RESTORATION AND MONITORING OF COMMON MURRE COLONIES IN CENTRAL CALIFORNIA: ANNUAL REPORT 2017

REPORT TO THE
LUCKENBACH TRUSTEE COUNCIL

Cassie M. Bednar, Gerard J. McChesney, Stefanie D. Collar, Justin A. Windsor, Ryan J. Potter, Amy C. Wilson, Samuel Aguilar, Phillip J. Capitolo, and Richard T. Golightly

U.S. Fish and Wildlife Service
San Francisco Bay National Wildlife Refuge Complex
1 Marshlands Road
Fremont, CA 94555 USA

and

Humboldt State University
Department of Wildlife
1 Harpst St.
Arcata, CA 95521

FINAL REPORT
December 2018

RESTORATION AND MONITORING OF COMMON MURRE COLONIES IN CENTRAL CALIFORNIA: ANNUAL REPORT 2017

REPORT TO THE
LUCKENBACH TRUSTEE COUNCIL

Cassie M. Bednar[2,3], Gerard J. McChesney[1], Stefanie. D. Collar[2,3], Justin A. Windsor[2,3], Ryan J. Potter[2,3], Amy C. Wilson[2,3], Samuel Aguilar, Phillip J. Capitolo[4], and Richard T. Golightly[2]

[1]U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex,
1 Marshlands Road, Fremont, CA 94555 USA
[2]Humboldt State University, Department of Wildlife, Arcata, CA 95521 USA
[3]Mailing Address: U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, 1 Marshlands Road, Fremont, CA 94555 USA
[4] Institute of Marine Sciences, University of California,
115 McAllister Way, Santa Cruz, California 95060 USA

U.S. Fish and Wildlife Service
San Francisco Bay National Wildlife Refuge Complex
1 Marshlands Road
Fremont, CA 94555 USA

and

Humboldt State University
Department of Wildlife
1 Harpst Street
Arcata, CA 95521

FINAL REPORT
December 2018

Cover photo: Aerial photograph of Devil's Slide Rock, 17 June 2017 by P.J. Capitolo.

Suggested Citation: Bednar, C. M., G. J. McChesney, S.D. Collar, J.A. Windsor, R.J. Potter, A. C. Wilson, S.A. Aguilar, P. J. Capitolo, and R. T. Golightly. 2018. Restoration of Common Murre colonies in central California: annual report 2017. Unpublished report, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Fremont, California and Humboldt State University, Department of Wildlife, Arcata, California. 86 pages.

PROJECT ADMINISTRATION

Project Staff

Project Manager/Co-Principal Investigator: Gerard J. McChesney
Co-Principal Investigator: Richard T. Golightly
Wildlife Biologist: Cassie M. Bednar
Wildlife Biologist: (Point Reyes Headlands) Stefanie D. Collar
Wildlife Biologist (Devil's Slide): Justin A. Windsor
Wildlife Biologist (Castle-Hurricane): Ryan J. Potter
Wildlife Technician (Devil's Slide): Samuel Aguilar
Wildlife Technician (Devil's Slide): Amy C. Wilson

***Luckenbach* Trustee Council**

U.S. Department of the Interior

Representative: Carolyn Marn (U.S. Fish and Wildlife Service, Bay Delta Field Office, Sacramento, CA)
Alternate: Dave Press (U.S. National Park Service, Point Reyes National Seashore, Point Reyes Station, CA)
Alternate: Lisa Stevens

California Department of Fish and Wildlife

Representative: Laird Henkel (Office of Spill Prevention and Response, Sacramento, CA)
Alternate: Laird Henkel (Office of Spill Prevention and Response, Monterey, CA)
Alternate: Kathy Verrue-Slater

National Oceanic and Atmospheric Administration

Representative: Jennifer Boyce (NOAA Restoration Center, Long Beach, CA)
Alternate: Ericka Hailstocke-Johnson (NOAA Restoration Center, Long Beach, CA)

ABBREVIATIONS USED

BM227X = Bench Mark-227X

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

MLPA = Marine Life Protection Act

MPR = Millers Point Rocks

NOAA = National Oceanic and Atmospheric Administration

NPFC = National Pollution Funds Center

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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACKNOWLEDGMENTS

In 2017, the *Luckenbach* Oil Spill Trustee Council comprised of the California Department of Fish and Wildlife (CDFW), National Oceanic and Atmospheric Administration (NOAA), and Department of the Interior through the U.S. Fish and Wildlife Service (USFWS) and the National Park Service, provided funding and oversight.

Administrative support was provided by Anne Morkill, Chris Barr, Cindy Ballard, and Ellen Tong from the USFWS San Francisco Bay National Wildlife Refuge Complex. Additional support was provided by the staff at the Humboldt State University Sponsored Programs Foundation, especially Steve Karp, Pia Gabriel, and Leslie Rodelander. Database support was provided by Michael Cunanan (USFWS Inventory & Monitoring, Sacramento, CA).

Monitoring was conducted in collaboration with Seabird Protection Network outreach and education efforts by the staff of the Greater Farallones National Marine Sanctuary (GFNMS), including Paul Hobi, Wendy Kordesh and Karen Reyna. Research was conducted at the Devil's Slide Trail County Park, with assistance and permit support from Ramona Arechiga, Matt Del Carlo, Mark Rogers and Darrick Emil (San Mateo County Parks). Research at Point Reyes National Seashore (PRNS) was conducted under Permit No. PORE-2018-SCI-0001, with assistance from Ben Becker. Housing for our Point Reyes biologist was provided by PRNS with assistance from Ben Becker. We owe special thanks to our committed volunteers, Linda Schmid and Marjorie Siegel, for conducting surveys of Bird Island.

Funds for aerial photographic surveys of seabird colonies were provided by USFWS Region 8 Migratory Birds and CDFW. Support for aerial photographic surveys of seabird colonies was provided by: Amedee Brickee (USFWS Region 8 Migratory Birds); W. Breck Tyler (University of California Santa Cruz); Holly Gellerman and Laird Henkel (CDFW – Office of Spill and Prevention Response); Carie Battistone (CDFW-Wildlife Branch); and M. Green and M. McDowell (USFWS Region 1 Migratory Birds). Field assistance on surveys was provided by pilot Michael Breiling (CDFW-Air Services), Mike Parker (University of California, Santa Cruz), Anna Burkholder, and Sage Tezak. Aerial photographic surveys of seabird colonies within overflight-restricted areas of the Greater Farallones and Monterey Bay National Marine Sanctuaries were conducted under NOAA permit GFNMS-2012-001-A1 (issued to University of California, Santa Cruz).

EXECUTIVE SUMMARY

Efforts in 2017 marked the 22nd year of restoration and associated monitoring of central California seabird colonies by the Common Murre Restoration Project (CMRP). This project began 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 funds, the project was supported by settlement funds from the 1998 *Command* and extended *Luckenbach* oil spills. 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 additional central California colonies. Since 2005, standardized procedures for the surveillance and assessment of human disturbance at central California Common Murre colonies have been incorporated into daily survey methods. Additionally, the outcome of restoration efforts at DSR and recovery of other central California murre colonies continues to be monitored. The human disturbance assessments were used to inform outreach, education and enforcement and coordinated management efforts by the Seabird Protection Network (SPN; coordinated by the Greater Farallones National Marine Sanctuary; GFNMS) and to allow for evaluation of the success of those efforts. The goal of the SPN was to protect central California seabird breeding colonies primarily through reduction of human disturbance, which also enhanced the restoration of previously injured colonies.

Intensive monitoring of human disturbances (mainly aircraft and watercraft), seabird productivity, seabird attendance patterns and relative population sizes were conducted at three Common Murre colony complexes. In addition, less intensive monitoring of Common Murre attendance was conducted at Bird Island. In 2017 at Point Reyes Headlands (PRH), only one seabird disturbance event (watercraft, flushing) occurred; analyses of long-term average (2005-2017) data showed significant declining trends in the annual rates of aircraft and plane detections, watercraft detections, and watercraft disturbances. Devil's Slide Rock and Mainland (DSRM) continued to have the greatest combined aircraft and watercraft disturbance rates (0.036 disturbance events/hour) of all monitored colonies. Of the 19 disturbance events at DSRM, 16 (84%) included flushing. Analyses of long-term data showed declining trends of helicopter detections, and watercraft disturbances. Unlike previous years, Castle-Hurricane Colony Complex (CHCC) had the greatest combined detection rate (0.11 detections/hour) among all three colonies. There were five recorded events that caused disturbance (three agitation events and two flushing events) at CHCC in 2017 but analysis of annual changes of aircraft and watercraft disturbance rates from 2005-2017 did not show any significant trends across years.

General aviation (e.g., private or charter) helicopters were the most commonly observed aircraft, which caused 53% of disturbances at all monitored colonies. The second most observed was general aviation planes followed by recreational drones, U.S. Coast Guard helicopters, and military helicopters. Private recreational fishing boats accounted for 69% of watercraft detections but no disturbances were observed. Five watercraft were observed entering the special closure at PRH. One of these, a kayak, caused the only observed watercraft disturbance at our monitored sites in 2017. Five watercraft entered the special closure at DSR.

Seasonal attendance of Common Murres at PRH plots were consistent with long-term patterns, with similar or greater counts than in past years. At DSR in 2017, seasonal attendance during the pre-lay period was variable but similar to the long-term average (2008-2016); during incubation and chick rearing seasonal attendance was greater than the long-term average. At CHCC, seasonal counts were either consistent with or below long-term patterns. Counts from aerial photographic surveys were 15% and 28% greater than in 2016 at DSR and CHCC, respectively.

Common Murre productivity (chicks fledged per pair) at PRH plots was greater than the long-term average, and the highest recorded since 2010. Murre productivity was also greater than the long-term average at DSR but similar to average at CHCC.

During predator surveys, the highest non-anthropogenic disturbance rate was recorded at PRH; Turkey Vultures caused the greatest number of disturbance events although the majority of disturbances occurred during the last week of monitoring and outside productivity plots. At DSR, Common Ravens caused high numbers of disturbance events and caused the higher rates of flushing events than were recorded at either PRH or CHCC. At CHCC, Western Gulls caused the greatest rate of non-anthropogenic disturbance, but Brown Pelicans caused the greatest rate of flushing events.

In 2017, Brandt's Cormorant (*Phalacrocorax penicillatus*) nest counts from ground monitoring were greater than in 2015 and 2016 at both DSRM and CHCC; at PRH, nest counts were greater in 2017 than in 2015 (cormorant nests were not monitored at PRH in 2016). Brandt's Cormorant productivity in 2017 was near average at PRH but below average at DSRM and CHCC. Productivity of Pelagic Cormorants (*Phalacrocorax pelagicus*), Western Gulls (*Larus occidentalis*) and Black Oystercatchers (*Haematopus bachmani*) was monitored at both DSRM and CHCC. Productivity of Pelagic Cormorants at DSRM was below average and the lowest recorded since monitoring began in 2006. At CHCC, Pelagic Cormorant productivity was near average. Western Gulls productivity was below average at DSRM but above average at CHCC. One Black Oystercatcher nest successfully fledged one chick at CHCC.

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 and 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 Devil's Slide Rock (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), and 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 central California murre population has had 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 impact 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, because the company responsible for the *Luckenbach* no longer existed. The Oil Spill Liability Trust Fund pays for oil spill cleanup and restoration of impacted natural resources when there is no responsible party. The fund has been sustained by fees from the oil industry and managed by the NPFC.

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) have implemented the SPN, in coordination with the CMRP, to restore seabird colonies harmed by these oil spills through reductions in human disturbance. 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 were utilized to guide education and outreach efforts and to assess the success of those efforts.

Colony surveillance and monitoring efforts 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). In 2005-2016, less intensive surveys also were 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 to document potential murre attendance and breeding were also conducted twice per week at the small Bird Island (near Point Bonita) colony in Marin County.

Here, we summarize colony surveillance and monitoring efforts conducted at central California nearshore murre colonies in 2017. As in past years, we recorded and categorized aircraft, watercraft and other disturbances to seabirds; murre seasonal attendance patterns; and productivity (or reproductive success). We also recorded Brandt's Cormorant (*Phalacrocorax penicillatus*) relative breeding population sizes and productivity, as well as relative breeding population sizes and/or productivity of Pelagic Cormorants (*P. pelagicus*), Black Oystercatchers (*Haematopus bachmani*), Western Gulls (*Larus occidentalis*), and Pigeon Guillemots (*Cepphus columba*). We reported data from aerial photographic surveys for colonies between Point Resistance and Hurricane Point.

METHODS

Study Sites

Three colony complexes, PRH, DSCC and CHCC, were monitored for productivity, disturbance and attendance of seabirds in 2017 (Figure 1). Only seabird attendance was monitored at Bird Island. PRH (Figure 2) is located within the Point Reyes National Seashore (PRNS), Marin County. Bird Island is located near the mouth of the Golden Gate within Golden Gate National

Recreation Area, Marin County. DSCC, located in San Mateo County, consists of the colonies Devil's Slide Rock and Mainland (DSRM) and San Pedro Rock (SPR; Figure 3 and 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 areas that are either privately, state or county-owned. At each colony, individual rocks and mainland cliffs with nesting seabirds were identified by their recognized subcolony numbers, subcolony names, or subarea. In this report, colonies were ordered north to south within each section.

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, observation hours from all vantage points were combined. 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). Also, time transiting between vantage points was not included in observation hours.

Disturbance

Anthropogenic Disturbance Events

Anthropogenic disturbance affecting murres or other seabirds was recorded at each study colony. These 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 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).

Monitoring effort was calculated (see above) for each colony and colony complex except for Bird Island. In order to compare disturbance among colonies and among years, disturbance rates were calculated. Anthropogenic disturbance rates were calculated during the breeding season as the number of disturbance events per hour of observation at each colony complex. To examine long-term trends in anthropogenic disturbances, Generalized Linear Models with a Poisson distribution (or Quasi-poisson in cases of "overdispersion") (R Core Team, 2018) were used to predict trends in annual changes in detection and disturbance rates for aircraft and watercraft during 2005-2017. Percent annual changes in rate, confidence intervals and p-values were reported.

For the annual Pacific Coast Dream Machines event that took place on 30 April at the Half Moon Bay Airport, observers monitored potential disturbance events at DSR. This event included an aircraft fly-in which in some years has 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 within about 1,500 ft (460 m) horizontal distance, as well as all watercraft within about 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. Detection rates were calculated as the number of aircraft or watercraft observed within these zones per observation hour, using monitoring effort for each colony complex. All watercraft entering the Egg Rock/DSR and PRH Special Closures were recorded and reported to Cal-TIP ("Californians Turn in Poachers;" CDFW) or to 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.

Predator Surveys
In 2017, non-anthropogenic disturbance events were recorded mainly during standardized predator surveys. The protocol was based on surveys conducted by the CMRP in 1999-2001 and were reinstated in 2017 to more efficiently and randomly capture non-anthropogenic disturbances and to compare past and current disturbance rates. These surveys were conducted in two-hour time segments between 0600-1800 h at murre productivity monitoring overlooks for each colony. Each two-hour time segment between 0600-1800 h was monitored within a two week time 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 (Table 1), as well as the species, numbers of individuals, and behaviors of birds disturbed.

Monitoring effort during predator watches was recorded in order to calculate rates of disturbance during predator surveys. Any anthropogenic disturbances observed during predator surveys were recorded. Incidental non-anthropogenic disturbance events that occurred outside of predator surveys were recorded at the discretion of biologists and reported separately.

Common Murre Seasonal Attendance Patterns

Seasonal attendance of murres at each colony was monitored from standardized mainland observation points using 65-130X or 15-60X spotting scopes. Attending murres were counted at each colony, subcolony, or index plot. Three consecutive counts were made and counts were averaged for most surveys. Seasonal attendance data were collected regularly at all colonies throughout the field season, until all chicks fledged and adult attendance ceased. Breeding season counts were conducted during a standardized period between 1000-1400 h. Murre counts were compared to weekly long-term means (2008-2016), and to 95% confidence intervals.

Point Reyes Headlands

Seasonal attendance at PRH was recorded at all murre subcolonies visible from mainland observation points once per week from 17 April to 12 August (Figure 2). Attendance was recorded at established Type II index plots (see Birkhead and Nettleship 1980) on Lighthouse (LRH; Ledge, Edge, and Dugout plots), Boulder, Flattop, Middle, Beach, and Cone rocks. Counts of index plots were conducted three times per survey and averaged. All other entire visible areas of subcolonies were counted once per survey.

Bird Island

Murres were first recorded attending Bird Island among nesting Brandt's Cormorants in 2007 (McChesney et al. 2008), and breeding was first confirmed in 2008 (McChesney et al. 2009). In 2017, monitoring of this recent colonization continued and observations were conducted by trained volunteers twice per week. From 9 May to 18 August, counts were conducted during two time periods: early morning (0700-0900 h) and late afternoon (after 1500 h), of both the north (from the bluff above the north end of Rodeo Beach) and south (from the Bird Island overlook) sides of Bird Island.

Devil's Slide Rock & Mainland, San Pedro Rock

Murres on DSR were photographed and counted every other day from 19 April to 16 August from the Traditional Pullout. A Canon EOS 80D camera with a 300 mm telephoto lens was used. Birds were counted using digital photo count software. On Devil's Slide Mainland (DSM), attendance patterns were monitored once per week from wherever murres could be viewed (see map, Figure 3 and 4). 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 nearby nesting Peregrine Falcons (*Falco peregrinus*). A new overlook, Below PEFA Pt., was added to observation points in 2017 in order to view a new nesting area (DSRM-05-D) where Brandt's Cormorants were observed nesting for the first time. At SPR, bird counts were conducted once per week throughout the breeding season from Pipe Pullout.

Castle-Hurricane Colony Complex

Seasonal attendance of murres was monitored for all active subcolonies visible from accessible, standardized mainland observation points (Figure 5). Counts were conducted twice per week during the breeding season from 17 April to 3 August. At four subcolonies, separate subarea counts were 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). Subarea CRM-06-A was observed from the Castle Pullout.

Common Murre Productivity

As in previous years, productivity (chicks fledged per pair) of murres was monitored at PRH, DSRM and CRM daily or near daily from standardized mainland observation points using either 65-130x or 15-60x spotting scopes. At the PRH LHR plots, all followed sites were mapped and numbered using digiscoped photographs of the colony and updated photographs from 2015 (the last previously monitored season). At DSR, all followed sites were mapped and numbered using digiscoped photographs of the 2017 colony and updated photographs from the 2016 breeding season, as well as 2017 aerial photographs. At CRM-04 plot, locations of returning or new breeding and territorial sites were identified using maps and photographs updated from the 2016 breeding season. At CRM-03-B, productivity was not followed for the 2017 season due to time restrictions, because murres do not nest there every year, and because murres have unusually poor breeding success there.

A breeding site was defined 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. Some territorial sites were likely breeding sites where eggs were lost at the time of laying, or shortly after but without detection. A sporadic site was defined as a location attended for at least two days but for less than 15% of monitored days. Chicks were considered to have fledged if they survived at least 15 days. Results from 2017 were compared to previous long-term means: PRH, 1996-2002, 2005-2015 (n=18 years); and DSR and CRM, 1996-2016 (n=21 years).

Point Reyes Headlands

Murre productivity was monitored at PRH within two established Type II plots on LHR. Ledge Plot and Edge Plot were located in the interior and edge of the colony, respectively. Because only one biologist monitored the PRH field site in 2017, the boundaries of Ledge and Edge plots were adjusted to reduce the number of monitored breeding sites.

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, see Birkhead and Nettleship 1980) were established on DSR in 2006 (McChesney et al. 2006; Figure 6). Boundary adjustments were made to plots A and C in 2007, and difficult sites were dropped from plots B and C in 2012. These adjusted plots (A, B, and C) were utilized for monitoring in 2008-2013. Prior to the 2014 field season, difficult to observe sites were dropped from plot A and B, and more suitable sites were added. This resulted in 47 and 21 fewer sites followed compared to 2013 in plots A and B respectively. Plot C was eliminated from monitoring entirely for the 2014 field season because of difficult viewing conditions (compared to 13 sites followed in 2013). In 2015, a new plot was added called Plot D, which was located on a ledge below Plot A (Figure 6). This plot was added in an effort to capture edge effects which were previously captured by following Plot C. In 2017, Plot D maintained the same 25 sites as in 2016. At DSM, murres were observed attending cliff habitats in subareas DSRM-05-C and DSRM-05-D; however no breeding sites were confirmed. All active sites in plots and subareas were monitored beginning 17 April.

Castle-Hurricane Colony Complex

All active murre breeding and territorial sites were monitored within a standardized plot on CRM-04 (established in 1996) beginning 17 April. Murres attended subcolony CRM-03-B through the breeding season where productivity monitoring had been conducted in past years, but they were not monitored in 2017 because of time restrictions and because murres have unusually poor breeding success there.

Common Murre Co-attendance and Chick Provisioning

Murre co-attendance and chick provisioning observations, or time budget surveys, were not conducted in 2017.

Nest Surveys

To assess locations of nesting areas, relative breeding population sizes, and potential impacts from disturbance, nest and bird surveys of non-murre seabird species were conducted at each colony in conjunction with murre colony attendance surveys. At PRH, land-based nest and bird counts of non-murre seabirds were conducted three times (6 June, 14 June and 22 June) to capture peak nest counts for the breeding season. Because of reduced staffing at PRH, survey effort was less than past years when surveys were conducted weekly through most of the season. Surveys were conducted weekly at 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, only well-built nests (i.e., those beyond the poorly built stage) were counted. 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

Breeding phenology and reproductive success (clutch sizes, brood sizes and chicks fledged per pair) of Brandt's Cormorants were monitored at PRH, DSRM and CHCC wherever vantage points provided adequate viewing. At PRH in 2017, Brandt's Cormorants were monitored at Arch Rock (PRH-11-D), Wishbone and Spine points (PRH-11-E), Sloppy Joe (PRH-12), Border Rock (PRH-14-C), and Miwok Rock (PRH-14-D). At DSRM, monitoring was conducted at DSR (DSRM-01), Upper Mainland South (DSRM-05-A Upper), Lower Mainland South (DSRM-05-A Lower), South of Turtlehead Cliffs (DSRM-05-C) and Below PEFA Pt. (DSRM-05-D). At CHCC, monitoring was conducted at CRM-03-A, CRM-03-B, and CRM-09.

Monitored nests were observed every one to seven days from mainland vantage points using binoculars and spotting scopes. Chicks were considered to have fledged if they survived to at least 30 days of age. 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 2017 were compared to prior long-term means for PRH (1997-2001, 2006-2015; n = 15 years), DSRM (1997-2007, 2009-2016; n = 19 years), and CHCC (1997-2001, 2006-2016; n = 16 years).

Pelagic Cormorant, Black Oystercatcher, and Western Gull Productivity

Productivity of Western Gulls and Black Oystercatchers was monitored at select nests that were visible from mainland observation points at DSRM and CHCC. Productivity of Pelagic Cormorants was also monitored at DSRM and CHCC. Nests were observed at least once per week. Chicks were considered to have fledged if they survived to at least 30 days. Feathering status was used 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). Results were compared to long-term averages for DSRM (2006-2016; n=11 years) and CHCC (2006-2011, 2016; n=7 years).

Pigeon Guillemot Surveys

To assess relative population size and seasonal attendance patterns, standardized counts were conducted 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. Surveys at all colonies were conducted between 30 minutes after sunrise and 0830 h and in Beaufort states <4. From mid-April to 5 May, when counts often peak, surveys were conducted twice per week (weather permitting) then about once per week thereafter. At PRH, water easily visible from the Point Reyes lighthouse (corresponding to subcolonies PRH-01, 02, 03 and 04; Figure 2) was surveyed. At DSCC, the entire area from the south side of San Pedro Rock to the South Bunker (DSRM-04; Figure 3 and 4) was surveyed. At CHCC, the area between Esselen Rock (BM227X-02) and the HPR boundary was surveyed; the portion of the survey area between Rocky Point and Esselen Rock was dropped in 2014 due to access issues for certain vantage points, thus, comparisons to prior years must take into account the variation caused by changing vantage points.

Common Murre and Brandt's Cormorant Breeding Population Sizes

Aerial photographic surveys of central California Common Murre, Brandt's Cormorant and Double-crested Cormorant colonies were conducted on 4, 6 and 17 June by University of California Santa Cruz and CDFW in cooperation with USFWS. Active colonies at the Farallon Islands were photographed from a Partenavia aircraft by two photographers with digital SLR cameras. Nearshore colonies between Point Resistance and Point Sur were photographed from a Cessna aircraft by one photographer. PRH was not photographed in 2017. Counts were obtained from murre and Brandt's Cormorant colonies using Image Pro Plus software (Media Cybernetics, 2007). Photographs were selected to provide the most complete colony coverage with high quality imagery. All visible murres were individually counted from each subcolony or subarea; these counts were summed to provide whole-colony counts. 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, a correction factor was applied to the raw aerial photograph counts to account for breeding birds not present and non-breeding birds present at the time of the survey. For 2017, we used the correction factor of 1.64 derived for murres in 2017 at nearby Southeast Farallon Island (Warzybok et al. 2018). 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.

For examining long-term patterns in murre breeding population sizes over time, we applied correction factors to past years counts from annual Southeast Farallon Island values provided by Point Blue Conservation Science (1985-2016) or from other sources for earlier years (e.g., Sowls et al. 1980, Briggs et al. 1983). Exceptions were for DSR in 1996-2007 when breeding population size estimates were derived from murre productivity monitoring at the colony (Parker et al. 2007; USFWS, unpubl. data).

For Brandt's Cormorants, whole-colony nest counts were obtained from aerial photographs of all monitored colonies as well as other nearshore colonies between PRS and Point Año Nuevo. Counts included territorial sites, poorly built nests, active well-built nests, (well-built) nests with 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 population trends, annual murre population estimates and cormorant nest counts at each colony (or colony complex) dating back to 1979 were plotted and fitted with a LOESS curve (R Core Team, 2018) and 95% confidence intervals. Linear trends were determined for estimates from the 1999-2017 period using 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 until the mid-2010s. Following several years of warm water conditions associated with the "blob", cooler sea surface temperatures have returned in recent years.

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

RESULTS

Anthropogenic Disturbance

During the 2017 field season, monitoring effort across PRH, DSCC and CHCC totaled 1131 on - site hours (Table 2). There were 72 aircraft overflights recorded within our monitoring areas at PRH (Table 3), DSRM (Table 3) and CHCC (Table 4) combined; these included 20 from planes, 38 from helicopters and 14 from drones (Table 3 and 4). Overall, 24 of these overflights resulted in disturbance to seabirds (e.g. agitation, displacement or flushing). A total of five plane and 19 helicopter overflights caused disturbance. Sixteen helicopters caused displacement and/or flushing of murres. The most frequently detected aircraft categories were general aviation helicopters and general aviation planes (Appendix 1). The third most observed was recreational drones with 14 observations, all of which occurred at CHCC and none of which caused detectable disturbance to seabirds. There were 15 total watercraft detections within 1,500 feet of monitored colonies, including 11 recreational fishing boats, three kayaks and one Jet Ski (Appendix 2); six of these entered Special Closures at PRH and DSR, with one resulting disturbance at PRH. Due to inconsistencies in data recording, results of watercraft detections at DSRM should be considered a minimum estimate and comparisons to previous years should be considered with caution.

A total of 26 Wildlife Disturbance Reports were completed and submitted to the Seabird Protection Network in 2017 (one from PRH, 20 from DSCC and five at CHCC). This included 21 reports of flushing and five reports of agitation and displacement. Twenty-five of the reports involved aircraft disturbance, and one involved watercraft disturbance. All Special Closure violations were reported to the SPN and CDFW.

Point Reyes Headlands

Two helicopters and five watercraft were detected at PRH in 2017 (Table 3; Figure 7 and 8). The only disturbance recorded was from one kayak rowing between nearshore rocks within the Special Closure near Sloppy Joe (PRH-12) which caused approximately 200 Brandt's Cormorants, 50 Pigeon Guillemots and 75 Western Gulls to flush from their nesting and roosting rocks.

The 2017 combined aircraft and watercraft disturbance rate was the lowest observed at PRH since standardized disturbance monitoring began in 2005 (0.003 disturbances/hr). No planes were detected at PRH but the detection rates for helicopters was 0.006 detections/hr and for watercraft was 0.02 detections/hr. There was a significant declining annual change in the rate of plane (-14.2% annual change, $P<0.001$), aircraft (combined helicopters and planes; -12.7% annual change, $P<0.001$) and watercraft (-23.3% annual change, $P<0.001$) detections during 2005-2017 (Table 3). There was also a significant declining trend in the annual change of the disturbance rate of all disturbances at PRH (-16.6% annual change, $P=0.03$; Table 3).

Devil's Slide Rock and Mainland

In 2017, 19 (46%) aircraft overflights resulted in disturbance to seabirds. Disturbance events were caused by five planes (10% of all overflights at DSR) and 15 helicopters (36% of all overflights at DSR). There were 16 total flushing events, including eight from general aviation helicopters, four USCG helicopters, two military helicopters, and two general aviation planes (Appendix 1). The largest disturbance event was from a general aviation helicopter that flushed 400 murres (Table 5). No disturbance events were observed during the eight watercraft detections at DSR, including five detections inside the Devil's Slide Rock Special Closure. The rate of disturbance events involving displacement and/or flushing of seabirds (0.04 disturbances/hr) was greater than in 2016 (0.03 disturbances/hr).

For long-term trends, there were significant decreases in rates of watercraft disturbances, and helicopter detections (Table 3; Appendix 4 and 5).

The annual Pacific Coast Dream Machines event took place on 30 April in 2017 at the Half Moon Bay Airport. Weather conditions were calm and sky conditions were clear throughout the day. Observers were stationed at the observation point for DSR from 0810 h to 1600 h to record overflights and potential disturbance events. One plane caused flushing of murres and cormorants and three additional planes were recorded within the standard detection zone (1000 ft above sea level, 1500 ft horizontal distance). Seventy-three additional aircraft were observed outside the detection zone. Since dedicated observation during the Dream Machines event began in 2005, there has been a significant declining trend in annual change of aircraft detection rates (-15.7% annual change; $P=0.04$) but no significant trend in annual change of disturbance rates. As in prior years, SPN staff located at the Half Moon Bay Airport provided outreach to pilots during the event.

Castle-Hurricane Colony Complex

Fourteen drones, 13 helicopters, two planes, and one watercraft detection were recorded at CHCC with disturbance to seabirds occurring during five aircraft events. The rate of disturbance events involving displacement and/or flushing of seabirds (0.007 disturbances/hr; Table 4) was higher than in 2016 (0.0 disturbances/hr). There were two total flushing events, each by helicopters (Appendix 1). The largest disturbance event was by one general aviation helicopter that flushed 80 murres while agitating an additional 840 murres (Table 5). There was no significant trend found for the annual detection or disturbance rates for aircraft or watercraft detections and disturbances rates observed at CHCC (2001-2017; Table 4).

Non-Anthropogenic Disturbance

Point Reyes Headlands

Predator Survey
Surveys were conducted at LHR (PRH-03-B) for 95.5 hours. The non-anthropogenic disturbance rate during these observation hours was 2.3 disturbance events per hour, with an average of 4.3 disturbance events per two-hour predator watch (Table 6, Figure 11). Turkey Vultures caused the highest number of disturbance events, as well as disturbances that affected the largest number of Common Murres within a single disturbance. Ground harassment by Western Gulls, Common Ravens and Turkey Vultures was the most common behavior observed during disturbance events. Murres and Brandt's Cormorants primarily reacted to avian disturbance with agitation. Thirteen murre eggs and eleven murre chicks were depredated and scavenged by Western Gulls, Common Ravens and Turkey Vultures during predator surveys.

Incidental Non-Anthropogenic Disturbance
Incidental non-anthropogenic disturbance was recorded from all observation overlooks including LHR (PRH-03-B). The largest incidental non-anthropogenic event occurred on 8 July and was a result of Turkey Vultures flying over the colony near LHR. This disturbance caused 1000 murres to flush from Big Roost Rock (PRH-03-A) and an additional 300 murres on LHR to become agitated. No eggs or chicks were observed taken outside of the standard predator surveys.

Devil's Slide Rock and Mainland

Predator Survey
At DSR predator surveys were conducted for 107.3 hours. The non-anthropogenic disturbance rate during these observation hours was 0.7 disturbance events per hour. Common Ravens caused the highest rate of disturbance events and accounted for 90% of all the non-anthropogenic predator watch events during the season. Of the 75 total disturbance events that were recorded, 71 events included flushing of murres and/or Brandt's Cormorants, most caused by ravens. Ravens also depredated or directly caused the loss of 22 murre eggs and one murre chick during predator surveys. Other disturbance events were caused by Brown Pelicans (8%), Peregrine Falcons (1%), and Western Gulls (1%; Table 7, Figure 11).

Incidental Non-Anthropogenic Disturbance
Incidental non-anthropogenic disturbance was recorded from all DSRM overlooks. Common Ravens were responsible for the largest incidental disturbance events including the flushing of 218 murres from DSR on 30 April. All large incidental non-anthropogenic disturbance events occurred on or before 2 May, before egg laying commenced on 19 May.

Castle-Hurricane Colony Complex

Predator Survey
At Castle Rock (CRM-04), predator surveys were conducted for 82.7 hours. The non-anthropogenic disturbance rate during these observation hours was 1.6 disturbance events per hour. The species that caused the greatest number of disturbance events was Western Gull, which was responsible for 27% of all events. Of the 129 total events, 69 were characterized as flushing or displacement events with 22 caused by flying Brown Pelicans. During predator surveys one egg was displaced, three eggs were exposed and one chick was exposed but no eggs or chicks were taken (Table 7, Figure 11).

Incidental Non-Anthropogenic Disturbance
The largest incidental non-anthropogenic event was a group of flying pelicans which occurred on 2 June at and caused 174 murres and one Pelagic Cormorant to flush from three different subcolonies.

Common Murre Seasonal Attendance Patterns

Point Reyes Headlands

In 2017, all well-established nesting areas were active with confirmed breeding at PRH. The date of peak counts at subcolonies ranged from 19 April to 31 July. For 47% of active PRH subcolonies (Figure 12-16), peak numbers were recorded before the first egg lay date from our monitored plots on LHR (23 May). By the last colony count on 8 August, 63% of the subcolonies were no longer attended by murres while others, including plots on LHR (PRH-03-B), still had small numbers of birds, indicating that small numbers of chicks were still present (Figure 12).

Seasonal attendance patterns were similar to typical patterns at long-term plots, with more variable attendance during pre-egg laying, less variable attendance during the egg and early chick periods, and rapid declines during departure (Figures 12-13). Counts appeared to be generally greater than long-term averages at Dugout and Cone plots while counts at Edge, Ledge and Boulder plots were lower than long-term averages.

Bird Island

Surveys were conducted at Bird Island from 9 May to 18 August 2017. Murres were observed on 70% of observation days. The average number of murres observed on days when they were present, was five (range = 1-10, n = 40 days). Murres continued to use the small area under the last remains of a former U.S. Navy Compass House, on the far western end of the rock. Eggs were never seen but on 8 August four chicks were observed under the wooden structure on the island. One chick was observed fledging on 12 August.

Devil's Slide Rock, Mainland and San Pedro Rock

Devil's Slide Rock

Murres were observed on all count days between 19 April and 16 August 2017. Murres were completely absent from the rock on 17 August following the end of breeding activity (Figure 17). The greatest counts were recorded just before (8 May) and just after (28 May) the initiation of egg laying. The maximum count of 1,438 murres on 28 May was 15% less than the 2016 peak count of 1,707 murres. During the pre-laying period murres were observed leaving Devil's Slide Rock in large numbers in the afternoon, sometimes as a result of raven disturbance events. Attendance patterns became more consistent from early June through the incubation and early chick periods. At the end of July, numbers started to decrease quickly as chicks fledged.

Devil's Slide Mainland and San Pedro Rock

Murres attended Lower Mainland South (DSR-05-A Lower), South of Turtlehead Cliffs (DSRM-5-C) and Below PEFA Pt. (DSRM-05-D). Greatest attendance occurred at subarea DSRM-05-D, with an average of 137 murres, followed by DSRM-05-A (mean = 75 murres) and DSRM-05-C (mean = 16 murres), counted during the peak period. Attendance at mainland subcolonies in 2017 was generally greater compared to other recent years. However, no breeding sites were identified and attendance was rare after mainland Brandt's Cormorants abandoned their nesting territories (Figure 17). Murres were not observed on San Pedro Rock in 2017.

Castle/Hurricane Colony Complex

Attendance counts at all CHCC subcolonies began on 18 April. Despite some variation in attendance patterns between subcolonies, active breeding areas showed the typical pattern of low daily variability during the incubation and early chick stages followed by rapid declines in late July as chicks fledged (Figure 18-20). A surge in attendance at a few subcolonies in mid- to late July likely indicated increased attendance by subadult, prospecting birds. Murres were gone completely from CHCC except at HPR-02-Hump and HPR-02-Ledge by the end of monitoring on 3 August.

At the ephemeral Esselen Rock (BM227X-02) subcolony, small numbers of murres were recorded in attendance only on 14 and 26 May. In late June and July, small numbers of murres were observed attending the mainland cliffs at CRM-09 among nesting Brandt's Cormorants.

Common Murre Productivity

Point Reyes Headlands

A combined total of 76 sites were monitored at Ledge (n = 48) and Edge plots (n = 28) on LHR. The mean egg-laying date (exclusive of replacement eggs) for Edge and Ledge combined was 30 May (range = 17 May – 19 June; n = 73; Table 8), which was three days later (outside two standard errors) than the long-term mean (26 May ± 2.0 days). Four replacement eggs were laid. Two of these replacement eggs in Edge plot hatched and both chicks fledged. Overall productivity was 0.73 chicks fledged per pair which was the highest recorded since 2010 and greater than the long-term mean (1996-2017; Figure 21). Productivity was influenced by both high hatching (81.4%) and fledging (89.4%) success. Chicks fledged at an average age of 26 days (n = 55), and the last chick was observed on 12 August.

Devil's Slide Rock and Mainland

Of 203 sites documented within DSR plots, 189 (93%) were breeding, 11 (5%) were territorial, and three (1.4%) were sporadic. The first murre egg was observed on 19 May, in Plot B. At all sites combined, the mean egg-laying date (exclusive of replacement eggs) was 31 May ± 1.1 days (range = 19 May – 1 July, n = 189; Table 8), which was six days later (outside two standard errors) than the long-term average (25 May ± 1.9 days). A total of 195 eggs were laid, including 6 replacement eggs. Overall productivity of 0.85 chicks fledged per pair was greater than (outside the 95% confidence interval) the long-term average (0.65 ± 0.05; Table 8, Figure 21). Greater than average productivity was influenced by 88% hatching success and 94.2% fledging success. Chicks fledged at an average age of 26 ± 4.5 days (n = 126), and the last chick was seen on 8 August.

No breeding sites were identified on DSM. A single egg was observed within the mainland colony but it had already been abandoned.

Castle-Hurricane Colony Complex

Of 103 total monitored sites in the CRM-04 plot in 2017, 95 (92.2%) were breeding and 8 (7.8%) were territorial. The first murre egg was observed on 5 May. The mean egg-laying date was 16 May ± 0.72 days (range = 5 May – 10 June; n = 95), one day later than the long-term average of 15 May ± 2.2 days (Table 8). A total of nine replacement eggs were observed. Overall productivity at CRM-04 was 0.60 chicks per pair (within the 95% confidence interval; Table 8, Figure 21). Chicks that fledged remained on the rock for an average of 23 ± 3.3 days (n = 57) after hatching, and the last chick was seen on 18 July.

In 2017, productivity was not monitored at CRM-03-B but breeding was confirmed.

Brandt's Cormorant Nest Surveys and Productivity

Seasonal peak nest counts of Brandt's Cormorants were obtained from weekly land surveys. 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 tended to be more complete than land observations where views could be obscured.

Point Reyes Headlands

Nest surveys
Brandt's Cormorant nest surveys were conducted from 6 June to 22 June. Well-built nests were recorded at Pebble Point (PRH-05-C), Slide (PRH-06-B), Area C (PRH-06-C), Arch Rock (PRH-11-D), Wishbone and Spine Points (PRH-11-E), Sloppy Joe (PRH-12-A), Border Rock (PRH-14-C), and Miwok Rock (PRH-14-D) and PRH-14E. The single-day peak count of nests for all subcolonies combined was 245 nests on 6 June, a 20% increase from the 2015 peak single-day count (196). The sum of the seasonal peak counts for each subcolony was 270 nests, 27% greater than in 2015 (199 nests; Table 9).

Productivity
At PRH, 104 egg-laying sites were monitored at six subareas (Table 10). The start of nest monitoring for each subarea followed the timing of nest initiation: Arch Rock (PRH-11-D) began on 18 May, Spine Point (PRH-11-E) on 12 May, Wishbone Point (PRH-11-E) on 14 May, Sloppy Joe (PRH-12-A) on 10 May, Border Rock (PRH-14-C) on 29 April, and Miwok Rock (PRH-14-D) on 3 May. For all subareas combined, the average clutch initiation date was18 May ± 1.4 (range = 29 April – 13 June, n = 104) and 12 replacement clutches were observed (Table 10). The first chick was recorded on 31 May. Overall productivity was 1.9 chicks fledged per pair (subarea range = 1.0 – 3.0) which was within the 95% confidence interval of the long term mean (1.80 ± 0.2; Figure 27). Breeding success per nest was 0.79 (subarea range = 0.63 – 0.90, Table 10).

Bird Island

Surveys were conducted from 9 May to 19 August. Roosting Brandt's Cormorants were present predominately during the middle and end of the season (12 July – 13 August), with counts ranging from 0-57 roosting birds, but no nests were recorded.

Devil's Slide Rock and Mainland

Nest surveys
Nests and territorial sites were counted between 17 April and 10 July. The first well-built nests were observed on 8 May. The peak count of nests on DSR was 23 nests on 3 July. On the mainland, nesting occurred on Upper Mainland South (DSRM-05-A Upper; peak count of three nests), Lower Mainland South (DSRM-05-A Lower; peak count of 27 nests), South of Turtlehead Cliffs (DSRM-05-C; peak count of 13 nests) and Below PEFA Pt. (DSRM-05-D; peak count of 48 nests).

The peak single day count for DSRM combined was 105 nests on 12 June, 291% more than the 2016 peak count (36 nests). The sum of the seasonal peak counts was 129 nests (Table 9), 310% more than the 2016 seasonal peak count sum of 38 nests.

From the aerial survey on 17 June, 136 nests were counted. This count was 65% percent greater than the nest count recorded in 2016 (49).

Productivity
A total of 61 breeding sites were monitored at DSRM in 2017. Brandt's Cormorant nests were monitored on Devil's Slide Rock (DSRM-01), Lower Mainland South (DSRM-05-A Lower), and South of Turtlehead Cliffs (DSRM-05-C) and (DSRM-05-D; Table 11). The first egg was observed on DSR on 12 May. For all subareas combined, the mean clutch initiation date was 18 May ± 1.2 days (range = 29 April to 13 July). There were two replacement clutches. Overall productivity was 1.26 chicks fledged per pair (subarea range = 0 – 5; n = 61). Breeding success per nest was 0.55, indicating a relatively high rate (45%) of nest abandonment.

Castle-Hurricane Colony Complex

Nest surveys
Brandt's Cormorant nest surveys were conducted from 18 April to 14 July. Subcolonies or subareas with confirmed breeding in 2016 were CRM-03-A, CRM-03-B, CRM-06-BS, CRM-09, and HPR-02. The first well-built nests were observed on 7 April at CRM-03-B. At all CHCC subcolonies combined, the peak single survey nest count of 214 nests was recorded on 31 May; 520% more than the 2016 peak count of 41. The sum of the seasonal peak subcolony counts was 231 nests, 500% more than the 2016 count of 46 nests. From the aerial survey conducted on 17 June 307 nests were counted (Table 9). After comparing subcolony counts between land-based and aerial surveys, a combined total of 352 nests was obtained.

Productivity
Brandt's Cormorant productivity was monitored on CRM-03-A, CRM-03-B, and CRM-09 (Table 11). At all subareas combined, the mean clutch initiation date was 1 May ± 1.2. The first chick was observed on 8 May. The overall productivity at CRM of 1.33 chicks fledged per pair (subcolony range = 0 – 3.00; n = 169) was less than the long-term average of 1.8 ± 0.2, and outside the 95% confidence interval (Figure 22). Breeding success per nest was 0.66, indicating a fairly high rate (33%) of nest abandonment.

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

Nest and bird surveys

Seasonal peak counts of nests (Pelagic Cormorant, Western Gull, and Black Oystercatcher) or birds (Pigeon Guillemot) from were obtained from land-based observations and aerial surveys. Due to limited personnel, at PRH non-murre nest and bird surveys were conducted only three times during the peak of the breeding season to capture season high counts. Pelagic Cormorant nesting areas typically vary from year to year and some nests may not have been visible from land-based observation points. Because of this, nest counts should be considered a minimum estimate and comparisons to previous years should be considered with caution.

Pelagic Cormorant
In 2017, Pelagic Cormorant phenology and productivity was not monitored at PRH, in part because most nesting areas cannot be viewed from our mainland vantage points. On DSM Pelagic Cormorant productivity was monitored at three subareas: DSRM-02-MN; DSRM-05-A Lower; and DSRM-05-D. The first well-built nest was observed on 1 May. From a combination of land and aerial surveys, a peak count of 58 nests was recorded at DSRM. At CHCC, Pelagic Cormorant nests were observed on CRM-04, HPR-01, and HPR-03; the first well-built nests were observed on 18 April. From land and aerial surveys a peak count of 20 nests was recorded at CHCC (Table 9).

Western Gull
At PRH, a high count of 55 Western Gull nests were observed. At Bird Island 13 nests was recorded. Four Western Gull nests at DSRM and a high count of 36 nests at CHCC were observed across eleven individual areas (Table 9).

Black Oystercatcher
At PRH, four Black Oystercatchers nests were observed. No Black Oystercatcher nests were observed at DSRM. Five nests were observed at CHCC on CRM-01, CRM-02, CRM-03B, HPR-02, and HPR-04 (Table 9).

Pigeon Guillemot
The 2017 peak standardized count at PRH was 134 pigeon guillemots on 19 April. The 2017 peak standardized count at DSRM was 185 guillemots on 1 May which was 110% more than the 2016 count. At CHCC, the peak standardized count was 31 guillemots on 7 June, 16% less than the in 2016 (Table 9).

Productivity

Productivity monitoring for Pelagic Cormorants, Western Gulls and Black Oystercatchers was conducted at DSRM and CHCC.

Pelagic Cormorant
At DSRM, Pelagic Cormorant productivity was monitored at two subareas: DSRM-02-MN and DSRM-05-D. The first egg was recorded on 8 May. Productivity of 0.33 chicks fledged per pair was outside the lower 95% confidence interval of the long-term mean (1.62 ±0.14 chicks fledged per pair; 2006–2015; Table 12, Figure 23). This was the lowest productivity recorded at DSRM since monitoring began in 2006. At CHCC, Pelagic Cormorant productivity was monitored on CRM-04 starting 6 May with the first egg being seen 8 May. Productivity of 0.67 chicks fledged per pair was within the 95% confidence interval of the long-term mean (0.63 ±0.17; Table 12, Figure 23).

Western Gull
Nests were monitored at DSRM and CHCC. Gull productivity at DSRM of 0.50 chicks fledged per pair was below the 95% confidence interval of the long-term mean (0.65 ±0.08; Figure 18).

At CHCC, productivity from eleven monitored nests was 0.73 chicks fledged per pair which was greater than the long-term mean and above the 95% confidence interval (0.54 ±0.07, Table 12, Figure 24).

Black Oystercatcher
CHCC was the only colony with followed nests in 2017. Five nests fledged 0.2 chicks per pair (Table 12).

Breeding Population Sizes

Counts from aerial photographs were obtained from all nearshore Common Murre and Brandt's Cormorant colonies within the Gulf of the Farallones region, as well as CHCC further south, except for PRH which was not photographed in 2017. Because of their greater completeness from land-based surveys, aerial photographic surveys are used for standardized estimates of breeding population sizes and trends of these species in the California Current System.

Common Murre

Raw bird counts of Common Murres were obtained from aerial survey photographs. To estimate breeding population sizes, a correction factor of 1.64 was applied to all counts (see Methods). Long-term patterns of population sizes for the period 1979-2017, using population estimates, were presented in Figures 25-27. Nearly all colonies have shown recovery since the large declines of the mid-1980s, including significant increases since 1999. Numbers at PRH, Point Resistance and Double Point Rocks have been stable since about 2011. Millers Point Rocks (MRP) was the only colony in the region showing decline. Likely, the correction factor applied to estimate breeding population size provides an overestimate for the MPR colony. Land-based monitoring of MPR in 2005-2015 showed that murre attendance was highly variable from year to year and even seasonally; most birds did not breed birds and often abandoned the colony early in the breeding season.

After rapid increase in the 2000s, numbers at DSR also have been relatively stable since 2012. Applying the correction factor to the aerial survey count yielded an estimate of 2,906 breeding murres or about 1,453 breeding pairs (Figure 26). This estimate continues to be 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 (Figure 26). During the aerial survey, an additional 36 murres were counted on DSM.

At CHCC, numbers of murres continue to increase, including significant increasing trends at both CRM and HPR from 1999-2017. The total breeding population estimate of 9,981 breeding murres for all of CHCC, including 7,875 birds at CRM and 1,284 birds at HPR, was the highest observed to date.

Brandt’s Cormorant

Brandt’s Cormorant nest totals were counted from aerial survey photographs and during land based observations. As described above, aerial survey counts were combined with land-based counts at monitoring colonies to provide more precise estimates of breeding population sizes. PRH, DBCC, DSRM and CHCC Brandt’s Cormorant breeding population sizes were variable since monitoring began in 1979, however high nest counts were recorded at all four colonies in the early to mid-2000s. From aerial surveys in 2017, 254 nests were counted at DBCC, 136 nests were counted at DSRM and 307 nests were counted at CHCC (Table 9, Figure 28).

DISCUSSION

Anthropogenic Disturbance

For the first time since 2005, CHCC had a higher rate of detected aircraft than PRH and DSRM. This increase was caused in part by the frequent helicopter traffic to the area south of Pfeiffer Canyon Bridge, which collapsed earlier in the year closing Highway 1 and road access to the area. This increased helicopter traffic also resulted in the highest helicopter disturbance rates at CHCC since 2010. In addition to helicopter traffic, drone detections at CHCC increased substantially compared to previous years. No drones caused disturbance in 2017 but as this technology continues to grow in popularity and availability, continued monitoring of their impacts is crucial. Although disturbance rates at CHCC continue to be lower than at DSRM, there has been no significant long-term change in the annual change of detection or disturbance rates at CHCC. PRH continued to have lower aircraft and watercraft detection and disturbance and rates than DSRM and CHCC, with no aircraft detections. The significant declining trends of aircraft and watercraft detections suggest that anthropogenic activity is decreasing in the PRH area. Consistent with past years, DSRM had the greatest rates of disturbance among monitored colonies, the majority of which were caused by helicopters. There was a significant declining trend in the detection rates of helicopters, but so far, this has not resulted in significant declining or inclining trends in the disturbance rate caused by helicopters. Although the trends were not significant, for the second year in a row disturbance rates at DSR were the lowest since standardized disturbance monitoring began in 2005. Also for the second year in a row, there continued to be significant declining trend in the disturbance rates of watercraft, suggesting decreased watercraft activity at DSR. In addition, no watercraft were observed inside the special closure at DSR, and only one was observed within the special closure at PRH. Reductions of aircraft and watercraft disturbance are a major goal of the SPN and it appears there has been a decrease of both at DSRM and PRH.

Although there were some detections and one disturbance during the Pacific Coast Dream Machine Event in 2017, the number of aircraft flying over recorded outside of the detection zone was the greatest we have recorded since 2013. The disturbance rate was higher than 2016 (when no disturbances were recorded) but lower than the long-term average. The persistent presence of GFNMS and the SPN outreach staff at this event appears to have resulted in a decrease of low overflights at DSR. Reductions in watercraft entering special closures also may be due in part to a combination of outreach efforts and continued communication between field staff and CDFW wardens, who promptly respond and contact boaters.

Non-Anthropogenic Disturbance

Results from predator surveys varied widely between the PRH, DSRM and CHCC. Although rates of disturbance were lower at DSR, murres and Brandt's Cormorants at DSR were more likely to flush during each disturbance event they were at PRH or CHCC. Also at DSR, more seabirds were disturbed and more eggs were lost per disturbance event than at PRH or CHCC. Turkey Vultures caused the majority of disturbance events at PRH but caused none at DSR or CHCC. Common Ravens caused high rates of disturbance at PRH and DSR, but none at CHCC. Western Gulls caused the majority of disturbance (90 events) at CHCC but most of these disturbance events were less severe, agitation events.

Although the sources and levels of non-anthropogenic disturbance varied across PRH, DSRM and CHCC, one commonality was non-anthropogenic disturbance rates appeared to be greater than anthropogenic disturbance rates at all three colonies. Non-anthropogenic disturbance rates at DSR and PRH were two orders of magnitude greater than disturbance rates from anthropogenic sources. The differences between non-anthropogenic and anthropogenic disturbance rates were not as great at CHCC; however, due to the road closure, anthropogenic rates were likely higher at this site than in typical years. The frequency of non-anthropogenic disturbance events is of concern, especially at the relatively small, and therefore more vulnerable, DSR colony. However, avian disturbance does not appear to be greatly impacting murre productivity, at least in our monitored plots, where breeding success was high in 2017.

Attendance and Reproductive Success

The standardized land-based maximum and the aerial count of the murre colony on DSR in 2017 was more than observed in 2016. Higher attendance counts may be due to the shift to El Niño neutral conditions, characterized by near average ocean temperatures, which were observed in the spring leading up to the breeding season (Wells et al., 2017). Although the count of murres was higher than 2017, it was not greater than the counts from 2014 and 2015. Regardless, the colony appears to be similar in number to the early 1980s, prior to extirpation in the mid-1980s. Aerial counts at CHCC continue to increase. This colony complex was slower to begin recovery than most other central California colonies (Carter et al. 2001). Numbers at CRM appear to be at or above 1979-1982 levels, while HPR is still somewhat below the 1979-1982 period. Lower numbers are especially evident at the larger HPR-02 subcolony.

Seasonal attendance among most subcolonies and plots within PRH, DSRM and CHCC was similar to the long-term average. The exceptions were PRH-13-CP, DSM, and HPR-02. PRH-13-CP and DSM both had higher seasonal attendance than the long-term average and HPR-02 had lower seasonal attendance for the second year in a row. Higher than average attendance at DSM could result from juveniles from the DSR colony prospecting in higher numbers, but this subcolony has yet to establish consistent breeding. The low seasonal attendance at HPR-02 does not appear to reflect the overall attendance at HPR, which had the highest aerial murre count since 1981.

Seasonal attendance phenology was also consistent with the long-term averages at PRH, DSRM and CHCC. The consistently high attendance throughout the latter portion of the season could reflect the relatively high productivity recorded, as high numbers of adults were still attending chicks late into July. Consistent attendance at all three colonies also suggests that strong upwelling in the spring (Wells et al., 2017) may have increased ocean productivity and allowed for attendance throughout the summer.

Murre breeding was later than average at PRH, DSRM and CHCC in 2017 but similar to 2016. Late breeding often is associated with low breeding success (Boekelheide et al. 1990). However, murre productivity was considerably greater than average at PRH and DSR and near average at CHCC. At PRH LHR, productivity at Edge Plot was the highest observed since monitoring began in 1996. Productivity at DSR and PRH was also the highest observed since the warm water "blob" phenomenon began in this region in 2014.

High productivity in 2017 may have resulted from a shift to El Niño neutral conditions and the dissipation of the "blob" (McClatchie et al. 2016). Following the 2015-16 El Niño, in 2017 central California ocean conditions returned to average sea surface temperature and upwelling rates in the winter and early spring (Wells et al. 2017). At the offshore Farallon Islands, monthly mean SST was greater than average throughout most of the spring and summer (March, April, June, August; Warzybok et al. 2018). As with nearshore colonies, the long-term murre plot population at the Farallon Islands were similar to 2016. Unlike the high breeding success observed at PRH and DSRM breeding success for murres on the Farallon Islands was similar to the long-term average (Warzybok et al. 2018).

As in 2016, Central California fisheries data indicated abundant juvenile rockfish, and market squid but low abundances of northern anchovy and Pacific sardine. Unlike 2016, there was abundance of krill and around average records of sanddabs (Wells et al. 2017). Consistent with fisheries data, Common Murre at the Farallon Islands primarily fed juvenile rockfish, followed by anchovy and sardine, to their chicks. Brandt's Comorant primarily fed chicks anchovy and flatfishes (Warzybok et al. 2018). We assume that seabirds at nearshore, monitored colonies fed on similar prey however, differences in ocean conditions and available resources between the nearshore colonies and the Farallon Islands may be the cause of the differences in breeding success.

Despite relatively high attendance for much of the breeding season, no murre breeding was observed on DSM in 2017. Breeding by low numbers of murres has occurred on DSM nearly every year since 2005, although breeding locations often change and breeding success has been poor. As is typical, murres on DSM attended among nesting Brandt's Cormorants (Manuwal and Carter, 2001, Capitolo et al. 2005) in new subcolony DSRM-05-D. Once Brandt's Cormorants abandoned these nests in early July, murres stopped attending on the mainland almost entirely.

Unlike several past years, disturbance from pelicans did not appear to be the cause of abandonment in this colony.

Brandt's Cormorants nest numbers in 2017 were greater than 2015 at PRH and greater than 2016 at DSRM and CHCC. Although nest numbers were high at all three colonies, productivity was similar to the long-term average at PRH and below the long-term average at DSR and CHCC. Many nests that set up early in the season at DSR and CHCC had abandoned by early July. Aerial surveys confirmed that there were also more Brandt's nests at PRH, DSRM and CHCC than in previous years. Breeding phenology was similar to the average at all monitored colonies. Unlike the mainland, the nearby Farallon Islands experienced lower than average numbers of breeding pairs but above average productivity (Warzybok et al. 2018). Like differences in murre productivity between nearshore and offshore colonies, the differences in Brandt's Cormorant productivity may be the result of differences in ocean conditions in the nearshore and offshore environments.

As in 2016 Pelagic Cormorants experienced high nest abandonment in early July at DSRM resulting in below average productivity. At CHCC, Pelagic Cormorant productivity was similar to the long-term average. Pelagic Cormorants on the Farallon Islands experienced higher than average productivity (Warzybok et al. 2018). At DSRM, Western Gulls had, below average productivity, similar to 2016, as well as relatively low numbers of nests. At CHCC, Western Gulls had above average productivity and the highest productivity recorded since 2010.

There are some inherent problems in the examination of Brandt's and Pelagic Cormorant nest data. Cormorants typically do not nest on the same subcolonies from year to year, and it is likely that some nests each year are not visible, thus not counted, from our land observation locations. Because of this limitation, nest counts for these species should be considered minimum counts, and comparisons to previous years and between sites should be considered with caution. Boat and/or aerial surveys could provide coverage that is more complete. Aerial surveys were completed in 2017 however, these data only represent a snapshot of the total season.

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 2017 field season marked the fourth 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 continued in 2017 in cooperation with CDFW and University of California, Santa Cruz. However, sustained funding is currently unavailable. As murre numbers have increased, land-based counts have become more difficult and even less accurate. Additionally, Brandt's Cormorant nests are often only visible from aerial photographs.

- 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.

LITERATURE CITED

Birkhead, T. R., and D. N. Nettleship. 1980. Census methods for murres, Uria species: a unified approach. Canadian Wildlife Service Occasional Paper Number 43.

Boekelheide, R.J., D.G. Ainley, S.H. Morrell, H.R. Huber, and T.J. Lewis. 1990. Common Murre. Pages 245-275 *in* (D.G. Ainley and R.J. Boekelheide, eds.), Seabirds of the Farallon Islands: Ecology, Dynamics, and Structure of an Upwelling System Community. Stanford University Press, Stanford, California.

Briggs K. T., W. B. Tyler, D. B. Lewis, and K. F. Dettman. 1983. Seabirds of central and northern California, 1980-1983: status, abundance and distribution. Center for Marine Studies, University of California, Santa Cruz. Report to Minerals Management Service.

Capitolo, P. J., H. R. Carter, G. J. McChesney and M. W. Parker. 2005. Common Murres prospecting within cormorant colonies in Del Norte and Humboldt counties, California, 1996-2004. Northwestern Naturalist 86:144-150.

Capitolo, P. J., G. J. McChesney, H. R. Carter, M.W. Parker, L. E. Eigner and R.T. Golightly. 2014 Population trends of Brandt's Cormorants in the Gulf of the Farallones, California, 1979-2006. Marine Ornithology 42:35-48.

Carter, H. R., and R. T. Golightly (eds.). 2003. Seabird injuries from the 1997-1998 Point Reyes Tarball Incidents. Unpublished Report, Humboldt State University, Department of Wildlife, Arcata, California.

Carter, H. R. and K. A. Hobson. 1988. Creching behavior of Brandt's Cormorant chicks. Condor 90:395-400.

Carter, H. R., G. J. McChesney, D. L. Jaques, C. S. Strong, M. W. Parker, J. E. Takekawa, D. L. Jory, and D. L. Whitworth. 1992. Breeding populations of seabirds in California, 1989-1991. Vols. 1 and 2. Unpublished draft report, U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Dixon, California.

Carter, H. R., U. W. Wilson, R. W. Lowe, D. A. Manuwal, M. S. Rodway, J. E. Takekawa, and J. L. Yee. 2001. Population trends of the Common Murre (*Uria aalge californica*). pp. 33-133 in Manuwal, D.A., H.R. Carter, T.S. Zimmerman, and D.L. Orthmeyer (eds.), Biology and conservation of the Common Murre in California, Oregon, Washington, and British Columbia. Volume 1: Natural History and population trends. U.S. Geological Survey, Information and Technology Report, USGS/BRD/ITR-2000-0012, Washington, D.C.

Carter, H. R., V. A. Lee, G. W. Page, M. W. Parker, R. G. Ford, G. Swartzman, S. W. Kress, B. R. Siskin, S. W. Singer, and D. M. Fry. 2003. The 1986 Apex Houston oil spill in central California: seabird injury assessments and litigation process. Marine Ornithology 31:9-19.

Command Trustee Council. 2004. Command Oil Spill Final Restoration Plan and Environmental Assessment. U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, California Department of Fish and Game, California Department of Parks and Recreation, and California State Lands Commission.

Forney, K. A., S. R. Benson, and G. A. Cameron. 2001. Central California gillnet effort and bycatch of sensitive species, 1990-98. in E. F. Melvin and J. K. Parrish, (eds.), Seabird bycatch: trends, roadblocks, and solutions. University of Alaska Sea Grant, Fairbanks, Alaska.

Fuller, A. R., G. J. McChesney, R. T. Golightly. 2018. Aircraft disturbance to Common Murres (*Uria aalge*) at a breeding colony in central California, USA. Waterbirds 41: 257-267.

Hampton, S., R. G. Ford, H. R. Carter, C. Abraham and D. Humple. 2003. Chronic oiling and seabird mortality from the sunken vessel S.S. *Jacob Luckenbach* in central California. Marine Ornithology 31:35-41.

Luckenbach Trustee Council. 2006. S.S. *Jacob Luckenbach* and Associated Mystery Oil Spills Final Damage Assessment and Restoration Plan/Environmental Assessment. Prepared by California Department of Fish and Game, National Oceanic and Atmospheric Administration, United States Fish and Wildlife Service, and National Park Service.

Manuwal, D. A., H. R. Carter. 2001. Natural History of the Common Murre (*Uria aalge californica*). pp: 1-32. in: Manuwal D. A., H. R. Carter, T. S. Zimmerman, D. L. Orthmeyer, (eds). Biology and conservation of the Common Murre in California, Oregon, Washington, and British Columbia 1.

McChesney, G. J. 1997. Breeding biology of the Brandt's Cormorants on San Nicolas Island, California. Unpublished M.S. thesis, California State University, Sacramento, California.

McChesney G. J., H. R. Carter. 1999. Protocol for Counting Seabirds from Aerial Photographs of Breeding Colonies and Roosts in California. Unpublished report. U.S. Geological Survey: Biological Resources Division Western Ecological Research Center, Dixon, California and Humboldt State University: Department of Wildlife, Arcata, California.

McChesney, G. J., L. E. Eigner, T. B. Poitras, P. J. Kappes, D. Le Fer, L. Nason, P. J. Capitolo, H. Beeler, C. Fitzpatrick, R. T. Golightly, K. S. Bixler, H. R. Carter, S. W. Kress, and M. W. Parker. 2006. Restoration of Common Murre colonies in central California: annual report 2005. Unpublished report, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California

McChesney, G. J., L. E. Eigner, T. B. Poitras, P. J. Kappes, N. M. Jones, D. N. Lontoh, P. J. Capitolo, R. T. Golightly, D. Le Fer, H. R. Carter, S. W. Kress, and M. W. Parker. 2007. Restoration of Common Murre colonies in central California: annual report 2006. Unpublished report, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California.

McChesney, G. J., L. E. Eigner, P. J. Kappes, T. B. Poitras, D. N. Lontoh, S. J. Rhoades, N. J. Metheny, R. T. Golightly, P. J. Capitolo, H. R. Carter, S. W. Kress, and M. W. Parker. 2008. Restoration of Common Murre colonies in central California: annual report 2007. Unpublished report, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California

McChesney, G. J., D. N. Lontoh, S. J. Rhoades, K. A. Borg, E. L. Donnelly, M. E. Gilmour, P. J. Kappes, L. E. Eigner, and R. T. Golightly. 2009. Restoration of Common Murre colonies in central California: annual report 2008. Unpublished report, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, California

McClatchie, S., R. Goericke, A. Leising, T.D. Auth, E. Bjorkstedt, R.R. Robertson, and many others. 2016. State of the California Current 2015–16: comparisons with the 1997–98 El Niño. California Cooperative Fisheries Investigations 57: 5-61.

Media Cybernetics (2007). Image-Pro Plus. (Version 6.2.1). Silver Spring, Maryland.

Page, G. W., H. R. Carter, and R. G. Ford. 1990. Numbers of seabirds killed or debilitated in the 1986 Apex Houston oil spill in central California. pp. 164-174. in Sealy, S.G. (ed.), Auks at sea. Studies in Avian Biology 14.

Parker, M. W., S. W. Kress, R. T. Golightly, H. R. Carter, E. B. Parsons, S. E. Schubel, J. A. Boyce, G. J. McChesney, and S. M. Wisely. 2007. Assessment of social attraction techniques used to restore a Common Murre colony in central California. Waterbirds 30:17-28.

R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Rojek, N. A., M. W. Parker, H. R. Carter, and G. J. McChesney. 2007. Aircraft and vessel disturbances to Common Murres at breeding colonies in central California, 1997-1999. Marine Ornithology 35:67-75.

Roletto, J., J. Mortenson, I. Harrald, J. Hall, and L. Grella. 2003. Beached bird surveys and chronic oil pollution in central California. Marine Ornithology 31:21-28.

Sowls, A. L., A. R. DeGange, J. W. Nelson, and G. S. Lester. 1980. Catalog of California seabird colonies. U.S. Fish and Wildlife Service, Biological Services Program, FWS/OBS 37/80.

Takekawa, J. E., H. R. Carter, and T. E. Harvey. 1990. Decline of the Common Murre in Central California 1980-1986. Pp. 149-163. In Sealy, S.G. (ed.), Auks at sea. Studies in Avian Biology.

Warzybok, P.M., M. Johns, and R.W. Bradley. 2018. Population Size and Reproductive Performance of Seabirds on Southeast Farallon Island, 2017. Unpublished report to the U.S. Fish and Wildlife Service. Point Blue Conservation Science, Petaluma, California. Point Blue Conservation Science Contribution Number 2158.

Wells, B. K., I. D. Schroeder, S. J. Bograd, E. I. Hazen, M. G. Jacox, A. Leising, and many others. 2017. State of the California Current 2016-17: still anything but “normal” in the north. California Cooperative Fisheries Investigations 58: 2-55.

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	**Explanation**
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 2017 to August 2017.

Colony/Colony Complex	Start date	End date	No. of Obs. Days	Total hours
Point Reyes Headlands	4/17/2017	8/12/2017	87	318
San Pedro Rock	4/17/2017	8/16/2017	11	1.6
Devil's Slide Rock & Mainland	4/17/2017	8/16/2017	119	532
Castle-Hurricane Colony Complex	4/7/2017	8/3/2017	75	279

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 and Devil's Slide Rock and Mainland (DSRM), 2017. Detection and disturbance rates reported as numbers per observation hour. Quasi-poisson regressions were run to assess the annual change in detections and disturbance rates from 2005-2017. Percent annual change is reported if significant trends were observed.

Colony	Source	Total Detections	Number Detections /hr.	Number of Disturbance Events			Disturbance Rates: Events/hr.		Annual change in Detection Rates (2005-2017)			Annual change in Disturbance Rates (2005-2017)		
				A	D	F	Total/hr.[1]	Flush or Displace/ hr.	% Annual Change[2]	95% CI	P-value	% Annual Change[2]	95% CI	P-value
PRH	Plane	0	0.00	0	0	0	0.00	0.00	-14.2%	(-19.6- -8.4)	<0.001	-	-	-
	Helicopter	2	0.006	0	0	0	0.00	0.00	-	-	-	-	-	-
	Drones	0	0.00	0	0	0	0.00	0.00	-	-	-	-	-	-
	Aircraft Total	**2**	**0.006**	**0**	**0**	**0**	**0.00**	**0.00**	**-12.7%**	**(-15.7- -7.8)**	**<0.001**	**-**	**-**	**-**
	Watercraft	5	0.02	0	0	1	0.003	0.003	-23.3%	(-27.3- -12.7)	<0.001	-	-	-
	PRH Total	**7**	**0.02**	**0**	**0**	**1**	**0.003**	**0.003**	**-18.6%**	**(-24.6 -7.3)**	**0.002**	**-16.6%**	**(-28.7- -2.4)**	**0.03**
DSRM	Plane	18	0.03	2	0	2	0.007	0.004	-	-	-	-	-	-
	Helicopter	23	0.04	1	0	14	0.03	0.03	-6.6%	(-10.2- -2.2)	0.01	-	-	-
	Drones	0	0.00	0	0	0	0	0	-	-	-	-	-	-
	Aircraft Total	**41**	**0.08**	**3**	**0**	**16**	**0.04**	**0.03**	**-**	**-**	**-**	**-**	**-**	**-**
	Watercraft	8	0.02	0	0	0	0	0	-16.8%	(-19.5- -11.0)	<0.001	-26.1%	(-31.8- -11.1)	0.007
	DSRM Total	**49**	**0.09**	**3**	**0**	**16**	**0.04**	**0.03**	**-**	**-**	**-**	**-**	**-**	**-**

[1] Events during which birds exhibited agitation or alert behaviors (A), flushing (F), or displacement (D).
[2] Only significant values shown. A dash indicates no significant value.

Table 4. Total detected watercraft and aircraft, and resulting disturbances to all seabirds (Common Murres, Brandt's Cormorants, and Brown Pelicans) at Castle-Hurricane Colony Complex (CHCC), 2017. Detection and disturbance rates reported as numbers per observation hour. Quasi-poisson regressions were run to assess the annual change in detections and disturbance rates from 2005-2017. Percent annual change is reported if significant trends were observed.

Colony	Source	Total Detections	Number Detections /hr.	Number of Disturbance Events			Disturbance Rates: Events/hr.		Annual change in Detection Rates (2005-2017)			Annual change in Disturbance Rates (2005-2017)		
				A	D	F	Total/hr.[1]	Flush or Displace/hr.	% Annual Change[2]	95% CI	P-value	% Annual Change[2]	95% CI	P-value
CHCC	Plane	2	0.007	1	0	0	0.004	0.00	-	-	-	-	-	-
	Helicopter	13	0.05	2	0	2	0.01	0.007	-	-	-	-	-	-
	Drones	14	0.05	0	0	0	0.00	0.00	-	-	-	-	-	-
	Aircraft Total	**29**	**0.14**	**3**	**0**	**2**	**0.02**	**0.007**	**-**	**-**	**-**	**-**	**-**	**-**
	Watercraft	1	0.004	0	0	0	0.00	0.00	-	-	-	-	-	-
	CHCC Total	**30**	**0.11**	**3**	**0**	**2**	**0.02**	**0.007**	**-**	**-**	**-**	**-**	**-**	**-**

[1] Events during which birds exhibited agitation or alert behaviors (A), flushing (F), or displacement (D).
[2] Only significant values shown. A dash indicates no significant values.

Table 5. Number of disturbance events and mean numbers (range) of Common Murres (COMU), Brandt's Cormorants (BRCO) and Brown Pelicans (BRPE) disturbed (agitated, displaced and/or flushed; Dist.) and displaced/flushed (D/F) at Point Reyes Headlands, Devil's Slide Rock and Mainland and Castle-Hurricane Colony Complex, 2017. A dash indicates no events observed.

Source	Mean Number Seabirds Disturbed	Mean Number Seabirds Flushed/ Displaced	COMU Disturbance				BRCO Disturbance				BRPE Disturbance			
			No. of Dist. Events	Mean No. Birds Dist.	No. of D/F Events	Mean No. Birds D/F	No. Dist. Events	Mean No. Birds Dist.	No. of D/F Events	Mean No. Birds D/F	No. Dist. Events	Mean No. Birds Dist.	No. of D/F Events	Mean No. Birds D/F
Point Reyes Headlands (PRH)														
Plane	0	0	-	-	-	-	-	-	-	-	-	-	-	-
Helicopter	0	0	-	-	-	-	-	-	-	-	-	-	-	-
Watercraft	200	200	-	-	-	-	1	200	1	200	-	-	-	-
Total	**200**	**200**	**-**	**-**	**-**	**-**	**1**	**200**	**1**	**200**	**-**	**-**	**-**	**-**
Devil's Slide Rock and Mainland (DSRM)														
Plane	656 (6-1120)	13 (6-20)	4	656 (5-1120)	2	12 (5-20)	1	1	1	1	-	-	-	-
Helicopter	970 (318-1500)	119 (5-400)	15	967 (318-1500)	14	116 (5-400)	4	10 (3-25)	4	10 (3-25)	-	-	-	-
Watercraft	0	0	-	-	-	-	-	-	-	-	-	-	-	-
Total	**904 (5-1500)**	**106 (5-400)**	**19**	**902 (5-1500)**	**16**	**103 (5-400)**	**5**	**8 (3-25)**	**5**	**8 (3-25)**	**-**	**-**	**-**	**-**
Castle-Hurricane Colony Complex (CHCC)														
Plane	50	0	1	50	-	-	-	-	-	-	-	-	-	-
Helicopter	303 (30-840)	55 (30-80)	4	303 (30-840)	2	55 (30-80)	-	-	-	-	-	-	-	-
Watercraft	0	0	-	-	-	-	-	-	-	-	-	-	-	-
Total	**252 (30-840)**	**55 (30-80)**	**5**	**252 (30-840)**	**2**	**55 (30-80)**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Table 6. Number of disturbance events and mean numbers (range) of Common Murres (COMU) disturbed (agitated, displaced and/or flushed; Dist.) and displaced/flushed (D/F) during Predator Watch surveys at Point Reyes Headlands, 2017.

Source	No. of Dist. Events	Mean No. Birds Dist.	No. of D/F Events	Mean No. Birds D/F	No. Eggs Exposed/Taken	No. Chicks Exposed/Taken
Point Reyes Headlands						
BRCO	1	7	1	7	0/0	0/0
BRPE	4	182 (30-400)	1	100	0/0	0/0
CAGO	1	57 (20-100)	0	0	0/0	0/0
CORA	59	50 (1-500)	9	31 (1-100)	0/7	0/1
TUVU	83	131 (3-1000)	12	29 (5-100)	0/0	0/4
UNGU	2	23 (15-30)	0	0	0/0	0/0
WEGU	70	31 (1-300)	10	5 (1-15)	0/6	0/6
Total	**220**	**77** **(1-1000)**	**31**	**20** **(1-100)**	**0/13**	**0/11**

Table 7. Number of disturbance events and mean numbers (range) of Common Murres (COMU), disturbed (agitated, displaced and/or flushed; Dist.) and displaced/flushed (D/F) during Predator Watch surveys at Devil's Slide Rock and Castle-Hurricane Colony Complex, 2017.

Source	No. of Dist. Events	Mean No. Birds Dist.	No. of D/F Events	Mean No. Birds D/F	No. Eggs Exposed/Taken	No. Chicks Exposed/Taken
Devil's Slide Rock and Mainland						
BRPE	9	79 (2-700)	8	18 (2-50)	0/0	0/0
CORA	64	102 (1-1200)	33	26 (1-143)	3/22	0/1
PEFA	1	150	1	150	0/0	0/0
WEGU	1	11	1	11	0/0	0/0
Total	**75**	**98** **(1-1200)**	**43**	**27** **(1-150)**	**3/22**	**0/1**
Castle-Hurricane Colony Complex						
BRCO	7	21 (1-150)	3	3 (1-5)	0/0	1/0
BRPE	25	57 (5-600)	18	15 (5-55)	0/0	0/0
CAGU	1	26 (2-50)	0	0	0/0	0/0
PECO	1	3 (1-8)	0	0	0/0	0/0
UNGU	1	23 (16-30)	0	0	0/0	0/0
WEGU	94	47 (1-400)	6	5 (1-18)	3/0	0/0
Total	**129**	**46** **(1-600)**	**27**	**11** **(1-55)**	**3/0**	**1/0**

Table 8. Common Murre breeding phenology and reproductive success at Point Reyes Lighthouse Rock (PRH-03-B, 2 plots and combined), Devil's Slide Rock & Mainland (DSR, 3 plots and combined; DSM), and Castle Rocks & Mainland (1 plots), 2017. Means are accompanied by ranges and n in parenthesis.

Colony/Plot	No. Sites Monitored	No. Egg Laying Sites	Mean Lay Date[1]	No. Eggs Laid	Mean Hatch Date	Hatching Success[2]	Mean Fledge Date	Fledging Success[3]	Chicks Fledged per Pair
Point Reyes Headlands (PRH)									
PRH-03-B-Edge	28	28	27 May (5/23-6/5; 26)	31	1 July (6/24-7/30; 23)	77% (31)	26 July (7/22-8/12; 21)	92% (24)	0.75 (28)
PRH-03-B-Ledge	48	47	1 June (5/17-6/19; 47)	48	1 July (6/20-7/16; 40)	85% (48)	27 July (7/15-8/6; 34)	87% (39)	0.72 (47)
PRH (combined)	**76**	**75**	**30 May (5/17-6/19; 73)**	**79**	**1 July (6/20-7/30; 63)**	**82% (79)**	**27 July (7/15-8/12; 55)**	**90% (63)**	**0.73 (75)**
Devil's Slide Rock and Mainland (DSRM)									
DSR-A	104	97	31 May (5/19-7/1; 97)	100 (97)	2 July (6/24-7/12; 97)	89% (100)	27 July (7/16-8/5; 84)	97% (88)	0.87 (96)
DSR-B	73	67	30 May (5/22-6/28; 67)	69 (67)	2 July (6/23-7/21; 67)	93% (69)	28 July (7/18-8/7; 62)	98% (63)	0.90 (67)
DSR-D	25	25	31 May (5/21-6/10; 25)	26 (25)	3 July (6/27-7/14; 25)	77% (26)	27 July (7/17-8/2; 17)	85% (20)	0.72 (25)
DSR (combined)	**203**	**189**	**31 May (5/19-7/1; 189)**	**195 (189)**	**2 July (6/23-7/21; 189)**	**86% (195)**	**27 July (7/16-8/7; 163)**	**94% (171)**	**0.85 (189)**
Castle Rocks and Mainland (CRM)									
CRM-04	103	95	16 May (5/5-6/10; 95)	104	17 June (6/6-7/4; 76)	73% (76)	10 July (6/29-7/18; 57)	75% (76)	0.60 (57)

[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).

Table 9. High counts of nests and breeding birds from aerial and land surveys of nests for Common Murres (COMU), Brandt's Cormorants (BRCO), Pelagic Cormorants (PECO), Western Gulls (WEGU) and Black Oystercatchers (BLOY), 2017. Pigeon Guillemots (PIGU) counts reported are for bird (not nest) peak counts only. A dash indicates no survey was conducted.

		COMU[1]	BRCO			PECO			WEGU[4]	BLOY[4]	PIGU[4]
Complex	Colony	Aerial[2]	Land[3]	Aerial[2]	Combined	Land[3]	Aerial[2]	Combined[4]	Land[2]	Land[2]	Land/ Water[2]
PRH	Point Reyes	-	270	-	270	16	-	16	55	4	134
DBCC	Point Resistance	5,408	-	1	1	-	0	0	-	-	-
	Miller's Point Rocks	301	-	146	146	-	7	7	-	-	-
	Double Point Rocks	10,927	-	107	107	-	1	1	-	-	-
	Bird Island	6	0	0	0	2	0	2	7	0	0
DSCC	DSRM	1,808	129	136	136	53	12	58	8	0	40
	San Pedro Rock	0	0	0	0	0	0	0	2	0	12
CHCC	Bench Mark-227X	0	0	0	0	0	0	0	5	0	14
	CRM	4,802	206	225	270	7	20	20	15	3	12
	HPR	1,284	25	82	82	7	0	7	16	2	10

[1] Nests and birds counted from aerial survey conducted on 17 June 2017.
[2] Sum of high season nest (BRCO and PECO) and bird (COMU, WEGU, BLOY and PIGU) counts during land-based surveys.
[3] For combined counts, land-based and aerial counts were compared. Nests accounted from the aerial survey were combined with the land-based count.
[4] Aerial counts are not reported for nests of WEGU and BLOY due to incomplete aerial photograph coverage.

Table 10. Brandt's Cormorant breeding phenology and reproductive success at Point Reyes Headlands, 2017. Means are accompanied by ranges and n in parenthesis.

Colony/ Subcolony	No. Breeding Sites	Clutch Initiation Date[1]	Clutch Size[1]	Breeding Success[2]	No. Chicks Fledged/Pair[2]	Breeding Success/ Nest[3]
Point Reyes Headlands (PRH)						
Arch Rock (PRH-11-D)	8	22 May (5/18-5/28; 8)	3.1	48% (25)	1.50 (0-3; 8)	0.63 (8)
Spine Point (PRH-11-E)	19	22 May (5/12-6/13; 19)	2.9	78% (58)	2.37 (0-3; 19)	0.84 (19)
Wishbone Point (PRH-11-E)	25	21 May (5/14-6/1; 25)	3.2	52% (81)	1.68 (0-3; 25)	0.84 (25)
Sloppy Joe (PRH-12-A)	26	24 May (5/10-6/9; 26)	3.3	56% (92)	2.0 (0-3; 26)	0.80 (26)
Border Rock (PRH-14-C)	16	10 May (4/29-5/23; 16)	3.1	58% (53)	1.94 0-3; 16)	0.75 (16)
Miwok Rock (PRH-14-D)	10	13 May (5/3-5/30; 10)	2.7	70% (31)	1.90 (0-3; 10)	0.90 (10)
PRH Total	**104**	**18 May (4/29-6/13; 104)**	**3.1 (104)**	**58% (340)**	**1.93 (0-3; 104)**	**0.79 (104)**

[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

Table 11. Brandt's Cormorant breeding phenology and reproductive success at Devil's Slide Rock & Mainland and Castle Rocks & Mainland, 2017. Means are accompanied by ranges and n in parenthesis.

Colony/ Subcolony	No. Breeding Sites	Clutch Initiation Date[1]	Clutch Size[1]	Breeding Success[2]	No. Chicks Fledged/Pair[2]	Breeding Success/ Nest[3]
Devil's Slide Rock and Mainland (DSRM)						
Devil's Slide Rock (DSRM-01)	23	29 May 5/12-7/13; 23)	3.4	43% (23)	1.61 (23)	0.65 (23)
Mainland South (DSRM-05-A Lower)	5	24 May 5/15-6/6; 5)	2.8	35% (5)	1.20 (5)	0.60 (5)
South of Turtlehead Cliffs (DSRM-05-C)	19	9 May (4/29-5/29; 19)	3.7	49% (19)	1.79 (19)	0.84 (19)
Below PEFA Point (DSRM-05-D)	14	13 May 5/7-6/5; 14)	1.3	0% (14)	0 (14)	0 (14)
DSRM Total	**61**	**18 May (4/29-7/31; 61)**	**3.1**	**34% (187)**	**1.26 (61)**	**0.55 (61)**
Castle Hurricane Colony Complex (CHCC)						
CRM-03-A	10	8 May (5/3-5/11; 10)	3.1	32% (10)	1.00 (0-3; 10)	0.50 (10)
CRM-03-B	92	24 April (4/8-5/27; 92)	3.0	49% (92)	1.51 (0-3; 139)	0.75 (92)
CRM-09	67	10 May (4/13-6/5; 61)	2.9	39 (67)	1.13 (0-3; 76)	0.57 (67)
CHCC Total	**169**	**1 May (4/8-6/5; 163)**	**3.0**	**44% (510)**	**1.33 (0-3; 169)**	**0.66 (169)**

[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

Table 12. Productivity of Pelagic Cormorants, Black Oystercatchers, and Western Gulls at Point Reyes Headlands, Devil's Slide Rock and Mainland, and Castle Rocks & Mainland, 2016. Means are accompanied by ranges and n in parenthesis.

	Pelagic Cormorant				Black Oystercatcher				Western Gull			
Colony	Number of Breeding Sites	Number of Chicks Fledged	Number of Chicks Fledged/ Pair (Productivity)	Breeding Success/ Nest[1]	Number of Breeding Sites	Number of Chicks Fledged	Number of Chicks Fledged/ Pair (Productivity)	Breeding Success/ Nest[1]	Number of Breeding Sites	Number of Chicks Fledged	Number of Chicks Fledged/ Pair (Productivity)	Breeding Success/ Nest[1]
DSRM	36	12	0.33 (0-2; 36)	0.17	0	-	-	-	4	2	0.50 (0-2; 4)	0.25 (4)
CHCC	6	4	0.67 (1-3; 6)	0.33	5	1	0.20 (0-1; 5)	0.20 (5)	11	8	0.73 (0-3; 11)	0.45 (11)

[1] Breeding success per nest is defined as the proportion of egg-laying nests that fledged at least one chick.

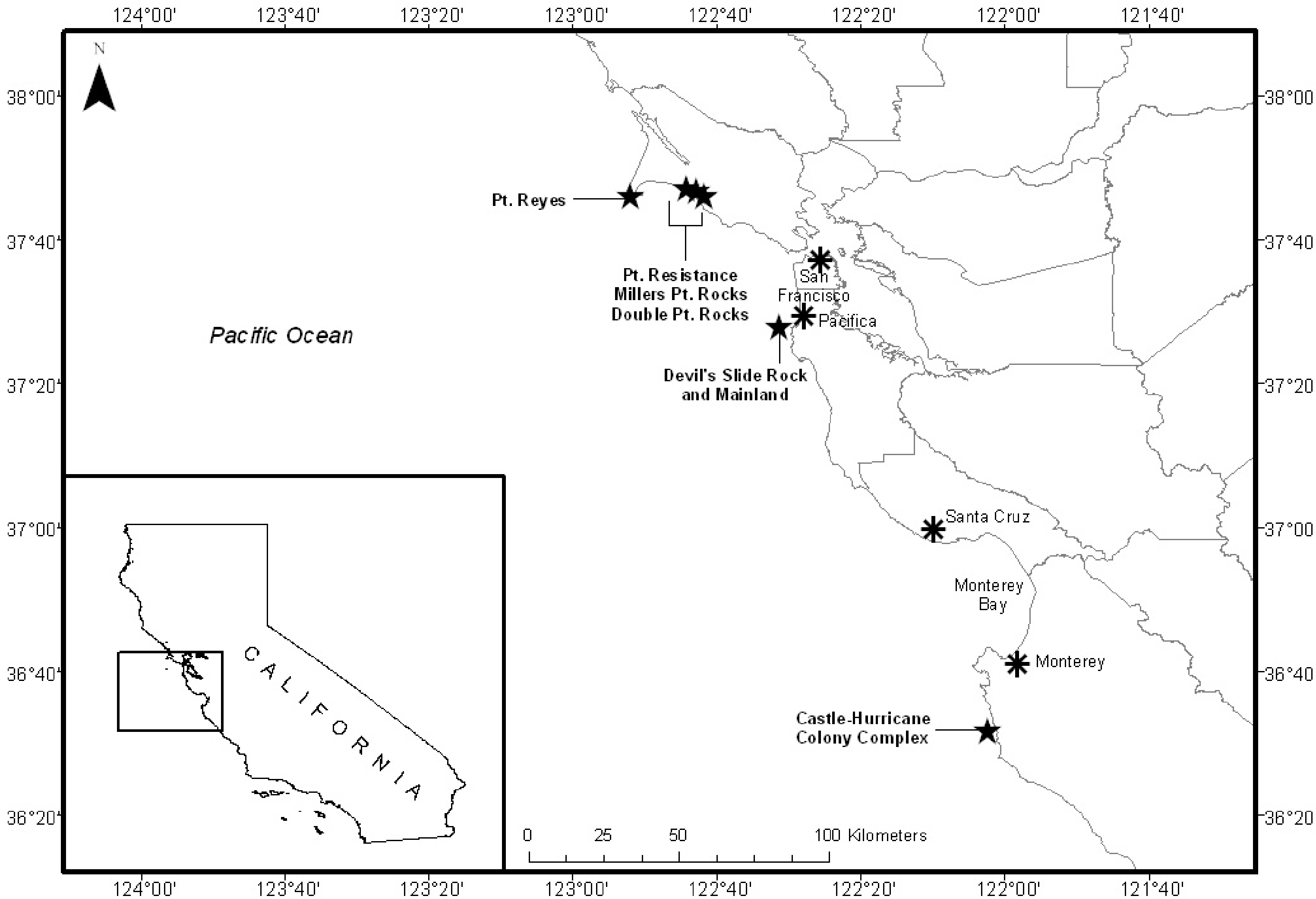


Figure 1. Study area showing locations of study colonies or colony complexes along the Central California coast where seabird disturbance, attendance and breeding biology were monitored. Pt. Resistance, Miller's Pt. and Double Pt. were not monitored in 2017.

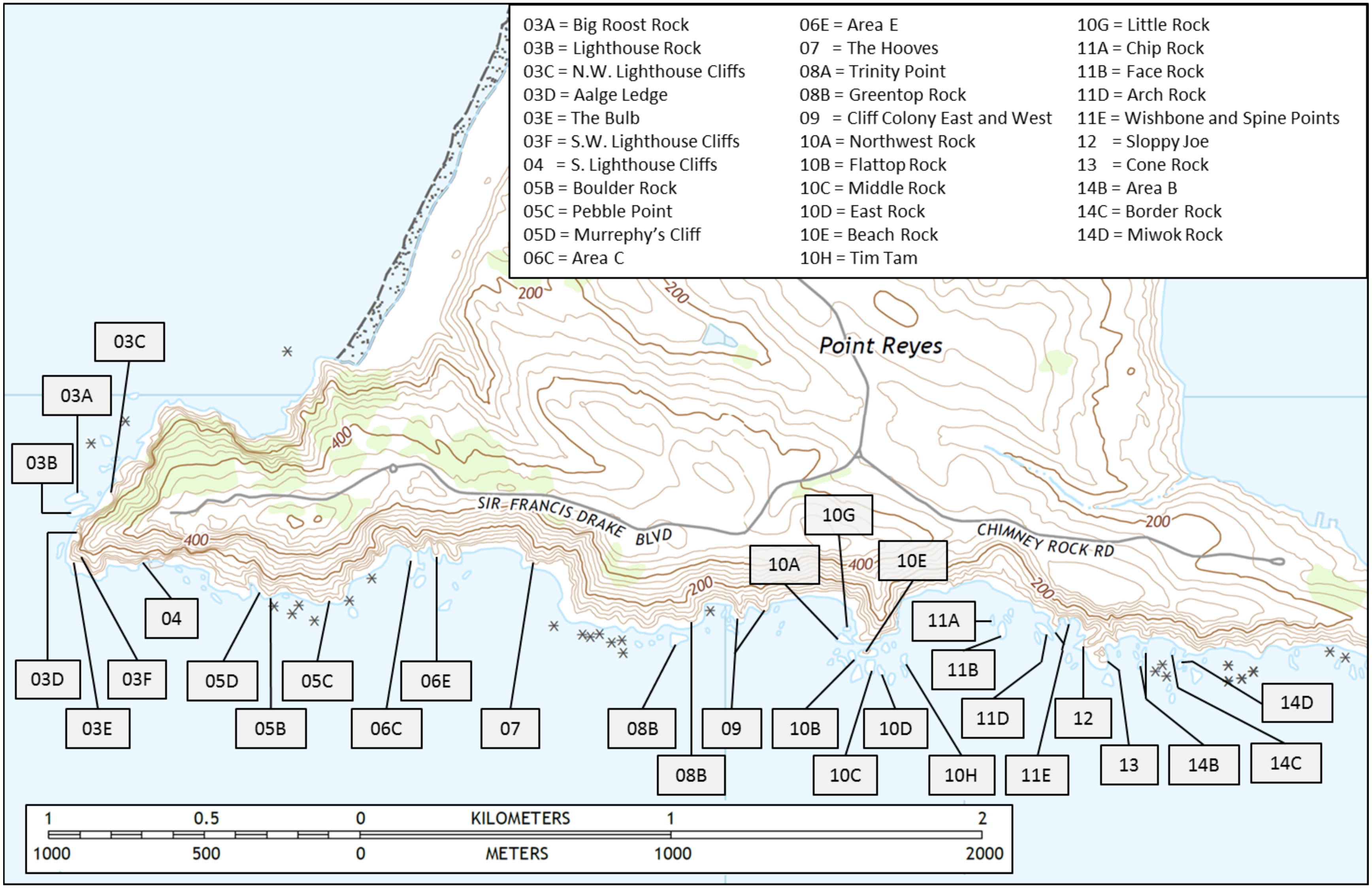


Figure 2. Point Reyes Headlands, including subcolonies 03A through 14D.

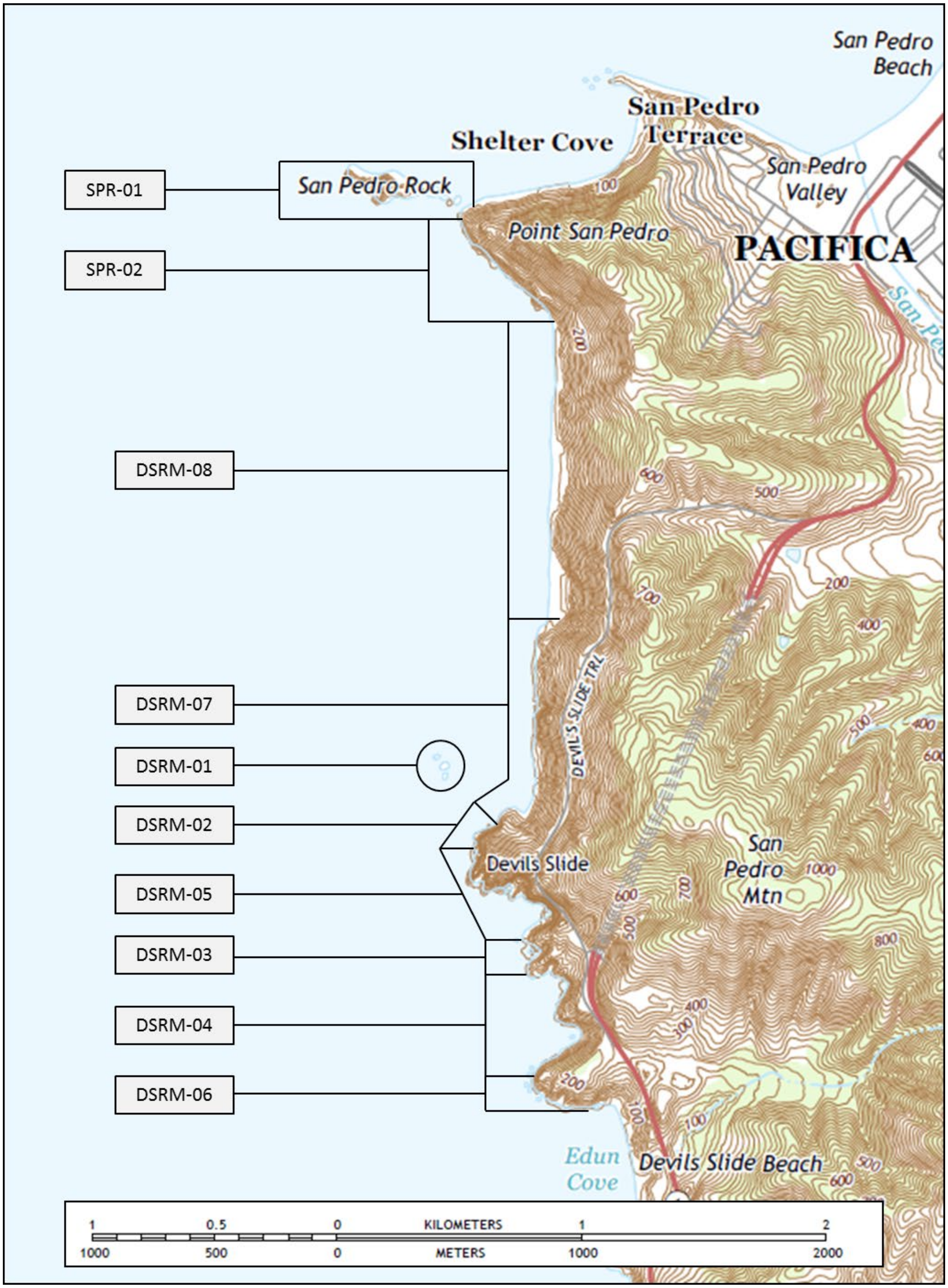


Figure 3. Devil's Slide Colony Complex, including San Pedro Rock and Devil's Slide Rock & Mainland colonies and subcolonies.

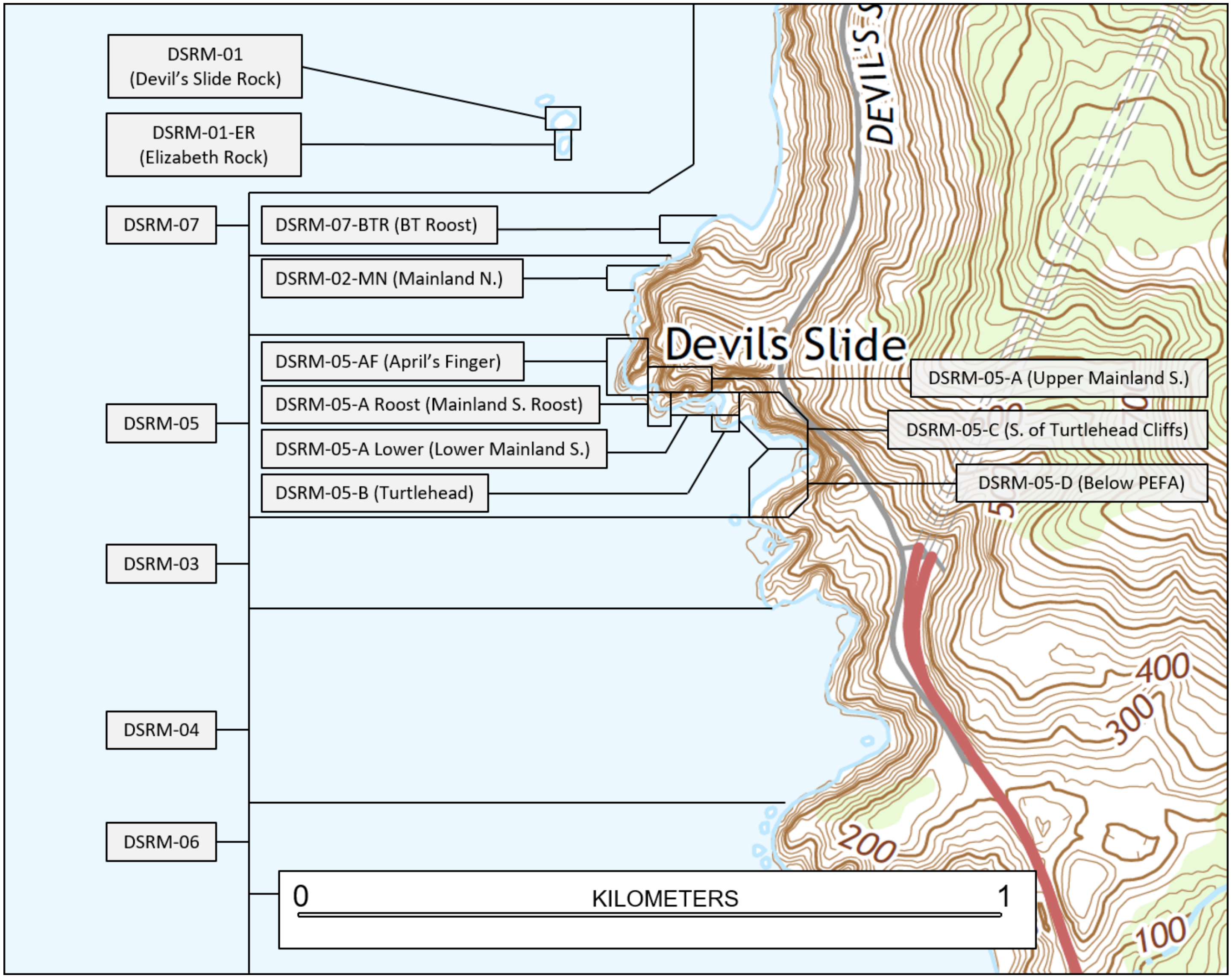


Figure 4. Devil's Slide Colony close-up, showing all subcolonies within DSRM-01, 07, 02 and 05.

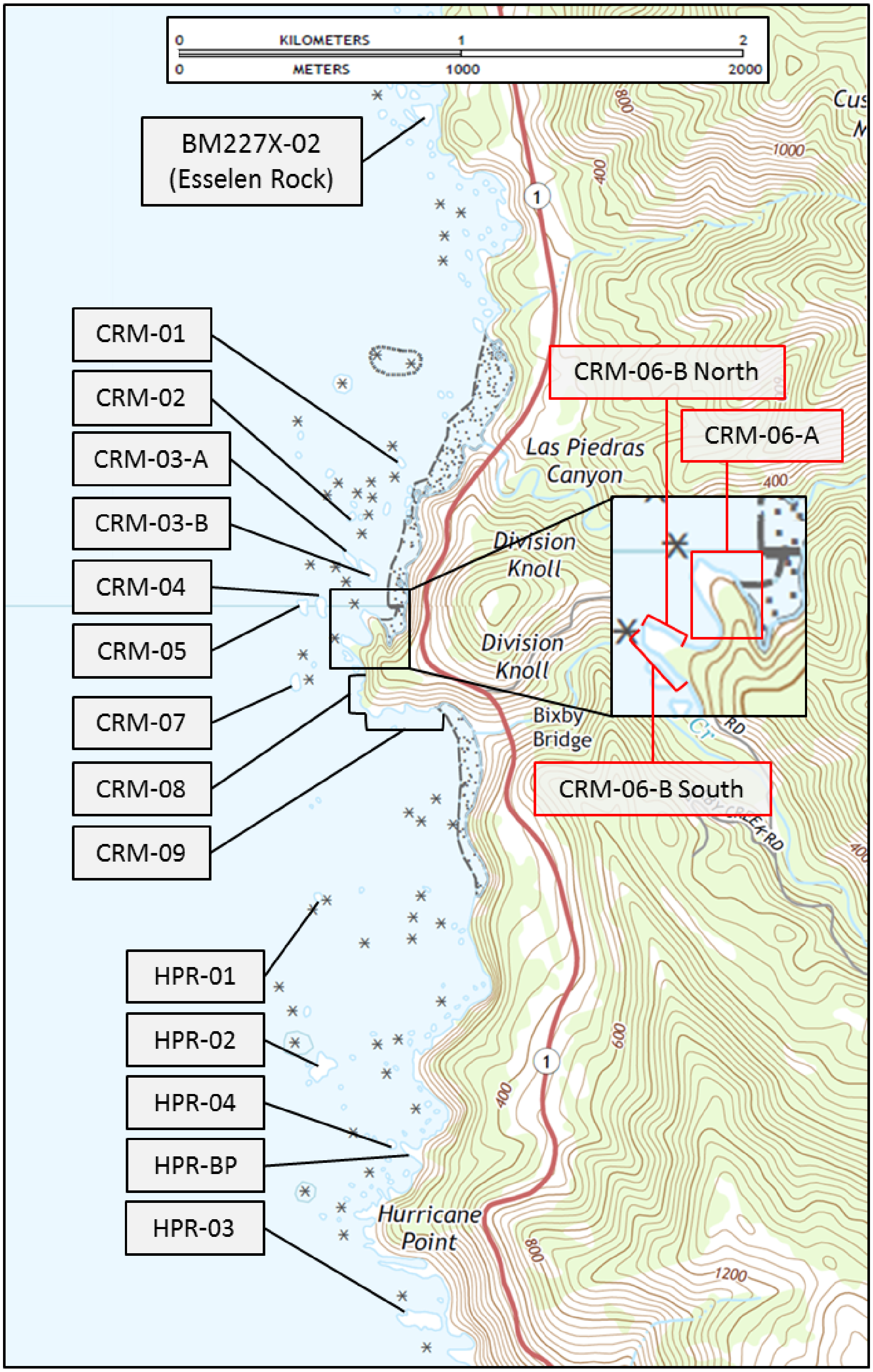


Figure 5. Castle-Hurricane Colony Complex, including Bench Mark-227X (BM227X), Castle Rocks and Mainland (CRM), and Hurricane Point Rocks (Hurricane) colonies and subcolonies.

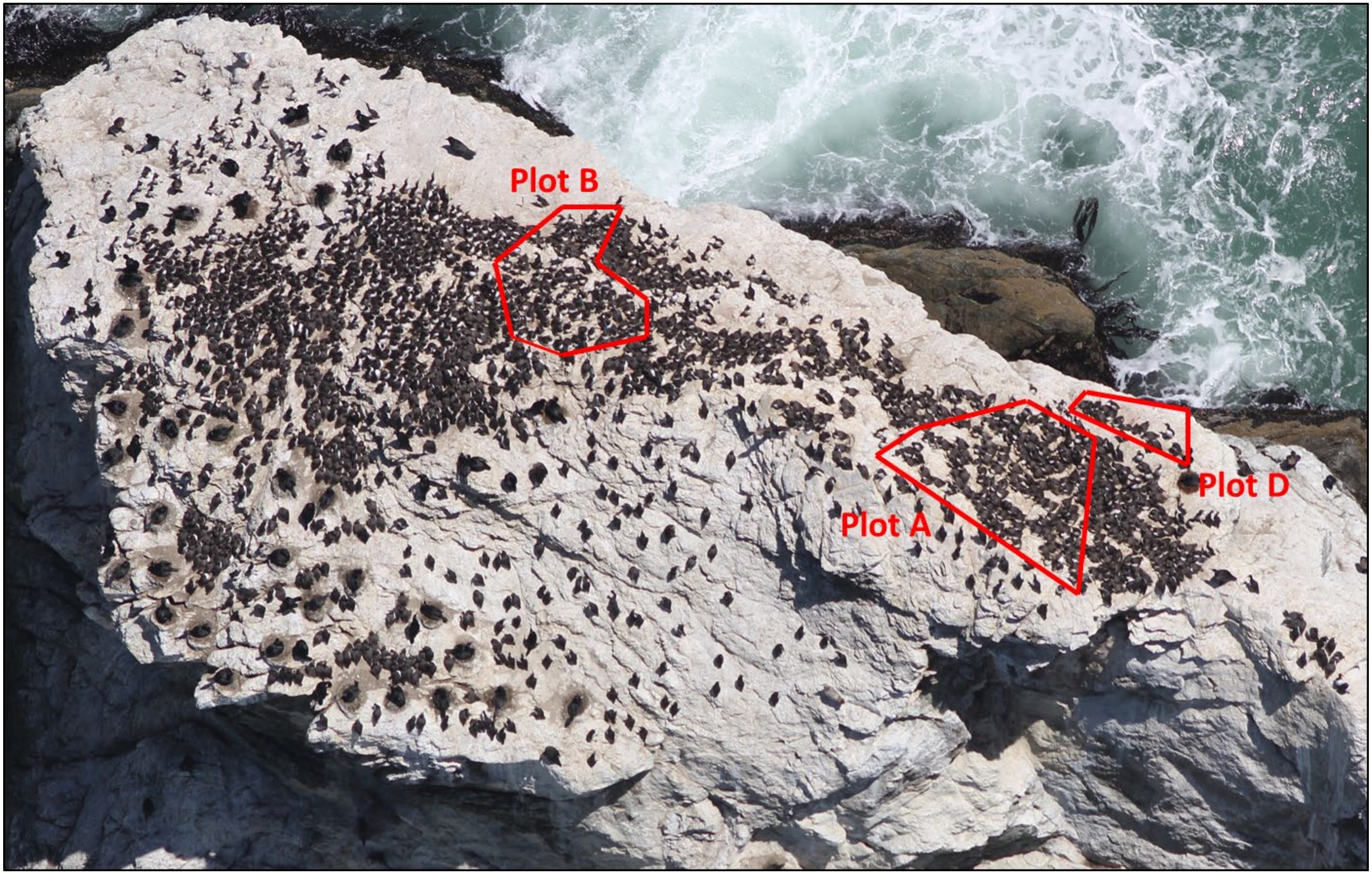


Figure 6. Aerial photograph of Devil's Slide Rock, 17 June 2017, showing the distribution of the Common Murre and Brandt's Cormorant breeding colony and boundaries of murre productivity plots.

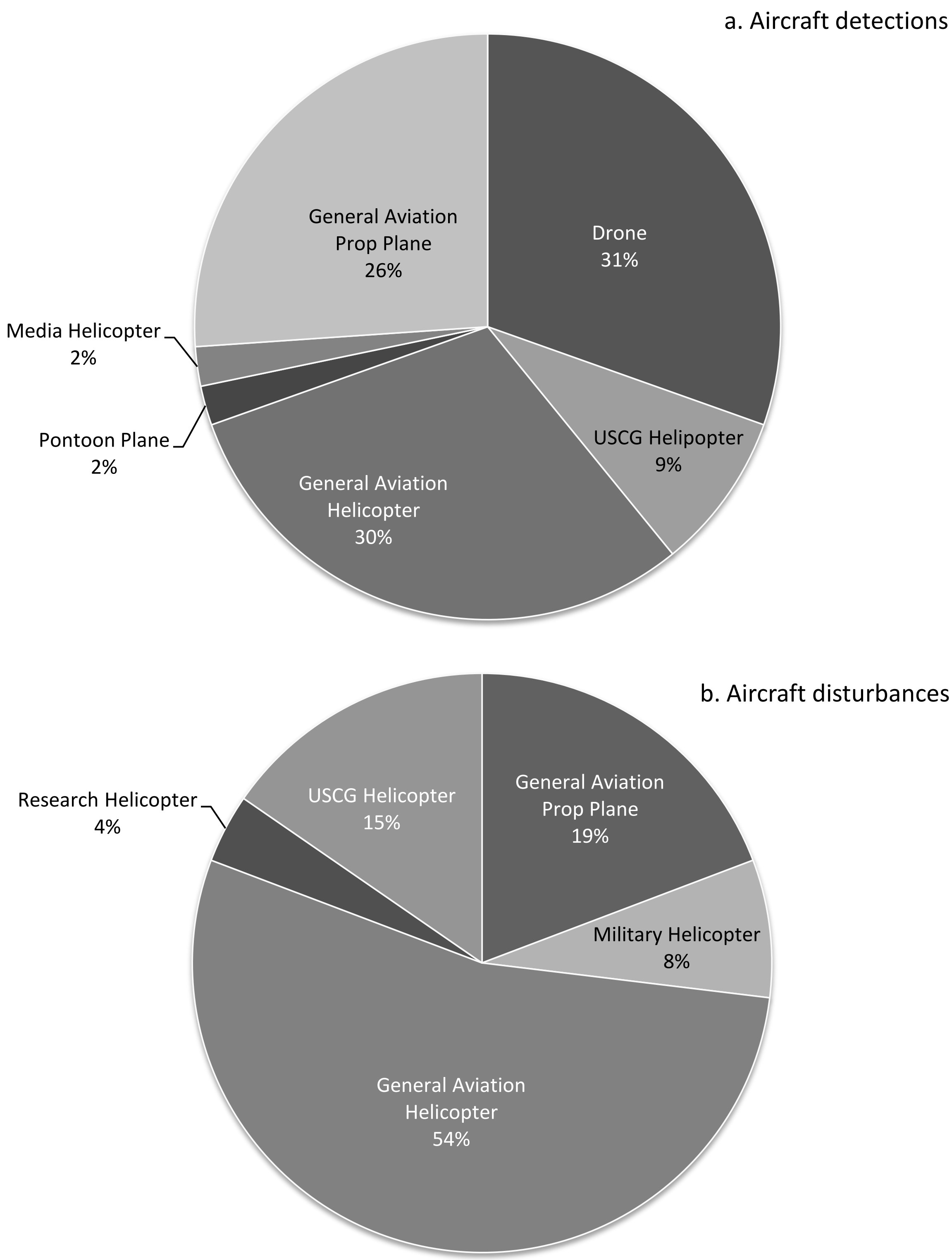
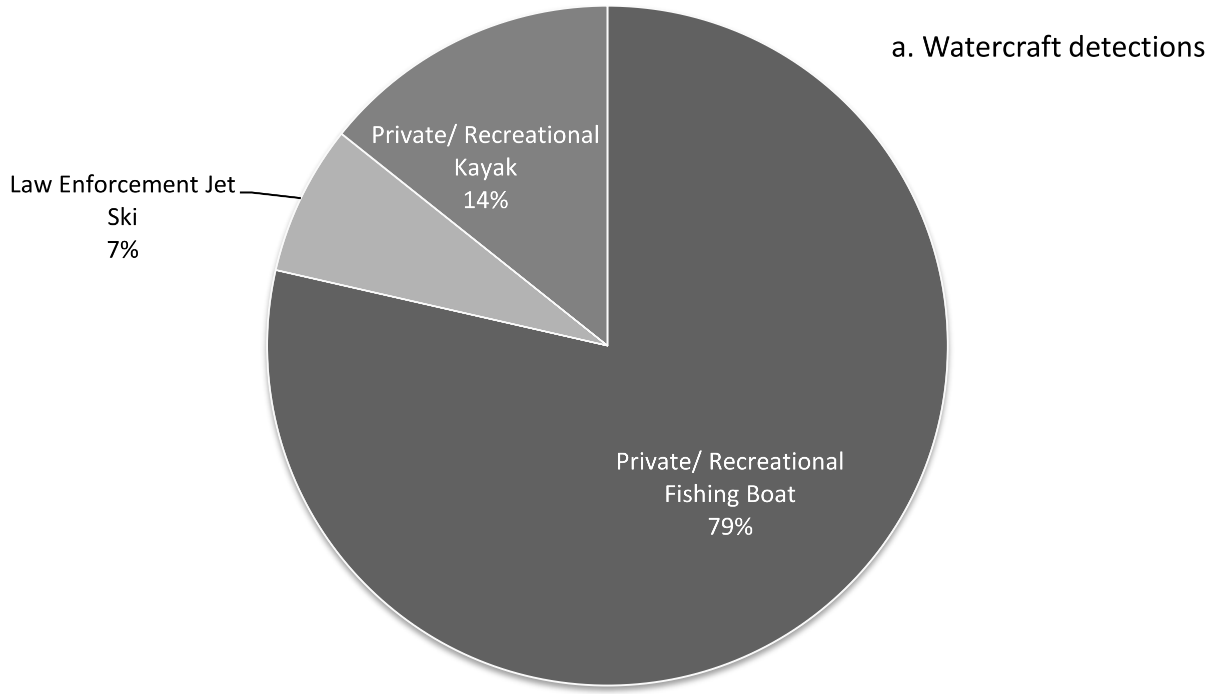


Figure 7. a. Aircraft detections (n = 46) and b. aircraft disturbances (n = 26) at Point Reyes Headlands, Devil's Slide Rock and Mainland and Castle-Hurricane Colony Complex combined in 2017, categorized by type.



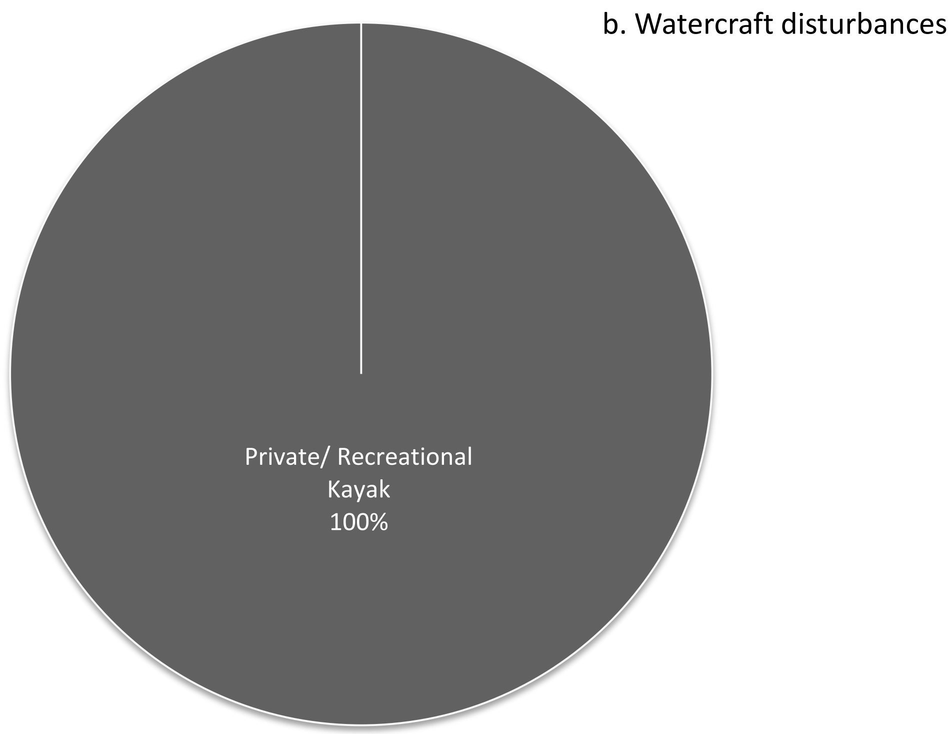


Figure 8. a. Watercraft detections (n = 14) and b. watercraft disturbances (n = 1) at Point Reyes Headlands, Devil's Slide Rock and Mainland and Castle Hurricane Colony Complex combined in 2017, categorized by type.

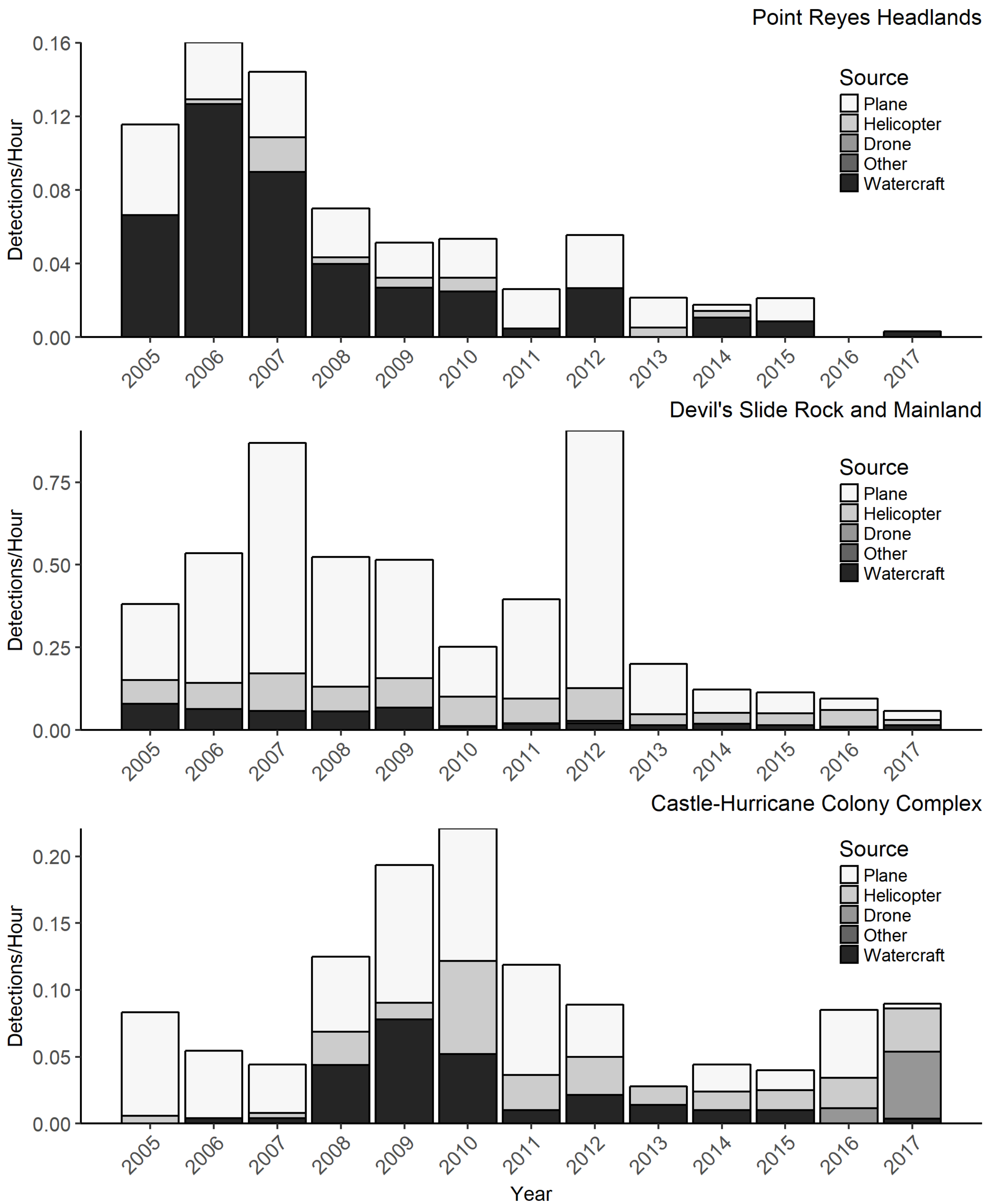


Figure 9. Detection rates (number of detections per observation hour) of watercraft, helicopters, planes, drones and other anthropogenic sources at Point Reyes Headlands, Devil's Slide Rock and Mainland, and Castle-Hurricane Colony Complex from 2001 to 2017. Note different scales between graphs.

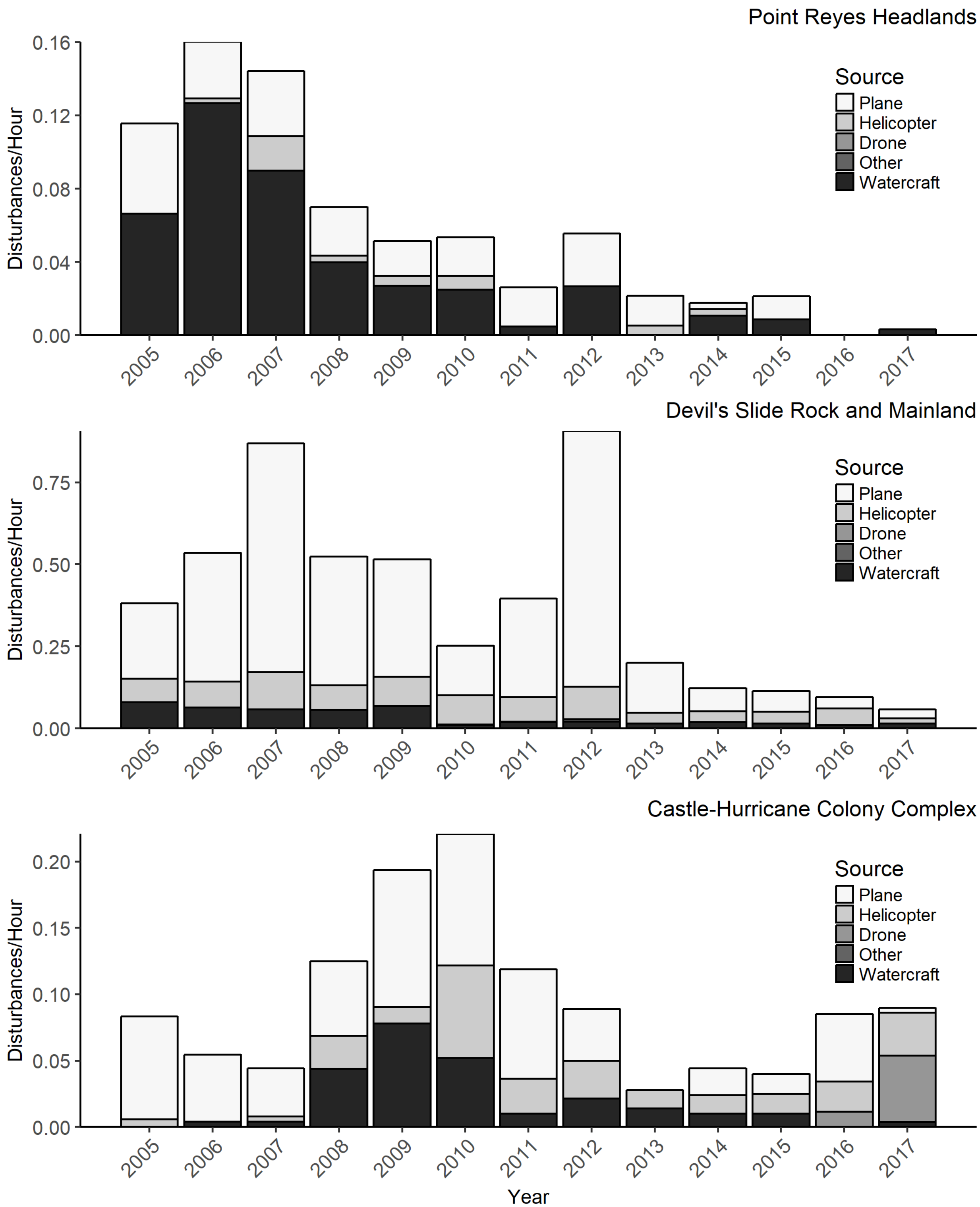


Figure 10. Disturbance rates (number of seabird disturbances per observation hour) from watercraft, helicopters, planes, and other anthropogenic sources at Point Reyes Headlands, Devil's Slide Rock and Mainland, and Castle-Hurricane Colony Complex from 2001 to 2017.

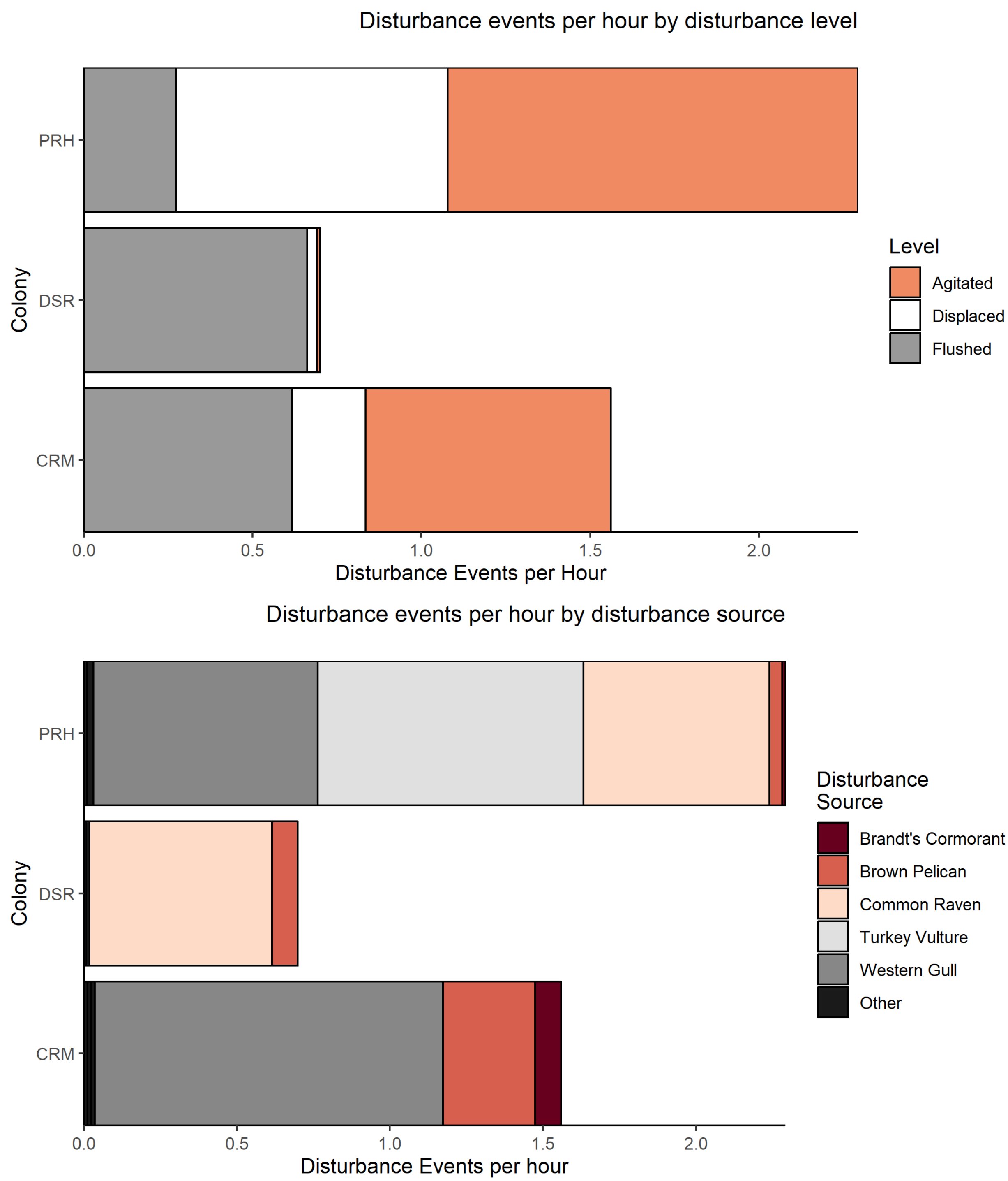


Figure 11. Non-anthropogenic disturbance events per hour during predator watch surveys, by disturbance level and disturbance source. Species included in "Other" caused five or less disturbance events and includes Canada Goose, Peregrine Falcon, California Gull, Pelagic Cormorant and unknown gull.

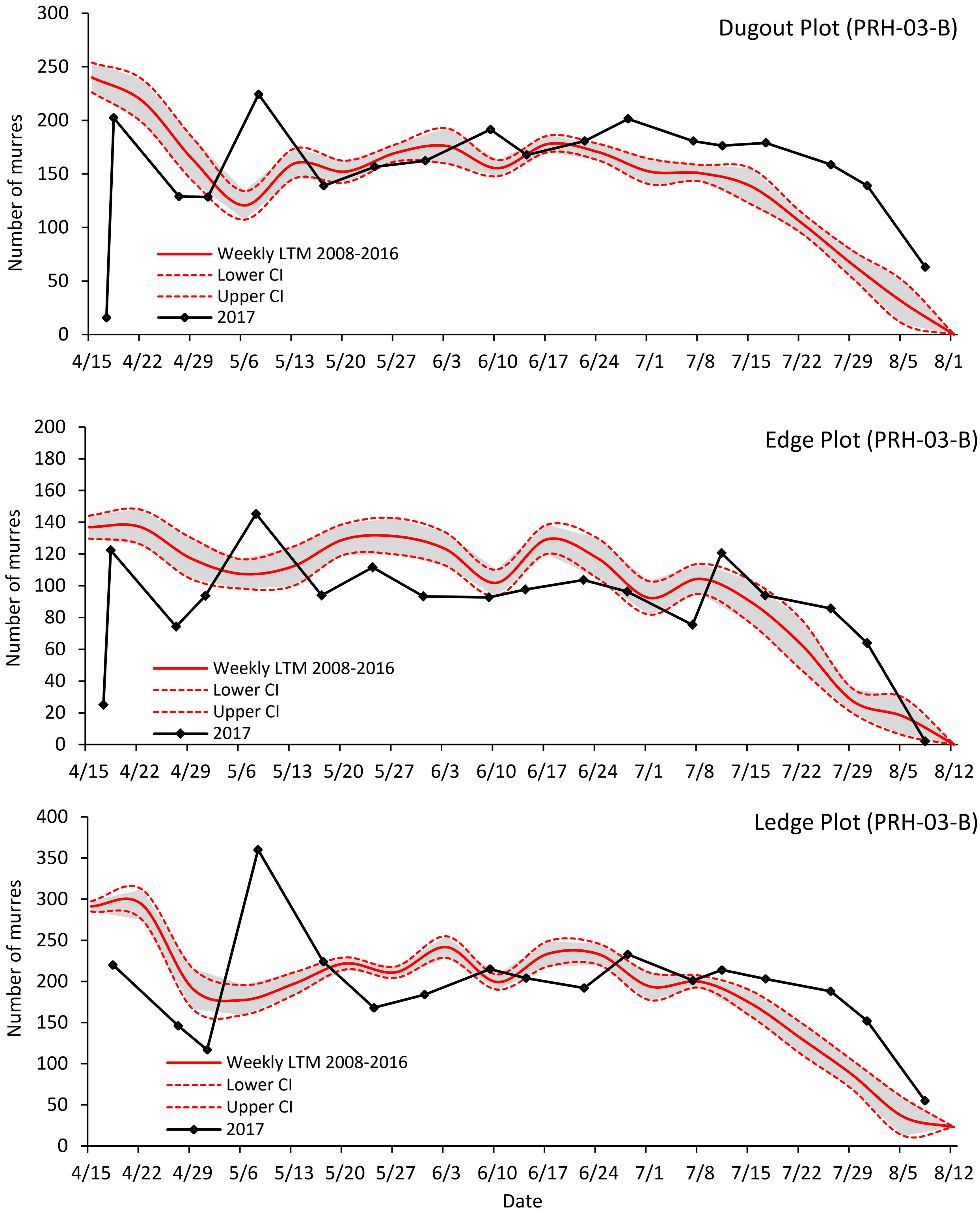


Figure 12. Seasonal attendance of Common Murres at Point Reyes Headlands Lighthouse Rock plots (three plots; PRH-03-B) and Devils Slide Mainland (DSM) in 2017 compared to long-term mean (LTM, 2008-2016).

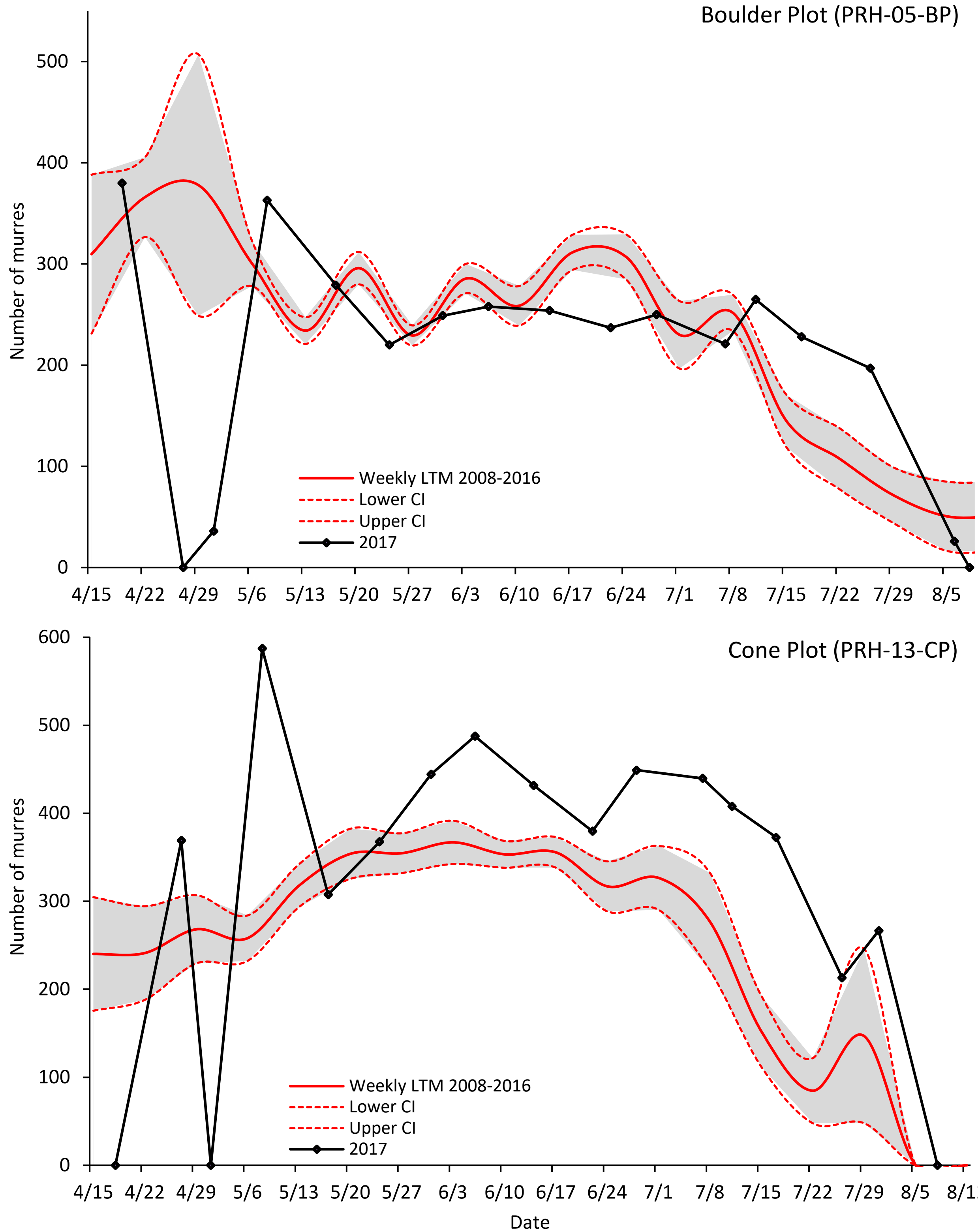


Figure 13. Seasonal attendance of Common Murres at Point Reyes Headlands (subcolonies: PRH-05-BP and PRH-13-CP) in 2017 compared to long-term mean (LTM, 2008-2016).

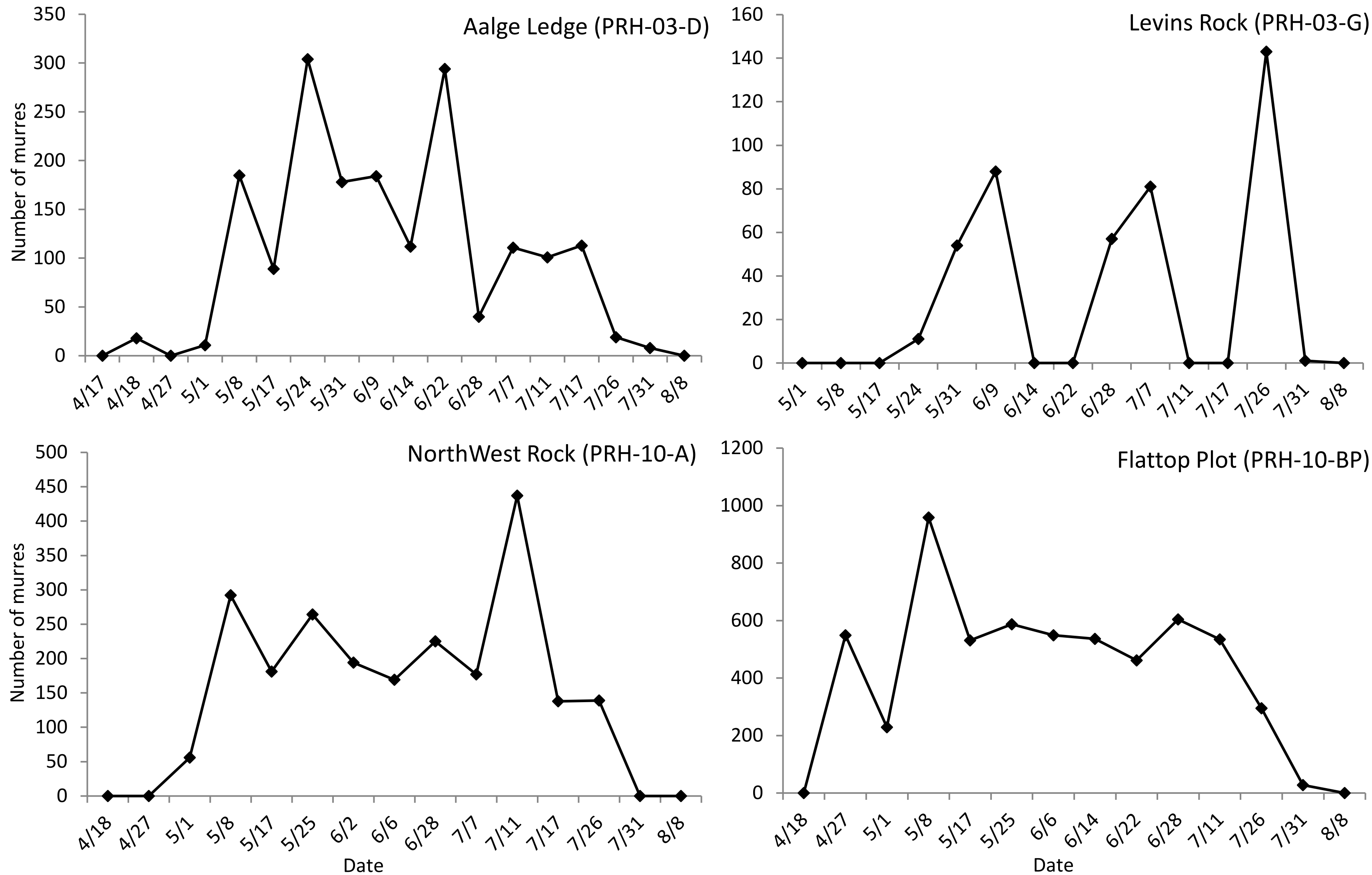


Figure 14. Seasonal attendance of Common Murres at Point Reyes Headlands (subcolonies: PRH-03-D, 03-G, 10-A and 10-BP) from 18 April to 8 August, 2017.

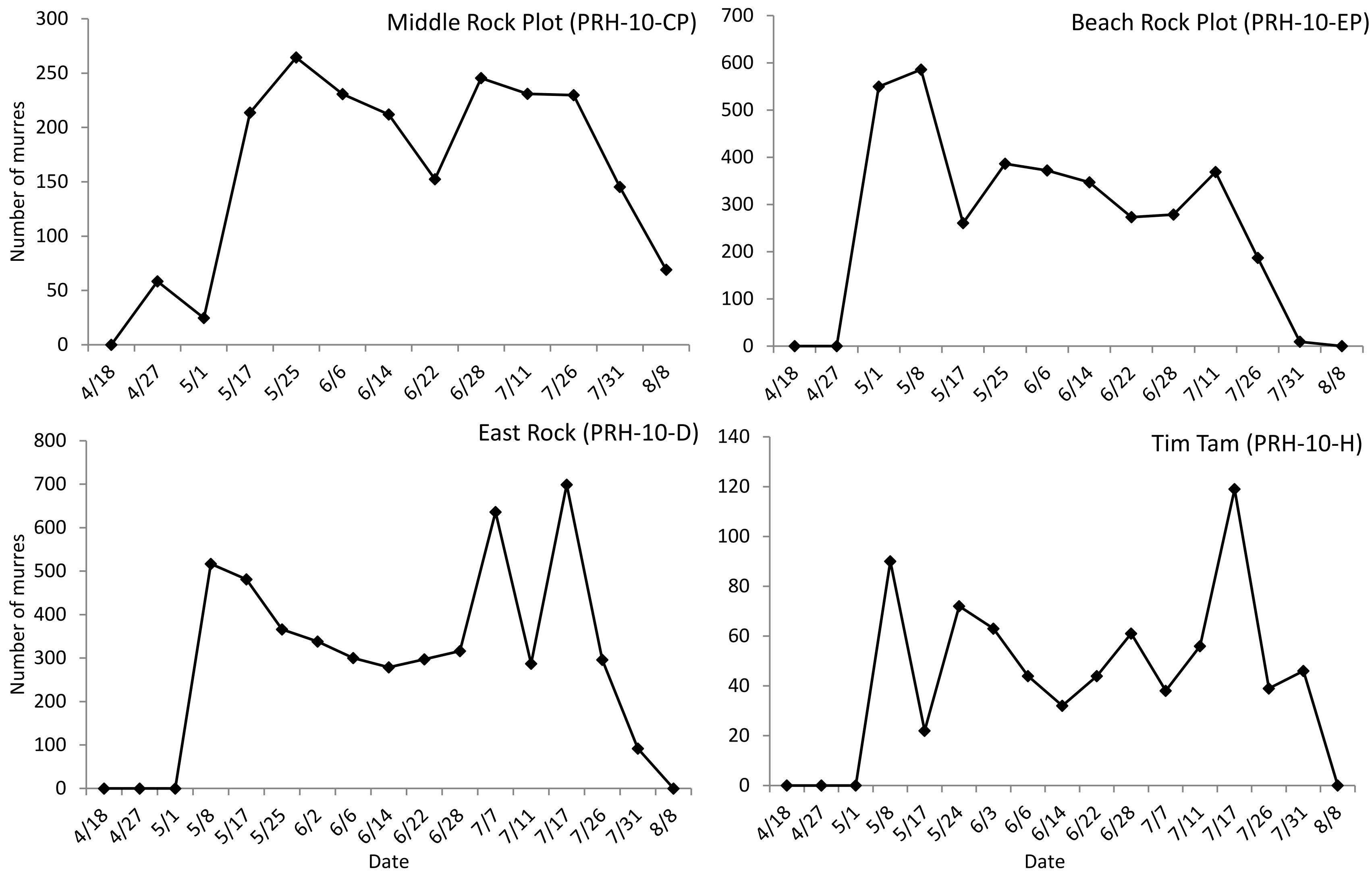


Figure 15. Seasonal attendance of Common Murres at Point Reyes Headlands (subcolonies: PRH-10-CP, 10-EP, 10-D and 10-H) from 18 April to 8 August, 2017.

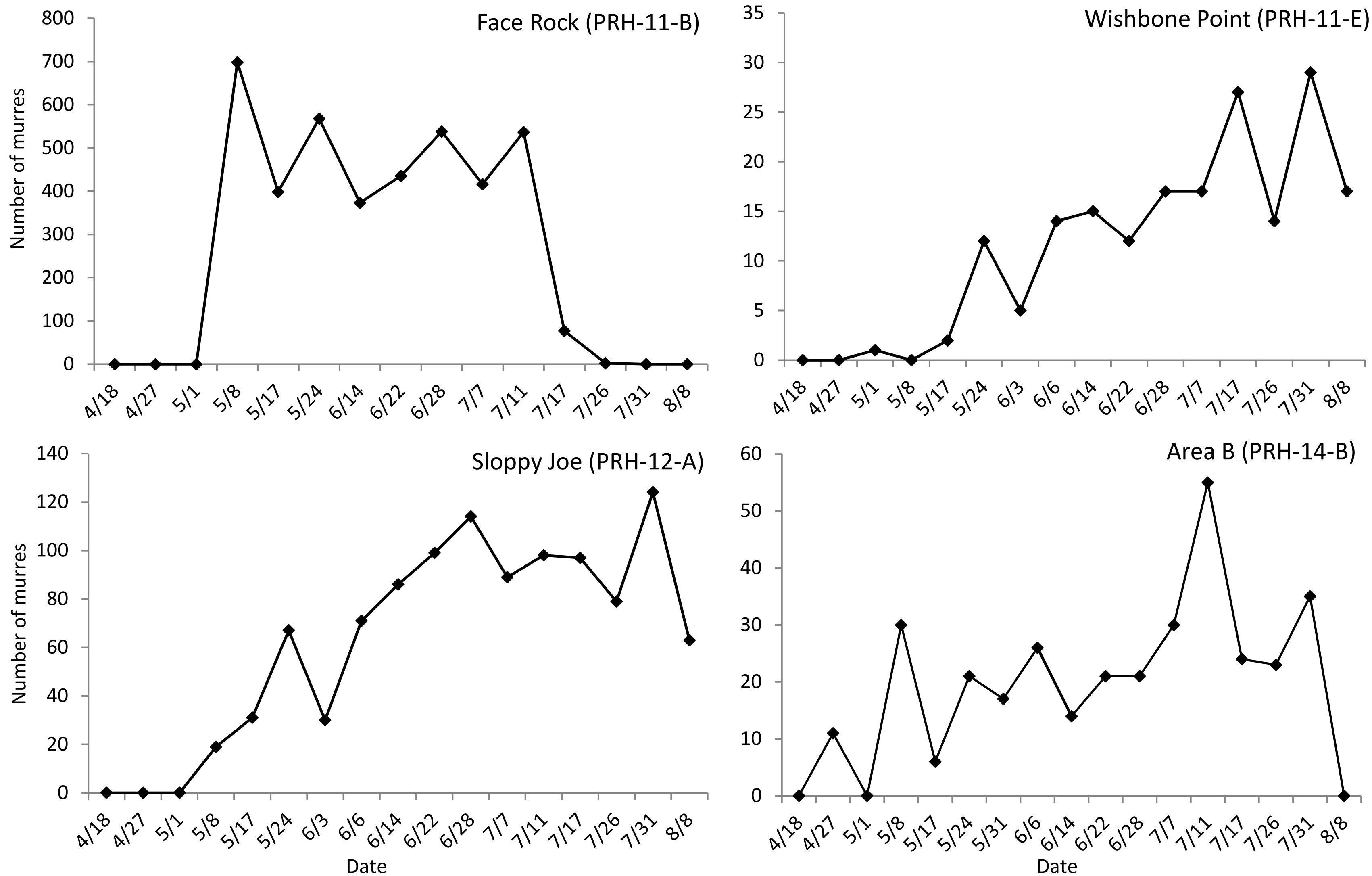


Figure 16. Seasonal attendance of Common Murres at Point Reyes Headlands (subcolonies: PRH-11-B, 11-E, 12-A and 14-B) from 18 April to 8 August, 2017.

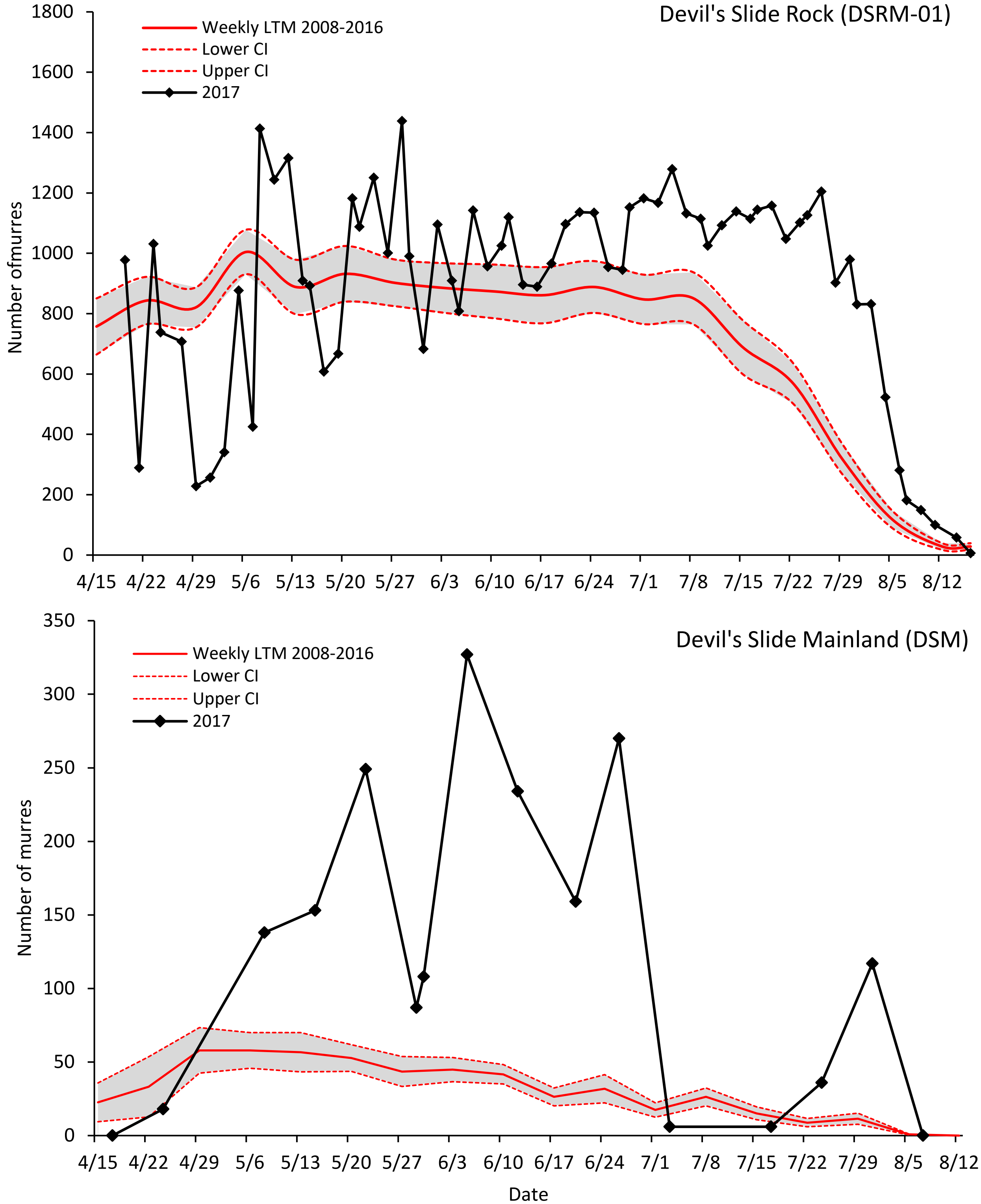


Figure 17. Seasonal attendance of Common Murres at Devil's Slide Rock (DSRM-01) and Devil's Slide Mainland (DSM) colonies in 2017 compared to long-term mean (LTM, 2008-2016).

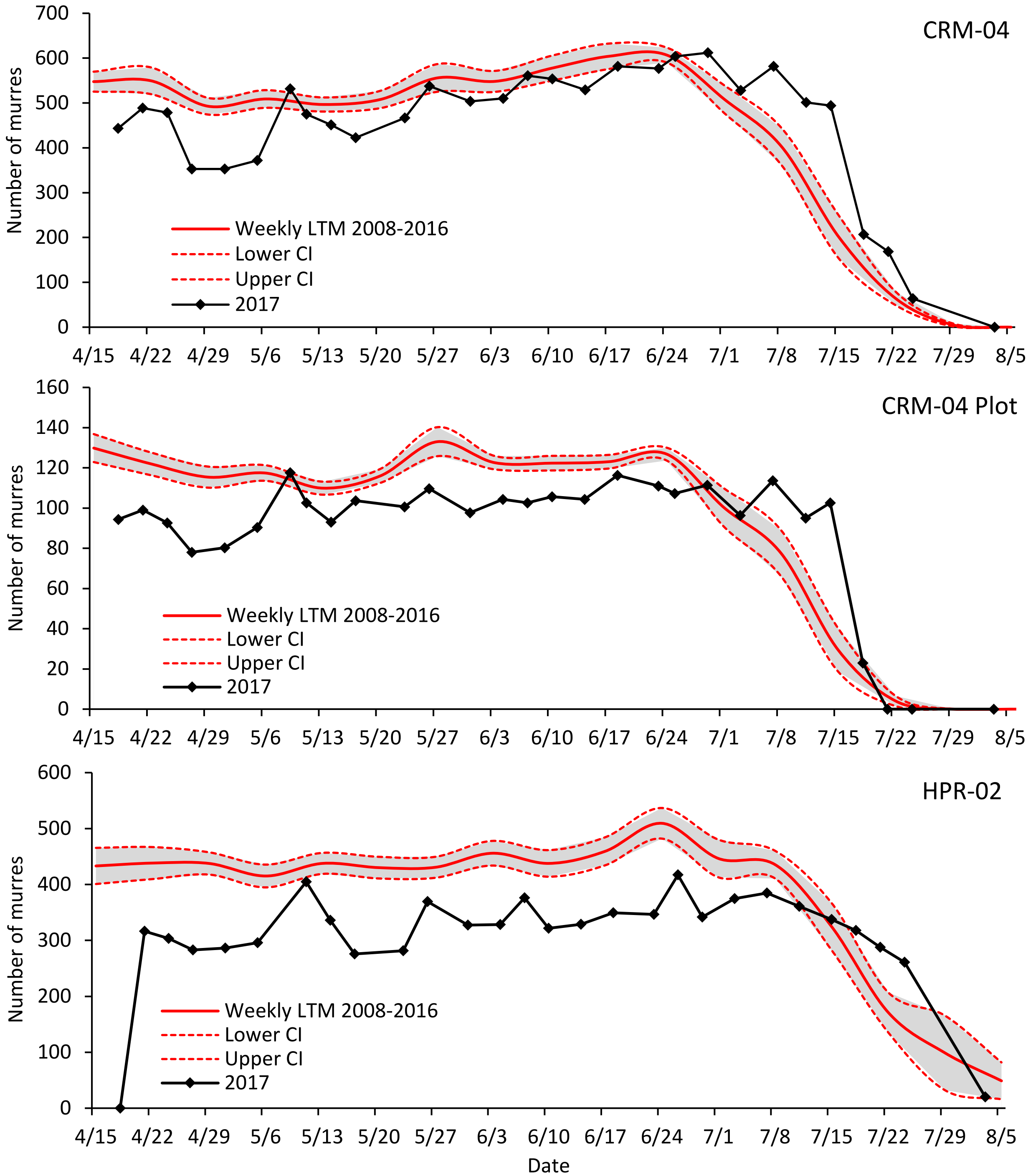


Figure 18. Seasonal attendance of Common Murres at Castle Rocks (CRM-04) and Castle Rock plot (CRM-04-P) and Hurricane Rocks colony HPR-02 in 2017 compared to long-term mean (LTM, 2008-2016).

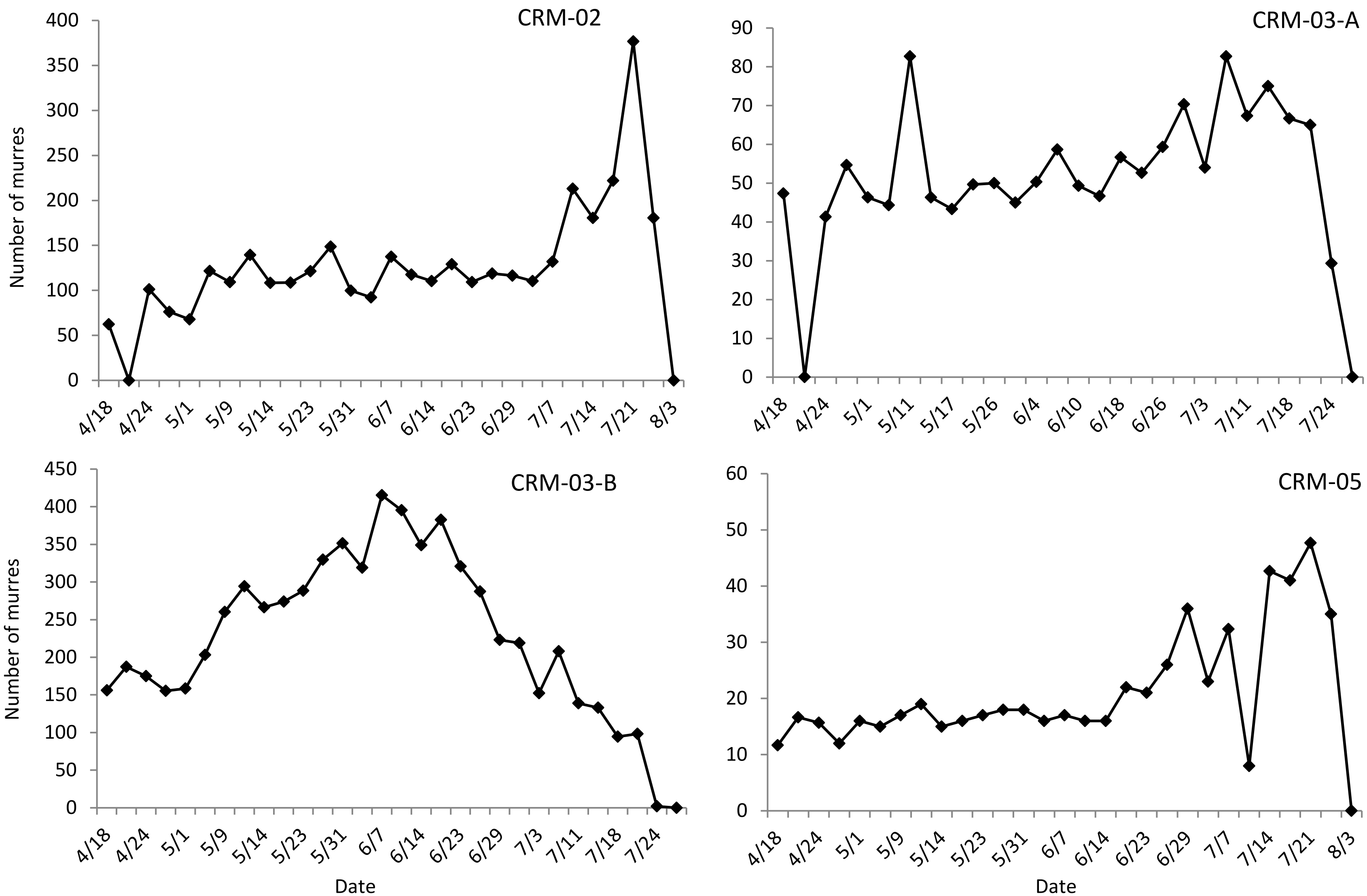


Figure 19. Seasonal attendance of Common Murres at Castle-Hurricane Colony Complex (subcolonies: CRM-02, 03-A, 03-B and 05) from 18 April to 3 August, 2017.

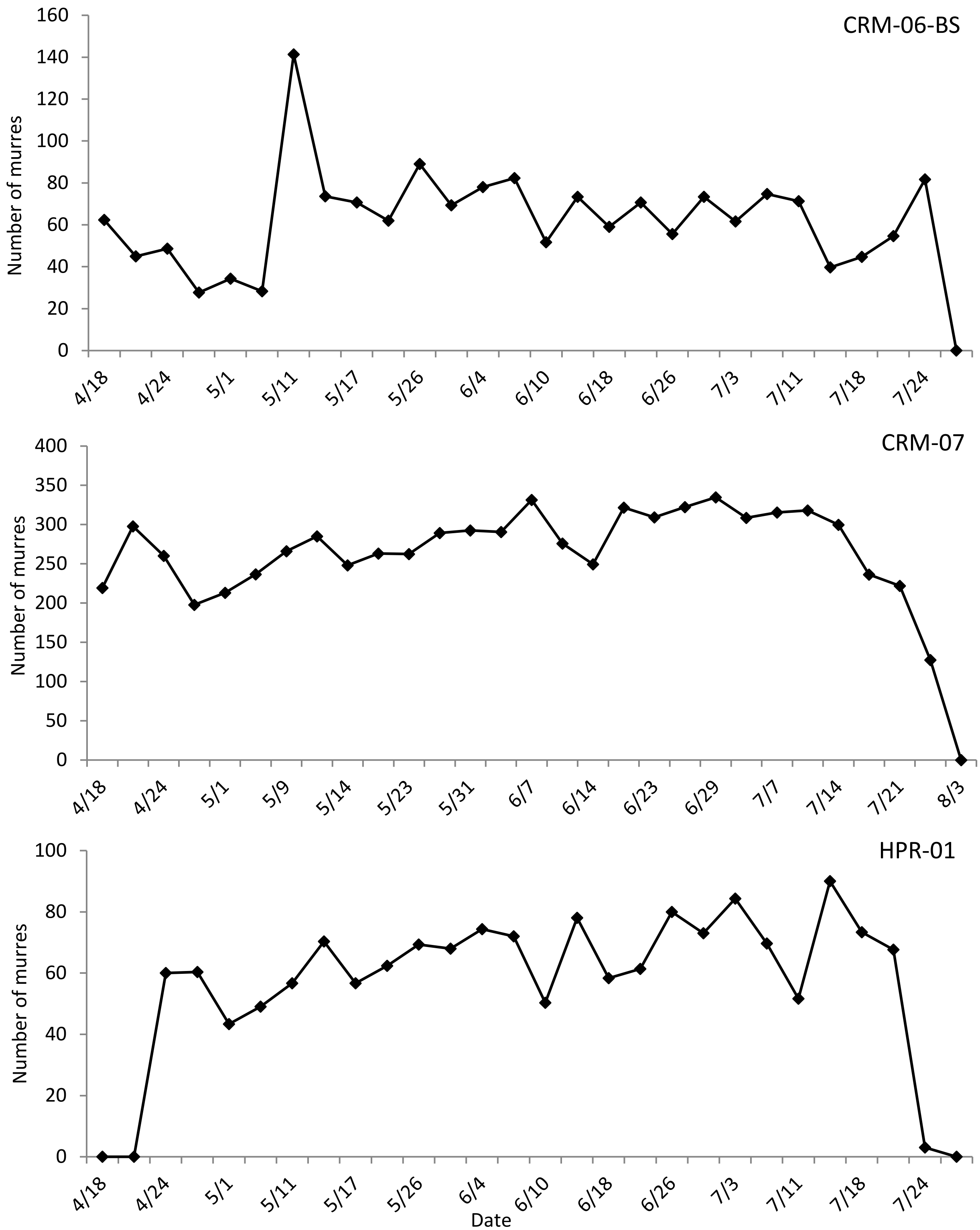


Figure 20. Seasonal attendance of Common Murres at Castle-Hurricane Colony Complex (subcolonies: CRM- 06-BS, 07 and HPR-01) from 18 April to 3 August, 2017.

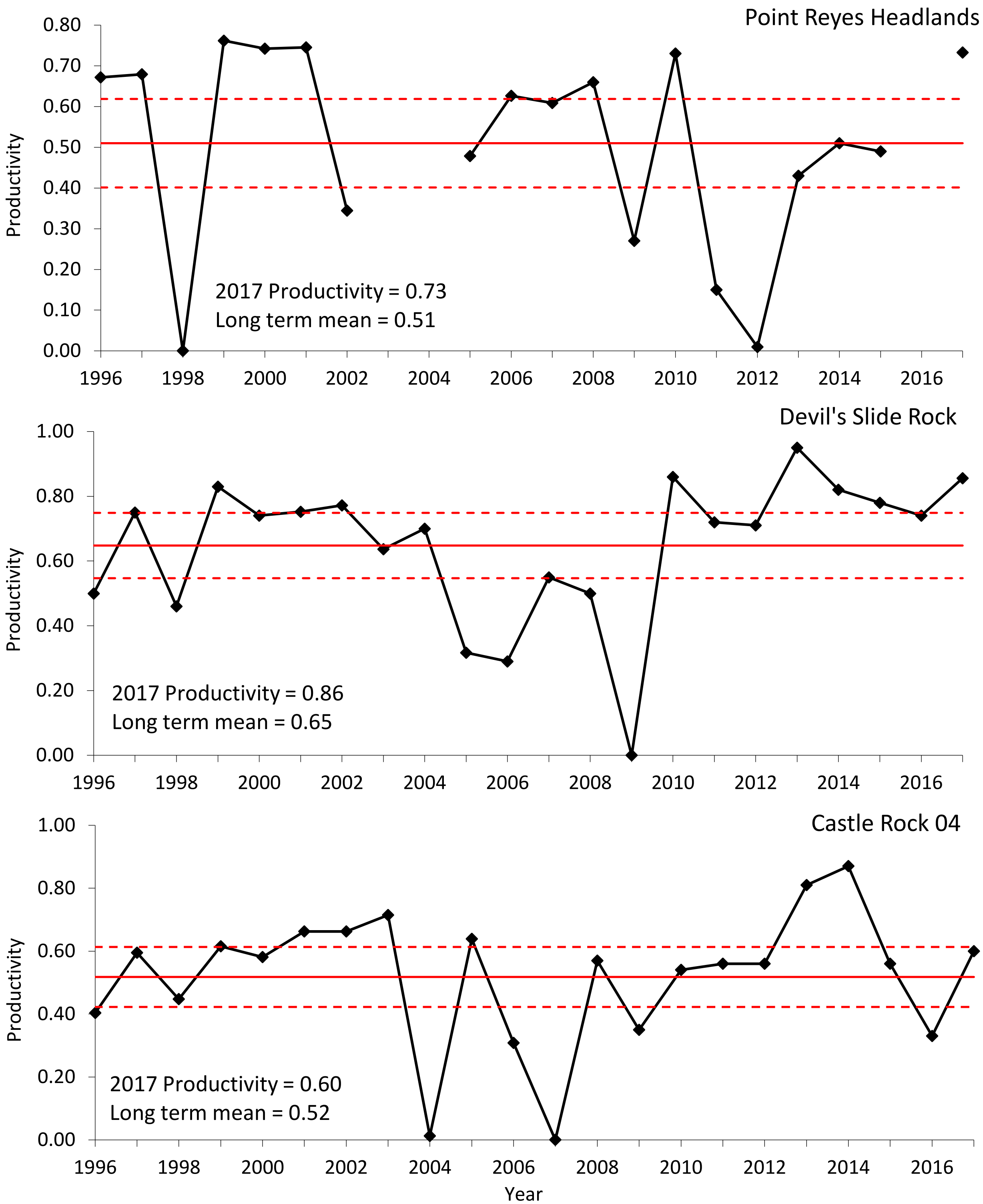


Figure 21. Productivity (chicks fledged per pair) of Common Murres at Point Reyes Headlands, Devil's Slide Rock and Castle Rock -04 from 1996-2017. The solid horizontal line indicates the long-term weighted mean (1996-2016) and the dashed lines represent the 95% confidence interval.

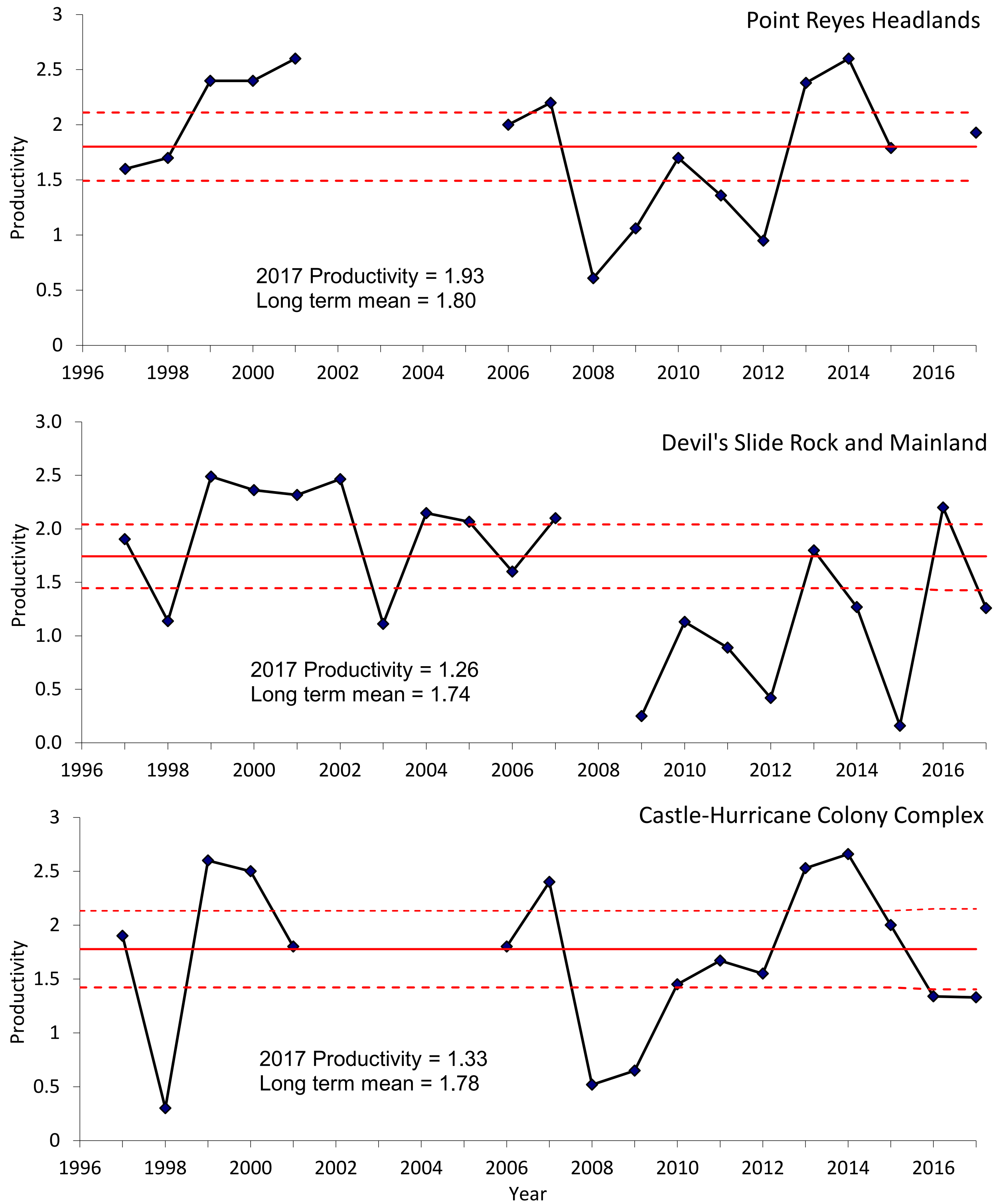


Figure 22. Productivity (chicks fledged per pair) of Brandt's Cormorants at Point Reyes Headlands, Devil's Slide Rock and Mainland and Castle-Hurricane Colony Complex from 1997-2017. The solid horizontal line indicates the long-term weighted mean (1996-2016) and the dashed lines represent the 95% confidence interval.

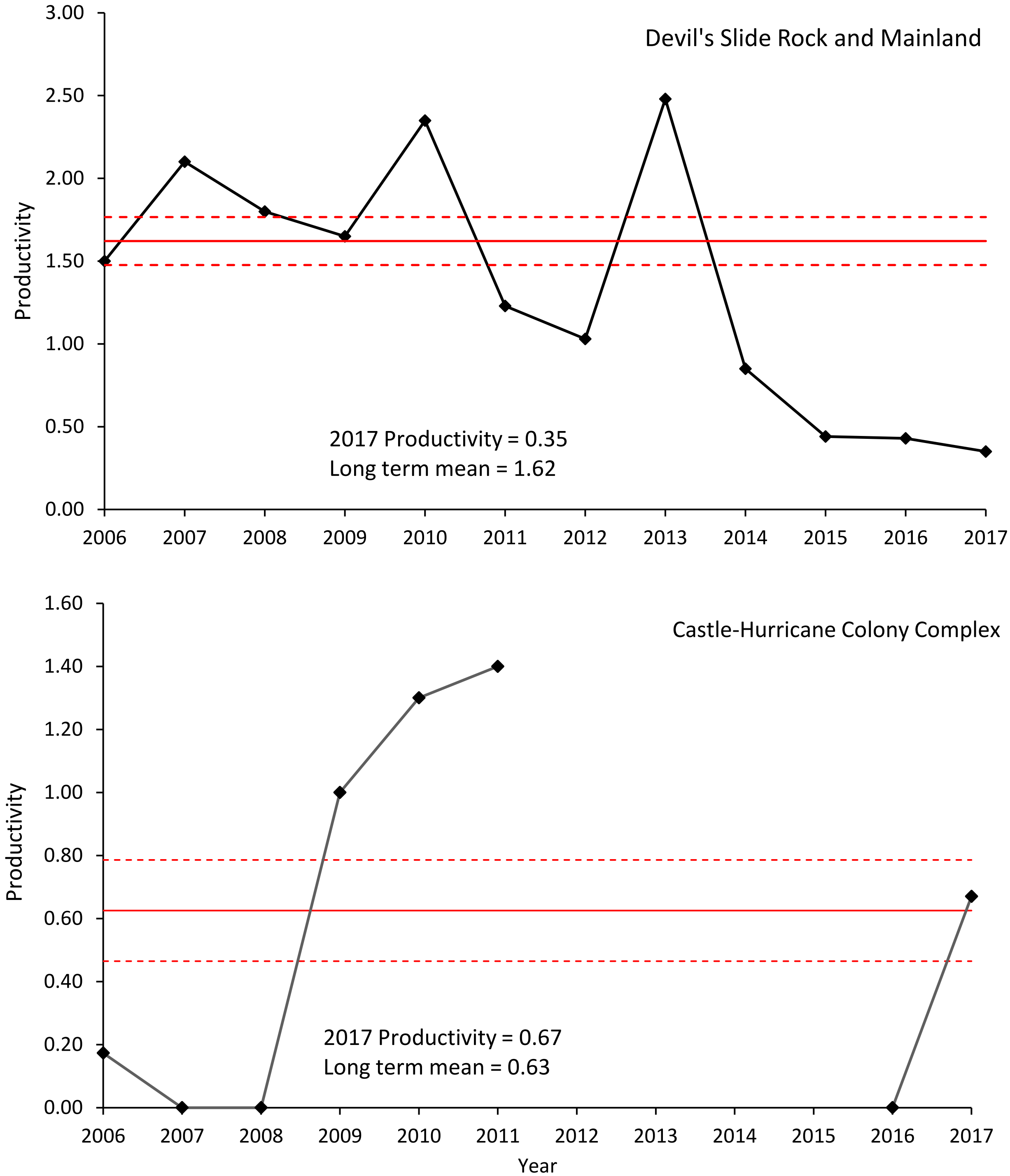
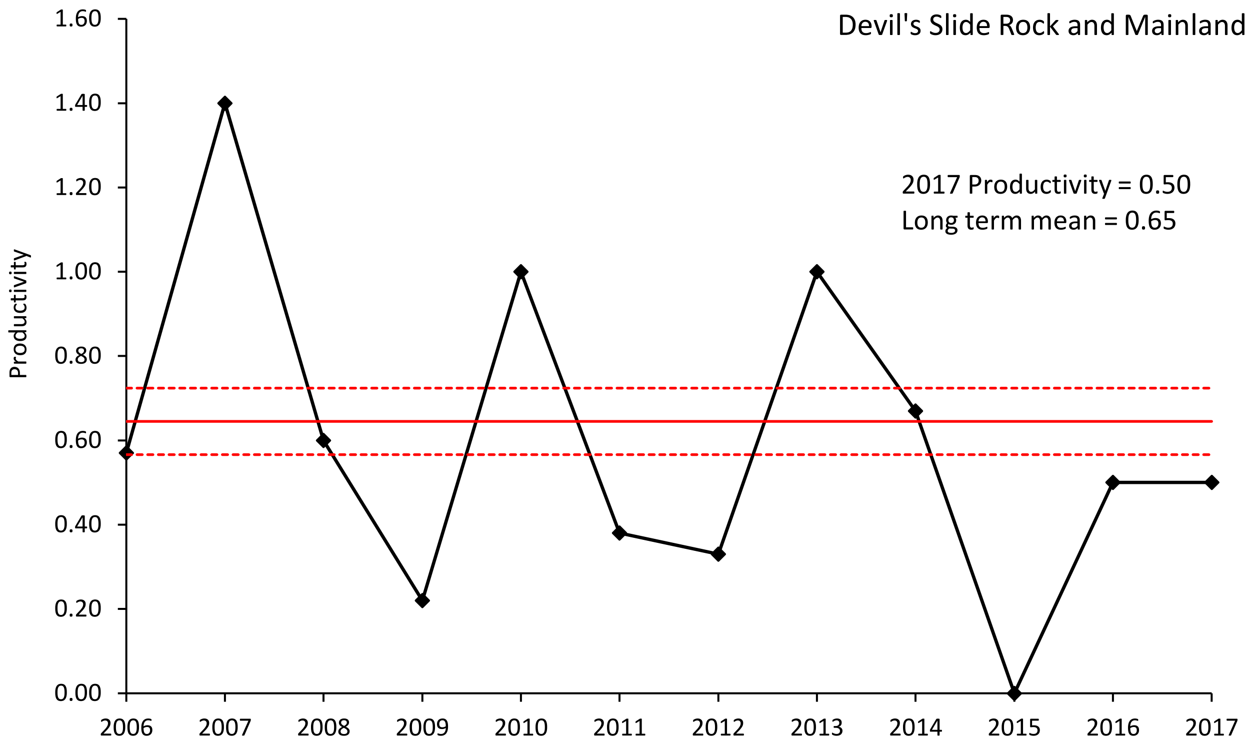


Figure 23. Productivity (chicks fledged per pair) of Pelagic Cormorants at Devil's Slide Rock and Mainland and Castle-Hurricane Colony Complex from 2006-2017. The solid horizontal line indicates the long-term weighted mean (2006-2016) and the dashed lines represent the 95% confidence interval. Data was not collected at CHCC for Pelagic Cormorants between 2012 - 2015.



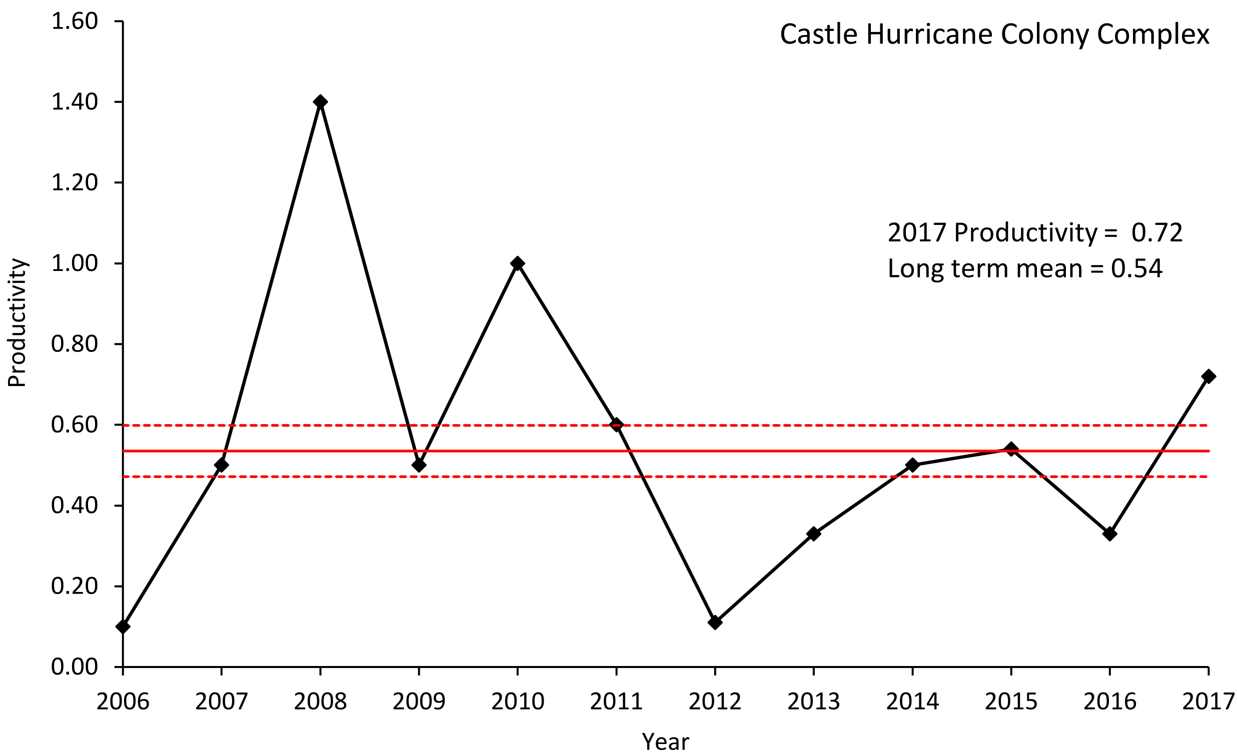


Figure 24. Productivity (chicks fledged per pair) of Western Gulls at Devil's Slide Rock and Mainland and Castle-Hurricane Colony Complex from 2006-2017. The solid horizontal line indicates the long-term weighted mean (2006-2016) and the dashed lines represent the 95% confidence interval.

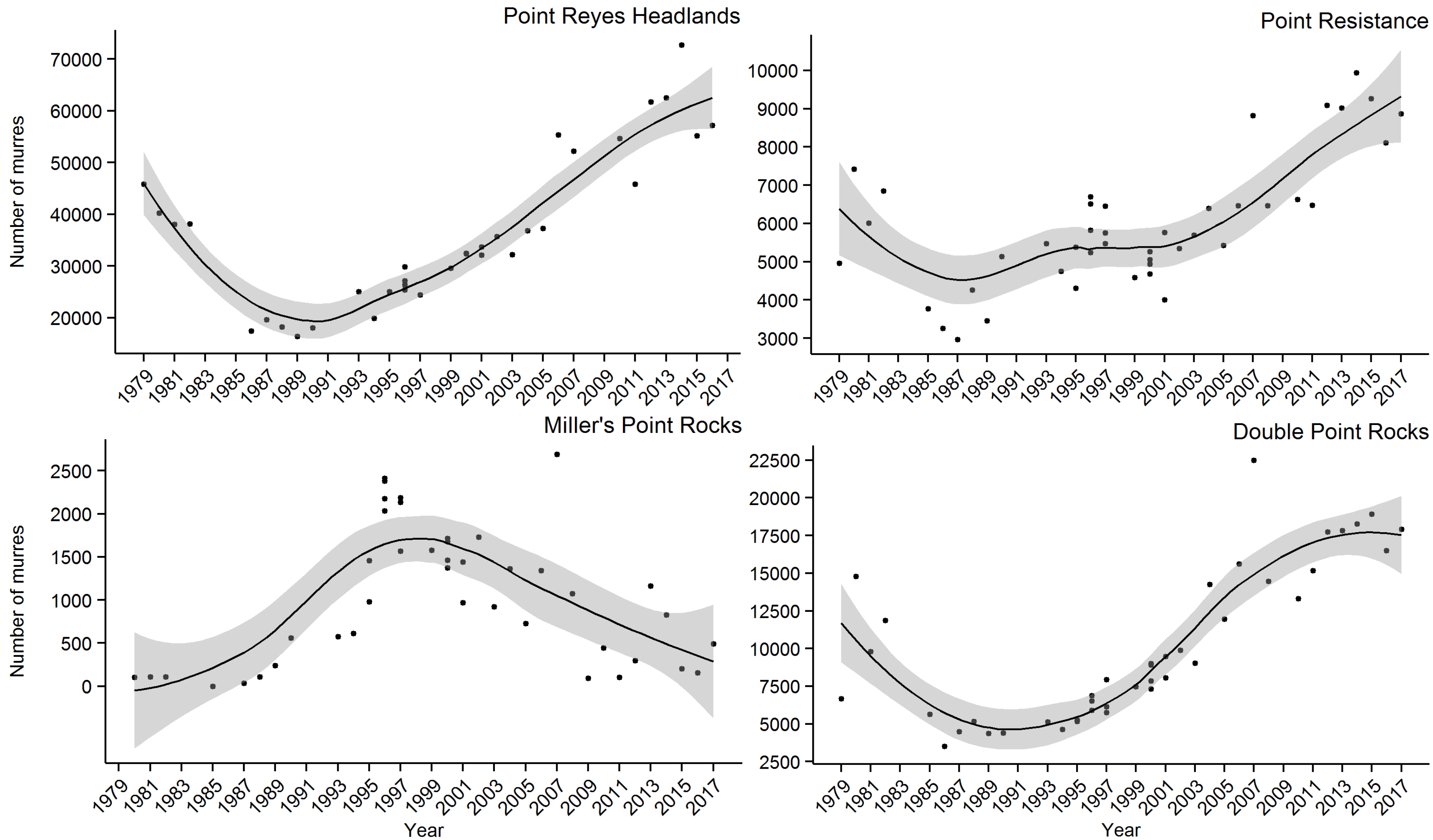


Figure 25. Common Murre breeding population trends at Point Reyes Headlands, Point Resistance, Millers Point Rocks and Double Point Rocks, 1979-2017. Data points are raw counts from aerial photographic surveys multiplied by correction factors (see Methods). LOESS curves (R Core Team, 2013) are shown with 95% confidence intervals. Note different scales between graphs.

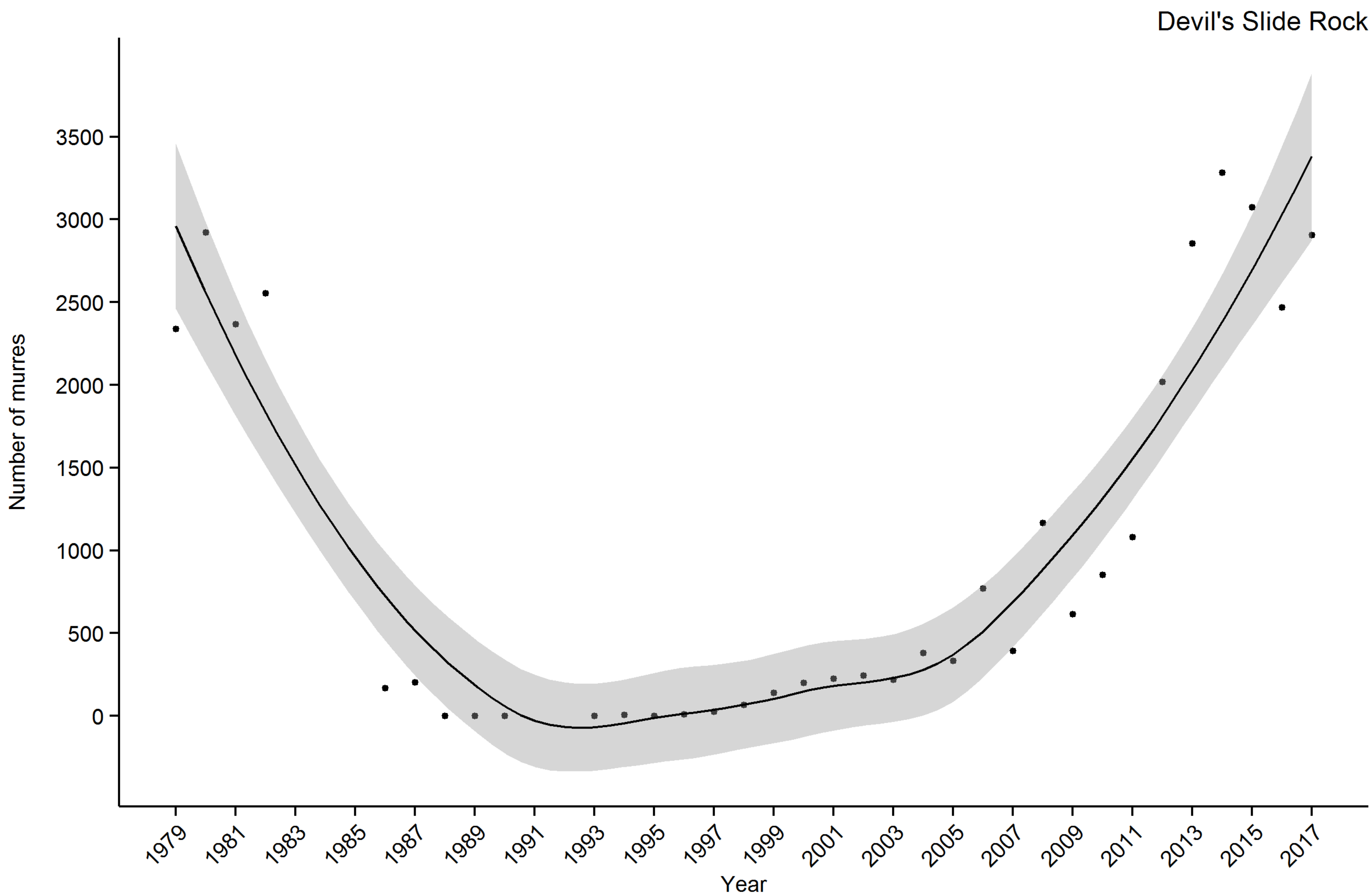


Figure 26. Common Murre breeding population trends at Devil's Slide Rock, 1979-2017. Data points are number of breeding birds from colony monitoring (1996-2007) or raw counts from aerial photographic surveys multiplied by correction factors (all other years; see Methods). LOESS curve is shown with 95% confidence intervals (R Core Team, 2013).

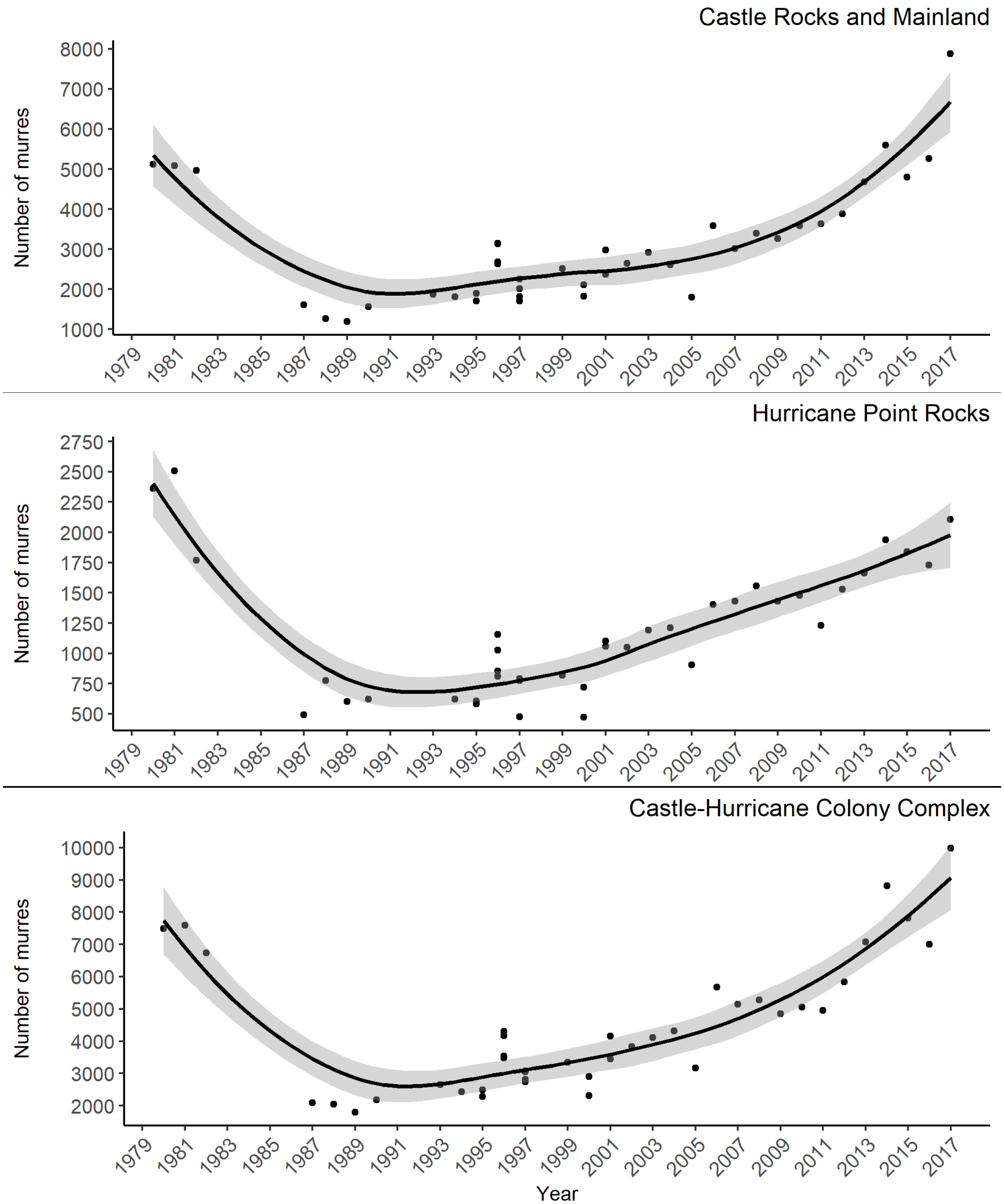


Figure 27. Common Murre breeding population trends at the Castle Rocks & Mainland and Hurricane Point Rocks colonies as well as the combined Castle-Hurricane Colony Complex, 1979-2017. Data points are raw counts from aerial photographic surveys multiplied by correction factors (see Methods). LOESS curves are shown with 95% confidence intervals (R Core Team, 2013). Note different scales between graphs.

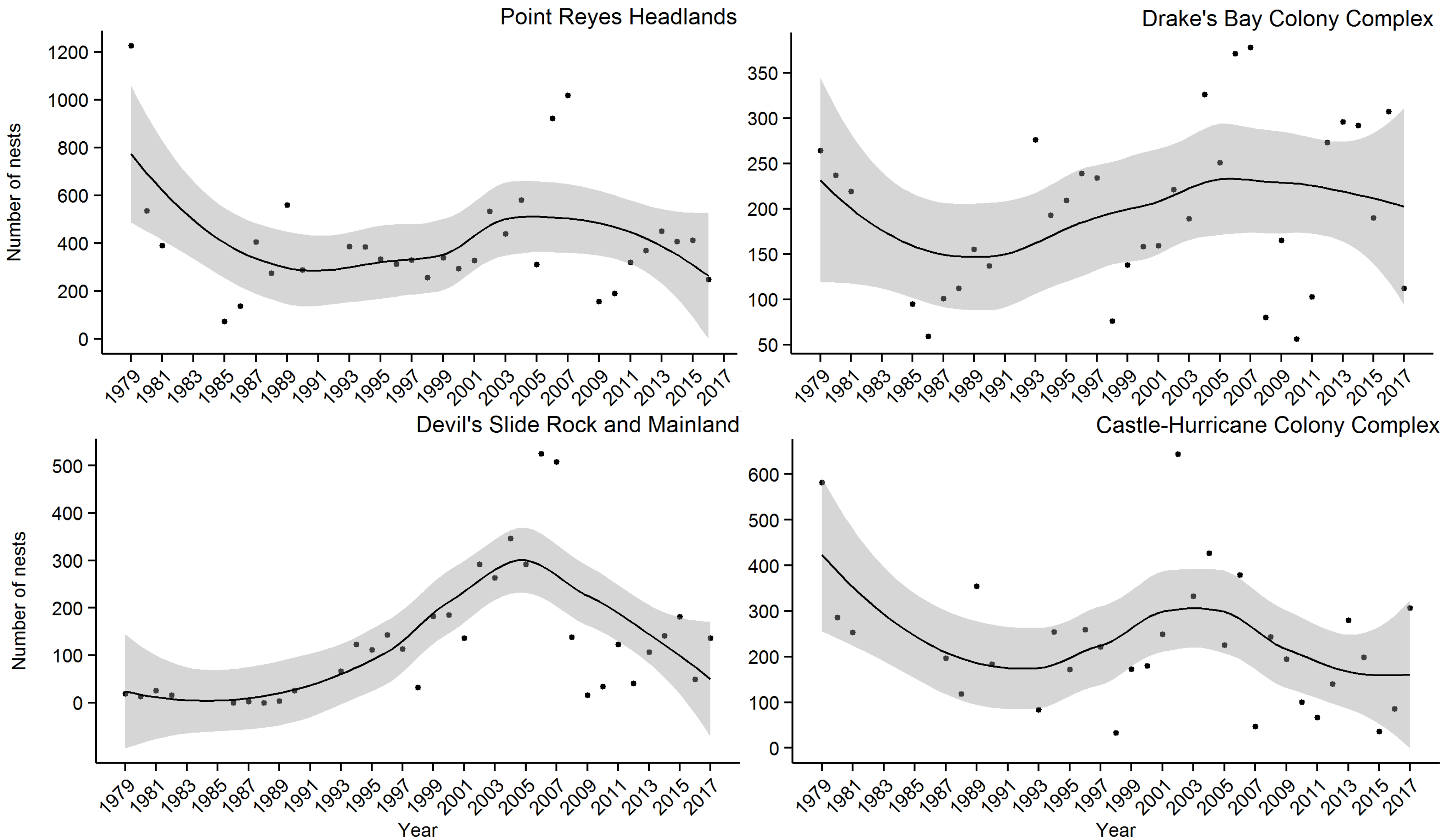


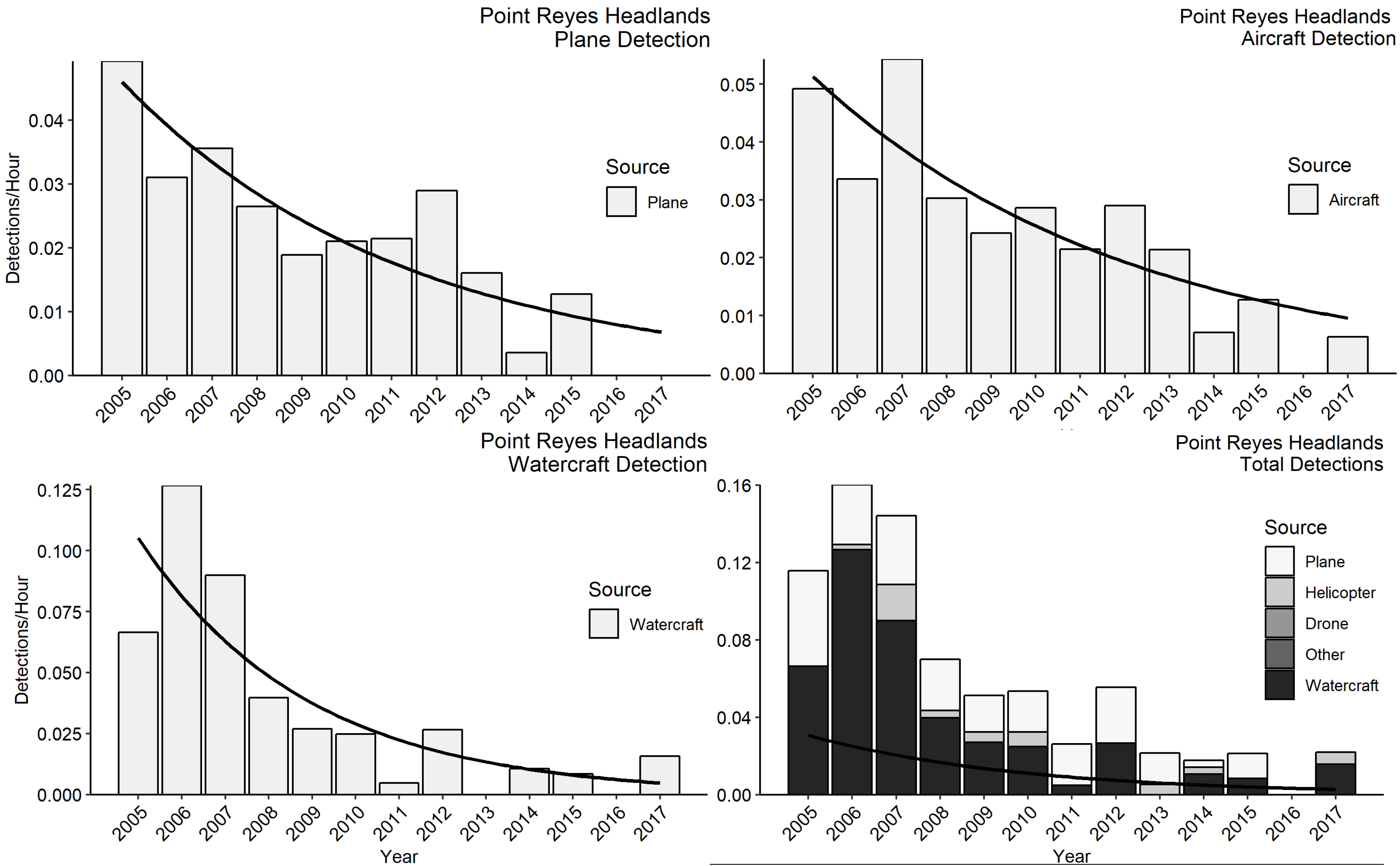
Figure 28. Brandt's Cormorant nest count trends from aerial photographic surveys for Point Reyes Headlands, Drake's Bay Colony Complex, Devil's Slide Rock and Mainland and Castle-Hurricane Colony Complex, 1979-2017. LOESS curves are shown with 95% confidence intervals (R Core Team, 2013). Note different scales between graphs.

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 2017.

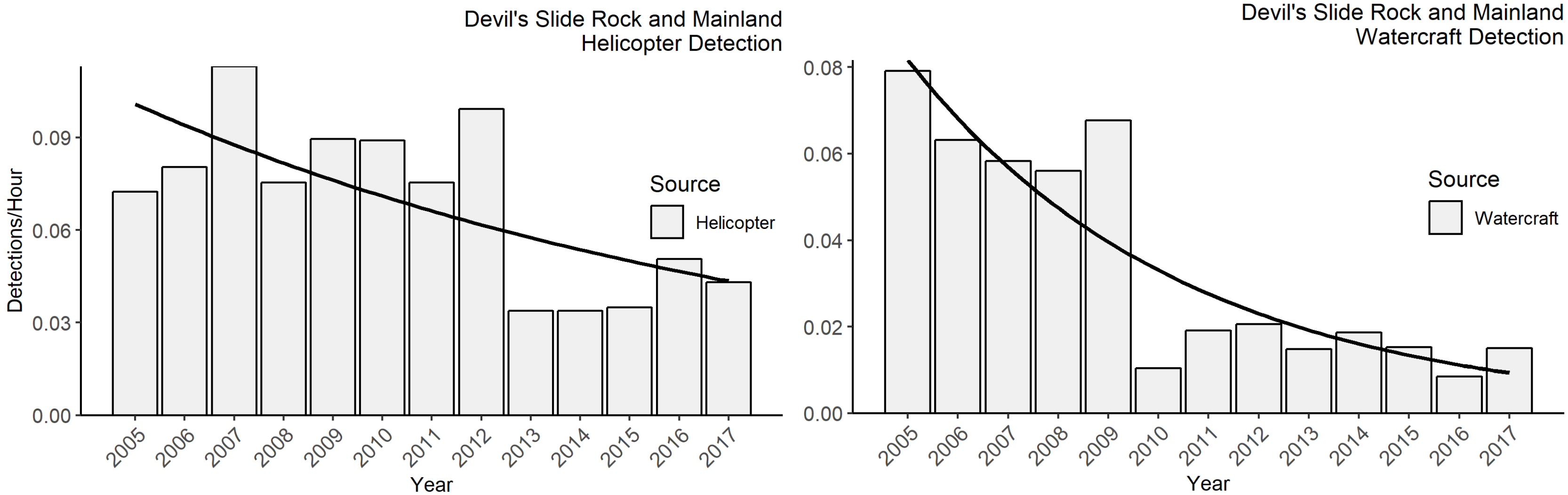
Aircraft Type	Total Detections			Total Disturbance Events		Number of Agitation Events		Number of Displacement Events		Number of Flushing Events	
	Plane	Drone	Helo	Plane	Helo	Plane	Helo	Plane	Helo	Plane	Helo
Point Reyes Headlands											
USCG	0	0	2	0	0	0	0	0	0	0	0
Devil's Slide Rock and Mainland											
Military	0	0	0	0	2	0	0	0	0	0	2
Private/Recreational	12	0	5	4	9	2	1	0	0	2	8
USCG	0	0	2	0	4	0	0	0	0	0	4
Media	0	0	1	0	0	0	0	0	0	0	0
Castle-Hurricane Colony Complex											
Private/Recreational	1	14	9	1	4	1	2	0	0	0	2
Total	**13**	**14**	**19**	**5**	**19**	**3**	**3**	**0**	**0**	**2**	**16**

Appendix 2. Number of watercraft detected categorized by type and resulting disturbance events recorded at Point Reyes Headlands, Devil's Slide Rock and Mainland, and Castle-Hurricane Colony Complex, 2017.

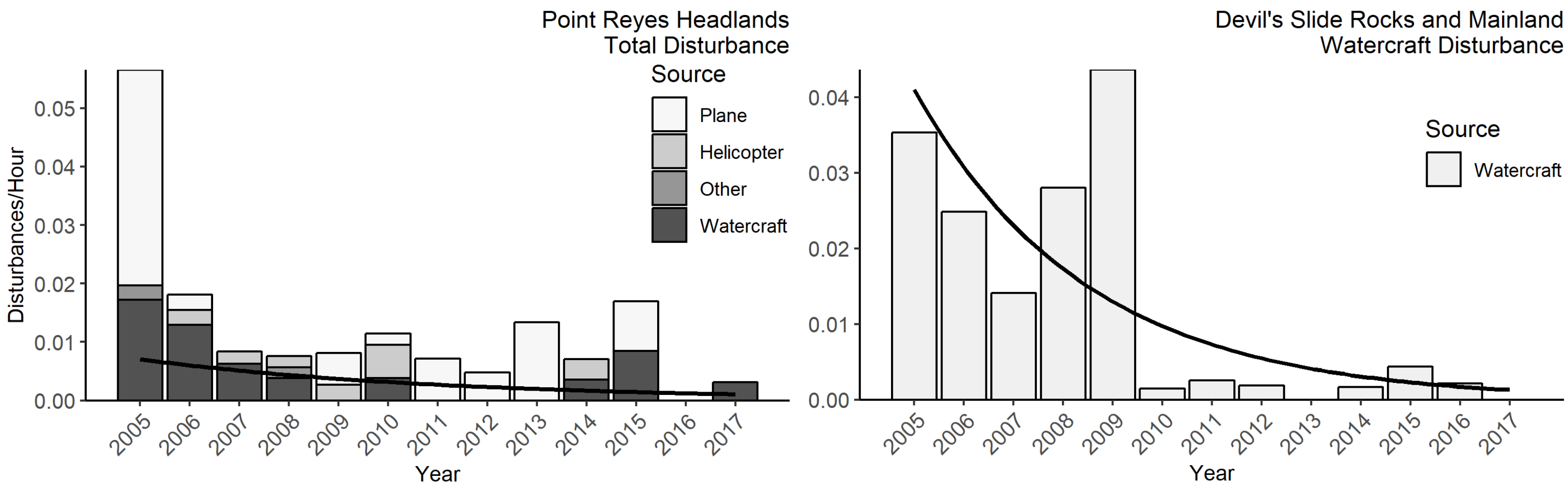
Watercraft Type	Total Detections	Total Disturbance Events	Number of Agitation Events	Number of Displacement Events	Number of Flushing Events
Point Reyes Headlands					
Recreational (<25') Small Private	5	0	0	0	0
Kayak	1	1	0	0	1
Devil's Slide Rock and Mainland					
Recreational (<25') Small Private	5	0	0	0	0
Kayak	2	0	0	0	0
Law Enforcement Jet Ski	1	0	0	0	0
Castle-Hurricane Colony Complex					
Recreational (<25') Small Private	1	0	0	0	0
Total	**15**	**1**	**0**	**0**	**1**



Appendix 3. Detection rates at Point Reyes Headlands with significant trends from 2005-2017. Regression trendlines are shown.



Appendix 4. Detection rates at Devil's Slide Rock and Mainland with significant trends from 2005-2017. Regression trendlines are shown.



Appendix 5. Disturbance rates at Point Reyes Headlands and Devil's Slide Rock and Mainland with significant trends from 2005-2017. Regression trendlines are shown.