RESTORATION AND MONITORING OF COMMON MURRE COLONIES IN CENTRAL CALIFORNIA: ANNUAL REPORT 2019

REPORT TO THE *LUCKENBACH* TRUSTEE COUNCIL

Cassie M. Bednar, Gerard J. McChesney, Amy C. Wilson, Shannon D. Carvey, Derek P. Harvey, Emily K. Schmidt, Aspen A. Ellis, , Richard T. Golightly, and Phillip J. Capitolo

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FINAL REPORT
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Cover photo: Aerial photograph of Devil's Slide Rock, 7 July 2019 by P. J. Capitolo

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ABBREVIATIONS USED

BM227X = Bench Mark-227X

CCS = California Current System

CDFW = California Department of Fish and Wildlife

CHCC = Castle-Hurricane Colony Complex (includes Bench Mark-227X, Castle Rocks and Mainland, and Hurricane Point Rocks)

CMRP = Common Murre Restoration Project

CRM = Castle Rocks and Mainland

DBCC = Drakes Bay Colony Complex (includes Point Resistance, Millers Point, and Double Point)

DPR = Double Point Rocks

DSCC = Devil's Slide Colony Complex (includes Devil's Slide Rock & Mainland, and San Pedro Rock)

DSM = Devil's Slide Mainland

DSR = Devil's Slide Rock

DSRM = Devil's Slide Rock and Mainland

GFNMS = Greater Farallones National Marine Sanctuary

HPR = Hurricane Point Rocks

LHR = Lighthouse Rock

MPR = Millers Point Rocks

NOAA = National Oceanic and Atmospheric Administration

NPFC = National Pollution Funds Center

NPS = National Park Service

OSLTL = Oil Spill Trust Liability Fund

PRH = Point Reyes Headlands

PRNS = Point Reyes National Seashore

PRS = Point Resistance

SPN = Seabird Protection Network

SPR = San Pedro Rock

USCG = U.S. Coast Guard

USFWS = U.S. Fish and Wildlife Service

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ACKNOWLEDGMENTS

In 2019, the *Luckenbach* Oil Spill Trustee Council, comprised of California Department of Fish and Wildlife (CDFW), National Oceanic and Atmospheric Administration (NOAA), and Department of the Interior through U.S. Fish and Wildlife Service (USFWS) and National Park Service, provided funding and oversight.

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EXECUTIVE SUMMARY

Efforts in 2019 were the 24th year of restoration and associated monitoring of central California seabird colonies by the Common Murre Restoration Project. This project first conducted fieldwork in 1996 with the goal to restore breeding colonies of seabirds, especially those of Common Murres (*Uria aalge*), that were harmed by the 1986 *Apex Houston* oil spill, as well as by gill net fishing and other impacts. Subsequent to the original *Apex Houston* settlement, natural resource damage assessment settlement funds from the 1998 *Command* and extended *Luckenbach* oil spills have supported the project since 2005 and 2010, respectively. From 1995 to 2005, the primary goals were to restore the previously extirpated Devil's Slide Rock (DSR) colony using social attraction techniques, and to assess restoration needs at other central California colonies. Since 2005, we have incorporated standardized procedures for the surveillance and assessment of human disturbance at central California Common Murre colonies into daily survey methods. Additionally, we continue to monitor the outcome of initial recolonization efforts at DSR and recovery of other central California murre colonies. The human disturbance assessments are used to inform outreach, education and regulatory efforts by

the Seabird Protection Network (SPN; coordinated by the Greater Farallones National Marine Sanctuary; GFNMS) and allow for evaluation of the success of those efforts. The goal of the SPN is to protect central California seabird breeding colonies primarily through reduction of human disturbance, which also enhances the restoration of previously injured colonies.

We conducted monitoring of human disturbance (mainly aircraft and watercraft), non-anthropogenic disturbance, seabird productivity, seabird attendance patterns and relative population sizes at three Common Murre colony complexes. In addition, a volunteer conducted less intensive monitoring of Common Murre attendance at Bird Island. In 2019, at Point Reyes Headlands (PRH) we recorded the second highest disturbance rate (0.03 disturbances/hour) since dedicated monitoring began in 2005. The majority (75%) of disturbance events at PRH were agitation events caused by aircraft. However, analysis of long-term data (2005-2019) showed significant declines in the annual change of both watercraft detections and watercraft disturbances. Devil's Slide Rock and Mainland (DSRM) continued to have greater combined aircraft and watercraft disturbance rates (0.10 disturbance events/hour) than PRH and the Castle-Hurricane Colony Complex (CHCC). DSRM also experienced the highest disturbance rate since 2012. Of the 44 disturbance events at DSRM, 14 (32%) included flushing of common murres. Despite these relatively high disturbance rates, examination of long-term (2005-2019) trends in the annual change of aircraft and watercraft disturbance rates at DSRM showed significant declining trends of plane, helicopter and combined aircraft detection rates as well as watercraft disturbance rates. In 2019, CHCC experienced the greatest total disturbance rate (0.03 disturbances/hour) recorded since 2010, with nine disturbance events: seven from aircraft and two from watercraft. Examination of long-term (2008-2019) trends at CHCC showed a significant declining trend in plane detections, but no significant trends in disturbance rates.

General aviation (e.g., private or charter) planes were the most commonly observed aircraft, and caused 40% of aircraft disturbances at all monitored colonies. The second and third most observed aircraft were USCG helicopters (14% of aircraft detections) and unknown planes (9% of aircraft detections). General aviation planes, USCG helicopters and unknown planes also caused the most disturbance events. Private recreational fishing boats accounted for 74% of watercraft observed. Only one watercraft caused a disturbance event in 2019; a commercial fishing boat displaced and flushed Brandt's Cormorants during two separate events at CHCC. We did not observe any watercraft entering the Special Closures at PRH or DSRM in 2019.

In 2019, seasonal attendance patterns of Common Murres at PRH count plots were generally similar to long-term averages. At DSR, murre seasonal attendance was generally greater than average, especially during the pre-lay period. Several days of lower attendance in early June corresponded with warm air temperatures. Seasonal attendance was mainly near or below average at CHCC plots but murres persisted later into the season than was typical, suggestive of late breeding.

Common Murre productivity (chicks fledged per pair) at PRH plots was lower than average, and the lowest recorded since 2012. Murre productivity was also lower than average at DSR but near average at CHCC.

During focused non-anthropogenic disturbance surveys (“Avian Disturbance Survey”), the greatest overall disturbance rate was recorded at PRH. Western Gulls (*Larus occidentalis*) at LHR caused the greatest number of disturbance events observed during non-anthropogenic disturbance surveys, but Canada Geese (*Branta canadensis*), Turkey Vultures (*Cathartes aura*), Brown Pelicans (*Pelecanus occidentalis*), Common Ravens (*Corvus corax*) and an unknown source caused disturbance to a greater number of murres during recorded events. Similar to 2017 and 2018, at DSRM, Common Ravens caused the greatest rate of disturbance; they also contributed to the most events that included displacement and flushing of murres. The total non-anthropogenic disturbance rate during avian disturbance surveys at CHCC was lower than at DSR and PRH, with Western Gulls causing the greatest overall rate of disturbance.

In 2019, Brandt’s Cormorant nests counted from land-based monitoring were greater at PRH and DSRM than were counted in 2018. Nests counted at CHCC in 2019 were lower than counted in 2018 but still relatively high. Brandt’s Cormorant productivity in 2019 was near average at PRH and DSRM but below average at CHCC. We monitored productivity of Pelagic Cormorants (*P. pelagicus*), Western Gulls and Black Oystercatchers (*Haematopus bachmani*) at both DSRM and CHCC. Productivity of Pelagic Cormorants at DSRM was lower than the long-term average. At CHCC, no Pelagic Cormorants were visible for monitoring. Western Gull productivity was lower than long-term average at both DSRM and CHCC. We monitored one Black Oystercatcher nest at DSRM but no chicks fledged. Three Black Oystercatcher chicks successfully fledged at CHCC.

Aerial photographic surveys of Double-crested Cormorant, Brandt’s Cormorant and Common Murre colonies were conducted by P. Capitolo (U.C. Santa Cruz). In 2019, surveys were hampered because of both funding delays and inadequate funds. Most of our monitored colonies were either not surveyed or were surveyed too late in the season to provide counts that would be comparable to other years. Thus, in 2019, only counts from DSRM are reported, and the Common Murre count was similar to 2018.

INTRODUCTION

In central California, Common Murre (*Uria aalge,* hereafter referred to as murre) breeding colonies occur on nearshore rocks and adjacent mainland cliffs between Marin and Monterey counties as well as on the North and South Farallon Islands, which are 20 to 40 km offshore of San Francisco (Carter et al. 1992, 2001). A steep decline in the central California population occurred between 1980 and 1986 which was attributed primarily to mortality associated with gill-nets and oil spills, including the 1986 *Apex Houston* oil spill (Page et al. 1990; Takekawa et al. 1990; Carter et al. 2001, 2003). Between 1982 and 1986, a colony of about 3,000 breeding murres on Devil's Slide Rock (DSR) in northern San Mateo County was extirpated. Since 1995, the Common Murre Restoration Project (CMRP) has sought to restore DSR and other central California colonies using several techniques, including social attraction. Social attraction techniques were utilized at DSR between 1996 and 2005 (McChesney et al. 2006; Parker et al. 2007), but were discontinued after the colony appeared to be restored and self-sustaining. Restoration efforts at other murre colonies in central California have focused on documenting the impacts of human disturbance, gill-net mortality, and other threats to colonies, as well as working with government agencies and the public to reduce these impacts.

Since the early 1990s, the size of the central California murre population has shown an increasing trend due to implementation of restrictions on gill-net fishing, favorable prey conditions, and other factors (Carter et al. 2001; USFWS, unpublished data). However, anthropogenic impacts to murres continue to occur and may continue to affect the population. Gill-net mortality continued until the California Department of Fish and Wildlife (CDFW) enacted an emergency closure of the gill-net fishery in September 2000, followed by a permanent closure in September 2002 in waters less than 110 meters deep (60 fathoms) from Point Reyes to Point Arguello (Forney et al. 2001). Extensive oil pollution (e.g., 1998 *Command* oil spill and a series of oil releases from the sunken vessel *S.S. Jacob Luckenbach* from the early 1990s to the early 2000s) continued to kill thousands of murres in central California (Carter 2003; Carter and Golightly 2003; Hampton et al. 2003; Roletto et al. 2003). Disturbances from aircraft and watercraft have affected colonies as well (Rojek et al. 2007; Fuller et al. 2018; USFWS, unpublished data).

Beginning in 1995, restoration and associated monitoring of murre colonies in central California have been funded largely through oil spill restoration plans and associated trustee councils, including the *Apex Houston* (1995-2009), T/V *Command* (2005-2009), and, beginning in 2010, the *Jacob Luckenbach*. On 14 July 1953, the *S.S. Jacob Luckenbach* collided with the freighter *Hawaiian Pilot* and sank in 55 meters of water approximately 27 kilometers southwest of San Francisco. The *S.S. Jacob Luckenbach* was loaded with 457,000 gallons of bunker fuel, which subsequently leaked periodically during winter storms. Using chemical analysis, oil that was associated with several mystery spills was linked to this vessel, including the Point Reyes tar ball incidents of winter 1997-1998 and the San Mateo Mystery Spill of 2001-2002. In the summer of 2002, the U.S. Coast Guard (USCG) and the *Luckenbach* trustees removed much of the oil from the vessel and sealed the remaining oil inside (Hampton et al. 2003). An estimated 51,569 seabirds were killed between 1990 and 2003 from Bodega Bay to Monterey Bay, including 31,806 murres (*Luckenbach* Trustee Council 2006).

The USCG National Pollution Funds Center (NPFC) awarded $22.7 million to implement 14 restoration projects. The award was a result of a claim filed by the *Luckenbach* trustees in 2006 for funding from the Oil Spill Liability Trust Fund (OSLTF), as the company responsible for the *Luckenbach* no longer existed. The OSLTF pays for oil spill cleanup and restoration of impacted natural resources when there is no responsible party.

The Central California Seabird Colony Protection Project, now called the Seabird Protection Network (SPN), was initiated by the *Command* Oil Spill Restoration Fund (Command Trustee Council 2004) in 2005 and was extended in 2010 with *Luckenbach* funds. The Greater Farallones National Marine Sanctuary (GFNMS) implement the SPN in coordination with the CMRP, to restore seabird colonies harmed by these oil spills primarily through reducing human disturbance. The GFNMS focuses on the outreach, education and regulatory components, while the CMRP conducts the colony surveillance and monitoring component of the program. Surveillance and monitoring data from these colonies guide education and outreach and are used to assess the success of those efforts.

Colony surveillance and monitoring have focused on three colonies or colony complexes established as murre restoration or reference sites in 1996: Point Reyes Headlands (PRH), Devil's Slide Colony Complex (DSCC), and Castle-Hurricane Colony Complex (CHCC). From 2005-2016, less intensive surveys were also conducted at three additional colonies in the Drakes Bay Colony Complex (DBCC): Point Resistance (PRS), Millers Point Rocks (MPR), and Double Point Rocks (DPR). Colony count surveys documented potential murre attendance and breeding and were conducted once per week at Bird Island (near Point Bonita) in Marin County.

Here we summarize colony surveillance and monitoring efforts conducted at central California nearshore murre colonies in 2019. As in past years, we recorded and categorized aircraft, watercraft and other disturbances to seabirds. We also investigated murre seasonal attendance patterns and productivity (reproductive success). Further, we recorded Brandt's Cormorant relative breeding population sizes and productivity, as well as relative breeding population sizes and/or productivity of Pelagic Cormorants, Black Oystercatchers, Western Gulls, and Pigeon Guillemots. In 2019, we reported data from aerial photographic surveys for only DSRM.

METHODS

Study Sites

We monitored three colony complexes, PRH, DSCC and CHCC, for productivity, disturbance and attendance of seabirds in 2019 (Figure 1). PRH, (Figure 2) is located within the Point Reyes National Seashore, Marin County. DSCC, located in San Mateo County, consists of the colonies Devil's Slide Rock and Mainland (DSRM) and San Pedro Rock (SPR; Figures 3, 4). CHCC in Monterey County consists of the colonies Bench Mark-227X (BM227X), Castle Rocks & Mainland (CRM), and Hurricane Point Rocks (HPR; Figure 5). The offshore rocks of DSCC and CHCC are within the California Coastal National Monument. Mainland portions of DSCC are either part of the Devil's Slide Trail County Park or are privately owned. Mainland portions of

CHCC are either privately, state or county-owned. At each colony, individual rocks and mainland cliffs with nesting seabirds were identified by their recognized subcolony number, subcolony name, or subarea. In this report, colonies are ordered north to south within each section. Seabird attendance at Bird Island, which is located near the mouth of the Golden Gate within Golden Gate National Recreation Area, in Marin County also was monitored by volunteers.

Monitoring Effort

To track monitoring effort, observers recorded a start time to the nearest minute upon arrival at a field vantage point and an end time when departing the vantage point. From these data, observation hours were totaled irrespective of the number of observers (i.e., *not* a calculation of person-hours). For calculating the total observation hours for a colony or colony complex, we combined observation hours from all vantage points. When multiple observers were present at multiple vantage points simultaneously, the total hours of observation were calculated as hours on site regardless of the number of people observing (i.e., not double counted). In addition, time transiting between vantage points (even on foot) was not included in observation hours.

Disturbance

Anthropogenic Disturbance Events

Anthropogenic disturbance affecting murres or other seabirds was recorded at each study colony. These disturbances included any instances in which adult birds were alarmed or agitated (e.g., head-bobbing in murres, raised head or wing-flapping in cormorants), displaced (i.e., birds moved from breeding or roosting site but did not fly away) or flushed (i.e., birds left the colony or roost) as a result of human activity. Numbers of disturbed seabirds within each disturbance category, for each disturbance event, were recorded. Numbers of eggs or chicks exposed, displaced, or depredated or otherwise lost (taken) were also recorded. When seabirds were disturbed by a human source (e.g., helicopter with recorded tail number), a SPN wildlife disturbance report was filed. These reports included pertinent information on the event and photos (when available).

We calculated monitoring effort for each colony and colony complex except for Bird Island. In order to compare disturbance among colonies and among years, disturbance rates were calculated. We calculated anthropogenic disturbance rates during the breeding season as the number of disturbance events per hour of observation at each colony complex. We used a Generalized Linear Model with a Poisson distribution (or Quasi-poisson in cases of "overdispersion"; R Core Team, 2018) to examine long-term trends in anthropogenic disturbance and to predict trends in annual changes in detection and disturbance rates for aircraft and watercraft during the period 2005-2019. We report percent annual changes in rate, confidence intervals and p-values.

For the annual Pacific Coast Dream Machines (a local aircraft fly-in festival) event that took place 28 April 2019 at the Half Moon Bay Airport, observers monitored potential disturbance events at Devil's Slide Rock (DSR). This event included an aircraft fly-in and air tours, which in some years have caused high rates of seabird disturbance. In 2009, the SPN began conducting outreach specifically directed toward pilots attending this event and has continued to do so each year since.

In addition to disturbance events, all aircraft flying at or below an estimated 1,000 ft (305 m) above sea level and 1,500 ft (460 m) horizontal distance, as well as all watercraft within an estimated 1,500 ft (460 m), of the nearest seabird breeding or roosting area were recorded to identify use patterns of potential sources of anthropogenic disturbance. We calculated detection rates as the number of aircraft or watercraft observed within these given zones per observation hour, using monitoring effort for each colony complex. We recorded and reported all watercraft entering the Egg Rock/Devil's Slide Rock and PRH Special Closure areas to Cal-TIP ("Californians Turn in Poachers") or to California Department of Fish and Wildlife (CDFW) wardens directly as well as to the SPN. Special Closures are no-entry zones designated by CDFW under the California Marine Life Protection Act to protect important seabird and marine mammal colonies from disturbance.

Non-anthropogenic Disturbance Events

In 2019, non-anthropogenic disturbance events (e.g., avian, other wildlife, etc.) were recorded mainly during focused "Avian Disturbance Surveys." We based the protocol for this survey on surveys conducted by the CMRP in 1999-2001 and reinitiated in 2017 to more efficiently and randomly record non-anthropogenic disturbances at PRH, DSRM and CHCC. We conducted avian disturbance surveys in two-hour time segments between 0600-1800 h at murre productivity monitoring overlooks. We monitored each two-hour time segment between 0600-1800 h within a two-week period. Observers recorded all non-anthropogenic disturbance events including the species and number of individuals causing disturbance, the types of behaviors exhibited by the disturbance source (Table 1), as well as the species, numbers of individuals, and behaviors of birds disturbed.

We recorded monitoring effort during avian disturbance surveys to calculate rates. Any anthropogenic disturbances that occurred during avian disturbance surveys were also recorded. In addition, we separately recorded major incidental non-anthropogenic disturbance events that occurred outside the avian disturbance surveys.

Common Murre Seasonal Attendance Patterns

We monitored seasonal attendance patterns of murres at PRH, DSCC and CHCC nesting areas throughout the field season until all chicks fledged and adult attendance ceased. Counts were conducted from standardized mainland observation points using 65-130X or 15-60X spotting scopes. Survey frequency and methods varied somewhat depending on location. Most counts were conducted during a standardized period between 1000-1400 h, but count times were sometimes extended if necessary to complete the count. At productivity plots and a subset of subcolonies and subareas, we compared murre counts to weekly long-term patterns (2008-2018) and 95% confidence intervals. Results are reported as above or below average if they fell outside the 95% confidence interval surrounding the long-term mean.

At several subcolonies within PRH and CHCC, we recorded attendance at established index plots. Plots were utilized at subcolonies with larger populations where whole counts were not practical or feasible. Plot maps were created using photographs and recognizable landmarks within the subcolonies to maintain consistent boundaries across seasons.

Point Reyes Headlands

Murre attendance counts at PRH typically were counted once per week. However, in 2019, restoration of the Point Reyes Lighthouse limited our access to the observation point for conducting murre productivity monitoring on Lighthouse Rock (LHR). Thus, from 21 April to 10 May we shifted time typically spent monitoring murre productivity to conducting an additional weekly seasonal attendance survey (resulting in two surveys per week) of PRH except at LHR, which was still surveyed once per week (Figure 2). From 10 May through 12 August, access to the lighthouse was less restricted; therefore, we resumed the regular survey schedule of recording seasonal attendance once per week for all PRH areas

Index plots were counted three times per survey with the average of those counts reported. Plots included: LHR (Ledge, Edge, and Dugout plots), Boulder, Flattop, Middle, Beach, and Cone Rocks. We counted all other visible areas of subcolonies once per survey.

Bird Island

In 2019, monitoring of this very small and ephemeral colony was conducted by a trained volunteer once per week in April and from mid-June through mid-July; volunteer availability was limited and counts could not be conducted in May and the beginning of June. Counts were conducted during late afternoon (after 1500 h) from a south facing overlook on the bluff above the north end of Rodeo Beach (on the Rodeo Beach Coastal Trail, approximately 920 meters north of Bird Island).

Devil's Slide Rock, Mainland and San Pedro Rock

We counted murres on DSR every other day from 22 April to 13 August from the Traditional Pullout (Figure 3). Photographs of the DSR colony were taken with a Canon EOS 80D camera with a 300 mm telephoto lens. Birds were counted later using Image Pro Plus software (Media Cybernetics, 2007). On Devil's Slide Mainland (DSM), we monitored attendance patterns once per week wherever we could view murres (see map, Figure 3 and 4); murres were counted three times per survey with the average of the three reported. As in previous years, access to the best observation point for viewing Lower Mainland South (DSRM-05-A Lower) and Turtlehead Boulder was limited to short periods of time in order to minimize disturbance to nesting Peregrine Falcons (*Falco peregrinus*). At SPR, we conducted bird counts once per week throughout the breeding season from Pipe Pullout (Figure 3).

Castle-Hurricane Colony Complex

We monitored seasonal attendance of murres for all active subcolonies visible from accessible, standardized mainland observation points (Figure 5). Counts were conducted twice per week during the breeding season from 23 April to 28 July. At four subcolonies, separate subarea counts were also conducted: CRM-04 (productivity plot and entire rock), CRM-03B (south and east sides), CRM-06-B (also called CRM-06-South; south side only), CRM-06-A (also called CRM-06-North; north side only), and HPR-02 (Ledge and Hump plots). We observed a small portion of subarea CRM-06-A from the Castle Pullout (Figure 5). For all areas, murres were counted three times per survey with the average of the three reported.

Common Murre Productivity

As in previous years, productivity (chicks fledged per pair) of murres was monitored at PRH, DSRM and CRM, from standardized mainland observation points using the Type I method outlined in Birkhead and Nettleship (1980), with some modifications. Type I monitoring is characterized by daily or near daily observations from fixed observation points throughout the murre breeding season to record accurate observations of egg laying, chick hatching and chick fledging. Plots in the Type I method should consist of approximately 80 breeding pairs of cliff nesting murres, with a clear view of individuals from an vantage point higher than the colony (Birkhead and Nettleship 1980). We used either 65-130x or 15-60x spotting scopes. At the PRH LRH plots, we mapped and numbered all followed sites using photographs of the colony from both 2018 and 2019. At DSR, we mapped and numbered all followed sites using digiscoped photographs from both 2018 and 2019. At CRM-04-P, locations of returning or new breeding and territorial sites were identified using maps and photographs updated from the 2018 breeding season. We did not follow productivity at CRM-03-B for the 2019 season due to time restrictions, because murres do not nest there every year, and because murres have unusually poor breeding success there.

We defined a breeding site as a site where an egg was observed or inferred based on adult behaviors. A territorial site was defined as a location with attendance greater than or equal to 15% of monitored days but where an egg was not observed or inferred based on adult behaviors. We defined a sporadic site as a location attended for at least two days but for less than 15% of monitored days. Some territorial and sporadic sites were likely breeding sites where eggs were lost at the time of laying or shortly after but without detection. Chicks were considered to have fledged if they survived to at least 15 days of age and were not known to perish before disappearing from the breeding site. In cases when the hatch date was not known and the chick disappeared before the 15th day after it was first observed, chick plumage stages were also used to age the chick and determine whether or not to consider the chick fledged. We compared results from 2019 to previous long-term means: PRH, 1996-2002, 2005-2015, 2017-2018 (n=20 years) DSR and CRM, 1996-2018 (n=23 years).

Point Reyes Headlands

We monitored murre productivity at PRH within two established Type I plots (Birkhead and Nettleship 1980) on LHR. Ledge Plot and Edge Plot were located in the interior and edge of the colony, respectively. We monitored 196 sites, including 112 sites in Ledge Plot and 84 sites in Edge Plot.

Devil's Slide Rock and Mainland

Due to widespread colony growth and the increasing difficulty of monitoring the entire colony, three Type I plots (A, B and C, Birkhead and Nettleship 1980) were established on DSR in 2006 (McChesney et al. 2006; Figure 6). Since 2006, as plots continued to fill in with increased numbers of murres, we have adjusted plot boundaries based on the visibility of sites. In 2014, we deleted Plot C entirely due to poor viewing conditions and in 2015 we added Plot D to continue monitoring the edge effects previously captured in Plot C (Figure 6). In addition, we have deleted individual sites within current plot boundaries if productivity data could not consistently be obtained due to poor viewing conditions. We have added new sites within current boundaries (Figure 7) as new birds have established territorial or breeding sites.

In 2019, we monitored 205 sites within DSR plots (Figure 7). We monitored all active sites in plots beginning 22 April. We also observed murres sporadically on DSRM-05-A-Lower, DSRM-05-A-Roost, DSRM-05-B and DSRM-05-C, but no evidence of breeding was detected.

Castle-Hurricane Colony Complex

We monitored 107 active murre breeding and territorial sites within one Type I plot on CRM-04 (established in 1996) beginning 11 April.

Nest Surveys

To assess locations of nesting areas, relative breeding population sizes, and potential impacts from disturbance, we conducted nest and bird surveys of non-murre seabird species at each colony in conjunction with murre colony attendance surveys. Surveys were conducted weekly at PRH, DSRM and semi-weekly at CHCC between mid-April and 10 July. Brandt's Cormorant nests and territorial sites were classified into five groups that described nesting stages: territorial site, poorly built nest, fairly built nest, well-built nest, and nests with brooded chicks. In addition, large, wandering ("creching") cormorant chicks were counted. See McChesney et al. (2007) for more detailed descriptions of nest categories. For other species, we only counted well-built nests (i.e., those beyond the poorly built stage). Nest counts reported were the sum of seasonal peak counts of well-built nests (including nests with chicks) at each subcolony or subarea.

Brandt's Cormorant Productivity

We monitored breeding phenology and reproductive success (clutch sizes, brood sizes and chicks fledged per pair) of Brandt's Cormorants at PRH, DSRM and CHCC wherever vantage points provided adequate viewing. At PRH in 2019, we monitored Brandt's Cormorants on Northwest Rock (PRH-10-A), Beach Rock (PRH-10-E), Little Rock (PRH-10-G), Arch Rock (PRH-11-D), Spine Point (PRH-11-E-Spine), Wishbone Point (PRH-11-E-Wish), and Mainland (PRH-14-E; Figure 2). At DSRM, we monitored at DSR (DSRM-01), Lower Mainland South (DSRM-05-A Lower), Upper Mainland South (DSRM-05-A-Upper), DSRM-05-C, and DSRM-04 (from the South Bunker Overlook; Figure 3 and 4). At CHCC, we conducted monitoring at CRM-03-B and CRM-09 (Figure 5).

We observed monitored nests every one to seven days from mainland observation points using binoculars and spotting scopes. We considered chicks fledged if they survived to at least 30 days of age and were not known to perish afterward. After that age, chicks typically begin to wander from their nests and become impossible to associate with specific nests without marking (Carter and Hobson 1988, McChesney 1997). Results from 2019 were compared to prior long-term means for PRH (1997-2001, 2006-2015, 2017-2018; n=17 years), DSRM (1997-2007, 2009-2018; n=21 years), and CHCC (1997-2001, 2006-2018; n=18 years).

Pelagic Cormorant, Black Oystercatcher, and Western Gull Productivity

We monitored productivity of Western Gulls and Black Oystercatchers at select subcolonies or subareas that were easily visible from mainland observation points at DSRM and CHCC. Productivity of Pelagic Cormorants was monitored only at DSRM. Nests were examined at least once per week. We considered chicks fledged if they survived to at least 30 days of age and were not known to perish afterward. We used feathering status as a proxy for chick age if precise age was not known (i.e., chicks that were greater than 75% feathered were considered to have fledged). We compared results to long-term averages for DSRM (2006-2018; n=13 years). We could not monitor productivity of Pelagic Cormorants at CHCC because no visible nests advanced beyond the territory stage.

Pigeon Guillemot Surveys

To assess relative population size and seasonal attendance patterns, we conducted standardized counts from mid-April to late June for birds rafting on the water and roosting on land (intertidal and nesting areas) at PRH, DSCC and CHCC. We conducted surveys at all colonies between 30 minutes after sunrise and 0830 h. In previous years we only conducted Pigeon Guillemot surveys in Beaufort states <4. In 2019, however, we conducted surveys in all weather states to roughly examine whether weather impacted counts. In addition, from mid-April to 5 May, when numbers often peak, we conducted surveys daily, and about once per week thereafter. At PRH, the area to the north and east of Point Reyes (PRH-01, 02, 03 and 04; Figure 2) was surveyed. At DSCC, we surveyed the entire area from the south side of SPR to the South Bunker (DSRM-04; Figures 3, 4).

Common Murre and Brandt's Cormorant Breeding Population Sizes

The University of California, Santa Cruz conducted aerial photographic surveys of central California Common Murre, Brandt's Cormorant and Double-crested Cormorant colonies on 6 July. P. Capitolo photographed active colonies at the Farallon Islands and nearshore colonies between Lobos Rocks and Point Sur with a digital SLR camera from a Partenavia fixed-wing aircraft. Because colonies were photographed well after the typical date range for aerial surveys and after most breeding murres and Brandt's Cormorants either had large chicks or had failed, counts were only obtained for DSRM and comparisons to previous years should be considered with caution.

To obtain counts from the DSRM colony, we selected photographs to provide the most complete colony coverage with high quality imagery. Counts of murres and Brandt's Cormorants were obtained using Image Pro Plus software (Media Cybernetics, 2007). We individually counted all visible murres from each DSRM subcolony or subarea; these counts were summed to provide whole-colony count. For further information on aerial photographic survey methods, see McChesney and Carter (1999), Carter et al. (2001), and Capitolo et al. (2014). To obtain murre breeding population size estimates, we applied a correction factor to the raw aerial photograph counts to account for breeding birds not present and non-breeding birds present at the time of the survey. We used the correction factor of 1.92 derived for murres in 2019 at nearby Southeast Farallon Island (Johns and Warzybok. 2019). It is not clear how appropriate the Farallon correction factor is for other colonies, but we believe it provides a reasonable estimate of breeding population sizes at most colonies and assists in making standardized comparisons. Furthermore, because aerial surveys were conducted later in the season than is typical and about a month after the Farallones correction factor was calculated, we have not included the 2019 estimate in long-term trend analyses of murre breeding population size at DSRM.

For Brandt's Cormorants, counts included territorial sites, poorly built nests, active well-built nests, nests with brooded chicks, abandoned nests (well-built nest with no birds present), and empty nests (well-built nest with no adult present). For further description of counting protocol and nest categories used for aerial photograph counting, see McChesney and Carter (1999) and Capitolo et al. (2014).

To examine long-term Brandt's Cormorant population trends at DSRM, we plotted and fitted annual cormorant nest counts dating back to 1979 with a LOESS curve (R Core Team, 2018) and 95% confidence intervals. We determined linear trends for estimates from the 1999-2019 period using a Generalized Linear Model with a Poisson distribution (or Quasi-poisson in cases of overdispersion; R Core Team, 2018). These years correspond to the period following the very strong 1997-98 El Niño and the shift to a colder water regime that persisted for several years.

To provide more complete breeding population estimates of Brandt's Cormorants at DSRM, we compared peak subcolony and subarea counts from land-based surveys with aerial photograph counts. We then combined the higher counts between methods for each area to provide a combined population estimate (total number of nesting pairs).

RESULTS

Anthropogenic Disturbance

During the 2019 field season, monitoring effort across PRH, DSCC and CHCC totaled 1470.6 observation hours (Table 2). There were 129 aircraft observed (detection and disturbance events combined) within our monitoring areas at PRH, DSRM and CHCC combined; these included 75 planes, 46 helicopters, five drones and three unknown aircraft (Table 3). Overall, 74 (57%) of these overflights resulted in disturbance to seabirds (e.g. agitation, displacement or flushing). A total of 42 planes, 30 helicopters, and two unknown aircraft caused disturbance. Sixteen helicopters and four planes caused displacement and/or flushing of murres. The most frequently detected aircraft categories were general aviation planes, private/recreational planes and USCG helicopters (Figure 8, Appendix 1, 2). At PRH from 2005-2019, there were no significant trends in detection or disturbance rates of aircraft (Table 4). At DSRM from 2005-2019, there were significant declining trends in the change of annual plane, helicopter, and aircraft combined detection rates, but no significant trends in aircraft disturbance rates. There were also significant declining trends in annual plane detections rates at CHCC, but no significant trends in aircraft disturbance rates (Table 4).

There were 38 watercraft observed within 1,500 feet of monitored colonies, including 28 recreational fishing boats, four commercial fishing boats, two charter fishing boats, and one sailboat. The only watercraft that caused a disturbance was a fishing boat that caused two events of flushing and displacement of Brandt's Cormorants at CHCC (Appendix 3). There were significant declining trends in the change of annual watercraft detection rates at PRH and in the change of annual watercraft disturbance rates at PRH and DSRM (Table 4). Due to inconsistencies in data recording of watercraft detections at DSRM for 2015-2018, trends were not analyzed and comparisons to those years should be considered with caution. There were no significant trends in annual watercraft detection or disturbance rates at CHCC.

A total of 75 SPN Wildlife Disturbance Reports were submitted in 2019 (20 from PRH, 47 from DSCC and eight from CHCC). This included 21 reports of flushing and/or displacement and 54 reports of agitation. Seventy-three of the reports involved aircraft disturbance and two involved watercraft disturbance.

We recorded no watercraft entering the Special Closures at DSR or PRH in 2019.

Point Reyes Headlands

We recorded 40 aircraft and 15 watercraft within our detection zones at PRH in 2019 (Table 3; Figure 8 and 9). There were 20 aircraft events that caused disturbances to murres (five flushing events and 15 agitation events). Detection rates in 2019 were slightly lower than 2018 but greater than all other years since 2008 (Table 10). The 2019 combined aircraft disturbance rate was 0.03 disturbances/hr, the same rate as in 2018; these two years had the greatest observed aircraft disturbance rates since 2005 (Table 11). Despite these higher values, no significant trends in aircraft disturbances have been detected. We recorded 15 watercraft within the detection zone, but none of these caused a disturbance. There was a significant declining trend in the annual change in the detection rate of watercraft (-14.9% annual change, P=0.003) and in the disturbance rate of watercraft (-22.8% annual change, P=0.03, Table 4).

Devil's Slide Rock and Mainland

In 2019 at DSRM, 47 overflights resulted in disturbance to seabirds. Twenty-four planes, 22 helicopters, and one unknown aircraft caused disturbance. The rate of disturbance events (0.10 disturbances/hr) was greater than in 2018 but analysis of long-term trends showed a significant declining trend in annual change in the rate of detection of helicopters (-5.8% annual change, P=0.006), planes (-12.1% annual change, P=0.03), and all aircraft combined (-10.6% annual changes, P=0.02; Table 4). There were 14 total flushing events caused by aircraft, including three general aviation helicopters, two general aviation planes, two military helicopter, three USCG helicopters, two commercial helicopters, one media helicopters, and one unknown helicopter (Appendix 1). The largest disturbance event was on 20 May when a general aviation helicopter caused 1,100 murres to be agitated, and 150 murres and 20 Brandt's cormorants to flush (Table 5). We detected ten watercraft within 1,500 ft of the colony, but none of these were observed to cause disturbances. There was a significant declining trend in the annual change of disturbance rates for watercraft at DSRM (-25.7% annual change, P=0.002, Table 4, Appendix 5).

In 2019, the annual Pacific Coast Dream Machines event took place on 28 April at the Half Moon Bay Airport. Weather conditions were overcast with a high cloud ceiling (>1000 ft) and wind at a Beaufort rating of three throughout the day. We stationed observers at the observation point for DSR from 0708 h to 1800 h to record overflights and disturbance events. There were ten aircraft detected within 1500 ft of the colony, all of which caused disturbances. One helicopter caused flushing of murres and nine planes caused agitation of murres. During this event we observed twenty-eight additional aircraft outside the detection zone, the fewest observed outside the detection zone since 2014. Since dedicated observations during the Dream Machines event began (2005) there has been a significant declining trend in annual change of aircraft detection rates (-13.6% annual change; P=0.02) but no significant trend in annual change of disturbance rates. As in previous years, SPN staff located at the Half Moon Bay airport provided outreach to pilots during the event.

Castle-Hurricane Colony Complex

In 2019, we recorded 11 helicopters, seven planes, two drones and 13 watercraft in the CHCC detection zones with disturbance to seabirds occurring during seven aircraft events and two watercraft events. The rate of disturbance events involving displacement and/or flushing of seabirds (0.01 disturbances/hr; Table 3) was lower than in 2018. A single military helicopter and two private/recreational fishing vessels (Appendix 1) caused the only observed flushing events. A military helicopter on 15 July caused the largest disturbance event observed at CHCC when 63 murres were flushed and 104 were agitated (Table 6). The two watercraft disturbances observed at CHCC occurred on 7 May when a private/recreational fishing boat displaced 50 and flushed five Brandt's Cormorants from CRM-02. Later that day the same boat caused a second, larger disturbance, flushing 75 Brandt's Cormorants from CRM-02. For the first time since monitoring began we observed a significant declining trend in plane detection rates (-8.8% annual change, P=0.03, Table 4) at CHCC. There were no other significant trends in detection rates or disturbance rates at CHCC in 2019.

Non-Anthropogenic Disturbance

Point Reyes Headlands

Avian Disturbance Surveys
We conducted 94.6 hours of avian disturbance surveys at LHR (PRH-03-B). The non-anthropogenic disturbance rate during this period was 6.7 disturbance events per hour, with an average of 12.5 disturbance events per survey. This was the greatest disturbance rate between PRH, DSRM and CHCC. Western Gulls caused the greatest number of disturbances at PRH, followed by Common Ravens (Table 7). Western Gull and Common Raven presence in the colony was the most common behavior to cause agitation in murres. Western Gulls and Common Ravens were observed depredating twelve murre eggs during avian disturbance surveys (Table 7, Figure 12).

Incidental Non-Anthropogenic Disturbance
In addition to standardized avian disturbance surveys, we recorded incidental non-anthropogenic disturbance from all observation overlooks including LHR (PRH-03-B). We did not observe any events resulting in disturbances greater than 100 flushed murres; however, we observed ravens taking an additional 14 eggs from LHR.

Devil's Slide Rock and Mainland

Avian Disturbance Surveys
At DSR, we conducted 90.8 hours of avian disturbance surveys. The non-anthropogenic disturbance rate during these observations was 2.8 disturbance events per hour. Common Ravens caused the highest rate of disturbance events and accounted for 50% of all the events during the season. Ravens also depredated or directly caused the loss of 12 murre eggs and one murre chick during non-anthropogenic disturbance surveys. Brown Pelicans, Western Gulls, Brandt's Cormorants, and a Northern Gannet (*Morus bassanus*) caused additional disturbance events (Table 8).

Incidental Non-Anthropogenic Disturbance
We recorded incidental non-anthropogenic disturbance from DSRM overlooks. Common Ravens were responsible for three of the four observed incidental non-anthropogenic disturbance events, and Brown Pelicans were responsible for one event. The largest event occurred on 4 June when a pair of ravens, working cooperatively, displaced and flushed 200 murres, flushed 15 Brandt's Cormorants and took one murre egg.

Castle-Hurricane Colony Complex

Avian Disturbance Surveys
At CRM-04, we conducted 81.2 hours of avian disturbance surveys. The non-anthropogenic disturbance rate during this period was 1.9 disturbance events per hour. Western Gulls caused the greatest number of disturbance events, and were responsible for 89% of all events. Brown Pelicans flying over caused the second highest number of disturbance events (10% of all events). Seven of the 129 disturbance events we observed were characterized as flushing or displacement events (Figure 12). A Western Gull caused the largest event on 18 June, resulting in the agitation of 200 murres. We did not observe any eggs or chicks exposed, displaced or taken during avian disturbance surveys. (Table 8).

Incidental Non-Anthropogenic Disturbance
At CHCC in 2019, there was one incidental non-anthropogenic disturbance event large enough to be recorded outside of avian disturbance surveys. On 2 May, one Turkey Vulture circling above CRM-06-S caused 160 murres to flush. We did not observe any other eggs or chicks exposed or taken during the 2019 season.

Common Murre Seasonal Attendance Patterns

Point Reyes Headlands

In 2019, we confirmed all well-established murre nesting areas that had active breeding at PRH. The date of peak counts at subcolonies ranged from 3 May to 21 July. Attendance patterns at established count plots generally followed typical patterns (Figures 13, 14). Patterns at other count areas (Figure 15-18) mainly varied depending on whether they were more established nesting areas or had larger numbers of non-breeders. The first observations of unattended subcolonies began on 29 July (PRH-11-B), and of the active subcolonies, 75% were no longer attended by the last colony count on 12 August.

Bird Island

Surveys were conducted at Bird Island from 24 April to 14 July 2018. Murres were observed on 33% of observation days. An average of 44 murres (range = 7-69, n = 4 days) were counted on days when they were present. Murres were observed using the small area under the last remains of a former U.S. Navy Compass House, on the far western end of the rock. However, unlike previous years, murres also were observed congregating near the cliffs on the north and west sides of the island. Ravens were observed going under the structure of the Compass House on two of the four days murres were present. More murres were counted, on average, in 2019 compared to 2018, but on fewer observation days. No eggs or chicks were observed at Bird Island in 2019.

Devil's Slide Rock, Mainland and San Pedro Rock

Devil's Slide Rock

We observed murres on all count days between 22 April and 7 August 2019. Murres were completely absent from DSR on 9 August following the end of breeding activity (Figure 19). Peak count was during the pre-egg-laying period (first egg observed on 17 May) on 5 May. The maximum count of 1,972 murres occurred on 5 May and was 22% more than the 2018 peak count of 1,575 murres. During the pre-laying period murres were observed leaving DSR in large numbers in the afternoon. On 22 May, we observed the lowest attendance of murres during the breeding season (757 murres) following a week of intermittent rain, wind and large swells. During this survey, in addition to low attendance, we also observed many abandoned and displaced eggs. Another dip in colony attendance occurred on 9 and 10 June, during a heat wave where temperatures reached over 32°C and skies were clear for several days. During this period, we observed murres leaving the colony in large numbers and abandoning eggs. Attendance patterns were mostly consistent, with the exception of the heat wave, from 3 June through the incubation and early chick periods. From 3 June to 29 July counts maintained an average of 1,066 (range: 874-1,386) murres but after 29 July numbers decreased quickly as chicks fledged and birds abandoned eggs that had failed to hatched.

The seasonal attendance pattern was relatively similar to the long-term pattern (2008-2018) except that counts were consistently greater than average in 2019 (Figure 19); this reflects both increased colony size over earlier years and perhaps a change in count methodology in 2018 from real-time counts through spotting scopes to automated counts from photographs. Counts from photographs appear to be much less variable than spotting scope counts. Therefore, use of these data for long-term analyses should take these methodological differences into account.

Devil's Slide Mainland and San Pedro Rock

We observed murres attending Lower Mainland South (DSRM-05-A Lower) and intermittently amongst nesting and roosting Brandt's Cormorants at other Mainland South subareas (DSRM-05-A Roost, DSRM-05-B, DSRM-05-C, and SPR-01-Nose). An average of 20 murres attended DSRM-05-A Lower intermittently from 24 April until 17 June, after which attendance all but ceased; no evidence of breeding was observed. We recorded a small group of murres (3-16) throughout the breeding season, 28 May through 7 August, on DSRM-05-C near nesting Brandt's Cormorants, but with no confirmed breeding. Seasonal attendance at mainland subcolonies in 2019 was consistent with long-term patterns (2008-2018) during early pre-laying but below the average throughout the rest of the season. We observed one murre on San Pedro Rock on 9 July, on the so-called Nose where social attraction equipment was utilized in 1998-2007.

Castle-Hurricane Colony Complex

Attendance counts at CHCC subcolonies began on 23 April. Murre attendance across most subcolonies was greatest in late April to mid-May (Figures 20-22). Typically, CHCC subcolonies are mostly empty by the end of July. In 2019, relatively high numbers still present at several subcolonies suggests prolonged breeding at those areas, perhaps because of a delayed onset to egg-laying, high numbers of relays, or both. On the contrary, CRM-04, where our productivity plot is located, was largely empty of murres by the end of July.

Common Murre Productivity

Point Reyes Headlands

We monitored a combined 196 sites in Ledge (n = 112) and Edge plots (n = 84) on LHR, 148 of which were breeding sites. The mean egg-laying date (exclusive of replacement eggs) for Edge and Ledge plots combined was 1 June (range = 18 May – 2 July; n = 113; Table 9), five days later (outside two standard deviations) than the long-term mean (26 May ± 1.8 days). We recorded 20 replacement eggs in Edge and Ledge Plots. Overall productivity was 0.06 chicks fledged per pair, which was well below average and the lowest recorded since 2012 (Table 9, Figure 23). Productivity was influenced by low hatching (19.5%) and fledging (32.3%) success. Chicks fledged at an average age of 23 ± 5.1 days (n = 31), and the last chick was observed on 7 August (Table 9).

Devil's Slide Rock and Mainland

Of 198 attended sites documented within DSR plots, 171 (86%) were breeding, 23 (12%) were territorial, and four (2%) were sporadic. The first murre egg observed was on 17 May, in productivity plot A, and it was depredated by ravens. At all sites combined, the mean egg-laying date for first eggs was 26 May ± 7.2 days (range = 17 May – 20 June, n = 136), later than (outside two standard deviations) the long-term average (28 May ± 1.7 days). We recorded 181 eggs laid, including 11 replacement eggs. Overall productivity of 0.15 chicks fledged per pair was well below average (0.66 ± 0.05; Table 9, Figure 23); only 2009, when no chicks fledged, was worse. Lower than average productivity was influenced by both low (36%) hatching and fledging (20%) success. Chicks that fledged remained on DSR for an average of 23 ± 4.1 days (n = 27), and the last chick was seen on 4 August.

There were no breeding attempts recorded on DSM in 2019.

Castle-Hurricane Colony Complex

Of 107 total monitored sites in the CRM-04 plot in 2019, 73 (68%) were breeding and 34 (32%) were territorial or sporadic. The first egg observed was on 7 May. The mean egg-laying date was 24 May ± 1.3 days (range = 7 May – 15 June; n = 53), nine days later (outside two standard deviations) than the long-term mean of 15 May ± 1.9 days. We recorded four replacement eggs. Overall productivity at CRM-04 of 0.45 chicks per pair was near to slightly below average (Table 9, Figure 23). Chicks that fledged remained for an average of 21 ± 1.3 days (n = 34) after hatching, and the last chick was seen on 21 July.

In 2019, we did not monitor productivity at the colony CRM-03-B. We confirmed breeding, but did not observe chicks. Attendance patterns showed that murres abandoned the rock mid-June (Figure 21), indicating that all breeding attempts failed.

Brandt's Cormorant Nest Surveys and Productivity

We reported seasonal peak nest counts of Brandt's Cormorants obtained from weekly land surveys and aerial surveys (DSRM only; Table 10). In most cases, not all nests were visible from our observation points, so nest counts should be considered a minimum. Consequently, comparisons to previous years should also be considered with caution. Aerial counts tend to be more complete than other methods where views could be obscured. Therefore, when available, we use aerial counts for long-term trend analysis. Land based surveys provide minimum counts in years when aerial surveys are not conducted and in some cases, provide counts for areas that were not covered in aerial surveys.

Point Reyes Headlands

Nest surveys

We conducted Brandt's Cormorant nest surveys from 21 April to 15 July. Nesting was widespread, with well-built nests recorded at Rock 3 (PRH-02-A), Rock 2 (PRH-02-B), a peninsula west of Green Top (PRH-08), Cliff Colony East (PRH-09-A), Cliff Colony West (PRH-09-B), Northwest Rock (PRH-10-A), Middle Rock (PRH-10-C), East Rock (PRH-10-D), Beach Rock (PRH-10-E), Rock 37 (PRH-10-F), Little Rock (PRH-10-G), Face Rock (PRH-11-B), Arch Rock (PRH-11-D), Spine Point (PRH-11-E-Spine), Wishbone Point (PRH-11-E-Wish), and Mainland (PRH-14-E). The single-day count of nests for all subcolonies combined was 240 nests on 1 July. Aerial surveys were not conducted and nests outside of observable locations were not documented. The sum of land-based seasonal peak counts from each subcolony was 303 nests, 69% greater than in 2018 (156 nests; Table 10).

Productivity

At PRH, we monitored 135 nests at seven subareas, all of which were egg-laying sites (Table 11). We began monitoring after nest initiation at the following subcolonies: Northwest Rock (PRH-10-A) on 18 May; Beach Rock (PRH-10-E) on 1 June, Little Rock (PRH-10-G) on 14 May, Arch Rock (PRH-11-D) on 13 May, Spine Point (PRH-11-E-Spine) on 13 May, Wishbone Point (PRH-11-E-Wish) on 13 May, and Mainland (PRH-14-E) on 21 May. For all subareas combined, the average clutch initiation date was 18 May ± 8.95 (range = 28 April – 29 June, n = 129). The first chick hatched on 1 June. Overall productivity of 2.06 chicks fledged per pair (subarea range = 1.06 – 2.75) was near or slightly above (within the 95% confidence interval) the long-term mean (1.86 ± 0.6; Figure 24). Breeding success per nest (egg-laying nests that fledged at least one chick) was 0.84 (subarea range = 0.39 – 1.0; Table 11), and there were two replacement clutches.

Bird Island

Surveys were conducted at Bird Island from 24 April to 14 July 2019. Roosting Brandt's Cormorants were present predominately during the middle and end of the season (5 June–14 July), with counts ranging from 3-18 roosting birds. No Brandt's Cormorant nests were observed on Bird Island and we suspect no breeding occurred in 2019.

Devil's Slide Rock and Mainland

Nest surveys
We counted nests and territorial sites between 22 April and 9 July. We observed the first well-built nests on 24 April. The peak count of nests on DSR was 25 on 3 June. On the mainland, nesting occurred on April's Finger (DSRM-05-AF; peak count of three nests), Lower Mainland South (DSRM-05-A-Lower; peak count of five nests), Upper Mainland South (DSRM-05-A-Upper; peak count of six nests), South of Turtlehead Cliffs (DSRM-05-C; peak count of 33 nests), and DSRM-04 (peak count of 24 nests).

The peak single-day count for DSRM combined was 91 nests on 9 July, 102% more than the 2018 peak count (45 nests). The sum of the seasonal peak counts was 98 nests, 14% more than the 2018 seasonal peak count sum of 86 nests.

From aerial surveys, 11 Brandt's Cormorant nests were counted that could not be seen from mainland vantage points. Thus, by combining aerial and land-based surveys we obtained a total count of 133 total nests (Table 10).

Productivity
We monitored 89 breeding sites at DSRM in 2019. Brandt's Cormorant nests were monitored on DSR (DSRM-01), Lower Mainland South (DSRM-05-A Lower), Upper Mainland South (DSRM-05-A Upper), DSRM-05-C, and DSRM-04. We observed the first eggs on DSRM-05-C on 29 April. For all subareas combined, the mean clutch initiation date was 9 May ± 7.5 days (range = 26 April to 17 June). Overall productivity of 1.89 chicks fledged per pair (subarea range = 0–3; n = 85) was near or slightly above (within the 95% confidence interval) the long-term mean (1.71 ± 0.42; Figure 24). Overall breeding success/nest was 0.85 with one replacement clutch (Table 12).

Castle-Hurricane Colony Complex

Nest surveys
We conducted Brandt's Cormorant nest surveys from 23 April to 27 July. Subcolonies or subareas with confirmed breeding in 2019 were CRM-03-B, CRM-07, CRM-09, BM227X-02, and a large unnamed rock west of BM227X-02. We observed the first well-built nests on 11 April at CRM-03-B, on 23 April at BM227X-02, and on 27 April at CRM-09. At all CHCC subcolonies combined, we recorded the peak single nest count survey of 194 nests on 5 June, which was 54% higher than the 2018 peak count of 112. The sum of the seasonal peak subcolony counts was 212 nests, 43% higher than the 2018 count of 148 nests (Table 10).

Productivity
We monitored Brandt's Cormorant productivity on CRM-03-B and CRM-09 (Table 12). The mean clutch initiation date was 27 April ± 5.26 days. We observed the first chick on 17 May. The overall productivity at CRM of 0.95 chicks fledged per pair (subcolony range = 0–3.0; n =

76) was lower than the long-term mean of 1.62 ± 0.7 (Figure 24). Breeding success per nest was 0.66 (Table 12).

Pelagic Cormorant, Black Oystercatcher, Western Gull, and Pigeon Guillemot

Nest and bird surveys

We recorded seasonal peak counts of nests (Pelagic Cormorant, Western Gull, and Black Oystercatcher) or birds (Pigeon Guillemot) from land-based observations and aerial surveys (Table 10). Pelagic Cormorant nesting areas typically vary from year to year and often nests are not visible from land-based vantage points. Because of this, nest counts should be considered a minimum estimate and comparisons to previous years should be considered with caution.
The maximum number of Pelagic Cormorant nests at each subcolony at DSRM yielded a total count of 29 nests. At CHCC, we observed only one Pelagic Cormorant territory from our mainland vantage points.

The 2019 peak standardized count for Pigeon Guillemots from each subcolony at PRH was 96, 34% less than observed in 2018. The 2019 peak standardized count at DSRM was 164 guillemots on 7 May; 15% less than the 2018 count. At CHCC, the peak standardized count was 57 guillemots on 24 April; 30% lower than we observed in 2018 (Table 10).

Productivity

We conducted productivity monitoring for Western Gulls, Black Oystercatchers and Pelagic Cormorants at DSRM and CHCC and summarized the results (Table 13).

Pelagic Cormorant
At DSRM, we monitored Pelagic Cormorant productivity at DSRM-05-C and DSRM-04. The first egg was recorded on 13 May. Overall productivity of 0.6 chicks fledged per pair was well below the long-term mean (1.5 ± 0.8; Table 13, Figure 25). At CHCC, we did not conduct productivity monitoring for Pelagic Cormorants because only one territory was observed on CRM-07, which did not advance in nesting stage.

Western Gull
Gull productivity at DSRM was 0.25 chicks fledged per pair, which was lower than the long-term mean (0.64 ± 0.16). At CHCC, productivity from six monitored nests was 0.5 chicks fledged per pair, which was also lower than the long-term mean (0.62 ± 0.12; Table 13, Figure 26).

Black Oystercatcher
For the first time since 2014 at DSRM, a Black Oystercatcher nest was visible to follow for productivity. The pair was observed incubating one egg on 3 June on Keyhole Rock (DSRM-08). A single chick hatched on or near 5 July but did not fledge. At CHCC, four oystercatcher nests

were monitored including nests at CRM-01, CRM-02, CRM-03-B, and HPR-04. All four nests hatched chicks and three chicks fledged with 0.75 chicks fledged per pair (Table 13).

Common Murre and Brandt's Cormorant Breeding Population Sizes

In most past years dating to 1993, we have obtained counts from aerial photographs of all nearshore murre and Brandt's Cormorant colonies in the Gulf of the Farallones area and at CHCC in Big Sur. Because of the better area coverage in comparison to land-based surveys, we have used aerial photographic surveys for standardized estimates of breeding population sizes and trends of these species in the California Current System (CCS) (Carter et al. 2001, Capitolo et al 2014, Ainley et al. 2018).

Over the last 10+ years, funding for aerial photographic surveys has been greatly reduced. In 2019, funding delays and lack of adequate funding greatly impeded these surveys. In addition to being incomplete, surveys were conducted well past standardized timing, after many murres and Brandt's Cormorants had already failed nesting, and after many Brandt's Cormorant chicks had begun to wander from the parent nests. Thus, counts were only obtained from DSRM and CHCC. However, only data from DSRM are presented as we felt other survey results had insufficient value. Comparisons to previous years should be considered with caution.

Common Murre

Raw bird counts of Common Murres were obtained from aerial survey photographs. To estimate breeding population sizes, a correction factor of 1.92 was applied to 2019 counts (see Methods). This very high correction factor was associated with low attendance of breeders during the survey period at Southeast Farallon Island, which was associated with high breeding failure (Johns and Warzybok 2019).

From aerial photographs obtained at DSRM on 7 July, 1,955 murres were counted on DSR. Applying the correction factor to the aerial survey count yielded an estimate of 3,754 breeding murres or about 1,877 breeding pairs (Figure 28). This estimate was 23% greater than the estimate we calculated in 2018 (2,899 murres). Another 147 murres were counted on the Devil's Slide Mainland; most of these were non-breeders.

Since 2013, aerial counts of DSR murres have been similar to the historic estimates of 2,300-2,923 breeding birds in 1979-1982 prior to colony extirpation (Sowls et al. 1980, Briggs et al. 1983, Carter et al. 2001). DSR has shown a significant increasing trend in breeding population size since 1999.

Brandt's Cormorant

At DSRM, 123 Brandt's Cormorant nests were counted from aerial photographic surveys on 7 July (Table 10). Breeding population trends at DSRM based on aerial photographic surveys are shown in Figure 27. Breeding population sizes have varied considerably since monitoring began in 1979 (Capitolo et al. 2014). At DSRM and most other Gulf of the Farallones colonies over the last two decades, cormorant numbers increased dramatically during the 2000-2007 period then declined rapidly in relation to a decline in the prey base (Ainley et al. 2018). In recent years, Brandt's Cormorant numbers have largely recovered to about average long-term values.

DISCUSSION

Anthropogenic Disturbance

As in most recent years, DSRM experienced higher anthropogenic detection and disturbance rates than other monitored colonies. At PRH in the last two years an increase in aircraft activity has resulted in the greatest disturbance rates observed since the earliest years of disturbance monitoring. Although aircraft detection and disturbance rates at DSRM have also been slightly greater in the last few years, rates are still lower than earlier years of the project (2005-2012) and we continue to see declining trends, especially in detection rates of aircraft. At CHCC, detection and disturbance rates, as well as disturbance sources, continue to vary considerably from year to year; however, it appears that plane activity within the detection zone in the area may be declining. Disturbance and detection rates at DSRM during the Pacific Coast Dream Machines event were lower in 2019 than in 2018, and there continues to be a significant declining trend in the annual change of detection rates during the event. Although detection rates continue to decline, the lack of significance in disturbance rate trends indicate the continuing need for the GFNMS SPN outreach staff presence during the event.

At PRH, increasing detection and disturbance rates were mainly attributed to general aviation planes, which were seen at a greater rate than has been typical. However, detection rates at PRH were still lower than we observed at DSRM. Drones have been observed frequently at CHCC in recent years. Two were observed in 2019 but did not cause disturbance.

In 2019, there were only two disturbance events from watercraft observed across all three colonies, and no alleged Special Closure violations. At PRH and DSRM, there continues to be significant declining trends in the annual change of watercraft disturbance rates. The two watercraft disturbances at CHCC were the first we have observed since 2015. These declining trends indicate that boaters are increasingly aware of Special Closures and appropriate behavior around sensitive seabird nesting colonies. Continued communication between field staff and CDFW wardens, including enforcement of Special Closures, as well as continued GFNMS SPN outreach will hopefully continue to prevent future violations and disturbances.

Non-Anthropogenic Disturbance

Non-anthropogenic disturbance surveys

Results from non-anthropogenic disturbance surveys varied widely between PRH, DSRM and CHCC. Disturbance rates at PRH continue to be higher than at DSRM or CHCC, with Western Gulls causing the majority of total events and displacing/flushing events. Like 2018, ravens continued to be the main contributor to egg loss at PRH and DSRM. It is possible that low chick numbers associated with prey shortages contributed to the relatively low numbers of chicks that were observed to be depredated in 2019. As in 2018, Common Ravens caused the majority of disturbance events at DSRM but in 2019 there were more than ten times more disturbance events observed. Secondary to ravens, Brown Pelicans and Western Gulls continued to be contributors to non-anthropogenic disturbance at DSRM. At CHCC in 2018, Western Gulls caused the most disturbance events, but Brown Pelicans caused the most displacement/flushing events.

We suspect that the Common Raven disturbance observed in 2019 at DSRM continues to be from one resident pair, which, later in the season, was seen with two juvenile ravens (which we suspect were young of this pair) on DSR. The frequency of non-anthropogenic disturbance events is of concern, especially at the relatively small, and therefore more vulnerable, DSR colony. Extremely low productivity at PRH observed in 2019, may have been exacerbated by the high rates of non-anthropogenic disturbance we observed.

Attendance and Reproductive Success

The standardized land-based maximum and the aerial counts of the murre colony on DSR in 2019 were both greater than in 2018. High attendance in the pre-laying period may be attributed to high co-site attendance by mated pairs. However, the high attendance recorded during these surveys contrasted with relatively low daily breeding site attendance noted by observers, which made tracking many sites very difficult. We do not have an explanation for these differences. It is possible that larger than usual numbers of non-breeders were present on the colony peripheries or outside of our plots, but this was not recorded by observers.

In 2019, murre breeding was later than the long-term average at all colonies, as indicated by both productivity monitoring and seasonal attendance counts. Despite high failure rates, more birds than usual continued to attend some breeding areas beyond our monitoring cut-off dates. Late breeding often is associated with low breeding success (Boekelheide et al. 1990). Productivity was very low at PRH and DSRM, with almost complete reproductive failure of murres at PRH. At PRH, productivity was only lower in 1998 (strong El Niño conditions) and 2012 (major Brown Pelican disturbances). At DSR, only the total reproductive failure year of 2009 (anchovy population crash) had lower productivity than in 2019. In contrast, productivity at CHCC was near average. Similar to murres, Pelagic Cormorants and Western Gulls also showed low productivity in 2019. In contrast to the other monitored species, Brandt's Cormorant productivity at PRH and DSRM was near average, but less than average at CHCC.

The reasons for low nesting success for monitored seabirds in the region, with the exceptions of CHCC murres and Brandt's Cormorants nesting at Gulf of the Farallones colonies, are not entirely clear. At the nearby but offshore South Farallon Islands, results from 2019 were similar to our mainland colonies, with low breeding success for most species including Common Murres, except for Brandt's Cormorants (Johns and Warzybok 2019). At the Farallones, sea surface temperatures in winter-spring 2019 were above average, consistent with El Niño conditions that often result in warm, low ocean productivity conditions. Poor breeding success of many Farallon breeding species, including murres, may have been associated with a lack of juvenile rockfish in chick diets, a possible result of the warm water (Johns and Warzybok 2019). Juvenile rockfish are often a major component of Farallon seabird chick diets in productive years. Instead, in 2019 murres and some other species fed their chicks mainly northern anchovy (*Engraulis mordax*). Anchovies have high caloric value and often are a major seabird prey item. Surveys indicated that anchovies were in high abundance in the region in 2019 (Thompson et al. 2019). However, at the Farallones, murre chick provisioning was very low and adults took very long foraging trips, suggesting that birds had to work very hard to procure prey for chicks. Also, many anchovies were too large for the small murre chicks to eat (Johns and Warzybok 2019). Brandt's Cormorants will also feed extensively on anchovies. It is possible that Brandt's Cormorants were better able to find adequate sized anchovies to feed their chicks, possibly assisted by the cormorants' regurgitation of partially digested food. More information about the ecological effects of conditions in 2019 is necessary to better interpret seabird productivity during the year.

Recommendations for Future Management, Monitoring and Research

• Outreach and education efforts targeting aircraft and watercraft user groups should be continued and adapted to changing sources and characteristics of disturbance.

• The Devil's Slide pedestrian trail was completed in March of 2014, and the 2019 field season marked the sixth year of pedestrian access to the span of road above DSM. While no pedestrian-related disturbances were recorded, monitoring should be continued to detect any new or different types of potential disturbance. The presence of thousands of visitors throughout the seabird season provided a great opportunity for outreach.

• Annual aerial surveys of central California murre and Brandt's Cormorant colonies cannot be sustained at current funding levels. These surveys provide the best, and preferable, means of monitoring these species populations in a standardized fashion (Bridgeland et al. 2018). They also provide a substantial complement to our efforts to document the success of murre restoration efforts.

• As the numbers and densities of murres on monitored breeding colonies increase, continued evaluation of monitoring methods for productivity (especially at DSR) will be necessary. This will include adjustments to plot boundaries and elimination of sites that are difficult to view.

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Table 1. Behavior categories used to record disturbances in standardized non-anthropogenic disturbance surveys. Each behavior is described as either occurring in the air or on land and as either an active or passive action.

Behavior	**Behavior Description**
Presence	Causing a disturbance to the colony just by presence, not actively harassing (Land, Passive)
Ground harass	Walking through the colony in a threatening manner (Land, Active)
Lunge	Lunging at COMU with beak (Land, Active)
Pull	Pulling a COMU by the wing, foot or beak (Land, Active)
Snatch	Snatching an unattended or poorly guarded egg or chick without driving the parent off the site (Land, Active)
Easy picking	Taking unattended eggs or chicks following a flushing event (Land, Active)
Scavenging	Consuming an abandoned egg, dead chick, or dropped fish (Land, Passive)
Flyover	Flying over a colony without pause (only recorded if it causes a disturbance) (Air, Passive)
Air lunge	A flying predator lunges at a COMU on the ground (Air, Active)
Air hovering	Hovering over a colony (Air, Passive)
On the wing	Taking a flying adult COMU from the air (Air, Active)
Air attack	Chasing a flying adult COMU from air (Air, Active)

Table 2. Monitoring effort of study colonies or colony complexes, April 2019 to August 2019.

Colony or Colony Complex	**Start date**	**End date**	**Observation Days**	**Total hours**
Point Reyes Headlands	4/19/2019	8/15/2019	107	721
San Pedro Rock	4/19/2019	8/15/2019	11	1.6
Devil's Slide Rock & Mainland	4/16/2019	8/16/2019	109	451
Castle-Hurricane Colony Complex	4/11/2019	7/31/2019	73	297

Table 3. Total detected watercraft and aircraft, and resulting disturbances to all seabirds (Common Murres, Brandt's Cormorants, and Brown Pelicans) at Point Reyes Headlands (PRH), Devil's Slide Rock and Mainland (DSRM) and Castle-Hurricane Colony Complex, 2019. Disturbances are number of alert, displaced, and flushed birds. Detection and disturbance rates reported as numbers per observation hour.

Disturbance Source	Total Detections	Detections/ hr.	# Alert Birds	# Displaced Birds	# Flushed Birds	Total Disturbed/hr.	Total Flushed or Displaced/hr.
Plane (PRH)	30	0.042	13	0	2	0.021	0.003
Helicopter (PRH)	8	0.011	1	0	3	0.006	0.004
Drones (PRH)	0	0.0	0	0	0	0.0	0.0
Unknown Aircraft (PRH)	2	0.003	1	0	0	0.001	0.0
Aircraft Total (PRH)	40	0.056	15	0	5	0.028	0.007
Watercraft (PRH)	15	0.021	0	0	0	0.0	0.0
PRH Total	**55**	**0.076**	**15**	**0**	**5**	**0.028**	**0.007**
Plane (DSRM)	38	0.084	22	0	2	0.053	0.004
Helicopter (DSRM)	27	0.060	10	0	12	0.049	0.027
Drones (DSRM)	3	0.007	0	0	0	0.0	0.0
Unknown Aircraft (DSRM)	1	0.002	1	0	0	0.002	0.0
Aircraft Total (DSRM)	69	0.153	33	0	14	0.104	0.031
Watercraft (DSRM)	10	0.022	0	0	0	0.0	0.0
DSRM Total	**79**	**0.175**	**33**	**0**	**14**	**0.104**	**0.031**
Plane (CHCC)	7	0.024	3	0	0	0.010	0.0
Helicopter (CHCC)	11	0.037	3	0	1	0.013	0.003
Drones (CHCC)	2	0.007	0	0	0	0.0	0.0
Aircraft (CHCC)	20	0.067	6	0	1	0.024	0.003
Watercraft (CHCC)	13	0.044	0	0	2	0.007	0.007
CHCC Total	**33**	**0.111**	**6**	**1**	**2**	**0.030**	**0.010**

Table 4. The percent annual change, 95% confidence intervals, and p-value results from Poisson or quasi-poisson regression statistics for annual change in a. detection rates (2005-2019) and b. disturbance rates (2005-2019) for aircraft and watercraft at Point Reyes Headlands (PRH), Devil's Slide Rock Mainland (DSRM) and Castle-Hurricane Colony Complex. Only significant values shown.

a. Detections

Disturbance Source	Percent Annual Change	95% Confidence Interval	P-value
Watercraft (PRH)	-14.9%	-19.7% – -6.9%	0.003
Plane (DSRM)	-12.1%	-18.9% – -2.2%	0.03
Helicopter (DSRM)	-5.8%	-8.8% – -2.3%	0.006
Aircraft Total (DSRM)	-10.6%	-16.5% – -2.5%	0.03
DSRM Total	**-10.6%**	**-17.7% – -0.6%**	**0.04**
Plane (CHCC)	-8.8%	-14.3% – -1.6%	0.03

b. Disturbances

Disturbance Source	Percent Annual Change	95% Confidence Interval	P-value
Watercraft (PRH)	-22.8%	-30.7% – -5.8%	0.03
Watercraft (DSRM)	-25.7%	-30.4% – -12.5%	0.002

Table 5. Number of disturbance events from anthropogenic sources and mean numbers (range) of Common Murres and Brandt's Cormorants disturbed (agitated, displaced and/or flushed) and displaced/flushed at Point Reyes Headlands and Devil's Slide Rock and Mainland, 2019.

Species and Colony		**Plane**	**Helicopter**	**Unknown Aircraft**	**Total**
Common Murre (PRH)	Number of Disturbance Events	15	4	1	**20**
Common Murre (PRH)	Mean Number Birds Disturbed	2387 (100-6400)	3352 (10-6300)	1000 (1000-1000)	**2511 (10-6400)**
Common Murre (PRH)	Number of Displaced/Flushed Events	2	3	0	**5**
Common Murre (PRH)	Mean Number of Birds Displaced/Flushed	202 (5-400)	270 (10-500)	0	**243 (5-500)**
Common Murre (DSRM)	Number of Disturbance Events	22	21	1	**44**
Common Murre (DSRM)	Mean Number Birds Disturbed	583 (100-1200)	850 (100-1600)	1 (1100-1100)	**422 (100-1600)**
Common Murre (DSRM)	Number of Displaced/Flushed Events	2	12	0	**14**
Common Murre (DSRM)	Mean Number of Birds Displaced/Flushed	35 (20-50)	46 (4-150)	0	**45 (4-150)**
Brandt's Cormorant (DSRM)	Number of Disturbance Events	1	8	0	**9**
Brandt's Cormorant (DSRM)	Mean Number Birds Disturbed	5 (5-5)	13 (1-50)	0	**12 (1-50)**
Brandt's Cormorant (DSRM)	Number of Displaced/Flushed Events	1	8	0	**9**
Brandt's Cormorant (DSRM)	Mean Number of Birds Displaced/Flushed	5 (5-5)	13 (1-50)	0	**12 (1-50)**
Total DSRM Seabirds	**Mean Number Seabirds Disturbed**	**583 (100-1200)**	**855 (100-1600)**	**1100**	**725 (100-1600)**
Total DSRM Seabirds	**Mean Number Seabirds Displaced/Flushed**	**38 (20-55)**	**55 (4-170)**	**0**	**52 (4-170)**

Table 6. Number of disturbance events and mean numbers (range) of Common Murres and Brandt’s Cormorants disturbed, displaced and/or flushed and displaced/flushed at Castle-Hurricane Colony Complex (CHCC), 2019.

Species and Colony		**Plane**	**Helicopter**	**Watercraft**	**Total**
Common Murre (CHCC	Number of Disturbance Events	3	4	0	**7**
Common Murre (CHCC)	Mean Number Birds Disturbed	39 (18-60)	52 (7-167)	0	**47 (7-167)**
Common Murre (CHCC)	Number of Displaced/Flushed Events	0	1	0	**1**
Common Murre (CHCC)	Mean Number of Birds Displaced/Flushed	0	63 (63-63)	0	**63 (63-63)**
Brandt’s Cormorant (CHCC)	Number of Disturbance Events	0	0	2	**2**
Brandt’s Cormorant (CHCC)	Mean Number Birds Disturbed	0	0	65 (55-75)	**65 (55-75)**
Brandt’s Cormorant (CHCC)	Number of Displaced/Flushed Events	0	0	2	**2**
Brandt’s Cormorant (CHCC)	Mean Number of Birds Displaced/Flushed	0	0	65 (55-75)	**65 (55075)**
Total CHCC Seabirds	**Mean Number Birds Disturbed**	**39 (18-60)**	**52 (7-167)**	**65 (55-75)**	**47 (7-167)**
Total CHCC Seabirds	**Mean Number of Birds Displaced/Flushed**	**0**	**63 (63-63)**	**65 (55-75)**	**64 (55-75)**

Table 7. Number of disturbance events and mean numbers (range) of Common Murres disturbed (agitated, displaced and/or flushed) and displaced/flushed by disturbance source during avian disturbance surveys at Point Reyes Headlands, 2019.

Disturbance Source	Brandt's Cormorant	Brown Pelican	Canada Goose	Pelagic Cormorant	Peregrine Falcon	Common Raven	Turkey Vulture	Unknown	Western Gull	**Total**
Number of Disturbance Events	29	37	6	1	1	177	8	1	459	**719**
Mean Number of Birds Disturbed	7 (1-50)	800 (1-6000)	2187 (20-4000)	1 (1-1)	5 (5-5)	279 (1-6000)	1826 (5-5000)	1000 (1000-1000)	72 (1-3000)	**196.19 (1-6000)**
Number of Displaced/ Flushed Events	23	15	0	1	0	84	1	0	211	**335**
Mean Number of Birds Displaced/ Flushed	4 (1-15)	15 (1-50)	0	1 (1-1)	0	50 (1-1000)	5 (5-5)	0	4 (1-300)	**16.29 (1-1000)**
Number of Eggs Exposed or Taken	0/0	0/0	0/0	0/0	0/11	0/0	0/0	0/0	0/1	**0/12**
Number of Chicks Exposed or Taken	0/0	0/0	0/0	0/0	0/1	0/0	0/0	0/0	0/0	**0/3**

Table 8. Number of disturbance events and mean numbers (range) of Common Murres disturbed (agitated, displaced and/or flushed; Dist.) and displaced/flushed by disturbance source (top row) during avian disturbance surveys at a. Devil's Slide Rock and b. Castle-Hurricane Colony Complex, 2019.

a. Devil's Slide Rock and Mainland

Disturbance Source	Brown Pelican	Common Raven	Western Gull	Brandt's Cormorant	Northern Gannet	**Total**
Number of Disturbance Events	66	11	60	28	7	**322**
Mean Number of Birds Disturbed	137 (1-1000)	115 (1-1150)	71 (1-500)	4 (1-30)	52 (1-300)	**100.12 (1-1150)**
Number of Displaced/Flushed Events	21	91	21	25	3	**161**
Mean Number of Birds Displaced/Flushed	4 (1-21)	14 (1-120)	3 (1-10)	3 (1-14)	2 (1-3)	**9.47 (1-120)**
Number of Eggs Exposed or Taken	0/0	13/12	0/0	0/0	0/0	**13/12**
Number of Chicks Exposed or Taken	2/0	0/1	0/0	0/0	0/0	**2/1**

b. Castle-Hurricane Complex

Disturbance Source	Brown Pelican	Peregrine Falcon	Western Gull	**Total**
Number of Disturbance Events	13	1	115	**129**
Mean Number of Birds Disturbed	42 (9-140)	50 (50-50)	33 (1-200)	**34.19 (1-200)**
Number of Displaced/Flushed Events	2	0	5	**7**
Mean Number of Birds Displaced/Flushed	11 (10-12)	0	3 (1-8)	**5 (1-2)**
Number of Eggs Exposed or Taken	0/0	0/0	0/0	**0/0**
Number of Chicks Exposed or Taken	0/0	0/0	0/0	**0/0**

Table 9. Common Murre breeding phenology and reproductive success at a. Point Reyes Lighthouse Rock, b. Devil's Slide Rock, and c. Castle Rocks & Mainland, 2019. Means (range; n) are reported.[1]Calculated using first eggs only; i.e., does not include replacement clutches. [2]Hatching success is defined as the number of eggs hatched per eggs laid (includes both first and replacement clutches). [3]Fledging success is defined as the number of chicks fledged per eggs hatched (includes both first and replacement clutches).

a. Point Reyes Headlands

Plot	PRH-03-B-Edge	PRH-03-B-Ledge	**PRH plots combined**
Number Sites Monitored	84	112	**196**
Number Egg Lay Sites	64	84	**148**
Mean Lay Date[1]	28 May (5/18-6/28; 47)	02 June (5/19-7/2; 66)	**01 June (5/18-07/02; 113)**
Number Eggs Laid	68	100	**168**
Mean Hatch Date	27 June (6/17-7/22; 16)	04 July (6/23-8/1; 13)	**30 June (6/17-8/1; 29)**
Hatching Success[2]	27.7% (65)	14.1% (99)	**19.5% (164)**
Mean Fledge Date	22 July (7/16-8/7; 8)	17 July (7/15-7/19; 2)	**21 July (7/15-8/7; 10)**
Fledging Success[3]	44.4% (18)	15.4% (13)	**32.3% (31)**
Chicks Fledged per Pair	0.12 (58)	0.02 (82)	**0.06 (140)**

b. Devil's Slide Rock

Plot	DSRM-01-A	DSRM-01-B	DSRM-01-D	**DSRM-01 plots combined**
Number Sites Monitored	104	74	27	**205**
Number Egg Lay Sites	91	65	21	**177**
Mean Lay Date[1]	29 May (5/17-6/20; 74)	27 May (5/21-6/19; 49)	25 May (5/21-6/4; 13)	**28 May (5/17-6/20; 136)**
Number Eggs Laid	93	66	22	**181**
Mean Hatch Date	29 June (6/19-7/26; 26)	01 July (6/21-7/22; 20)	30 June (6/26-7/9; 3)	**30 June (6/19-7/26; 49)**
Hatching Success[2]	35.5% (93)	40% (70)	23.8% (21)	**25.9% (184)**
Mean Fledge Date	23 July (7/1508/2; 16)	24 July (7/16-8/4; 10)	26 July (7/26-7/26; 1)	**24 July (7/15-8/4; 27)**
Fledging Success[3]	48.5% (33)	35.7% (28)	20% (5)	**40.9% (177)**
Chicks Fledged per Pair	0.18 (91)	0.15 (65)	0.05 (21)	**0.15 (177)**

c. Castle Rock and Mainland

Plot	CRM- 04-P
Number Sites Monitored	107
Number Egg Lay Sites	73
Mean Lay Date[1]	24 May (5/7-6/15; 53)
Number Eggs Laid	77
Mean Hatch Date	26 June (6/15-7/19; 36)
Hatching Success[2]	64% (75)
Mean Fledge Date	17 July (7/8-7/23; 34)
Fledging Success[3]	68.8% (48)
Chicks Fledged per Pair	0.45 (73)

Table 10. High counts of nests and breeding birds from aerial (conducted on 7 July 2019) and land surveys of nests for Common Murres, Brandt's Cormorants, Pelagic Cormorants, Western Gulls, and Black Oystercatchers, 2019. Pigeon Guillemots counts reported are for bird (not nest) peak counts only and as Land/Water counts. A dash indicates no survey was conducted. [1]Sum of high season nest (Brandt's and Pelagic Cormorants, Western Gull and Black Oystercatcher) and bird (Common Murre and Pigeon Guillemot) counts during land-based surveys. [2]For total counts, land-based and aerial counts were compared. Nests accounted from the aerial survey were combined with the land-based count. [3]Aerial counts are not reported for nests of WEGU, BLOY and PIGU due to incomplete aerial photograph coverage.

Type of Survey and Colony location	**Common Murre**	**Brandt's Cormorant[1,2]**	**Pelagic Cormorant[1,2]**	**Western Gull[1,3]**	**Black Oystercatcher[1,3]**	**Pigeon Guillemot[1,3]**
Land – Point Reyes	-	303	20	91	3	96
Aerial – Point Reyes	-	-	-	-	-	-
Total – Point Reyes	-	-	-	-	-	-
Land – Bird Island	-	4	0	14	-	-
Aerial – Bird Island	-	-	-	-	-	-
Total – Bird Island	-	-	-	-	-	-
Land – Devil's Slide Rock & Mainland	-	98	29	4	1	81
Aerial – Devil's Slide Rock & Mainland	2102	123	13	-	-	-
Total – Devil's Slide Rock & Mainland	-	133	29	-	-	-
Land – Gray Whale Cove	-	0	4	0	-	0
Aerial – Gray Whale Cove	-	0	0	-	-	-
Total – Gray Whale Cove	-	-	-	-	-	-
Land – San Pedro Rock	-	0	0	1	-	83
Aerial – San Pedro Rock	-	0	0	-	-	-
Total – San Pedro Rock	-	-	-	-	-	-
Land – Bench Mark-227X	-	116	0	4	0	29
Aerial – Bench Mark-227X	-	-	-	-	-	-
Total – Bench Mark-227X		-	-	-	-	-
Land – Castle Rock & Mainland	-	96	0	6	3	25
Aerial – Castle Rock & Mainland	-	-	-	-	-	-
Total – Castle Rock & Mainland	-	-	-	-	-	-
Land – Hurricane Point Rocks	-	0	0	5	1	3
Aerial – Hurricane Point Rocks	-	-	-	-	-	-
Total – Hurricane Point Rocks	-	-	-	-	-	-

Table 11. Brandt's Cormorant breeding phenology and reproductive success at Point Reyes Headlands (PRH), 2019. Reported are means (range; n). [1]Includes first clutches only. [2]Includes replacement clutches. See text for details. [3]Breeding success per nest is defined as the proportion of egg-laying nests that fledged at least one chick.

Colony or Subcolony	**Number Breeding Sites**	**Clutch Initiation Date[1]**	**Clutch Size[1]**	**Breeding Success[2]**	**Number Chicks Fledged/Pair[2]**	**Breeding Success/ Nest[3]**
Northwest Rock (PRH-10-A)	21	18 May (05/14-05/26; 20)	3.20	71.4% (67)	2.20 (0-3; 20)	0.90 (20)
Beach Rock (PRH-10-E)	29	01 June (05/24-06/29; 27)	2.85	60% (87)	1.86 (0-4; 28)	0.89 (28)
Little Rock (PRH-10-G)	5	14 May (05/12-05/16; 5)	3.40	83.3% (17)	2.75 (2-3; 4)	1.00 (4)
Arch Rock (PRH-11-D)	20	13 May (05/08-05/20; 20)	2.60	32.9% (52)	1.06 (0-3; 18)	0.39 (18)
Spine Point (PRH-11-E-Spine)	30	13 May (04/28-05/22; 29)	3.45	71.9% (105)	2.43 (0-4; 28)	0.93 (28)
Wishbone Point (PRH-11-E-Wish)	25	13 May (05/06-05/18; 23)	3.35	67.9% (87)	2.42 (0-3; 24)	0.96 (24)
Mainland (PRH-14-E)	5	21 May (05/16-05/28; 5)	3.20	56.7% (16)	1.75 (0-3; 4)	0.75 (4)
Point Reyes Total	**135**	**18 May (04/28-06/29; 129)**	**3.12**	**62.6% (431)**	**2.06 (0-4; 126)**	**0.84 (126)**

Table 12. Brandt's Cormorant breeding phenology and reproductive success at Devil's Slide Rock & Mainland (DSRM) and Castle Rocks & Mainland (CHCC), 2019. Reported are means (range; n). [1]Includes first clutches only. [2]Includes replacement clutches. See text for details. [3]Breeding success per nest is defined as the proportion of egg-laying nests that fledged at least one chick.

Colony or Subcolony	Number Breeding Sites	Clutch Initiation Date[1]	Clutch Size[1]	Breeding Success[2]	Number of Chicks Fledged/Pair[2]	Breeding Success/ Nest[3]
Devil's Slide Rock (DSRM-01)	25	10 May (05/02-06/01; 21)	3.25	44% (69)	1.38 (0-3; 24)	0.67 (24)
DSRM-05	40	08 May (04/26-06/17; 40)	3.50	54% (142)	1.97 (0-3; 39)	0.87 (39)
DSRM-04	24	11 May (04/30-05/28; 24)	3.62	67% (87)	2.32 (1-3; 22)	1.00 (22)
Devil's Slide Rock & Mainland Total	**89**	**09 May (04/26-06/17; 85)**	**3.48**	**55% (298)**	**1.89 (0-3; 85)**	**0.85 (85)**
CRM-09	12	-	-	33%	1.00 (0-2; 12)	0.58 (12)
CRM-03-B	64	27 April (4/16-05/11; 60)	2.98	31% (191)	0.94 (0-3; 64)	0.67 (64)
Castle Rocks & Mainland Total	**76**	**27 April (04/16-05/11; 60)**	**2.98**	**31% (223)**	**0.95 (0-3; 76)**	**0.66 (76)**

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Table 13. Productivity of Pelagic Cormorants, Black Oystercatchers, and Western Gulls at Point Reyes Headlands (PRH), Devil's Slide Rock and Mainland (DSRM), and Castle Rocks & Mainland (CHCC), 2019. Means (range; n) or (n) are reported.[1]Breeding success per nest is defined as the proportion of egg-laying nests that fledged at least one chick.

Productivity at Colony	**Pelagic Cormorant**	**Black Oyster Catcher**	**Western Gull**
Number Breeding Sites (PRH)	-	-	-
Number Chicks Fledged (PRH)	-	-	-
Number of Chicks Fledged/Pair (Productivity) (PRH)	-	-	-
Breeding Success/Nest[1] (PRH)	-	-	-
Number Breeding Sites (DSRM)	15	1	3
Number Chicks Fledged (DSRM)	9	0	1
Number of Chicks Fledged/Pair (Productivity) (DSRM)	0.60 (0-2; 15)	0 (0-0; 1)	0.25 (0-1; 4)
Breeding Success/Nest[1] (DSRM)	0.40 (15)	0 (1)	0.25 (4)
Number Breeding Sites (CHCC)	0	4	6
Number Chicks Fledged (CHCC)	0	3	3
Number of Chicks Fledged/Pair (Productivity) (CHCC)	0	0.75 (0-2;4)	0.50 (0-3; 6)
Breeding Success/Nest[1](CHCC)	0	0.67 (3)	0.17 (6)

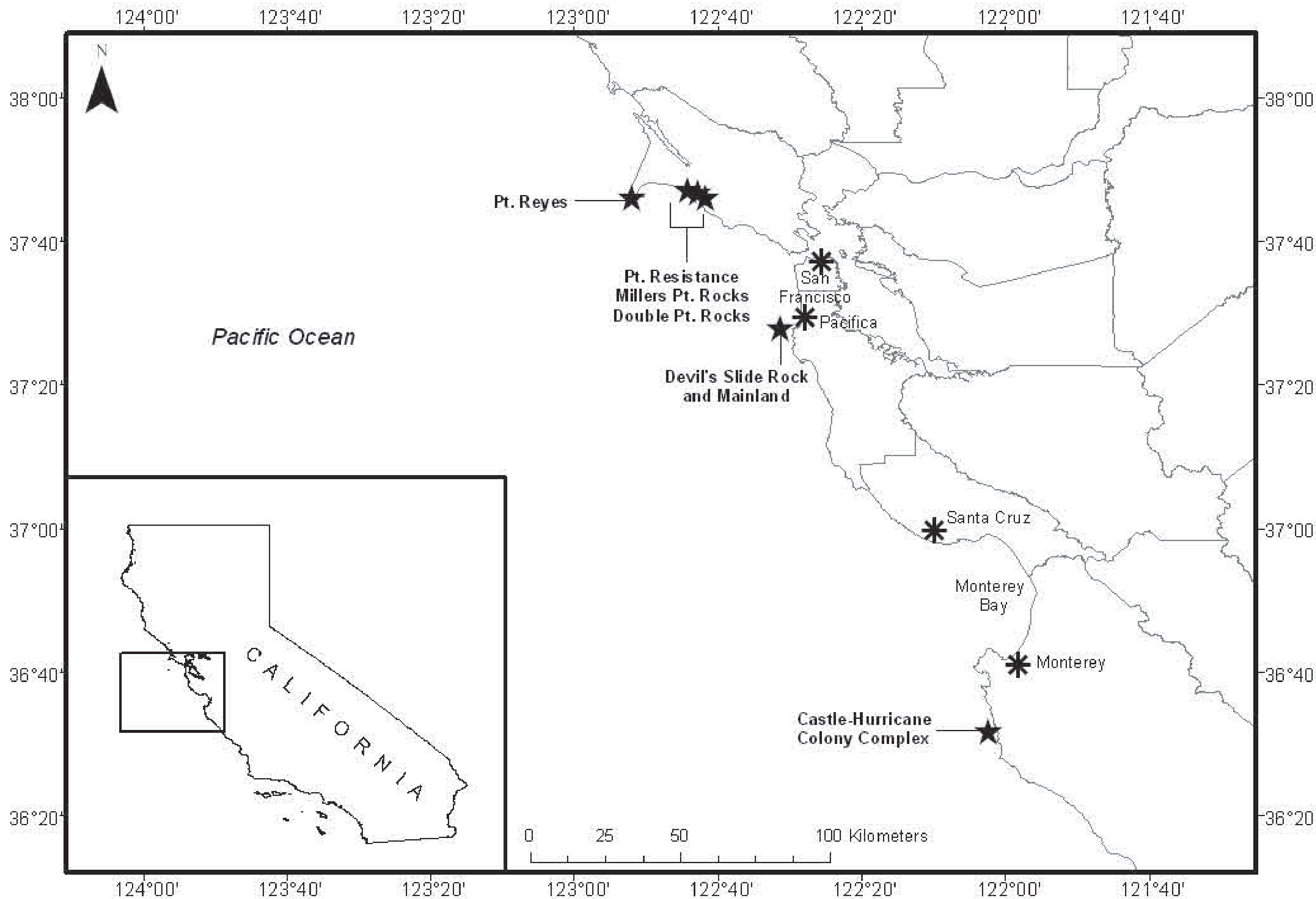


Figure 1. Study area, showing locations of study colonies or colony complexes along the Central California coast where we monitored seabird disturbance, attendance and breeding biology. Pt. Resistance, Miller's Pt. and Double Pt. were not monitored in 2019.

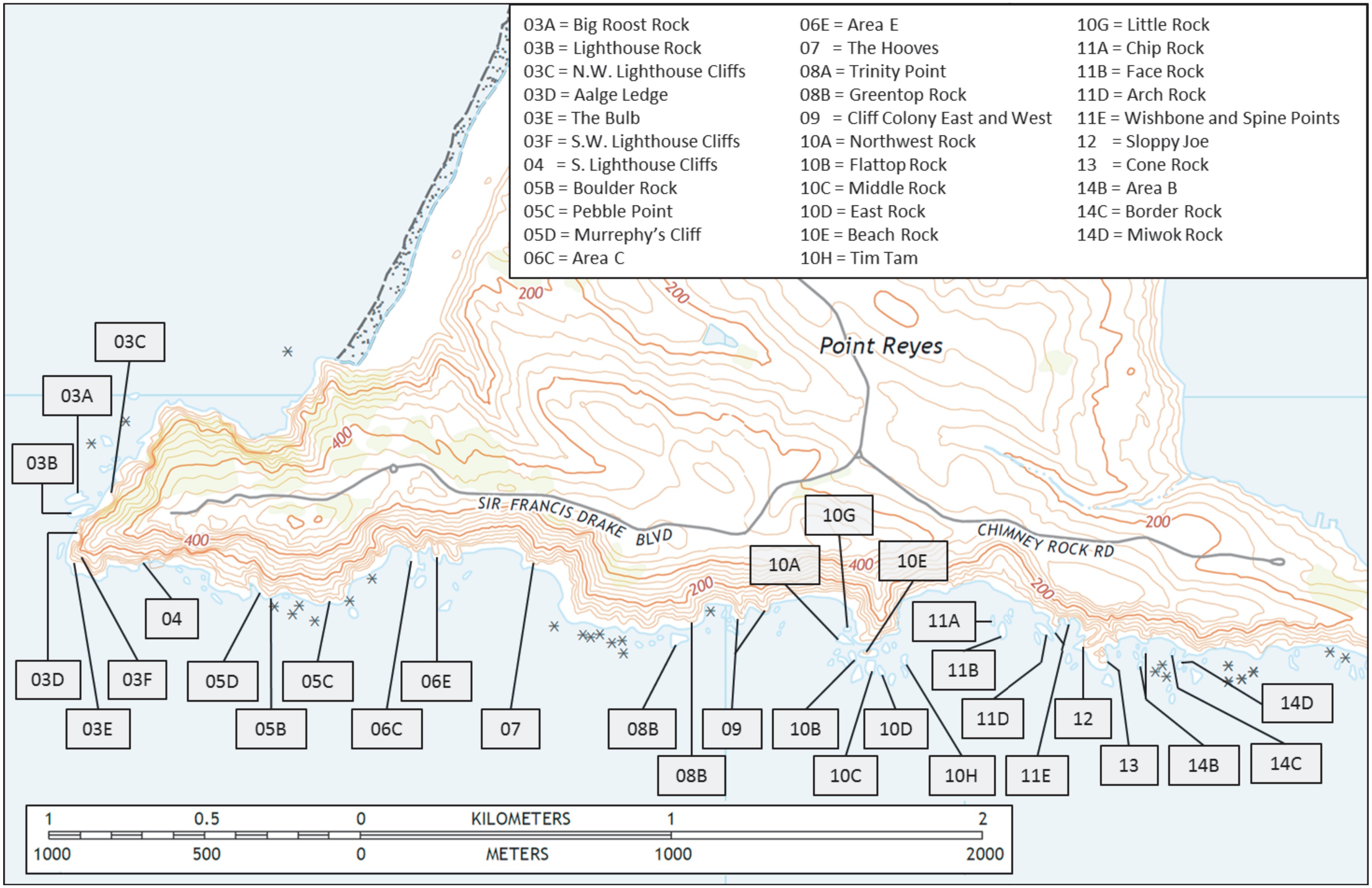


Figure 2. Point Reyes Headlands, including subcolonies 03A through 14D.

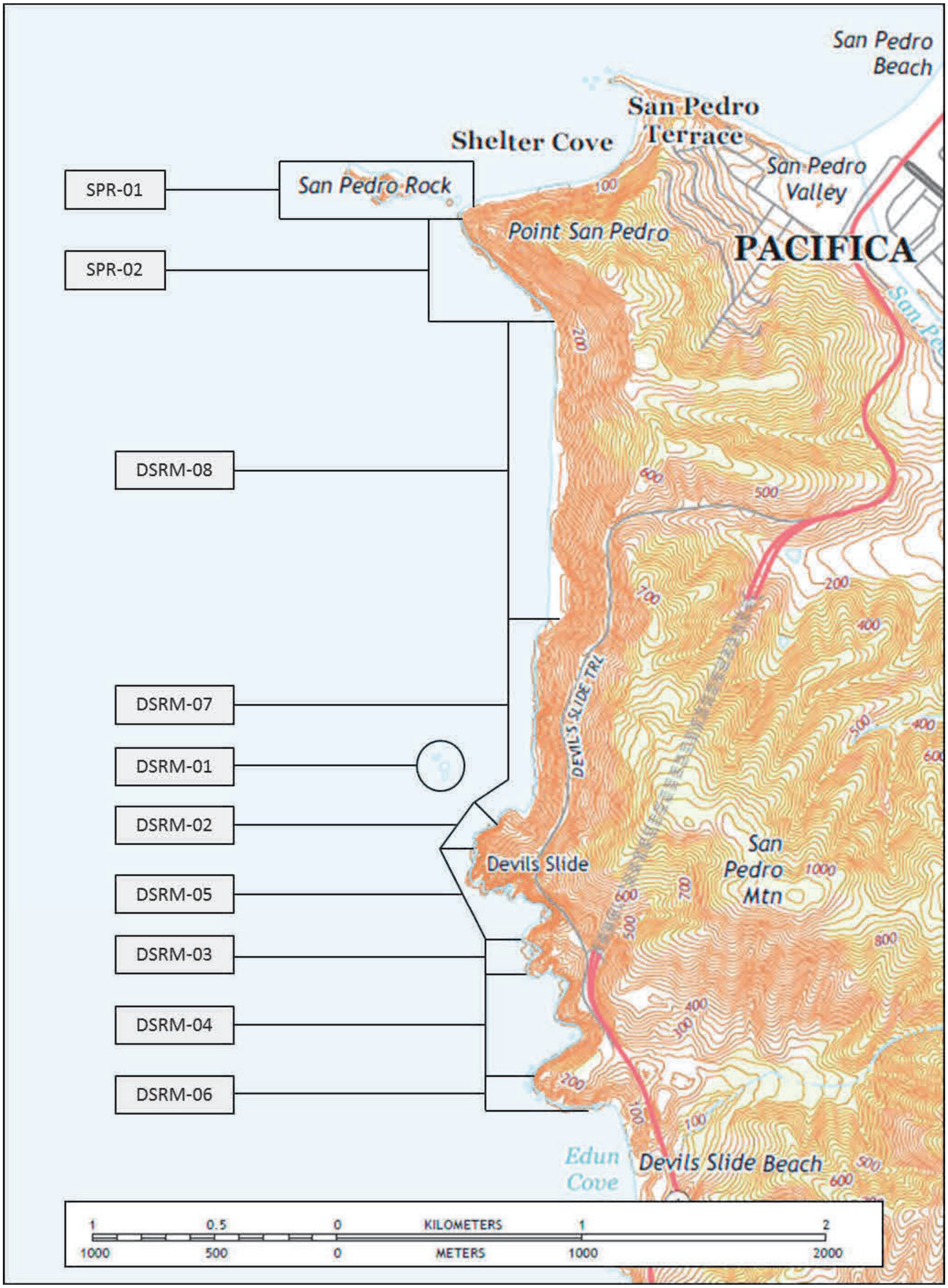


Figure 3. Devil's Slide Colony Complex, including San Pedro Rock and Devil's Slide Rock & Mainland colonies and subcolonies.

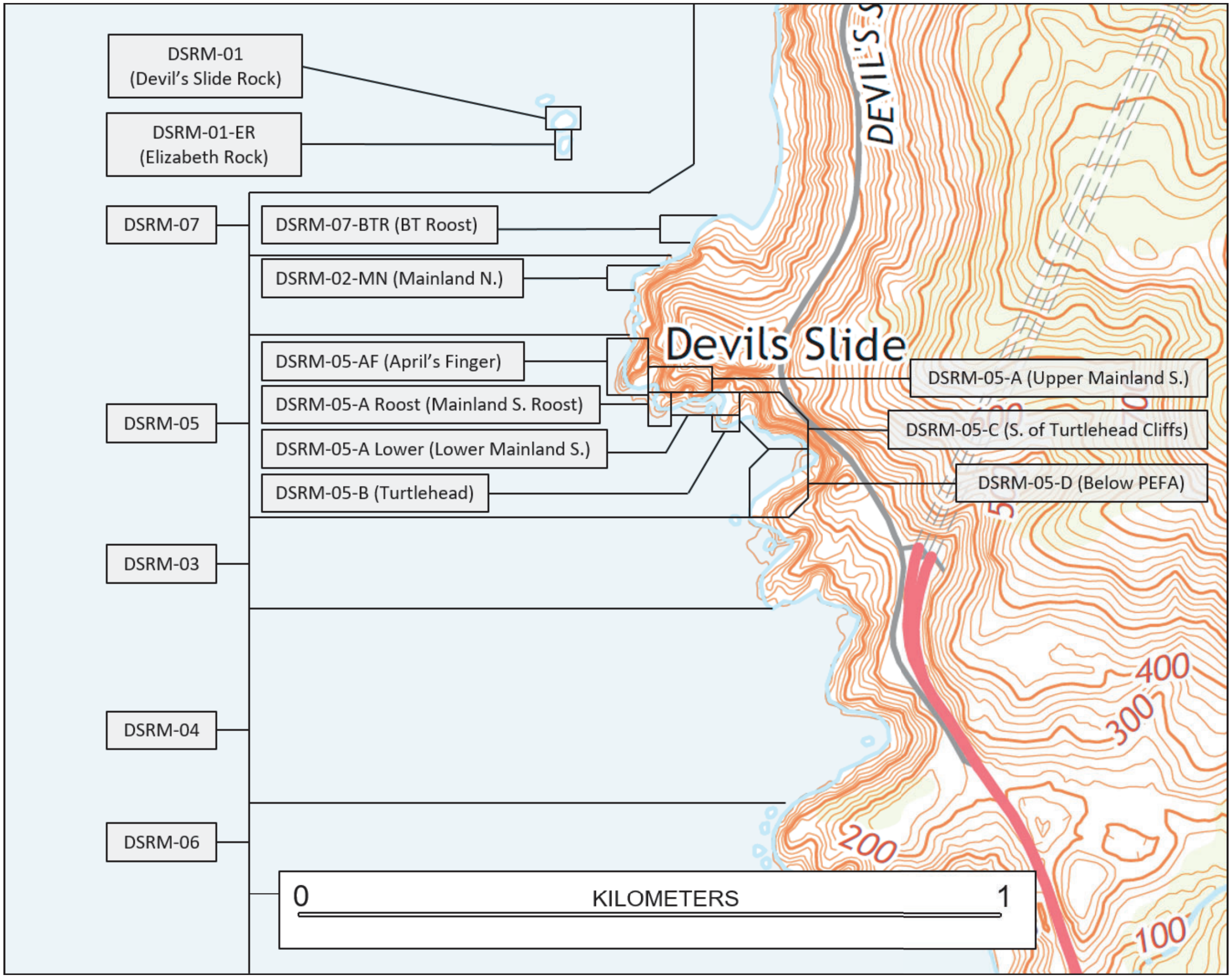


Figure 4. Devil's Slide Colony close-up, showing all subcolonies within DSRM-01, 07, 02 and 05.

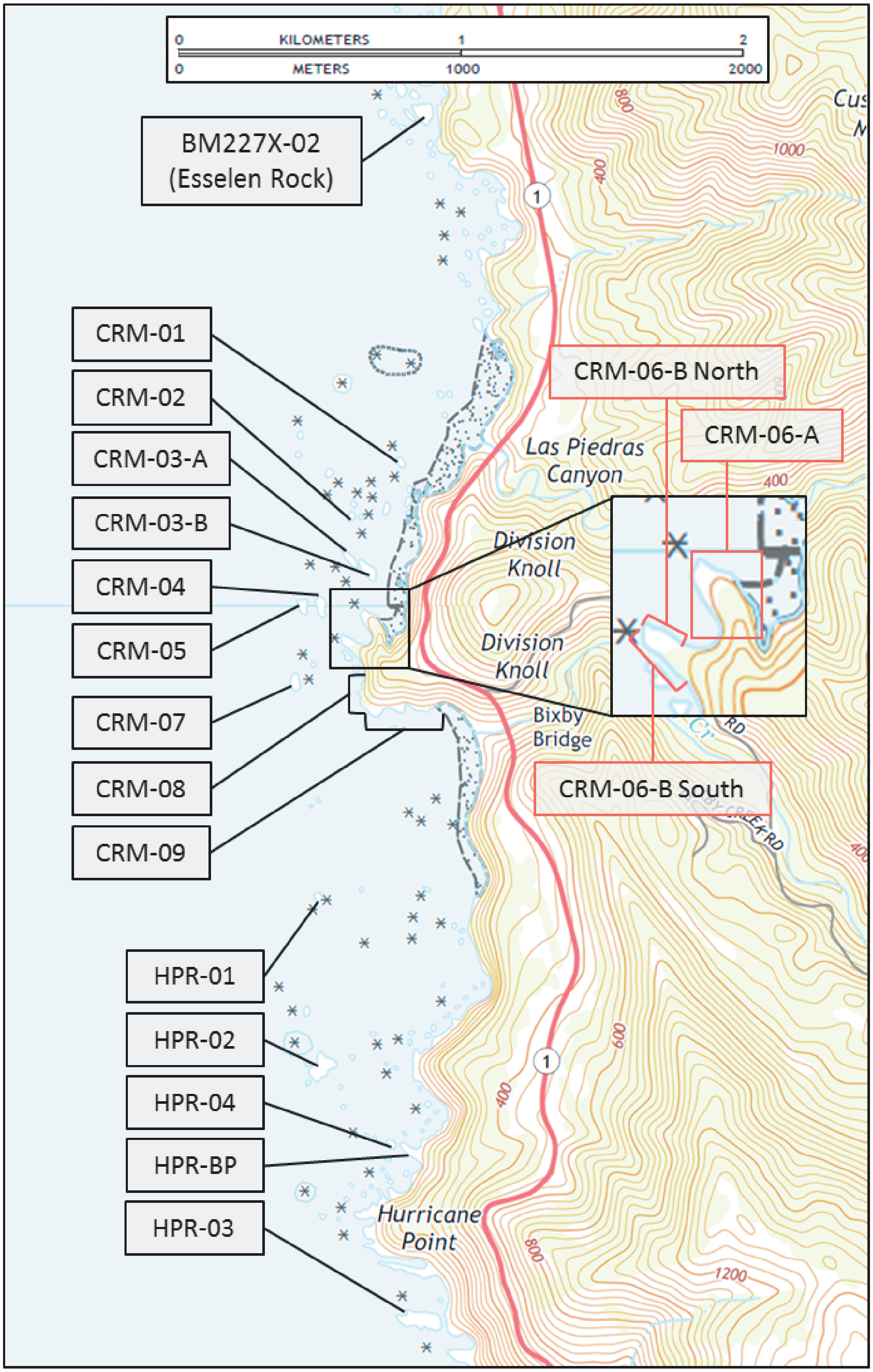


Figure 5. Castle-Hurricane Colony Complex, including Bench Mark-227X (BM227X), Castle Rocks and Mainland (CRM), and Hurricane Point Rocks (Hurricane) colonies and subcolonies.

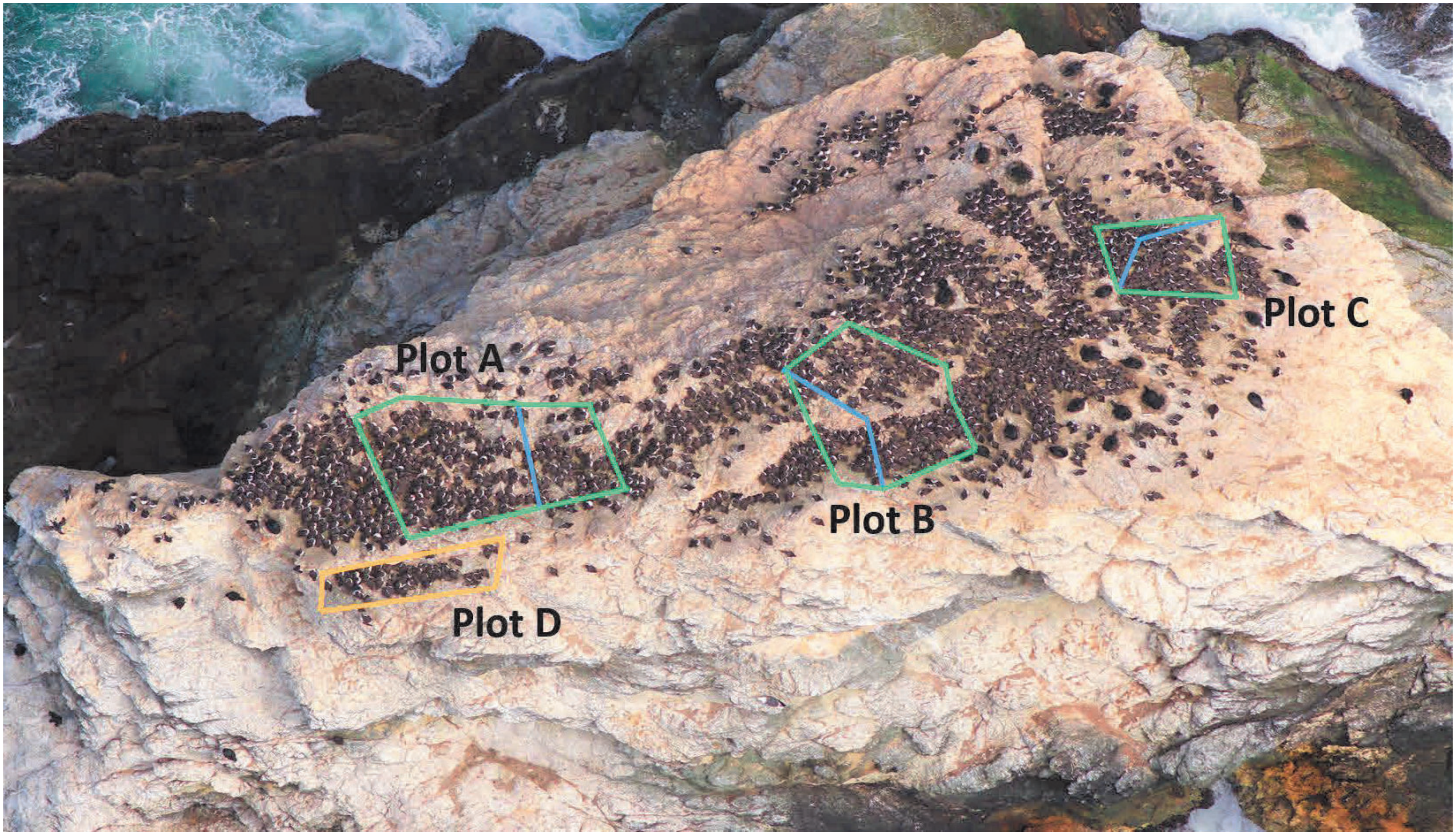


Figure 6. Common Murre Plot boundaries on Devil's Slide Rock from 2006-2019 (view from the south). Green boundaries show plot boundaries for the 2006 season, blue boundaries show adjustments made to Plots A, B and C for 2007 and subsequent seasons (productivity was followed in remaining larger sections only). Plot C was no longer followed beginning in 2014 and Plot D was added for the 2015 and subsequent seasons.

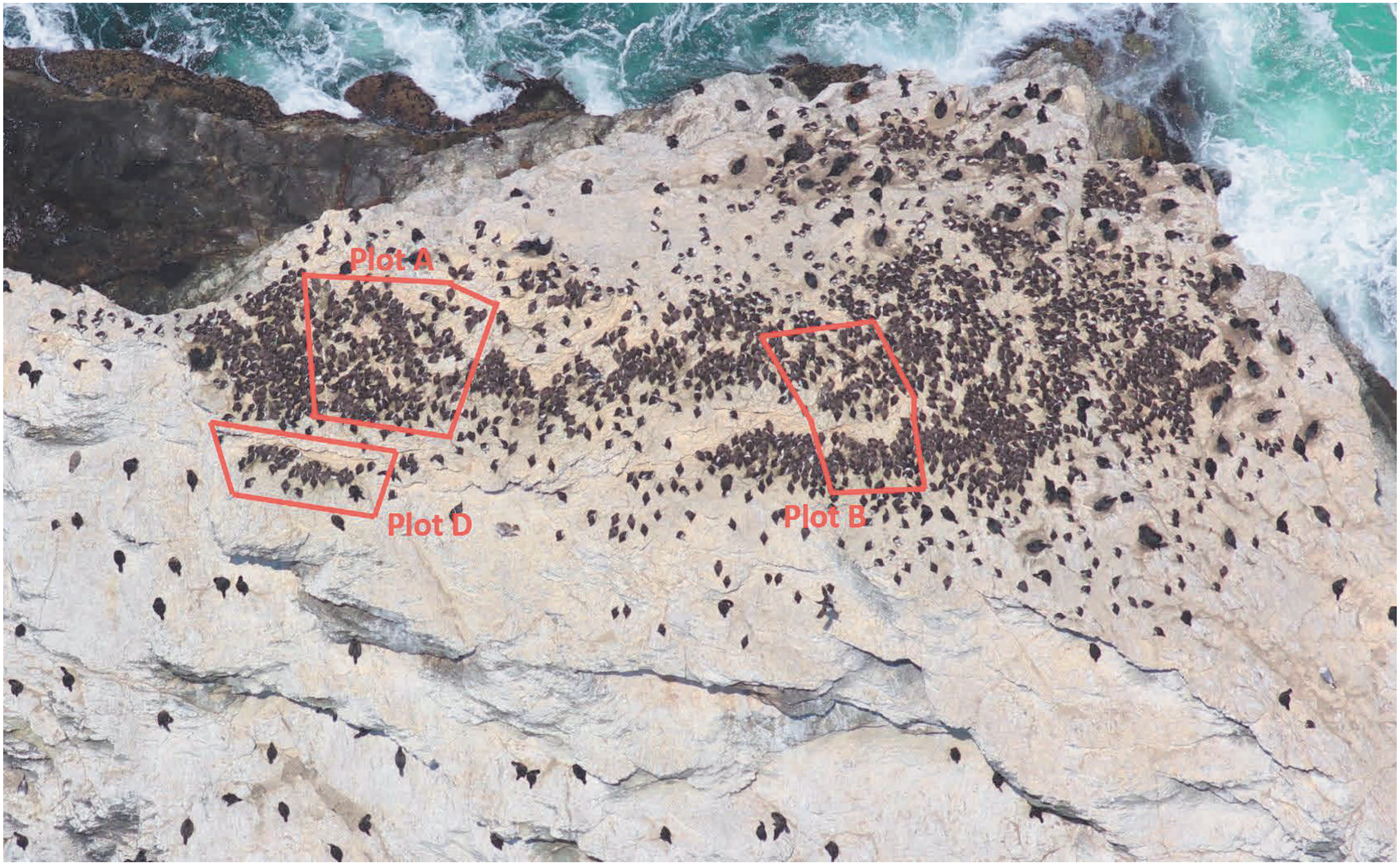
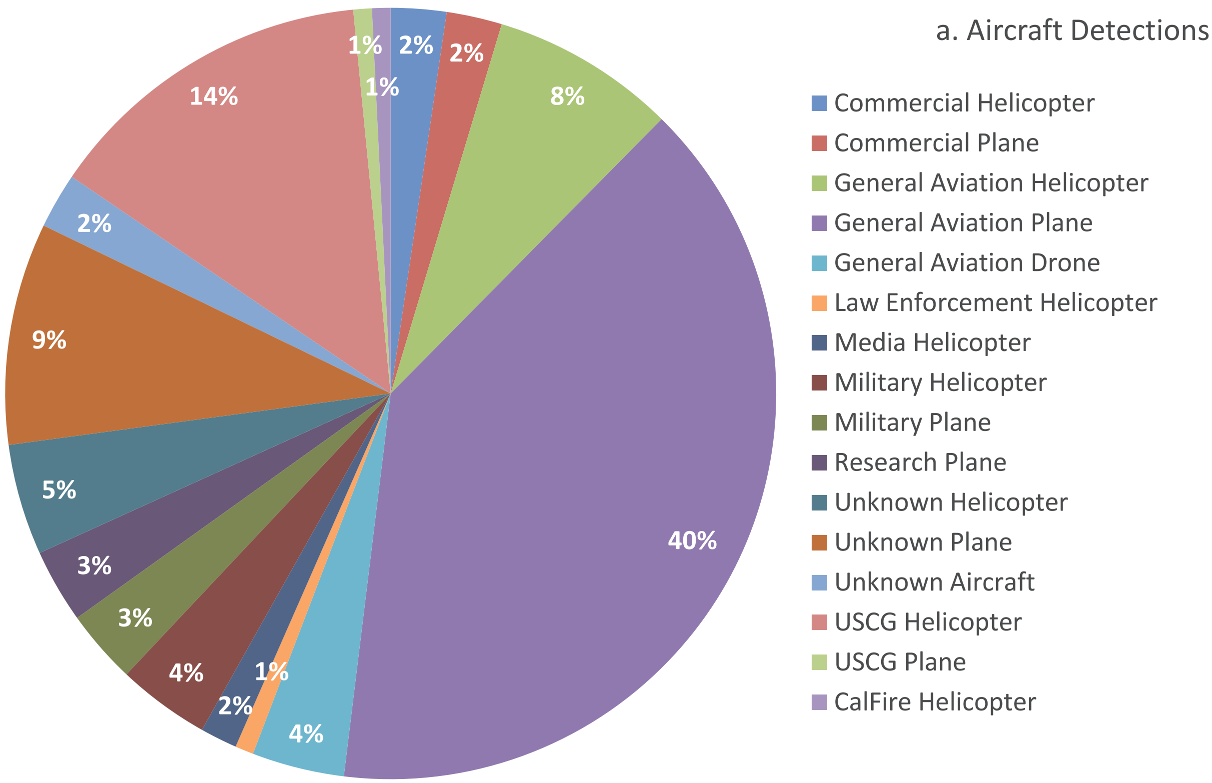


Figure 7. Aerial photograph of Devil's Slide Rock, 4 June 2018, showing the distribution of the Common Murre and Brandt's Cormorant breeding colony and boundaries of murre productivity plots. View from the south.



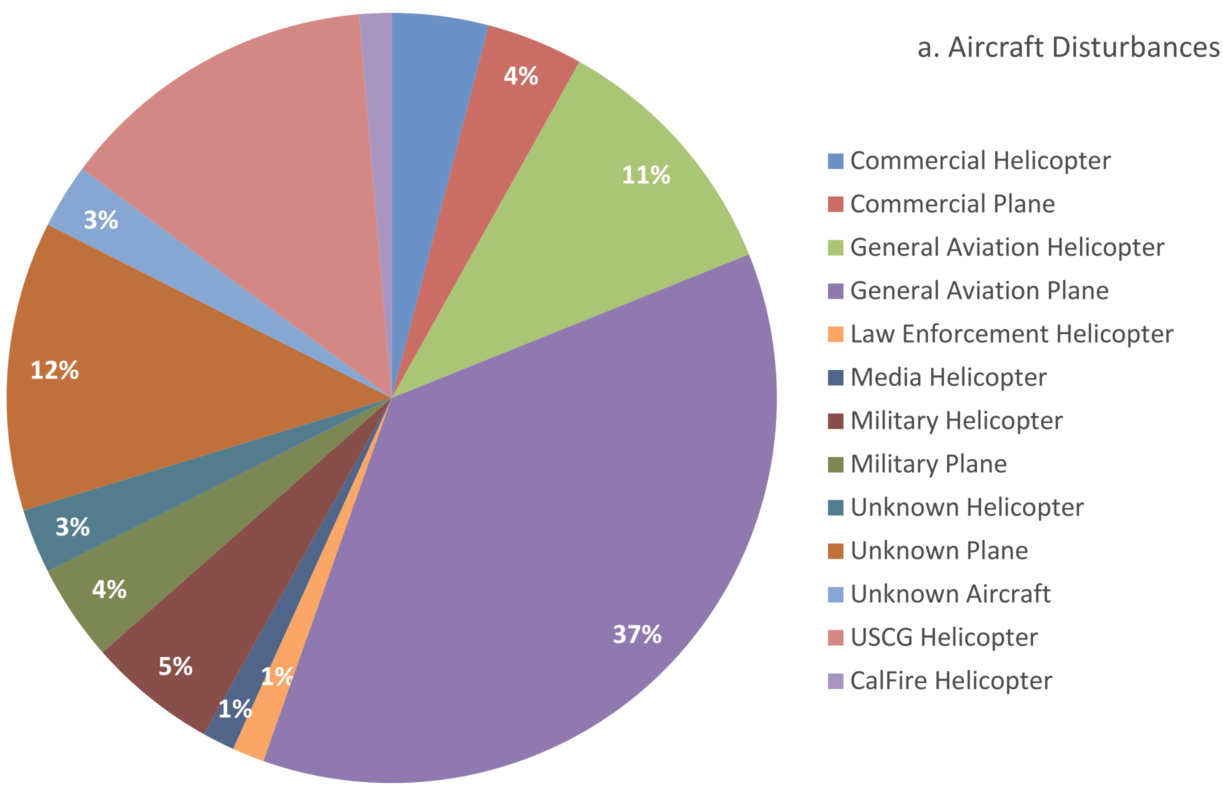
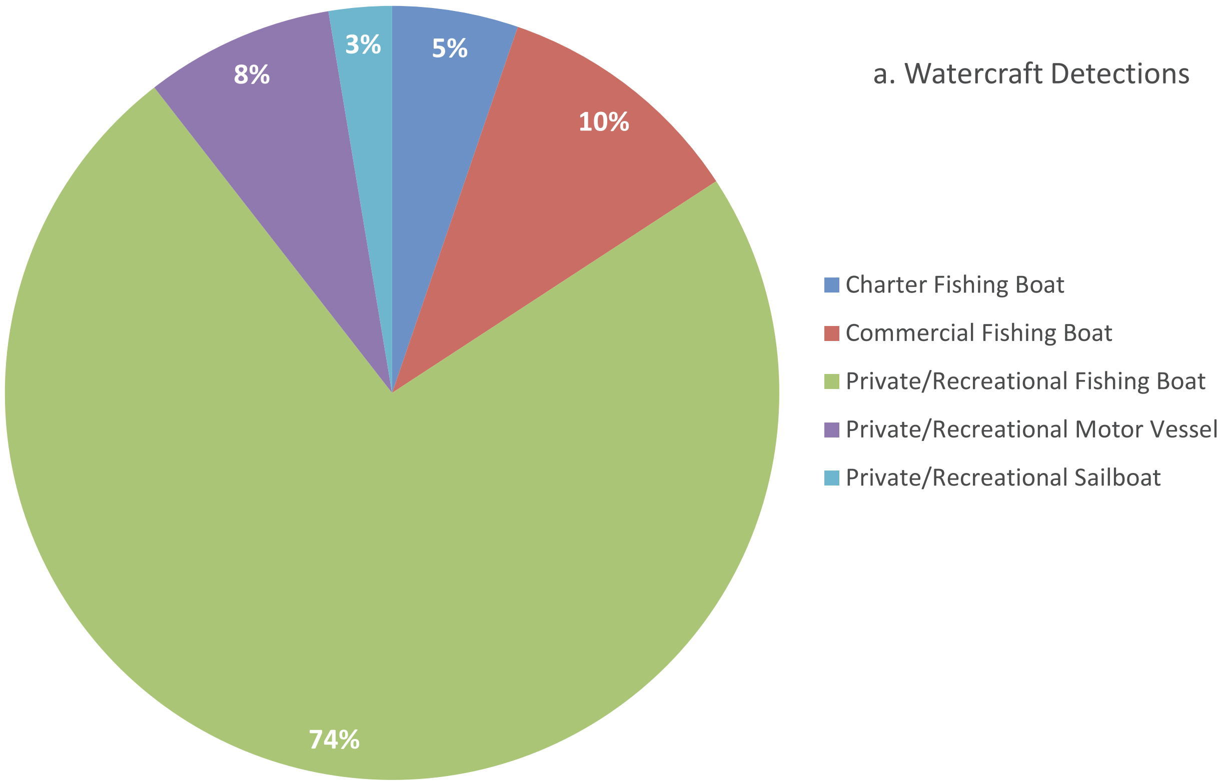


Figure 8. a. Aircraft detections (n = 129) and b. aircraft disturbances (n = 74) at Point Reyes Headlands, Devil's Slide Rock and Mainland and Castle-Hurricane Colony Complex combined in 2019, categorized by type.



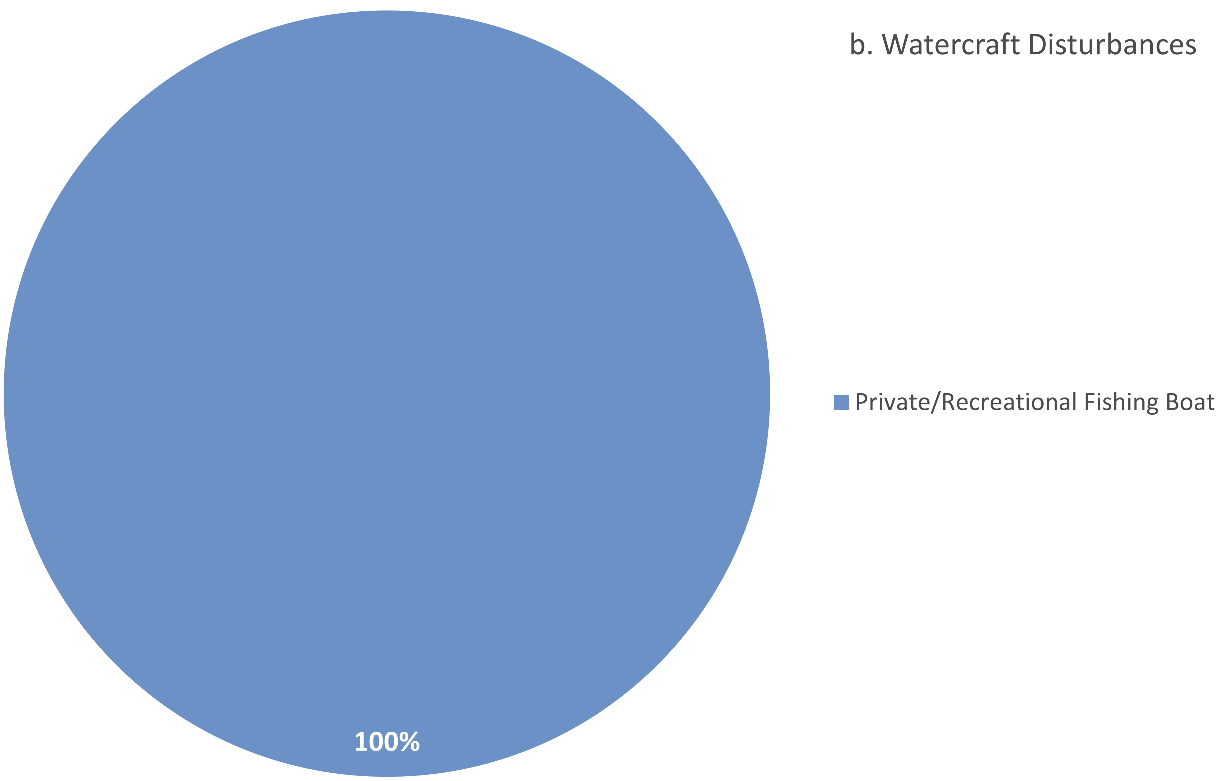


Figure 9. a. Watercraft detections (n = 38) and b. watercraft disturbances (n = 1) at Point Reyes Headlands, Devil's Slide Rock and Mainland and Castle Hurricane Colony Complex combined in 2019, categorized by type.

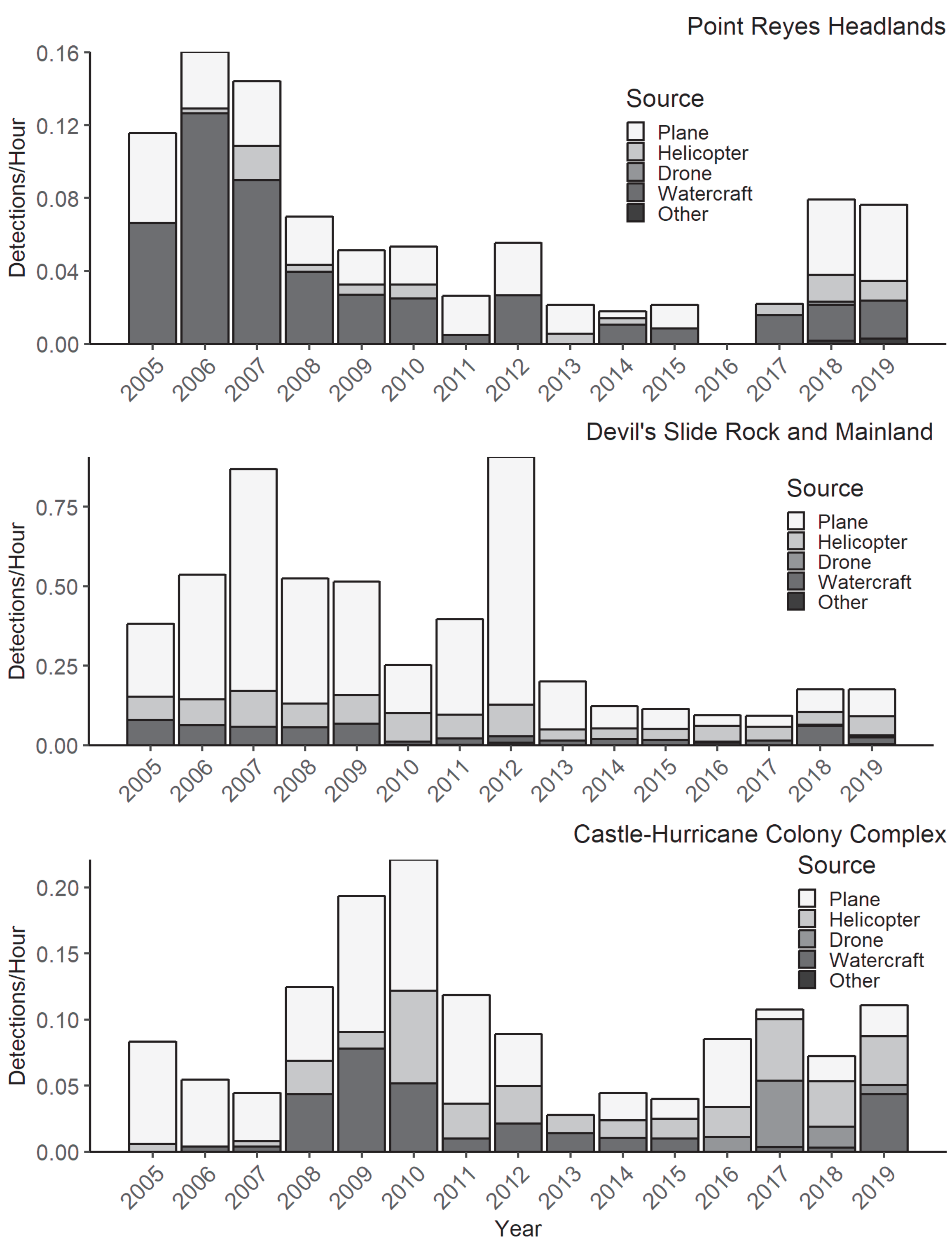


Figure 10. Detection rates (number of detections per observation hour) of watercraft, helicopters, planes, drones and other anthropogenic sources at Point Reyes Headlands, Devil's Slide Rock and Mainland, and Castle-Hurricane Colony Complex from 2005 to 2019. Note different scales between graphs. Point Reyes Headlands was not monitored in 2016.

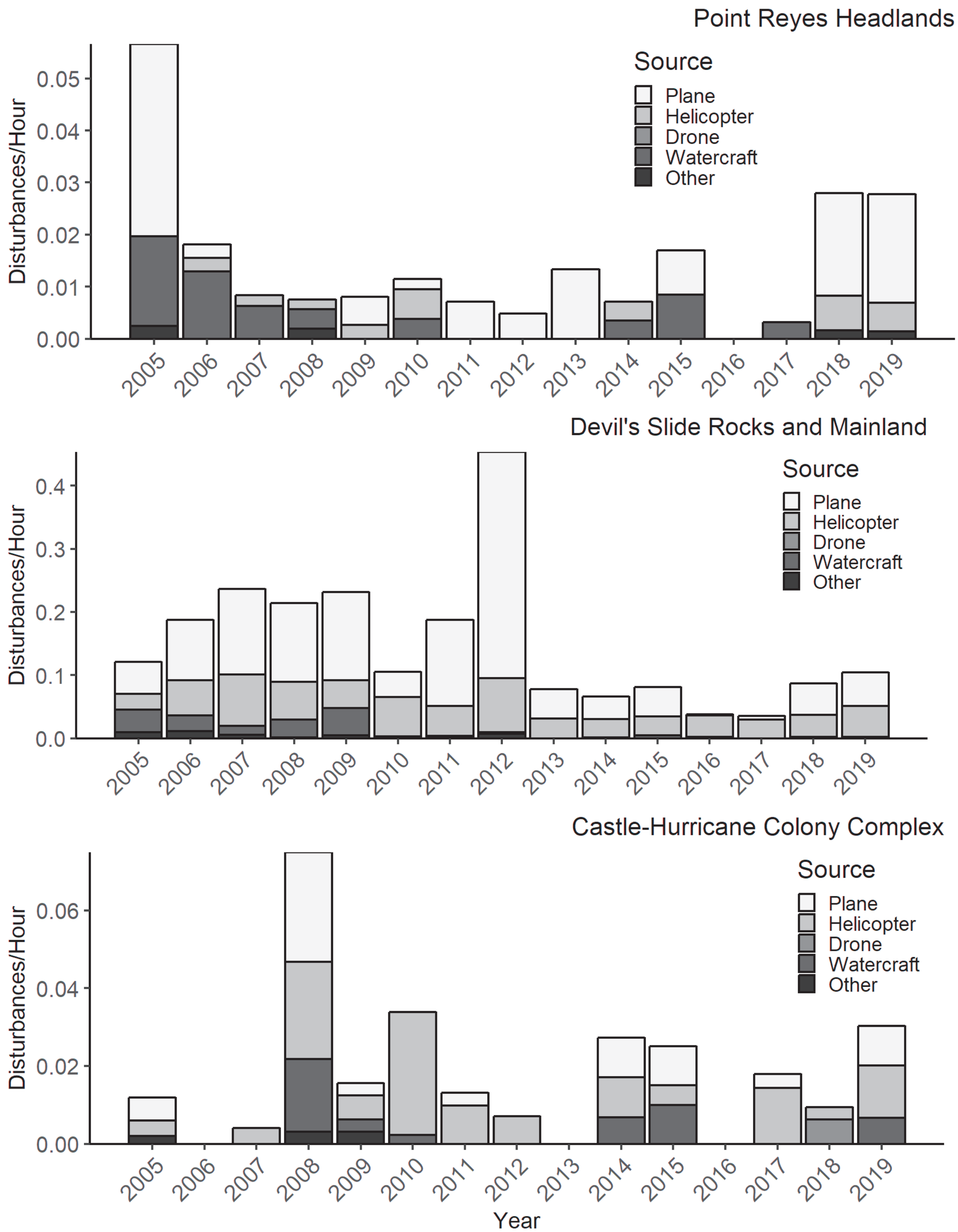


Figure 11. Disturbance rates (number of disturbances per observation hour) of watercraft, helicopters, planes, drones and other anthropogenic sources at Point Reyes Headlands, Devil's Slide Rock and Mainland, and Castle-Hurricane Colony Complex from 2001 to 2019. Note different scales between graphs. Point Reyes Headlands was not monitored in 2016.

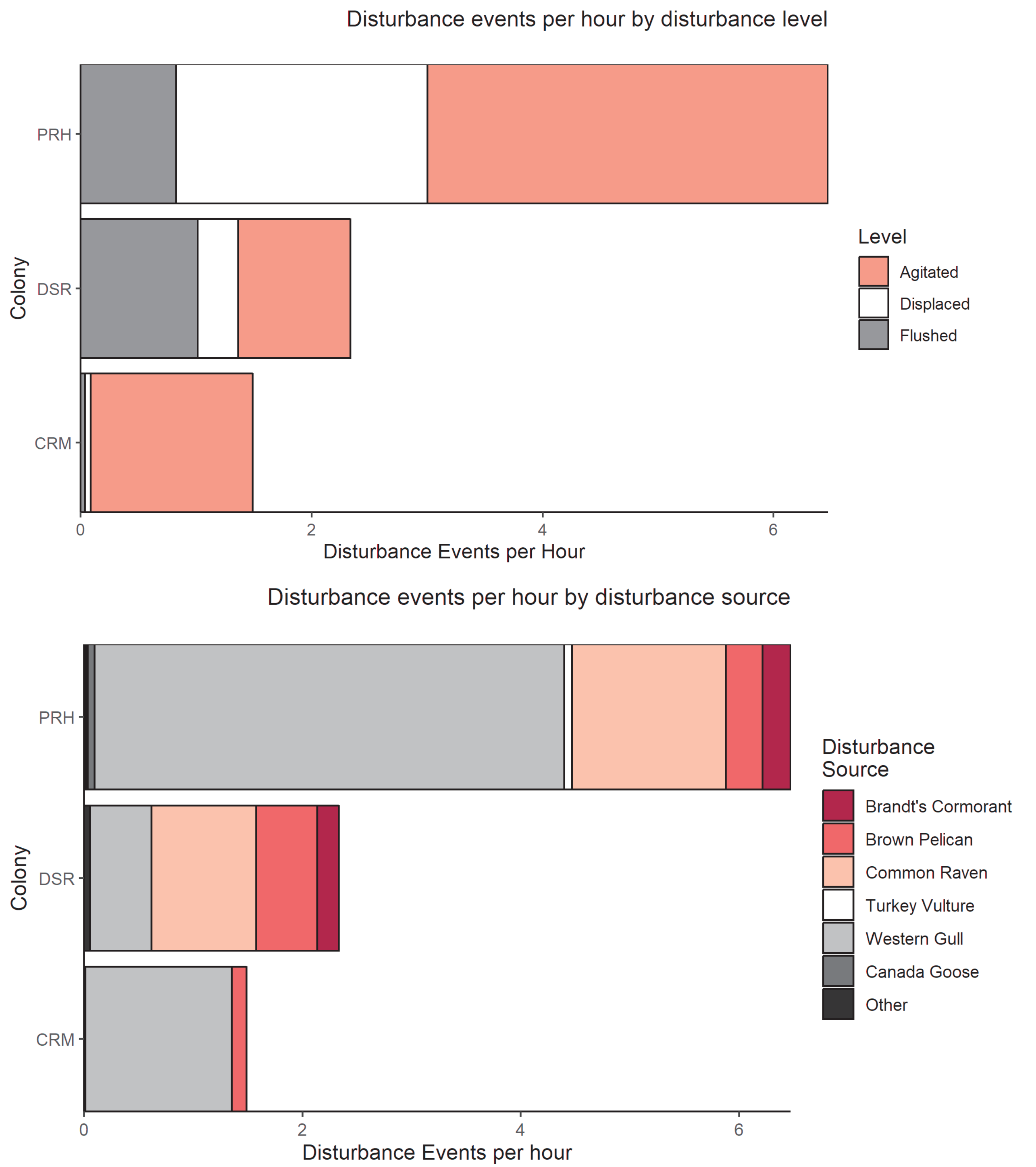


Figure 12. Non-anthropogenic disturbance events per hour during predator watch surveys, by disturbance level and disturbance source. Species included in “Other” caused five or less disturbance events and includes Peregrine Falcon, Northern Gannet, Pelagic Cormorant, and unknown sources.

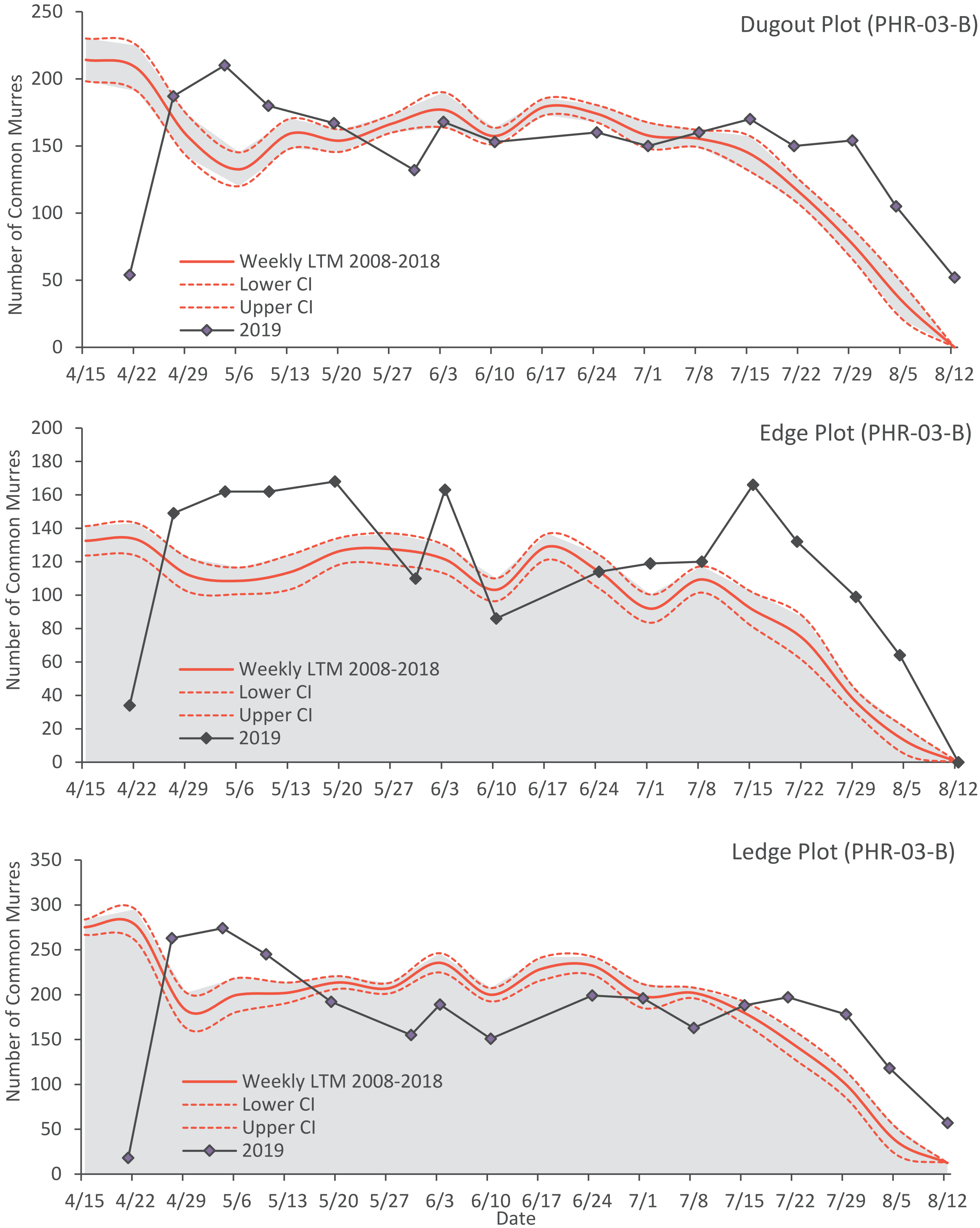


Figure 13. Seasonal attendance of Common Murres at Point Reyes Headlands Lighthouse Rock plots (three plots; PRH-03-B) in 2019 compared to long-term mean (LTM, 2008-2018).

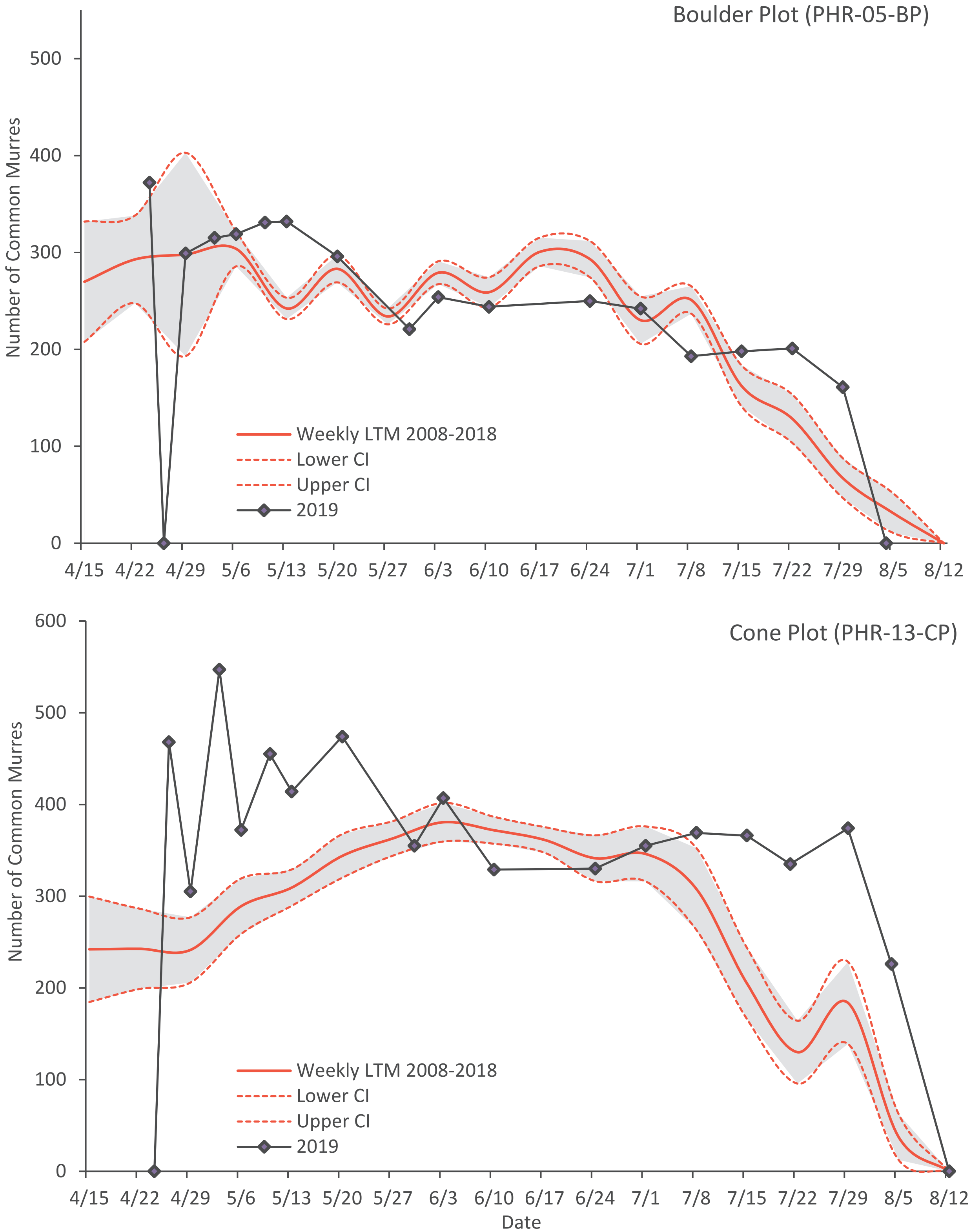


Figure 14. Seasonal attendance of Common Murres at Point Reyes Headlands (subcolonies: PRH-05-BP and PRH-13-CP) in 2019 compared to long-term mean (LTM, 2008-2018).

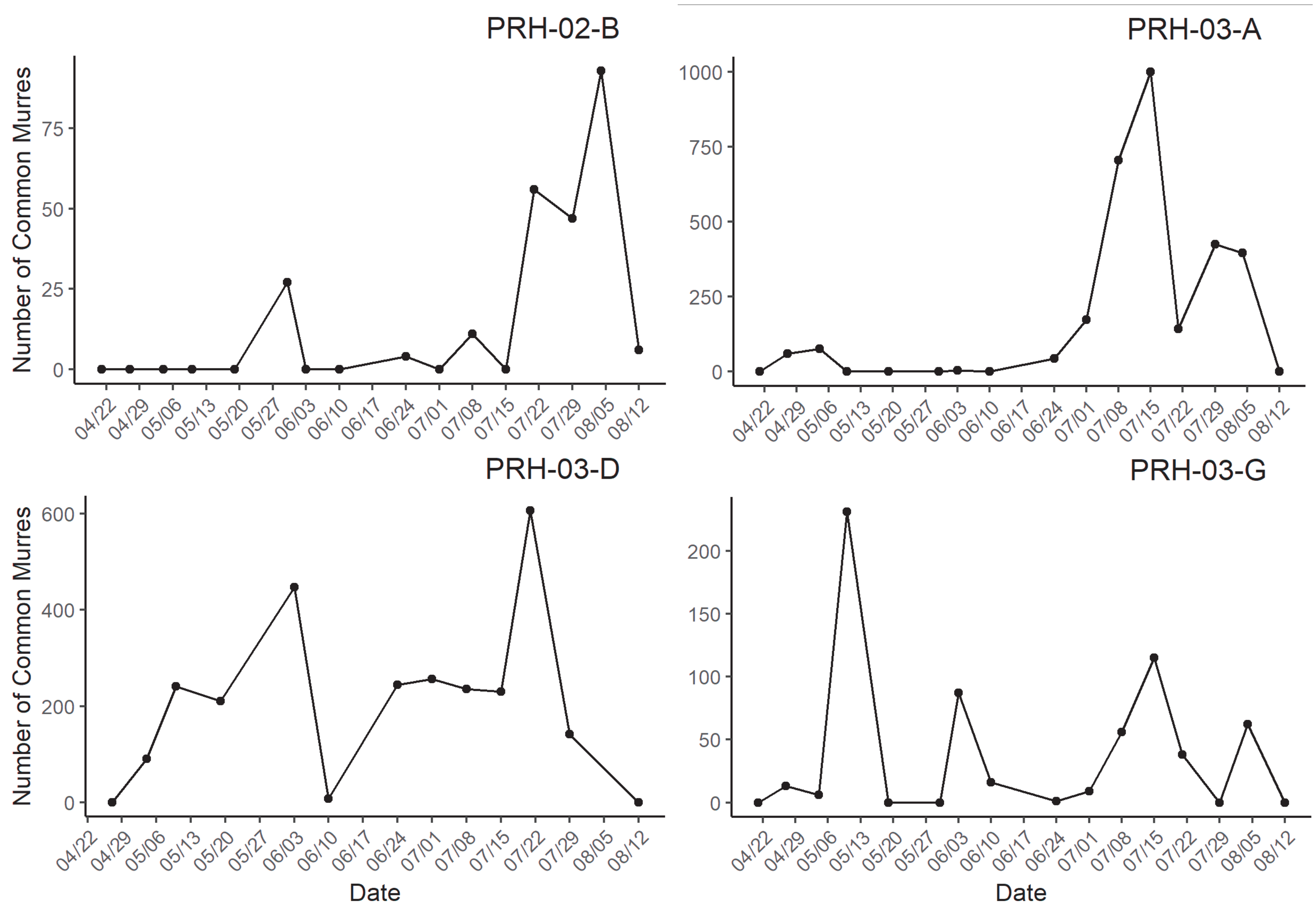


Figure 15. Seasonal attendance of Common Murres at Point Reyes Headlands (subcolonies: PRH-02-B (Rock 2), 03-A (Big Roost Rock), 03-D (Aalgae Ledge) and 03-G (Levin's Rock)) from 21 April to 12 August, 2019.

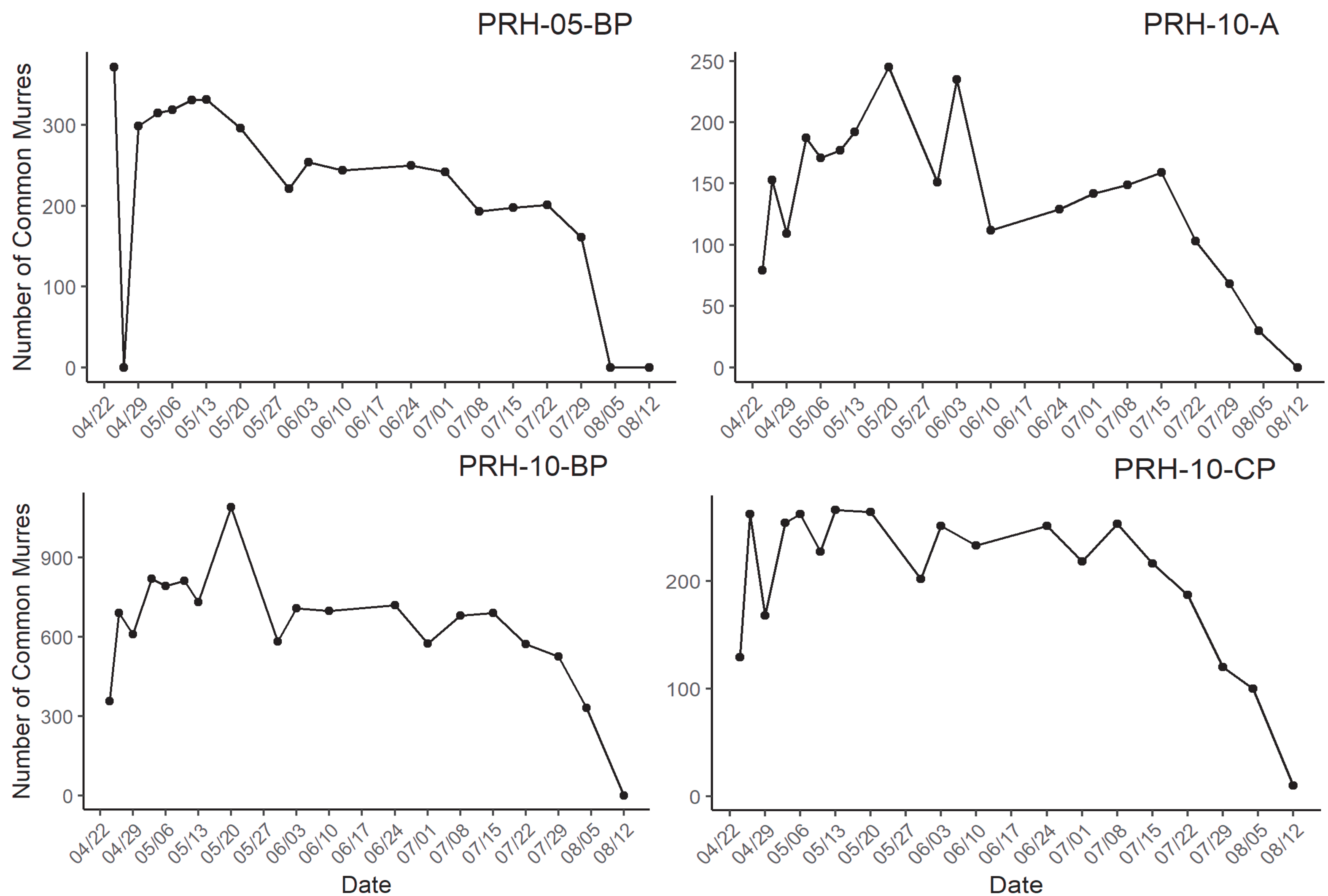


Figure 16. Seasonal attendance of Common Murres at Point Reyes Headlands (subcolonies: PRH-05-BP (Boulder Rock Plot), 10-A (Northwest Rock), 10-BP (Flattop Rock Plot) and 10-CP (Middle Rock Plot)) from 21 April to 12 August, 2019.

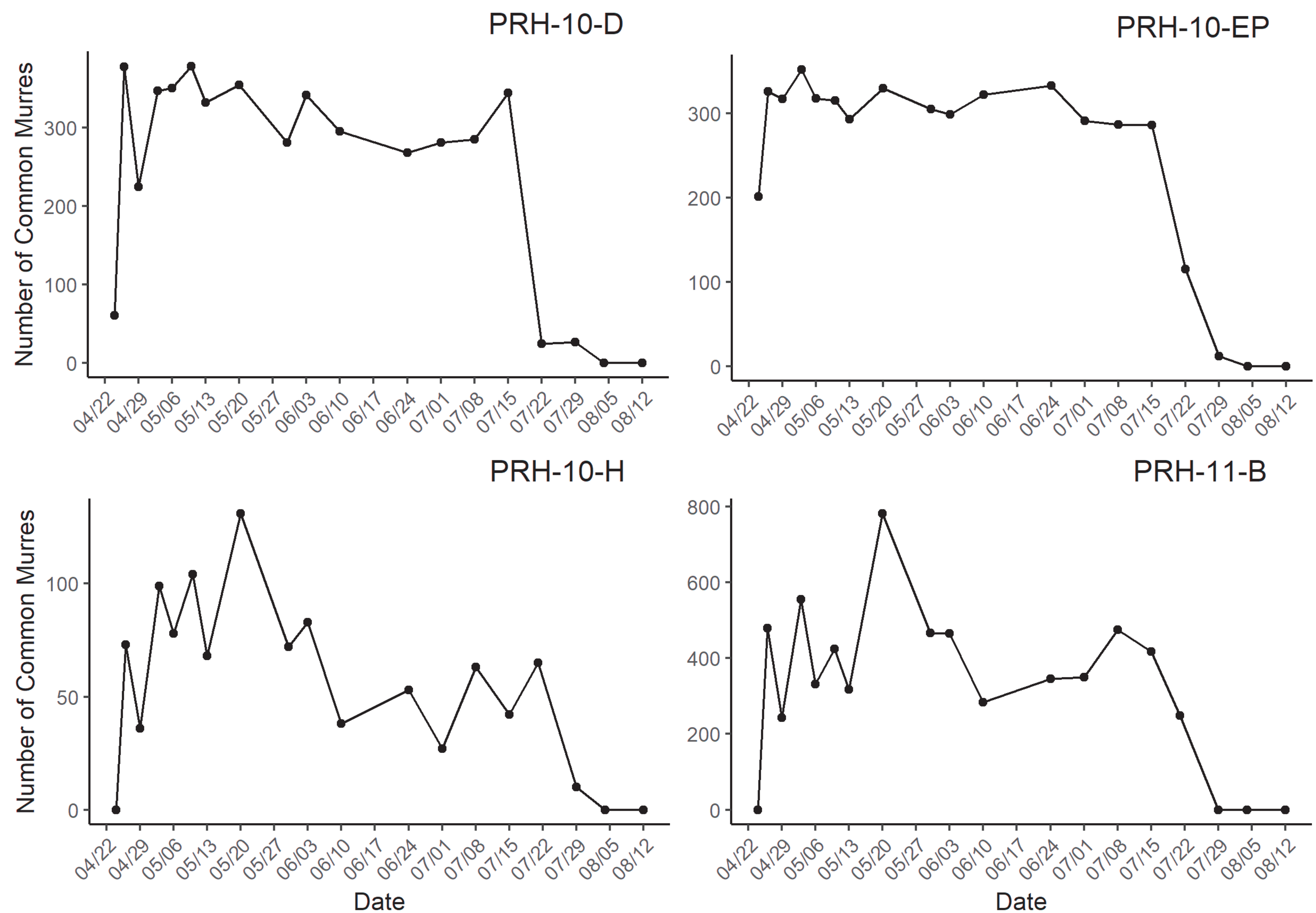


Figure 17. Seasonal attendance of Common Murres at Point Reyes Headlands (subcolonies: PRH-10-D (East Rock), 10-EP (Beach Rock Plot), 10-H (Tim Tam Rock) and 11-B (Face Rock)) from 21 April to 12 August, 2019.

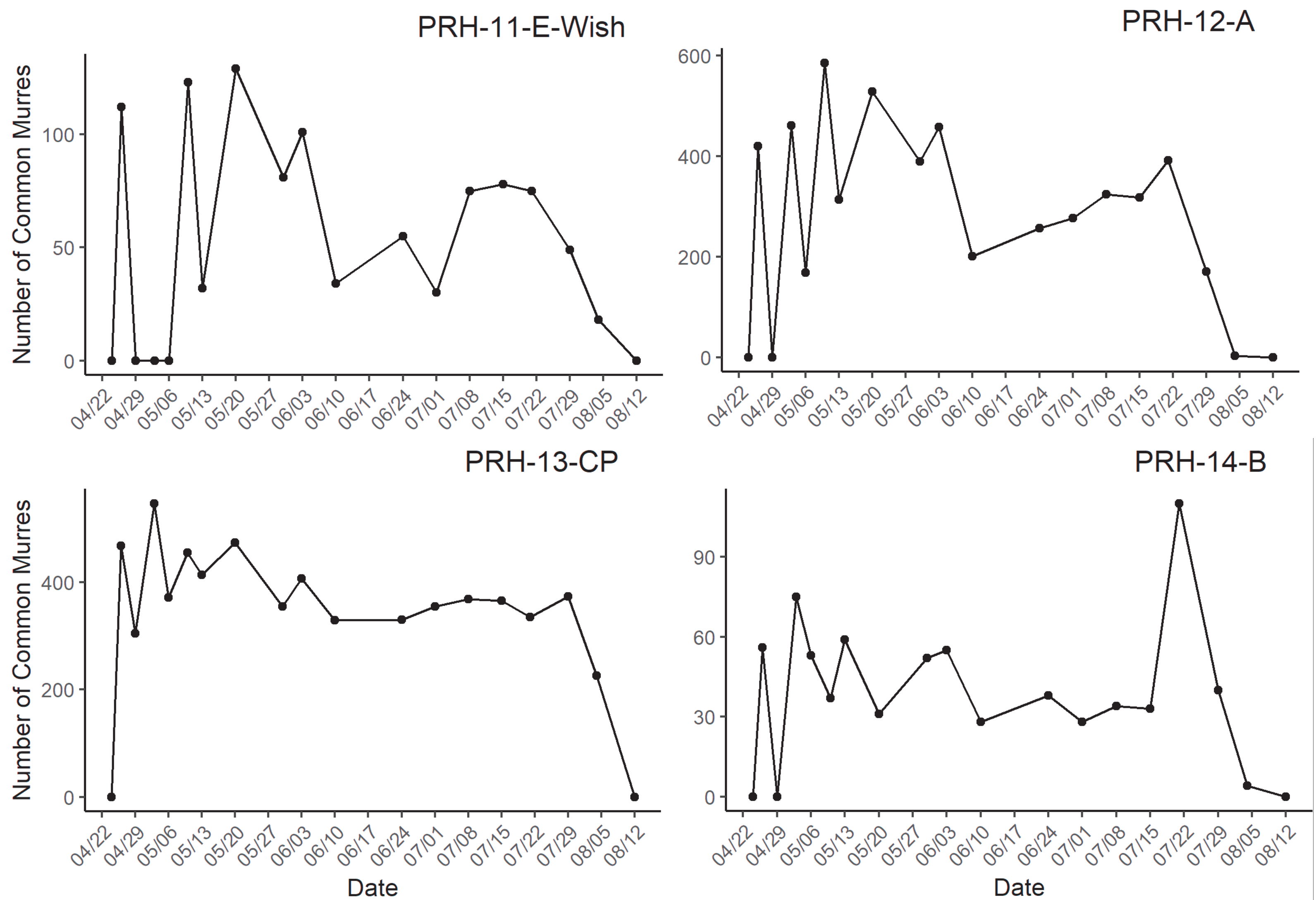


Figure 18. Seasonal attendance of Common Murres at Point Reyes Headlands (subcolonies: PRH-11-E-WISH (Wishbone Point), 12-A (Sloppy Joe), 13-CP (Cone Plot) and 14-B (Area B)) from 21 April to 12 August, 2019.

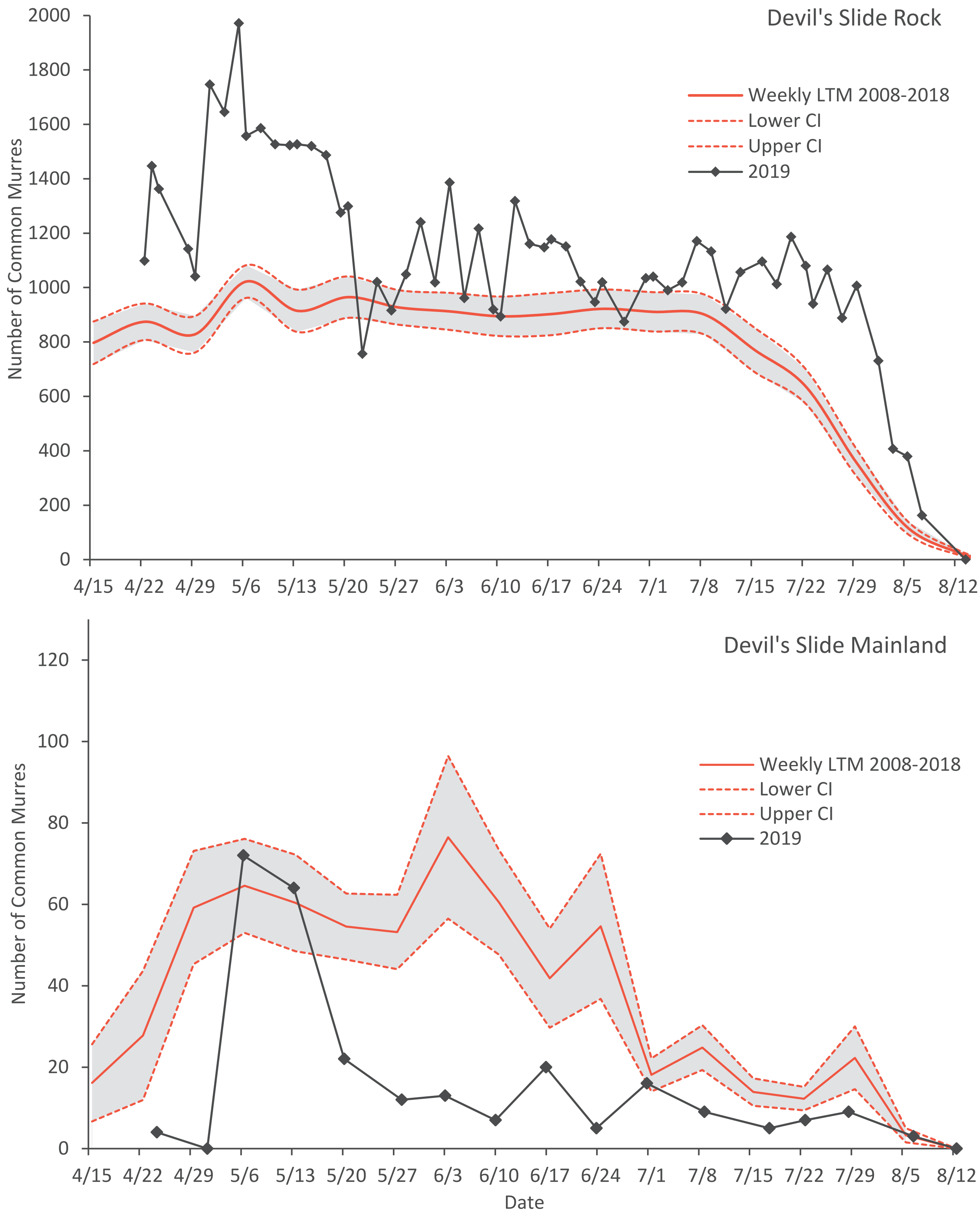


Figure 19. Seasonal attendance of Common Murres at Devil's Slide Rock (DSRM-01) and Devil's Slide Mainland (DSM) colonies in 2019 compared to long-term mean (LTM, 2008-2018).

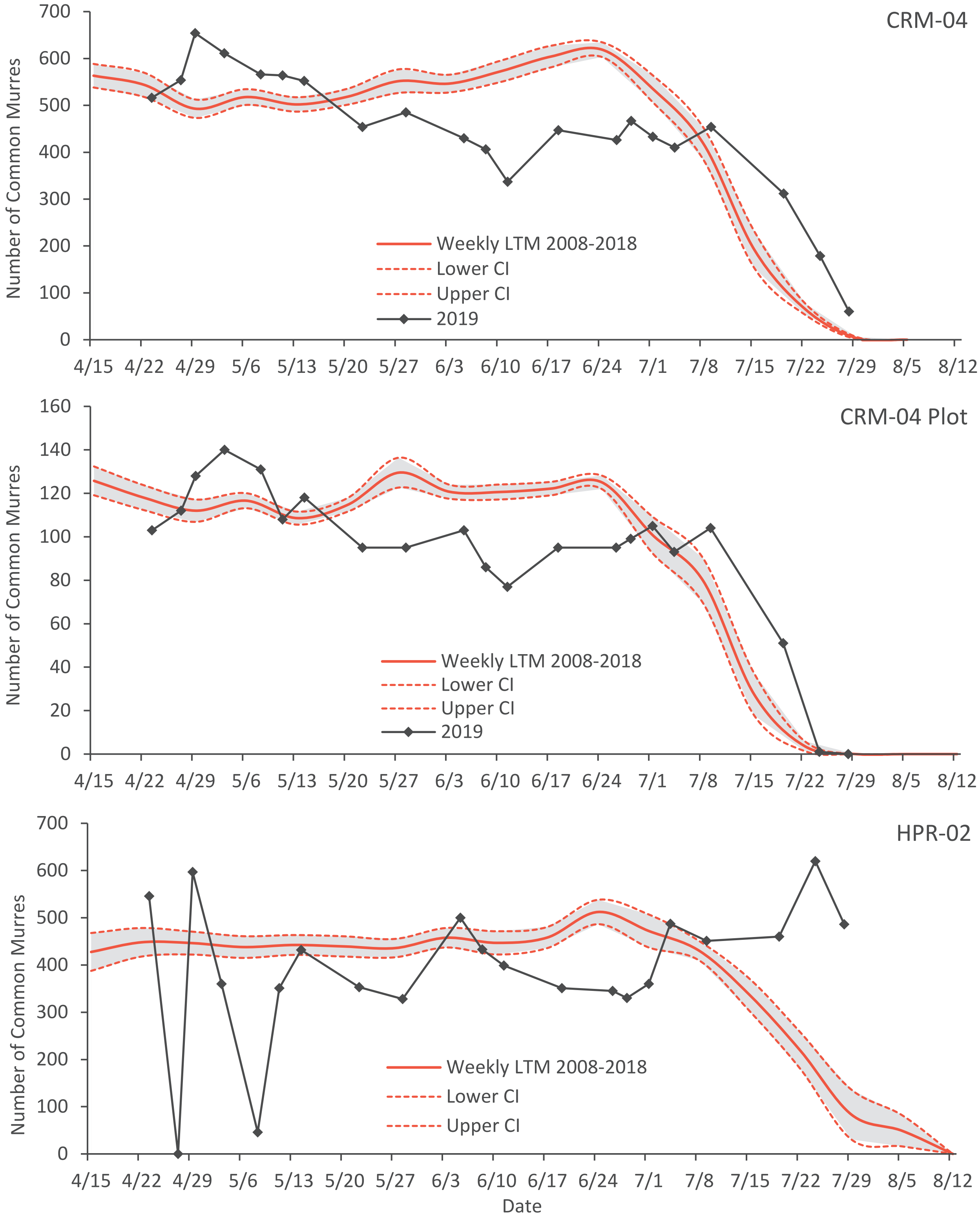


Figure 20. Seasonal attendance of Common Murres at Castle Rocks (CRM-04) and Castle Rock plot (CRM-04-P) and Hurricane Rocks colony HPR-02 in 2019 compared to long-term mean (LTM, 2008-2018).

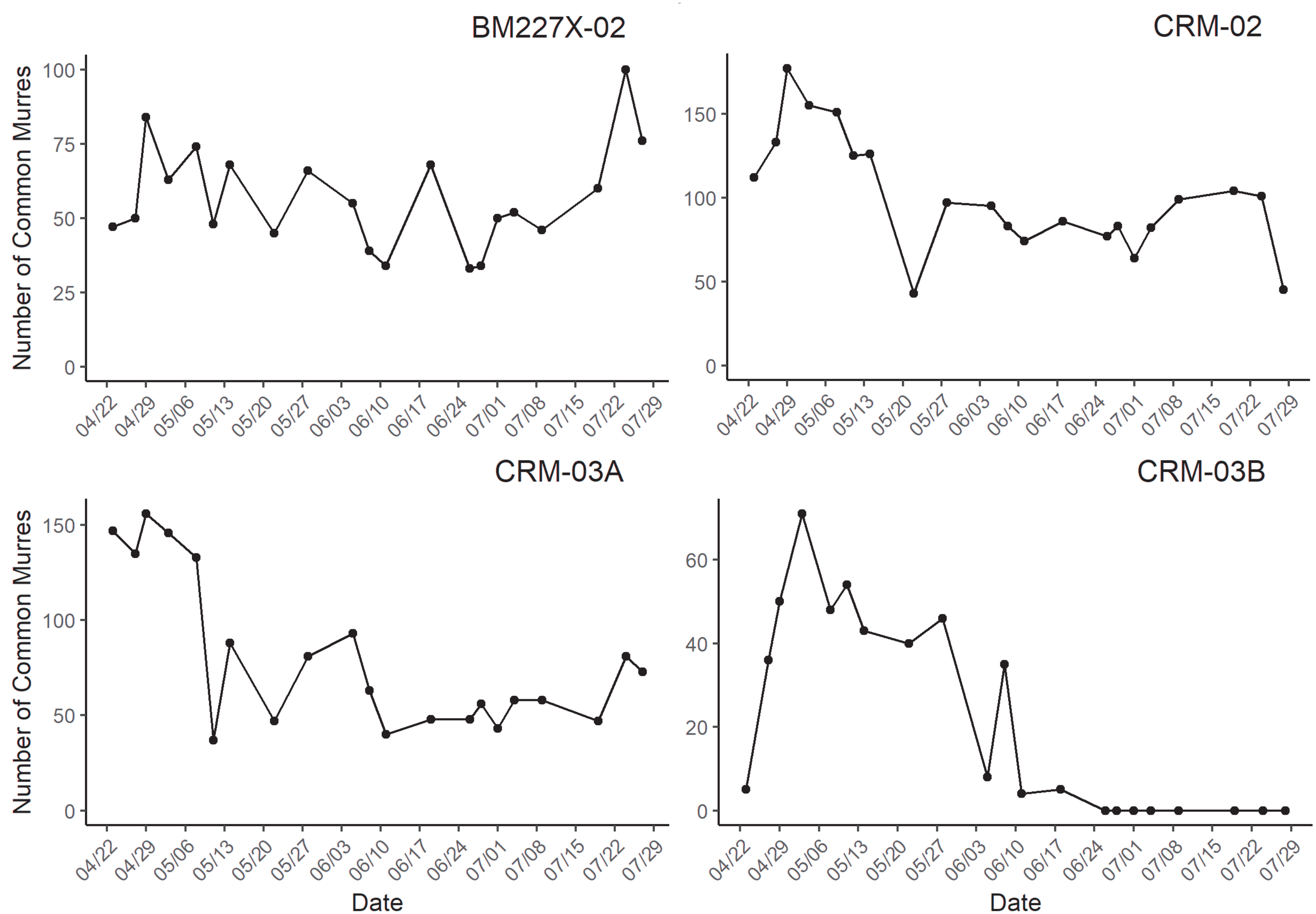


Figure 21. Seasonal attendance of Common Murres at Castle-Hurricane Colony Complex (subcolonies: BM227X-02, CRM-02, 03-A, 03-B) from 23 April to 28 July, 2019.

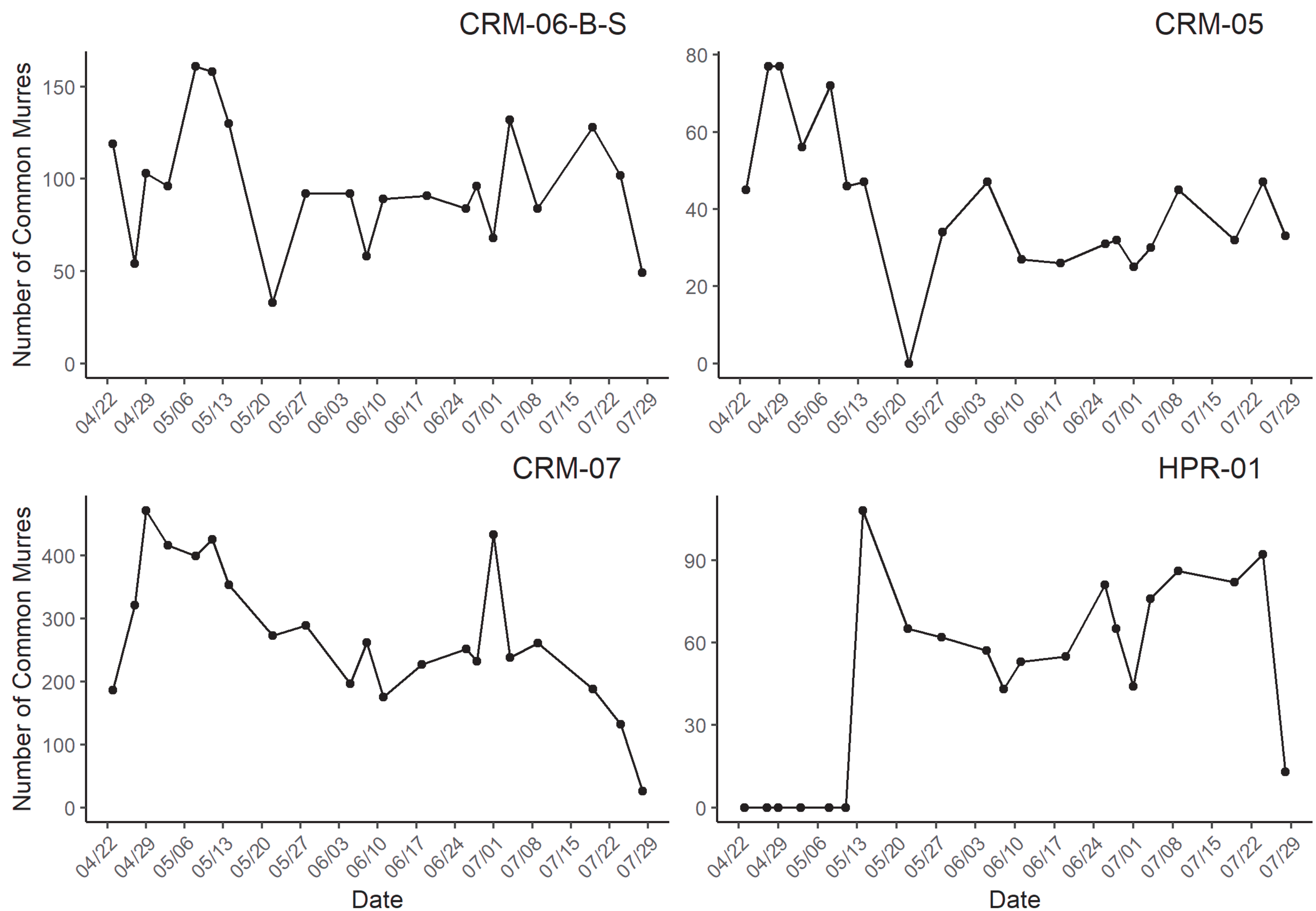


Figure 22. Seasonal attendance of Common Murres at Castle-Hurricane Colony Complex (subcolonies: CRM-06-B-S, 05, 07, and HPR-01) from 23 April to 28 July, 2019.

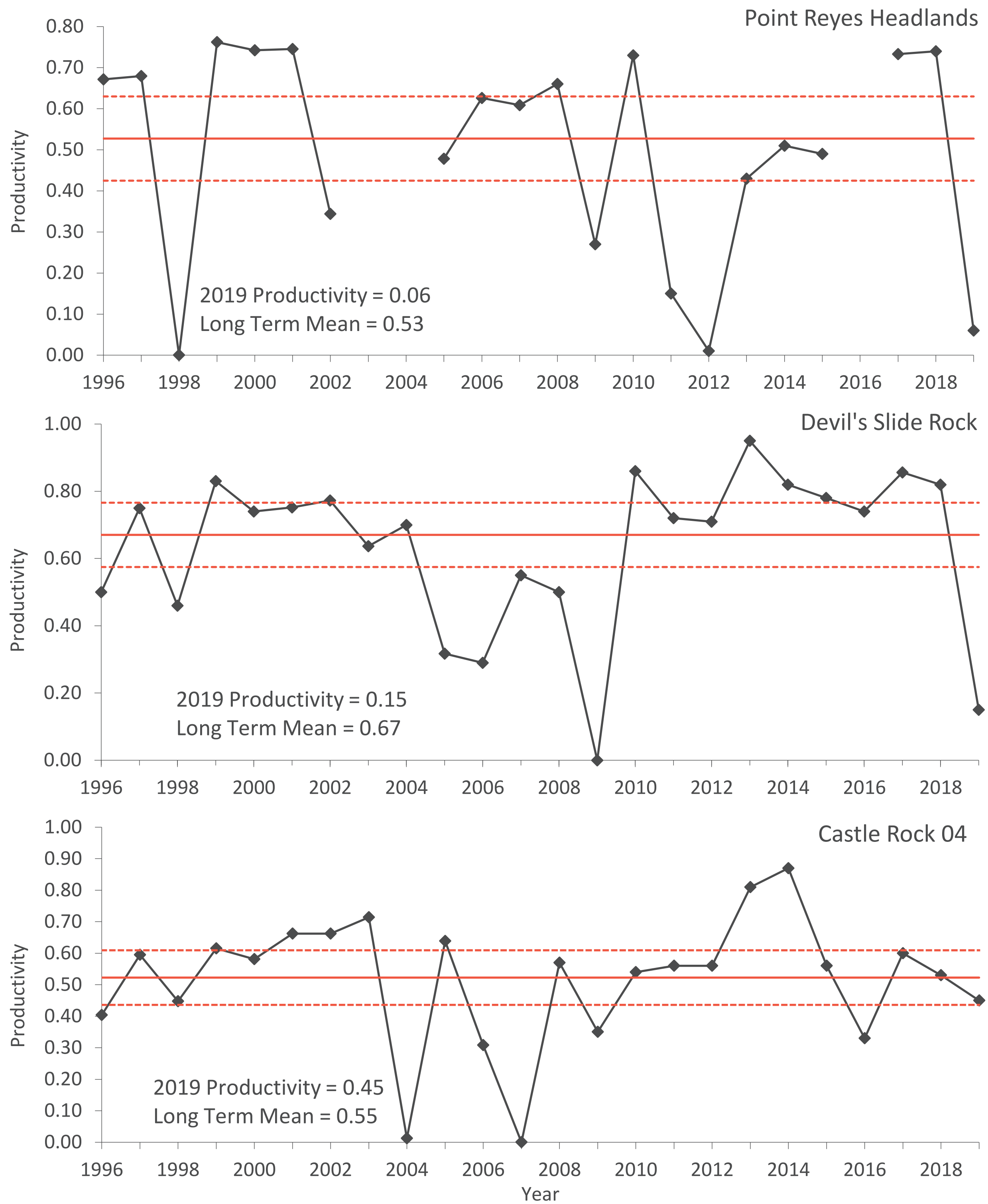


Figure 23. Productivity (chicks fledged per pair) of Common Murres at Point Reyes Headlands, Devil's Slide Rock and Castle Rock -04 from 1996-2019. The solid horizontal line indicates the long-term weighted mean (1996-2018) and the dashed lines represent the 95% confidence interval.

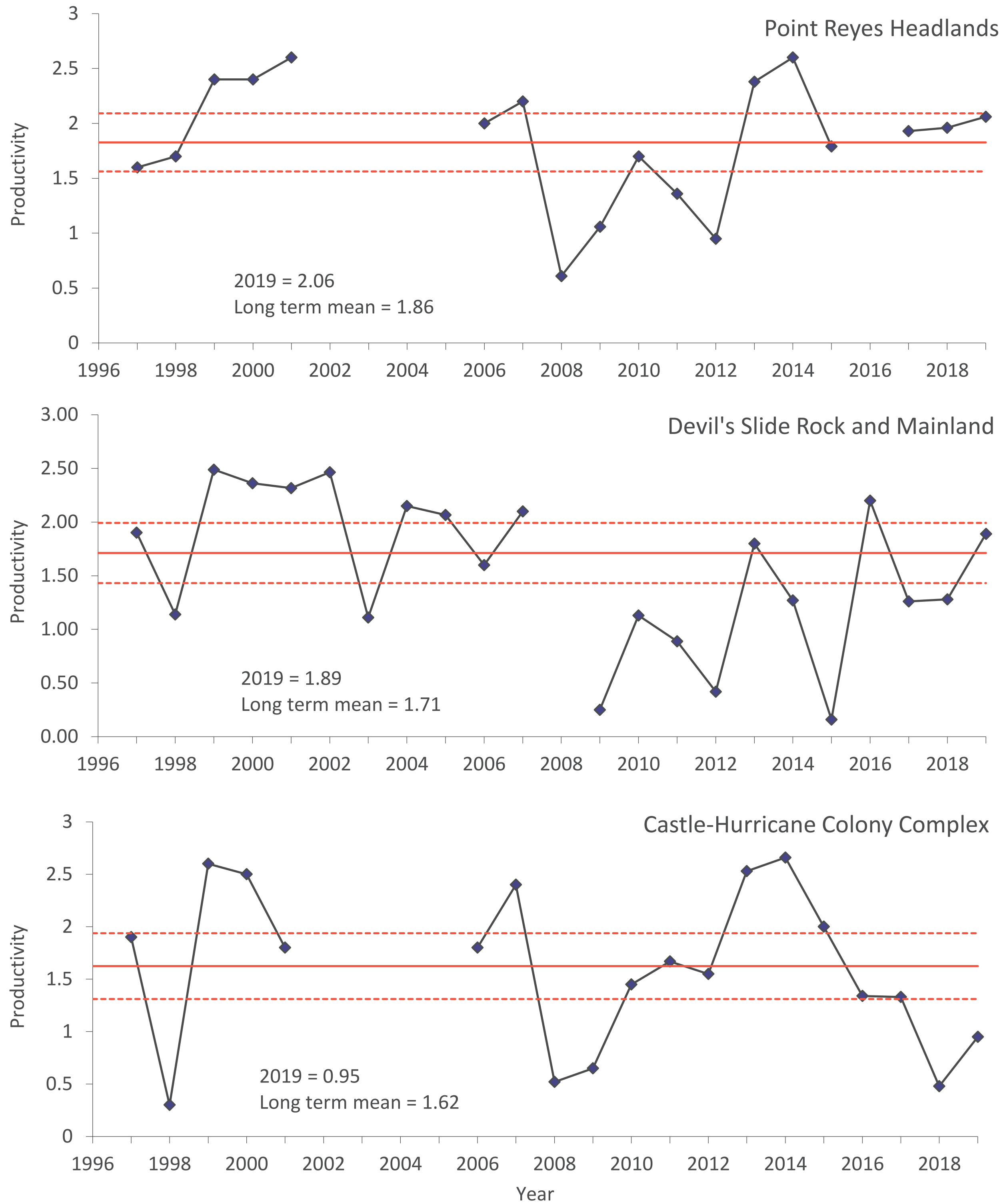


Figure 24. Productivity (chicks fledged per pair) of Brandt's Cormorants at Point Reyes Headlands, Devil's Slide Rock and Mainland and Castle-Hurricane Colony Complex from 1997-2019. The solid horizontal line indicates the long-term weighted mean (1996-2018) and the dashed lines represent the 95% confidence interval.

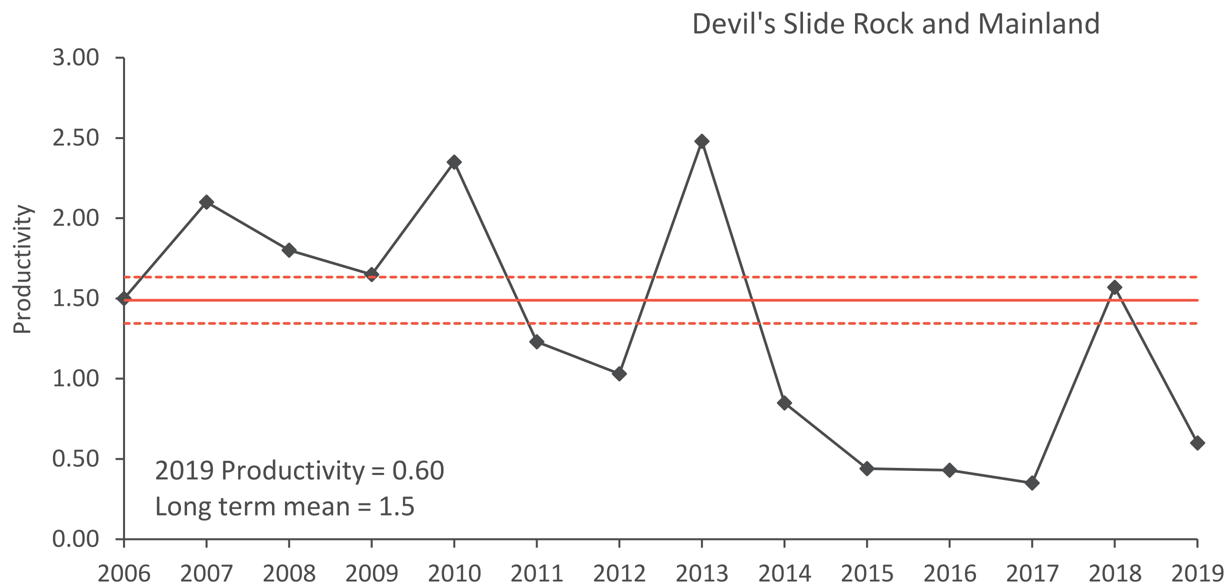


Figure 25. Productivity (chicks fledged per pair) of Pelagic Cormorants at Devil's Slide Rock and Mainland from 2006-2019. The solid horizontal line indicates the long-term weighted mean (2006-2018) and the dashed lines represent the 95% confidence interval.

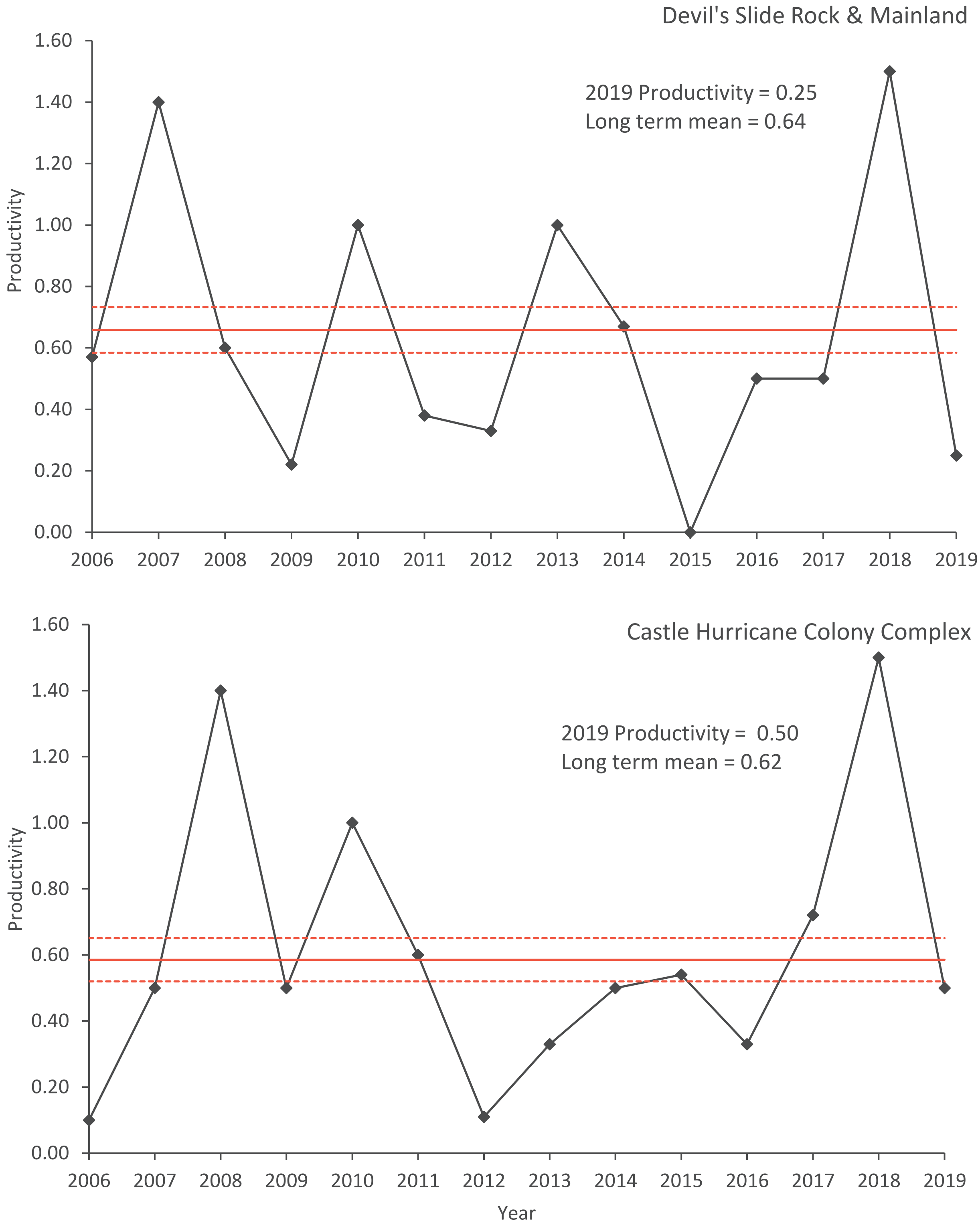


Figure 26. Productivity (chicks fledged per pair) of Western Gulls at Devil's Slide Rock and Mainland and Castle-Hurricane Colony Complex from 2006-2019. The solid horizontal line indicates the long-term weighted mean (2006-2018) and the dashed lines represent the 95% confidence interval.

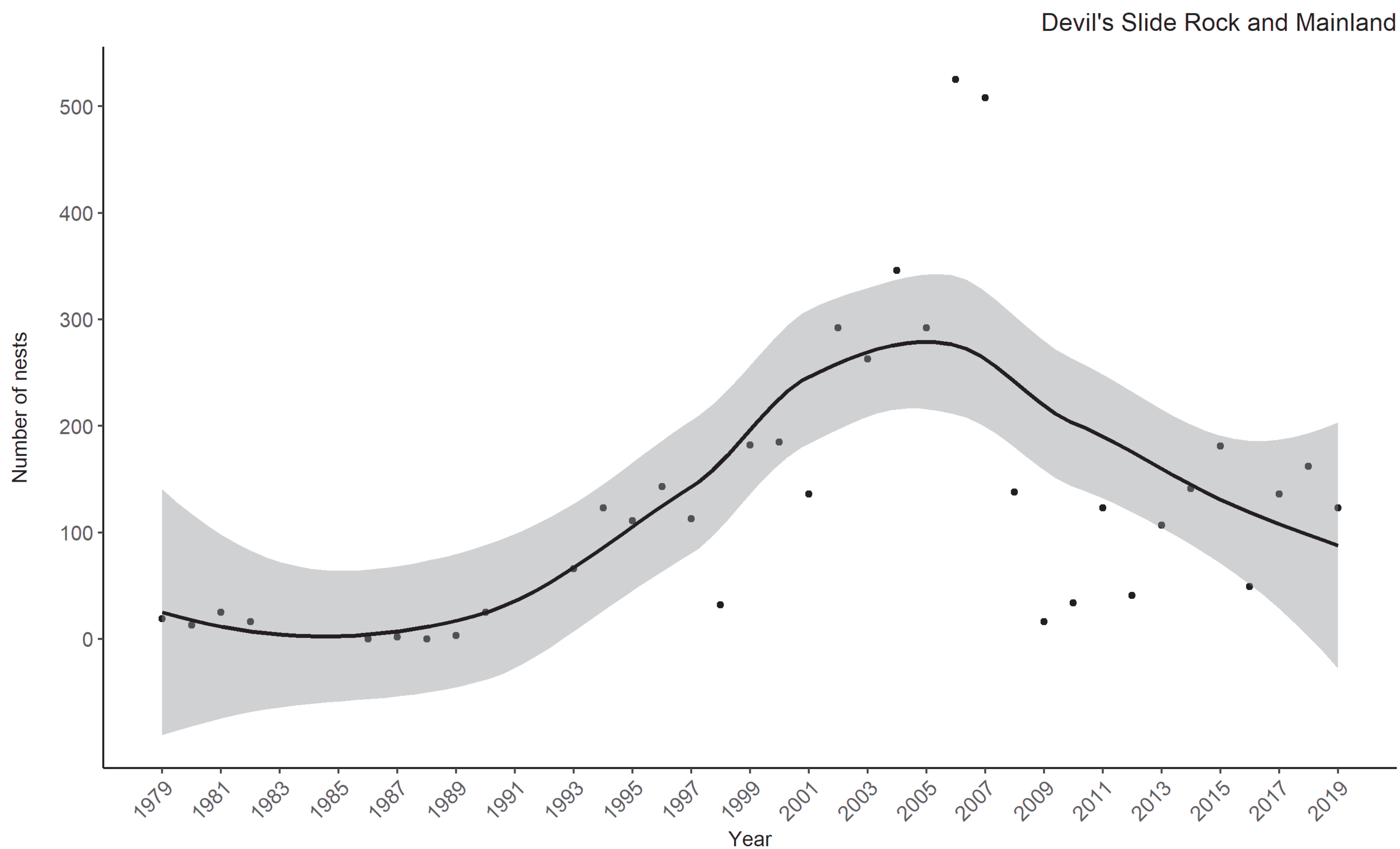


Figure 27. Brandt's Cormorant breeding population trends at Devil's Slide Rock and Mainland, 1979-2019. LOESS curves is shown with 95% confidence intervals (R Core Team, 2018).

Appendix 1. Number of aircraft overflights observed (detections and disturbances) and separated by type and resulting disturbance events recorded at Point Reyes Headlands, Devil's Slide Rock and Mainland, and Castle-Hurricane Colony Complex in 2019.

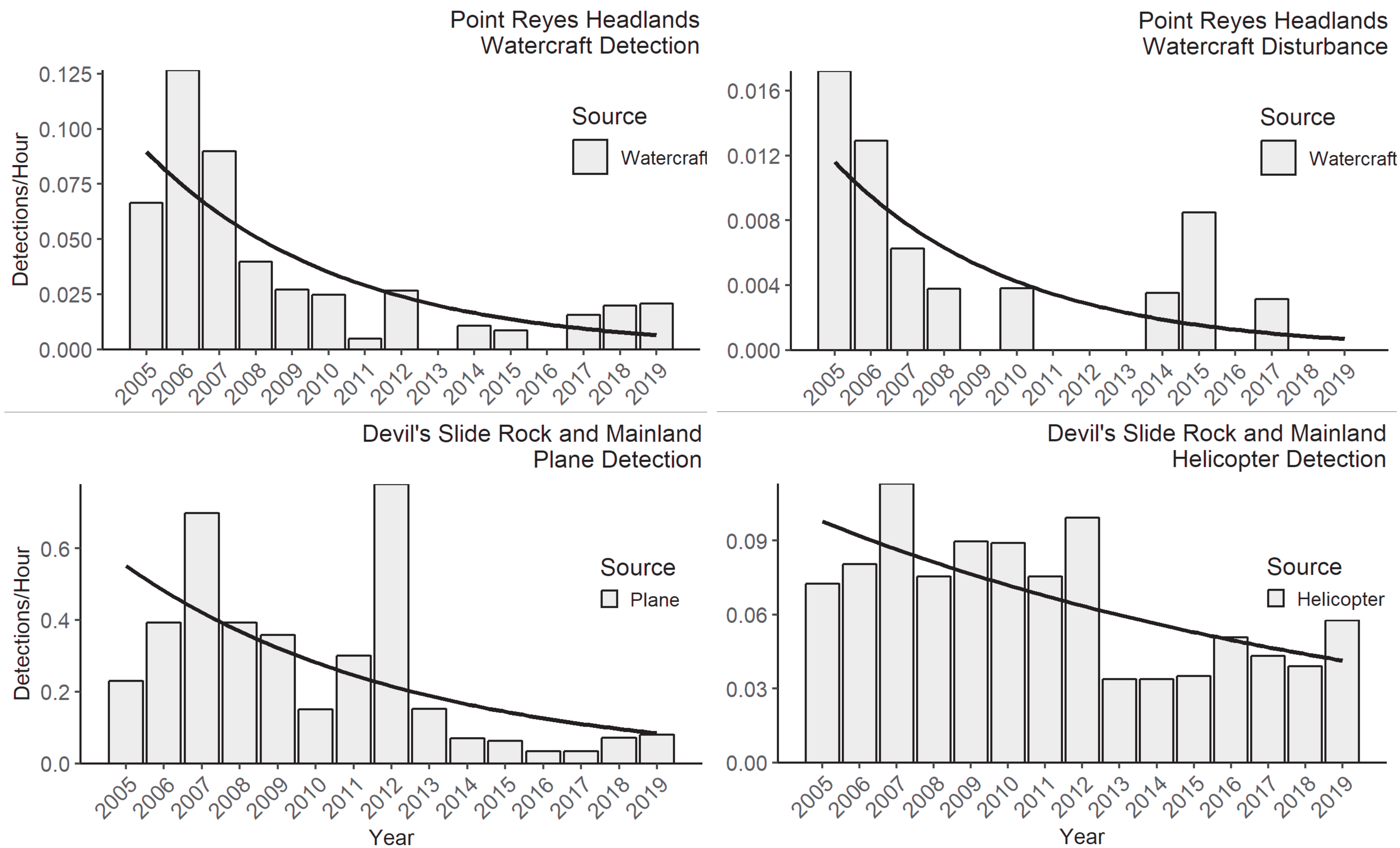
	Total Detections				Total Disturbance Events				Number of Agitation Events				Number of Displacement Events		Number of Flushing Events	
Colony Aircraft Type	Heli-copter	Model Plane/ Drone	Plane	Unk.	Heli-copter	Model Plane/ Drone	Plane	Unk.	Heli-copter	Model Plane/ Drone	Plane	Unk.	Heli-copter	Plane	Heli-copter	Plane
Point Reyes Headlands																
CalFire	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Commercial	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
Military	0	0	2	0	0	0	2	0	0	0	2	0	0	0	0	0
General Aviation	0	0	16	0	0	0	5	0	0	0	5	0	0	0	0	0
USCG	5	0	1	0	3	0	0	0	1	0	0	0	0	0	2	0
Devil's Slide Rock and Mainland																
Commercial	3	0	2	0	3	0	2	0	1	0	2	0	0	0	2	0
General Aviation	7	3	31	0	6	0	21	0	3	0	19	0	0	0	3	2
Law Enforcement	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Media	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Military	4	0	1	0	3	0	1	0	1	0	1	0	0	0	2	0
Research	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
USCG	9	0	0	0	6	0	0	0	3	0	0	0	0	0	3	0
Unknown	1	0	0	1	1	0	0	1	0	0	0	1	0	0	1	0
Total	**35**	**3**	**68**	**3**	**26**	**0**	**39**	**1**	**11**	**0**	**35**	**2**	**0**	**0**	**15**	**4**

Appendix 2. Number of aircraft overflights observed (detections and disturbances) and separated by type and resulting disturbance events recorded at Point Reyes Headlands, Devil's Slide Rock and Mainland, and Castle-Hurricane Colony Complex in 2019.

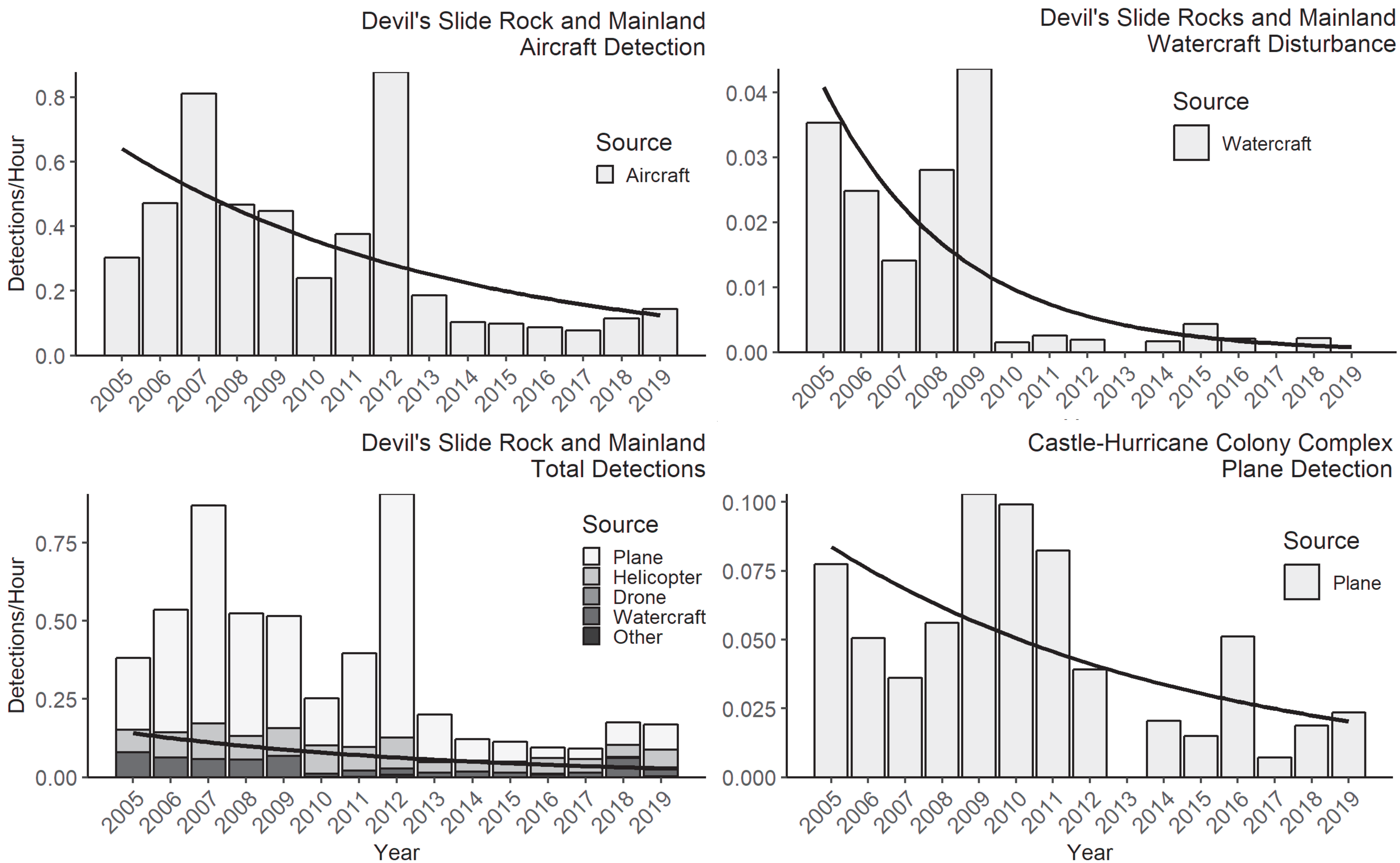
	Total Detections				Total Disturbance Events				Number of Agitation Events				Number of Displacement Events		Number of Flushing Events	
Colony Aircraft Type	Heli-copter	Model Plane/ Drone	Plane	Unk.	Heli-copter	Model Plane/ Drone	Plane	Unk.	Heli-copter	Model Plane/ Drone	Plane	Unk.	Heli-copter	Plane	Heli-copter	Plane
Castle-Hurricane Colony Complex																
General Aviation	3	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0
Media	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Military	1	0	1	0	2	0	0	0	0	0	0	0	0	0	1	0
Private/Recreational	3	2	3	0	2	0	0	0	2	0	0	0	0	0	0	0
Unknown	3	0	2	0	0	0	2	0	1	0	2	0	0	0	0	0
Total	**11**	**2**	**7**	**0**	**4**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**0**	**0**	**1**	**0**

Appendix 3. Number of watercraft detected categorized by type and resulting disturbance events recorded at Point Reyes Headlands (PRH), Devil's Slide Rock and Mainland (DSRM) and Castle-Hurricane Colony Complex (CHCC) in 2019.

Watercraft Type and Colony	Total Detections	Total Disturbance Events	Number Agitation Events	Number Displacement Events	Number Flushing Events
(<16') Private/Recreational Fishing Boat (PRH)	1	0	0	0	0
(16'-25') Private/Recreational Fishing Boat (PRH)	12	0	0	0	0
(>25') Commercial Fishing Boat (PRH)	2	0	0	0	0
(16'-25') Private/Recreational Fishing Boat (DSRM)	6	0	0	0	0
Charter Fishing Boat (DSRM)	2	0	0	0	0
Commercial Fishing Boat (DSRM)	2	0	0	0	0
(<16') Private/Recreational Fishing Boat (CHCC)	2	0	0	0	0
(16'-25') Private/Recreational Fishing Boat (CHCC)	8	2	0	0	2
(16'-25') Private/Recreational Sailboat (CHCC)	1	0	0	0	0
(>25') Private/Recreational Fishing Boat (CHCC)	2	0	0	0	0
Total	**38**	**2**	**0**	**0**	**2**



Appendix 4. Detection and disturbance rates at Point Reyes Headlands and Devil's Slide Rock and Mainland with significant trends from 2005-2019. Regression trend lines are shown.



Appendix 5. Detection and disturbance rates at Devil's Slide Rock and Mainland and Castle-Hurricane Colony Complex with significant trends from 2005-2019. Regression trend lines are shown.