Point Blue Report

Population size and reproductive performance of seabirds on Southeast Farallon Island, 2019

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

December 2019

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EXECUTIVE SUMMARY

(1) Under cooperative agreement with USFWS/Farallon Islands 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 1968. We also collect information on oceanic conditions (sea surface temperature) and prey use (diet composition).

(2) The mean seasonal SST for 2019 was warmer than 2018 and the long-term mean for summer, a product of weak El Niño conditions in the Pacific during 2019. Monthly values except July were all above average when compared to the long-term record, especially May and June which were 1.3 and 1.8 degrees warmer respectively.

(3) Breeding populations where lower compared to 2018 and the long-term record for most species. Substantial declines in the number of breeding birds were observed for Cassin's Auklets, Pigeon Guillemots, and Common Murres, while Brandt's Cormorants, Pelagic Cormorants, and Western Gulls showed similar numbers to last season.

(4) Reproductive success for 2019 was lower for all species when compared to last season. In particular the Alcids including Common Murres, Pigeon Guillemots, Rhinoceros Auklets, and Cassin's Auklets suffered some of the lowest fledgling rates ever recorded.

(5) Anchovy replaced juvenile rockfish (*Sebastes spp*.) again as the dominant component of chick diet for Common Murres and Rhinoceros Auklets. Juvenile rockfish were virtually absent in the Rhinoceros Auklet and Common Murre chick diet. Krill abundance seemed low throughout the season, with clear blue unproductive water dominating the marine environment around the island, and very few provisioning Cassin's noted during the chick rearing period.

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 the summer of 2019. Eleven species were monitored: Ashy Storm-petrel (ASSP), Double-crested Cormorant (DCCO), Brandt's Cormorant (BRAC), Pelagic Cormorant (PECO), Western Gull (WEGU), California Gull (CAGU), 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) that breed on the island were grouped with ASSP for monitoring. Peregrine Falcon and Common Raven have historically bred on SEFI, but did not attempt to do so in 2019. At least 4 pairs of Canada Geese bred on the island and fledged a total of at least 14 chicks.

GENERAL METHODS

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 51 years for each species. We included the 80% prediction interval (dashed horizontal lines) with the long-term productivity graphs (Fig. 1a) to help highlight the extreme years (i.e. those years that fall into the upper or lower 10% of the distribution). 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.

Population size and island-wide chick production was estimated for all species except ASSP and RHAU. These estimates are derived through a combination of island-wide counts (WEGU, BRAC, DCCO, TUPU), index plot counts (COMU), and burrow density (RHAU, CAAU). Catch per unit effort during mist netting seasons is used as a proxy for population trends for ASSP, as their nocturnal behavior and cryptic breeding sites makes it difficult to obtain an accurate census. Breeding population size estimates (number of individuals) are presented in Table 2 and Figure 5. All estimates include West End Island unless otherwise stated.

RESULTS & DISCUSSION BY SPECIES

Ashy Storm-petrel

ASSP (*Oceanodroma homochroa*)

ASSP pairs laid eggs in 49% of the 91 followed sites (n=45) during 2019, approximately 29% lower than the occupancy rate observed last season. There were 3 new breeding sites discovered during 2019 while 2 previously followed sites were dropped from the study either due to collapse of the LHH wall or because they had not been occupied for at least 6 years. There were an additional 6 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 median laying was 13 June. This is approximately 15 days later than last season (Fig. 2). Overall productivity for this species was 0.58 chicks fledged per pair (including all relay attempts). This is approximately 12% lower than last season and 19% below the long-term average productivity for this species (Fig. 1a).

We continued our long-term mark/recapture study to estimate ASSP population trends. We operated regular netting locations (Lighthouse Hill and Carp Shop) on 6 evenings between April and August. As a result, a total of 232 new Ashy Storm-petrels were banded and 36 birds that had been previously banded were recaptured, for a total of 268 birds handled. The mean standardized capture rate during 2019 netting sessions was 15.03 birds per hour (se = 3.82, n= 6; Fig. 10). This is approximately 33% lower than during 2018 and 36% lower than the mean capture rate for the previous 10 years. Our most productive netting session was on 4 May during which we captured 91 birds. Poor netting conditions resulted in no netting sessions during the month of July. There were also 3 new Leach’s Storm-petrels banded this season.

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. 2019). A recent 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 et al. 2019). 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 et al. 2019). However, further reduction in owl numbers is needed to produce an increasing population (Nur et al. 2019). 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

BRAC (*Phalacrocorax penicillatus*)

Productivity information is gathered from 2 sub-colonies viewed from the Corm Blind and Sea Lion Cove Blind. Mean productivity for the Corm Blind colony was 1.73 fledglings per pair. This is approximately 7% lower than last season and 21% higher than the long-term mean productivity for this species (Fig. 1a). The first eggs were observed on 5 May at the Corm Blind and 15 May at Sea Lion Cove. Median laying date for both colonies was 25 May, 8 days later than the long-term median for this species (Fig. 2). Mean clutch size was 2.83 eggs per nest and hatching success was 75%. Mean brood size was 1.73 chicks per nest, 86% of which survived to fledging age. A total of 353 chicks were banded this season, with the last chicks departing the colony by early September.

The BRAC breeding population was censused with ground- and boat-based surveys, during which 3,620 "well-built" nests were counted (Fig. 6). We then multiplied the number of nests by 2 to yield an overall population estimate of 7,240 breeding birds (Table 2). This estimate is only 6 birds less than 2018 and approximately 32% above the 10-year average (Table 2). We multiplied the total number of nests by the mean productivity to estimate an island-wide production of approximately 6,262 fledglings. Although the estimated breeding population was similar to last year, both colonies were noticeably less dense compared to previous years. This was mostly due to birds relocating to other colonies across the island.

Brandt's cormorant populations have gone through periods of growth and decline since the early 1980's (Nur and Sydeman 1999, Fig. 5) but began to recover during the early 2000's. The BRAC breeding population expanded rapidly from 1999 to 2007, followed by a rapid decline in 2007. 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. A regional population trend analysis of the last decade has demonstrated a shift in the population from the Farallones to more mainland colonies 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 had gradually declined up until 2017. The population has since rebounded to the 2013 estimate; however, the numbers suggest they are still less than one-third of the population observed before the crash in 2007.

Pelagic Cormorant

PECO (*Phalacrocorax pelagicus*)

Pelagic cormorants experienced a complete reproductive failure this year, similar to what has been observed in previous years. Of the 75 sites followed for productivity estimates, very little nest attendance was noted island-wide and only 1 was confirmed to have eggs. Several nests had birds in incubation posture on multiple checks, suggesting they may have laid eggs and then abandoned. No chicks were seen in any of the followed sites, however, there was one site discovered on Falcon's Roost in September that had 2 large, mostly-feathered chicks.

The PECO breeding population was censused during ground- and boat-based surveys, where a total of 81 fair to well-built nests were counted (Fig. 7). We then multiplied this number by 2 to yield an overall breeding population of 162 birds (Table 2). Similar to Brandt's Cormorant, this estimate for Pelagic Cormorants is nearly identical to the estimate for 2018 and 36% lower than the 10-year average. Breeding populations were extremely low through 2007 but had been slowly increasing in recent years before suffering additional small-scale crashes in 2015, 2018, and this season (Fig. 5).

Double-crested Cormorant

DCCO (*Phalacrocorax auritus*)

The only DCCO colony in the island group is located on Maintop on West End Island. Counts of this colony were conducted every five days (weather permitting) from atop Lighthouse Hill on SEFI using a spotting scope. A total of 16 counts were made in 2019, beginning on 27 April and ending on 20 July, when juveniles became indistinguishable from adults. A high count of 99 "well-built" nests with birds in incubating posture was made on 4 June. Minimum population size was estimated by multiplying this high count of well-built nests by two, yielding a total of 198 breeding birds. This estimate is approximately 7% lower than 2018 and 20% below the 10-year average population for this species (Table 2). There was a high count of 115 chicks observed during the 20 July census.

Western Gull

WEGU (*Larus occidentalis*)

Western gull productivity was 0.93 chicks per pair, approximately 27% lower than last season an 6% lower than the long-term mean productivity for this species (Fig. 1a). The earliest lay date across followed plots was 28 April, with a median lay date of 13 May (Fig. 2). Mean clutch size was 2.86 eggs per nest and mean brood size was 1.94 chicks per nest, 46% of which survived to fledge. There were 529 chicks banded at the colony this season with the last chicks fledging and departing the colony by the end of August.

The WEGU census was conducted on 31 May. 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 8,865, approximately 99 fewer than last season (Fig. 8). 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 (1.559) 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 13,820 birds (Table 2). The population estimate for WEGU is approximately 0.4% higher than 2018 and 10% lower than the 10-year average (Table 2). The estimated overall production of fledglings on SEFI in 2019 was 6,426.

California Gull

CAGU (*Larus californicus*)

Only a handful of CAGU were seen on nests, continuing a recent trend of complete reproductive failure for this species on SEFI. 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 at least 9 CAGU were seen on well-built nests, but no chicks were ever observed. Continual disturbance from California sea lions in the two main breeding areas on the marine terrace coupled with a history of breeding failure likely contributed to the low breeding effort. It seems logical to assume the breeding population of CAGU on SEFI is no longer viable. The peak count for total birds was 101 on 11 May, mostly of roasting individuals on the Marine Terrace.

Common Murre

COMU (*Uria aalge*)

Productivity is monitored annually from 2 followed study plots; Upper Shubrick Point (USP) from the Murre Blind and Upper Upper (UU) from the Corm Blind. Late season rainstorms that flooded eggs and a record setting heat wave in June led to major egg failures and chick abandonment at both colonies. A total of 226 active Common Murre breeding sites were monitored daily in the USP study plot, where productivity was only 0.32 chicks fledged per pair. This is approximately 57% lower than last season and 56% lower the long-term average of 0.72 (Fig. 1a). Egg laying was slightly delayed this year, with the first egg observed in this plot on 11 May. Median laying date for USP was 19 May, approximately a week later than the long-term median lay date for this colony. Sixty percent of eggs hatched but only 53% of the hatched chicks survived to fledge.

The colony of Common Murres in Upper UU had similar reproductive success to the colony at USP. The first eggs were also observed on 11 May this season, with a median lay date just a few days later than USP of 22 May. A total of 152 breeding sites were monitored in UU this season. Reproductive success for this colony was 0.34 chicks fledged per breeding pair. Sixty-six percent of the eggs hatched and again only 52% of chicks survived to fledge (Table 1).

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 was photographed using a DSLR and telephoto for 10 consecutive days. Total COMU within plots in photos were counted using the program ImageJ. 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 4% lower than 2018 (Figure 11) but still 10% higher than during the last complete all-island count in 2006. 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 232,140 birds (Figure 7). Though this remains low compared to historic estimates that exceeded half a million birds, it represents tremendous recovery from previous population declines (Ainley and Lewis, 1974; Sydeman et al. 1997). There has been relatively little change in the last 5 years, indicating that the rapid population growth experienced during the early to mid-2000's has reached an asymptote.

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 1.92. 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

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. It is also important to note that the change in methods for counting plots (images vs. averaged daily replicate counts) may change annual count numbers. We feel, however, with the increase in density of birds within some plots, using photographs will make counts more accurate going forward.

Pigeon Guillemot

PIGU (*Cepphus columba*)

A total of 99 sites were monitored during 2019, of which 73 were observed with at least one egg, 4 fewer active sites then in 2018. The majority of nest sites were located on Lighthouse Hill or at Garbage Gulch, with a few additional sites in the Habitat Sculpture, as well as in Rhinoceros Auklet and Cassin's Auklet nest boxes. Productivity for 2019 was 0.21 fledglings produced per pair (Table 1). This was approximately 61% lower than 2018 and 74% below the long-term mean productivity for this species (Fig. 1a). The first eggs were observed on 12 May, with a median lay date of 11 June (Fig. 2). This was 10 days later than last season and 13 days later than the long-term median lay date for this species. The mean clutch size was 1.29 eggs per nest with 49% of those eggs hatching successfully. Mean brood size was 0.67 chicks per nest with 31% of those chicks surviving to fledging age. Years of high productivity for guillemots are driven by their ability to successfully fledge a second chick, when food availability and feeding rates are high enough to reduce sibling competition. During 2019, only 19 out of 73 active sites (26%) contained a full clutch of two eggs, from which none were able to fledge two chicks. There were a total of 22 guillemot chicks banded on SEFI this season.

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 2,351 birds on 24 April. This count was approximately 33% lower than the peak count from 2018 and 25% lower than the 10 year mean for morning surveys (Table 2 and Fig. 5). This population estimate does not necessarily represent breeding birds because the census method does not distinguish between breeders and non-breeders. The raft counts 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.

Tufted Puffin

TUPU (*Fratercula cirrhata*)

The island-wide TUPU survey was conducted in two parts; the first survey takes place from late May to early June and the second survey from late July to early August. Tufted Puffin population estimates are based on the overall number of active sites observed during our surveys. 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 2019 surveys, a total of 187 active sites were observed. Based on these observations, we estimated a breeding population of 374 birds (Table 2). This estimate is 8% lower than 2018 and 21% greater than the 10-year average population for this species. The 2019 estimate ends a 7-year trend of an increasing number of individuals for this population (Fig. 5). While puffin numbers have been declining in other regions along the west coast, the Farallon population has displayed an overall increasing trend since the early 2000's.

Rhinoceros Auklet

RHAU (*Cerorhinca monocerata*)

There were a total of 150 sites (boxes, crevices, and cave sites) monitored in 2019, 72 of which were occupied by a breeding pair. This includes sites in CAAU nest boxes, PIGU nest boxes at Garbage Gulch, and the Habitat Sculpture. Forty-seven percent of nest boxes were occupied compared to 62% of camera sites, both similar to occupancy rates in 2018. Productivity during 2019 was 0.41 fledglings per pair. This is approximately 41% lower than the productivity observed in 2018 and 28% lower the long-term mean productivity for this species (Fig. 1a). The first eggs were observed on 21 April, and the median laying date was 6 May. This is approximately 9 days later than the long-term median for this species (Fig. 2). Sixty-seven percent of the eggs successfully hatched and 62% of those chicks survived to fledge. There were a total of 18 Rhinoceros Auklet chicks banded this season.

An island-wide estimate of breeding population size for RHAU is difficult to obtain because they nest underground and are only active at dawn or dusk. Netting for mark/recapture and diet sampling was continued in 2019. During these netting sessions a total of 44 new birds were banded and 105 were recaptured (13 birds were recaptured multiple times during the season). Recapture rates were similar to last season, however, the number of new birds banded during netting sessions was approximately 38% lower than last season.

Cassin's Auklet

CAAU (*Ptychoramphus aleuticus*)

Productivity of Cassin's Auklets breeding in PRBO study boxes fell to only 0.13 chicks fledged per breeding pair (including relay attempts). This was 84% lower than 2018 and 83% lower than the long-term average of 0.75 chicks per pair for this species (Fig. 1a). Eighteen percent of the eggs hatched and 57% of those chicks survived to fledge. Cassin's Auklets are the only Alcid capable of successfully fledging multiple broods in the same season; a behavior only exhibited in the southern portion of their range (Ainley et al. 2011). Given the ability to double brood is driven in part by the most capable breeders (Johns et al. 2018) during periods of high productivity in the region (Johns et al. 2017), conditions were apparently too poor this season to support any double brooding attempts, as none were recorded in any followed sites. The first egg was observed on 16 April and the median laying date for PRBO boxes was 26 April. This was approximately 25 days later than last season and 12 days later than the long-term average (Fig. 2).

We also report the productivity of all followed sites in addition to that of the PRBO study boxes. This is done to account for years of low breeding propensity (such as 2005) by increasing the sample size to more accurately reflect the success of the whole island population. The same is probably true for years of very high productivity (such as 2010). If all followed sites where an egg was laid were included in the analysis for this season, productivity would be 0.10 chicks per pair (n=158). This is approximately 23% lower than the estimate derived from PRBO boxes. Only 50 chicks were banded this season.

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 2019, we counted a total of 256 burrows/crevices in the index plots. Therefore, using the same methodology, but with the updated whole island estimate generated in 2009, we estimated a 2019 breeding population of roughly 16,511 birds ([256/225] x 14512) on Southeast Farallon Island. Total island-wide production (number of breeding pairs x mean productivity) was estimated at an extremely low 743 fledglings on SEFI. The breeding population estimate is approximately 38% lower than in 2018 and 19% lower than the 10-year average (Table 2).

Farallon Cassin's auklets declined considerably since the early 1970's (Fig. 5), 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 breeding population experienced a rapid increase in numbers, before declining again during 2005 and 2006, coinciding with reduced breeding effort and lower reproductive success. The population again rebounded to approximate peak numbers by 2014. Burrow and crevice counts for 2019 were approximately 38% lower than in 2018 and 8% lower than the long-term average number of burrows observed since the index plots were established in 1991 (Table 3). The greatest increases in burrow counts were in areas above where California Sea Lions have access, with mass hauling out by sea lions likely leading to a reduction in burrow densities on the Marine Terrace. 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.

Non-seabird Species

In past seasons, Peregrine Falcons, Common Ravens, and Canada Geese have bred on SEFI during the seabird season. During 2019, it appears only Canada Geese attempted to breed. Four pairs of Canada Geese were present on the island by mid-March and at least 4 attempted to nest. The first nest was discovered between the Stone House and Gravity Tank on 27 March with 8 eggs. A total of 16 goslings were frequently seen from 4 different pairs (clutch sizes 6, 4, 4, and 2) by the end of May, 15 of which were assumed to have fledged by August. An additional nest with 5 eggs was found late in the season by Heligoland on 29 May. From mid-March until late July, 1-4 Peregrine Falcons were seen daily. Nesting activity was never confirmed, and it is unlikely any nested on the main island this season. 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.

OCEAN CONDITIONS AND SEABIRD DIET

As an indicator of local ocean conditions, sea surface temperature (SST) was measured daily from Water Temperature Point near East Landing. This year was considered warmer than average in terms of SST conditions, with monthly values higher than the long-term means for all months except July (Fig. 4a, b). During 2019, the mean seasonal SST from March to August was 12.81°C (Fig. 3). This was 0.83°C warmer than the 2018 season and 0.78°C warmer than the long-term mean for these months.

Chick provisioning data is collected throughout the chick-rearing period for five species as a means of determining diet and feeding rates and as another 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 2019, juvenile rockfish showed a substantially lower occurrence in chick diet compared to previous seasons (Figs. 12 and 13). Rockfish comprised only 4% of the diet for Common Murres, 2% for Rhinoceros Auklets, and 15% for Pigeon Guillemots. Anchovies were a significant component of the diet for Common Murres and Rhinoceros Auklets during 2019, which accounted for 83% of the diet for Common Murres and 96% of the Rhinoceros Auklet diet (Fig. 12). Flatfish, sculpins, saury, and squid were other important components of the diet this season but in relatively small proportions. Pellet samples from Brandt's cormorants have not yet been examined for 2019, however, preliminary results may indicate fewer otoliths than in previous years, must of which were dominated by anchovy. Figure 13 shows diet results of Brandt's cormorants from previous years. Cassin's Auklet diet cannot be identified in the field and is still being analyzed, but preliminary results suggest larval fish and mysids may have dominated the chick diet instead of krill.

SUMMARY

The 2019 seabird breeding season was a poor year in terms of productivity for most of the followed species (Fig. 1a, b). All species with the exception of Brandt's Cormorants showed a marked decrease in breeding success compared to long-term trends. Common Murres, Pigeon Guillemots, and Cassin's Auklets in particular exhibited some of the lowest fledgling rates ever recorded from the Farallones. In contrast, Brandt's Cormorants achieved fledgling rates similar to those of the previous 5 years and higher than the long-term mean. In the most extreme cases, Pelagic Cormorants and California Gulls completely failed to fledge any chicks this year, however, this may reflect intrinsic or ecological factors beyond environmental condition. For example, the California Gull colony has been declining for the last several years and has been largely unsuccessful since they colonized the island in 2008, while populations in and around San Francisco Bay continue to thrive.

Annual variability in reproductive effort generally tracks conditions building up to the breeding season, where poor foraging conditions and a lack of prey can lead to higher winter mortality, reduced colony attendance, and fewer breeding birds. Reduced breeding population estimates for most species during 2019 strengthen our assessment of a poor year for the island. This was most apparent in our estimate of breeding Cassin's Auklets on SEFI, where low burrow counts translated to a substantial decrease in the assumed breeding population size. It is not yet known if the apparent population declines reflect adult mortality or simply reduced breeding propensity in poor conditions.

As a more direct measure of environmental condition and indirect measure of marine productivity, local SST was much higher in 2019 when compared to the long-term record. ENSO positive conditions were present during the late winter and persisting into the breeding seasons, resulting in below 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 poor oceanic conditions resulted in generally low breeding success for most species. Reproductive timing in terms of lay dates were also delayed for all species, another indication of less than favorable foraging conditions leading up to the breeding season.

Finally, diet information collected from provisioning parents provides a direct measure of prey availability during the breeding season and an indirect metric for the capacity of the local environment to support certain fish species. Rockfish have been an important component of seabird diet at the Farallones, where a high proportion of rockfish in the diet of chicks typically correlates with high productivity. During 2019, however, juvenile rockfish were virtually absent from Rhinoceros Auklet and Common Murre deliveries and lower than average for Pigeon Guillemots. The overall reduced abundance likely played a role in lower than average breeding success and reduced feeding rates this year. Seabirds instead relied more heavily on anchovy, flatfishes, and other alternate prey to make up the difference. Seabirds are frequently able to successfully switch prey in response to availability, but it often comes at the cost of longer foraging trips and more energy expended by adults when provisioning dependent offspring (Warzybok et al. 2018). This was evident during 2019 with greatly decreased feeding rates and prolonged foraging trips, sometimes lasting more than a day between chick feedings. Although anchovies are high quality prey, the cost of retrieving them may have been too high this season. Additionally, many of the anchovies that were brought back to the colony were too large for chicks to handle, therefore making them unavailable to the chicks. This was likely also a consequence of poor ocean productivity leading to low anchovy spawning success and fewer small anchovies available as prey. Historically, 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 five years, surpassing juvenile rockfishes this 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. (2019), 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 use of PIT tags and RFID readers has been implemented the last few years but technical challenges have prevented us from fully evaluating their success. We recommend continuing this work in 2020 and integrating ongoing 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, PIGU, and now COMU and should be considered for BRAC and, if possible, ASSP. 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, both locally around the Farallon Islands NWR and in their overwintering habitat.

(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 has been taken with studies of winter habitat use by Cassin's auklets, Rhinoceros Auklets, and Pigeon Guillemots over the last few years. These data are currently being analyzed and are showing some interesting patterns. We recommend increased efforts on these and other species as well as future studies to help examine how conditions at their wintering grounds impact populations and reproductive success for the Farallon colony.

(4) Tufted Puffins are difficult to monitor, and thus little is known about their reproductive success on the Farallones. With populations in decline along much of the west coast of the U.S., it is becoming increasingly important to develop an understanding of the factors that influence their breeding success. We propose assessment and modification of our research methods on puffins, including the potential use of nest boxes or nest cameras to allow more detailed reproductive monitoring of 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.

LITERATURE CITED

Ainley, D.G. and T.J. Lewis. 1974. The History of Farallon Island Marine Bird Populations, 1854-1972. Condor 76:432-446.

Ainley, D.G. and R.J. Boekelheide (eds.) 1990. Seabirds of the Farallon Islands: Ecology, Dynamics, and Structure of an Upwelling-system Community. Stanford University Press. Stanford, CA.

Ainley, D. G., Santora, J. A., Capitolo P. J., Field, J. C., Beck, J. N., Carle, R. D., … Jahncke, J. 2018. Ecosystem-based management affecting Brandt's Cormorant resources and populations in the Gulf of the Farallones, California. Biological Conservation, 217:407-418.

Bradley, R., P. Warzybok, D. Lee, and J. Jahncke. 2011. Assessing Population Trends of the Ashy Storm Petrel on Southeast Farallon Island, California. Unpublished report to the US Fish and Wildlife Service. PRBO Conservation Science, Petaluma, California. PRBO Contribution Number 1780.

Barber, R.T., F.P. Chavez, and J.E. Kogelschatz. 1985. Biological effects of El Niño. pp. 399-438. In: M. Vegas (Ed) Seminario Regional Ciencas Tecnologia y Agression Ambiental: El Fenomeno 'El Niño'. Contec Press, Lima, Peru.

Carter. H.R., G.J. McChesney, D.L. Jaques, C.S. Strong, M.W. Parker, J.E. Takekawa, D.L. Jory, and D.L. Whitworth. 1992. Breeding populations of seabirds in California, 1989-1991. Unpublished Report of the U.S. Fish and Wildlife Service, Dixon, California.

Johns, M.E., P. Warzybok, R. Bradley, J. Jahnke, M. Lindberg, G.A. Breed. 2018. Increased reproductive investment associated with greater survival and longevity in Cassin's auklets. Proceedings of the Royal Society B, 285:20181464.

Johns, M.E., P. Warzybok, R. Bradley, J. Jahnke, M. Lindberg, G.A. Breed. 2017. Age, timing, and a variable environment affect double brooding in a long-lived seabird. Marine Ecology Progress Series, 564: 187-197.

Nur, N. and W.J. Sydeman. 1999. Survival, breeding probability, and reproductive success in relation to population dynamics of Brandt's Cormorants *Phalacrocorax penicillatus*. Bird Study, 46:2-13.

Nur, N. and W.J. Sydeman. 2002. Statistical analysis of the 'k' correction factor used in population assessments of murres: Implications for monitoring. Unpublished Final Report, Point Reyes Bird Observatory, Stinson Beach, CA; U.S. Fish and Wildlife Service, Newark, CA.

Nur, N., R. Bradley, P. Warzybok , L. Salas, and J. Jahncke. 2019. Evaluating population impacts of predation by owls on storm petrels in relation to proposed island mouse eradication. Ecosphere, 10(10).

Sydeman, W.J., S.D. Emslie, and P. Pyle. 1987. Population size and reproductive success of seabirds breeding on the Farallon Islands National Wildlife Refuge in 1987. Report to the Farallon National Wildlife Refuge, Newark, California.

Sydeman, W.J., H.R. Carter, J.E. Takekawa, and N. Nur. 1997. Common Murre *Uria aalge* population trends at the South Farallon Islands, California, 1985-1995. Unpublished Final Report, Point Reyes Bird Observatory, Stinson Beach, CA; U.S. Geological Survey, Dixon, CA; and U.S. Fish and Wildlife Service, Newark, CA.

Sydeman, W.J., N. Nur, E.B. McLaren, and G.J. McChesney. 1998. Status and trends of the Ashy Storm-petrel on Southeast Farallon Island, California, based upon capture-recapture analyses. The Condor, 100: 438-447.

Sydeman, W.J., M.M. Hester, J.A. Thayer, F. Gress, P. Martin, J. Buffa. 2001. Climate change, reproductive performance and diet composition of marine birds in the southern California Current system, 1969-1997. Progress in Oceanography, 49:309-329.

Warzybok, P., J. A. Santora, D.G. Ainley, R.W. Bradley, J.C. Field, P.J. Capitolo, R.D. Carle, M. Elliott, J.N. Beck, G.J. McChesney, M.M. Hester, & J. Jahncke. (2018). Prey switching and consumption by seabirds in the central California Current upwelling ecosystem: Implications for forage fish management. Journal of Marine Systems, 185, 25-39.

TABLES & FIGURES

Table 1. Mean (± SD) productivity of eight species of seabirds at Southeast Farallon Island, California, 2019. 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	2.98 ± 0.67 *(56)*	2.06 ± 1.12 *(51)*	1.73 ± 1.02 *(56)*	1.73 ± 1.02 *(56)*	0.66 ± 0.35 *(51)*	0.86 ± 0.27 *(44)*
PECO	0	0	0	0	0	0
WEGU	2.86 ± 0.40 *(176)*	1.94 ± 1.06 *(176)*	0.93 ± 0.91 *(175)*	0.93 ± 0.91 *(175)*	0.67 ± 0.36 *(176)*	0.46 ± 0.36 *(149)*
COMU* USP	1.00 (209)	0.60 ± 0.49 (209)	0.32 ± 0.47 (209)	0.32 ± 0.47 (209)	0.60 ± 0.49 (209)	0.53 ± 0.50 (126)
COMU* UU	1.00 (145)	0.66 ± 0.47 (145)	0.34 ± 0.48 (145)	0.36 ± 0.48 (145)	0.66 ± 0.47 (145)	0.52 ± 0.50 (96)
PIGU	1.29 ± 0.46 *(70)*	0.67 ± 0.72 *(70)*	0.21 ± 0.41 *(70)*	0.21 ± 0.41 *(70)*	0.49 ± 0.46 *(70)*	0.31 ± 0.41 *(37)*
RHAU*	1.00 *(70)*	0.67 ± 0.47 *(70)*	0.41 ± 0.50 *70)*	0.41 ± 0.50 *70)*	0.67 ± 0.47 *(70)*	0.62 ± 0.49 *(47)*
CAAU* PRBO	1.00 *(39)*	0.18 ± 0.39 *(39)*	0.10 ± 0.31 *(39)*	0.13 ± 0.34 *(39)*	0.18 ± 0.39 *(39)*	0.57 ± 0.53 *(7)*
CAAU* ALL	1.00 (158)	0.22 ± 0.41 *(158)*	0.09 ± 0.29 *(158)*	0.10 ± 0.30 *(158)*	0.22 ± 0.41 *(158)*	0.44 ± 0.50 *(34)*
ASSP*	1.00 *(43)*	0.83 ± 0.38 *(41)*	0.58 ± 0.50 *(43)*	0.58 ± 0.50 *(43)*	0.83 ± 0.38 *(41)*	0.73 ± 0.45 *(34)*

* 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, 2009-2019. Estimates include Southeast and West End Islands unless otherwise noted.

Species	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2009-2019 average
DCCO	198	214	226	232	104	364	364	220	360	260	194	249
BRCO	7,240	7,246	4,582[b]	4,824	5,742	6,566[b]	7,412	3,450[b]	4,916	5,132	1,248	5,470
PECO	162	160	312[b]	308	234	440[b]	372	298[b]	206	320	268	254
WEGU	13,820	13,769	13,245	10,044	11,164	18,686	21,148	15,846	17,406	18,218	15,747	15,372
CAGU	18	9	10	30	184	514	522	70	208	396	192	196
PIGU [d]	2,351	3,500	2,044	2,009	3,157	4,459	3,880	3,645	3,461	3,317	2,851	3,152
TUPU [c]	374	406	396	376	326	288	286	244	246	234	216	308
CAAU [a]	16,511	26,573	21,026	20,059	25,606	28,444	22,574	19,607	17,866	12,964	14,512	20,522

[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)

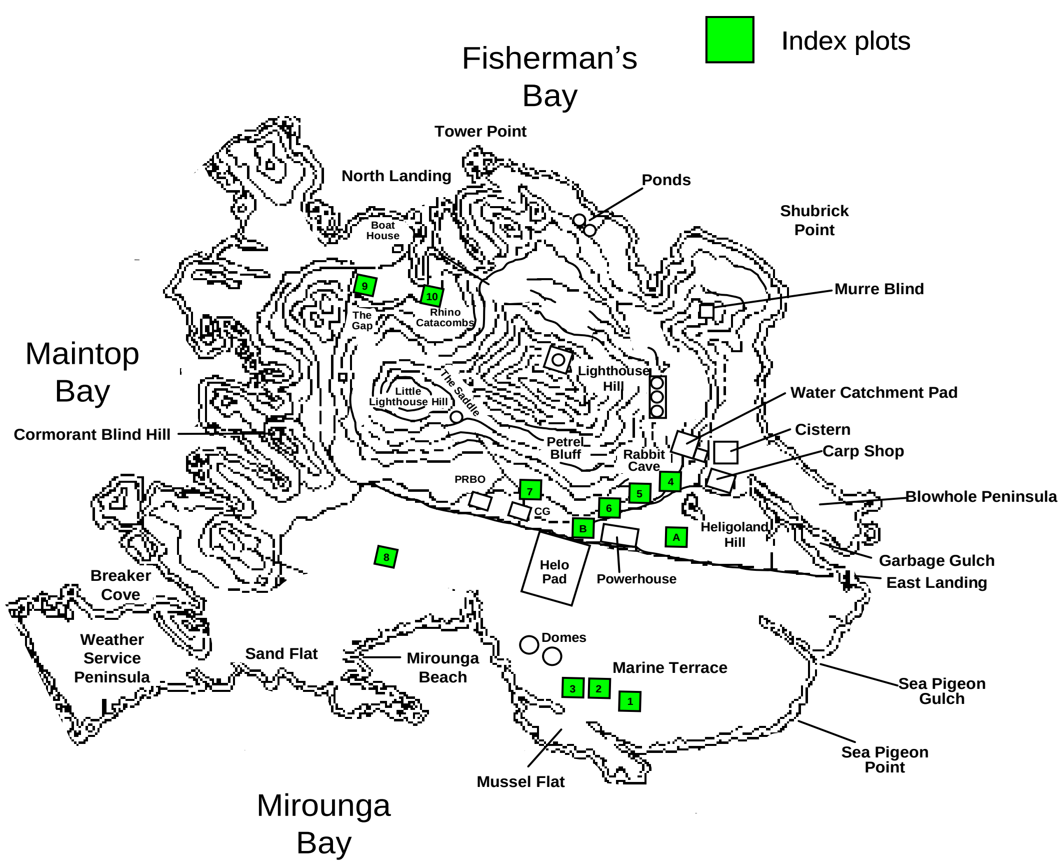
[d] Estimates derived from morning raft counts. Evening counts used prior to 2002 and are considerably lower (see text).

Table 3. Cassin's Auklet burrow counts from 12 (10m x 10m) index plots on Southeast Farallon Island for 2019. 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
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
2018	4	9	25	29	33	5	23	25	109	87	21	42	412
2019	6	9	9	12	14	3	14	12	72	58	17	30	256
2009-2019 average	18	13	21	18	19	9	14	15	79	43	9	23	280

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, 2018, and 2019 are likely due to extremely high numbers of California Sea Lions hauling out and crushing burrows in those areas.

Cassin's Auklet Index Plots



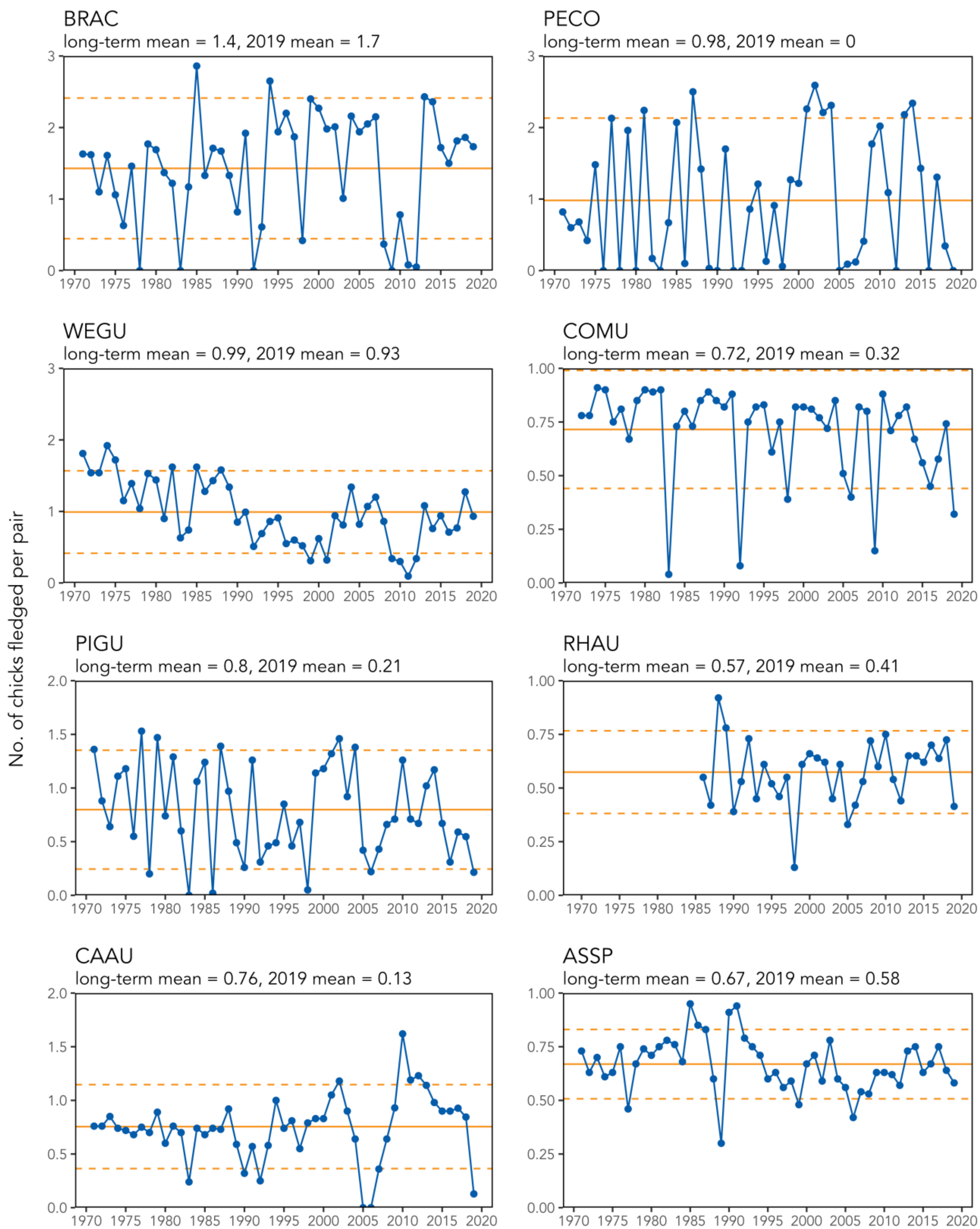


Figure 1a. Productivity of 8 seabird species on Southeast Farallon Island, 1971 – 2019, measured as the number of chicks fledged per breeding pair (includes first attempts, relays, and second broods). The

solid orange line indicates mean productivity from all attempts between 1971 and 2018. Dashed orange lines represent 80% prediction intervals around the long-term mean.

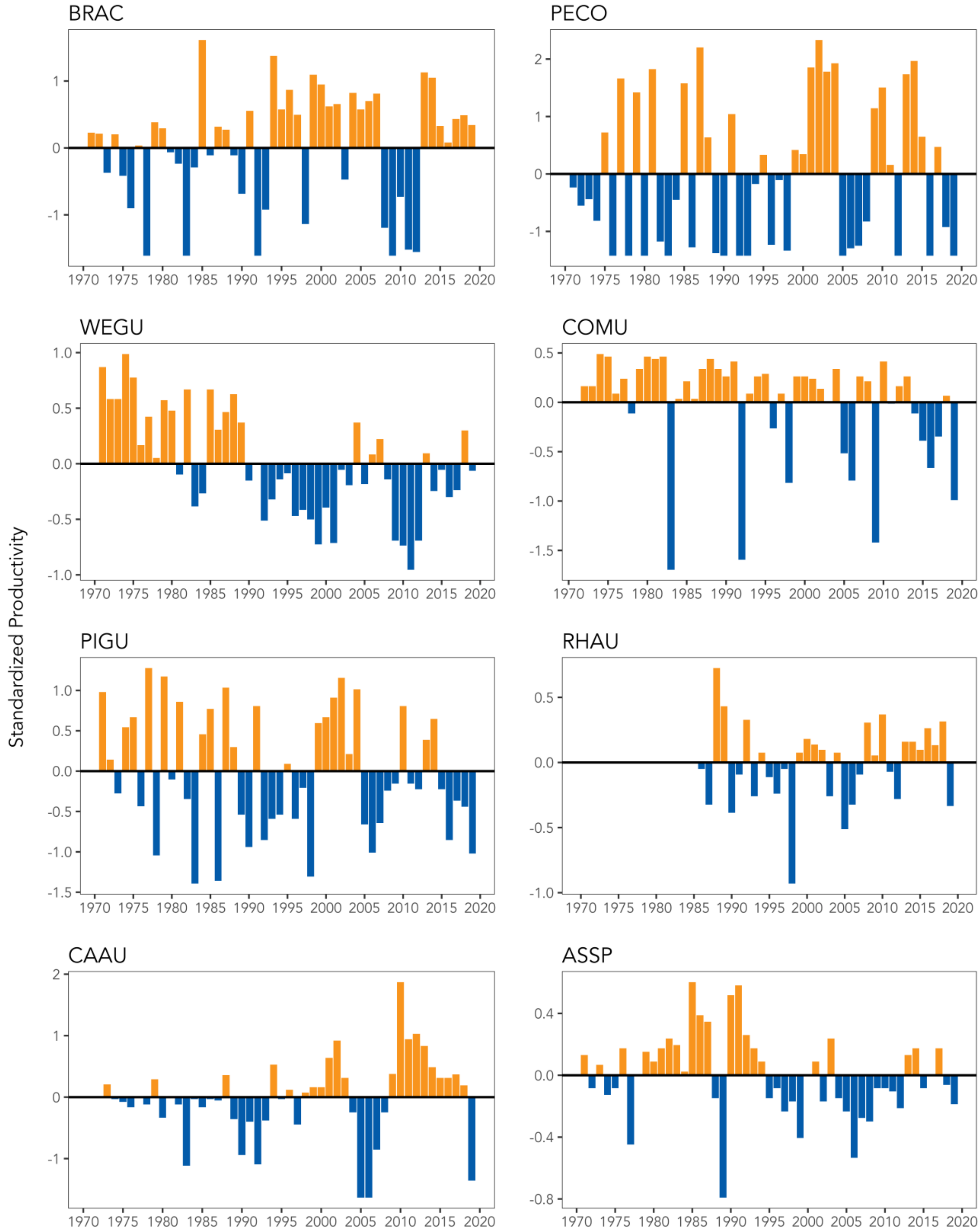


Figure 1b. Standardized productivity anomalies (annual productivity – long-term mean) for 8 seabird species on Southeast Farallon Island, 1971 – 2019.

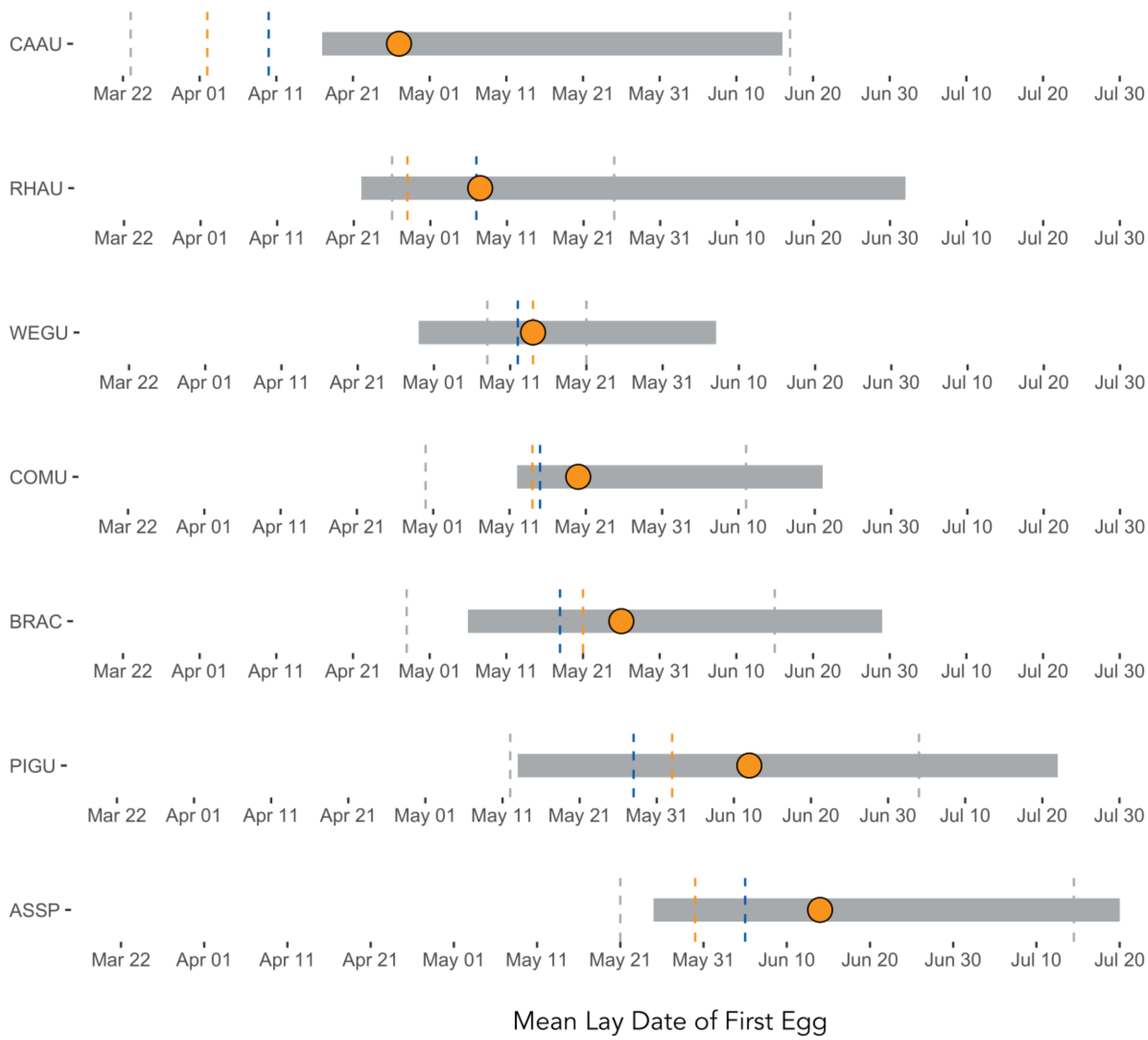


Figure 2. Phenology for 8 seabird species on Southeast Farallon Island, for the first egg in first attempts only. Orange circle represents median lay date for 2019, grey bar corresponds to the range of lay dates in 2019 (min and max). Median lay date for 2018 shown as orange dashed line, long-term median as blue dashed line, and years with the earliest and latest median lay dates as grey dashed lines.

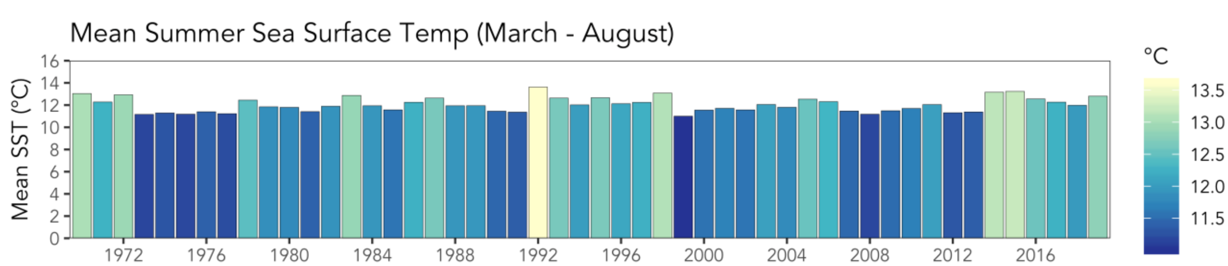


Figure 3. Annual mean summer (March – August) sea surface temperature (SST) for Southeast Farallon Island, 1968 – 2019. SST was measured daily from Water Sample Point, near East Landing. Lighter shades represent warmer temperatures, darker shades cooler temperatures.

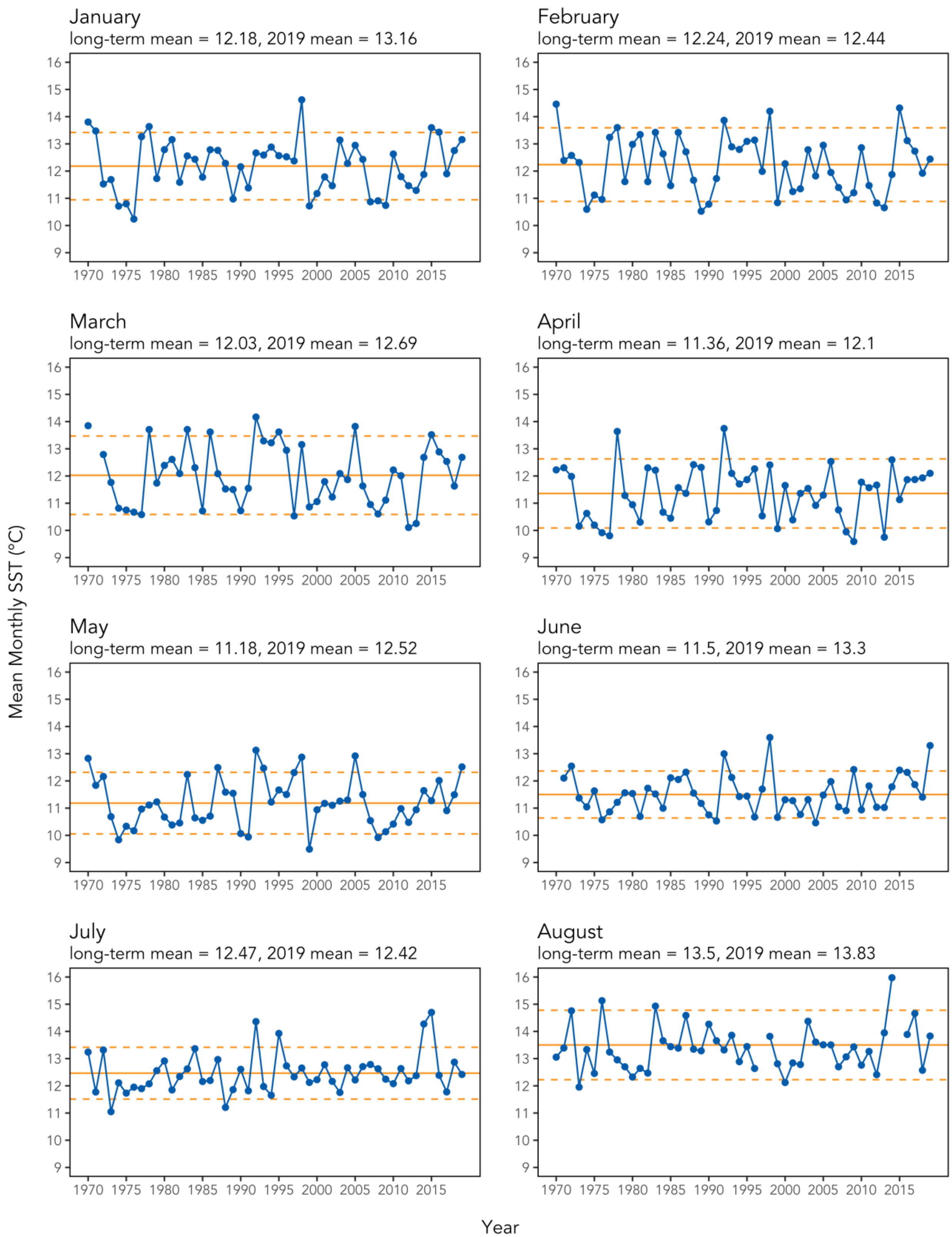


Figure 4a. Monthly mean sea surface temperature (SST) at Southeast Farallon Island, 1971 – 2019. SST was measured daily from Water Sample Point, near East Landing. The solid orange line indicates the long-term mean, and dashed orange line the 80% prediction interval for the long-term mean.

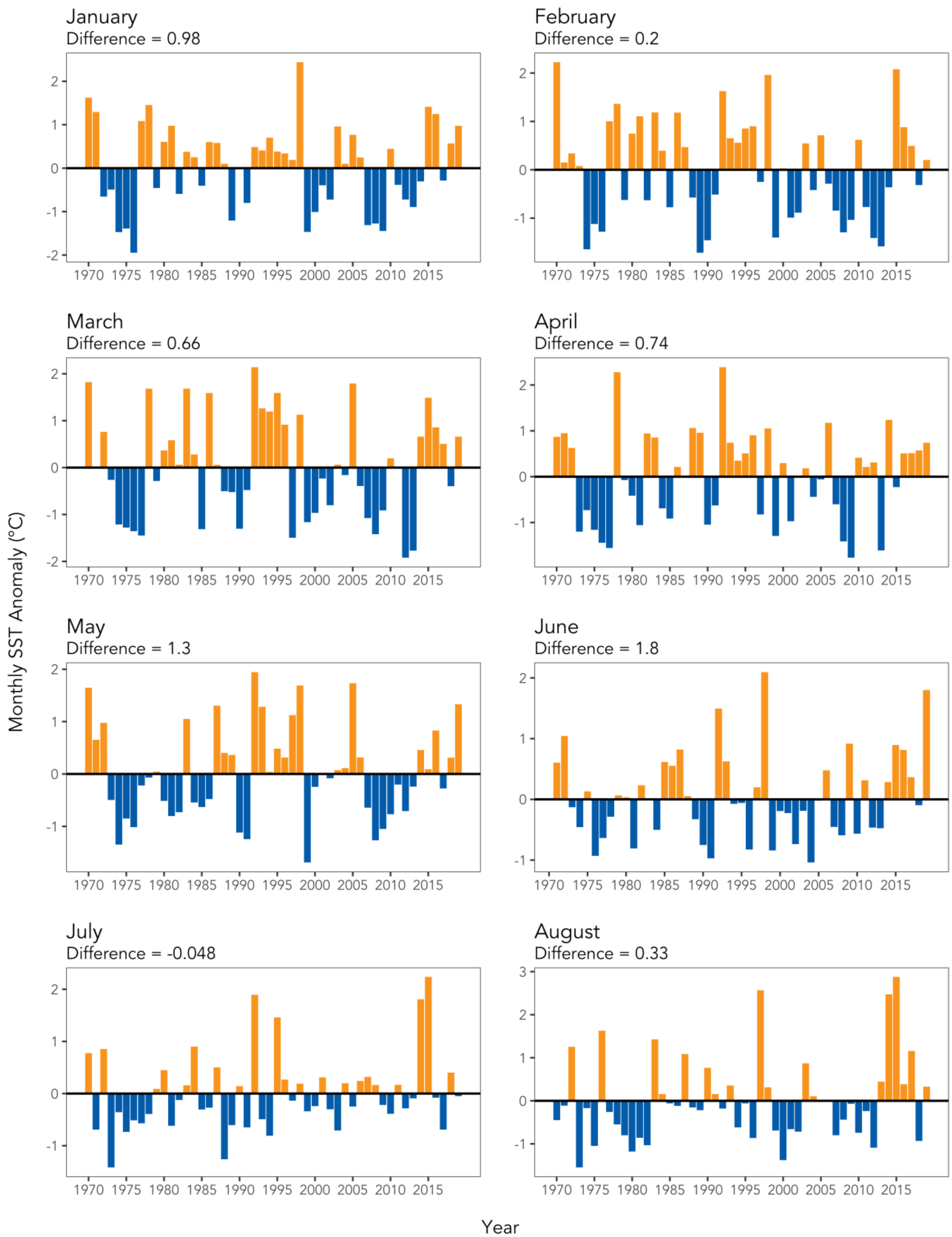


Figure 4b. Standardized monthly sea surface temperature (SST) anomalies (annual mean – long-term mean) for Southeast Farallon Island from 1971 – 2019.

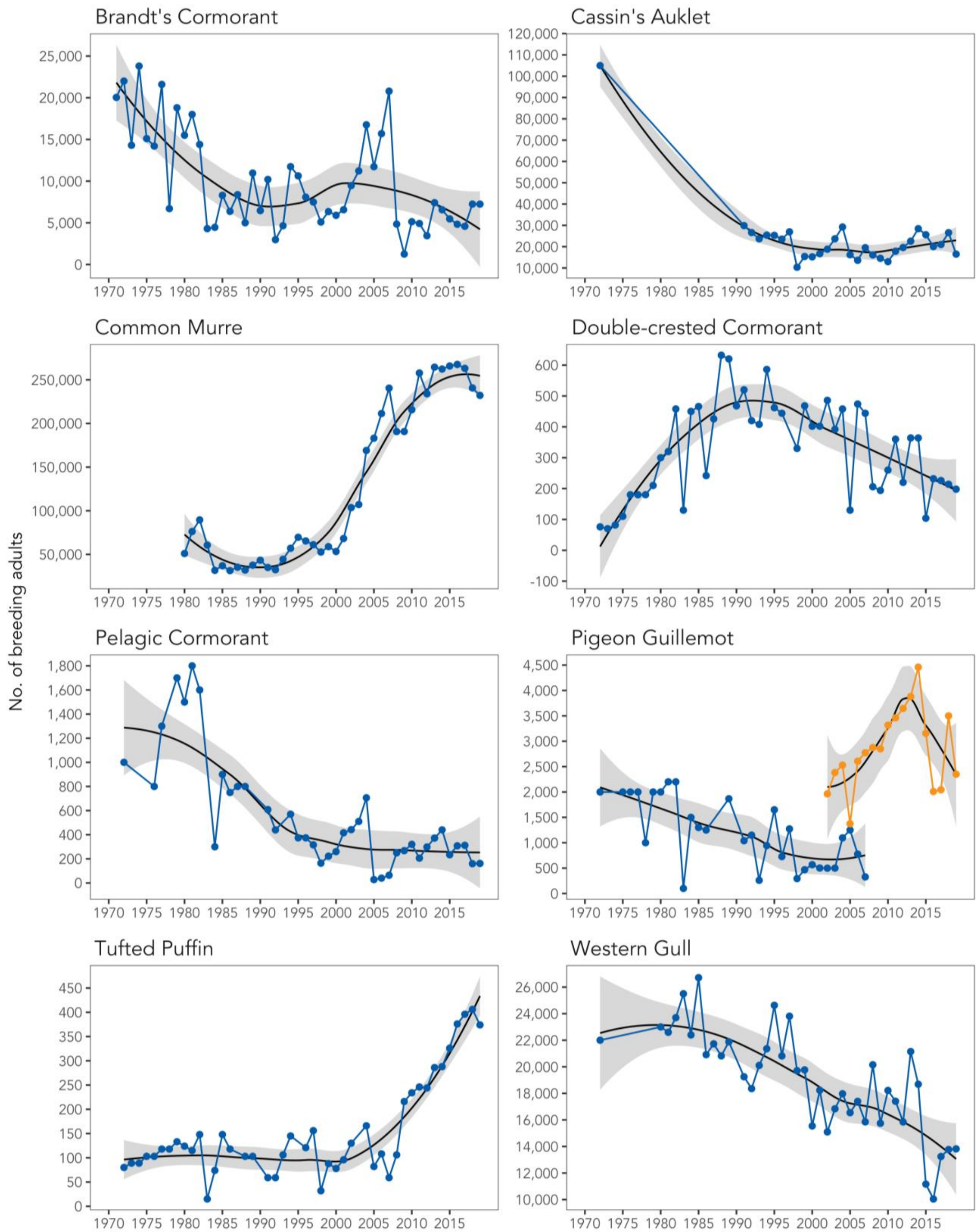


Figure 5. Population trends for 8 seabird species on Southeast Farallon Island, 1971 – 2019, determined by counts of individuals or nests in all visible areas on SEFI and West End. Loess trend lines and shaded confidence intervals illustrate long-term trend. For PIGU, blue points correspond to evening raft counts and orange dots to morning raft counts. Since 2006, COMU estimates are based on changes in index plots (see Fig. 11 and text).

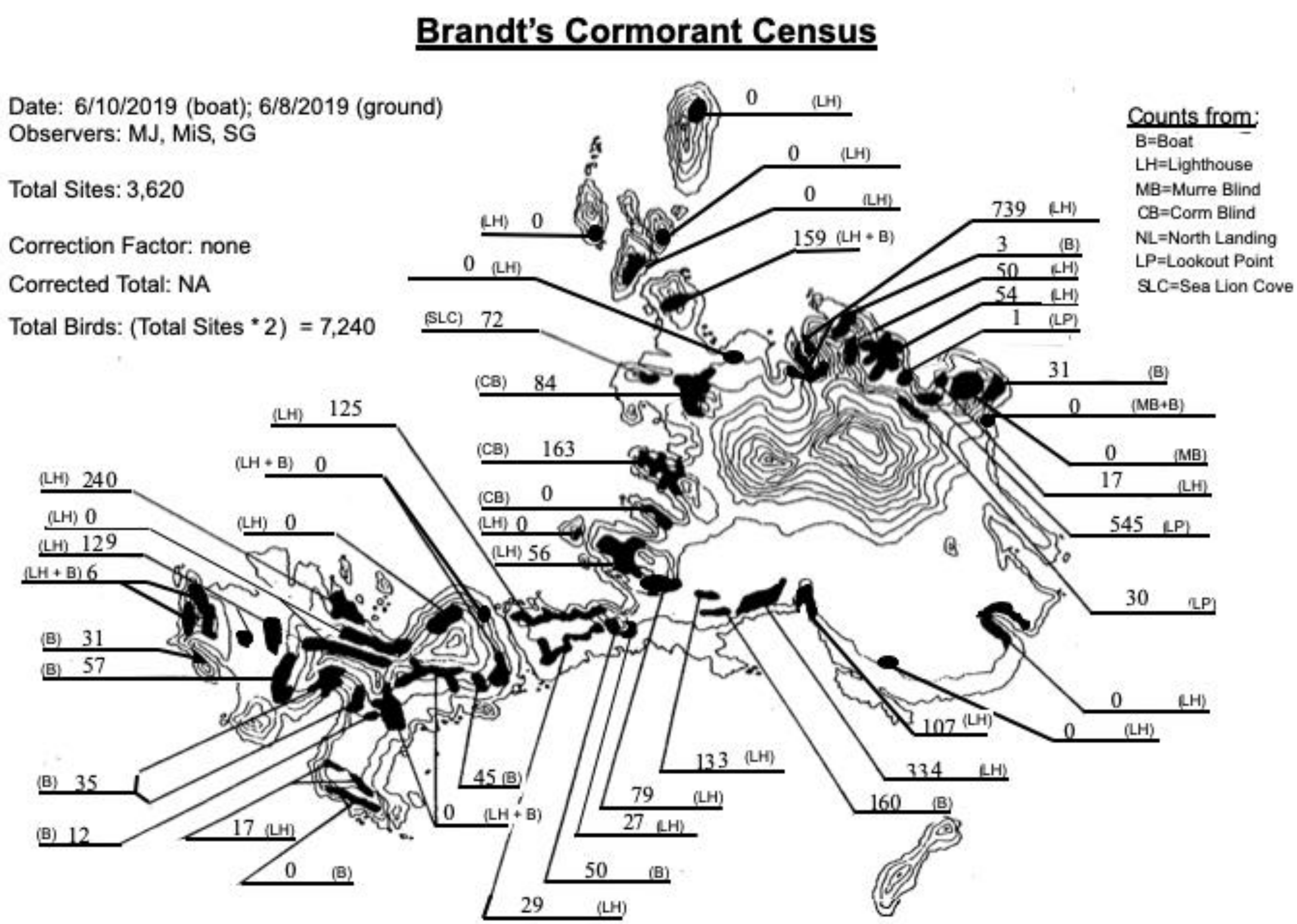


Figure 6: Counts of Brandt's Cormorants on Southeast Farallon Island during the 2019 census. Surveys were conducted from the following locations: Lighthouse Hill (LH), Murre Blind (MB), Cormorant Blind (CB), North Landing (NL), and Boat (B).

Pelagic Cormorant Census

Date: 6/10/2019 (boat); 6/8/2019 (ground)

Observers: MJ, MiS, SG

Total Sites: 81

Correction Factor: none

Corrected Total: NA

Total Birds: (Total Sites * 2) = 162

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

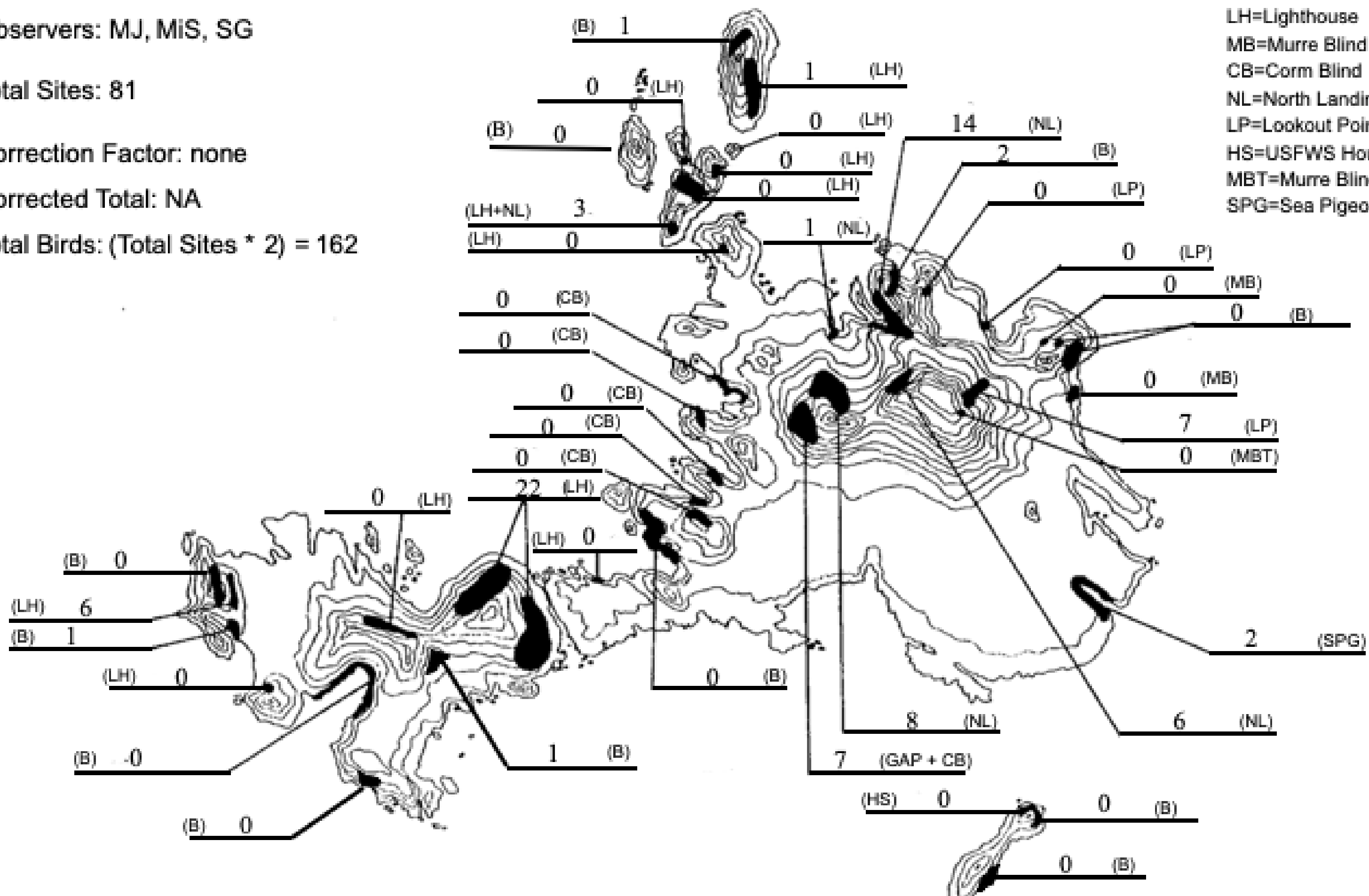


Figure 7: Counts of Pelagic Cormorants on Southeast Farallon Island during the 2019 census. Surveys were conducted from the following locations: Lighthouse Hill (LH), Lookout Point (LP), Murre Blind (MB), Cormorant Blind (CB), North Landing (NL), USFWS House (HS), Murre Blind Trail (MBT), Sea Pigeon Gulch (SPG), and Boat (B).

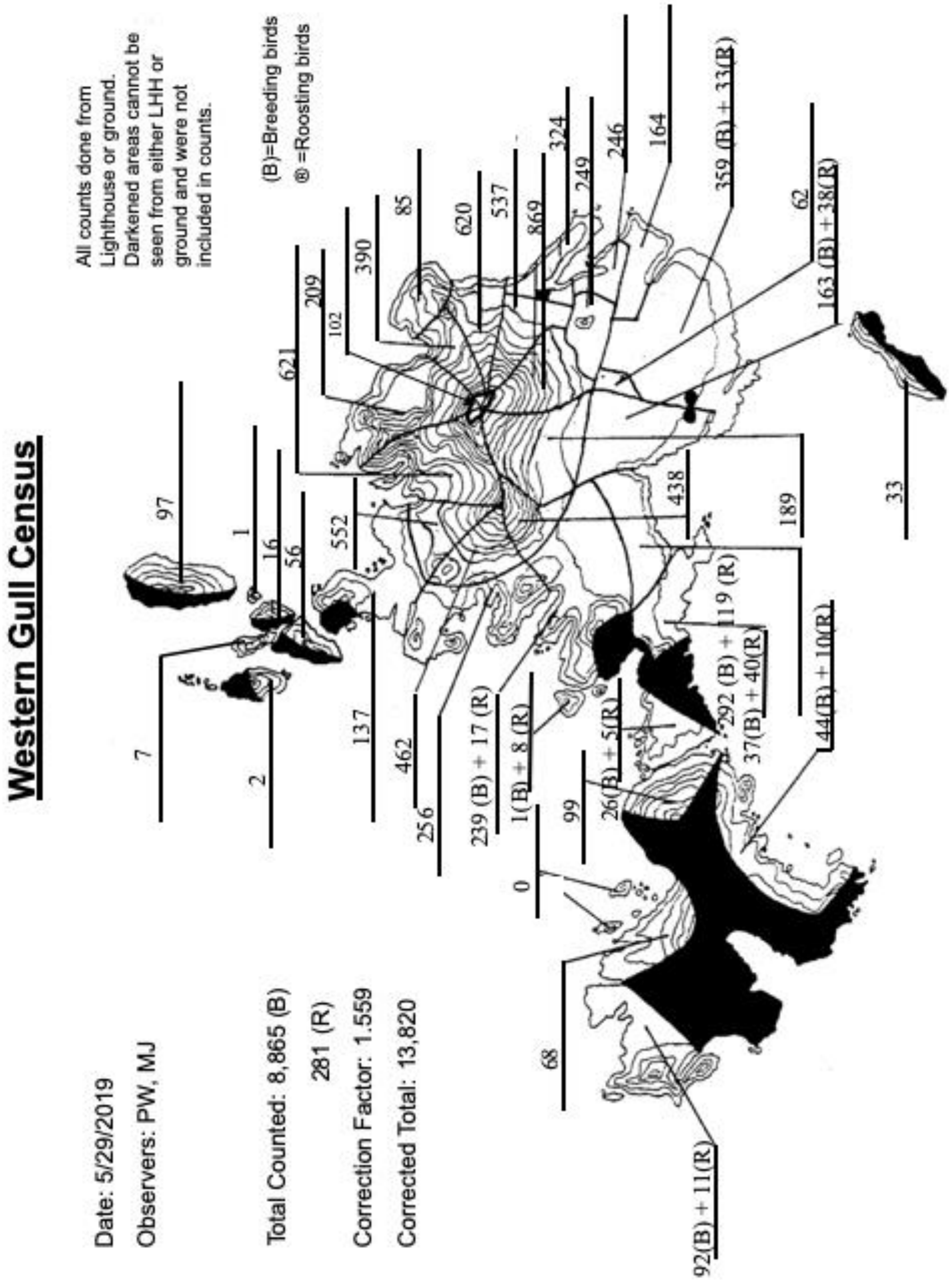


Figure 8: Counts of Western Gulls on Southeast Farallon Island during the 2019 census.

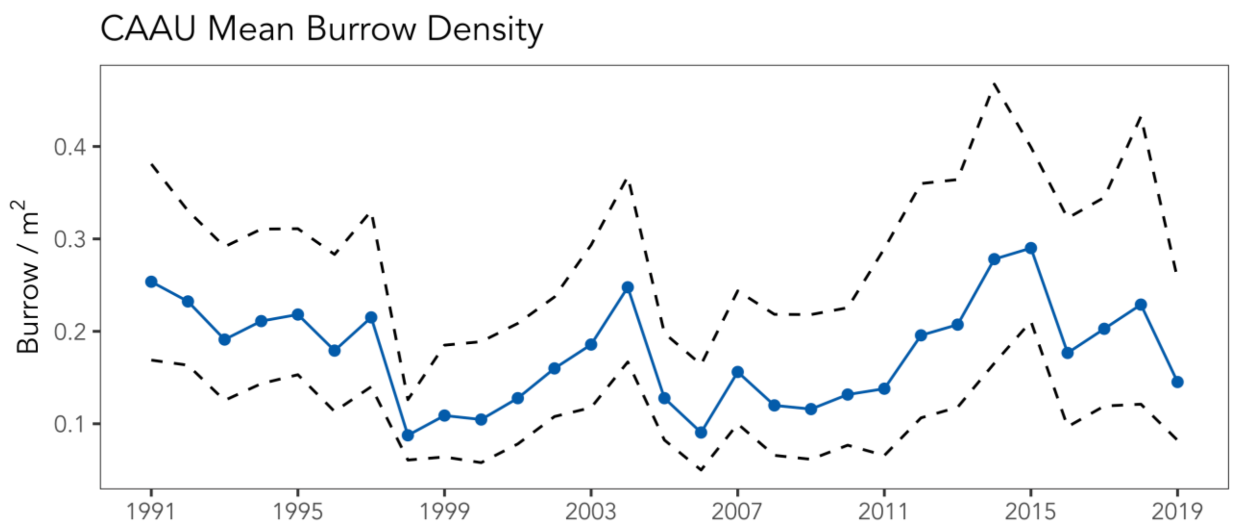


Figure 9. Geometric mean burrow/crevice density in 12 Cassin's Auklet index plots from 1991 to 2019. The blue line represents annual mean values. The dashed line represents the upper and lower 95% confidence intervals.

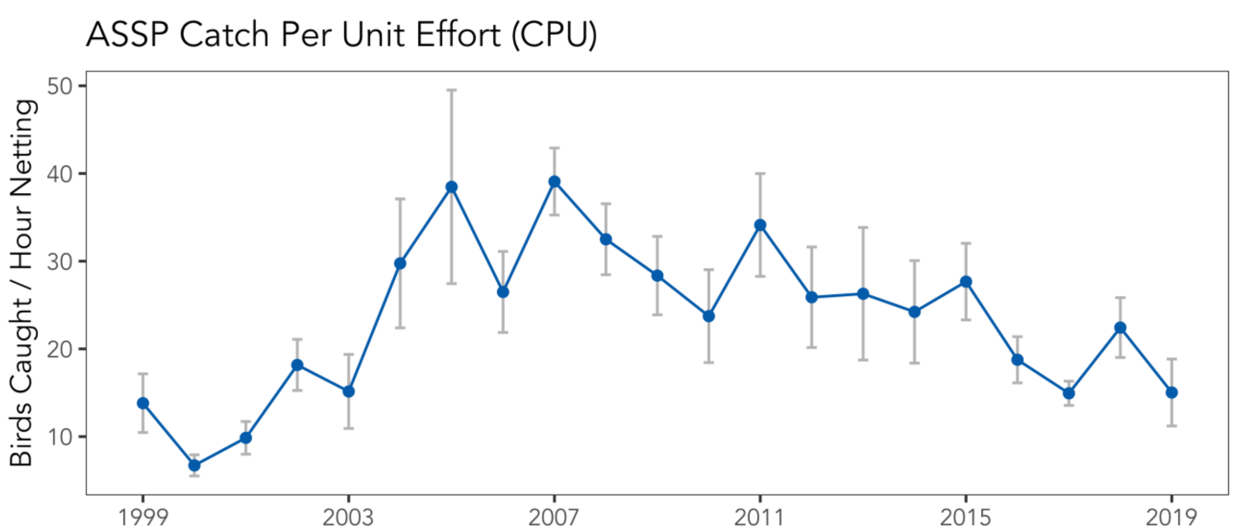


Figure 10. Mean number of Storm-petrels caught per hour of netting effort on SEFI from 1999 to 2019. Error bars represent the standard error for the mean calculated from all capture sessions in a given season.

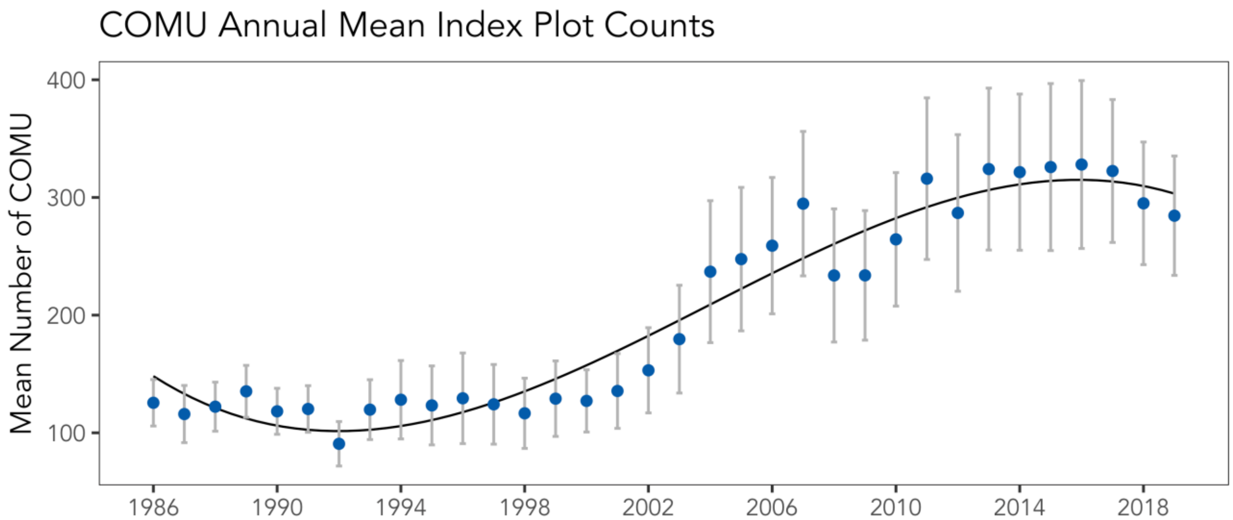


Figure 11. Mean annaul counts for Common Murre index plots from 1986 to 2019. Error bars represent the standard error for the mean calculated from all capture sessions in a given season.

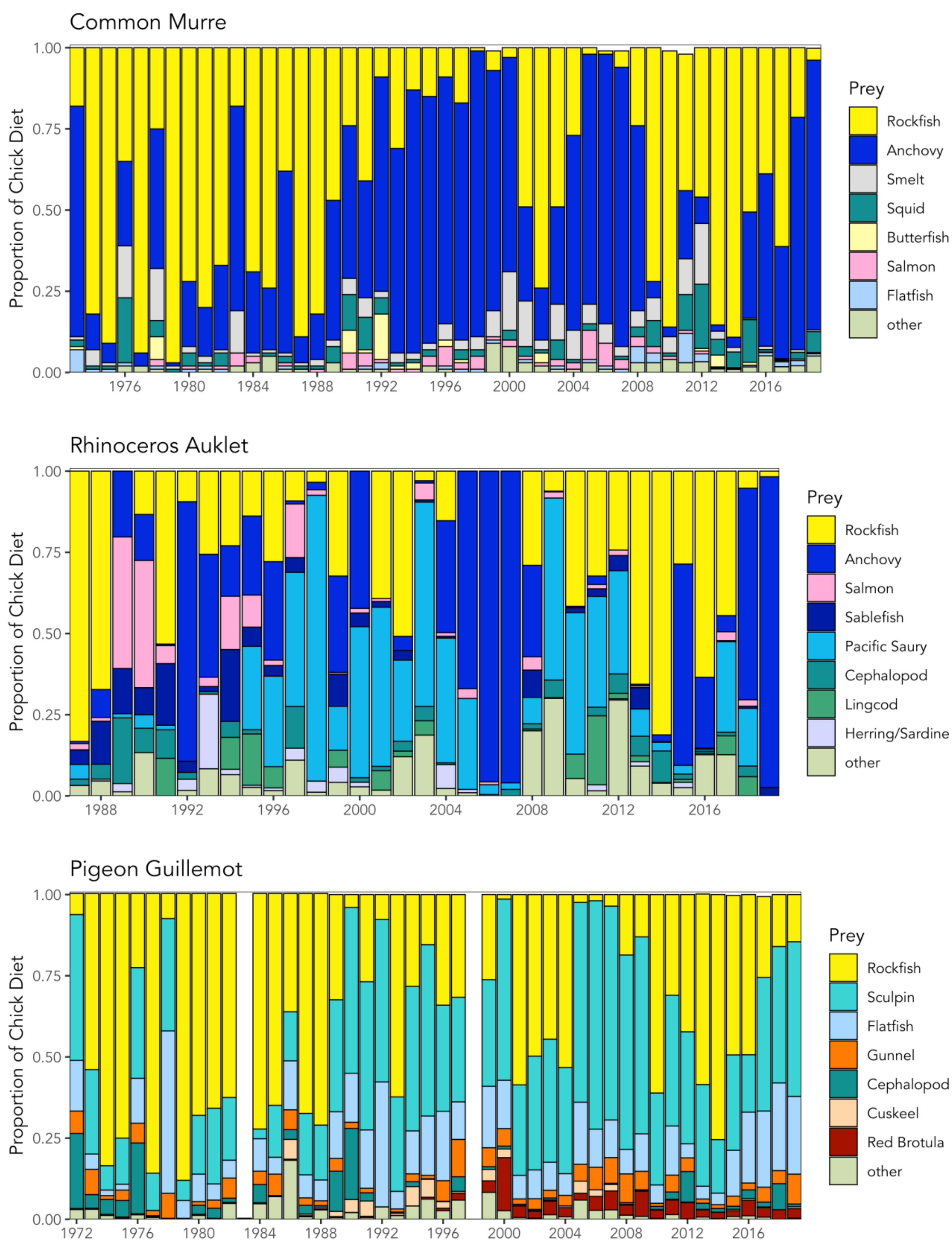


Figure 12. Annual proportion of common prey items in the chick diet of three species of seabirds on Southeast Farallon Island.

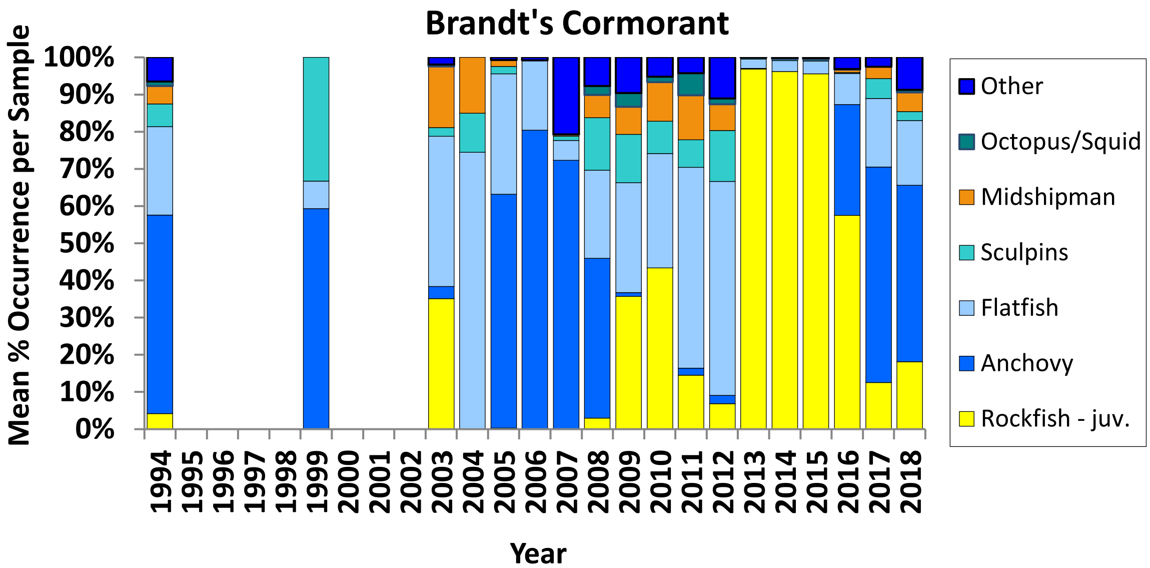


Fig. 13 Mean percent occurrence per sample of common prey items by year in the diet of Brandt's Cormorants on Southeast Farallon Island. As of this report, cormorant diet data has not been analyzed for 2019.

APPENDICES

Appendix I. Calculation of correction factor for Western Gull census, 2019.

Area	Nest Count	Bird Count	Correction Factor
C	74	94	1.569
K	116	146	1.585
H (H1 only)	222	291	1.524
Total			**1.559**

Appendix II.

Calculation of correction factor for Common Murre colony attendance, 2019. 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 10 (1000)	226	223	2.03
June 11 (1000)	226	230	1.97
June 12 (1000)	226	242	1.87
June 13 (1000)	226	243	1.86
Mean	226	235	**1.93**

UU

Date (Time)	Breeding Sites	No. of birds	Correction Factor
June 10 (1000)	152	158	1.92
June 11 (1000)	152	140	2.17
June 12 (1000)	152	163	1.87
June 13 (1000)	152	177	1.72
Mean	152	160	**1.92**

Mean correction factor for SEFI 2019: **1.92**