Point Blue Report

Population size and reproductive performance of seabirds on Southeast Farallon Island, 2018

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

December 2018

M. Johns and P. Warzybok
California Current Group
Point Blue Conservation Science

Conservation science for a healthy planet

3820 Cypress Drive, #11 Petaluma, CA 94954
T 707.781.2555 | F 707.765.1685
pointblue.org

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Mike Johns and Pete Warzybok

Acknowledgements

We are indebted to our research assistants: Piero Becker, Sophie Bennett, Gavan Borgias, Katherine Douglas, Clare Flynn, Cole Jower, Amy Miles, Holly Pickett, and Amanda Spears for their invaluable assistance in the field. Point Blue staff biologists Mike Johns and Pete Warzybok trained and supervised research assistants. Jim Tietz supervised data collection during the fall. We are also very grateful for the continued financial and logistical support provided by the U.S. Fish and Wildlife Service, Bently Foundation, Baker Trust, Marisla Foundation, Mead Foundation, Campini Foundation, Bernice Barbour Foundation, Kimball Foundation, RHE Charitable Foundation, Volgenau Foundation, Grand Foundation, National Fish and Wildlife Foundation, Farallon Islands Foundation, Farallon Patrol, individual donors to our Farallon Program, and Point Blue colleagues on the mainland. This is Point Blue contribution no. 2210.

Suggested Citation

Johns, M.E. and P. Warzybok. 2018. Population Size and Reproductive Performance of Seabirds on Southeast Farallon Island, 2018. Unpublished report to the U.S. Fish and Wildlife Service. Point Blue Conservation Science, Petaluma, California. Point Blue Conservation Science Contribution Number 2210.

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TABLE OF CONTENTS

LIMITED RIGHTS DISCLOSURE 4
EXECUTIVE SUMMARY 5
INTRODUCTION 6
METHODS AND RESULTS 6
Reproductive Performance 6
Population Estimates 10
Ocean conditions and Seabird Diet 13
DISCUSSION 14
Weather and Ocean Conditions 14
Productivity 15
Populations 16
Summary 19
RESEARCH AND MANAGEMENT RECOMMENDATIONS 20
TABLES 24
FIGURES 27
APPENDICES 39

LIMITED RIGHTS DISCLOSURE

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 1968. 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 varied between species during 2018 relative to recent years.

(3) Generally normal conditions persisted during 2018. The mean seasonal SST for 2018 was slightly cooler than 2017 but remained higher than the long-term mean. Monthly values were similar to the mean for all individual months except August, which was colder than normal.

(4) During 2018, breeding populations where higher for some species and lower for relative to 2017. Brandt's Cormorants rebounded slightly from a general decline in recent years, while Cassin's Auklets and Western Gulls exhibited moderate increases. We observed a substantial increase in our estimate of Pigeon Guillemots compared to last year. Double-crested Cormorants exhibited modest declines while Common Murres and Pelagic Cormorants exhibited large declines relative to last season.

(5) Reproductive success was higher for all species except Pelagic Cormorants, Pigeon Guillemots, Ashy Storm-petrels, and Cassin's Auklets when compared to 2017. Western Gulls and Common Murres exhibited productivity rates higher than the long-term mean for those species.

(6) Anchovy replaced juvenile rockfish (*Sebastes spp*.) as the dominant component of chick diet for the Common Murre and Rhinoceros Auklet. Juvenile rockfish was nearly absent from Rhinoceros Auklet diet, and less than half as abundant in Common Murre diet compared to 2017. Krill once again seemed to be available for Cassin's Auklets throughout the season, however, auklets still showed only moderate breeding success with no 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 2018. We monitored eleven species: Ashy Storm-petrel (ASSP), Double-crested Cormorant (DCCO), Brandt's Cormorant (BRCO), 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) 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 2018, and have not for several years. At least 2 pairs of Canada Geese bred on the island and fledged a total of 8 chicks.

METHODS AND RESULTS

Reproductive Performance

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 50 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, poor visibility of DCCO and CAGU nesting areas, and limited number of BLOY, detailed reproductive data were not collected for these species.

Brandt's Cormorant – BRCO productivity remained similar to last season. Mean productivity for the Corm Blind colony was 1.86 fledglings per pair. This is approximately 3% greater than last season and 30% higher than the long-term mean productivity for this species (Fig. 1a). The first eggs were observed on May 5th at both the Corm Blind and the Sea Lion Cove colonies. Median laying date for the colony was 20 May, 3 days later than the long-term median for this species (Fig. 2). All nests where at least one egg was laid 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 2.83 eggs per nest and hatching success was 75%. Mean brood size was 2.26 chicks per nest, 79% of which survived to fledging age. A total of 430 chicks were banded this season with the last chicks departing the colony by early September.

Pelagic Cormorant **–** PECO experienced a near reproductive failure this year, similar to what was observed in 2016. Of the 75 sites followed for productivity estimates, 36 were regularly attended during the season and only 24 were confirmed to have laid eggs. Mean productivity for the colony was 0.34 chicks fledged per breeding pair. This is approximately 66% lower 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. For those we were able to observe, mean clutch size was 2.53 eggs per nest and mean brood size was 0.86 chicks per nest. Birds began attending sites and building nests in early March, but the first eggs were not observed until June 14th. The first chicks were observed on July 4th, the same as 2017.

Western Gull **–** WEGU productivity was 1.27 chicks per pair, approximately 65% higher than last season an 28% higher than the long-term mean productivity for this species (Fig. 1a). The first eggs were observed on the island on April 26th. Of the eggs laid, 70% hatched and 60% of those chicks survived to fledge. Mean clutch size was 2.80 eggs per nest and mean brood size was 2.02 chicks per nest. There were 649 chicks banded at the colony this season with the last chicks fledging and departing the colony by the end of August.

California Gull **–** 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 at least 3 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 persistent breeding failure likely contributed to the low breeding effort.

Common Murre **–** During 2018, 280 Common Murre sites were monitored daily in the Upper Shubrick Point (USP) study plot, of which 231 were breeding sites (where an egg was laid). Productivity was 0.74 chicks fledged per pair. This is approximately 28% higher than last season and 4% higher the long-term average of 0.71 (Fig. 1a). Egg laying was slightly earlier than average with the first egg observed in this plot on 29 April. Median laying date for the plot was 13 May, equal to the long-term this colony. Eighty-eight percent of eggs hatched but only 84% of the hatched chicks survived to fledge.

The colony of Common Murres in Upper Upper (UU), under the Cormorant Blind, had similar reproductive success to the colony at USP. The first eggs were observed on 2 May this season, and the median lay date for the plot was 14 May, just a day after the first egg at USP. There were a total of 184 sites monitored in UU this season, 146 of which were breeding sites. Reproductive success for this colony was 0.79 chicks fledged per breeding pair. Ninety-six percent of the eggs hatched and 81% 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 101 sites were monitored during 2018, of which 77 were observed with at least one egg, the same number of active sites as in 2017. 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 2018 was 0.55 fledglings produced per pair (Table 1). This was approximately 5% lower than 2017 and remains 32% below the long-term mean productivity for this species (Fig. 1a). The first eggs were observed on 17 May, and the median egg laying date was 1 June (Fig. 2). This was 10 days earlier than last season and 4 days later than the long-term median laying date for this species. The mean clutch size was 1.31 eggs per nest with 65% of those eggs hatching successfully. Mean brood size was 0.83 chicks per nest with 67% of the chicks produced survived to fledging age. No sites were successful at fledging a complete brood of two chicks, and only 44 of the 77 active sites were able to fledge a single chick. There were a total of 42 guillemot chicks banded on SEFI this season.

Rhinoceros Auklet – There were a total of 150 sites (boxes, crevices, and cave sites) monitored in 2018, 69 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 percent of nest boxes were occupied compared to 70% of camera sites, both slightly higher than the occupancy rates in 2017. Productivity during 2018 was 0.72 fledglings per pair. This is approximately 13% higher than the productivity observed in 2017 and 26% above the long-term mean productivity for this species (Fig. 1a). The first eggs were observed on 17 April, the same as in 2017, and the median laying date was 27 April. This is approximately 9 days earlier than the long-term median for this species (Fig. 2). Eighty-three percent of the eggs successfully hatched and 88% of those chicks produced survived to fledge. There were a total of 26 Rhinoceros Auklet chicks banded this season with the last chick fledging from a followed site on by the end of August.

Cassin's Auklet – Productivity of Cassin's Auklets breeding in PRBO study boxes remained high with 0.84 chicks fledged per breeding pair (including relay attempts). This was 10% lower than 2017 and 12% higher than the long-term average of 0.75 chicks per pair for this species (Fig. 1a). Seventy-five percent of the eggs hatched and 97% of those chicks survived to fledge. There were 7 double brood attempts this season, none of which were successful. The first egg was observed on 22 March and the median laying date for PRBO boxes was 1 April. This was approximately 30 days earlier than last season and 13 days earlier 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 0.78 chicks per pair (n=207). This is approximately 7% lower than the estimate derived from PRBO boxes. There were 33 double brood attempts across all sites, 2 of which were successful. Island wide, there were a total of 346 chicks banded.

Ashy Storm-Petrel – ASSP pairs laid eggs in 69% of the 90 followed sites (n=62) during 2018, approximately 20% higher than the occupancy rate observed last season. There were 5 new breeding sites discovered during 2018 while 19 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 2 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 9 May and the median laying date for the colony was 29 May. This is approximately 17 days earlier than last season (Fig. 2). Overall productivity for this species was 0.64 chicks fledged per pair (including all relay attempts). This is approximately 15% lower than last season and 5% below 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 2018, it appears that only the Canada Geese attempted to breed. Four pairs of Canada Geese were present on the island by mid-March and three attempted to nest. The first nest was discovered atop Little Lighthouse Hill on 9 March with at least 3 eggs. Tall grasses and reduced search efforts likely lead to missing nests, however, 2 pairs were observed wandering around the Marine Terrace by April. Eight chicks (7 from one nest and 1 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 23 July.

From mid-March until mid-May, 1-4 Peregrine Falcons were seen daily, however, by early May there was only one falcon sporadically seen around the island and showed 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.

Population Estimates

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 5. 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 9 evenings between April and August. As a result, we banded a total of 528 new Ashy Storm-petrels and recaptured 48 that had been previously banded, for a total of 576 birds handled. The mean standardized capture rate during 2018 netting sessions was 22.43 birds per hour (s.e. = 3.41, n= 9; Fig. 10). This is approximately 50% higher than during 2017 and 13% lower than the mean capture rate for the previous 10 years. Our most productive netting session was on 17 June during which we captured 119 birds. There were also 6 new Leach's Storm-petrels banded this season.

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 17 counts were made in 2018, beginning on 26 April and ending on 15 July, when juveniles became indistinguishable from adults. On 21 May we counted a peak number of 107 "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 214 breeding birds. This estimate is approximately 5% lower than 2017 and 15% below the 10-year average population for this species (Table 2). There was a high count of 143 chicks observed during the 10 July census.

Brandt's Cormorant – The BRCO breeding population was censused during ground- and boat-based surveys. During the surveys we counted 3,623 "well-built" nests (Fig. 6). We then multiplied the number of nests by 2 to yield an overall population estimate of 7,246 breeding birds (Table 2). This estimate is 58% higher than 2017 and approximately 50% above the 10-year average (Table 2). This is the first time the population has grown since a brief increase in 2013. We multiplied the total number of nests by the mean productivity to estimate an island-wide production of approximately 6,883 fledglings.

Pelagic Cormorant – The PECO breeding population was censused during ground- and boat-based surveys, where a total of 80 fair to well-built nests were counted (Fig. 7). We then multiplied this number by 2 to yield an overall breeding population of 160 birds (Table 2). This estimate for Pelagic Cormorants is approximately 49% lower than 2017 and 47% lower than the 10-year average.

Western Gull – 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 8,964, approximately 775 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 (1.536) 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 13,769 birds (Table 2). The population estimate for WEGU is approximately 4% higher than 2017 and 15% lower than the 10-year average (Table 2). 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 8,743 fledglings on SEFI in 2018.

California Gull – CAGU were censused every five days throughout the season beginning on 1 May. A peak count of only 3 "well-built" nests was counted on 15 June resulting in a breeding population estimate of just 6 birds. It's safe to assume the breeding population of CAGU on SEFI is no longer viable. The peak count for total birds was 9 on 25 June, down from a peak count of 570 in 2014 and 18 last season. No chicks were produced this season.

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 was photographed using a DSLR and telephoto lens once a day for 10 consecutive days. Total COMU within plots in photos are 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 8% lower than 2017 (Figure 11) but still 12% 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 240,703 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 1.73. 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 3,500 birds on 20 April. This count was approximately 71% higher than the peak count from 2017 and 10% higher than the 10 year mean for morning surveys (Table 2 and Fig. 5).

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 2018 surveys, a total of 203 active sites were observed. Based on these observations, we estimated a breeding population of 406 birds (Table 2). This estimate is 3% greater than 2017 and 40% greater than the 10-year average population for this species. The 2018 estimate once again surpassed the previous record high count in our time series (Fig. 5). This is the 6th consecutive season and 9th 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). Netting for mark/recapture and diet sampling was continued in 2018. A total of 71 new birds were banded and 91 were recaptured (13 birds were recaptured multiple times during the season). Recapture rates were much higher than last season, and the number of new birds banded during netting sessions was approximately 78% higher 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 2018, we counted a total of 412 burrows/crevices in the index plots. Therefore, using the same methodology, but with the updated whole island estimate generated in 2009, we estimated a 2018 breeding population of roughly 26,573 birds ([412/225] x 14512) on Southeast Farallon Island. Total island-wide production (number of breeding pairs x mean productivity) was estimated at 11,160 fledglings on SEFI. The breeding population estimate is approximately 26% higher than in 2017 and 34% higher than the 10-year average (Table 2).

<u>Ocean conditions and Seabird Diet</u>

Sea surface temperature (SST) is measured daily from Water Temperature Point near East Landing as an indicator of local ocean conditions. During 2018, the mean seasonal SST from March to August was 11.82°C (Fig. 3). This was 0.42°C cooler than the 2017 season and 0.2°C cooler than the long-term mean for these months. 2018 was considered a normal year in terms of SST conditions, with monthly values close to the long-term mean for all individual, and below average for August (Fig. 4a, 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 2018, juvenile rockfish were a less prevalent item in chick diet compared to previous seasons (Figs. 12 and 13). Rockfish comprised 21% of the diet for Common Murres, 5% for Rhinoceros Auklets, and 16% for Pigeon Guillemots. As was seen during the past two seasons, the vast majority of the juvenile rockfish that were identified to species 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. Anchovies were a significant component of the diet for Common Murres and Rhinoceros Auklets during 2018, which accounted for 72% of the diet for Common Murres and 65% 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. Preliminary analysis of a subsample of Brandt's Cormorant pellets indicates a greater reliance on anchovy (46%) and flatfishes (18%), and a reduced consumption of rockfish (20%) compared to recent seasons (Fig. 13). 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 2018, 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 earlier relative to last season and the long-term median, another indication of favorable foraging conditions.

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 2018, juvenile rockfish were less abundant compared to previous years. Furthermore, 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 (Warzybok et al. 2018).

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 four years, surpassing juvenile rockfishes this year.

Productivity

The 2018 seabird breeding season was an average year in terms of productivity for most of the followed species (Fig. 1a, b). All species, with the exception of Pelagic Cormorants that showed a marked decrease in breeding success compared to last year, achieved fledging rates similar to the long-term mean. Brandt's Cormorant, Western Gulls, Common Murres, Rhinoceros Auklets, and Cassin's Auklets all exhibited greater than average success, while Pigeon Guillemots and Ashy Storm-petrels fell slightly below average.

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, but only appeared to affect certain species. This year all species were well within this range (Fig. 1a), further indicating average conditions.

Cassin's Auklets continued to exhibit relatively high productivity. This year, however, marks the end of 9-year consecutive period where they have averaged greater than 0.9 chicks fledged per pair after having only achieved that mark 4 times in the previous 39 seasons. Nearly all of the chicks this year were fledged from first broods. 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 prolonged upwelling strength in the region (Johns et al. 2017), conditions were likely fair enough early in the season to allow second brood attempts but declined late season before chicks from second broods could hatch.

In contrast, reproductive success of Common Murres climbed above the long-term productivity rate this year, breaking a 4-year period of lower than average rates. Although Western Gull predation of chicks continues to be an issue for the USP study plot, improved fledging rates led to higher productivity. Similar productivity rates were observed at the UU colony. 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 5 seasons, albeit by a slimmer margin of only 5% during 2018 (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 6th consecutive year. The high productivity this year was likely sustained by an increase in anchovy abundance. Pigeon Guillemot productivity, in contrast, remained below average for the 4th consecutive year due to reduced clutch sizes and poor fledging success. 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 2018, only 24 out of 81 active sites (30%) contained a full clutch of two eggs, from which none were able to fledge two chicks. As with the auklets, rockfish were far less prevalent in the chick diet compared to previous years, with sculpins and flatfishes relatively more abundant.

Brandt's Cormorants experienced slightly higher reproductive success this season compared to 2017, but overall nest numbers particularly at the Sea Lion Cove colonies were reduced compared to previous years. While several nests did ultimately fail, there were fewer recorded cases of nest abandonment this season. Pelagic Cormorants, on the other hand, experienced a near total failure this year following a somewhat average year in 2017. This reduction in breeding success manifested itself into delayed egg laying, nest abandonment, and a reduction in the total number of active nests.

Despite an overall downward trend in annual productivity rates since the 1970's, Western Gull productivity was above the long-term mean this year with just over 1 chick fledged per pair. Intraspecific predation of neighboring chicks continued to be the single greatest cause of mortality.

Ashy storm-petrel productivity was roughly equal to the long-term mean, following a brief increase in 2017. As with other species, storm-petrels initiated breeding earlier this season compared to the long-term median.

Populations

Breeding population sizes were higher than the 2018 estimates for all species except Double-crested Cormorant, Pelagic Cormorant, and Common Murre. Decreases ranged from approximately 5% for Double-crested Cormorants to 50% for Pelagic Cormorants when compared to last season. Increases ranged from 4% for Western Gulls to 42% for Pigeon Guillemots.

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 2018, guillemot numbers increased by about 42% relative to last year. In contrast, occupancy of monitored PIGU crevices was slightly lower this season with approximately 79% of historically followed sites used by breeding guillemots during 2018, down from 81% last season.

Common Murres are by far the most abundant species present on the Farallones with just under 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). 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 (~8%) in murre numbers this year when compared to 2017 but overall counts remain approximately 14% 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 reached an asymptote.

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.

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. 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 previous two seasons. Burrow and crevice counts for 2018 were approximately 26% higher than in 2017 and 50% higher 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. Very high nest box occupancy during 2018 suggests 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 2018 continuing this trend. While puffin numbers have been declining 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 33% higher than the capture rate for 2017.

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 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. 5) 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 five seasons. This was the first season where the BRCO breeding population showed a substantial increase since 2013. The current population, however, remains less than one-third of the population observed before the crash but equivalent to estimates made during the early 2000’s. The Pelagic Cormorant breeding population crashed following a peak in 2004, and has been slow to recover. Breeding populations were extremely low through 2007 but had been slowly increasing in recent years before suffering additional small-scale crashes in 2015 and this season (Fig. 5).

Summary

The 2018 seabird breeding season was characterized by average sea-surface temperatures (SST) throughout most of the season. The mean seasonal SST for 2018, though lower than last season, was above the long-term average while with mean monthly values remaining slightly warmer than average 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 opposite is true with cold water, which typically leads to greater productivity and breeding success. The generally average conditions observed this season resulted in roughly average reproductive success.

During 2018, breeding populations were largely similar or slightly higher than last season. California Gulls and Pelagic Cormorants were the only ones to exhibit significant declines while Pigeon Guillemots and Brandt's Cormorants 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.

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 2019 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 in 2015 with the deployment of small GLS tags on Cassin's and Rhinoceros Auklets, and in 2017 on Pigeon Guillemots. 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 (± SD) productivity of eight species of seabirds at Southeast Farallon Island, California, 2018. 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	2.83 ± 0.67 *(53)*	2.26 ± 1.14 *(57)*	1.78 ± 1.01 *(58)*	1.86 ± 0.96 *(58)*	0.75 ± 0.35 *(53)*	0.79 ± 0.23 *(49)*
PECO	2.53 ± 1.06 *(15)***	0.86 ± 0.94 *(35)***	0.34 ± 0.60 *(32)*	0.34 ± 0.60 *(32)*	0.60 ± 0.57 *(13)*	0.54 ± 0.40 *(12)*
WEGU	2.80 ± 0.47 *(206)*	2.02 ± 1.07 *(205)*	1.27 ± 1.18 *(194)*	1.27 ± 1.18 *(194)*	0.70 ± 0.36 *(205)*	0.60 ± 0.42 *(165)*
COMU* USP	1.00 (231)	0.88 ± 0.33 (209)	0.74 ± 0.44 (209)	0.74 ± 0.44 (209)	0.88 ± 0.33 (209)	0.84 ± 0.37 (183)
COMU* UU	1.00 (146)	0.97 ± 0.18 (146)	0.79 ± 0.41 (145)	0.79 ± 0.41 (145)	0.97 ± 0.18 (146)	0.81 ± 0.39 (140)
PIGU	1.30 ± 0.46 *(77)*	0.83 ± 0.68 *(77)*	0.51 ± 0.50 *(77)*	0.55 ± 0.50 *(77)*	0.65 ± 0.47 *(77)*	0.67 ± 0.42 *(50)*
RHAU*	1.00 *(69)*	0.83 ± 0.38 *(69)*	0.72 ± 0.45 *(69)*	0.72 ± 0.45 *(69)*	0.83 ± 0.38 *(69)*	0.88 ± 0.33 *(57)*
CAAU* PRBO	1.00 *(45)*	0.76 ± 0.43 *(45)*	0.73 ± 0.45 *(45)*	0.84 ± 0.37 *(45)*	0.76 ± 0.43 *(45)*	0.97 ± 0.17 *(34)*
CAAU* ALL	1.00 (207)	0.81 ± 0.39 *(207)*	0.70 ± 0.46 *(207)*	0.78 ± 0.45 *(207)*	0.81 ± 0.39 *(207)*	0.86 ± 0.34 *(168)*
ASSP*	1.00 *(60)*	0.73 ± 0.45 *(59)*	0.63 ± 0.59 *(59)*	0.63 ± 0.59 *(59)*	0.73 ± 0.45 *(59)*	0.86 ± 0.35 *(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, 2008-2018. Estimates include Southeast and West End Islands unless otherwise noted.

Species	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2008-2018 average
DCCO	214	226	232	104	364	364	220	360	260	194	206	249
BRCO	7,246	4,582[b]	4,824	5,742	6,566[b]	7,412	3,450[b]	4,916	5,132	1,248	4,840	5,063
PECO	160	312[b]	308	234	440[b]	372	298[b]	206	320	268	250	288
WEGU	13,769	13,245	10,044	11,164	18,686	21,148	15,846	17,406	18,218	15,747	20,152	15,948
CAGU	9	10	30	184	514	522	70	208	396	192	534	267
BLOY	NA	38	28	38	46	36	40	48	38	38	40	NA
PIGU [d]	3,500	2,044	2,009	3,157	4,459	3,880	3,645	3,461	3,317	2,851	2,875	3,200
TUPU [c]	406	396	376	326	288	286	244	246	234	216	106	284
CAAU [a]	26,573	21,026	20,059	25,606	28,444	22,574	19,607	17,866	12,964	14,512	16,121	20,487

[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)

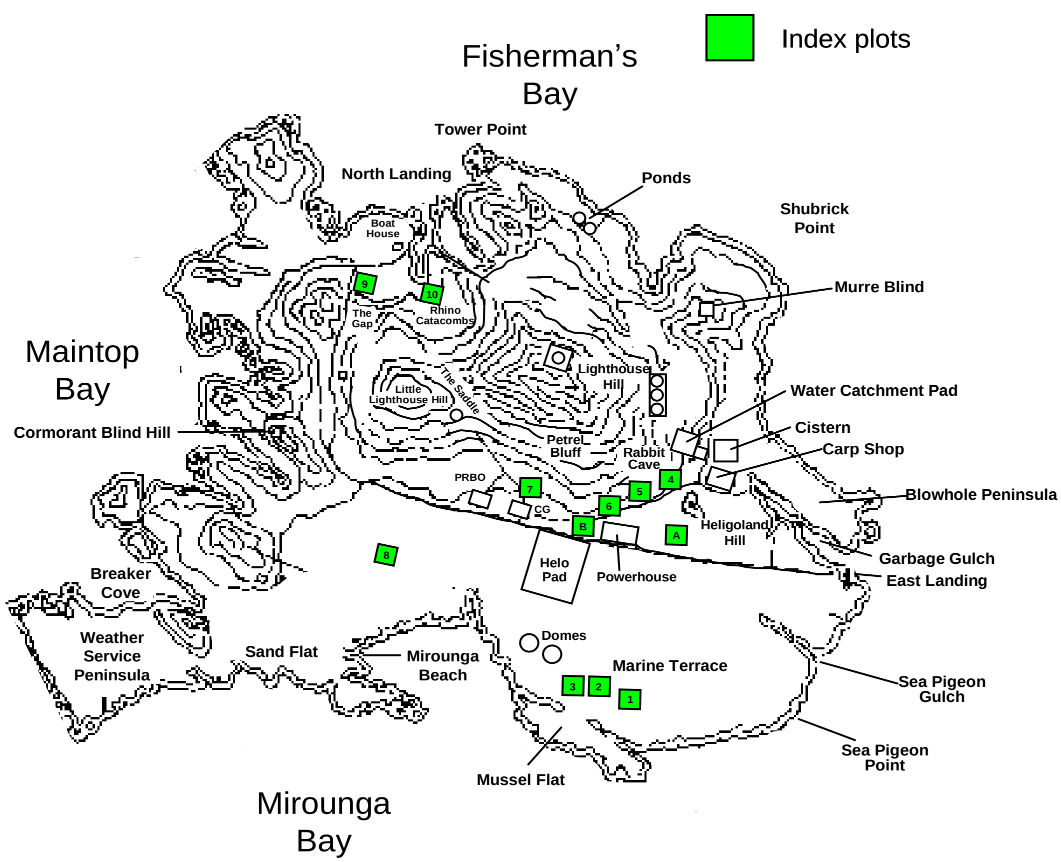
[d] Estimates derived from morning raft counts. Evening counts used prior to 2002 and are considerably lower (see text).

Table 3. Cassin's Auklet burrow counts from 12 (10m x 10m) index plots on Southeast Farallon Island for 2018. 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
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
2018	4	9	25	29	33	5	23	25	109	87	21	42	412
2008-2018 average	20	19	27	19	17	6	16	15	87	53	8	28	313

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



FIGURES

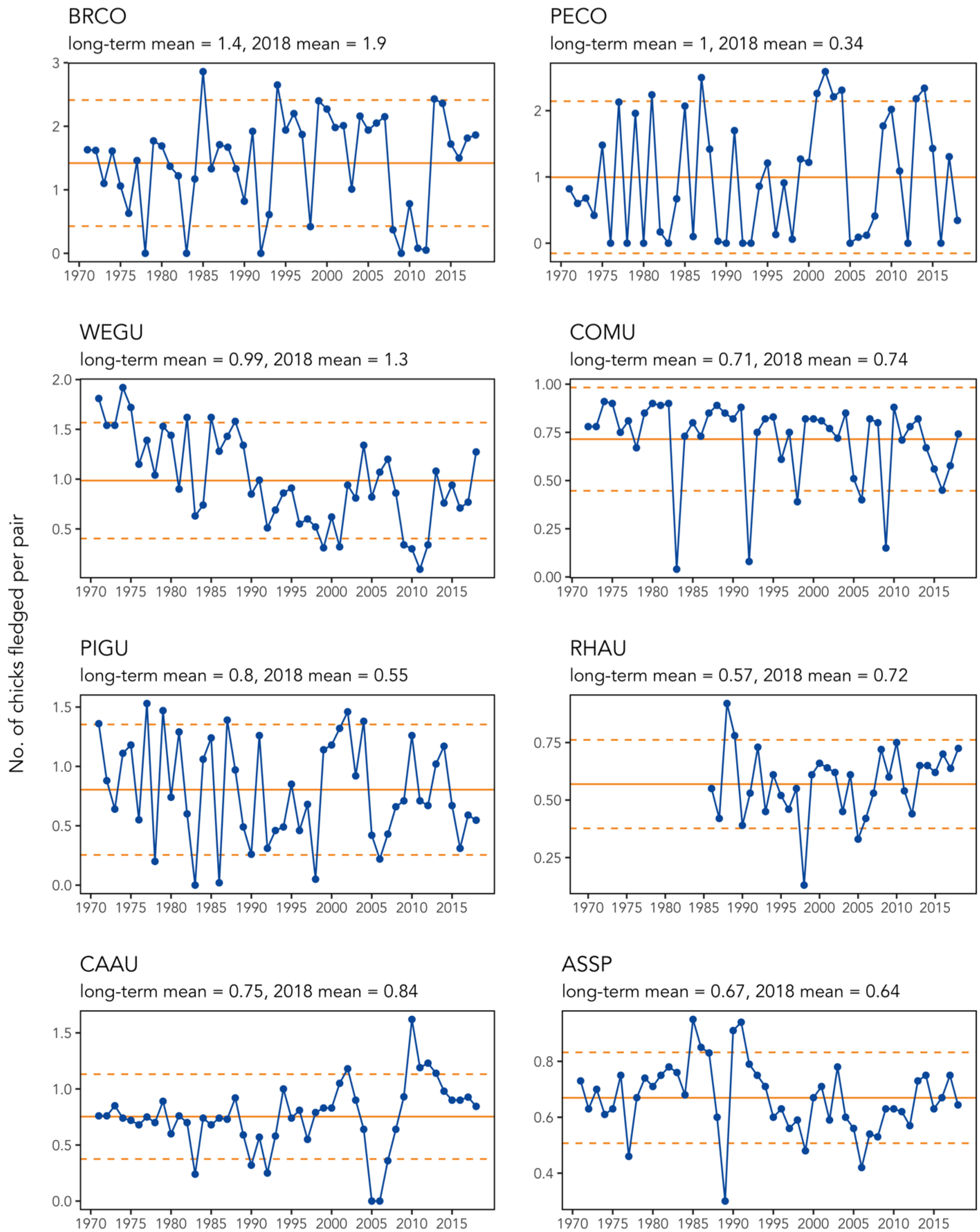


Figure 1a. Productivity of 8 seabird species on Southeast Farallon Island, 1971 – 2018, measured as the number of chicks fledged per breeding pair (includes first attempts, relays, and second broods). The solid orange line indicates mean productivity from all attempts between 1971 and 2017. Dashed orange lines represent 80% prediction intervals around the long-term mean.

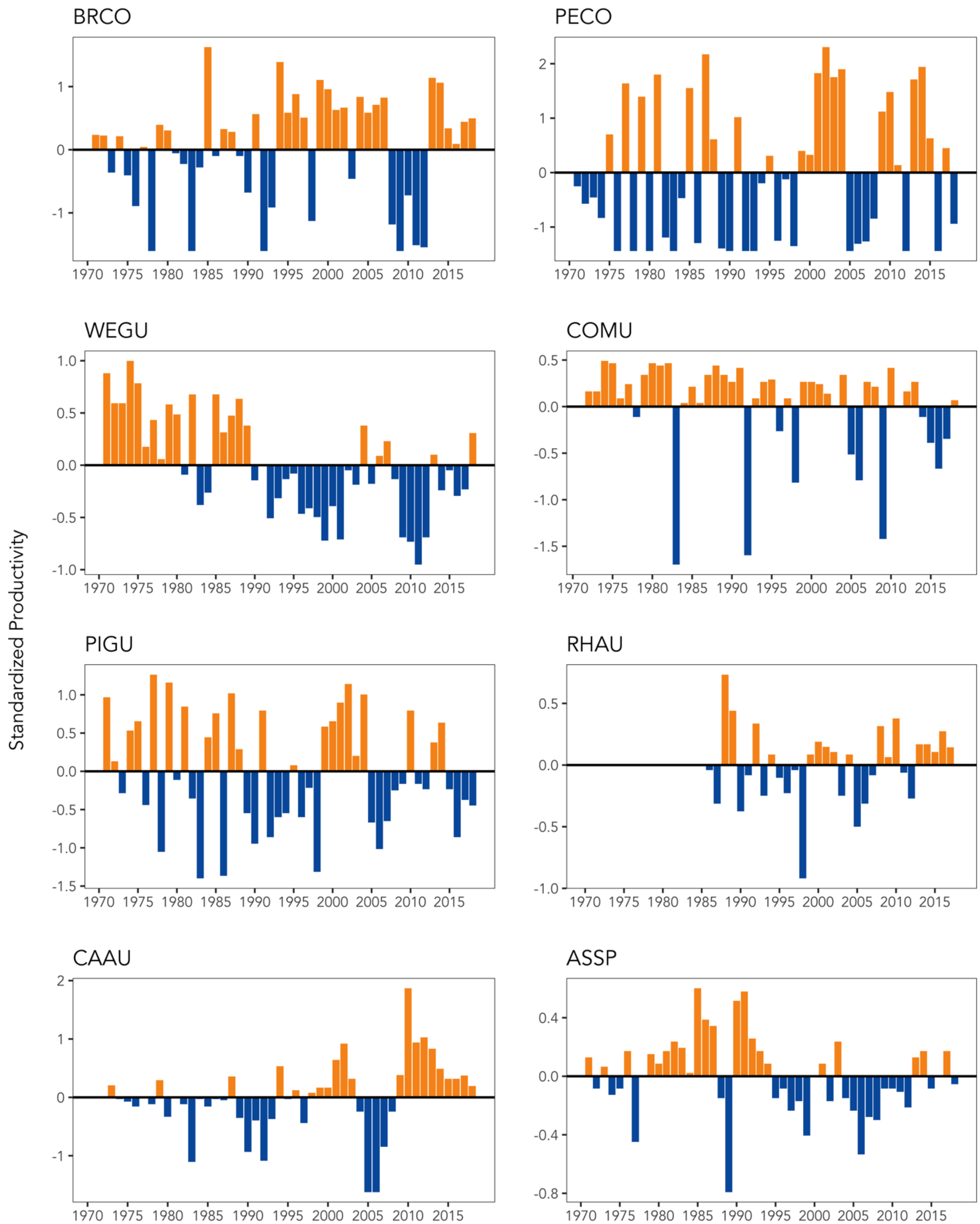


Figure 1b. Standardized productivity anomalies (annual productivity – long-term mean) for 8 seabird species on Southeast Farallon Island, 1971 – 2018.

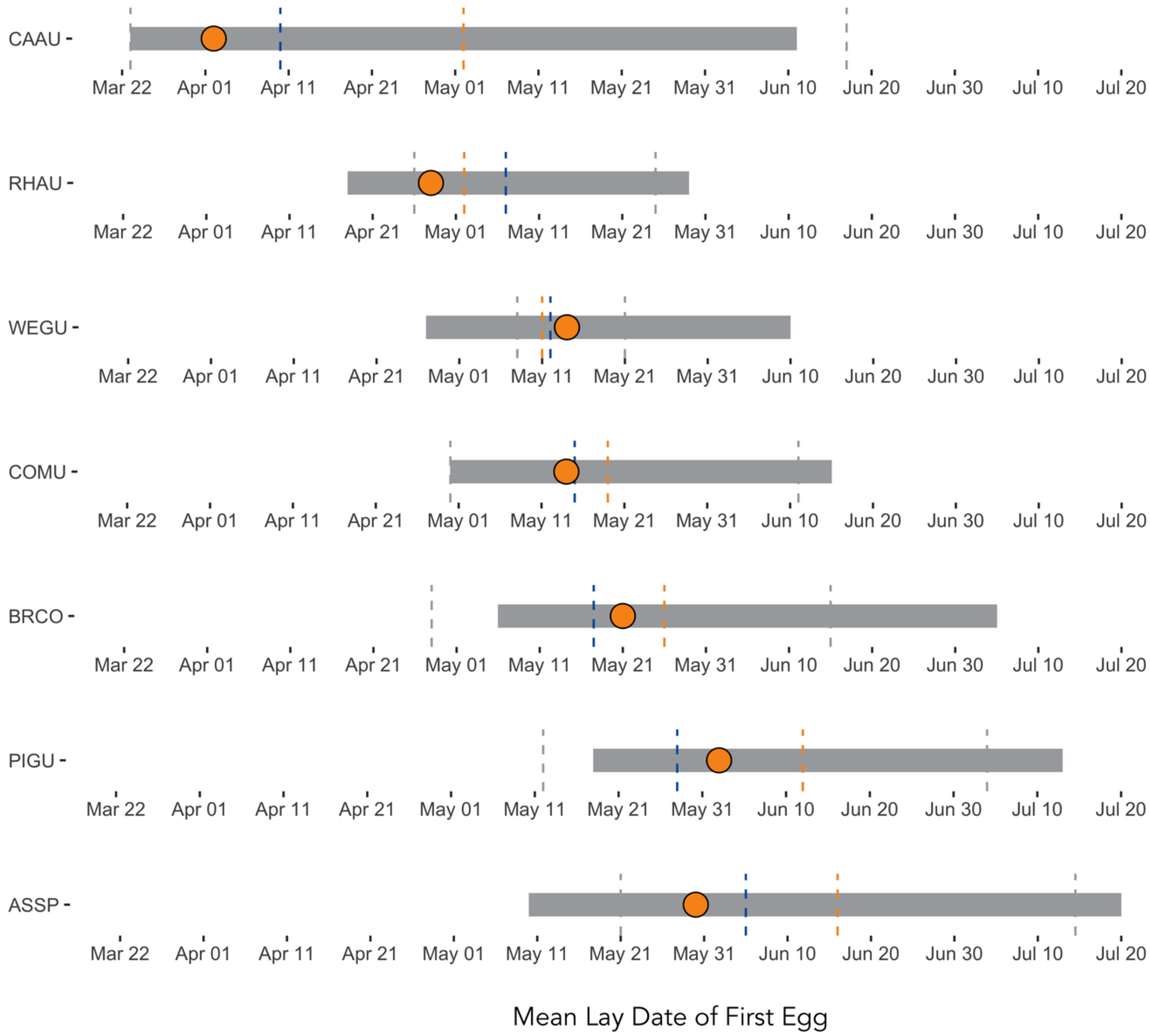


Figure 2. Phenology for 8 seabird species on Southeast Farallon Island, for the first egg in first attempts only. Orange circle represents median lay date for 2018, grey bar corresponds to the range of lay dates in 2018 (min and max). Median lay date for 2017 shown as orange dashed line, long-term median as blue dashed line, and years with the earliest and latest median lay dates as grey dashed lines.

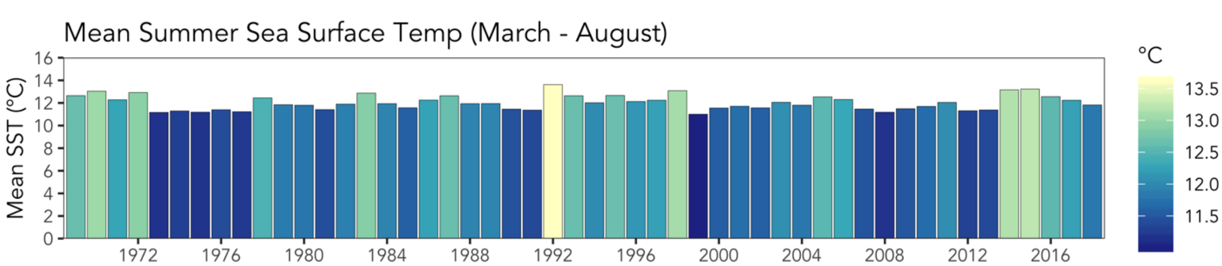


Figure 3. Annual mean summer (March – August) sea surface temperature (SST) for Southeast Farallon Island, 1968 – 2018. SST was measured daily from Water Sample Point, near East Landing. Lighter shades represent warmer temperatures, darker shades cooler temperatures.

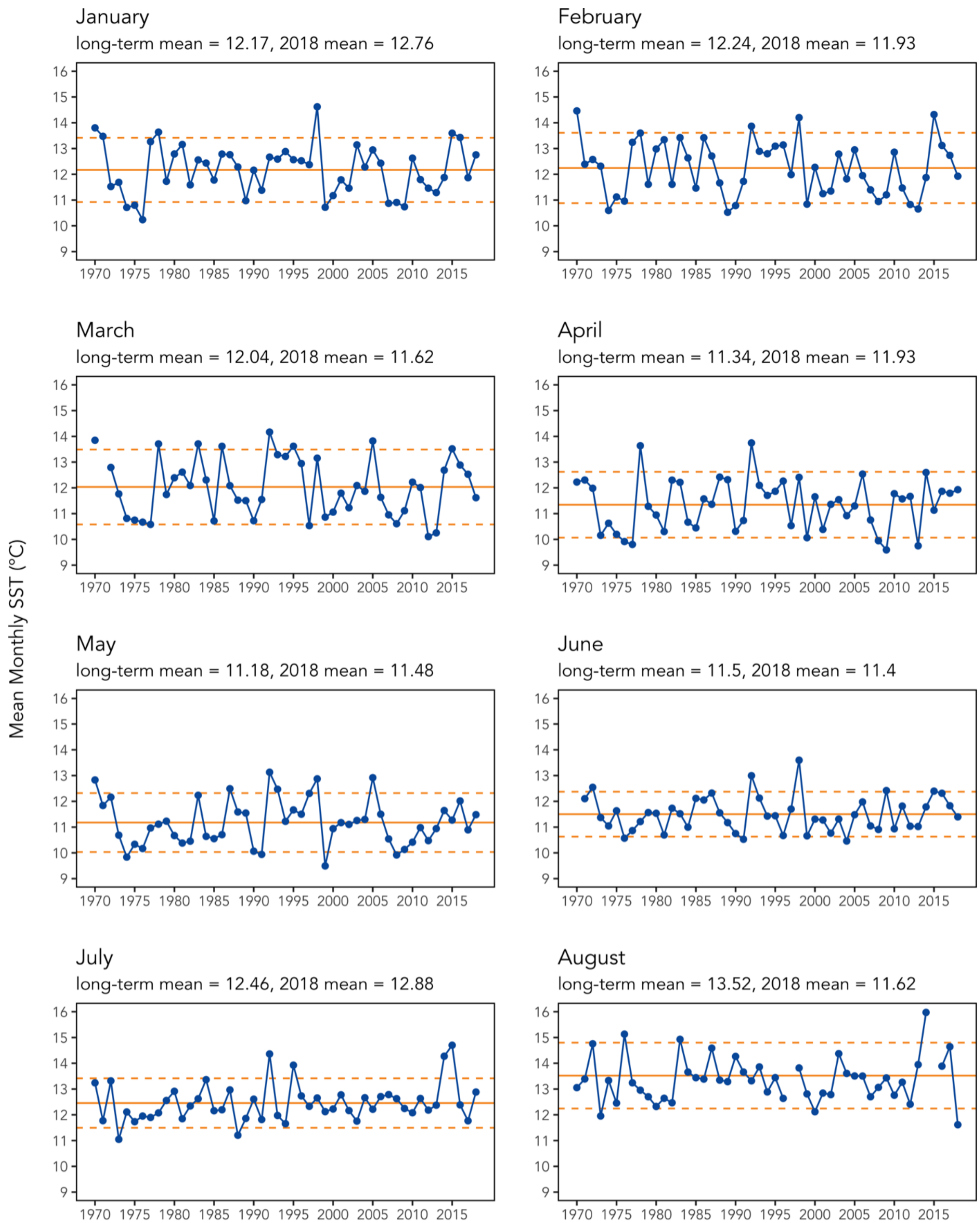


Figure 4a. Monthly mean sea surface temperature (SST) at Southeast Farallon Island, 1971 – 2018. SST was measured daily from Water Sample Point, near East Landing. The solid orange line indicates the long-term mean, and dashed orange line the 80% prediction interval for the long-term mean.

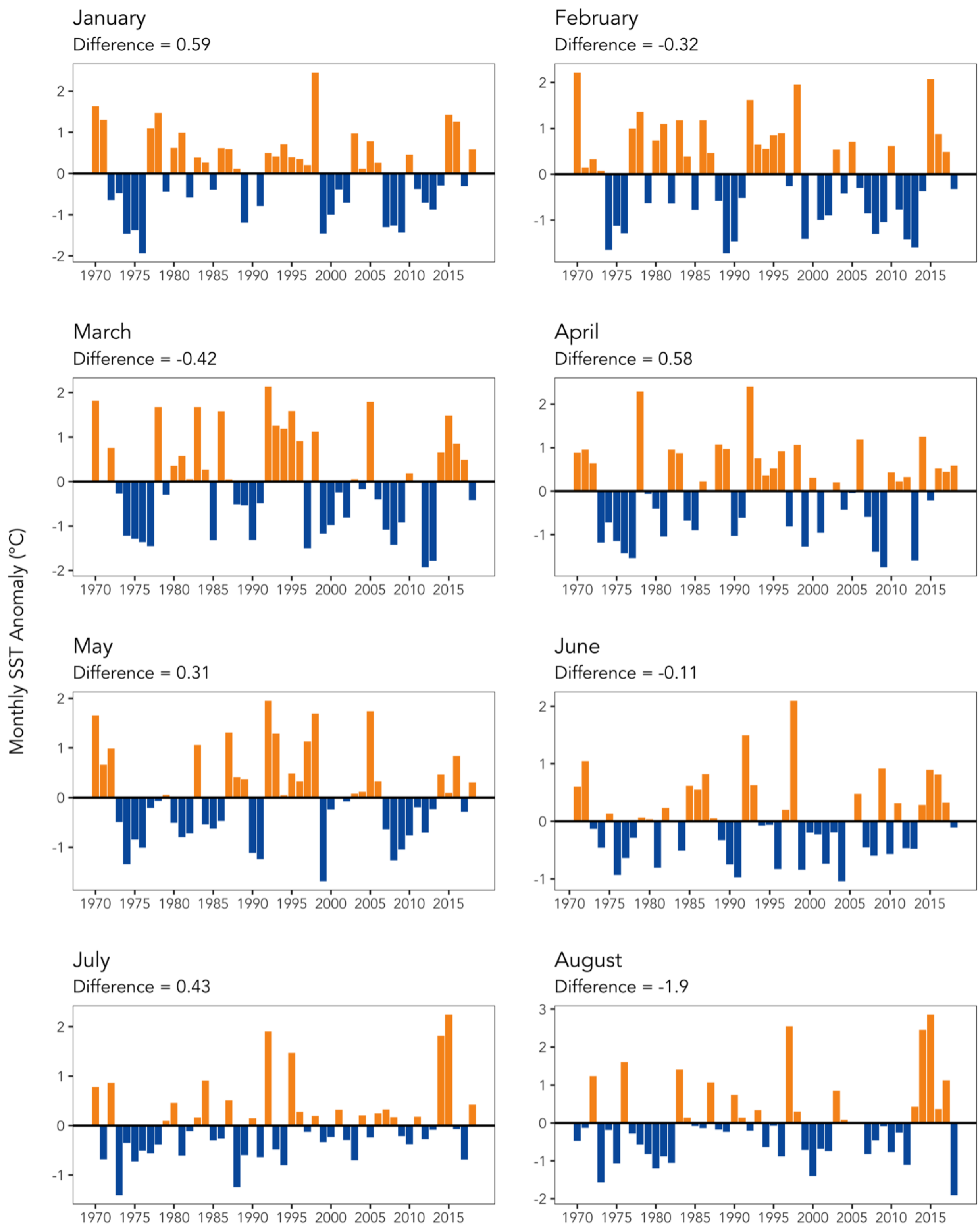


Figure 4b. Standardized monthly sea surface temperature (SST) anomalies (annual mean – long-term mean) for Southeast Farallon Island from 1971 – 2018.

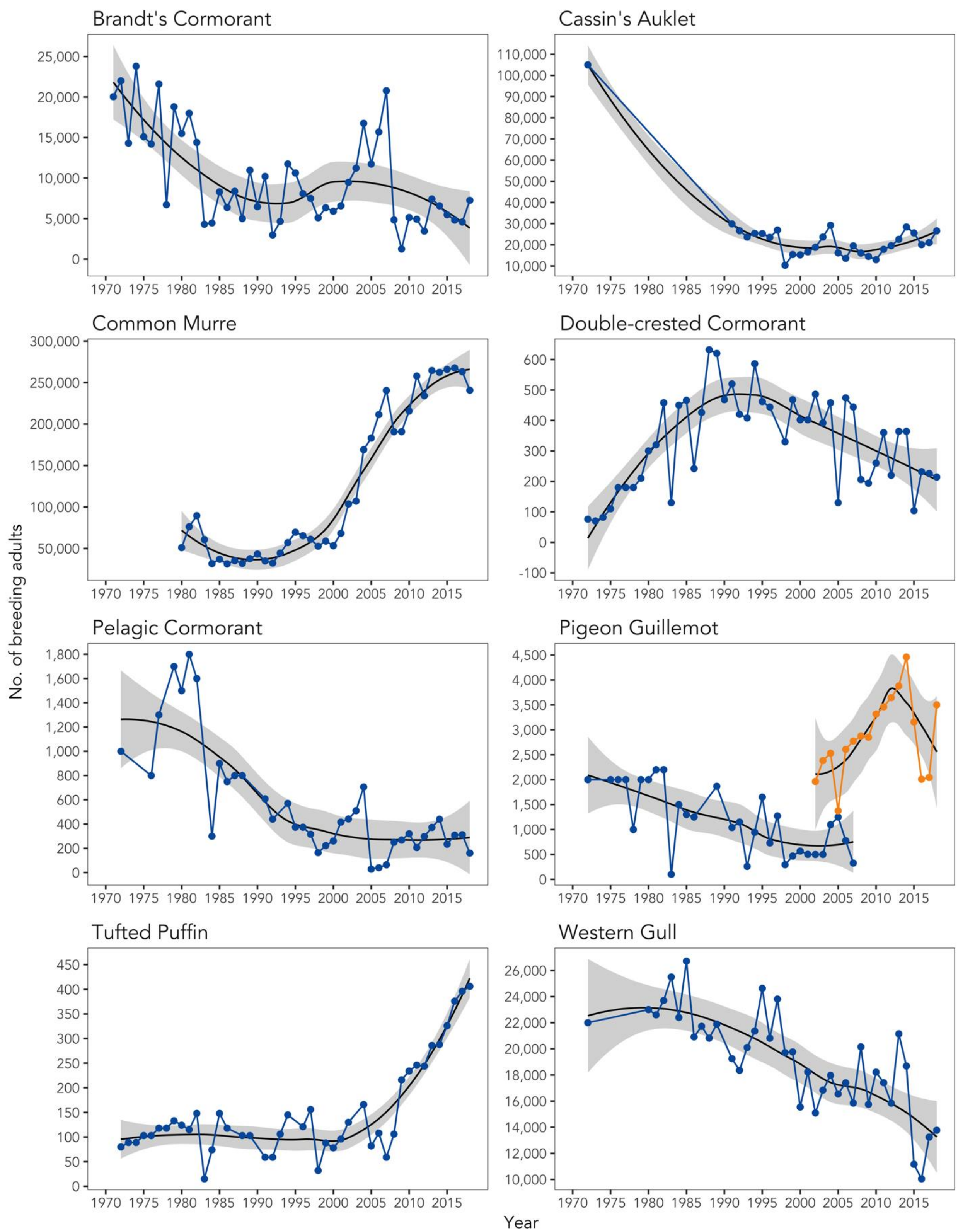


Figure 5. Population trends for 8 seabird species on Southeast Farallon Island, 1971 – 2018, determined by counts of individuals or nests in all visible areas on SEFI and West End. Loess trend lines and shaded confidence intervals illustrate long-term trend. For PIGU, blue points correspond to evening 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).

Brandt's Cormorant Census

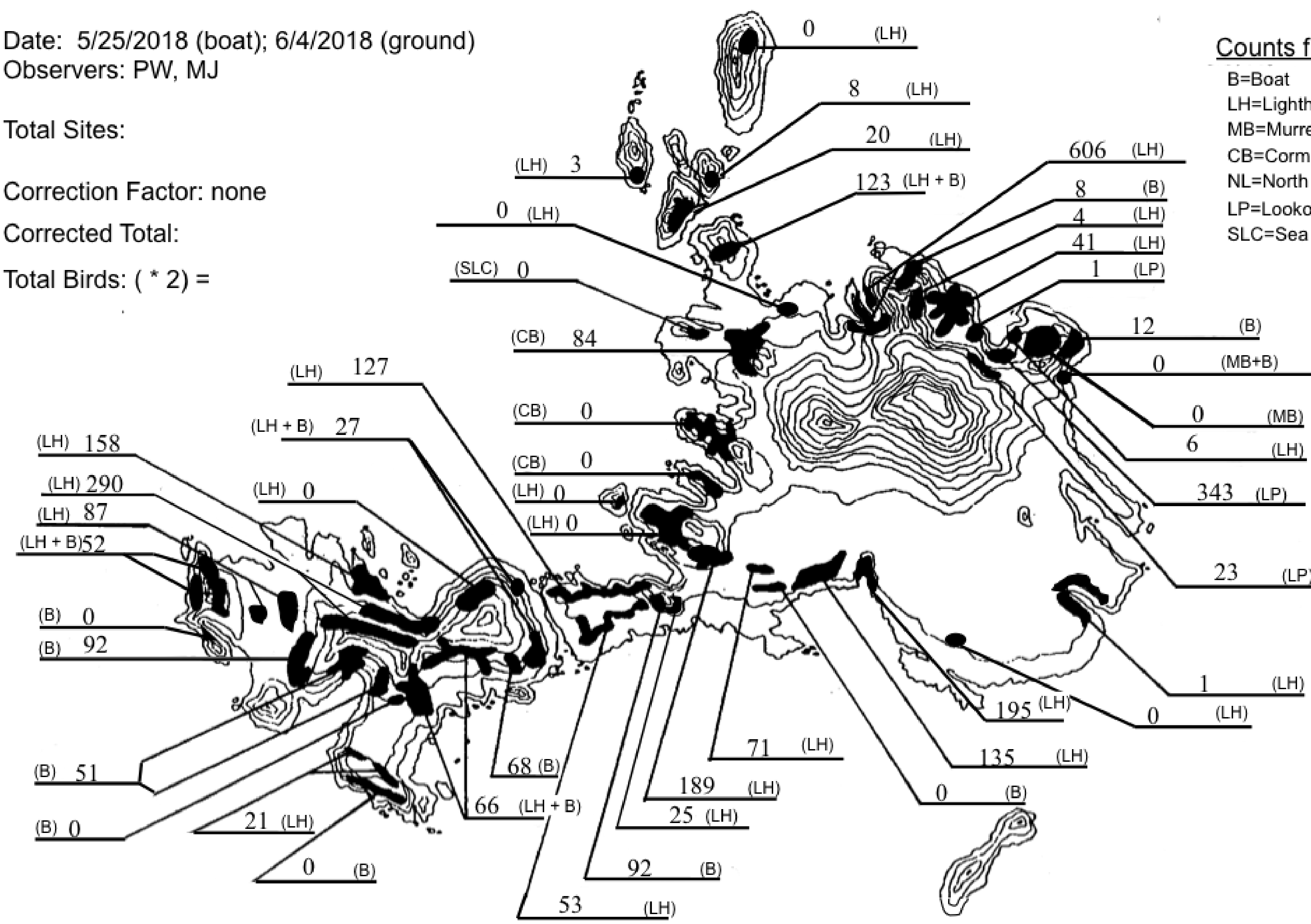
Date: 5/25/2018 (boat); 6/4/2018 (ground)
Observers: PW, MJ

Total Sites:

Correction Factor: none

Corrected Total:

Total Birds: (* 2) =



Counts from:
- B=Boat
- LH=Lighthouse
- MB=Murre Blind
- CB=Corm Blind
- NL=North Landing
- LP=Lookout Point
- SLC=Sea Lion Cove

Figure 6: Counts of Brandt's Cormorants on Southeast Farallon Island during the 2018 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: 5/25/2018 (boat); 6/4/2018 (ground)

Observers: PW, MJ, CJ

Total Sites: 86

Correction Factor: none

Corrected Total: 172

Total Birds: (corrected total * 2) =

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

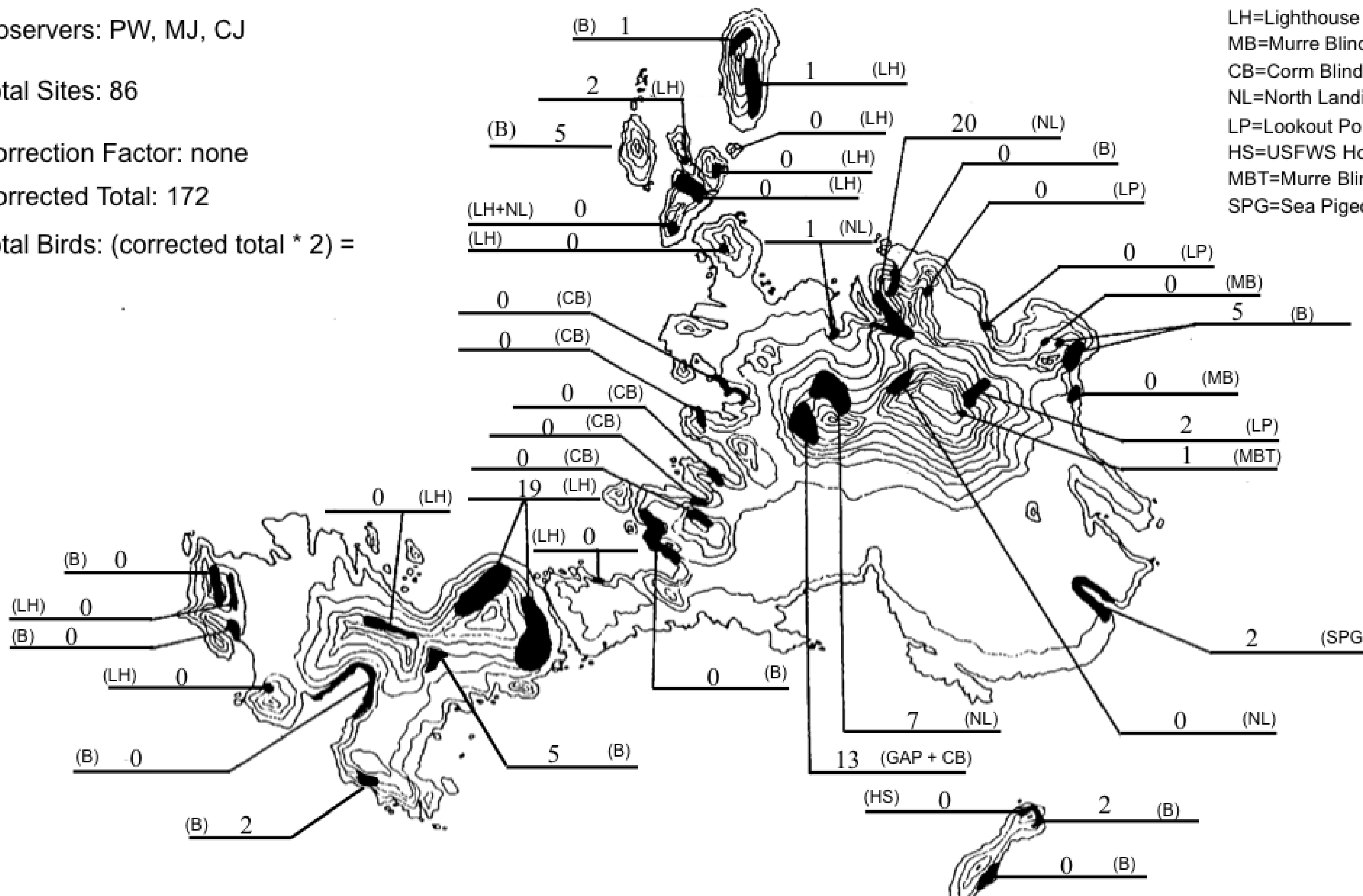


Figure 7: Counts of Pelagic Cormorants on Southeast Farallon Island during the 2018 census. Surveys were conducted from the following locations: Lighthouse Hill (LH), Lookout Point (LP), Murre Blind (MB), Cormorant Blind (CB), North Landing (NL), USFWS House (HS), Murre Blind Trail (MBT), Sea Pigeon Gulch (SPG), and Boat (B).

Western Gull Census

Date: 5/31/2018

Observers: PW, MJ

Total Counted: 8,964 (B)

487 (R)

Correction Factor: 1.54

Corrected Total: 13,804

All counts done from Lighthouse or ground. Darkened areas cannot be seen from either LHH or ground and were not included in counts.

(B)=Breeding birds

® =Roosting birds

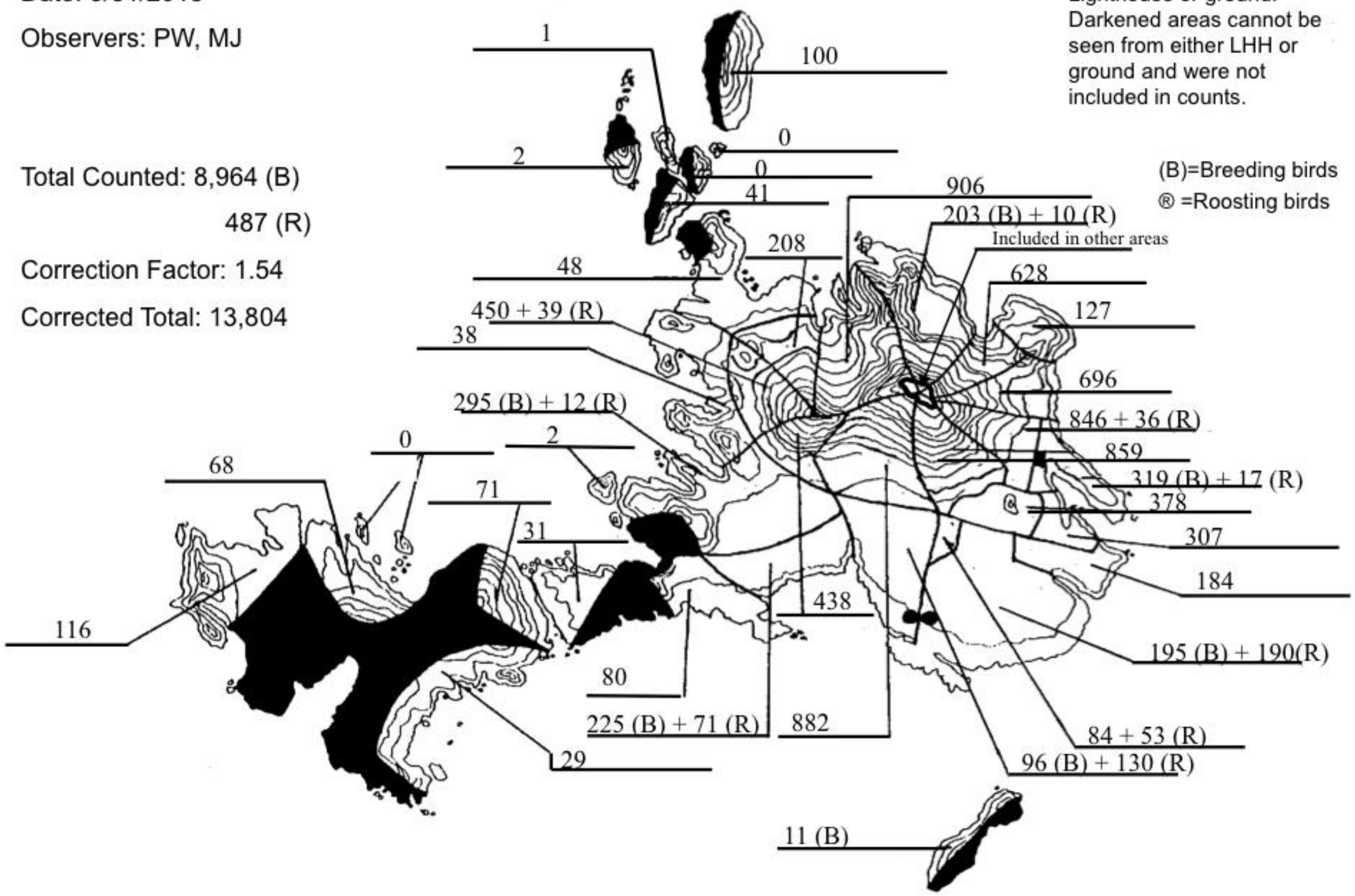


Figure 8: Counts of Western Gulls on Southeast Farallon Island during the 2018 census.

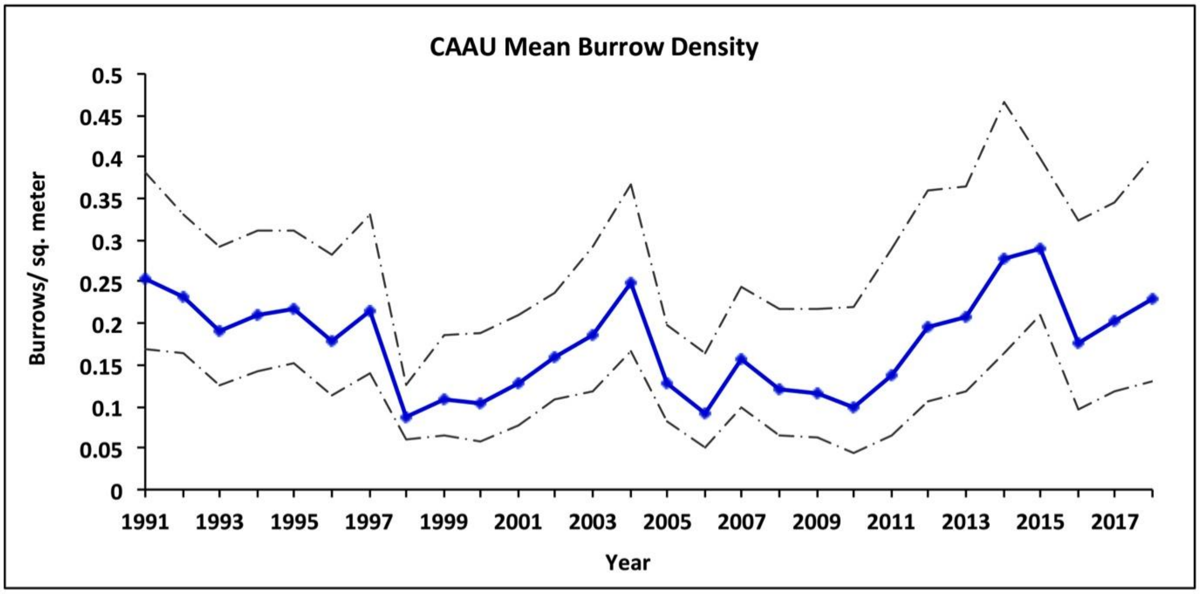


Fig. 9.

Geometric mean burrow/crevice density in our 12 Cassin's Auklet Index Plots from 1991 to 2018. The blue line represents the annual mean values. The dashed lines represent the upper and lower bounds of the 95% confidence interval.

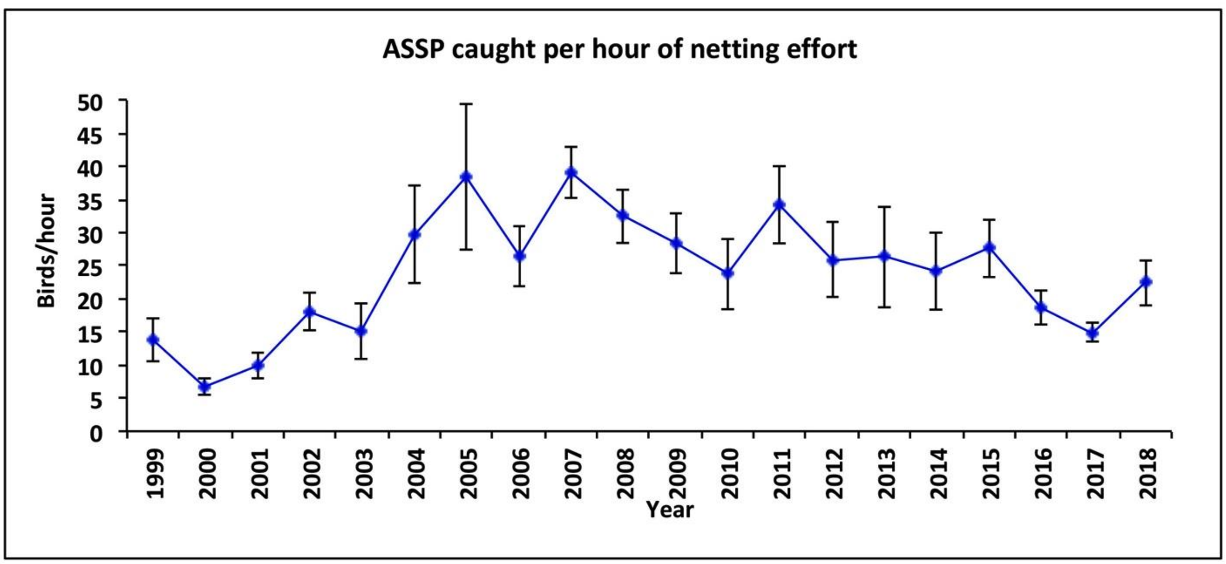


Fig 10.

Mean number of Storm-petrels caught per hour of netting effort on SEFI from 1999 to 2018. Error bars represent the standard error for the mean calculated from all capture sessions in a given season.

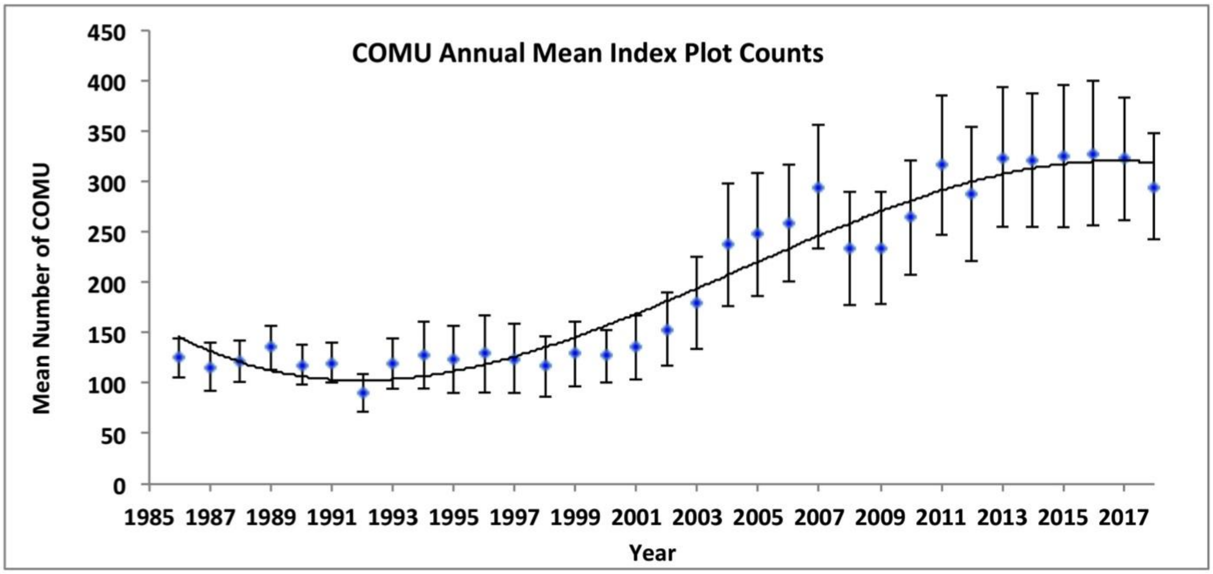


Fig. 11. Mean annual counts for Common Murre Index Plots from 1986 to 2018. Error bars represent the standard error of the mean calculated from all plots counted in any given season.

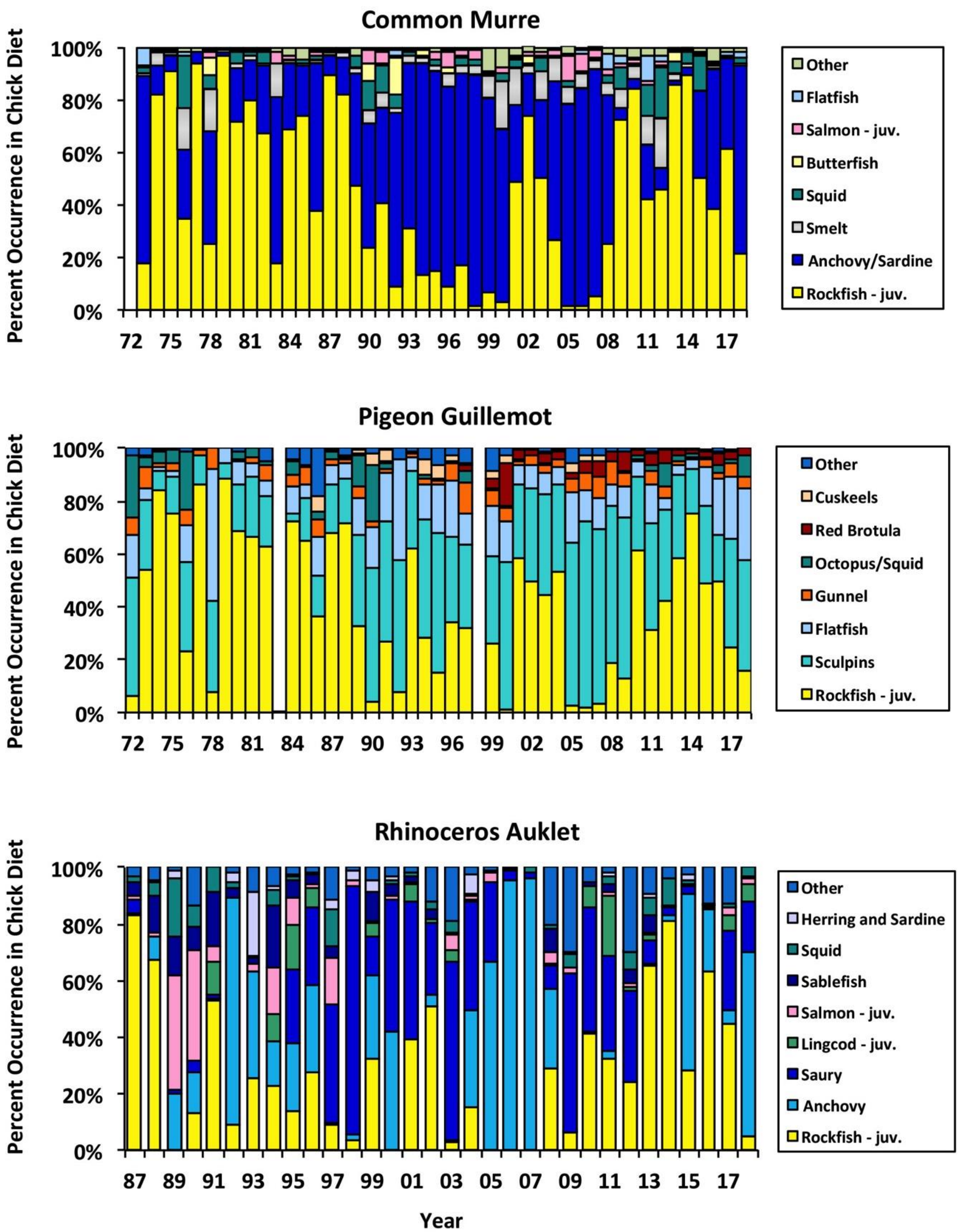


Figure 12. Percent occurrence of common prey items, by year, in the diet of three species of seabirds on Southeast Farallon Island.

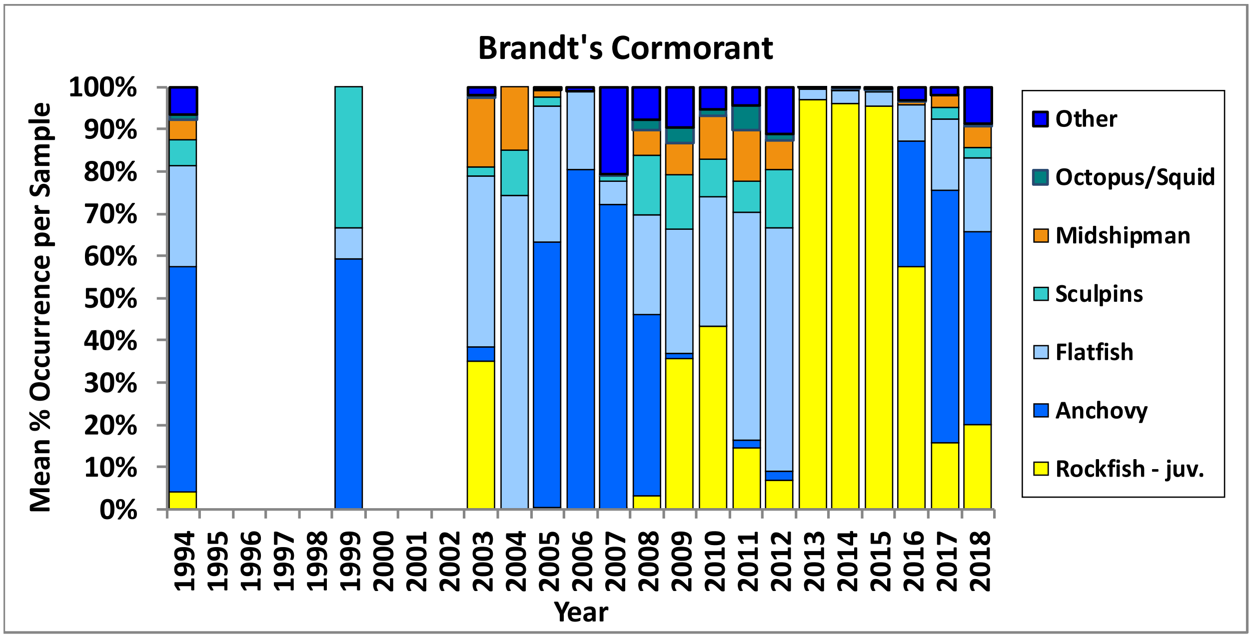


Fig. 13 Mean percent occurrence per sample of common prey items by year in the diet of Brandt's Cormorants on Southeast Farallon Island. Data for 2018 is based on analysis of a subsample of pellets analyzed as of December and should be considered preliminary.

APPENDICES

Appendix I. Calculation of correction factor for Western Gull census, 2018.

Area	Nest Count	Bird Count	Correction Factor
C	85	117	1.368
K	88	128	1.636
H (H1 only)	193	267	1.603
Total			**1.536**

Appendix II.

Calculation of correction factor for Common Murre colony attendance, 2018. 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 3 (1000)	231	272	1.70
June 4 (1000)	231	260	1.78
June 5 (1000)	231	270	1.71
June 6 (1000)	231	264	1.75
Mean	231	267	**1.73**

UU

Date (Time)	Breeding Sites	No. of birds	Correction Factor
June 3 (1000)	146	176	1.66
June 4 (1000)	146	162	1.80
June 5 (1000)	146	171	1.71
June 6 (1000)	146	165	1.77
Mean	146	169	**1.73**

Mean correction factor for SEFI 2018: **1.73**