minutes starting on 5 June.

Two weeks after deployment of the cameras at the island, a test camera on the mainland demonstrated a hardware issue that would prevent the June wakeup of the systems, and so we made a one-day trip to the island on 22 June to turn them on. The cameras then successfully recorded images until they were retrieved on 29 August (the tufted puffin camera was retrieved on 4 September).

On 15 July Arthur Kettle, Leslie Slater, and Georgia Lukas checked the cliff nester and tufted puffin cameras during a half--day visit by the R/V *Tiglax*. Afterward they and Sasha Kitayski briefly searched by skiff most of the main island and the Light Rock islet for murres and for kittiwakes on nests.

The cameras were retrieved by the field crew on 29 August.

Field camp visit: During the 25 August-5 September field camp visit the field crew accomplished the following:

Common murre and black-legged kittiwake: We retrieved the time-lapse cameras from the cliffs on 29 August. Afterward we skiffed around the island and the Light Rock islet searching all cliff-nester habitat and the water for murre and kittiwake nestlings or fledglings.

Tufted puffin: In the seven tufted puffin plots we counted burrows, searched for chicks, and recorded signs of occupancy.

Glaucous-winged gull: We counted glaucous-winged gull fledglings on the Amatuli Cove beach.

Fork-tailed storm-petrel: We counted burrows and chicks in the 11 fork-tailed storm-petrel plots. Chicks were measured and weighed. Mistnets were deployed on two nights for collecting fork-tailed storm-petrel diet samples (however, only one sample was collected)

Sea temperature: We pulled up the datalogger mooring in Amatuli Cove, offloaded the water temperature loggers, and reset the mooring.

Field camp: We conducted maintenance projects at the field camp.

RESULTS

Results from 2016 and (for parameters monitored in 2016) previous years are shown in the figures and tables following the narrative.

Common murre

Breeding performance: Analysis of the time-lapse images showed that in 2016 common murres failed to lay eggs in any of the productivity plots observed. This is the first complete egg-laying failure observed in the 24 years the plots have been monitored.

When we briefly searched most of the main island and the Light Rock islet on 15 July (approximately the mean laying period for murres at this location), murres were absent from many breeding areas; where present they were standing, rather than in incubation posture.

During our circumnavigation of the island On 29 August (when in previous years many-to-most murre chicks would still be on the cliffs), we viewed murre habitat and the water around the island and the Light Rock islet and saw no murre chicks or fledglings. Adult murres were absent from most of the usual breeding habitat.

In 2015 (a year with no field camp stay), we visited the island on 2 September and then also then saw no murre chicks, and saw none in the water. There were no adults seen on the cliffs. It's likely that there was no murre productivity in 2015. These two years—2015 and 2016—also had the warmest sea-surface temperatures (at the Seldovia tide station) of all of the AMNWR murre productivity monitoring years 1993-2016.

Population trend: Adult murres did sometimes attend nesting areas in the productivity plots (which are also being used for measuring population trend) in 2016. They were present on 7 May, when the cameras were installed (this is the earliest the cliff-nesting habitat has been observed through the monitoring years). From once-a-day camera images through 21 May, it appears that murres attended the ledges intermittently. This continued after the 90-minute photo interval began on 22 June, through to 29 August, when the cameras were removed.

Using the time-lapse images, cliff attendance of adult murres may be analyzed in the future, but this was not done for "Population trend" for this report because eggs were not laid. The monitoring protocol for the population index "census period" (mid-incubation to the start of fledging) is determined with eggs and chicks; there were no eggs laid in the plots this year.

Tufted puffin

Breeding performance: We found very few tufted puffin chicks and we were unable to retrieve any for estimating fledge-readiness. Tufted puffins in 2016 either fledged very few chicks or fledged them unusually early—we couldn't tell which. Our 2016 survey dates were before the time of fledging for most years. However, in 2016 we could have missed fledglings by a few days, or perhaps fledging was very low.

Black-legged kittiwake

Breeding performance: Analysis of the time-lapse images showed that kittiwakes failed to lay eggs in the productivity plots in 2016, and they built few nests. When we briefly searched by skiff most of the main island and the Light Rock islet for kittiwakes on nests on 15 July (when in productive years kittiwake egg would be hatching), we counted a total of 61.

Kittiwakes do occasionally have poor productivity years at East Amatuli—although since (and including) 1993 there have been only two other monitoring years when no chicks were produced (2015 is a possible third year: during our 1-day visit in 2015 we saw no kittiwake fledglings—it appeared that kittiwakes probably failed that year), and only one other year (1993) when neither chicks nor eggs were seen in the plots.

Population trend: As with murres, kittiwakes attended nesting areas intermittently in the productivity plots in 2016, during the cameras' deployment period 7 May to 29 August.

The "census period" for kittiwakes, as with murres, is mid-incubation to the start of fledging; thus we did not analyze the images for population trend counts.

Glaucous-winged gull

Based on our few but very low (0-1) beach counts of fledglings, glaucous-winged gulls apparently fledged very few chicks in 2016, and very few adults were seen.

Fork-tailed storm-petrel

Breeding performance: In 2016 we started our surveys before any of the fork-tailed storm-petrel chicks in the plots were ready to fledge; by the time we left the island fledging had begun. We found no dead chicks in the burrows, indicating good chick survival. The counts of chicks and large chicks were below the 18-year mean.

Population trend: The number of burrows found was the lowest in the 18 years of comparable monitoring.

Sea Temperature

From January through the mid-September end of the field season, weekly averages of sea-surface temperature recorded at East Amatuli increased each year after 2012 to (in 2016) two degrees above the 1994-2016 long-term average.

INTERESTING OBSERVATIONS

Pilot studies: We continued pilot studies for monitoring tufted puffin roosting behavior and population trend with time-lapse photography. A digital time-lapse camera recorded images of a hillside of active puffin habitat every 90 minutes for most of the field season. These and future images will be analyzed to test the feasibility of using this method for monitoring population trend and possibly productivity for the island's steep, fragile puffin habitat. Time-lapse photography of puffin habitat has the potential to decrease observer effects of population and productivity monitoring while increasing accuracy at this monitoring site.

ACKNOWLEDGMENTS

A big thank you to excellent field assistants Georgia Lukas and Dana Nelson. Thanks also to Aaron Christ, David Martindell, and Leslie Slater for help with the cameras, and Sasha Kitayski for help with a kittiwake nest count. The U.S. Fish and Wildlife Service's R/V *Tiglax* provided transportation for and assistance with camera deployment in May. Homer Ocean Charters provided transportation for the day-long camera-maintenance trip to the island in June. The *Tiglax* provided support during the July visit. Alaska Coastal Marine and the *Tiglax*, respectively, transported the field crew and our gear to and from the island safely and efficiently. Lisa Spitler was the contact for our daily check-in. Don Dragoo, Brie Drummond, and Heather Renner improved this report with their helpful reviews. Thanks to all who assisted.

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FIGURES AND TABLES

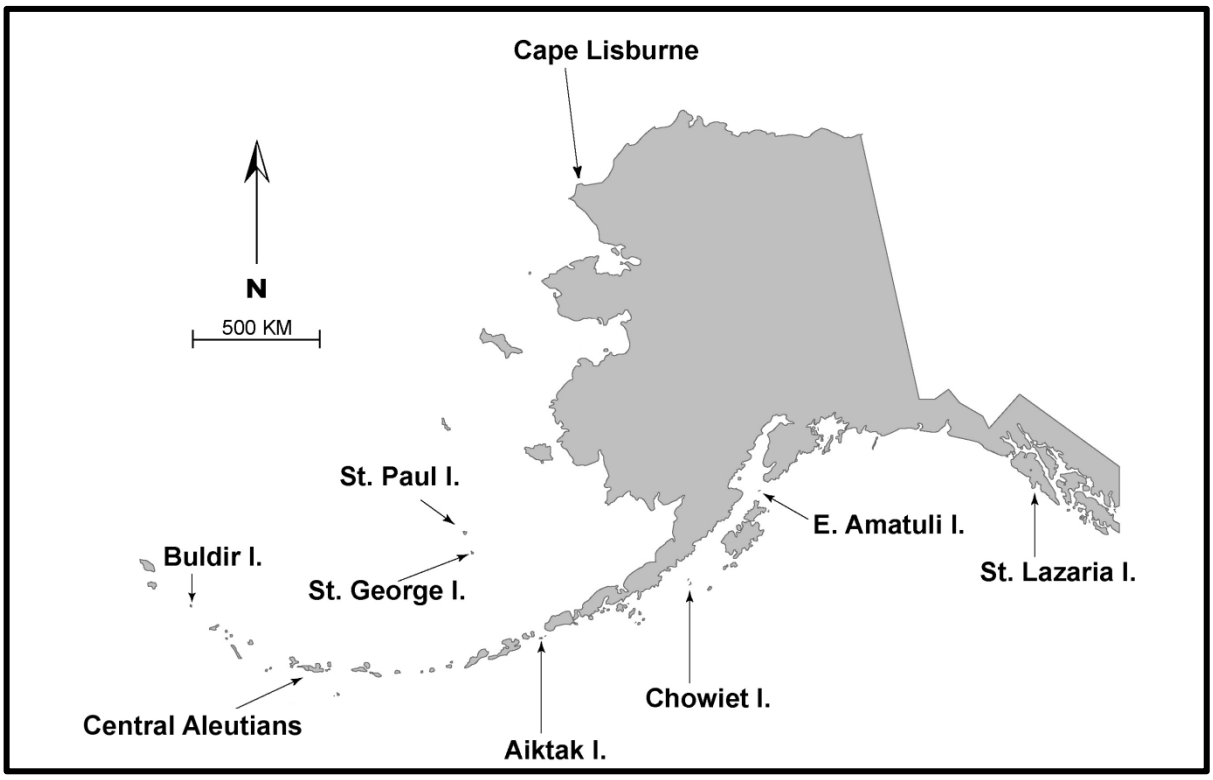

Figure 1. Location of East Amatuli Island and other annual monitoring sites across the Alaska Maritime National Wildlife Refuge.

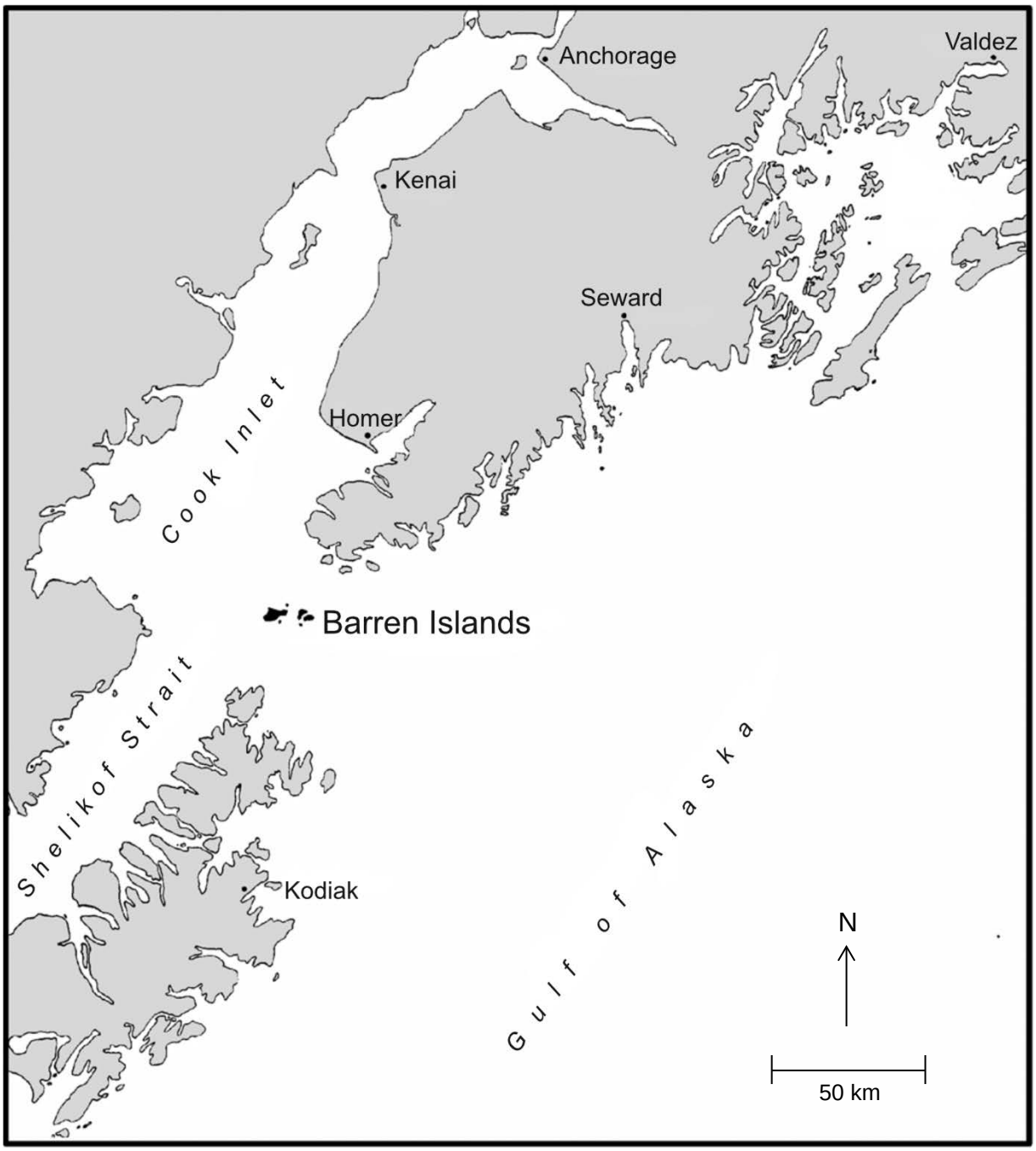

Figure 2. Location of the Barren Islands, Alaska

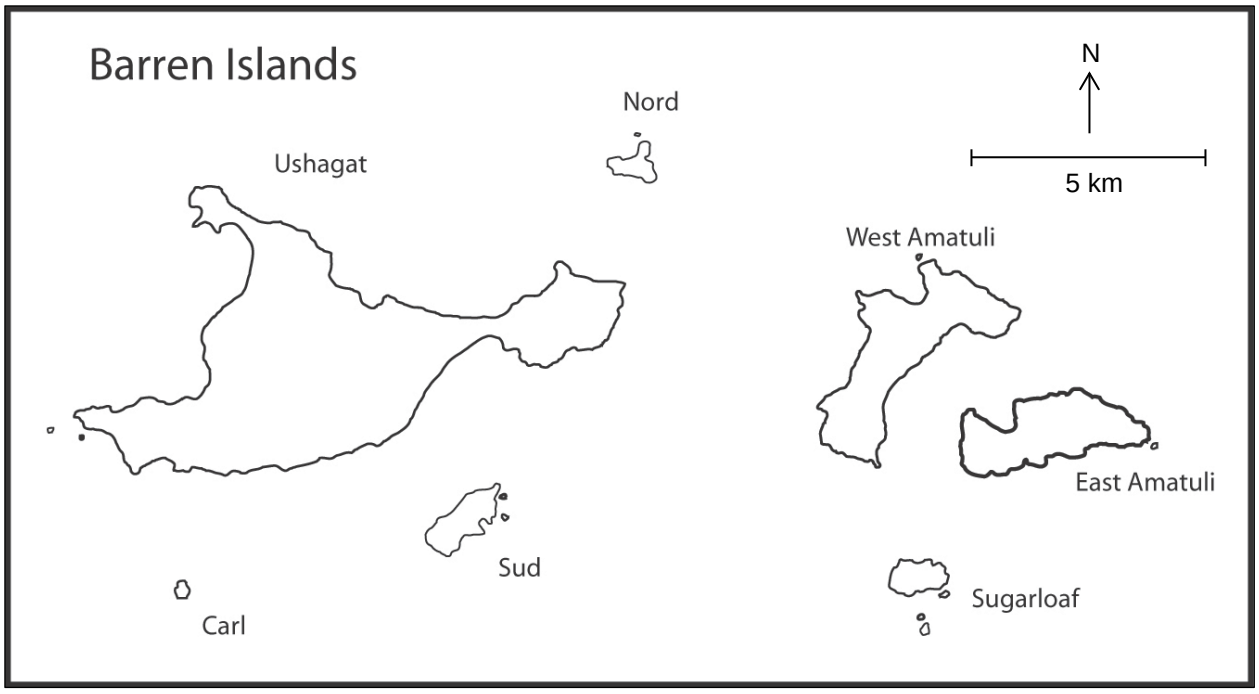

Figure 3. Map of the Barren Islands group.

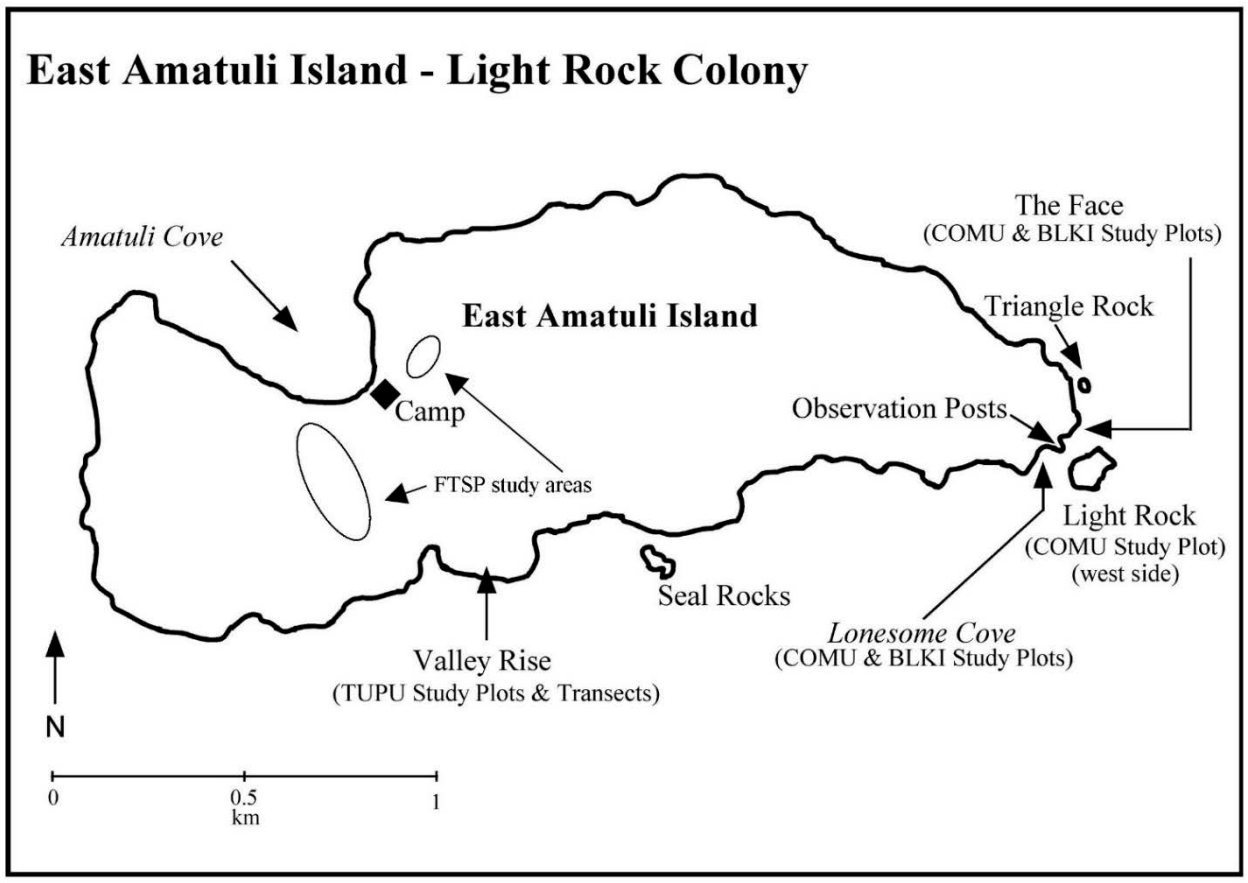

Figure 4. East Amatuli Island, showing locations of common murre (COMU), black-legged kittiwake (BLKI), tufted puffin (TUPU), and fork-tailed storm-petrel (FTSP) monitoring areas.

Table 1. Reproductive performance of common murres at East Amatuli Island, Alaska. Number of chicks observed in each plot more than 10 days after the plot's mean hatch date. A dash means no data were collected.

Year	Plot[a]										Total[b]
	1	2	3	4	5	6	7	8	9	10	
2011	18	12	8	19	22	19	6	18	6	4	132
2012	-	-	-	-	-	-	-	-	-	-	-
2013	16	18	14	16	29	23	19	21	18	18	192
2014	31	-	-	-	22	-	-	-	14	-	-
2015	-	-	-	-	-	-	-	-	-	-	-
2016	0	0	0	-	-	0	0	-	-	0	-

[a] Productivity plots 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 have respective field names M1-LC, M2-LC, M3-LC, M4-LC, M5-LR, M1-F, M2-F, M3-F, M4-F, and M5-F.
[b] Total shown only for years with observations of complete plot series.

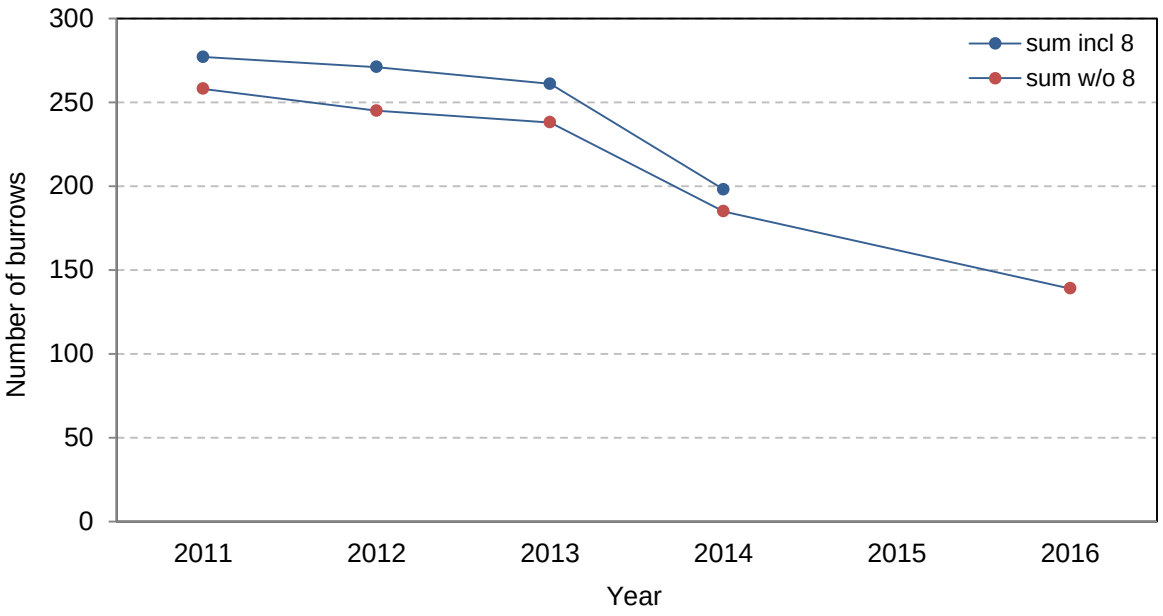

Figure 5. Summary number of burrows in tufted puffin plots at East Amatuli Island, Alaska with and without Plot 8, which was discontinued after the 2014 field season. The line spans a year without data: 2015.

Table 2. Number of tufted puffin burrows counted in plots at East Amatuli Island, Alaska.

Year	Plot[a]								Total all 8 plots	Total without Plot 8
	1	2	3	4	5	6	7	8		
2011	40	31	33	18	30	42	47	26	267	241
2012	-	-	-	-	-	-	-	-	-	
2013	43	23	38	27	27	51	29	23	261	238
2014	33	20	36	15	22	39	20	13	196	183
2015	-	-	-	-	-	-	-	-	-	
2016	26	11	13	16	16	34	23	-[b]	-	139

[a] Productivity plots 1, 2, 3, 4, 5, 6, 7, and 8 have respective field names “AC”, “BC”, “C”, “FWS TRANS”, “OC”, “GC”, “SF+EF”, and “UEVR”.
[b] Plot 8 was discontinued after the 2014 season because a nearby landslide made access hazardous.

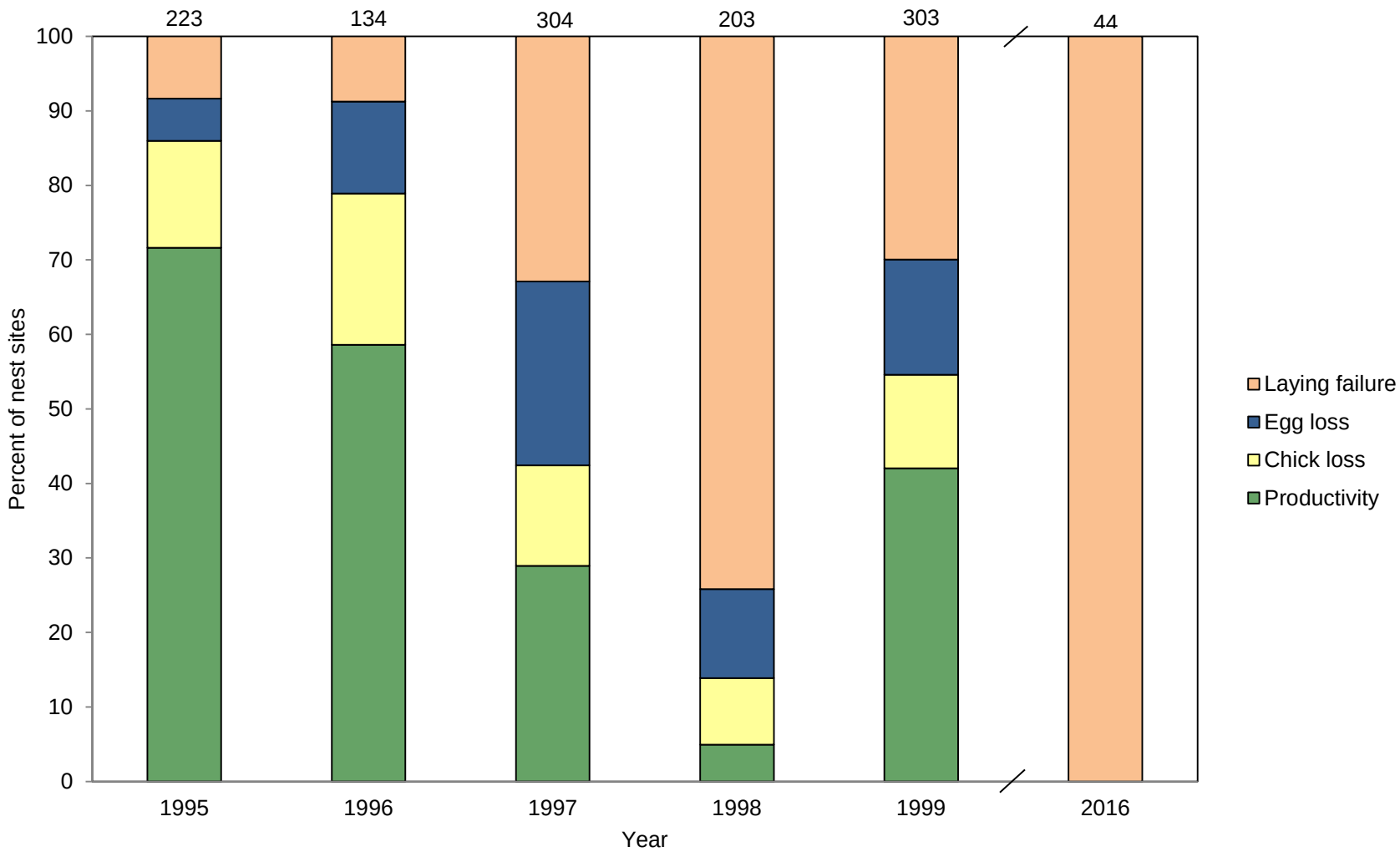

Figure 6. Reproductive performance of black-legged kittiwake nests in productivity plots at East Amatuli Island, Alaska. Laying failure = (A-B)/A, Egg loss = (B-D)/A), Chick loss = (D-F)/A, and Productivity = (F/A); where A = total nest sites, B = nest sites with eggs, D = nest sites with chicks, and F = nest sites with chicks fledged. Numbers above columns indicate sample sizes (A).

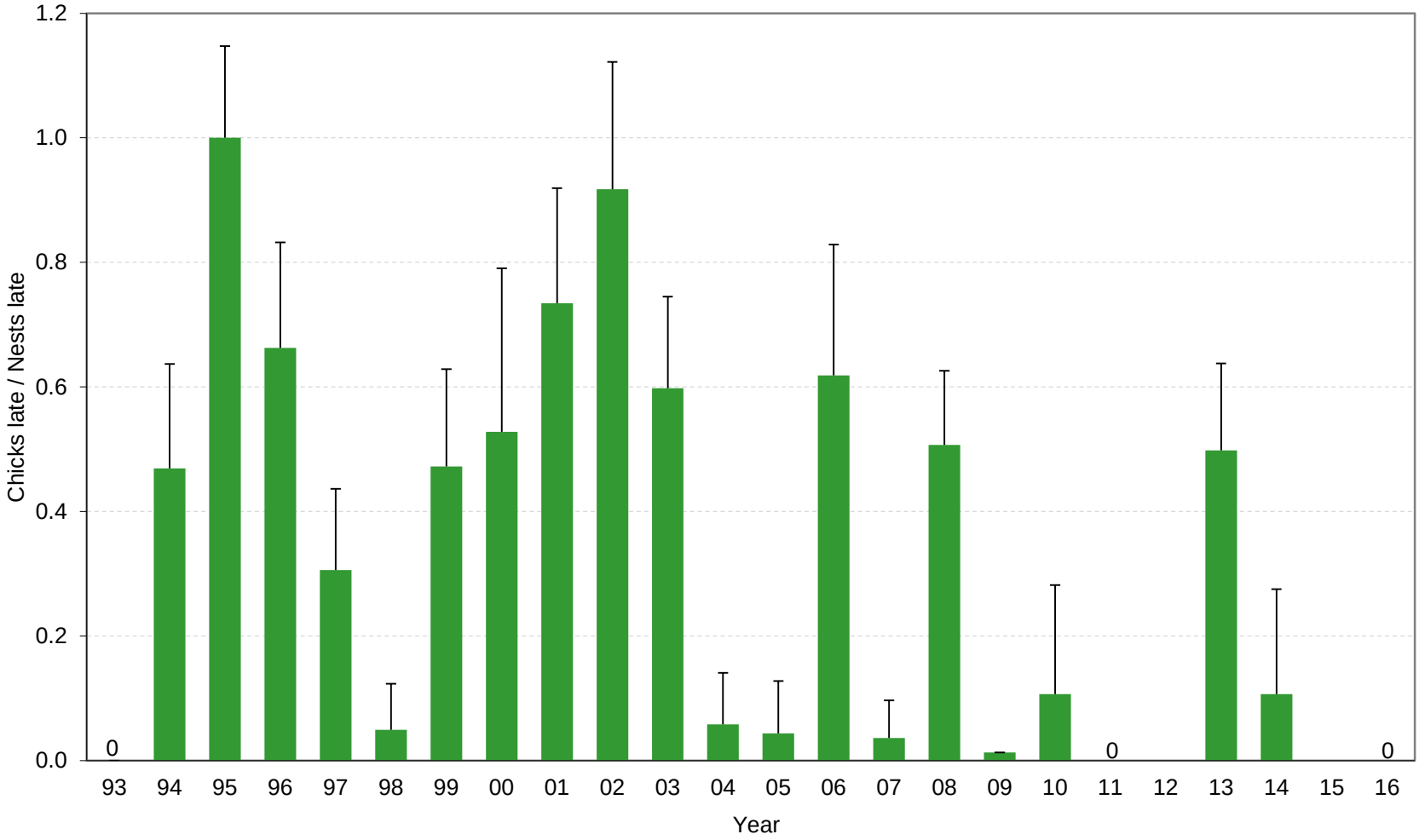

Figure 7. Chicks-late/Nests-late index for black-legged kittiwakes in monitoring plots at East Amatuli Island, Alaska. This index is a proxy for the standard “fledglings/nest-starts”; the proxy is used because in some years the analysis protocol for determination of fledglings from aged chicks could not be followed because observations began after chick-hatching had occurred. “Chicks late” is the number of chicks that disappeared after their plumage indicated they were ready to fledge or (during the years 2000-2003) were seen on or after their plot’s estimated fledge-start date. “Nests late” is the count of nests made during the nestling period. Error bars show one standard deviation with each plot’s ratio value as the sample unit. No data were collected in 2012 or 2015. For more information see Kettle (2016).

Table 3. Reproductive performance of black-legged kittiwakes on productivity plots at East Amatuli Island, Alaska. Observations covering most of the incubation period occurred only during 1994-1999 and in 2016; parameters requiring egg data are dashed for the other years. 1993-2014 data are from Kettle (2016).

Year	Number of plots	Total nest starts[a] (A')	Total adjusted nest starts (A)[b,c]	Nest sites with ≥ 1 egg (B)	Total eggs (C)	Nest sites with ≥ 1 chick[d] (D)	Adjusted nest sites with ≥ 1 chick (D')	Total chicks[d] (E)	Adjusted total chicks (E')	Nest sites with ≥ 1 chicks fledged (F)	Nest sites with ≥ 1 chicks "fledged"[e] (F')	Total chicks fledged (G)	Total chicks "fledged" (G')
1977	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	-	-
'80-'92	*no data*	-	-	-	-	-	-	-	-	-	-	-	-
1993	5	161	-	0	0	0	0	0	0	0	0	0	0
1994	4	173	130[c]	97	158	69	69	102	102	41	100	61	128
1995	11	370	223.0	339	607	318	192	512	320	160	295	223	426
1996	11	335	134.3	306	522	265	105	376	153	78	220	89	259
1997	11	304	304.0	204	285	129	129	168	168	88	95	93	102
1998	11	210	202.9	55	60	30	28	32	30	10	14	10	14
1999	11	311	302.8	218	294	170	165	211	205	127	133	143	150
2000	10	375	-	-	-	161	-	197	-	-	161	-	198
2001	11	448	-	-	-	251	-	330	-	-	251	-	329
2002	11	449	-	-	-	351	-	504	-	-	309	-	412
2003	11	470	-	-	-	264	-	345	-	-	235	-	281
2004	11	309	-	-	-	24	-	30	-	-	17	-	18
2005	11	274	-	-	-	11	-	12	-	-	11	-	12
2006	11	448	-	-	-	233	-	310	-	-	236	-	277
2007	11	467	-	-	-	25	-	26	-	-	15	-	17
2008	11	531	-	-	-	214	-	292	-	-	211	-	269
2009	10	303	-	-	-	17	-	17	-	-	4	-	4
2010	11	384	-	-	-	53	-	57	-	-	38	-	41
2011	11	235	-	-	-	0	-	0	-	-	0	-	0
2012	*no data*	-	-	-	-	-	-	-	-	-	-	-	-
2013	11	556	-	-	-	245	-	304	-	-	228	-	277
2014	6	225	-	-	-	80	-	103	-	-	24	-	24
2015	*no data*	-	-	-	-	-	-	-	-	-	-	-	-
2016	4	44	44	0	0	0	0	0	0	0	0	0	0

Table 3 (columns continued). Reproductive performance of black-legged kittiwakes on productivity plots at East Amatuli Island, Alaska. Observations covering most of the incubation period occurred only during 1994-1999 and in 2016; parameters requiring egg data are dashed for the other years. 1993-2014 data are from Kettle (2016).

Year	Laying success (B/A')	Laying failure (A'-B)/A'	Mean clutch size (C/B)	Nesting success (D/B)	Hatching success (E/C)	Egg loss (B-D)/A'	Chick success (G/E)	Chick loss (D'-F)/A	Egg success (G/C)	Fledging success (F/D)	Reprod. success (F/B)	Fledglings/ nest starts (G/A)	"Fledglings"/ nest starts (G'/A')	Prod. (F/A)	"Prod."[f] (F'/A')
1977	-	-	-	-	-	-	-	-	-	-	-	0.90[g]	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	0.15[g]	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	0.14[g]	-	-	-
'80-'92	*no data*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.75	0.25	1.63	0.71	0.65	0.22	0.60	0.22	0.39	0.59	0.42	0.47	*no data*	0.32	*no data*
1995	0.92	0.08	1.79	0.94	0.84	0.06	0.44	0.14	0.37	0.83	0.47	1.00	1.15	0.72	0.80
1996	0.91	0.09	1.71	0.87	0.72	0.12	0.24	0.20	0.17	0.74	0.25	0.66	0.77	0.58	0.66
1997	0.67	0.33	1.40	0.63	0.59	0.25	0.55	0.13	0.33	0.68	0.43	0.31	0.34	0.29	0.31
1998	0.26	0.74	1.09	0.55	0.53	0.12	0.31	0.09	0.17	0.36	0.18	0.05	0.07	0.05	0.07
1999	0.70	0.30	1.35	0.78	0.72	0.15	0.68	0.13	0.49	0.77	0.58	0.47	0.48	0.42	0.43
2000	-	-	-	-	-	-	-	-	-	-	-	-	0.53	-	0.43
2001	-	-	-	-	-	-	-	-	-	-	-	-	0.73	-	0.56
2002	-	-	-	-	-	-	-	-	-	-	-	-	0.92	-	0.69
2003	-	-	-	-	-	-	-	-	-	-	-	-	0.60	-	0.50
2004	-	-	-	-	-	-	-	-	-	-	-	-	0.06	-	0.06
2005	-	-	-	-	-	-	-	-	-	-	-	-	0.04	-	0.04
2006	-	-	-	-	-	-	-	-	-	-	-	-	0.62	-	0.53
2007	-	-	-	-	-	-	-	-	-	-	-	-	0.04	-	0.03
2008	-	-	-	-	-	-	-	-	-	-	-	-	0.51	-	0.40
2009	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	0.01
2010	-	-	-	-	-	-	-	-	-	-	-	-	0.10	-	0.09
2011	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	0.00
2012	*no data*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-	-	-	-	-	-	0.50	-	0.41
2014	-	-	-	-	-	-	-	-	-	-	-	-	0.11	-	0.11
2015	*no data*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[a] Raw count of nest-starts

[b] For years with observations during egg-hatching, "adjusted nests" are raw count of nests, minus nests with a large observation data gap around chick-hatching, minus a

(footnotes continued next page)

Table 3 (footnotes continued).

proportion of nests without chicks equal to the proportion of chick-nests that were dropped because of their hatch-date gap. It is this adjusted number of nests that is used as the divisor for ratios with numerators of: (1) chicks, (2) nests with chicks, (3) fledglings, or (4) nests with fledglings. Nests with large data gaps surrounding chick-hatching were dropped because (1) a chick could have been present and not seen before it died and (2) it couldn't be determined whether a chick that disappeared later fledged or did not, because the chick could not be aged with sufficient precision.

[c] In 1994 "Total adjusted nest starts" is the number of nest starts with definite content observation (whether empty or not) . That year, poor boating conditions created data gaps and uncertain nest-content observations.

[d] After 1999, observations began about halfway through the nestling period. Most eggs were not observed, and some chicks that died early may have been missed. For this reason ratios that rely on the number of eggs or chicks produced have not been calculated.

[e] Chicks "fledged" in quotes is based on chicks disappearing late in the season, rather than on ageing from hatch dates.

[f] "Prod." in quotes is Productivity (Nest sites with ≥ 1 chicks fledged) with chicks "fledged" based on chicks seen late in the season, rather than on chicks aged from hatch dates.

[g] 1977-1979 data are from Manuwal (1980).

Table 4. Standard deviation for reproductive performance parameters of black-legged kittiwakes on productivity plots at East Amatuli Island, Alaska. Values were calculated with ratio estimation. Sampling was clustered by plot. Pre-2015 data are from Kettle (2016).

Year	No. plots	Total nest starts	Laying success	Mean clutch size	Nesting success	Hatching success	Chick success	Egg success	Fledging success	Reprod. success	Fledglings/ nest starts[a]	Prod.[a]
1993	5	161	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	4	173	0.02	0.03	0.08	0.08	0.01	0.06	0.03	0.07	0.07	0.06
1995	11	370	0.02	0.03	0.02	0.04	0.05	0.04	0.12	0.05	0.07	0.05
1996	11	335	0.02	0.05	0.04	0.03	0.03	0.02	0.16	0.04	0.03	0.03
1997	11	304	0.04	0.03	0.04	0.05	0.05	0.04	0.05	0.04	0.04	0.04
1998	11	210	0.03	0.04	0.10	0.09	0.12	0.07	0.12	0.08	0.02	0.02
1999	11	311	0.03	0.02	0.03	0.04	0.04	0.04	0.03	0.05	0.04	0.03
2000	10	375	-	-	-	-	-	-	-	-	0.09	0.18
2001	11	448	-	-	-	-	-	-	-	-	0.05	0.24
2002	11	449	-	-	-	-	-	-	-	-	0.05	0.30
2003	11	470	-	-	-	-	-	-	-	-	0.05	0.20
2004	11	309	-	-	-	-	-	-	-	-	0.05	0.02
2005	11	274	-	-	-	-	-	-	-	-	0.02	0.01
2006	11	448	-	-	-	-	-	-	-	-	0.02	0.20
2007	11	467	-	-	-	-	-	-	-	-	0.07	0.01
2008	11	531	-	-	-	-	-	-	-	-	0.02	0.16
2009	10	303	-	-	-	-	-	-	-	-	0.03	0.00
2010	11	384	-	-	-	-	-	-	-	-	0.01	0.03
2011	11	235	-	-	-	-	-	-	-	-	0.00	0.00
2012	*no data*	-	-	-	-	-	-	-	-	-	-	-
2013	11	556	-	-	-	-	-	-	-	-	0.03	0.11
2014	6	225	-	-	-	-	-	-	-	-	0.03	0.01
2015	*no data*	-	-	-	-	-	-	-	-	-	-	-
2016	4	44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[a] During 2000-2014 fledging was based on chicks seen late in the season, rather than on chicks aged from hatch dates.

Table 5. Reproductive performance of black-legged kittiwakes on productivity plots at East Amatuli Island, Alaska in 2016. The four plots listed were observed with time-lapse cameras.

Parameter	Plot[a]											Total[b]	SD[c]
	1	2	3	4	5	6	7	8	9	10	11		
Total nest starts (A)	27	-	-	-	-	11	2	-	-	-	4	44	-
Total chicks “fledged” (G')	0	-	-	-	-	0	0	-	-	-	0	0	-
Nest sites with ≥ 1 chicks "fledged" (F')	0	-	-	-	-	0	0	-	-	-	0	0	-
"Fledglings"/nest starts (B'/A)	0.0	-	-	-	-	0.0	0.0	-	-	-	-	0.0	0.0
"Productivity" (F'/A)	0.0	-	-	-	-	0.0	0.0	-	-	-	-	0.0	0.0

[a] Productivity plots 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 have respective field names K1-LC, K2-LC, K3-LC, K4-LC, K6-LC, K7-LC, K1-F, K2-F, K3-F, K4-F, and K5-F.

[b] Ratios in “Total” column were calculated from sums in this column.

[c] Standard deviation was calculated with a ratio estimator (see Methods).

Table 6. Reproductive performance of black-legged kittiwakes on productivity plots at East Amatuli Island, Alaska in 2016.

Parameter	Plot											Total	SD[a]
	1	2	3	4	5	6	7	8	9	10	11		
Total nest starts (A)	27	-	-	-	-	11	2	-	-	-	4	44	-
Nest sites with ≥ 1 egg (B)	0	-	-	-	-	0	0	-	-	-	0	0	-
Total eggs (C)	0	-	-	-	-	0	0	-	-	-	0	0	-
Nest sites with ≥ 1 chick (D)	0	-	-	-	-	0	0	-	-	-	0	0	-
Total chicks (E)	0	-	-	-	-	0	0	-	-	-	0	0	-
Nest sites ≥ 1 chicks fledged (F)	0	-	-	-	-	0	0	-	-	-	0	0	-
Total chicks fledged (G)	0	-	-	-	-	0	0	-	-	-	0	0	-
Laying success (B/A)	0.00	-	-	-	-	0.00	0.00	-	-	-	0.00	0.00	0.00
Mean clutch size (C/B)	0.00	-	-	-	-	0.00	0.00	-	-	-	0.00	0.00	0.00
Nesting success (D/B)	0.00	-	-	-	-	0.00	0.00	-	-	-	0.00	0.00	0.00
Hatching success (E/C)	0.00	-	-	-	-	0.00	0.00	-	-	-	0.00	0.00	0.00
Chick success (G/E)	0.00	-	-	-	-	0.00	0.00	-	-	-	0.00	0.00	0.00
Egg success (G/C)	0.00	-	-	-	-	0.00	0.00	-	-	-	0.00	0.00	0.00
Fledging success (F/D)	0.00	-	-	-	-	0.00	0.00	-	-	-	0.00	0.00	0.00
Reproductive success (F/B)	0.00	-	-	-	-	0.00	0.00	-	-	-	0.00	0.00	0.00
Fledglings/nest starts (G/A)	0.00	-	-	-	-	0.00	0.00	-	-	-	0.00	0.00	0.00
Productivity (F/A)	0.00	-	-	-	-	0.00	0.00	-	-	-	0.00	0.00	0.00

[a] Standard deviation calculated with ratio estimation.

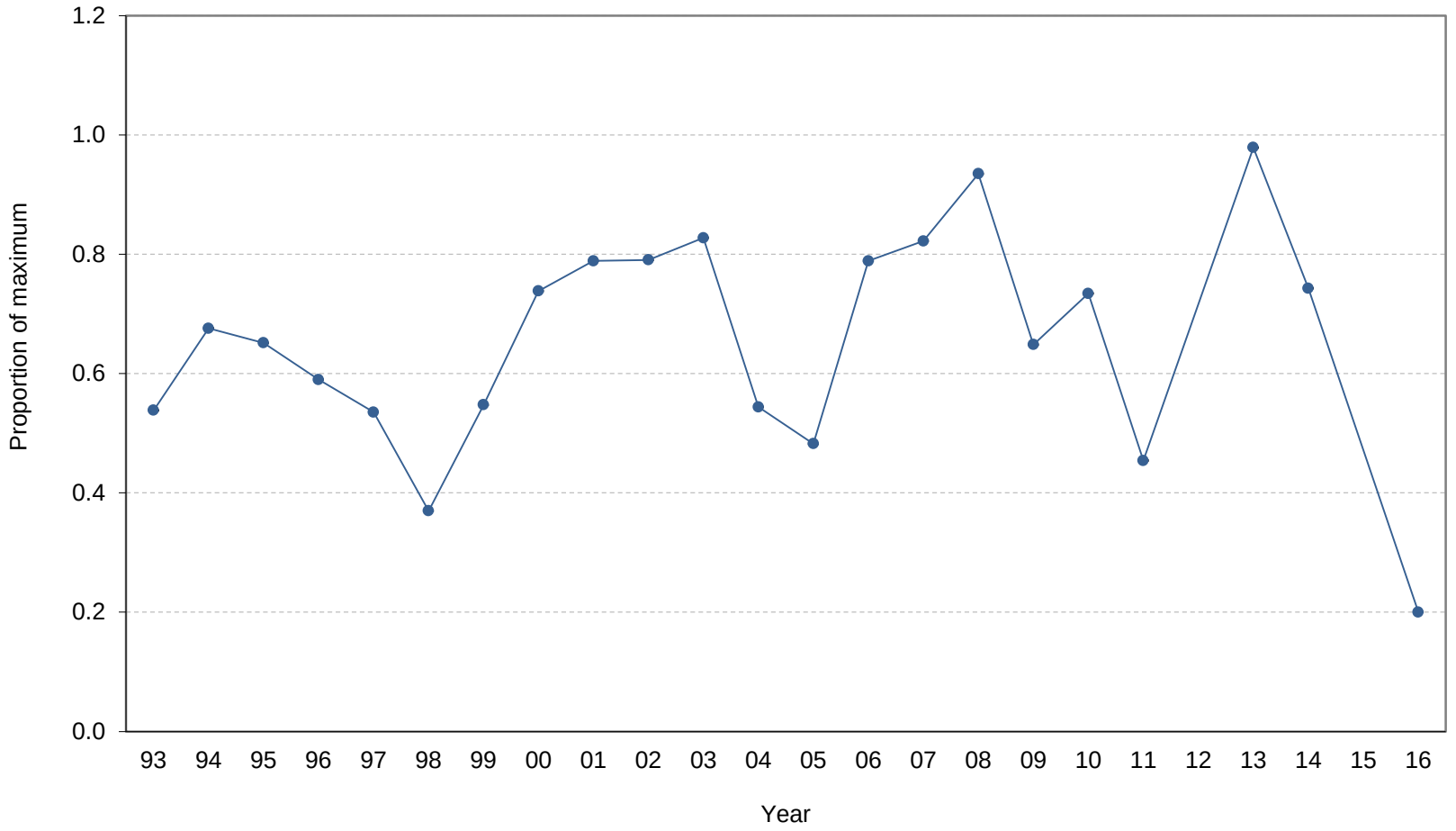

Figure 8. Number of black-legged kittiwake nest-starts counted on productivity plots at East Amatuli Island, Alaska. To calculate the index for each year, counts that year were summed across plots; then this sum was divided by the sum of the among-year maximum counts for those plots. The line spans the two years without data: 2012 and 2015.

Table 7. Number of black-legged kittiwake nest starts counted on productivity plots at East Amatuli Island, Alaska. Pre-2015 data are from Kettle (2016).

Year	Plot[a]											Total	Percent of max[b]
	1	2	3	4	5	6	7	8	9	10	11		
1993	34	41	33	-	-	-	28	25	-	-	-	161	0.54
1994	46	-	41	-	-	-	46	40	-	-	-	173	0.68
1995	46	26	35	29	36	35	49	29	33	29	23	370	0.65
1996	40	25	33	31	33	28	44	28	30	20	23	335	0.59
1997	34	22	35	27	26	32	36	34	24	11	23	304	0.54
1998	19	13	25	19	21	18	27	27	19	9	13	210	0.37
1999	31	20	34	28	34	32	37	30	26	20	19	311	0.55
2000	54	30	44	33	37	-	50	37	32	28	30	375	0.74
2001	54	40	58	34	32	48	55	41	31	25	30	448	0.79
2002	58	35	59	35	34	50	54	45	28	24	27	449	0.79
2003	59	35	68	31	39	49	53	44	32	31	29	470	0.83
2004	32	25	46	25	29	43	31	31	20	9	18	309	0.54
2005	21	4	50	15	23	27	35	33	22	26	18	274	0.48
2006	50	35	77	30	32	47	56	41	24	27	29	448	0.79
2007	54	26	76	32	38	46	55	39	37	34	30	467	0.82
2008	58	37	81	35	47	52	62	42	44	42	31	531	0.93
2009	37	22	67	-	42	35	39	27	25	28	23	345	0.65
2010	44	31	67	30	35	36	45	35	30	37	27	417	0.73
2011	30	19	35	20	37	27	32	23	12	12	11	258	0.45
2012	*no data*	-	-	-	-	-	-	-	-	-	-	-	-
2013	56	43	90	36	48	60	57	42	43	42	39	556	0.98
2014	47	37	64	29	42	37	43	38	24	34	27	422	0.74
2015	*no data*	-	-	-	-	-	-	-	-	-	-	-	-
2016	27	-	-	-	-	11	2	-	-	-	4	44	0.20
Max[c]	59	43	90	36	48	60	62	45	44	42	39	556	-

[a] Productivity plots 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 have respective field names K1-LC, K2-LC, K3-LC, K4-LC, K6-LC, K7-LC, K1-F, K2-F, K3-F, K4-F, and K5-F.
[b] Percent of sum of among-year maximum counts for the plots counted each year.
[c] Among-year maximum count

Table 8. Number of black-legged kittiwake eggs observed on productivity plots at East Amatuli Island, Alaska. Years not listed had data insufficient for egg counts. Pre-2016 data are from Kettle (2016).

Year	Plot											Total	Percent of max[a]
	1	2	3	4	5	6	7	8	9	10	11		
1993	0	0	0	-	-	-	0	0	-	-	-	0	0.00
1994	54	-	25	-	-	-	38	41	-	-	-	158	0.62
1995	84	52	56	44	61	54	70	48	50	47	41	607	1.07
1996	72	39	45	50	51	46	74	42	45	19	39	522	0.92
1997	34	19	18	21	23	41	32	35	28	9	25	285	0.50
1998	2	4	10	2	3	7	9	14	5	0	4	60	0.11
1999	29	18	35	26	32	34	28	30	29	14	19	294	0.52
2016	0	-	-	-	-	0	0	-	-	-	0	0	0.0
Max[b]	84	52	56	50	61	54	74	48	50	47	41	607	-

[a] For each year, percent of the sum of among-year maximum counts for the plots counted that year.
[b] Among-year maximum count.

Table 9. Clutch sizes of black-legged kittiwakes at East Amatuli Island, Alaska. Sample units consist of total nest sites, not plots. Pre-2016 data are from Kettle (2016). Years not listed had data insufficient for determination of clutch size.

Year	Total nest starts (A)	Nest sites w/ *x* eggs: 0	1	"1+?"	2	3	Nest sites w/ eggs (B)	Total eggs (C)	Mean clutch size (C/B)
1995	356	17	53	18	268	0	339	607	1.79
1996	333	27	52	39	214	1	306	522	1.71
1997	301	100	116	4	81	0	201	282	1.40
1998	209	155	49	0	5	0	54	59	1.09
1999	310	93	141	0	76	0	217	293	1.35
2016	44	0	0	0	0	0	0	0	0.00

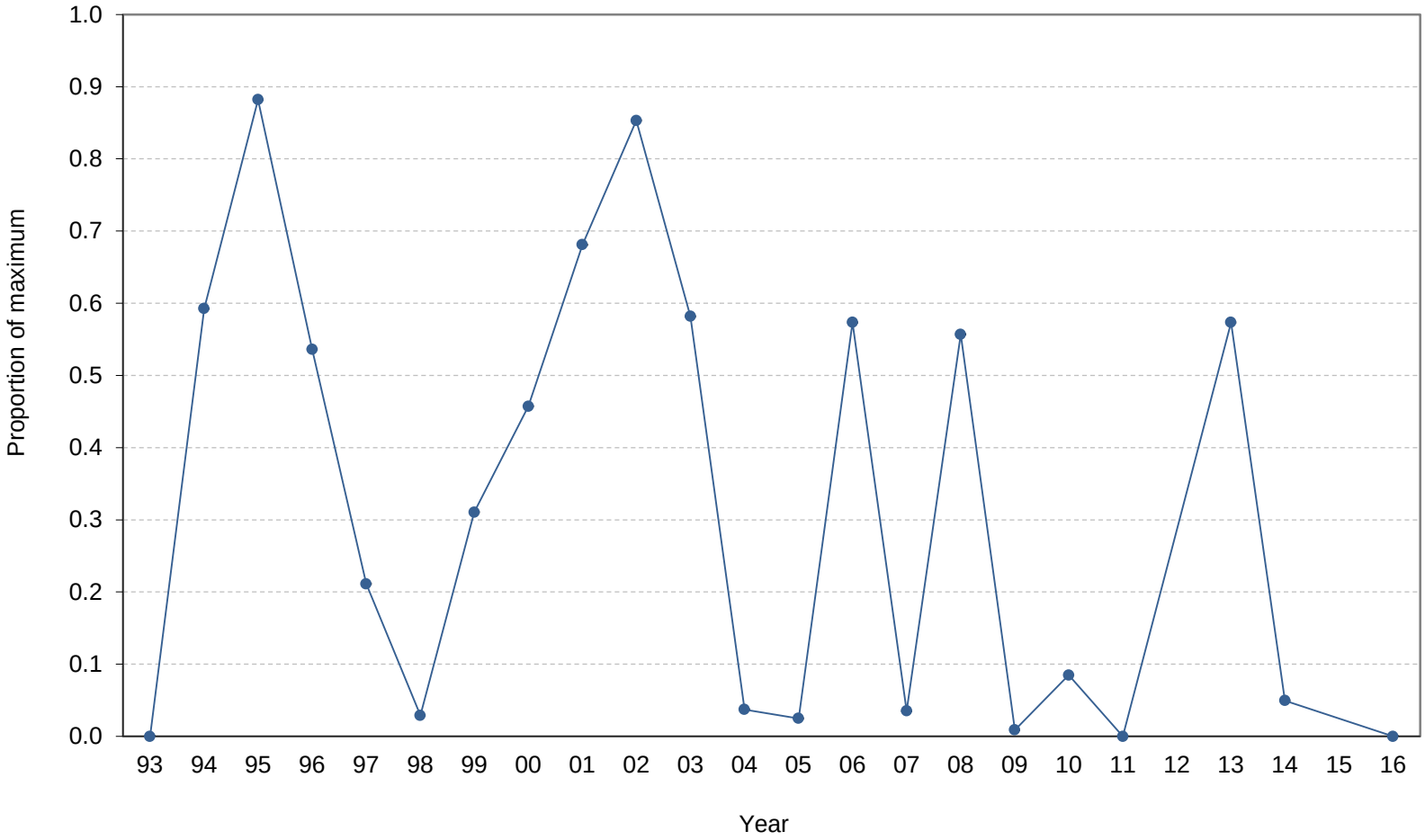

Figure 9. Number of black-legged kittiwake "fledglings" on productivity plots at East Amatuli Island, Alaska. A "fledgling" (in quotes) was determined from its presence on or after a "fledge start date" determined for each year, and from other late-season indicators, rather than by ageing from a chick-hatch date. To calculate the index for each year, counts each year were summed across plots; then this sum was divided by the sum of the among-year maximum counts for those plots. The line spans the two years without data: 2012 and 2015.

Table 10. Number of black-legged kittiwake "fledglings" on productivity plots at East Amatuli Island, Alaska. A "fledgling" (in quotes) was determined from its presence on and after a "fledge start date" determined for each year, and from other late-season indicators, rather than by ageing from a chick-hatch date. To calculate an index for each year, counts each year were summed across plots; then this sum was divided by the sum of the among-year maximum counts for those plots. Pre-2015 data are from Kettle (2016).

Year	Plot											Total	Percent of max[a]
	1	2	3	4	5	6	7	8	9	10	11		
1993	0	0	0	-	-	-	0	0	-	-	-	0	0.00
1994	37	-	30	-	-	-	41	20	-	-	-	128	0.59
1995	58	36	34	35	40	42	51	29	45	31	25	426	0.88
1996	30	13	28	30	22	31	40	13	24	11	17	259	0.54
1997	17	4	5	6	11	16	14	8	12	3	6	102	0.21
1998	0	1	4	2	0	2	5	0	0	0	0	14	0.03
1999	17	8	16	15	26	21	12	12	13	4	6	150	0.31
2000	38	15	34	2	6	-	42	14	23	13	11	198	0.46
2001	48	35	42	22	34	26	30	24	31	20	17	329	0.68
2002	56	28	69	40	24	50	54	35	19	13	24	412	0.85
2003	41	23	57	19	12	30	22	23	20	17	17	281	0.58
2004	0	1	2	3	0	0	0	4	4	2	2	18	0.04
2005	0	0	0	3	5	0	2	1	0	1	0	12	0.02
2006	44	32	31	21	32	23	30	17	14	18	15	277	0.57
2007	4	2	0	1	7	0	0	0	3	0	0	17	0.04
2008	21	15	44	11	28	21	39	29	24	21	16	269	0.56
2009	0	0	0	-	0	0	0	0	0	4	0	4	0.01
2010	1	0	0	0	0	0	1	4	13	15	7	41	0.08
2011	0	0	0	0	0	0	0	0	0	0	0	0	0.00
2012	*no data*	-	-	-	-	-	-	-	-	-	-	-	-
2013	33	20	49	22	20	23	28	18	27	29	8	277	0.57
2014	4	0	0	0	0	6	2	0	0	0	12	24	0.05
2015	*no data*	-	-	-	-	-	-	-	-	-	-	-	-
2016	0	-	-	-	-	0	0	-	-	-	0	0	0.00
Max[b]	58	36	69	40	40	50	54	35	45	31	25	426	-

[a] Percent of sum of among-year maximum counts for the plots counted each year.
[b] Among-year maximum count

Table 11. Number of black-legged kittiwake chicks observed on productivity plots at East Amatuli Island, Alaska. Years not listed had data insufficient for early chick counts. Pre-2016 data are from Kettle (2016).

Year	Plot											Total	Percent of max[a]
	1	2	3	4	5	6	7	8	9	10	11		
1993	0	0	0	-	-	-	0	0	-	-	-	0	0.00
1994	42	-	9	-	-	-	28	23	-	-	-	102	0.40
1995	67	42	38	38	48	50	64	37	59	35	34	512	0.90
1996	47	26	31	43	35	38	60	24	27	16	29	376	0.66
1997	27	16	7	14	14	23	19	14	20	4	10	168	0.30
1998	0	2	8	2	1	3	7	9	0	0	0	32	0.06
1999	21	11	24	19	30	26	18	17	25	6	14	211	0.37
2016	0	-	-	-	-	0	0	-	-	-	0	0	0.00
Max[b]	67	42	71	43	48	51	86	46	59	35	34	512	-

[a] For each year, percent of the sum of among-year maximum counts for the plots counted that year.
[b] Among-year maximum count.

Table 12. Number of glaucous-winged gull fledglings counted on Amatuli Cove Beach, East Amatuli Island, Alaska. Dashes indicate "no data".

Date	GWGU fledglings					
	2011	2012	2013	2014	2015	2016
31 Jul	0	*no*	-	0	*no*	-
01 Aug	-	*data*	-	0	*data*	-
02 Aug	-	-	0	0	-	-
03 Aug	0	-	0	0	-	-
04 Aug	0	-	0	-	-	-
05 Aug	0	-	0	0	-	-
06 Aug	0	-	0	0	-	-
07 Aug	0	-	2	0	-	-
08 Aug	0	-	0	0	-	-
09 Aug	0	-	2	2	-	-
10 Aug	0	-	2	5	-	-
11 Aug	-	-	4	2	-	-
12 Aug	1	-	5	0	-	-
13 Aug	1	-	6	0	-	-
14 Aug	-	-	9	5	-	-
15 Aug	-	-	7	3	-	-
16 Aug	-	-	9	2	-	-
17 Aug	1	-	12	0	-	-
18 Aug	0	-	14	2	-	-
19 Aug	0	-	30	1	-	-
20 Aug	1	-	9	4	-	-
21 Aug	0	-	12	5	-	-
22 Aug	1	-	13	2	-	-
23 Aug	0	-	12	3	-	-
24 Aug	6	-	3	9	-	-
25 Aug	0	-	16	-	-	-
26 Aug	3	-	8	5	-	-
27 Aug	2	-	15	3	-	-
28 Aug	2	-	26	5	-	-
29 Aug	2	-	24	9	-	-
30 Aug	0	-	21	5	-	-
31 Aug	3	-	16	1	-	-
01 Sep	0	-	21	5	-	-
02 Sep	0	-	26	2	-	0
03 Sep	1	-	34	2	-	1
04 Sep	0	-	14	3	-	0
05 Sep	0	-	15	7	-	-
06 Sep	3	-	23	2	-	-
07 Sep	0	-	12	2	-	-
08 Sep	0	-	9	6	-	-
09 Sep	0	-	13	5	-	-
10 Sep	0	-	10	2	-	-
11 Sep	0	-	4	1	-	-
12 Sep	0	-	6	2	-	-
13 Sep	0	-	1	0	-	-
14 Sep	0	-	1	0	-	-
15 Sep	0	-	1	0	-	-
Maximum	6	-	34	9	-	-

[a] *nd*="No data"

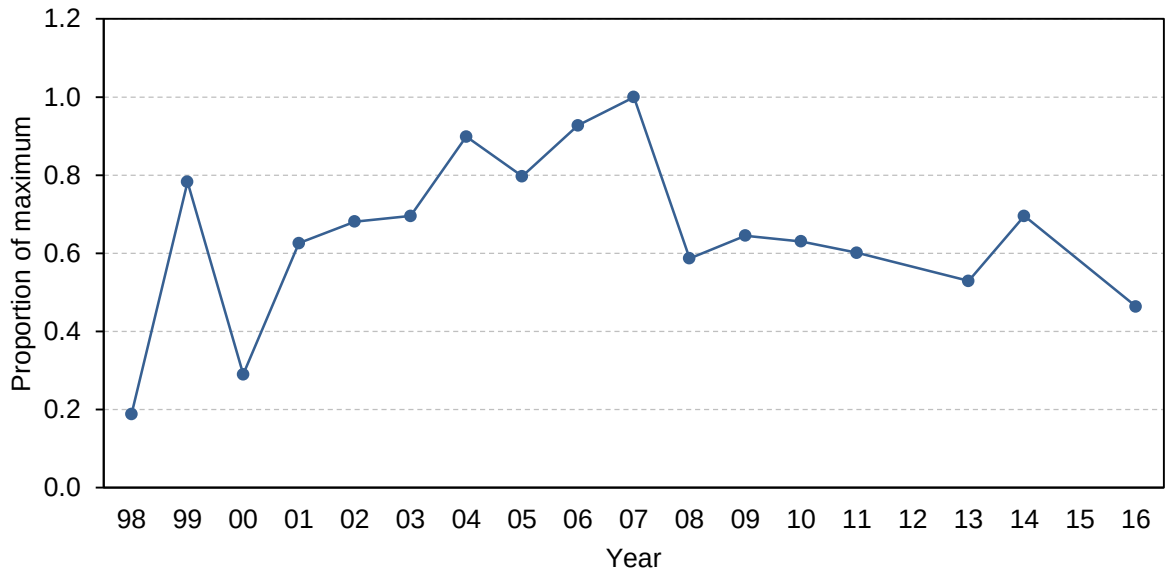

Figure 10. Number of fork-tailed storm-petrel chicks found in monitoring plots at East Amatuli Island, Alaska. Data are presented as the proportion of the among-year maximum count in Plots 1-4 and 6-11 in 2001 and Plots 1-11 in all other years. The line spans the two years without data: 2012 and 2015.

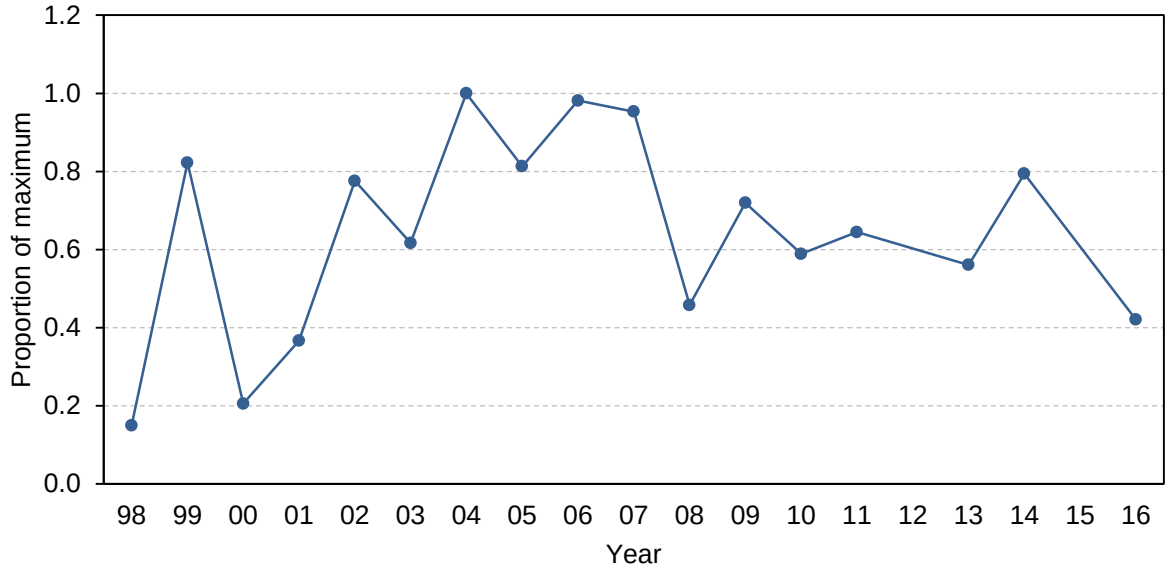

Figure 11. Number of large (mass >= 50 g) fork-tailed storm-petrel chicks found in monitoring plots at East Amatuli Island, Alaska. Data are presented as the proportion of the among-year maximum count in Plots 1-4 and 6-11 in 2001 and Plots 1-11 in all other years. The line spans the two years without data: 2012 and 2015.

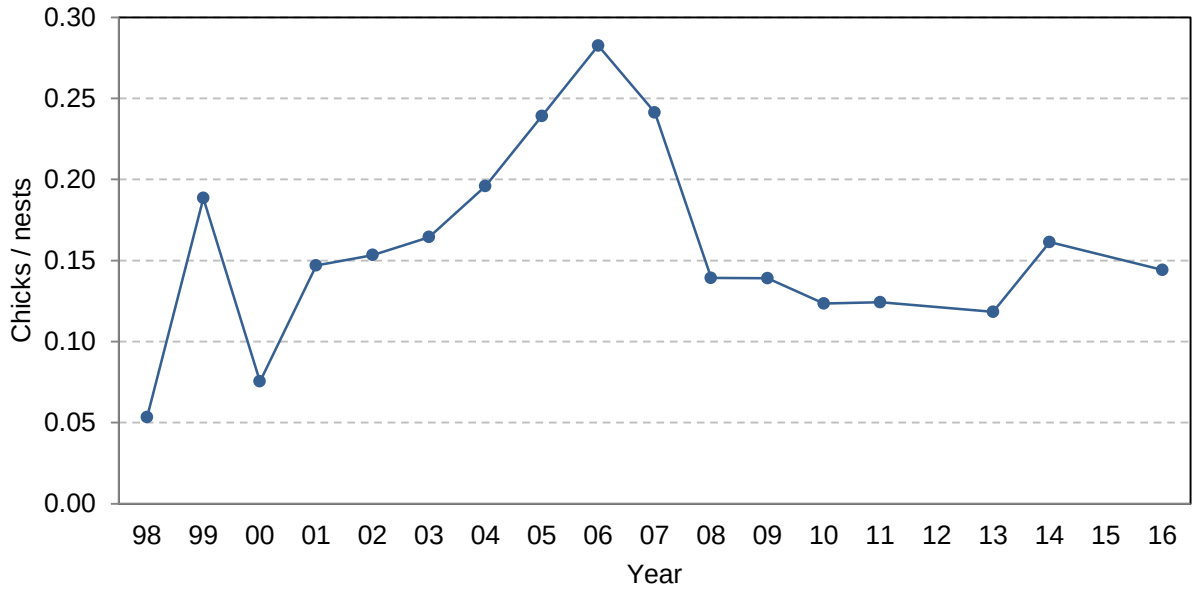

Figure 12. Proportion of burrows that contained fork-tailed storm-petrel chicks in monitoring plots at East Amatuli Island, Alaska. Data are from Plots 1-4 and 6-11 in 2001 and Plots 1-11 in all other years. The line spans the two years without data: 2012 and 2015.

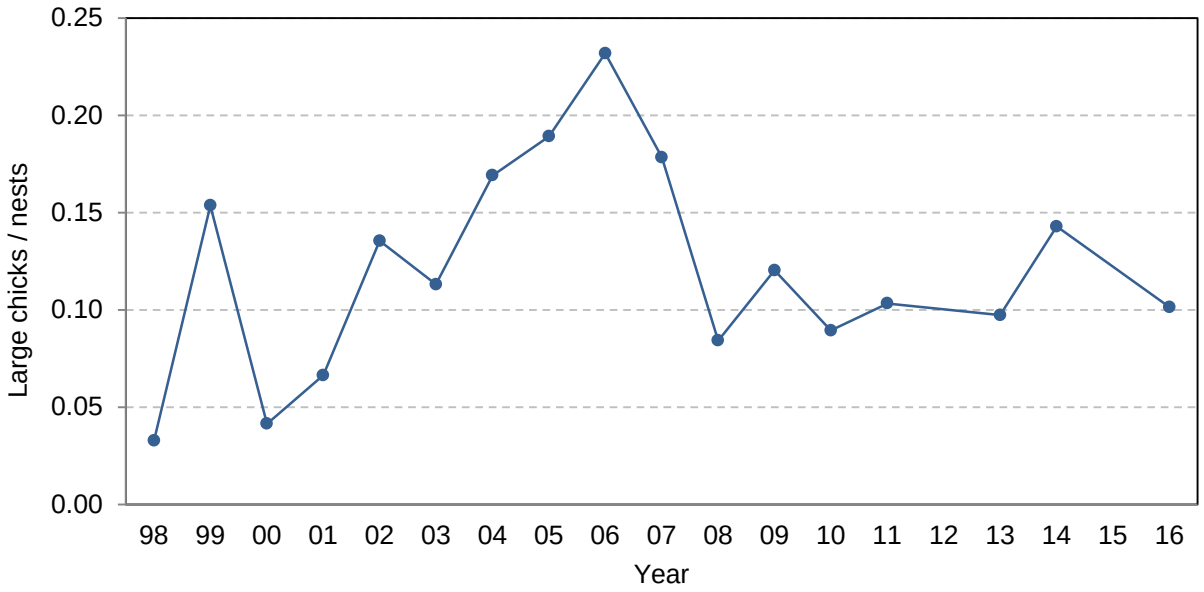

Figure 13. Proportion of burrows that contained “Large” (mass >= 50 g) fork-tailed storm-petrel chicks in monitoring plots at East Amatuli Island, Alaska. Data are from Plots 1-4 and 6-11 in 2001 and Plots 1-11 in all other years. The line spans the two years without data: 2012 and 2015.

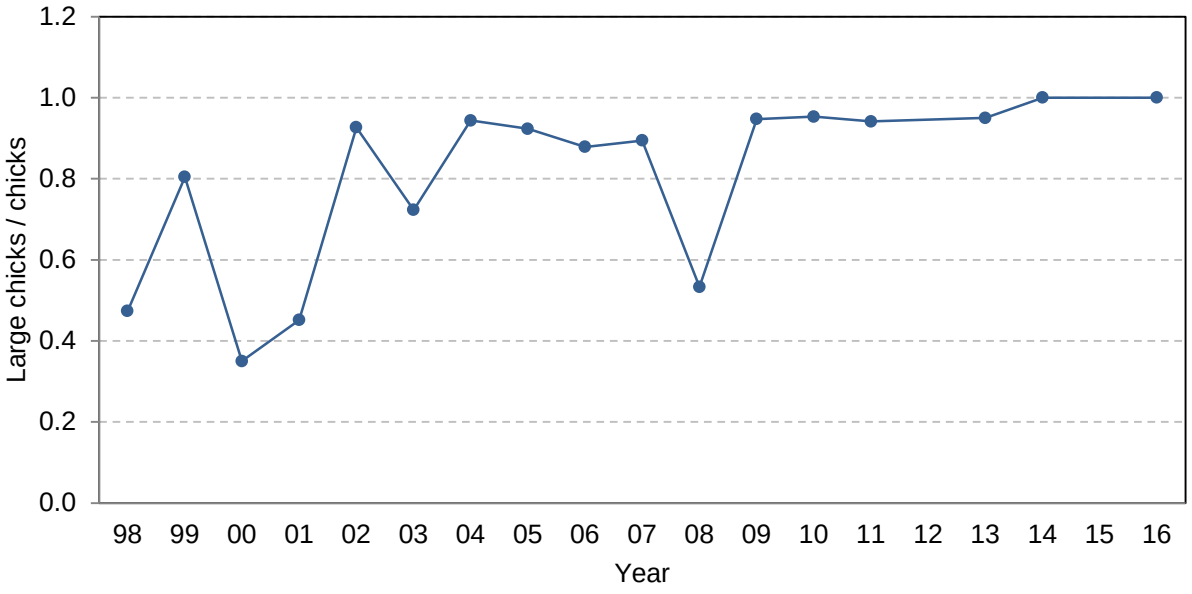

Figure 14. Proportion of fork-tailed storm-petrel chicks that reached “Large” size (mass >= 50 g) in monitoring plots at East Amatuli Island, Alaska. Data are from Plots 1-4 and 6-11 in 2001 and Plots 1-11 in all other years. The line spans the two years without data: 2012 and 2015.

Table 13. Indices for fork-tailed storm-petrel reproductive success (proportion of burrows that contain chicks, proportion of burrows with “Large” chicks, and proportion of chicks that survive to “Large” size) from monitoring plots at East Amatuli Island, Alaska. Pre-2014 data are from Kettle (2014).

Parameter	1998	1999	2000	2001[a]	2002	2003	2004	2005	2006	2007
Burrows (a)	488	573	531	558	613	584	633	460	453	572
Burrows with a chick (b)	26	108	40	82	94	96	124	110	128	138
Burrows with a chick weighed[b] (c)	26	106	35	54	89	84	113	94	118	113
Burrows that produced a “large” (mass > 50 g) chick (d)	16	88	22	37	83	66	107	87	105	102
Burrows with chick < 50 g at end of field season (e)	7	14	15	23	7	19	6	3	11	9
Proportion of burrows with a chick (b/a)	0.053	0.188	0.075	0.147	0.153	0.164	0.196	0.239	0.283	0.241
Proportion of burrows that contain a “large” chick (d/a)	0.033	0.154	0.041	0.066	0.135	0.113	0.169	0.189	0.232	0.178
Proportion of chicks that survived to “large” size ((d-e)/(c-e))	0.474	0.804	0.350	0.452	0.927	0.723	0.944	0.923	0.879	0.894

Table 13 (years continued). Indices for fork-tailed storm-petrel reproductive success (proportion of burrows that contain chicks, proportion of burrows with “Large” chicks, and proportion of chicks that survive to “Large” size) from monitoring plots at East Amatuli Island, Alaska. Pre-2014 data are from Kettle (2014).

Parameter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Burrows (a)	582	640	705	668	*no data*	617	595	*no data*	444
Burrows with a chick (b)	81	89	87	83	-	73	96	-	64
Burrows with a chick weighed[b] (c)	70	81	66	73	-	63	85	-	45
Burrows that produced a “large” (mass > 50 g) chick (d)	49	77	63	69	-	60	85	-	45
Burrows with chick < 50 g at end of field season (e)	25	5	2	5	-	3	1	-	0
Proportion of burrows with a chick (b/a)	0.139	0.139	0.123	0.124	-	0.118	0.161	-	0.144
Proportion of burrows that contain a “large” chick (	0.084	0.120	0.089	0.103	-	0.097	0.143	-	0.101
Proportion of chicks that survived to “large” size ((d-e)/(c-e))	0.533	0.947	0.953	0.941	-	0.950	1.00	-	1.00

[a] One plot was inadvertently omitted from field work in 2001; data are for 10 plots rather than all eleven.

[b] Each year there was a small proportion of chicks that either could not be measured or were alive but had not yet reached 50 g when we departed from the island. The calculation for fledging success omits those nests.

Table 14. Number of fork-tailed storm-petrel chicks found in monitoring plots at East Amatuli Island, Alaska. Pre-2014 data are from Kettle (2014).

Year	Plot[a]											Sum of 11 plots	Prop. of max[d]	Sum w/o Plot 5	Prop. of max[e]	Prop. of max of all plots surveyed[f]
	1	2	3	4	5	6	7	8	9	10	11					
1998	1	0	1	0	3	7	2	2	1	7	2	26	0.19	23	0.18	0.19
1999	11	4	13	4	12	18	12	9	11	9	5	108	0.78	96	0.73	0.78
2000	7	2	9	1	1	8	1	2	2	6	1	40	0.29	39	0.30	0.29
2001	11	5	13	4	*no data*[b]	9	8	14	8	7	3	-	-	82	0.63	0.63
2002	7	7	16	2	4	13	10	11	9	12	3	94	0.68	90	0.69	0.68
2003	4	6	14	3	6	11	17	16	6	8	5	96	0.70	90	0.69	0.70
2004	11	9	17	4	8	19	17	18	11	6	4	124	0.90	116	0.89	0.90
2005	19	9	14	6	5	15	6	16	7	10	3	110	0.80	105	0.80	0.80
2006	16	13	17	2	11	19	11	14	14	8	3	128	0.93	117	0.89	0.93
2007	10	14	24	2	7	18	13	20	15	11	4	138	1.00	131	1.00	1.00
2008	7	8	16	2	4	8	10	10	4	9	3	81	0.59	77	0.59	0.59
2009	6	11	10	1	5	2	13	20	10	7	4	89	0.64	84	0.64	0.64
2010	6	5	6	4	3	13	14	17	7	8	4	87	0.63	84	0.64	0.63
2011	6	5	7	2	3	11	16	15	6	8	4	83	0.60	80	0.61	0.60
2012	*no data*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2013	9	3	4	2	7	7	11	9	6	10	5	73	0.53	66	0.56	0.53
2014	4	10	5	3	10	13	18	13	7	12	1	96	0.70	86	0.66	0.70
2015																
2016	5	2	3	4	6	8	11	6	2	15	2	64	0.46	58	0.44	0.46
											Max.[c]	138		131		

[a] For this table plots have for this table been numbered east-to-west:1=plot “AW”; 2=“AE”; 3=“B”; 4=“EWL”; 5=“EWU”; 6=“EEL”; 7=“EEU”; 8=“DL”; 9=“DM”; 10=“DU”; 11=“F”.
[b] In 2001 plot 5 was accidentally omitted from the field surveys.
[c] Among-years maximum of sum of Plots 1-11
[d] (Sum from Plots 1-11) / (among-year maximum).
[e] (Sum from plots 1-4 and 6-11) / (among-year maximum).
[f] Proportion of among-year maximum for either plots 1-4 and 6-11 (2001) or plots 1-11 (all other years).

Table 15. Number of large (>=50 g by end of field season) fork-tailed storm-petrel chicks found in monitoring plots at East Amatuli Island, Alaska. Pre-2014 data are from Kettle (2014).

Year	Plot[a]											Sum of 11 plots	Prop. of max.[d]	Sum w/o Plot 5	Prop. of max.[e]	Prop. of max. of all plots surveyed[f]
	1	2	3	4	5	6	7	8	9	10	11					
1998	0	0	1	0	2	3	1	2	0	5	2	16	0.15	14	0.14	0.15
1999	8	3	13	2	8	17	8	6	9	9	5	88	0.82	80	0.79	0.82
2000	4	1	4	1	1	4	0	1	2	3	1	22	0.21	21	0.21	0.21
2001	7	4	7	2	*no data*[b]	4	3	5	2	2	1	-	-	37	0.37	0.37
2002	5	7	14	1	4	12	9	10	9	9	3	83	0.78	79	0.78	0.78
2003	3	4	7	2	4	8	8	12	6	7	5	66	0.62	62	0.61	0.62
2004	10	8	16	3	6	15	16	16	9	4	4	107	1.00	101	1.00	1.00
2005	16	7	12	3	4	12	5	11	6	6	2	84	0.79	80	0.79	0.79
2006	8	9	14	1	10	18	11	14	12	5	3	105	0.98	95	0.94	0.98
2007	6	10	17	2	5	15	8	16	12	8	3	102	0.95	97	0.96	0.95
2008	5	6	8	1	2	4	7	5	3	6	2	49	0.46	47	0.47	0.46
2009	6	9	9	1	4	2	13	16	8	7	2	77	0.72	73	0.72	0.72
2010	5	4	3	3	2	10	12	10	5	6	3	63	0.59	61	0.60	0.59
2011	5	4	6	2	2	10	13	13	5	5	4	69	0.64	67	0.66	0.64
2012	*no data*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2013	7	3	4	2	6	6	9	8	3	8	4	60	0.56	54	0.53	0.56
2014	4	10	5	2	9	13	16	13	5	7	1	85	0.79	76	0.75	0.79
2015	*no data*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2016	4	2	2	2	3	6	8	6	2	9	1	45	0.42	42	0.42	0.42
											Max.[c]	107		101		

[a] Plots have for this table been numbered east-to-west:1=Plot “AW”; 2=“AE”; 3=“B”; 4=“EWL”; 5=“EWU”; 6=“EEL”; 7=“EEU”; 8=“DL”; 9=“DM”; 10=“DU”; 11=“F”.
[b] In 2001 plot 5 was accidentally omitted from the field surveys.
[c] Among-years maximum of sum of Plots 1-11
[d] (Sum from Plots 1-11) / (among-year maximum).
[e] (Sum from plots 1-4 and 6-11) / (among-year maximum).
[f] Proportion of among-year maximum for either plots 1-4 and 6-11 (2001) or plots 1-11 (all other years).

Table 16. By-plot reproductive performance of fork-tailed storm-petrels in 2016 at East Amatuli Island, Alaska.

2016	Plot											Total
	1	2	3	4	5	6	7	8	9	10	11	
Burrows (a)	47	37	23	17	35	45	71	60	26	70	13	444
Burrows with a chick (b)	5	2	3	4	6	8	11	6	2	15	2	64
Burrows with a chick weighed[b] (c)	4	2	2	2	3	6	8	6	2	9	1	45
Burrows that produced a “large” (mass > 50 g) chick (d)	4	2	2	2	3	6	8	6	2	9	1	45
Burrows with chick < 50 g at end of field season (e)	0	0	0	0	0	0	0	0	0	0	0	0
Proportion of burrows with a chick (b/a)	0.11	0.05	0.13	0.24	0.17	0.18	0.15	0.10	0.08	0.21	0.15	0.14
Proportion of burrows that contain a “large” chick (d/a)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Proportion of chicks that survived to “large” size ((d-e)/(c-e))	0.09	0.05	0.09	0.12	0.09	0.13	0.11	0.10	0.08	0.13	0.08	0.10

Table 17. By-plot reproductive performance of fork-tailed storm-petrels in 2014 at East Amatuli Island, Alaska.

2014	Plot											Total
	1	2	3	4	5	6	7	8	9	10	11	
Burrows (a)	54	47	24	26	55	73	109	92	39	64	12	595
Burrows with a chick (b)	4	10	5	3	10	13	18	13	7	12	1	96
Burrows with a chick weighed[b] (c)	4	10	5	2	9	13	16	13	5	7	1	85
Burrows that produced a “large” (mass > 50 g) chick (d)	4	10	5	2	9	13	16	13	5	7	1	85
Burrows with chick < 50 g at end of field season (e)	0	0	0	0	0	1	0	0	0	0	0	1
Proportion of burrows with a chick (b/a)	0.07	0.21	0.21	0.12	0.18	0.18	0.17	0.14	0.18	0.19	0.08	0.16
Proportion of burrows that contain a “large” chick (d/a)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Proportion of chicks that survived to “large” size ((d-e)/(c-e))	0.07	0.21	0.21	0.08	0.16	0.18	0.15	0.14	0.13	0.11	0.08	0.14

Table 18. Grouped-plot reproductive performance of fork-tailed storm-petrels in 2016 at East Amatuli Island, Alaska. Plots were grouped to increase chick sample size for calculation of standard deviation using plots.

2016	Plot								Total[a]	SD[b]
	1	2+3	4+5	6	7	8+11	9	10		
Chicks (b)	5	5	10	8	11	8	2	15	64	-
Chicks weighed (c)	4	4	5	6	8	7	2	9	45	-
Chicks that reached 50 g (d)	4	4	5	6	8	7	2	9	45	-
Chicks alive but <50 g when we departed (e)	0	0	0	0	0	0	0	0	0	-
Large chicks/chicks ((d-e)/(c-e))	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00

[a] The sample unit for the fledging success index point calculation is the nest-site (not plots).
[b] Standard deviation was calculated with ratio estimation, using plots as the sample unit.

Table 19. Grouped-plot reproductive performance of fork-tailed storm-petrels in 2014 at East Amatuli Island, Alaska. Plots were grouped to increase chick sample size for calculation of standard deviation using plots.

2014	Plot								Total[a]	SD[b]
	1	2+3	4+5	6	7	8+11	9	10		
Chicks (b)	4	15	13	13	18	14	7	12	96	-
Chicks weighed (c)	4	15	11	13	16	14	5	7	85	-
Chicks that reached 50 g (d)	4	15	11	13	16	14	5	7	85	-
Chicks alive but <50 g when we departed (e)	0	0	0	1	0	0	0	0	1	-
Large chicks/chicks ((d-e)/(c-e))	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	0.00

[a] The sample unit for the fledging success index point calculation is the nest-site (not plots).
[b] Standard deviation was calculated with ratio estimation, using plots as the sample unit.

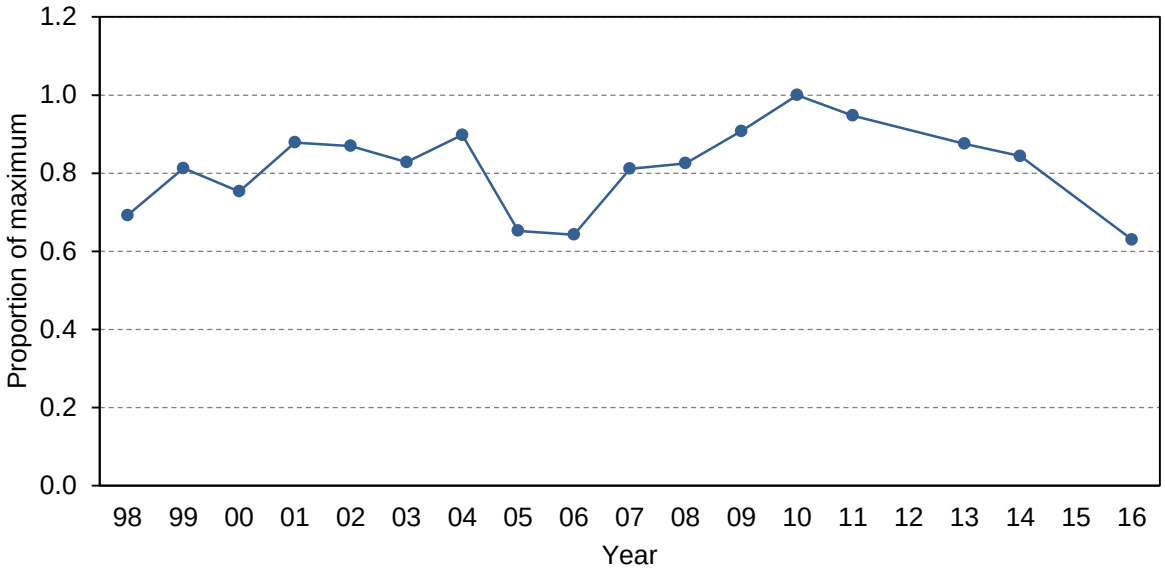

Figure 15. Number of burrows counted in fork-tailed storm-petrel plots at East Amatuli Island, Alaska. Data are presented as the proportion of the among-year maximum count in Plots 1-4 and 6-11 (2001) and Plots 1-11 (all other years). The line spans the two years without data: 2012 and 2015.

Table 20. Number of burrows counted in fork-tailed storm-petrel monitoring plots at East Amatuli Island, Alaska. Pre-2014 data are from Kettle (2014).

Year	Plot[a]											Sum of 11 plots	Prop. of max[d]	Sum w/o Plot 5	Prop. of max[e]	Prop. of max. combined[f]
	1	2	3	4	5	6	7	8	9	10	11					
1998	50	45	47	16	58	72	79	18	61	24	18	488	0.69	430	0.68	0.69
1999	53	49	48	25	64	79	92	69	25	55	14	573	0.81	509	0.80	0.81
2000	44	43	51	24	54	79	82	58	27	54	15	531	0.75	477	0.75	0.75
2001	53	51	52	25	*no data*[b]	80	98	86	36	64	13	-	-	558	0.88	0.88
2002	52	49	44	24	55	80	105	80	38	71	15	613	0.87	558	0.88	0.87
2003	51	44	35	20	64	77	72	86	38	81	16	584	0.83	520	0.82	0.83
2004	63	57	43	35	69	73	93	88	32	67	13	633	0.90	564	0.89	0.90
2005	48	45	37	19	53	63	76	52	26	44	6	460	0.65	406	0.64	0.65
2006	49	43	37	22	49	66	90	55	32	38	12	453	0.64	399	0.63	0.64
2007	47	55	48	23	57	69	85	86	31	58	13	572	0.81	515	0.81	0.81
2008	45	40	45	37	55	77	87	93	30	61	12	582	0.83	527	0.83	0.83
2009	53	53	35	38	56	74	108	107	36	64	16	640	0.91	584	0.92	0.91
2010	58	64	44	41	70	93	123	92	37	71	12	705	1.00	635	1.00	1.00
2011	57	50	37	29	74	87	113	91	35	79	16	668	0.95	594	0.94	0.95
2012	*no data*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2013	50	60	35	28	69	86	101	81	28	61	19	617	0.88	548	0.86	0.88
2014	54	47	24	26	55	73	109	92	39	64	12	595	0.84	540	0.85	0.84
2015																
2016	47	37	23	17	35	45	71	60	26	70	13	444	0.63	409	0.64	0.63
											Max.[c]	705		635		

[a] Plots have for this table been numbered east-to-west:1=Plot “AW”; 2=“AE”; 3=“B”; 4=“EWL”; 5=“EWU”; 6=“EEL”; 7=“EEU”; 8=“DL”; 9=“DM”; 10=“DU”; 11=“F”.

[b] In 2001 plot 5 was accidentally omitted from the field surveys.

[c] Among-years maximum of sum of Plots 1-11

[d] (Sum from Plots 1-11) / (among-year maximum).

[e] (Sum from plots 1-4 and 6-11) / (among-year maximum).

[f] Proportion of among-year maximum for either plots 1-4 and 6-11 (2001) or plots 1-11 (all other years).

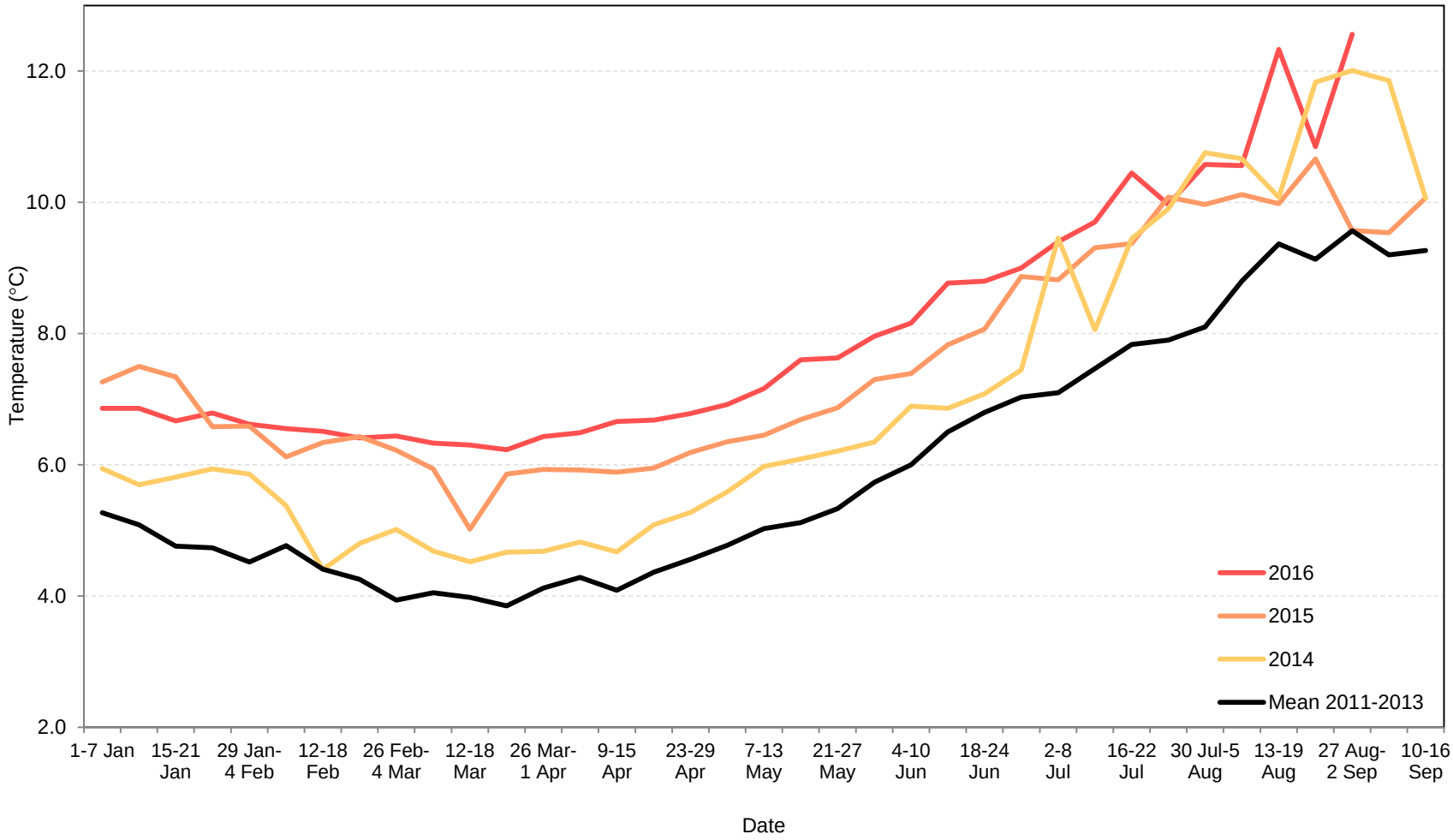

Figure 16. Mean weekly sea surface temperatures (°C) at East Amatuli Island, Alaska, showing annual increases from the 2011-2013 mean.

Table 21. Mean weekly sea surface temperatures (°C) at East Amatuli Island, Alaska.

Week			Mean 2011-2013	2011	2012	2013	2014	2015	2016
01 Jan	-	07 Jan	5.3	6.3	3.9	5.6	5.9	7.3	6.9
08 Jan	-	14 Jan	5.1	6.0	4.0	5.3	5.7	7.5	6.9
15 Jan	-	21 Jan	4.8	5.4	3.8	5.1	5.8	7.3	6.7
22 Jan	-	28 Jan	4.7	5.6	3.5	5.1	5.9	6.6	6.8
29 Jan	-	04 Feb	4.5	5.5	3.3	4.8	5.9	6.6	6.6
05 Feb	-	11 Feb	4.8	5.3	3.9	5.1	5.4	6.1	6.6
12 Feb	-	18 Feb	4.4	4.3	4.0	4.9	4.4	6.3	6.5
19 Feb	-	25 Feb	4.3	4.5	4.1	4.2	4.8	6.4	6.4
26 Feb	-	04 Mar	3.9	3.8	3.2	4.8	5.0	6.2	6.4
05 Mar	-	11 Mar	4.1	4.4	2.9	4.9	4.7	5.9	6.3
12 Mar	-	18 Mar	4.0	4.3	3.0	4.6	4.5	5.0	6.3
19 Mar	-	25 Mar	3.9	4.5	3.1	4.0	4.7	5.9	6.2
26 Mar	-	01 Apr	4.1	4.5	3.9	4.0	4.7	5.9	6.4
02 Apr	-	08 Apr	4.3	4.5	4.1	4.3	4.8	5.9	6.5
09 Apr	-	15 Apr	4.1	4.3	4.4	3.6	4.7	5.9	6.7
16 Apr	-	22 Apr	4.4	4.5	4.6	4.0	5.1	6.0	6.7
23 Apr	-	29 Apr	4.6	4.7	4.8	4.2	5.3	6.2	6.8
30 Apr	-	06 May	4.8	4.9	4.9	4.5	5.6	6.4	6.9
07 May	-	13 May	5.0	5.2	5.1	4.8	6.0	6.5	7.2
14 May	-	20 May	5.1	5.2	5.3	4.9	6.1	6.7	7.6
21 May	-	27 May	5.3	5.3	5.6	5.1	6.2	6.9	7.6
28 May	-	03 Jun	5.7	5.7	6.1	5.4	6.3	7.3	8.0
04 Jun	-	10 Jun	6.0	6.0	6.2	5.8	6.9	7.4	8.2
11 Jun	-	17 Jun	6.5	6.3	6.8	6.4	6.9	7.8	8.8
18 Jun	-	24 Jun	6.8	6.6	7.3	6.5	7.1	8.1	8.8
25 Jun	-	01 Jul	7.0	7.0	7.4	6.7	7.4	8.9	9.0
02 Jul	-	08 Jul	7.1	6.8	7.4	7.1	9.5	8.8	9.4
09 Jul	-	15 Jul	7.5	7.2	7.7	7.5	8.1	9.3	9.7
16 Jul	-	22 Jul	7.8	7.4	8.3	7.8	9.4	9.4	10.5
23 Jul	-	29 Jul	7.9	7.5	8.5	7.7	9.9	10.1	10.0
30 Jul	-	05 Aug	8.1	7.4	8.7	8.2	10.8	10.0	10.6
06 Aug	-	12 Aug	8.8	8.7	9.2	8.5	10.7	10.1	10.6
13 Aug	-	19 Aug	9.4	8.6	9.6	9.9	10.1	10.0	12.3
20 Aug	-	26 Aug	9.1	9.7	8.9	8.8	11.8	10.7	10.9
27 Aug	-	02 Sep	9.6	8.6	9.0	11.1	12.0	9.6	12.6
03 Sep	-	09 Sep	9.2	9.1	9.1	9.4	11.9	9.5	-
10 Sep	-	16 Sep	9.3	8.5	9.6	9.7	10.1	10.1	-

Table 22. History of seabird reconnaissance and monitoring at East Amatuli Island.

Years	Activity
1974-1975	Pre-Refuge biological reconnaissance of Barren Islands by Edgar Bailey
1976-1979	University of Washington (UW) Outer Continental Shelf Environmental Assessment Program (OCSEAP) biological studies for determining pre-oil-development status
1980-1984	Brief UW visits to study fork-tailed storm-petrel biology
1985-1989	Brief annual visits by Alaska Maritime National Wildlife Refuge (AMNWR) for monitoring mainly burrow-nesting seabirds
1990-1992	AMNWR post-*Exxon Valdez* oil spill boat-based common murre “Damage Assessment”
1990-1993	June-Sept UW post-oil spill Damage Assessment and Restoration Monitoring for the common murre; other seabird species also studied
1993-1999	June-Sept AMNWR post-oil spill Damage Assessment and Restoration Monitoring for the common murre; other seabird species also monitored
1995-1999	Barren Islands seabird component of *Exxon Valdez* Trustee Council’s Alaska Predator Ecosystem Experiment (APEX) project conducted by AMNWR June-Sept each year.
2000-2014	(Except 2012) July-Sept annual seabird monitoring by AMNWR
2015	Two-hour visit on 2 September to observe whether murre and kittiwakes bred
2016	Time-lapse cameras monitored cliff-nesters; storm-petrel and tufted puffin plots surveyed. 11-day field camp.