Point Blue Report

Population size and reproductive performance of seabirds on Southeast Farallon Island, 2017

Report to the U.S. Fish and Wildlife Service
Farallon National Wildlife Refuge

January 2018

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EXECUTIVE SUMMARY

(1) Under cooperative agreement with USFWS/Farallon NWR, Point Blue (formerly PRBO) monitors the population size and reproductive success of seabirds on Southeast Farallon Island (SEFI), California and has done so since 1971. We also collect information on oceanic conditions (sea surface temperature) and prey use (diet composition).

(2) In general, the number of birds attempting to breed were similar to last season but breeding success was higher during 2017 relative to recent years.

(3) Generally warm water conditions persisted during 2017. The mean seasonal SST for 2017 was cooler than 2016 but remained higher than the long-term mean. Monthly values were above the mean for all individual months except May and July.

(4) During 2017, breeding populations where higher for most species when compared to 2016. After recording the lowest Western Gull breeding population observed during our time series during 2016, this population rebounded slightly during 2017, while Cassin's Auklets, Pelagic Cormorants, Pigeon Guillemots, and Tufted Puffins exhibited moderate increases. Brandt's Cormorants and Double-crested Cormorants exhibited modest declines while California Gulls and Ashy Storm-petrels exhibited large declines relative to last season. In contrast, Tufted Puffins continued to increase, establishing a new high count for the fifth consecutive year.

(5) Reproductive success was higher for all species except Rhinoceros Auklets, when compared to 2016, though Common Murre, Pigeon Guillemot, and Western Gull remained below the long-term mean for that species.

(6) Juvenile rockfish (*Sebastes spp*.) remained the dominant component of chick diet for Common Murre and Rhinoceros Auklet, though, for auklets they were less abundant than last season. Anchovies were more prevalent than in previous years for all species and tertiary prey like flatfish and saury were also important. Krill once again seemed to be available for Cassin's Auklets throughout the season, allowing for high breeding success and even a few successful second broods.

INTRODUCTION

This report contains information on the reproductive performance and population size of seabirds on Southeast Farallon Island (SEFI; Farallon Islands National Wildlife Refuge) and West End Island (WEI), California, during 2017. We monitored twelve species: Ashy Storm-petrel (ASSP), Double-crested Cormorant (DCCO), Brandt's Cormorant (BRAC), Pelagic Cormorant (PECO), Western Gull (WEGU), California Gull (CAGU), Black Oystercatcher (BLOY), Common Murre (COMU), Pigeon Guillemot (PIGU), Tufted Puffin (TUPU), Rhinoceros Auklet (RHAU), and Cassin's Auklet (CAAU). In addition, small numbers of Leach's Storm-petrels (LHSP) breed on the island but are grouped with ASSP for monitoring. Peregrine Falcon and Common Raven have also bred on SEFI in recent years but did not attempt to do so in 2017, and have not for several years. Three pairs of Canada Geese bred on the island and fledged a total of seven chicks.

METHODS AND RESULTS

<u>Reproductive Performance</u>

The reproductive performance of seabirds on SEFI is summarized in Table 1 and compared to previous years (Fig. 1a, b). All reproductive parameters reported in Table 1 are based on nests in which at least one egg was produced. Clutch size, brood size, hatching success, and fledging success were determined for first attempts only. Hatching success is calculated as the number of chicks hatched divided by the number of eggs laid. Fledging success is calculated as the number of chicks fledged divided by the number of chicks hatched, for clutches in which at least one egg hatched. Productivity (number of chicks fledged per pair) was determined for first attempts and for all attempts (including first attempts, relays, and second-broods). We compared productivity for all attempts to values from the past 44 years for each species. For a detailed description of the methods used to determine reproductive success and breeding population size see Sydeman et al. (1987, 2001). Due to inaccessibility of TUPU crevices and poor visibility of DCCO and CAGU nesting areas, detailed reproductive data were not collected for these species.

Brandt's Cormorant –BRAC productivity increased during 2017 relative to last season. Mean productivity for the colony was 1.81 fledglings per pair. This is approximately 15% greater than last season and 28% higher than the long-term mean productivity for this species (Fig. 1a). The first eggs were observed on 10 May at both the Corm Blind and the Sea Lion Cove colony. The mean laying date for the colony was 26 May. The first eggs were observed on the same date as last season but the mean laying date was 8 days later than the long-term mean for this species. Large scale nest abandonment did not occur this season. All nests which had at least laid an egg were attended regularly, though a few nests still failed. California sea lions continued to haul out high in the Sea Lion Cove colony but cormorant nests were already well established and the sea lions did not appear to cause nest loss, at least among followed sites. Mean clutch size was 2.7 eggs per nest and hatching success was 72%. Mean brood size was 2.54 chicks per nest, 88% of which survived to fledging age. A total of 422 chicks were banded this season with the last chicks departing the colony by early September.

Pelagic Cormorant **–** PECO rebounded this season with above average breeding success during 2017 after experiencing wholesale reproductive failure during 2016. Of the 69 sites followed for productivity estimates, 36 were regularly attended during the season and 32 were confirmed to have laid eggs. Mean productivity for the colony was 1.31 chicks fledged per breeding pair. This is approximately 32% greater than the long-term mean productivity for this species. Hatching and fledging success are difficult to determine for this species due to the small number of nests where we can see the entire contents. However, for those we were able to observe, mean clutch size was 2.59 eggs per nest and mean brood size was 1.63 chicks per nest. Birds began attending sites and building nests in early March but the first eggs were not observed until 6 June. The first chicks were observed on 4 July.

Western Gull **–** WEGU productivity was slightly higher in 2017 when compared to last season, resulting in an average of 0.77 chicks per pair. This is approximately 8% higher than last season but remains 22% below the long-term mean productivity for this species (Fig. 1a). The first eggs were observed on the island on April 25th. Sixty-three percent of the eggs hatched but only 44% of those chicks survived to fledge. Mean clutch size was 2.61 eggs per nest and mean brood size was 1.69 chicks per nest, both roughly equivalent to the last two seasons. There were 411 chicks banded at the colony this season with the last chicks fledging and departing the colony by the end of August.

California Gull **–** CAGU put in a very poor breeding effort during 2017 and once again suffered complete reproductive failure. Very few birds established nests and only a handful were confirmed breeding. As in previous years, we monitored productivity of this species by counting the number of birds, nests, and young from the lighthouse every 5 days throughout the season. Based on these counts we were able to determine that the CAGU did lay eggs but no chicks were ever observed. Continual disturbance from California sea lions in the two main breeding areas on the marine terrace, coupled with persistent breeding failure likely contributed to the low breeding effort.

Black Oystercatcher **–** A total of 30 sites were monitored during 2017, of which 19 were considered active. An active site is defined as: (1) a territory occupied by a pair on at least two occasions during the season; (2) a territory in which a bird was seen in incubation posture; or (3) a territory where an egg or chick was observed. Eggs and/or chicks were documented at 11 of these active sites (58%) and 7 chicks appeared to fledge this season. This resulted in an estimate of 0.37 fledglings produced per pair. This average value is >400% higher than last season and the greatest number of chicks we have observed since 2013. Unusually large numbers of California Sea Lions continued to haul out high on the marine terrace and other traditional oystercatcher nesting areas, directly resulting in the failure of three nest sites and likely reducing overall nesting success. The first eggs were observed on 24 May and the first chicks were observed on 19 June. BLOY nests are cryptic and difficult to observe; therefore clutch size, hatching success and fledging success were not determined. There was one chick banded this season.

Common Murre **–** During 2017, 277 Common Murre sites were monitored daily in the Upper Shubrick Point (USP) study plot, of which 227 were breeding sites (where an egg was laid). Productivity was 0.58 chicks fledged per pair. This is approximately 29% higher than last season but remains 20% below the long-term average of 0.72 (Fig. 1a). Egg laying was slightly later than average with the first egg observed in this plot on 4 May. Overall mean laying date for the plot was 18 May; approximately 5 days later the long-term mean laying date for this colony. Eighty-five percent of eggs hatched but only 67% of the hatched chicks survived to fledge.

As has become the pattern the last few years, the colony of Common Murres in Upper Upper (UU), under the Cormorant Blind, performed much better than the colony at USP. The first eggs were observed on 8 May this season but the mean lay date for the plot was 22 May. There were a total of 163 sites monitored in UU this season; 129 of which were breeding sites, both of which were greater than last season. Reproductive success for this colony was 0.95 chicks fledged per breeding pair. Ninety-five percent of the eggs hatched and 98% of the chicks hatched surviving to fledge (Table 1). There was a much lower incidence of egg loss and gull predation when compared to the USP colony and to previous years at the UU colony.

Pigeon Guillemot **–** A total of 100 sites were monitored during 2017, of which 78 were observed with at least one egg (78% of the total number of sites). The majority of nest sites were located on Lighthouse Hill or at Garbage Gulch, but there were also four sites in the Habitat Sculpture, three in Rhinoceros Auklet nest boxes and one in a Cassin's Auklet nest box. Productivity for 2017 was 0.58 fledglings produced per pair (Table 1). This was approximately 87% greater than 2016 but remains 28% below the long-term mean productivity for this species (Fig. 1a). The first eggs were observed on 27 May, and the mean egg laying date was 11 June. This is 10 days later than last season and 13 days later than the long-term mean laying date for this species. The mean clutch size was 1.55 eggs per nest with 74% of those eggs hatching successfully. Mean brood size was 1.16 chicks per nest but only 56% of the chicks produced survived to fledging age. Only one site successfully fledged a complete brood of two chicks, while 58 sites laid eggs but were not able to fledge any chicks. There were a total of 46 guillemot chicks banded on SEFI this season with the last chick fledging from a followed site on September 14.

Rhinoceros Auklet – There were a total of 152 sites (boxes, crevices, and cave sites) monitored in 2017, 47% (n=72) of which were occupied by a breeding pair. This includes two Rhinoceros Auklets which bred in Cassin's Auklet nest boxes, one pair which bred in a PIGU box at Garbage Gulch, and one pair in the Habitat Sculpture. Forty-two percent of nest boxes were occupied compared to 56% of camera sites, both slightly higher than the occupancy rates in 2016. There were also 16 boxes occupied by other species (14 CAAU and 2 PIGU). Productivity during 2017 was 0.64 fledglings per pair. This is approximately 9% lower than the productivity observed in 2016 and 12% above the long-term mean productivity for this species (Fig. 1a). The first eggs were observed on 17 April and the mean laying date was 3 May. This is approximately 5 days earlier than the long-term mean for this species. Seventy-six percent of the eggs successfully hatched and 85% of those chicks produced survived to fledge. There were a total of 19 Rhinoceros Auklet chicks banded this season with the last chick fledging from a followed site on 29 August.

Cassin's Auklet – Occupancy of breeding birds in study boxes was very high during 2017 with 88% of the boxes (433 of 491) occupied this season, including 41 of 44 PRBO study boxes (93%). This is approximately equal to 2016. Productivity of auklets breeding in PRBO study boxes remained high with 0.93 chicks fledged per breeding pair (including relay attempts). This was 3% greater than 2016 and 24% higher than the long-term average of 0.75 chicks per pair for this species (Fig. 1a). Eighty-five percent of the eggs hatched and 94% of those chicks produced survived to fledge. There were only three second broods attempted this season, two of which were successful. The first egg was observed on 17 April but the mean laying date for PRBO boxes was not until 30 April. This was approximately 11 days later than last season and 13 days later than the long-term average.

For the past several seasons, we have reported the productivity of all followed sites in addition to that of the PRBO study boxes. This was done because we believed that in years of low breeding propensity (such as 2005) the increased sample size enabled us to more accurately reflect the success of the whole island population. The same is probably true for years of very high productivity. If all followed sites where an egg was laid were included in the analysis for this season, productivity would be 0.87 chicks per pair (n=189). This is approximately 6% lower than the estimate derived from PRBO boxes but within 2% to the "all sites" estimate for 2016. There were 12 second broods attempted across all sites, six of which were successful. Island wide, there were a total of 377 chicks banded with the last chick fledging from a followed site on October 20th.

Ashy Storm-Petrel – ASSP pairs laid eggs in 49% of the 109 followed sites (n=53) during 2017, approximately 4% higher than the occupancy rate observed last season. There were 14 new breeding sites discovered during 2017 while 10 previously followed sites were dropped from the study either due to collapse of the LHH wall (7 sites) or because they had not been occupied for at least 6 years (3 sites). There were an additional 3 sites in which an adult bird was observed on at least two occasions but no eggs or chicks were ever confirmed. It is possible that these birds attempted to breed but lost the egg before it could be observed, but for the purposes of our study, they were not considered breeding sites. The first eggs were observed on 24 May and the mean laying date for the colony was 15 June. This is approximately 15 days later than last season. Overall productivity for this species was 0.75 chicks fledged per pair (including all relay attempts). This is approximately 21% higher than last season and 14% above the long-term average productivity for this species (Fig. 1a).

Other breeders – In past seasons, Peregrine Falcons, Common Ravens and Canada Geese have bred on SEFI during the seabird season. However, during 2017, it appears that only the Canada Geese attempted to breed. Five pairs of Canada Geese were present on the island by mid-March and three attempted to nest. The first nest was discovered on the terrace to the south of the Helo Pad on 19 March with 9 eggs. In April, two additional nests were discovered; one on lower Lighthouse Hill behind the Power House that contained 6 eggs, and a third nest on Little Lighthouse Hill above Russia House with 2 eggs. Seven chicks (5 from one nest and 2 from another) were frequently seen accompanying the adults and were seen flying for the first time in early July. All geese departed the island by 13 July.

From mid-March until mid-May, 1-4 Peregrine Falcons were seen daily on SEFI. However, by early May, there was only one falcon sporadically seen around the island and there were no signs of nesting behavior. Peregrines last nested on the island in 2011. Common Ravens were not observed at the island this season and there has been no evidence of nesting since 2011.

<u>Population Estimates</u>

Population size and island-wide chick production was estimated for all species except ASSP and RHAU; breeding population size estimates (number of individuals) are presented in Table 2 and Figure 7. All estimates include West End Island unless otherwise stated.

Ashy and Leach's Storm-petrels – We continued our long-term mark/recapture study to estimate ASSP population trends. We operated our regular netting locations (Lighthouse Hill and Carp Shop) on 8 evenings between April and August. In addition, we conducted 5 additional netting sessions at non-standard sites in order to increase our sample size and to deploy special bands equipped with Radio Frequency Identification Tags (RFID). As a result, we banded a total of 370 new Ashy Storm-petrels and recaptured 69 that had been banded in previous years. In addition, there were 27 ASSP that were caught 2 or more times during the season (including one individual caught 5 times), resulting in a total of 474 birds handled. The mean standardized capture rate during 2017 netting sessions was 14.94 birds per hour (s.e. = 1.38, n= 8; see Figure 10). This is approximately 20% lower than during 2016 and 47% lower than the mean capture rate for the last 10 years. Our most productive netting session was on 22 May during which we captured 60 birds, including 1 recapture of a previously banded individual. There were also 7 new Leach's Storm-petrels banded this season and 1 new Fork-tailed Storm-petrel.

Double-crested Cormorant – The DCCO colony is located on Maintop on West End Island. Counts of this colony were conducted every five days from atop Lighthouse Hill on SEFI using a spotting scope. A total of 20 counts were made in 2017, beginning on 21 April and ending on 25 July, when juveniles became indistinguishable from adults. The colony seemed to initiate breeding exceptionally early with many adults building nests a full week before the traditional start of nesting surveys. On 31 May we counted a peak number of 113 "well-built" nests with birds in incubating posture. To estimate the minimum population size we multiplied the number of well-built nests by two, which yields a total of 226 breeding birds. This estimate is approximately 2.5% lower than 2016 and 32% below the 10-year average population for this species (Table 2). There was a high count of 103 chicks observed during the 15 July census.

Brandt's Cormorant – The BRAC breeding population was censused during ground-based surveys on 9 June. During the survey we counted 2,012 "well-built" nests (Fig. 2). No boat-based was conducted this year so a correction factor was determined to estimate the number of birds nesting on parts of the island not visible from vantage points on SEFI. Over the last five years, the boat census accounted for 12.18% of the Brandt's breeding habitat, while the land census accounted for 87.82%. Therefore, assuming the same proportions, we divided the land count by 0.8782 to arrive at an estimated total of 2,291 well-built nests on the island during 2017. We then multiplied the number of nests by 2 to yield an overall population estimate of 4,582 breeding birds (Table 2). This estimate is 5% lower than 2016 and approximately 29% below the 10-year average (Table 2). This was the fourth consecutive year of declining populations after a brief increase in 2013. We multiplied the total number of nests by the mean productivity to estimate an island-wide production of approximately 3,785 fledglings.

Pelagic Cormorant – The PECO breeding population was censused during a ground-based survey on 9 June. During the census, we counted a total of 116 fair to well-built nests (Fig. 3). As with Brandt's, there was no boat-based conducted this year so a correction factor was determined to estimate the number of birds nesting on parts of the island not visible from vantage points on SEFI. Over the last five years, the boat census accounted for approximately 25.73% of the PECO breeding habitat while the land count accounted for 74.27%. Therefore, assuming the same proportions, we divided the land count by 0.7427 to arrive at an estimated total of 156 well-built nests. We then multiplied this number by 2 to yield an overall breeding population of 312 birds (Table 2). This estimate for Pelagic Cormorants is approximately 1% higher than 2016 and 13% greater than the 10-year average.

Western Gull – The WEGU census was conducted on 6 June. To facilitate counting, the island was sub-divided into plots that were counted individually. Breeders and non-breeding (roosting) birds were counted separately. Counts of roosting birds were not included in the population estimate. The total number of birds counted on the island was 9,739, approximately 1,700 more than last season (Fig. 4). Because not all breeding birds were present at the time of the census, we calculated a correction factor to convert counts of individuals into breeding pairs. The correction factor was derived by multiplying the number of nests in the three study plots (C, H, and K) by 2, then dividing the product by the mean number of adults present in the plots during 3 replicate counts conducted at the same time as the all island census. We then multiplied the average correction factor (1.365) of these three plots by the total number of adults counted to arrive at our population estimate (Appendix I). Therefore, we estimated a total breeding population of 13,245 birds (Table 2). The population estimate for WEGU is approximately 32% higher than during 2016 (which was the lowest ever recorded for the Farallon population) and approximately 20% lower than the 10-year average (Table 2). The estimated population increase was mostly driven by an increase in the raw count and a slightly higher correction factor than last season. However, nest counts in all study plots were actually 13.5% lower, on average, this season when compared to 2016. As with other species, we estimated the overall chick production by multiplying the mean annual reproductive success by the number of breeding pairs to estimate an overall production of 5,099 fledglings on SEFI in 2017.

California Gull – CAGU were censused every five days throughout the season beginning on 6 April. A peak count of only 5 "well-built" nests was counted on 26 May resulting in a breeding population estimate of just 10 birds. This estimate is approximately 67% lower than the estimate for last season and 97% lower than the 10 year mean for this population. The peak count for total birds was 18 on 22 May, down from a peak count of 570 in 2014 and 87 last season. No chicks were produced this season.

Black Oystercatcher - We estimated the population of BLOY by surveying all known breeding sites visible from Lighthouse Hill and the marine terrace. Of the 38 sites that were monitored this year, 19 were considered active sites. Therefore, we estimated a breeding population of 38 birds, an increase of 36% relative to 2016 and approximately equal to the 10-year average population (Table 2). We estimated an island wide production of 7 chicks fledged. This estimate does not reflect birds that may have nested on parts of West End Island not visible from the SEFI vantage points.

Common Murre – The COMU breeding population is estimated in two ways. USFWS conducts annual aerial photographic surveys and counts the number of birds present in the photos when money for analysis becomes available. Unfortunately, while the raw photos exist, counts are not completed for all seasons. So, in order to continue to track population trends on an annual basis, Point Blue biologists count a subsample of the population contained within 23 individual Index Plots set up around SEFI and WEI. These are counted in early June during the peak incubation period. Each plot is counted three times each day for 10 consecutive days. Trends are determined by comparing the overall seasonal mean plot counts to the counts from the previous year to develop an index of population change. The mean plot counts for this season were approximately 2% lower than during 2016 (Figure 11) but still 24% higher than during the last complete all-island count. If we were to apply the percent difference in the index plots to the last complete all-island count, we may estimate a population of approximately 263,000 birds (Figure 7).

As in previous years, a correction factor was calculated using data from two of our study plots (Upper Shubrick Point and Upper Upper) to account for breeding adults not present during the census (Nur and Sydeman 2002). The correction factor was derived by multiplying the number of breeding sites in each plot by 2, and then dividing the product by the mean number of adults present on the survey dates (Appendix II), yielding a correction factor of 1.64. This method assumes that the additional birds observed in the plots are the mates of breeding individuals and not simply wanderers or non-breeders. This correction factor may be used to convert the number of birds counted during USFWS aerial surveys into an estimate of breeding pairs.

Pigeon Guillemot – Our estimate of the breeding population of PIGU is derived by counting adults rafting on the water around SEFI at dawn (0700-0830) throughout the month of April, before the birds begin regular attendance of sites. Our peak count during these morning surveys was 2,044 birds on 24 April. This count was approximately 2% higher than the peak count from 2016 but still 36% lower than the 10 year mean for morning surveys (Table 2 and Fig. 7). It is worth noting that persistent fog and strong winds during the last week of April prevented counts during the period immediately following our high count. As a result, it is possible that we missed the peak count and this estimate should be considered conservative.

Tufted Puffin – The island-wide TUPU survey was conducted primarily in two parts; from 24 May to 6 June and a second survey from 29 July to 11 August. The criteria for determining if a site was occupied by a breeding pair were as follows: (1) two or more sightings of a bird entering the site or two birds seen at the site on multiple occasions, (2) one or more sightings of a bird entering the site with nesting material early in the season, or (3) one or more sightings or a bird entering a site with fish late in the season. Note that survey methodologies were changed after the 2007 season to include a more comprehensive late season survey. See the 2008 report for details.

During the 2017 surveys, a total of 198 active sites were observed. Thirty-two sites were confirmed with chicks based on observations of birds delivering fish to the site and an additional 7 sites were observed with likely prey deliveries. Based on these observations, we estimated a breeding population of 396 birds (Table 2). This estimate is 5% greater than during 2016 and 78% greater than the 10-year average population for this species. The 2017 estimate once again surpassed the previous record high count in our time series (Fig. 7). This is the fifth consecutive season and eighth time in the last 10 seasons that the puffin population has set a new high count.

Rhinoceros Auklet – An island-wide estimate of breeding population size for RHAU is difficult to obtain because they nest underground and are crepuscular (active only at dawn or dusk). However, netting for mark/recapture and diet sampling was continued in 2017. A total of 40 new birds were banded and 60 were recaptured (15 birds were recaptured multiple times during the season). While recapture rates were similar to last season, the number of new birds banded during netting sessions was approximately 40% lower than last season.

Cassin's Auklet – Similar to the RHAU, CAAU is another burrow/crevice-nesting nocturnal seabird that is difficult to census. In 1991 we established twelve 10 x 10m index plots to monitor burrow density (Table 3). A complete census of nest sites on SEFI was conducted in 1989, at which time a breeding population of 29,880 birds was estimated (Carter et al. 1992). To estimate the breeding population in prior years, we applied the percent difference between the 1991 and current year counts in the index plots to the 1989 estimate. This calculation assumed that burrow counts in our index plots did not differ substantially between 1989 and 1991. Although index plot counts from 1989 are not available to test this assumption, this method provided our best estimate of population size and was employed until 2009. In September of 2009, we conducted a new all island burrow count, replicating the methods used by Carter et al. (1992). This method resulted in an estimate of only 14,512 Cassin's Auklets on SEFI and 17,640 including West End and the Islets.

During 2017, we counted a total of 326 burrows/crevices in the index plots. Therefore, using the same methodology, but with the updated whole island estimate generated in 2009, we estimated a 2017 breeding population of roughly 21,026 birds ([326/225] x 14512) on Southeast Farallon Island. Total island-wide production (number of breeding pairs x mean productivity) was estimated at 9,777 fledglings on SEFI. The breeding population estimate is approximately 5% higher than in 2016 and 7% higher than the 10-year average (Table 2).

Ocean conditions and Seabird Diet

Sea surface temperature (SST) is measured daily from water temperature point near East Landing as an indicator of local ocean conditions. During 2017, the mean seasonal SST from March to August was 12.27°C. This was 0.28°C cooler than the 2016 season but still 0.27°C warmer than the long-term mean for these months. Monthly values were above the mean for all individual months except May and July (Fig. 6a, b).

Chick provisioning data is collected throughout the chick rearing period for five species as a means of determining diet and feeding rates and as an indicator of local ocean conditions. Diet data is determined from standardized diet watches (COMU and PIGU), collection of dropped or regurgitated prey items (CAAU and RHAU) or by collecting regurgitated pellets of indigestible materials at the end of the season (BRAC). During 2017, juvenile rockfish were once again an important prey item in chick diet throughout much of the chick rearing period (Figs. 8 and 12), but overall proportions in the diet were reduced. Rockfish comprised 61% of the diet for Common Murres, 44% for Rhinoceros Auklets, and 25% for Pigeon Guillemots. As was seen during the past two seasons, the vast majority of the juvenile rockfish that were identified to species (70%) this season were Shortbelly Rockfish (*Sebastes jordanii*). The Shortbelly Rockfish were the main species encountered in seabird diet during the 70's and 80's but have generally been less dominant over the past two decades when a more varied species assemblage (including Yellowtail, Widow, Blue and Black Rockfish) has been more common. In addition to rockfish, anchovies were a significant component of the diet for Common Murres and Rhinoceros Auklets during 2017. Anchovy accounted for 35% of the diet for Common Murres and 28% of the Rhinoceros Auklet diet (Fig. 8). Flatfish, sculpins, saury, and squid were other important components of the diet this season but in relatively small proportions. Preliminary analysis of a subsample of Brandt's Cormorant pellets indicates a greater reliance on anchovy (55%) and flatfishes (17%), and a reduced consumption of rockfish (20%) compared to recent seasons (Fig. 12). Cassin's Auklet diet cannot be identified in the field and is still being analyzed but preliminary results suggest that krill was abundant throughout the season.

DISCUSSION

Weather and Ocean Conditions

Local oceanic conditions were generally average to slightly above average during 2017, with the seasonal average lower than the previous three summers. ENSO neutral conditions were present during the late winter and spring, resulting in generally average oceanic conditions throughout the summer. Typically, cool SSTs are correlated with greater ocean productivity in the California Current System resulting from stronger upwelling along the coast whereas warmer waters are generally nutrient poor and less productive (Barber et al. 1985). As may be expected, the generally average oceanic conditions resulted in generally average breeding success for most species with some just above the long-term mean and others just below but no anomalously poor or exceptionally good results. For many species, breeding was delayed relative to last season and the long-term mean, yet conditions remained favorable enough to result in second broods for Cassin's auklets.

Rockfish are an important component of seabird diet at the Farallones and a high proportion of rockfish in the diet typically correlates with high productivity. During 2017, juvenile rockfish were once again a major proportion of the diet but somewhat reduced in abundance compared to previous years. Furthermore, the rockfish in the murre and guillemot diet appeared to be smaller this season, resulting in less energy gained per fish delivery. The overall reduced abundance and smaller size likely played a role in lower than average breeding success and reduced feeding rates this year. With the reduced abundance of rockfish in the diet, seabirds relied more heavily on anchovy, flatfishes, and other alternate prey to make up the difference. This often leads to longer foraging trips and more energy expended by adults when provisioning dependent offspring.

Anchovies were the most important component of chick feedings for murres and auklets between 2002 and 2008 and were also a major component of Brandt's cormorant diet during years of high reproductive success (Fig. 12). This important prey had all but disappeared from the diet of Farallon seabirds between 2009 and 2014 but has returned as a major diet component during the last three years.

Productivity

The 2017 seabird breeding season was a mixed year in terms of productivity (Fig. 1a, b). All species except Rhinoceros Auklets experienced higher breeding success relative to last season. Rhinoceros Auklets were the only species to have lower productivity, but it remained greater than the long-term mean for this species. Likewise, Brandt's Cormorant, Pelagic Cormorant, Cassin's Auklet, and Ashy Storm-petrel all exhibited greater than average success while Common Murres, Pigeon Guillemots, and Western Gulls were slightly below average.

Black Oystercatchers had relatively good reproductive success in 2017 with a total of 7 chicks fledged, despite three nests being destroyed by California sea lions during the season.

As in previous years, we have included the 80% prediction interval (dashed horizontal lines) on the long-term productivity graphs (Fig. 1a) to help illustrate the signals in the annual mean productivity and to highlight the extreme years (i.e. those years that fall into the upper or lower 10% of the distribution). Note that strong El Niño years (1983, 1992, and 1998) fall below this range for most species while exceptionally good years will surpass the upper range. The 2015/2016 El Niño was reported as one of the strongest on record so we expected to see similar results to those previous years. This year all species were well within this range (Fig. 1a), further indicating average conditions.

Cassin's Auklets continued to exhibit relatively high productivity. 2017 marks the 9th consecutive year they have averaged greater than 0.9 chick fledged per pair after having only achieved that mark 4 times in the previous 38 seasons. They fledged the vast majority of chicks from first broods and a few individuals were able to successfully raise second broods. Cassin's Auklets are the only alcid capable of successfully fledging multiple broods in the same season, and they only do this in the southern portion of their range (Ainley et al. 2011). Given the ability to double brood is driven in part by upwelling strength in the region (Johns et al. 2017), this suggests that conditions were good enough throughout the season and into the fall to allow successful chick rearing and that prey remained available even late into the season.

In contrast, reproductive success of COMU, though better than last season, remained below the mean for the 4th consecutive year. Western Gull predation continues to be an issue for the USP study plot, resulting in lower overall fledging success. This coupled with reduced feeding rates and a reduction of juvenile rockfish in the diet led to reduced productivity. In contrast, the UU colony, where predation was not an issue this year, had relatively very high hatching and fledging success with 95% of eggs hatching and 98% of chick hatching surviving to fledge. After 23 straight years during which the USP study plot had the highest productivity of the followed sites on the island, the Upper Upper plot has now achieved higher success over the last four seasons (Table 1). The reasons for the switch seem to be related to higher predation by Western Gulls in the USP colony.

Rhinoceros Auklets exhibited higher than average breeding success for the fifth consecutive year despite a small decline relative to last season. The overall productive year was likely buoyed by the availability of juvenile rockfishes throughout the season coupled with an increase in anchovy abundance. Pigeon Guillemot productivity, in contrast, remained below average due to poor fledging success, particularly of second chicks. High productivity years for guillemots are driven by their ability to fledge the second chick from their broods. In productive years there is enough food available to feed both chicks and feeding rates are high enough that sibling competition is reduced. The opposite is true in poor years. During 2017, only 1 out of 78 sites which laid eggs was able to fledge both chicks. As with the auklets, rockfish remained an important component of chick diet but were not as abundant as in the last few seasons while flatfishes were relatively more abundant.

Brandt's Cormorants experienced higher reproductive success this season compared to 2016 but overall nest numbers were reduced. Interestingly, while several nests did ultimately fail, there were no recorded cases of nest abandonment this season. This is somewhat uncommon even in productive seasons. Pelagic Cormorants likewise rebounded nicely from total breeding failure during 2016 to produce a slightly higher than average number of chicks. Although egg laying appeared to be delayed, conditions during the middle and later parts of the season were sufficiently good to allow chicks to fledge.

Western Gull productivity, though greater than last season, remained below the long-term mean. Clutch size, brood size and hatching success were all similar to last season, but fledging success was slightly higher. Intraspecific predation continued to be the single greatest cause of mortality.

Ashy storm-petrel productivity increased relative to last season and was among the highest observed since the mid-90's. As with other species, storm-petrels initiated breeding later with the last chick fledging in mid-December. There did not seem to be a strong seasonal pattern in relation to fledging success as chicks that hatched earlier in the season fledged at about the same rate as those hatched later.

Other colonies monitored by Point Blue in central California showed similar patterns. The Brandt's Cormorant population at Vandenberg Air Force Base increased by almost 250% over 2016, and is more than half again as large as the 18-year average. The Pelagic Cormorant population also increased by 18% over last year, and is 30% greater than the 18-year average. Productivity for both species was higher than the previous three years, and values for both have returned to average. The population of Black Oystercatchers and Western Gulls remained similar to last year but about 14% above the 18-year average. Black Oystercatcher productivity was almost 7 times higher than last year, and is 35% higher than average, whereas Western Gulls almost doubled their productivity over last year, achieving slightly higher than average breeding success. (Robinette et al. 2017; J. Howar pers. comm).

Populations

Breeding population sizes were higher than the 2016 estimates for all species except Brandt's Cormorant, Double-crested Cormorant, Common Murre, and California Gull. Decreases ranged from approximately 3% for Double-crested Cormorants to 67% for California Gulls when compared to last season. Increases ranged from 1% for Pelagic Cormorants to 35% for Black Oystercatcher.

Pigeon Guillemot population estimates reported in this document do not necessarily represent breeding birds because the census method does not distinguish between breeders and non-breeders. The raft counts used to estimate the Pigeon Guillemots most likely reflect the total population attending the colony during the pre-breeding period, but may not represent the proportion of the population that breeds. That said, they typically rise or fall in concordance with measures of nest site occupancy, suggesting that they are a reliable index of overall trends in breeding guillemot abundance. During 2017, guillemot numbers increased by about 1% relative to last year. In contrast, occupancy of monitored PIGU crevices was slightly lower this season with approximately 81% of historically followed sites used by breeding guillemots during 2016, down from 85% last season. It is also possible that our raft count survey period ended prior to the peak in rafting activity of that some birds did not return to the colony until they were ready to breed. Breeding was slightly delayed this season so it is likely that some guillemots also returned to the island later this season and were not captured in our raft censuses.

Common Murres are by far the most abundant species present on the Farallones with greater than 250,000 birds. Though this remains low compared to historic estimates exceeding half a million birds, it represents tremendous recovery from previous population declines (Ainley and Lewis, 1974; Sydeman et al. 1997; Warzybok et al. 2016). While we no longer census the entire island, we continue to track murre population trends using our index plots. Index plot counts indicated a slight decrease (~2%) in murre numbers this year when compared to 2016 but overall counts remain approximately 25% higher than the last full island census in 2006 with relatively little change in the last 5 years, indicating that the rapid population growth experienced during the early to mid-2000's has leveled off.

It should be noted that although we believe that overall index plot trend reflects the population trend for the island, much of the change may be driven by differences in only a few of the index plots, particularly in the lower density plots on Fertilizer Flat, West End and the Islets. Other plots have remained stable or changed in opposition to the overall trend. The relative ability to detect changes in murre numbers is related to the level of saturation in a plot. Plots that are already very dense would not have the power to detect population growth because there is simply no room for more birds to breed in these areas. Conversely plots that are sparse have plenty of area for more birds to colonize but would not necessarily detect declines. Therefore, we believe that by combining the data from all of the plots we get a representative sample for the colony as a whole.

Farallon Cassin's Auklets declined considerably since the early 1970's (Fig. 7), and remain at less than one-third of the population estimate made in 1972. Unfortunately, no information is available on population numbers between 1972 and 1989. This population suffered substantial mortality during the strong 1997/1998 El Niño event and reached its lowest abundance (10,458 birds) in 1998. Between 2001 and 2004, the population was increasing rapidly. However, the breeding population declined again during 2005 and 2006, coinciding with reduced breeding effort and lower reproductive success before rebounding to approximate peak numbers by 2014. Warm ocean temperatures over the last two seasons coupled with a large increase in the number of California sea lions that haul out on the marine terrace have led to reduced burrow counts during the last two seasons. Burrow and crevice counts for 2017 were approximately 5% higher than in 2016 and 20% higher than the long-term average number of burrows observed since the index plots were established in 1991 (Table 3). The greatest increases were in burrow counts in areas with deep soil on the marine terrace. These plots were overrun with California sea lions during 2016 leading to very low burrow density that season. However, with fewer sea lions hauled out on the Marine Terrace during 2017, Cassin's were able to reoccupy these areas. Very high nest box occupancy during 2017 suggests that despite lower burrow density relative to a few years ago the overall number of birds breeding remains relatively stable. Our breeding population estimate assumes that habitat availability and mean nest site occupancy rates are relatively stable and similar to those observed during the last full island census in 2009. The loss of some nesting habitat due to the sea lion incursion may artificially lower our estimate if those birds were able to move to a different location on the island.

Tufted Puffin population estimates are based on the overall number of active sites observed during our surveys. The Farallon population has exhibited a continuous increasing trend since 2008, with 2017 once again setting a new high for the number of active nest sites observed for this species on the Farallones. While puffins continue to decline in other regions along the west coast, the Farallon population appears to be doing very well.

Approximately 50% of the world population of Ashy Storm-petrels breeds on the Farallones, but little is known about their true population status. Sydeman et al. (1998) reported a 35% decline in their population between 1972 and 1992 while analysis of a population index derived from catch per unit effort during netting suggests alternating periods of growth and decline (Bradley et al. 2011; Nur et al. in review). The mean catch per unit effort this season was approximately 20% lower than the capture rate for 2016 and the lowest capture rate observed at the Farallones since 2003. In contrast, crevice occupancy was similar to last season suggesting that the breeding population may not have dropped as much as the overall catch rate.

Recent new analysis, with updated methods and excluding suspected transients from the mist net data, confirmed the strong negative relationship between the abundance of burrowing owls during the winter-early spring and over-winter survival of ashy storm-petrels (Nur 2017). Analyses of storm petrel population size indicated that the declining trend seen from 2005 to 2010, during the time of increasing burrowing owl attendance, has abated in the most recent time period, 2010 to 2015, coinciding with a modest reduction in burrowing owl attendance (Nur 2017). However, further reduction in owl numbers is needed to produce an increasing population (Nur 2017). The population model we developed can provide guidance to managers in planning and implementing steps to aid a species of conservation concern and facilitate recovery.

Brandt's Cormorant and Pelagic Cormorant populations have gone through periods of growth and decline since the early 1980's (Nur and Sydeman 1999, Fig. 7) but began to recover during the early 2000's. The BRCO breeding population expanded rapidly from 1999 to 2007, but declined rapidly following the 2007 season. It is likely that some of the apparent decline was a result of birds either skipping breeding due to unfavorable conditions or moving to a different colony. Recent regional population trends analysis have demonstrated a regional shift in the population from the Farallones to more mainland colonies that has occurred over the last decade in response to changes in the abundance and distribution of anchovy (Ainley et al. 2018). After a sharp increase in 2013, the Brandt's population on the Farallones has declined during each of the past four seasons. The current population remains less than one-third of the population observed before the crash but are equivalent to population estimates made during the early 2000's. The Pelagic Cormorant breeding population peaked in 2004. However, the population crashed following that season and has been slow to recover. Breeding populations were extremely low through 2007 but had been slowly increasing in recent years before suffering another mini-crash in 2015, followed by incremental growth the last two seasons (Fig. 7). Other central CA sites experienced similar population growth this season.

<u>Summary</u>

The 2017 seabird breeding season was characterized by average sea-surface temperatures (SST) throughout most of the season. The mean seasonal SST for 2017, though lower than last season, was above the long-term average while mean monthly values remained slightly warmer than the long-term mean for most months. Warm water conditions, such as those observed during the recent El Niño, typically lead to unproductive ocean conditions, very low breeding success and even breeding failure for seabirds. The reverse is also true with cold water typically leading to greater productivity. The generally average conditions observed this season were more favorable than the previous two seasons and resulted in roughly average reproductive success. Cassin's Auklets attempted few second broods but did manage to successfully fledge chicks from several of them, with the last chicks fledging in October. While that is very late for auklets, it is a sign of generally productive ocean conditions persisting late into the fall.

During 2017, breeding populations were largely similar or slightly higher than last season. California Gulls and Ashy Storm-petrels (CPUE from mistnetting) were the only ones to exhibit significant declines while Western Gulls were the only species to show significant growth. The California Gull colony has been declining for the last several years and has been largely unsuccessful since they colonized the island in 2008. However, populations in and around San

Francisco Bay continue to thrive so the decline of the Farallon population is not of great concern.

Juvenile rockfish, always an important component of chick diet in productive years, was less abundant for most species while anchovy, flatfish, and saury increased in importance. The reduction in rockfish abundance likely prevented species from achieving higher productivity but successful prey switching allowed them to still achieve average or better reproductive success. Although diet analysis has not been completed, preliminary visual inspection of Cassin’s diet samples indicated that krill remained the dominant item in auklet prey. This likely allowed for the continued high breeding success for Cassin’s auklets and resulted in the production of enough juvenile forage fish for other species to fledge their chicks despite overall unfavorable conditions.

With ENSO neutral conditions persisting into the fall and La Niña conditions forecast for this winter and next spring, we would expect conditions to improve and for seabirds to experience a more productive season next year.

RESEARCH AND MANAGEMENT RECOMMENDATIONS

In addition to the continuation of research efforts, we recommend the following actions (listed in order of priority) for enhancing the protection, conservation and management of seabirds on SEFI:

1. Our results on the impacts of Burrowing Owls on Ashy Storm Petrel populations, form Nur et al. (in review), provide support for proceeding with efforts to reduce burrowing owl numbers on the Farallon Islands National Wildlife Refuge as a means to aid a species of conservation concern and facilitate recovery in the future. Novel techniques to aid in our understanding of ASSP populations should also be strongly considered. The first use of PIT tags and RFID readers was implemented during 2017 but technical difficulties prevented us from fully evaluating their success. We recommend continuing this work in 2018 and possibly integrating some physiological studies to further our understanding of the linkages between birds caught during mist-netting and breeding birds.

2. To further our understanding of the foraging ecology of SEFI seabirds, we recommend continuation and expansion of novel monitoring techniques including deployment of time-depth recorders, GLS and GPS tags (or similar devices) on multiple species of marine birds. This work has begun for CAAU, RHAU, and PIGU and should be considered for BRAC and COMU. Expanding the use of instrumentation to more species will allow us to inform management challenges from a community (instead of individual species) approach and to understand Farallon population trends (e.g. how food is affecting Cassin's Auklets and Brandt's Cormorants) in support of management decisions. Novel technology will also allow us to examine marine habitat use and foraging behavior, which is critical to the evaluation of current and potential new marine protected areas around the Farallon Islands NWR.

3. Relatively little is known about the activities of Farallon seabirds during the non-breeding season. We recommend the development of new research initiatives to examine the diet, energy expenditure, behavior, habitat use and environmental interactions of seabirds during the portion of their annual cycle when they are away from the colony in order to develop a more complete understanding of the factors influencing the Farallon populations. The first step in this direction was taken the last two seasons with the deployment of small GLS tags on Cassin's and Rhinoceros Auklets. These data are currently being analyzed and are showing some interesting patterns and we recommend increased efforts on these and other species.

4. Tufted Puffins are difficult to monitor and little is known about their reproductive success on the Farallones. With populations declining along much of the west coast of the U.S. it becomes more important to develop an understanding of the factors influencing this species. We propose assessment and modification of our research methods, including the potential use of nest boxes or nest cameras to allow limited monitoring of the breeding parameters for this species.

5. To understand and mitigate the effects of increasing average air temperature on seabirds nesting in artificial nest boxes, we have conducted a series of studies that examined differences in microclimate among traditional nest boxes, new nest box designs, and natural burrows. Several prototypes for new nest box designs and materials were deployed and tested during 2016 and 2017, leading to the development of a final design which will help facilitate research and be adaptable to a changing climate. Support will be needed to continue with the production and installation of more of these new style nest boxes in future seasons.

6. The Farallon Islands are a unique and fragile ecosystem which are likely to be greatly affected by the impacts of climate change including increasing air temperature, rising sea level, and disruption of ocean food webs. As such, it is important to conduct a SEFI specific climate change vulnerability assessment and develop a comprehensive climate-smart restoration plan for the Farallon Islands. Once completed, this plan can serve as a model for other coastal islands and seabird breeding areas and lead to island ecosystems with increases in plant and animal populations that are robust enough to survive the impacts of climate change.

7. For the last several years California sea lions have been hauling out on the marine terrace in increasingly large numbers. This behavior was not previously observed and is having an impact on several species of nesting seabirds, including Brandt's Cormorants, Cassin's Auklets, California Gulls and Black Oystercatchers. To quantify this impact, we propose to continue monitoring how sea lion distribution is changing and determine how much nesting habitat is being lost as a result. We suggest further analyzing the overall impacts that these changes may have on population estimates and productivity of these species.

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TABLES

Table 1. Mean (± 1 SD) productivity of eight species of seabirds at Southeast Farallon Island, California, 2017. Sample sizes in parentheses. All values based on first attempts only unless stated otherwise.

Species	Clutch Size (no. eggs laid)	Brood Size (no. chicks hatched)	Chicks Fledged/Pair	Chicks Fledged/Pair (includes relays)	Hatching Success	Fledging Success
BRCO	2.71 ± 0.64 *(70)*	2.22 ± 0.84 *(69)*	1.80 ± 0.93 *(75)*	1.81 ± 0.91 *(75)*	0.80 ± 0.28 *(68)*	0.81 ± 0.33 *(65)*
PECO	2.59 ± 0.62 *(17)***	1.63 ± 0.86 *(33)***	1.31 ± 0.89 *(36)*	1.31 ± 0.89 *(36)*	0.67 ± 0.38 *(10)*	0.92 ± 0.18 *(20)*
WEGU	2.61 ± 0.59 *(160)*	1.69 ± 1.09 *(160)*	0.77 ± 0.95 *(160)*	0.77 ± 0.95 *(160)*	0.63 ± 0.39 *(160)*	0.44 ± 0.42 *(127)*
COMU* USP	1.00 (227)	0.85 ± 0.35 (227)	0.57 ± 0.50 (227)	0.58 ± 0.50 (227)	0.85 ± 0.35 (227)	0.67 ± 0.47 (194)
COMU* UU	1.00 (129)	0.95 ± 0.21 (129)	0.94 ± 0.24 (129)	0.95 ± 0.21 (129)	0.95 ± 0.21 (129)	0.98 ± 0.13 (123)
PIGU	1.55 ± 0.50 *(78)*	1.16 ± 0.74 *(77)*	0.58 ± 0.52 *(77)*	0.58 ± 0.52 *(77)*	0.74 ± 0.42 *(77)*	0.56 ± 0.39 *(59)*
RHAU*	1.00 *(71)*	0.76 ± 0.42 *(71)*	0.64 ± 0.48 *(69)*	0.64 ± 0.48 *(69)*	0.76 ± 0.42 *(71)*	0.85 ± 0.36 *(52)*
CAAU* PRBO	1.00 *(41)*	0.85 ± 0.36 *(41)*	0.80 ± 0.40 *(41)*	0.93 ± 0.41 *(41)*	0.85 ± 0.36 *(41)*	0.94 ± 0.24 *(35)*
CAAU* ALL	1.00 (189)	0.87 ± 0.33 *(189)*	0.80 ± 0.40 *(189)*	0.87 ± 0.42 *(189)*	0.87 ± 0.33 *(189)*	0.92 ± 0.28 *(165)*
ASSP*	1.00 *(53)*	0.84 ± 0.37 *(51)*	0.75 ± 0.43 *(53)*	0.75 ± 0.43 *(53)*	0.84 ± 0.37 *(51)*	0.93 ± 0.26 *(43)*

* COMU, RHAU, CAAU and ASSP lay only one egg per clutch

** PECO sites are difficult to see into. Numbers are based on the maximum number of eggs or chicks observed

Note: CAAU "PRBO" productivity presented here is based on the PRBO study boxes only, and is the same as the long-term timeseries. CAAU "ALL" is the mean productivity observed across all monitored sites including PRBO, Known-Age and Habitat Sculpture boxes.

Table 2. Breeding population size estimates of seabird species on the South Farallon Islands, 2007-2017. Estimates include Southeast and West End Islands unless otherwise noted.

Species	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2007-2016 average
DCCO	226	232	104	364	364	220	360	260	194	206	444	275
BRCO	4,582[b]	4,824	5,742	6,566[b]	7,412	3,450[b]	4,916	5,132	1,248	4,840	20,788	6,492
PECO	312[b]	308	234	440[b]	372	298[b]	206	320	268	250	64	276
WEGU	13,245	10,044	11,164	18,686	21,148	15,846	17,406	18,218	15,747	20,152	15,852	16,426
CAGU	10	30	184	514	522	70	208	396	192	534	-	294
BLOY	38	28	38	46	36	40	48	38	38	40	42	39
PIGU [d]	2,044	2,009	3,157	4,459	3,880	3,645	3,461	3,317	2,851	2,875	2,774	3,243
TUPU [c]	396	376	326	288	286	244	246	234	216	106	59	238
CAAU [a]	21,026	20,059	25,606	28,444	22,574	19,607	17,866	12,964	14,512	16,121	19,540	19,729

[a] Estimate for Southeast Farallon Island only. Estimate from 2009 to present based on 2009 whole island burrow/crevice count. Prior to 2009 all estimates were based on 1989 survey (see text)

[b] No boat census conducted. Total estimate generated using correction factor for areas not surveyed.

[c] TUPU population estimates were recalculated in 2008 to correct for unequal survey effort in prior seasons (see text)

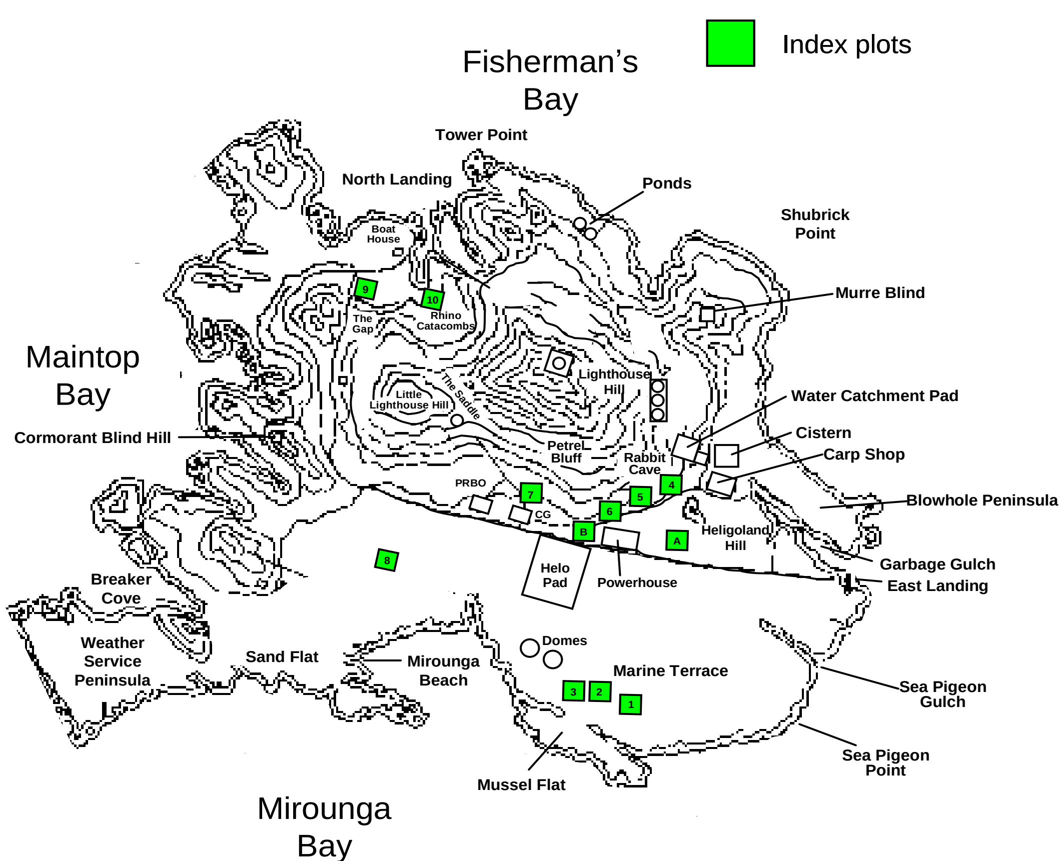
[d] Estimates derived from morning raft counts. Evening counts used prior to 2002 and are considerably lower (see text).

Table 3. Cassin's Auklet burrow counts from 12 (10m x 10m) index plots on Southeast Farallon Island for 2017. The previous 10 seasons as well as the initial plot counts from 1991 are shown for comparison.

Year	MT1	MT2	MT3	S4	S5	S6	S7	MT8	R9	N10	EA	EB	Total
1991	18	9	12	43	42	22	31	20	80	49	14	27	367
2007	26	13	23	18	14	6	17	10	73	22	5	13	240
2008	17	13	20	20	15	8	14	2	53	20	2	14	198
2009	13	11	27	11	5	5	8	8	81	41	2	13	225
2010	14	9	16	10	9	3	11	9	73	29	0	18	201
2011	17	14	27	12	9	4	17	9	90	54	1	23	277
2012	31	25	33	15	11	4	14	-	91	48	6	26	304
2013	31	31	26	17	15	4	16	11	98	60	7	34	350
2014	39	41	38	15	18	7	24	28	101	78	8	44	441
2015	39	25	23	29	27	17	21	26	90	54	14	32	397
2016	4	13	27	25	23	5	24	7	84	60	9	30	311
2017	10	14	37	24	27	8	4	20	83	47	16	36	326
2006-2015 average	25	20	26	16	14	6	16	13	83	45	5	24	293

Note: Plot MT8 not counted in 2012 due to high pinniped numbers and cormorants breeding in the area. Low burrow counts in plots MT1,2,3 and 8 in 2016 are likely due to extremely high numbers of California Sea Lions hauling out and crushing burrows in those areas.

Cassin's Auklet Index Plots



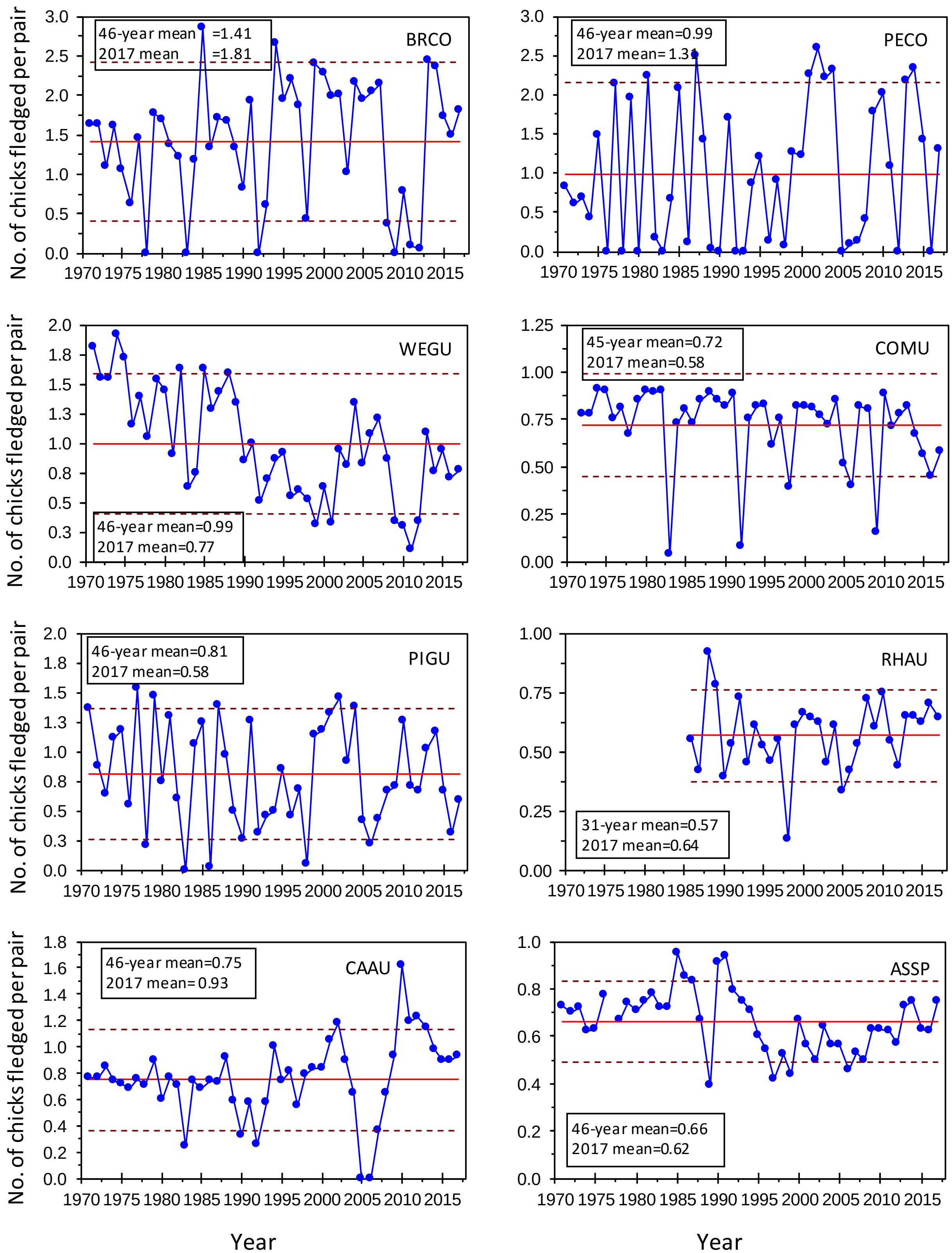


Fig. 1a. Productivity of 8 species of seabirds on Southeast Farallon Island, 1971-2017. Productivity is measured as number of chicks fledged per breeding pair (includes first attempts, relays and second broods). The bold horizontal line indicates mean productivity from all attempts between 1971 and 2016. The dashed lines represent the 80% prediction interval around the long term mean. Please note the different scales on the y-axis.

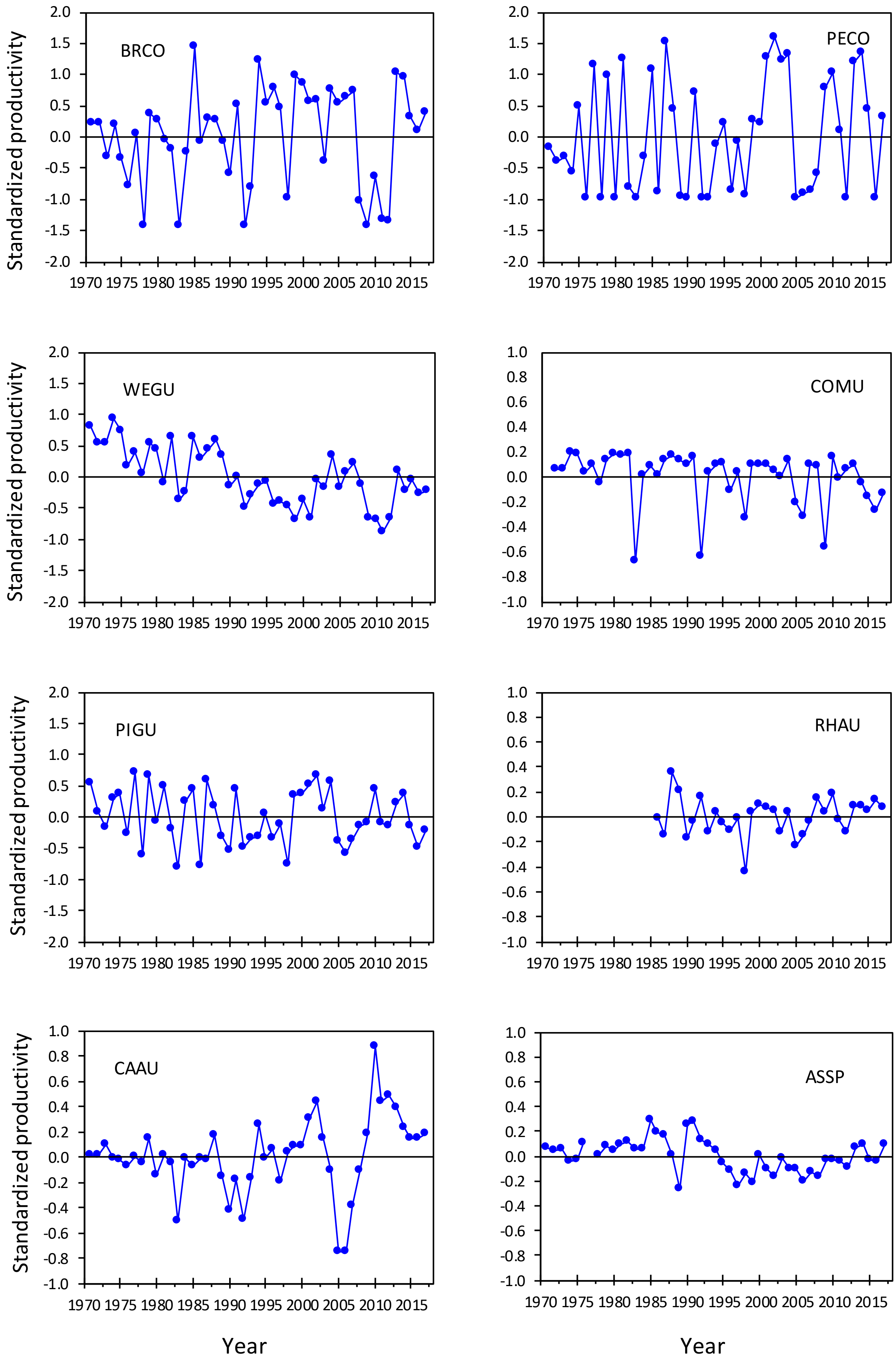


Fig 1b. Standardized productivity anomalies (annual productivity - long term mean) for 8 species of seabirds on SEFI, 1971-2017.

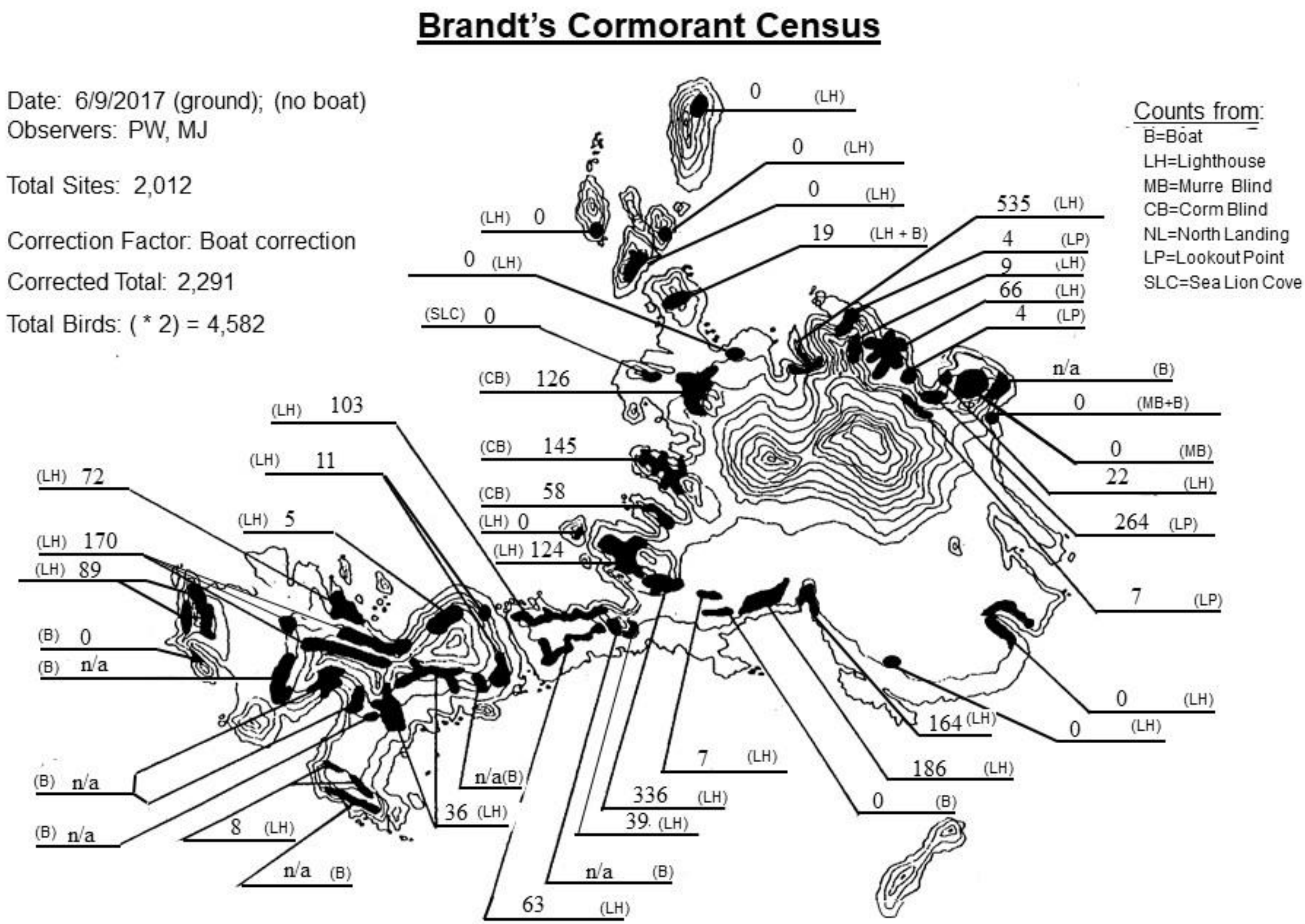


Figure 2: Counts of Brandt's Cormorants on Southeast Farallon Island during the 2017 census. Surveys were conducted from the following locations: Lighthouse Hill (LH), Murre Blind (MB), Cormorant Blind (CB), North Landing (NL), and Boat (B).

Pelagic Cormorant Census

Date: 6/9/2017 (land), (no boat)
Observers: PW, MJ

Total Sites: 116

Correction Factor: Boat correction

Corrected Total: 156

Total Birds: (corrected total * 2) = 312

Counts from:
B=Boat
LH=Lighthouse
MB=Murre Blind
CB=Corm Blind
NL=North Landing
LP=Lookout Point
HS=USFWS House
MBT=Murre Blind Trail
SPG=Sea Pigeon Gulch

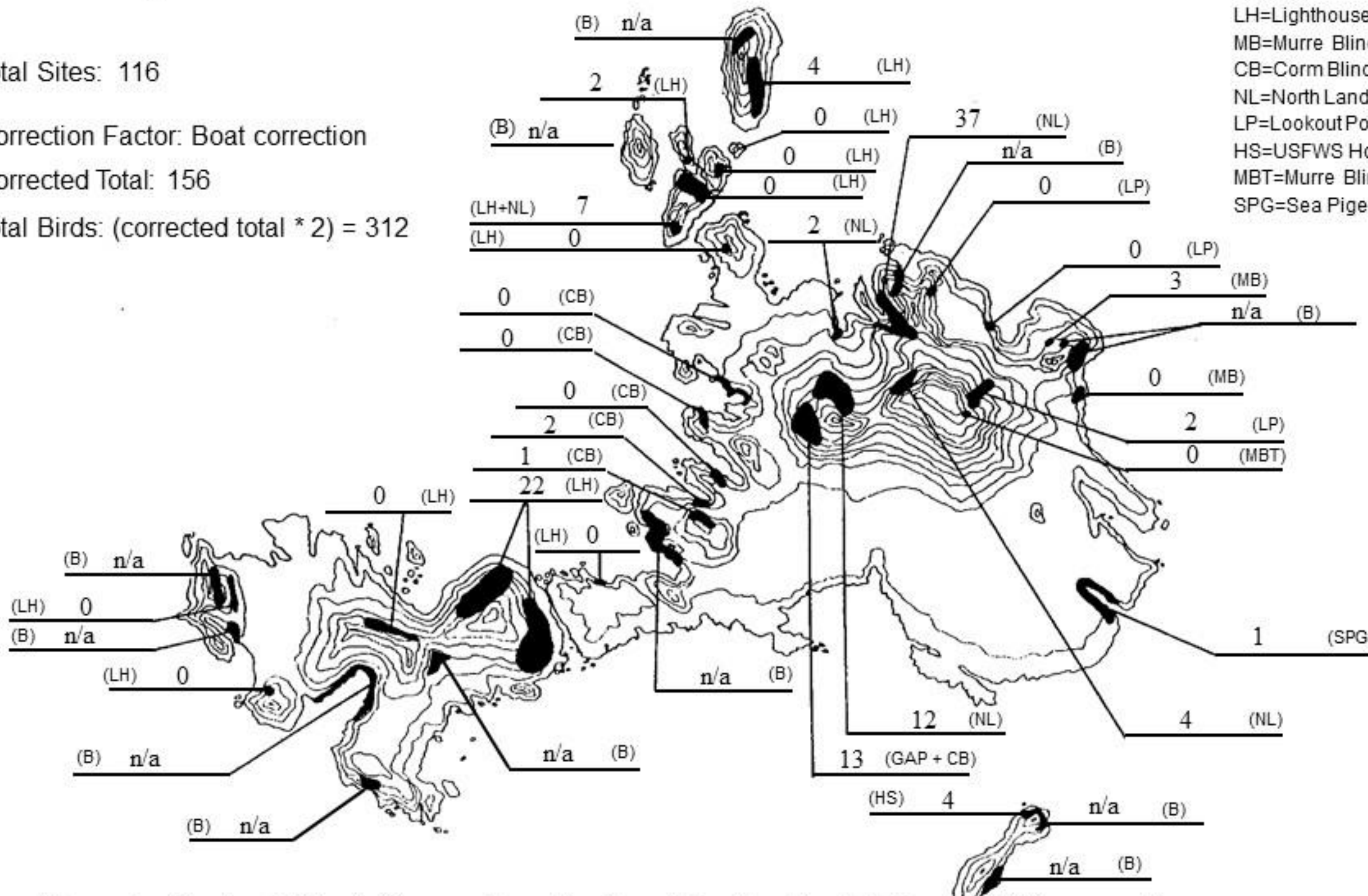


Figure 3: Counts of Pelagic Cormorants on Southeast Farallon Island during the 2017 census. Surveys were conducted from the following locations: Lighthouse Hill (LH), Lookout Point (LP), Murre Blind (MB), Cormorant Blind (CB), North Landing (NL), USFWS House (HS), Murre Blind Trail (MBT), Sea Pigeon Gulch (SPG), and Boat (B).

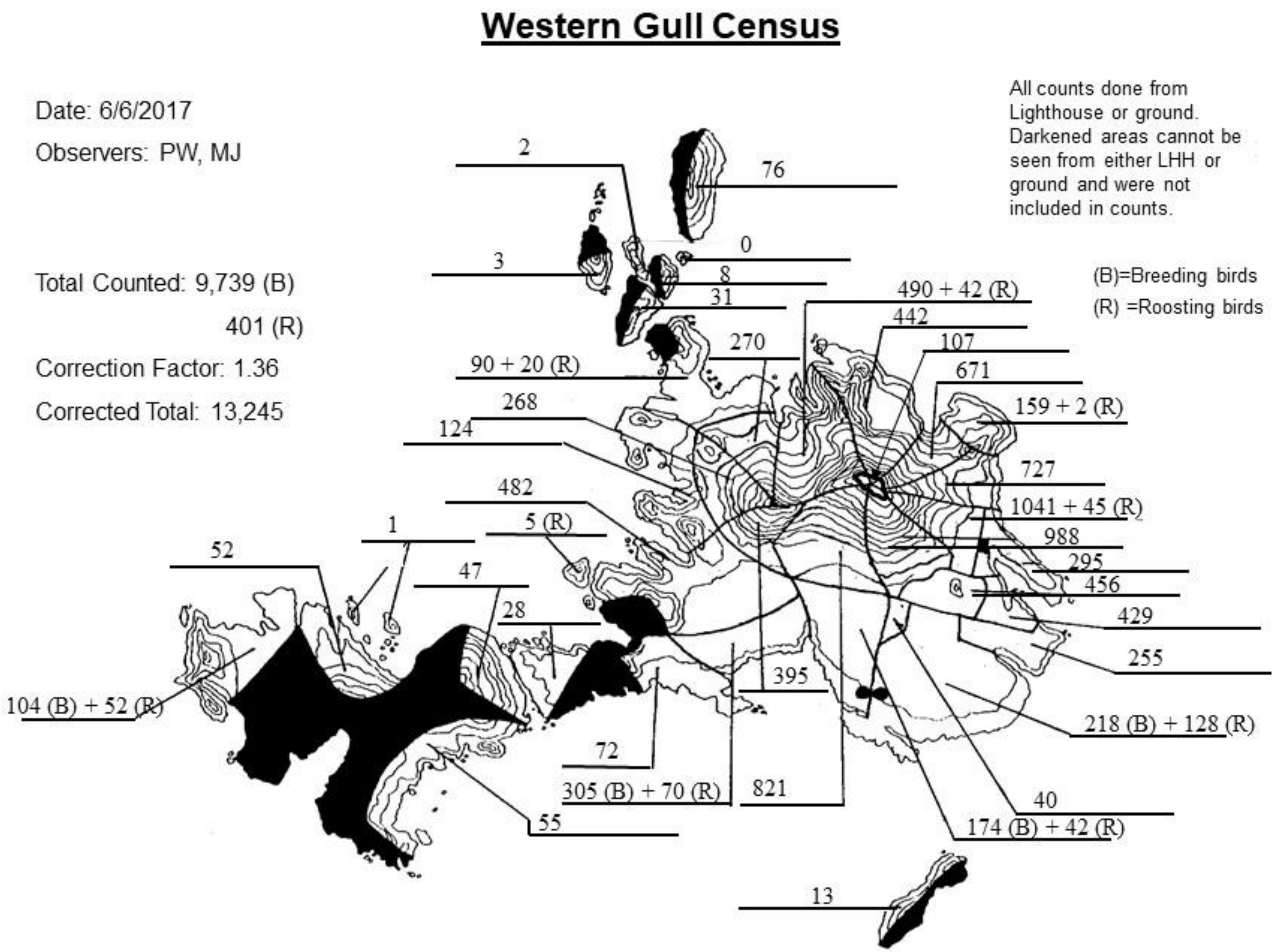


Figure 4: Counts of Western Gulls on Southeast Farallon Island during the 2017 census.

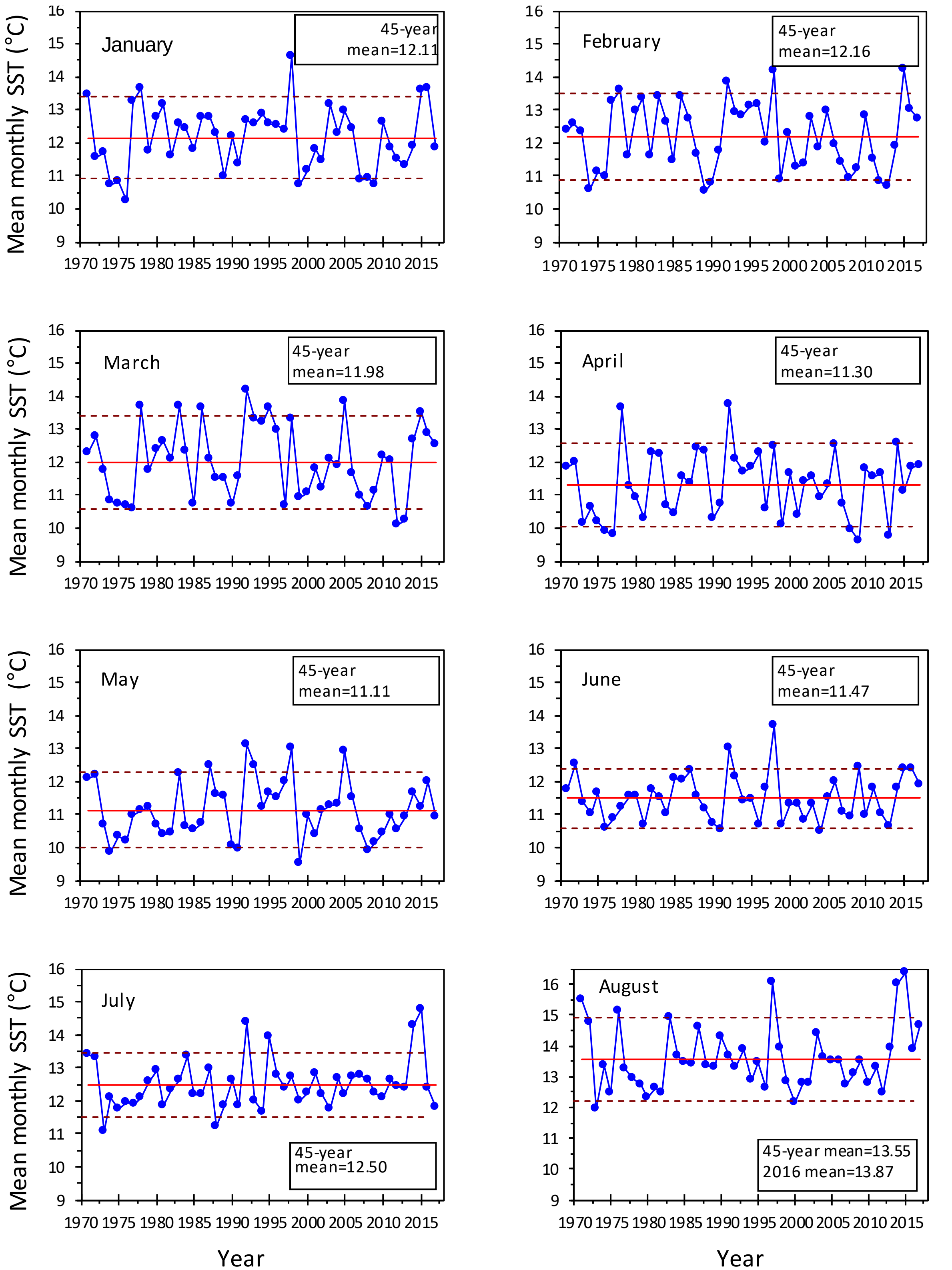


Fig. 6a. Monthly mean sea surface temperature (SST) at Southeast Farallon Island, 1971-2017. SST was measured daily from Water Sample Point, near East Landing. The bold horizontal line indicates mean monthly SST from 1971 to 2016. The dashed lines represent the 80% prediction interval for the long term mean.

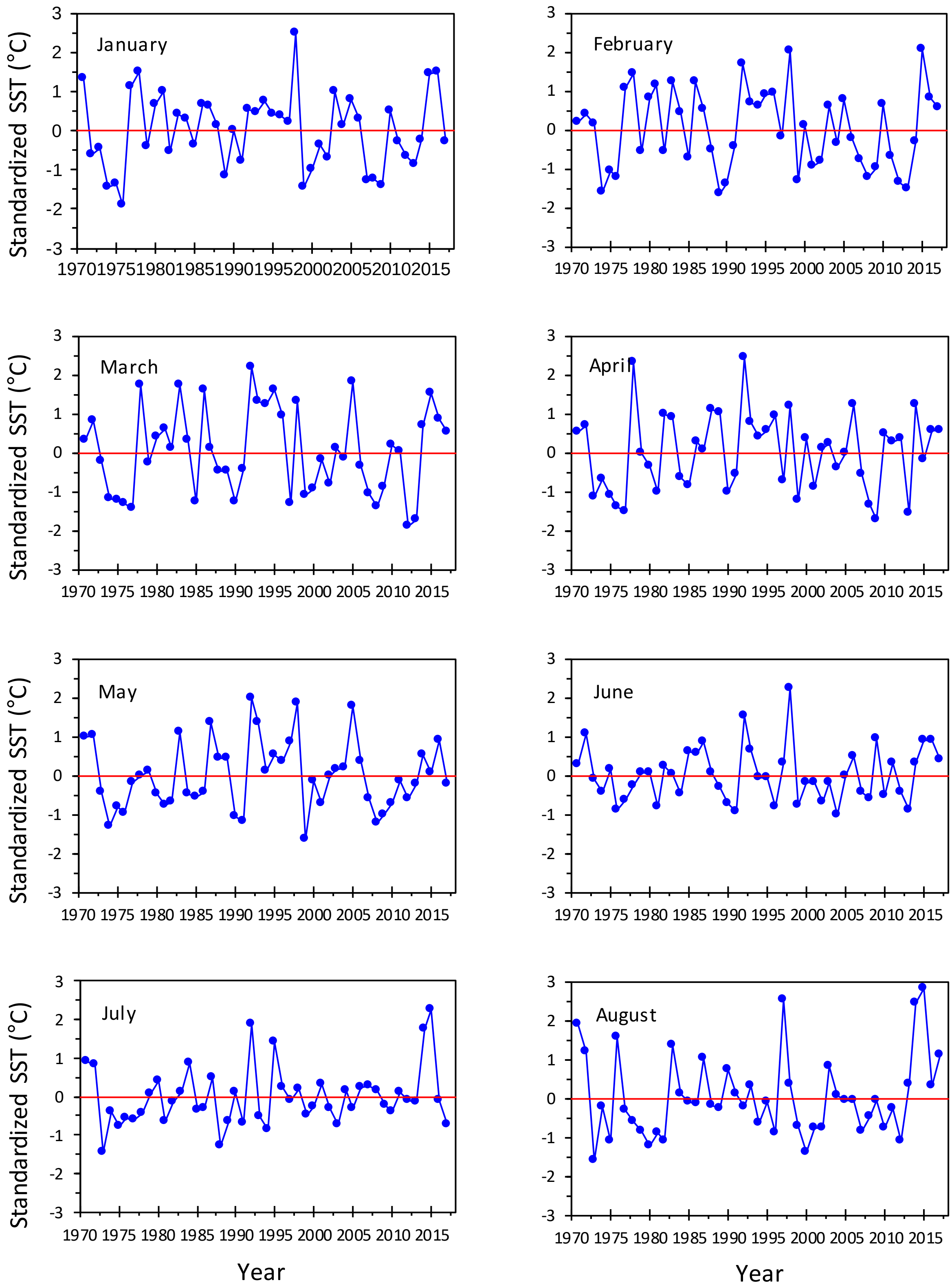


Fig. 6b Standardized Sea Surface Temperature (SST) anomalies (annual mean - long term mean) for SEFI, 1971-2017.

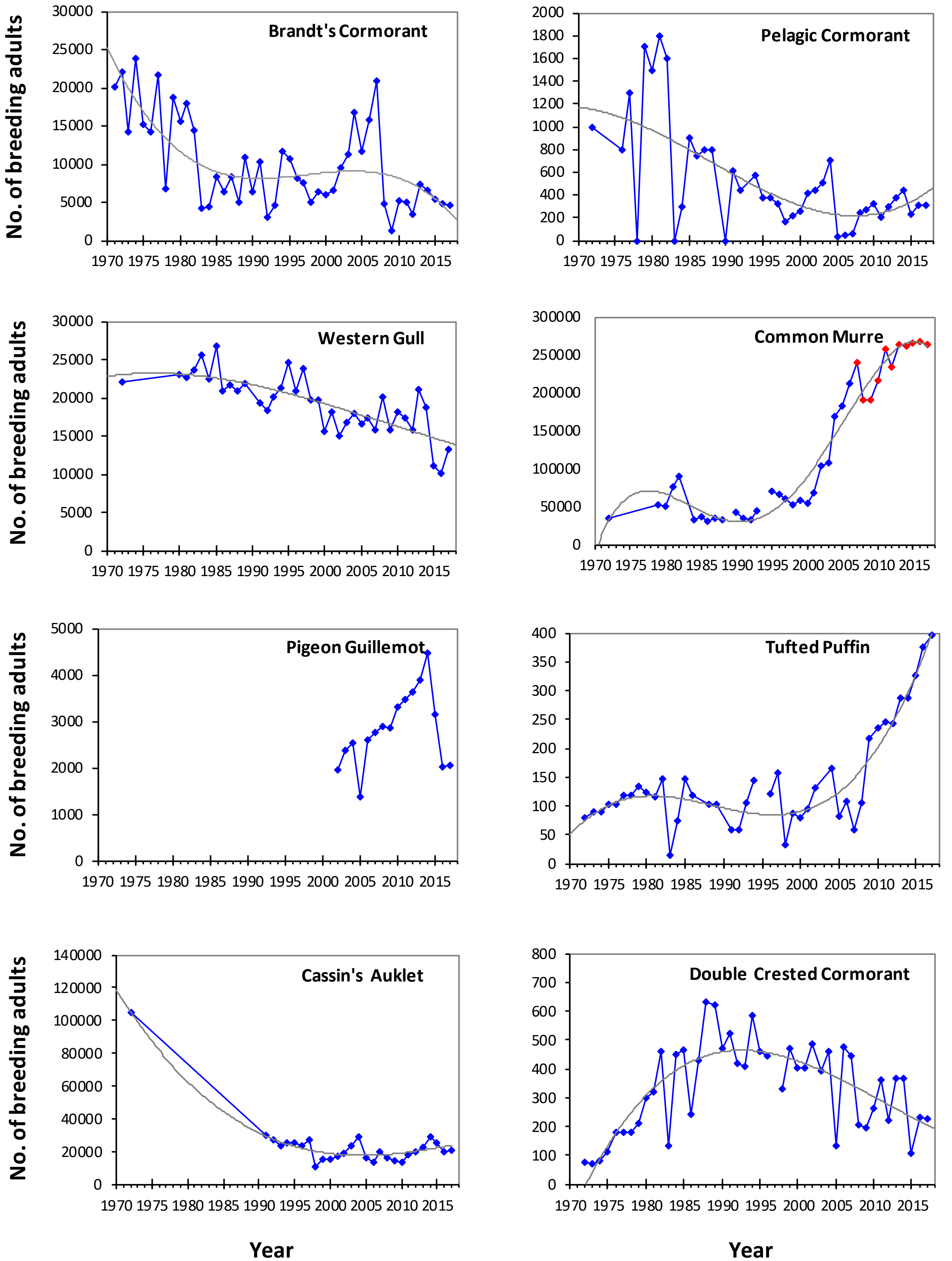


Fig. 7 Population trends for 8 species of seabirds on Southeast Farallon Island, 1972-2017. Populations determined by counting individuals or nests on all visible areas on SEFI and West End. Polynomial trend line (in gray) for each species included to illustrate long term trends. Note the different scales on the Y-axis. PIGU evening raft counts done prior to 2002 are not comparable to current methods and are not displayed. Since 2006, COMU population estimates are based on changes in the index plots (see Fig. 11 and text).

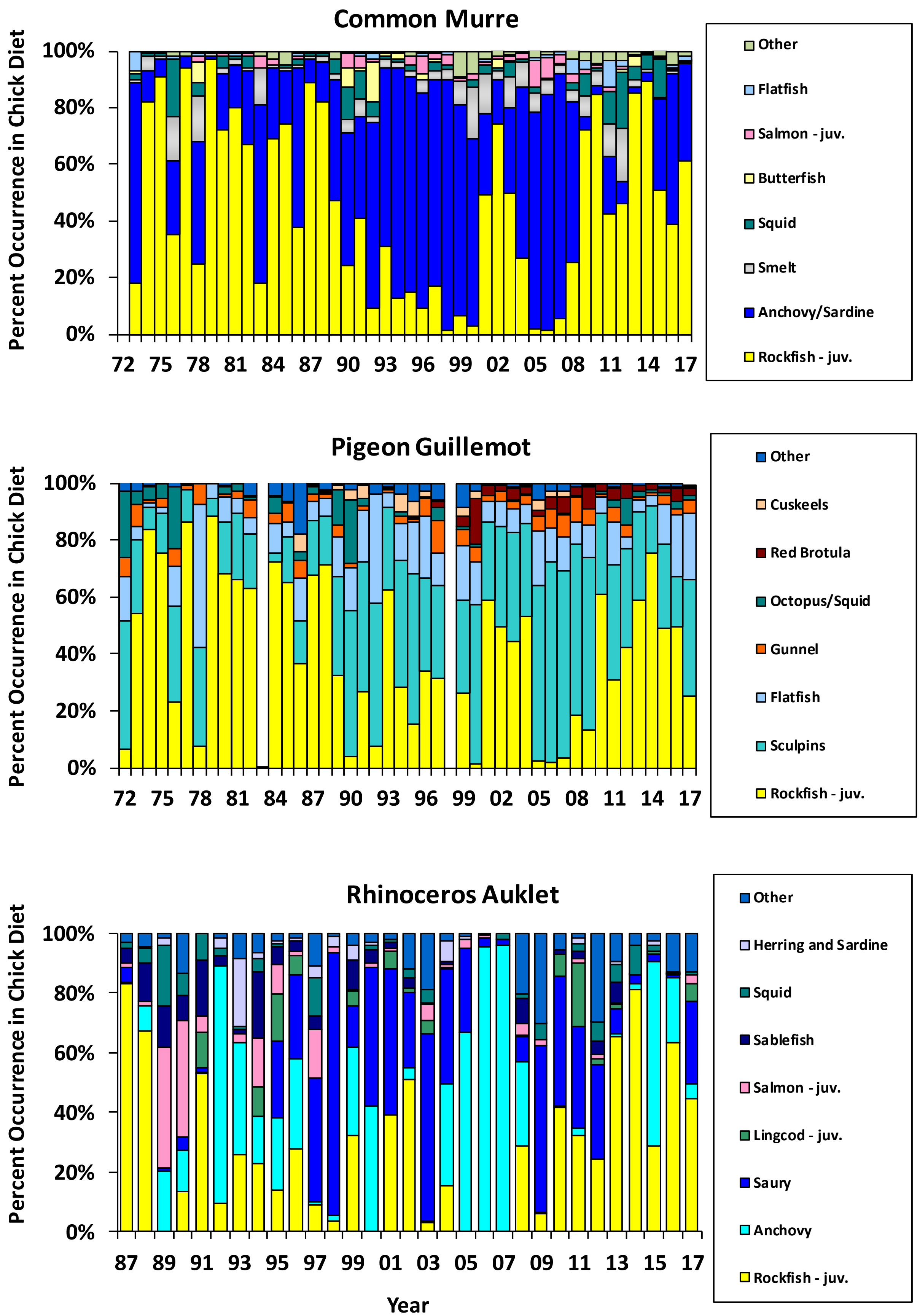


Fig. 8 Percent occurrence of common prey items, by year, in the diet of three species of seabirds on Southeast Farallon Island.

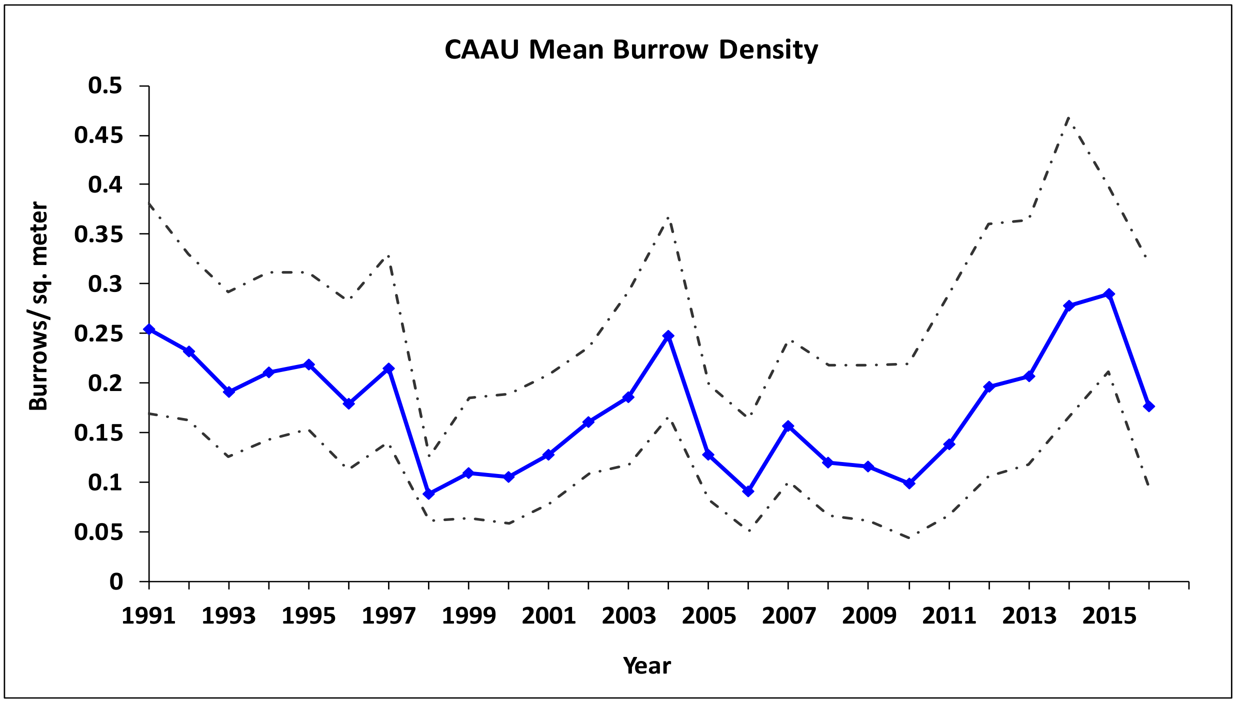


Fig. 9. Geometric mean burrow/crevice density in our 12 Cassin's Auklet Index Plots from 1991 to 2016. The blue line represents the annual mean values. The dashed lines represent the upper and lower bounds of the 95% confidence interval.

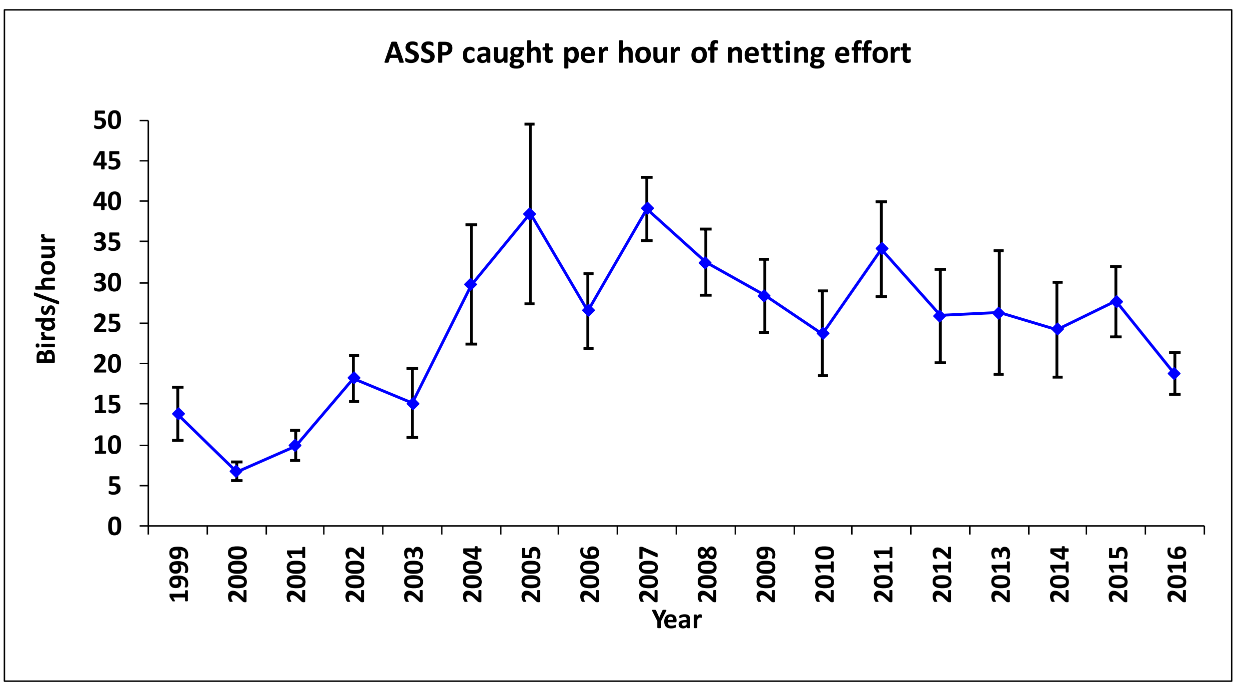


Fig 10. Mean number of Storm-petrels caught per hour of netting effort on SEFI from 1999 to 2016. Error bars represent the standard error for the mean calculated from all capture sessions in a given season.

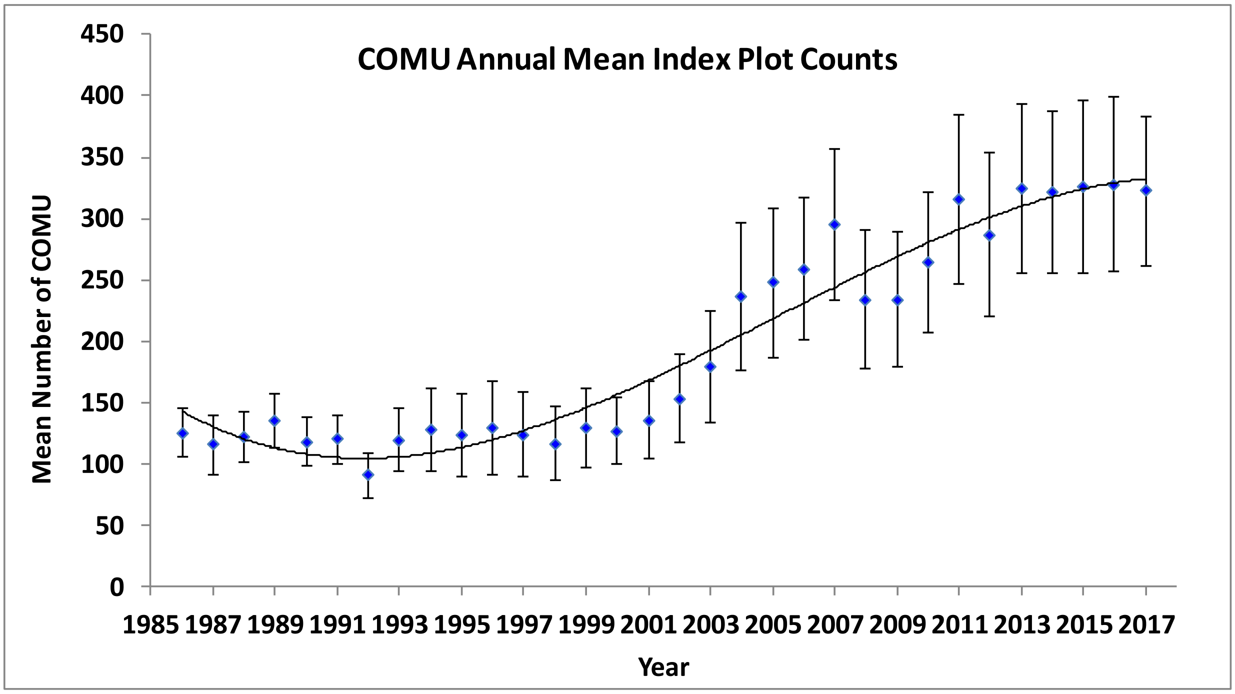


Fig. 11. Mean annual counts for Common Murre Index Plots from 1986 to 2017. Error bars represent the standard error of the mean calculated from all plots counted in any given season.

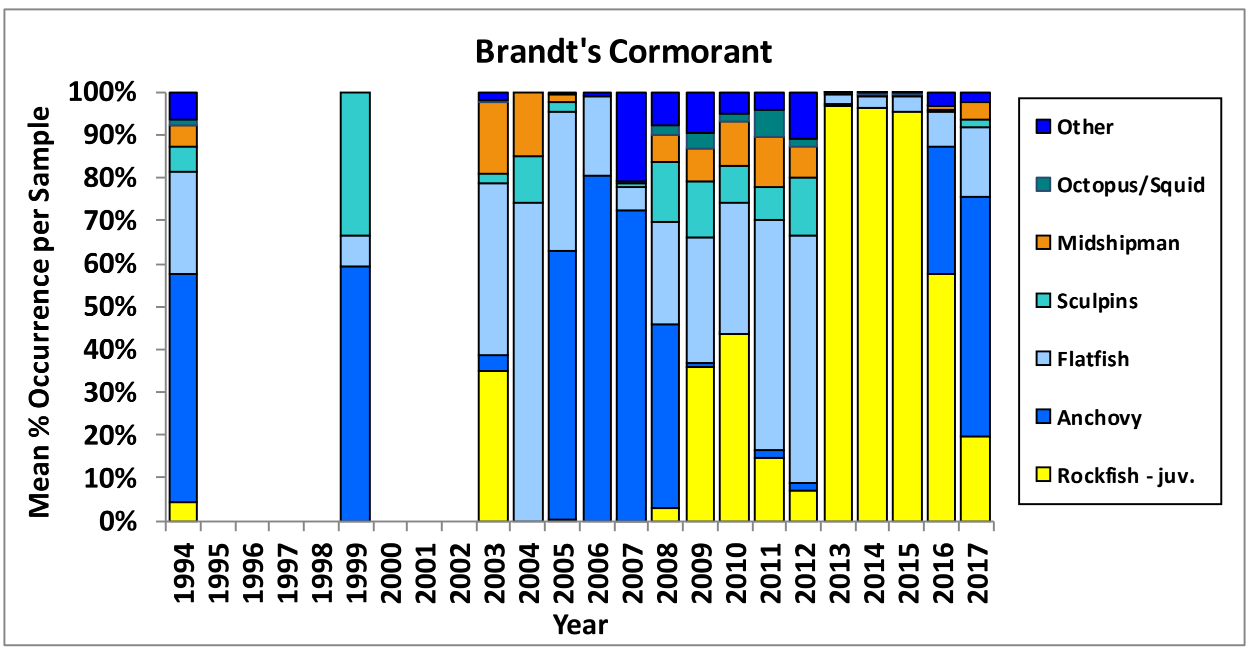


Fig. 12 Mean percent occurrence per sample of common prey items by year in the diet of Brandt's Cormorants on Southeast Farallon Island. Data for 2017 is based on analysis of a subsample of pellets analyzed as of December and should be considered preliminary.

APPENDICES

Appendix I. Calculation of correction factor for Western Gull census, 2017.

Area	Nest Count	Bird Count	Correction Factor
C	85	130	1.304
K	88	149	1.181
H (H1 only)	193	240	1.611
Total			**1.365**

Appendix II. Calculation of correction factor for Common Murre colony attendance, 2017. The correction factor was derived by multiplying the number of breeding sites in our two main study plots (USP and UU) by 2, and then dividing the product by the mean number of adults present in each plot on the census dates. The correction factors generated for each plot were then averaged to derive a correction factor for the entire population.

USP

Date (Time)	Breeding Sites	No. of birds	Correction Factor
June 5 (1000)	227	285	1.59
June 6 (1000)	227	271	1.68
June 7 (1000)	227	286	1.59
June 8 (1000)	227	266	1.71
Mean	227	277	**1.64**

UU

Date (Time)	Breeding Sites	No. of birds	Correction Factor
June 5 (1000)	129	153	1.69
June 6 (1000)	129	157	1.64
June 7 (1000)	129	173	1.49
June 8 (1000)	129	148	1.74
Mean	129	158	**1.64**

Mean correction factor for SEFI 2017: **1.64**