



Pacific Harbor Seal (*Phoca vitulina richardii*) Monitoring at Point Reyes National Seashore and Golden Gate National Recreation Area *2021 Annual Report*



Pacific harbor seals hauled out on a mudflat in Bolinas Lagoon, CA.
NPS / SARAH CODDE

Pacific Harbor Seal (*Phoca vitulina richardii*) Monitoring at Point Reyes National Seashore and Golden Gate National Recreation Area: 2021 Annual Report

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Abstract

Pacific harbor seals (*Phoca vitulina richardii*) are the most abundant and only year-round resident pinniped in the National Parks of the San Francisco Bay Area, California. Annual monitoring by National Park Service (NPS) staff, using peer-reviewed methods, began in 1996 with the current suite of monitoring sites adopted in 2000. The objectives of monitoring each site and the population as a whole are to: i) detect changes in population size, ii) detect changes in reproductive success as indicated by pup production, and iii) identify anthropogenic or environmental factors, including climate change, that may affect the condition of the population (Adams et al. 2009).

Members of the Harbor Seal Monitoring Volunteer Program and NPS staff conducted 172 harbor seal surveys throughout the 2021 breeding and molting seasons (March–May and June–July, respectively) once or twice per week at the eight largest Point Reyes National Seashore and Golden Gate National Recreation Area harbor seal colonies, collectively referred to as Marin County sites. During the breeding season, the peak count of adult and immature seals we recorded at all Marin County monitoring sites was 2,107 seals, which is below the 20-year average and is one of the lowest counts on record during the NPS study period. During the breeding season, we recorded 972 seal pups at all Marin County sites, which is slightly less than the 20-year average. During the molting season, volunteers and staff recorded 2,581 seals as the peak count for all Marin County sites, which is much lower than the 20-year average and is the lowest count on record during the study period.

During the monitoring surveys, we recorded 38 disturbances to seals. The most frequent causes were unknown sources (29%) and motorboats (26%). Coyotes became a primary source of disturbance at Drakes Estero in 2021, and staff and volunteers witnessed predation of harbor seal pups. Members of the Central California Regional Harbor Seal Monitoring Program (which includes NPS staff and volunteers) conducted thirteen regional surveys throughout the breeding and molting seasons at locations in San Francisco Bay and Mendocino, Sonoma, Marin, and San Mateo counties. Of these areas, Marin County sites accounted for 62% of breeding season adult and immature animals (2,093 of 3,399), 71% of pups (972 of 1,365), and 60% of seals during the molting season (2,369 of 3,970), all of which are similar proportions to past years.

Acknowledgments

Volunteers are the backbone of the harbor seal monitoring program. Thank you to all the volunteers who hiked many miles to survey harbor seals, including K. Ballinger, F. Booker, M. Burke, C. Cardosi, R. Catlin, D. Ford, J. Forsell, J. Heusler, K. Khtikian, J. Khudyakov, J. Lamphier, K. Liang, R. McLemore, W. Pettus, H. Rederer, B. Siegel, S. Snow, E. Sojourner, K. Soroca, S. Van Der Wal, and J. Winer.

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Lastly, we thank J. Hickey and J. Womble for their reviews and thoughtful edits of this report, and K. Sherrill for his management of the pinniped monitoring database.

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Introduction

The National Park Service (NPS) San Francisco Bay Area Network (SFAN) Inventory and Monitoring Program includes Golden Gate National Recreation Area (GOGA), John Muir National Historic Site, Pinnacles National Park, and Point Reyes National Seashore (PORE). SFAN has identified vital signs, indicators of ecosystem condition, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. The intent is to monitor an integrated set of vital signs that meet the needs of current park management, as well as indicate environmental conditions over time. Pacific harbor seals (*Phoca vitulina richardii*) represent a vital sign for SFAN because they are ecologically significant, are protected under the Marine Mammal Protection Act (P.L. 92-522), and are of high interest to the public (Adams et al. 2006; Adams et al. 2009). Pinnipeds, including harbor seals, also serve as indicators as they are directly and indirectly linked with changes in climate that may include sea level rise, changes in timing and magnitude of coastal upwelling, and changes in ocean temperature (Allen et al. 2011). Long-term monitoring studies of harbor seals have been conducted intermittently at the largest colonies in PORE since the 1970s (Chan 1979; Allen and Huber 1984; Allen et al. 1989; Sydeman and Allen 1999; Allen et al. 2004). Consistent annual monitoring has been conducted by NPS staff since 1996. Beginning in 2000, all of the current sites were consistently surveyed using the same methodology.

The Marine Life Protection Act (CDFG 2009) also identified harbor seals as a marine mammal species most likely to benefit from the establishment of marine protected areas (MPAs) in the north central California coast region. In 2010, the California Department of Fish and Wildlife, in cooperation with the NPS, designated five MPAs within PORE as well as three special closure areas for birds, that also likely benefit harbor seals. Monitoring data collected on harbor seals under this program may contribute to the assessment of the MPAs' efficacy (<https://www.wildlife.ca.gov/Conservation/Marine/MPAs/Network/North-Central-California>).

The information presented in this report is a summary of the harbor seal data collected at PORE and GOGA during the 2021 breeding and molting seasons, March–July. SFAN surveys were also conducted in conjunction with other agencies and organizations in adjacent areas (San Francisco Bay and Mendocino, San Mateo, and Sonoma counties). Data collected as part of these region-wide surveys are presented within this report. This report is not intended to analyze trends in the harbor seal data set, which are more appropriately investigated at long-term intervals (e.g., Sydeman and Allen 1999; Allen et al. 2004; Becker et al. 2011).

Background

Pacific harbor seals are the most numerous and only year-round resident pinniped in the national parks of the San Francisco Bay Area, California. Other pinniped species that are commonly present at PORE include northern elephant seals (*Mirounga angustirostris*), California sea lions (*Zalophus californianus*), and Steller sea lions (*Eumetopias jubatus*). The population of harbor seals at PORE represents the largest concentration on the mainland of the State of California, and accounts for approximately 20% of the pupping and molting population in the state (Lowry et al. 2005; Sydeman and Allen 1999). Much of the Point Reyes coastal zone remains relatively undeveloped and provides

good marine and terrestrial habitat for seals to rest, molt, feed, and breed where human encroachment is minimal. The inaccessibility of much of the area has historically afforded some protection from human disruption during the terrestrial resting and pupping periods of seals; however, some pinniped populations in California are still recovering from a long period of exploitation that did not end until the passage of the Marine Mammal Protection Act in 1972 (Sydeman and Allen 1999; Carretta et al. 2015). NOAA statewide surveys of harbor seals have documented recovery of the population since the 1980s with a peak in 2004; however, subsequent counts in 2009 and 2012 have been lower than the 2004 maximum count (Carretta et al. 2015). The NPS is charged with managing and minimizing disturbance to pinniped habitat and activities from the more than 2 million annual visitors at PORE and 15 million annual visitors at GOGA (NPS 2019). PORE and GOGA provide highly sought after viewing opportunities of pinnipeds for the public but also implement visitor management actions to reduce disturbance to seals at colonies, as needed.



The remote beach of the Double Point harbor seal colony at Point Reyes National Seashore.
NPS

Objectives

The objectives of monitoring each site and the population are to:

- detect changes in population size

- detect changes in pup production
- identify sources, frequency and level of effects of natural and anthropogenic disturbances on harbor seal haul-out site use and productivity

The primary parameters that we monitor include the number of pups and adults/immatures at each site, spatial distribution, phenology, and the number and type (or source) of disturbances during the breeding and molting seasons (Adams et al. 2009). The monitoring objectives and methodology are described in detail in the SFAN Pinniped Monitoring Protocol (Adams et al. 2009).

Methods

Study Area

The core study area extends from Tomales Point in the north, to and including San Francisco Bay (SFB; Figure 1). The Point Reyes peninsula extends from the mouth of Tomales Bay (Lat. 38°30'N) south to Bolinas Lagoon (Lat. 37°30'N). Point Bonita is located in the Marin Headlands, at the mouth of SFB in GOGA. A “haul-out site” is defined as a terrestrial location where seals aggregate for periods of rest, birthing, and nursing of young (Harvey 1987; Thompson 1987). For this report, the Point Reyes peninsula haul-out sites and Point Bonita haul-out site are collectively referred to as Marin County sites. PORE, GOGA, Greater Farallones National Marine Sanctuary, the California Department of Parks and Recreation, and county parks share jurisdiction over segments of this coastline, but overall, NPS lands account for most of the shoreline. Regional surveys of seals extend from the Mendocino County coastline at 38°57'27" N latitude south to the San Mateo County coastline at 37°31'58" N latitude, including several sites within SFB. Numerous haul-out sites are distributed along this wider stretch of shoreline north and south of the core study area (see more below in Sampling Design; Figure 1).

The topographic diversity of this coastal zone provides a broad range of substrates for harbor seals to come ashore for critical life-history events including pupping and molting. These habitats include tidal mud flats, offshore and onshore rocky tidal ledges, islets, and sandy beaches. Coastal embayment sites include Tomales Bay, Drakes Estero Complex, and Bolinas Lagoon. Coastal sites surveyed include Tomales Point, Point Reyes Headlands, Duxbury Reef, Double Point, and Point Bonita (Figure 1). Each colony site is comprised of several “subsites,” or distinct areas of beach, rock outcrops, or sandbars where harbor seals haul out. More details on distribution within each site can be found in SOP 1 of the SFAN Pinniped Monitoring Protocol (Adams et al. 2009).

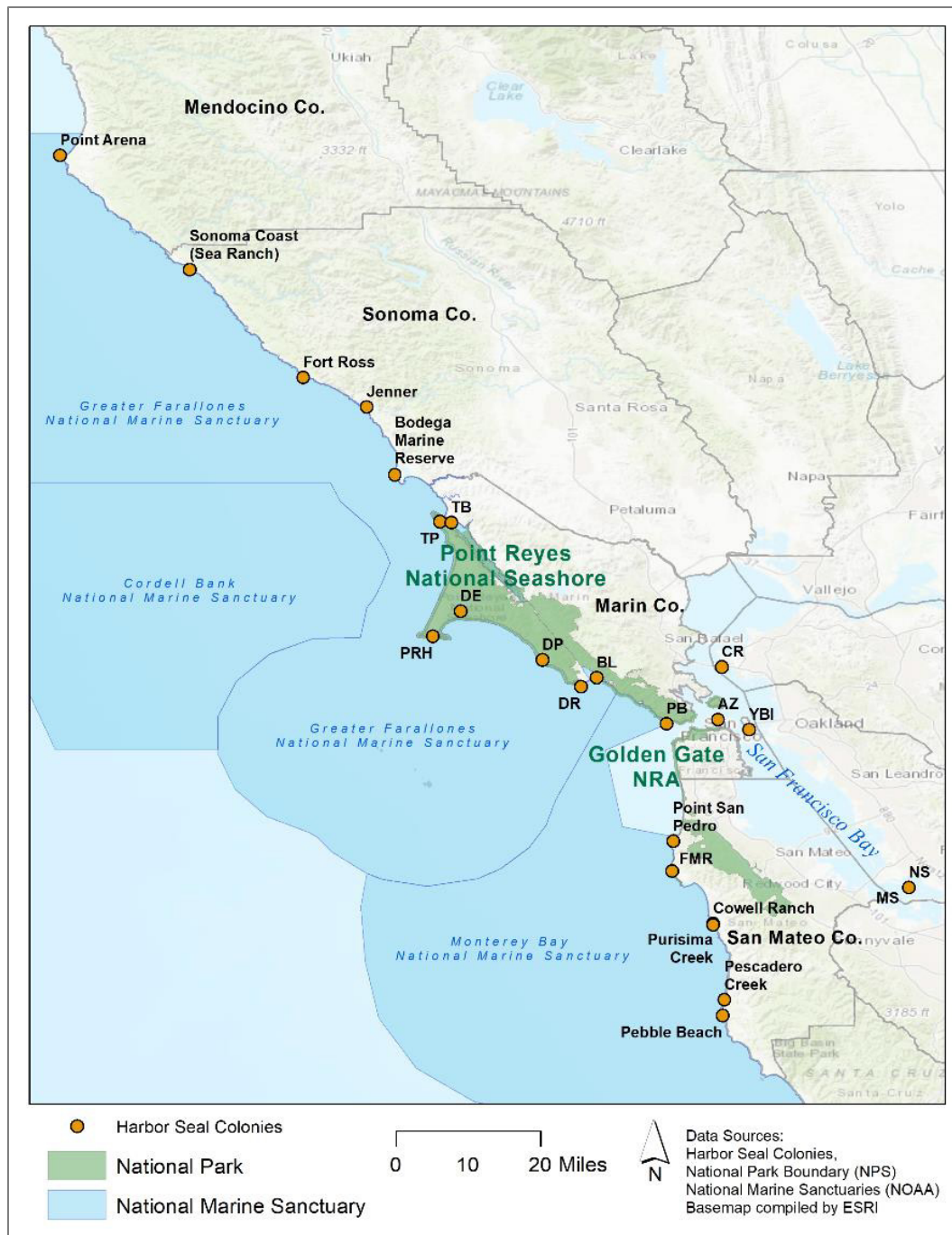


Figure 1. Regional harbor seal survey sites in San Francisco Bay and Mendocino, Sonoma, Marin, and San Mateo counties, California. Map does not show all of the regional survey locations included in Sonoma County. TB = Tomales Bay, TP = Tomales Point, DE = Drakes Estero, PRH = Point Reyes Headlands, DP = Double Point, DR = Duxbury Reef, BL = Bolinas Lagoon, PB = Point Bonita, CR = Castro Rocks, AZ = Alcatraz Island, YBI = Yerba Buena Island, NS = Newark Slough, MS = Mowry Slough, FMR = Fitzgerald Marine Reserve. Geographic coordinates for each monitoring location are maintained by the National Park Service.

NPS

Sampling Design

The current distribution of the harbor seal breeding/molting population allows us to monitor all primary sites in PORE and GOGA. Thus, spatial stratification or other sampling techniques were not needed to determine which haul-outs to monitor. SFAN relies upon other monitoring programs, such as the Greater Farallones National Marine Sanctuary Beach Watch program or National Marine Fisheries Service (NMFS) stock assessments that include aerial surveys, as well as reports from park visitors, including boaters, kayakers and the birding community, to locate new haul-outs in remote areas of the parks. The monitoring team conducts surveys during the breeding and molting seasons because these are sensitive and important times for the seals, and it is when they are hauled out in higher numbers and for longer periods of time in concentrated areas as compared to other times of the year. During the breeding season, adult females with pups spend more time onshore and this allows for determination of pup production. During the molt season, all age classes of seals haul out for longer periods of time, which allows for better estimation of the total population. Survey frequencies and timing capture the date of the first pup, the peak of the breeding and molting seasons, and have been shown to have sufficient power to detect meaningful population changes over time (Adams et al. 2009). This sampling design allows for SFAN data to inform and be included in NMFS stock assessments.

In addition to conducting detailed monitoring at PORE and GOGA, the NPS participates in regional harbor seal surveys during the breeding and molting seasons, with SFAN coordinating the central California coast surveys. Regional survey sites in the central California coast include colonies in Mendocino County (Point Arena), Sonoma County (Sea Ranch, South Sonoma sites, Fort Ross, Jenner, and Bodega Marine Reserve (not surveyed in 2021)), SFB (Castro Rocks, Alcatraz, Yerba Buena Island, Mowry Slough (not surveyed in 2021), and Newark Slough (not surveyed in 2021)), and San Mateo County (Fitzgerald Marine Reserve, Point San Pedro, Cowell Ranch Beach, Purisima Creek, Pescadero, and Pebble Beach; Figure 1). Surveys at Fort Ross began again in 2013 after not being conducted since 2006. Surveys at Point Arena started in 2019. The monitoring approach used by SFAN is consistent with that used in other surveys, allowing for the interpretation of results in a regional context.

Surveys

We conducted harbor seal surveys throughout the breeding (March 1st–May 31st) and molting (June 1st–July 31st) seasons once or twice per week at most Marin County locations in 2021. The two exceptions were Double Point, which we surveyed less often due to safety concerns while testing out a new observation spot, and Point Reyes Headlands, which is on the regional survey schedule on alternating weekends. We conducted surveys at medium to low tides (below 3 ft) during the day. We did not conduct surveys during poor weather conditions which may include heavy fog, winds greater than 30 mph, or rain, because of poor visibility and because harbor seals haul out in lower numbers in the rain (Jemison and Pendleton 2001). Not all seals are onshore during surveys and thus are not detected by counts; however, with standardized methods, the ground count surveys provide an index of abundance (see more detail in Data Management and Analysis; Adams et al. 2009; Harvey and Goley 2011; Carretta et al. 2015).

One NPS staff member and 22 trained volunteers conducted surveys, with each survey conducted by one to two people. Previously, NPS staff trained volunteer observers to monitor harbor seals at designated sites within PORE and GOGA, and the volunteers returned for the 2021 season with several years of experience. At most sites, observers surveyed for approximately two hours from fixed observation points with all subsites counted approximately every 30 minutes for a total of four counts each survey. Tomales Point, Bolinas Lagoon, and Duxbury Reef had only two counts separated by 30 minutes during each survey due to hiking/traveling time between subsites. For each subsite, the observer recorded the time, number of adult and immature seals, pups, dead pups, red-pelaged seals, and fresh shark-bitten seals on pre-formatted datasheets every half hour. Red pelage is easily identified and results from the deposition of iron oxide precipitates on the hair shaft; it usually extends from the head down to the shoulder and is of interest due to its rarity outside of the SFB (Allen et al. 1993). During the molting season (June–July), we counted all animals as adults and immature seals because of the difficulty in distinguishing large pups from immature seals.



Volunteer looking through a spotting scope during a harbor seal survey at Double Point in Point Reyes National Seashore.

NPS / S. ALLEN

We recorded disturbances and potential disturbances as they occurred. We defined a disturbance as any event that caused the seals to change their behavior, which included lifting their head (head alert), flushing (moving towards the water), or flushing into water, while potential disturbances were

defined as any anthropogenic event within a defined haul-out zone that had the potential to cause seals to react but was not noted to cause a disturbance. Observers recorded the time, source, and effect of each disturbance. The information on the effect included the reaction of the seals, the number of seals that reacted, and when and where they rehailed if they were flushed into the water. In some cases, the disturbance was not directly observed, but surveyors recorded the number of animals affected by the unknown source. We recorded disturbances by categories to assist with summary analyses (Table 1). Due to the large amount of time it took to travel between subsites, Tomales Point and Point Reyes Headlands surveyors were not at any one subsite for very long and were less likely to observe a disturbance. However, due to the remoteness of these sites, very few visitors frequent them, so we anticipated low levels of disturbance at them.

Table 1. Sources of disturbance and examples.

Source	Examples
Aircraft	Airplane, Drone, Hang glider, Helicopter, Ultralight
Bird	Eagle, Gull, Raven, Turkey vulture
Dog	Dog, Dog barking
Humans on foot	Clammer, Fisherman, Hiker, Horse rider, Kite flyer, Researcher
Motorboat	Motorboat, Personal watercraft
Non-Motorboat	Canoe, Kayak, Sailboat, Wind surfer
Other	Coyote, Other pinniped, Rock slide, etc.
Vehicle	Bus, Car, Motorcycle

On alternating weekends in March through July, members of the Central California Harbor Seal Regional Program conducted regional surveys at all sites included in the regional counts (see Figure 1). Due to staffing and volunteer constraints, surveys could not be conducted at Mowry and Newark Sloughs in San Francisco Bay and at Bodega Marine Reserve in Sonoma County in 2021. Participants in the region-wide surveys included various organizations and volunteers (see Appendix C). Regional counts could only be conducted between Thursday and Monday over the selected regional survey weekends, to ensure all surveys were conducted around the same time.

Data Management and Analysis

NPS staff stored and managed all count and disturbance datasheets from Marin County sites in a relational Microsoft Access database. At the end of the season, we error-checked all the electronic records against the paper datasheets for accuracy, and we reviewed all records to ensure that only accurate and complete count data were used for analysis and were defined as high quality data (Adams et al. 2009). We noted any incomplete counts, or counts that may have been hampered by poor weather conditions, as poor-quality surveys in the database and excluded those surveys from population count analysis. Weather conditions and incomplete surveys did not affect collection of disturbance data, so we summarized these data regardless of the quality of associated seal count data (see also Becker et al. 2011). Nevertheless, we retained all count data in the database, regardless of quality.

Although we collected harbor seal data according to subsites within each monitoring location, we did not report or analyze subsite data within this report. We identified the maximum site total for each survey by summing the subsite counts for each survey time interval and used those totals for data summaries and analyses. To summarize the data, we used customized tools in the database. During the breeding months of March, April, and May, the maximum total site count for each survey included two age classes: adult/immature and pup. We included live and dead pups in the maximum pup count.

Typically, harbor seals move very little between sites during both the pupping and molting seasons (Lowry et al. 2001; Cordes and Thompson 2015); therefore, we used the maximum number of seals counted at a site throughout the peak of each season for comparisons between years and sites, and we assumed that individual animals were not counted at more than one site. For the breeding season, we only used surveys that occurred from mid-April through mid-May (the expected range of the peak) to determine the maximum counts for adult/immature seals and pups at each site. During the molt season, we only used surveys that occurred after June 10 to determine the maximum counts for total seals due to the movement of seals during the time between the breeding and molt seasons that could cause a false peak. We summed together the maximum count at each location within a year to determine the yearly maximum total count for all Marin County sites combined. We determined the maximum total count for the breeding and molting seasons separately. Maximum counts at each location may have occurred on separate days (Barlow 2002). During the regional survey periods, it was not uncommon for a site to be surveyed more than once. In these cases, we used the survey with the higher seal count for regional summaries. We derived a regional population estimate by applying a correction factor of 1.54 (95% CI = 1.16–1.92), calculated in central and northern California to account for seals in the water during the molt season surveys (Harvey and Goley 2011). The correction factor was not used to estimate the population of individual Marin County sites because there currently is not enough information to determine if the correction factor can be used at an individual site level.

We averaged the total maximum counts of breeding season adult and immature seals, pups, and all age classes during the molting season across survey years 2000 through 2019 and compared that to the 2021 data. We did not conduct surveys in 2020 due to COVID-19 stay-at-home federal and state orders. For comparisons to past regional surveys, complete data sets for the locations outside of Marin County are only available since 2005. We added in surveys at Bodega Marine Reserve (Sonoma County) in 2010, Purisima Creek (San Mateo County) in 2012, Fort Ross (Sonoma County) in 2013, and Point Arena (Mendocino County) in 2019. We only included regional sites that were surveyed in 2021 in the graphs presented in the Results section, and we excluded data from earlier years from those sites that were not surveyed in 2021.

When examining disturbance events, we only used those that elicited a head-alert or flush reaction from the seals for analysis. Disturbance events were based on disturbance sources rather than the number of subsites or seals affected. We calculated disturbance rates from the number of disturbance events that occurred during the time period from the first observation to the end of the final observation period. Since we did not analyze the disturbance data for effects on the seal count data in

this report, we were able to use all actual disturbances for analysis regardless of the quality of the associated seal count data. We recorded potential disturbances (events that could potentially elicit a reaction from seals) to quantify any given type of disturbance recurring at a particular site, but this information was not analyzed in this report. These data may be used in the future to understand potential emerging disturbance issues at each location.

The harbor seal monitoring data may change over time as data are corrected and as data analysis procedures are improved. For this reason, summary data reported here for 2000 to 2019 may differ slightly from data summaries published in other harbor seal reports.

Results

Overall

In 2021, 22 volunteers and one NPS staff member completed 172 surveys at Marin County sites between March 1st and July 31st, with a total of approximately 285 hours of monitoring. Each location had between 19 and 27 high quality surveys, except for Point Reyes Headlands, which is on the regional survey schedule, and Double Point, which had a reduced number of surveys due to safety concerns while a new observation site was tested. At Marin County sites, we recorded a maximum of 2,107 adults/immatures and 972 pups during the breeding season (March–May) and 2,581 seals of all age classes during the molting season (June–July; Table 2).

Table 2. Summary data for harbor seal colonies during the 2021 monitoring seasons. Data from 2021 are compared to the 2000–2019 mean. SD = standard deviation.

Location	Max # Adults in Breeding Season ^A	2000–2019 Adult Mean (SD) ^A	Max # Pups in Breeding Season	2000–2019 Pup Mean (SD)	Max # Seals in Molting Season ^B	2000–2019 Molt Mean (SD) ^B	# Surveys ^C	Max # Reds ^D	Max # Shark Bites ^D
Tomales Bay	355	446 (71.0)	118	134 (41.2)	414	380 (127.9)	24	18	0
Tomales Point	272	338 (88.3)	62	127 (32.8)	339	460 (140.8)	19	3	0
Point Reyes Headlands	94	105 (28.4)	48	44 (11.0)	184	329 (108.7)	11	1	0
Drakes Estero Complex	550	752 (161.0)	231	344 (62)	598	1050 (284.0)	24	7	0
Double Point	341	504 (140.3)	228	287 (91)	253	869 (337.1)	11	7	1
Duxbury Reef	52	69 (32.3)	3	6 (3.3)	69	82 (45.7)	22	1	0
Bolinas Lagoon	326	313 (80.1)	270	171 (47.6)	619	517 (131.7)	21	20	3
Point Bonita	117	115 (36.2)	12	8 (5.2)	105	166 (44.6)	27	2	1
TOTAL	2107	2640 (324.4)	972	1121 (157.7)	2581	3852 (678.0)	159	59	5

^A Adults and immatures during the peak of the breeding season, mid-April to mid-May.

^B All age classes during the molt season, June 10–July 31.

^C Only surveys deemed as high quality (see methods).

^D The maximum number observed during a single census in March–July.

Adult and Pup Counts During the Breeding Season

Adults

During the 2021 breeding season, we counted a maximum of 2,107 adult and immature seals at Marin County sites, which is less than the 20-year average and one of the lowest counts on record for this monitoring study (Figure 2). Drakes Estero Complex had the most adults/immatures (550), followed by Tomales Bay (355) and Double Point (341; Table 2). All individual site counts in 2021 were lower than their respective counts in 2019 except at Double Point (Figure 3). Even though the adult and immature count at Double Point increased compared to 2019, the 2021 count is still far below the site's 20-year average (504; Table 2). Counts at Double Point have been decreasing since 2015.

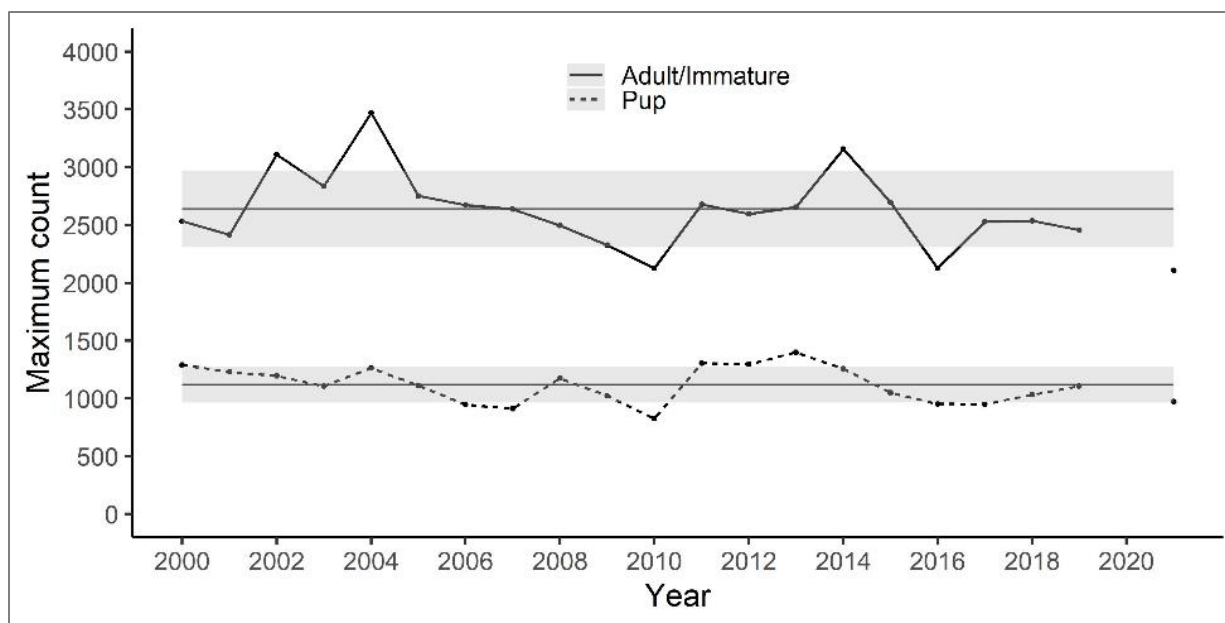


Figure 2. Maximum counts of harbor seal adults and immatures (solid line) and pups (dashed line) during the breeding season (March–May) for 2000–2021 at Marin County sites. The horizontal lines on the graph represent the means of the maximum adult counts (mean = 2,640.1) and pup counts (mean = 1,121.1) from 2000–2019 and the gray shaded areas represent one standard deviation from the mean (adult SD = 324.4 and pup SD = 157.7). Note there were no surveys in 2020.

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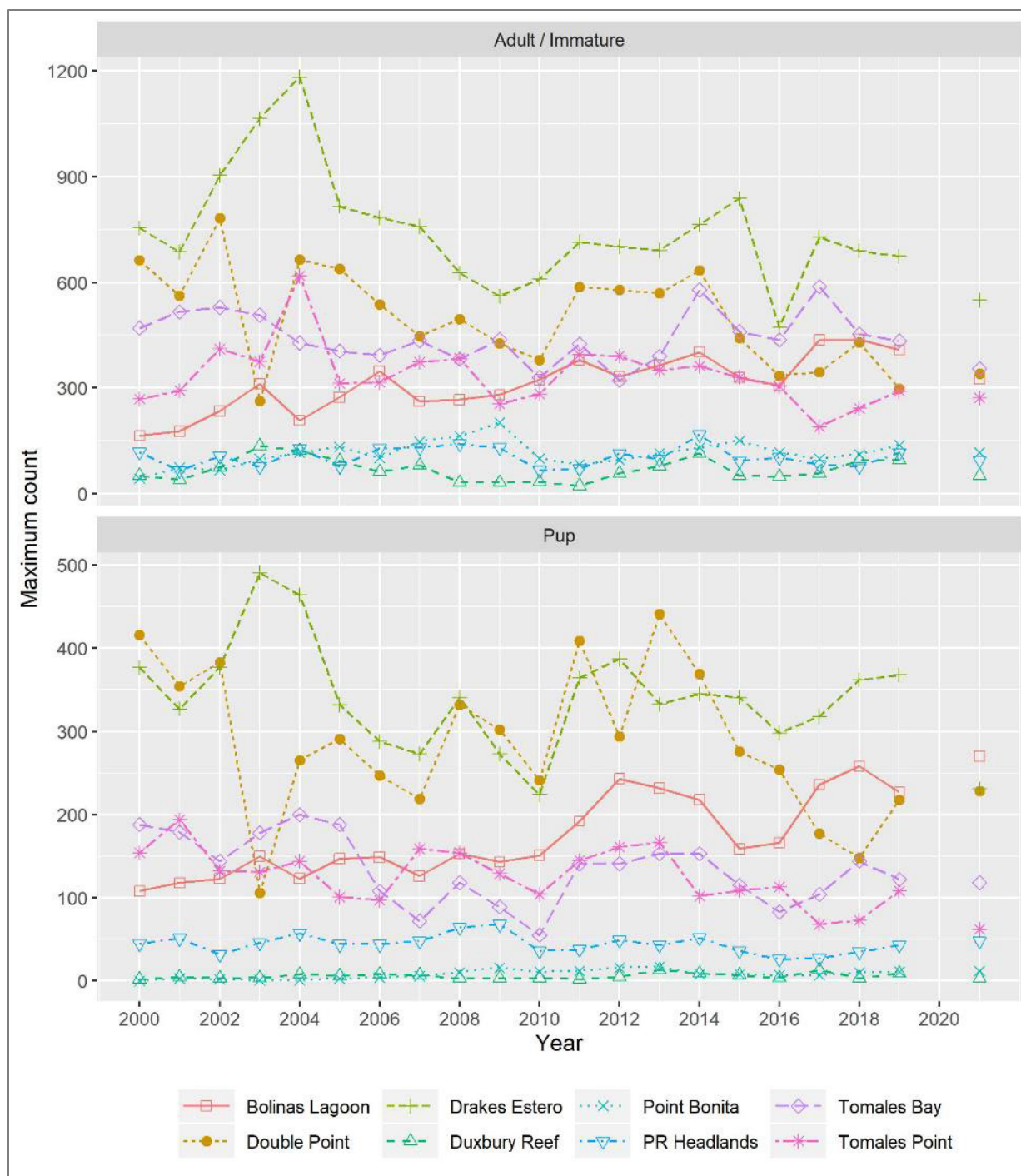


Figure 3. Maximum harbor seal adult/immature and pup counts at each of the Marin County locations during the breeding season (March–May), 2000–2021. The maximum counts at each site may have been observed on different days. Note there were no surveys in 2020.

NPS

Pups

The peak of pupping in Marin County is typically within a 2-week period between the end of April and early May, and this has remained constant throughout the 21-year study period. We recorded a maximum count of 972 pups for all Marin County sites during the 2021 breeding season, which is slightly less than the 20-year average but still within one standard deviation below the average (Figure 2). The primary pupping locations within the Marin County sites are Tomales Bay, Tomales Point, Drakes Estero, Double Point, and Bolinas Lagoon (Figure 3). Bolinas Lagoon had the most pups (270), followed by Drakes Estero (231) and Double Point (228; Table 2). The maximum pup count at Bolinas Lagoon was the largest count on record at this site and continues the trend of greater than average counts since 2012 at Bolinas Lagoon (Figure 3). We recorded a large decline from 2019 to 2021 at Drakes Estero, and this year's count was one of the lowest counts for the past 20 years. Double Point pup counts have been below the long-term average since 2017, but we saw a small increase in 2019 and 2021 compared to the 2017 and 2018 counts (Figure 3).

Phenology

Typically, the first viable pup is seen in mid-March at either Drakes Estero or Double Point. The first reported pup of 2021 was seen on March 19 at Bolinas Lagoon (Figure 4). The dates for the first reported pup at Double Point have not been accurate since 2017 due to fewer surveys being conducted, so we did not include them in Figure 4. There does not appear to be a trend in phenology when all sites are combined, but each site independently has varying trends and additional analyses are necessary to determine statistical significance (Figure 4).

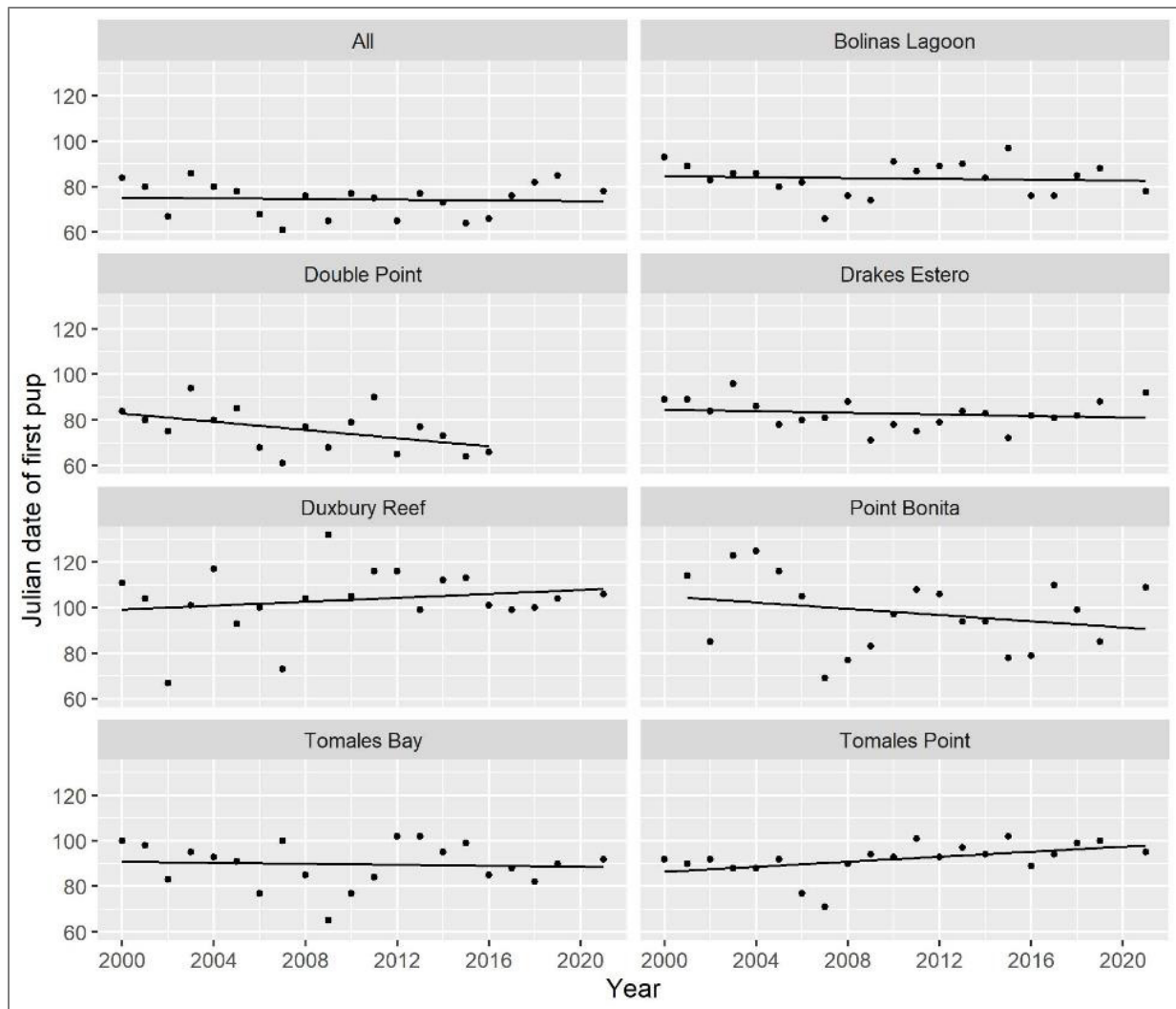


Figure 4. Date of first live pup observed for 2000–2021 for all sites combined and for each site. A linear trend line was fitted to the data points; however, no analyses were run to determine if the slope was different from zero as deeper analyses will be completed at a later date. Note there were no surveys in 2020.

NPS

Molt Counts

During the 2021 molt season, we counted a maximum of 2,581 seals (all age classes) for all Marin County sites, which is far below the 20-year average and is the lowest molt count in the history of the NPS monitoring program (Figure 5). Bolinas Lagoon had the highest count (619), followed by the Drakes Estero Complex (598; Table 2). We recorded a decrease compared to 2019 at all sites, except Bolinas Lagoon and Tomales Bay (Figure 6). Both Drakes Estero (598) and Double Point (253) had very low counts in 2021 compared to their respective site long-term averages (Drake Estero average = 1,050 and Double Point average = 869; Table 2). Drakes Estero and Double Point typically had the highest seal counts of all sites during the molt season, but that changed when Bolinas Lagoon started increasing in 2014 and Double Point started decreasing in 2016 (Figure 6). This is the first year that

Bolinas Lagoon had the highest seal count out of all Marin County sites. Although, with limited observations of Drakes Estero and Bolinas Lagoon in 2020, it is possible that Bolinas Lagoon had the highest number of all locations starting in 2020, and if so, we did not detect it due to reduced survey efforts during the SARS-COV2 pandemic.

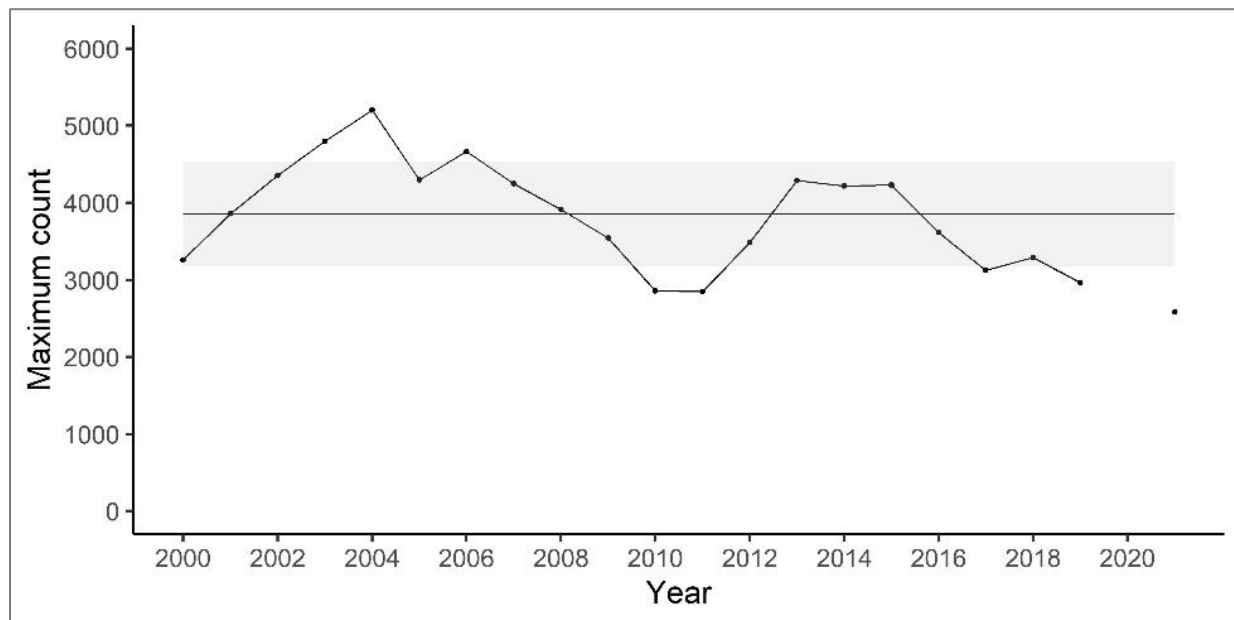


Figure 5. Maximum harbor seal counts during the molt season (June–July) for 2000–2021 at Marin County sites. The horizontal line on the graph represents the mean of the maximum molt counts from 2000–2019 (mean = 3,852.1) and the gray shaded area represents one standard deviation from the mean (SD = 678.0). Note there were no surveys in 2020.

NPS

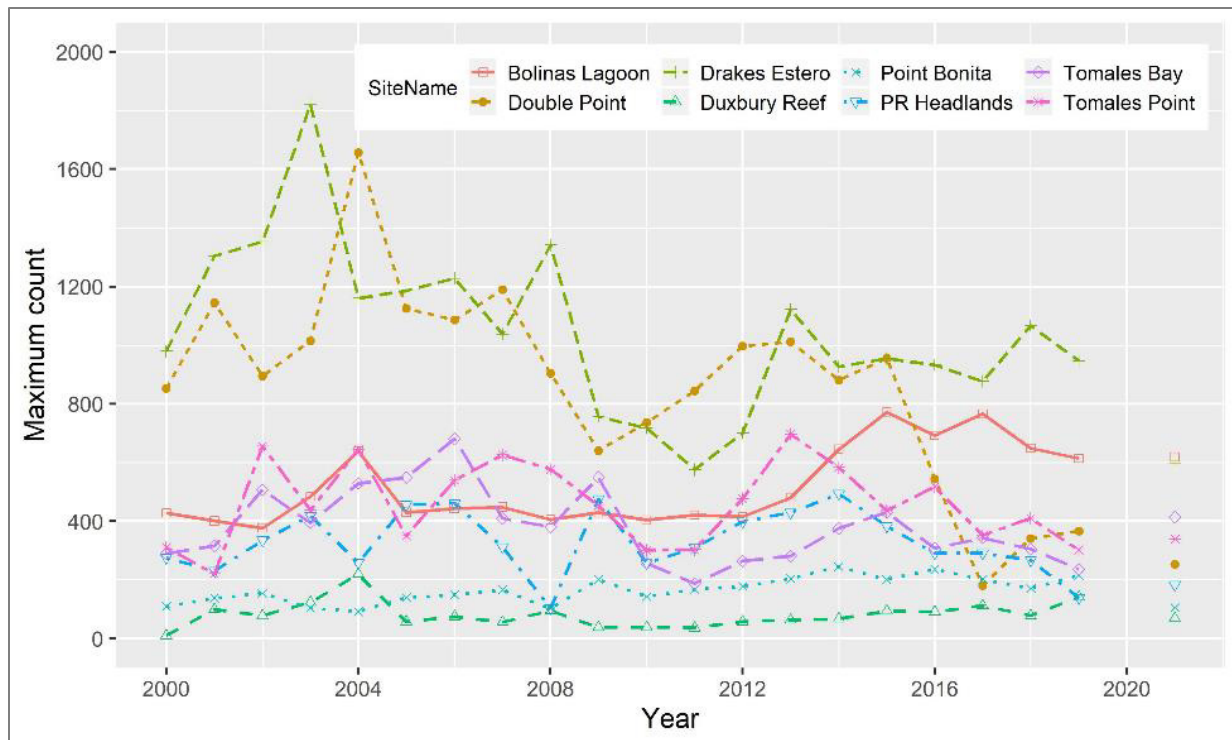


Figure 6. Maximum harbor seal counts at each of the Marin County sites during the molt season (June–July), 2000–2021. The maximum counts at each site may have been observed on different days. Note there were no surveys in 2020.

NPS

Disturbances

At the Marin County sites in 2021, we recorded 38 disturbances that elicited a response from harbor seals (Table 3). The most common disturbance sources in 2021 were unknown sources (29%) and motorboats (26%; Table 3). Motorboats and “other” were a higher percentage of total disturbance sources in 2021 than their respective long-term averages, while humans on foot was a much smaller percentage of the total disturbances as compared to its average. In 2021, all of the disturbances in the “other” source were caused by coyotes. The rate of disturbances per hour in 2021 was highest at Drakes Estero (0.29 disturbances/hour; Figure 7). Disturbances at this site were primarily from unknown sources and coyotes. This season there was a high number of disturbances by coyotes at Drakes Estero, including two separate disturbances when a coyote preyed on a harbor seal pup. The number of coyotes NPS staff and volunteers saw at Drakes Estero at any one time ranged from one to three coyotes. Although we saw bald eagles at Drakes Estero in 2021, their presence was not observed to disturb the seals.

Table 3. Number and percentage of identified sources of disturbances (head alert, flush, flush into water) for Marin County sites. The 2021 data are compared to the 2000–2019 mean (SD). Note the human category only includes sources of humans on foot.

Year(s)	Measure	Motorboat	Non-Motorboat	Vehicle	Dog	Aircraft	Human	Bird	Unknown	Other	Total
2021	(#)	10	1	0	0	1	5	5	11	5	38
	(%)	26	3	0	0	3	13	13	29	13	–
2000–2019 mean	(#)	17.5 (6.9)	9.6 (5.5)	3.4 (3.3)	0.7 (0.8)	8.2 (3.9)	33.4 (15.2)	9.8 (4.8)	28.4 (8.5)	5.0 (3.2)	116.0 (32.0)
	(%)	15.9 (7.6)	7.9 (3.3)	2.7 (2.0)	0.6 (0.7)	7.3 (3.7)	28.1 (8.0)	8.4 (4.0)	24.5 (4.0)	4.5 (2.7)	–

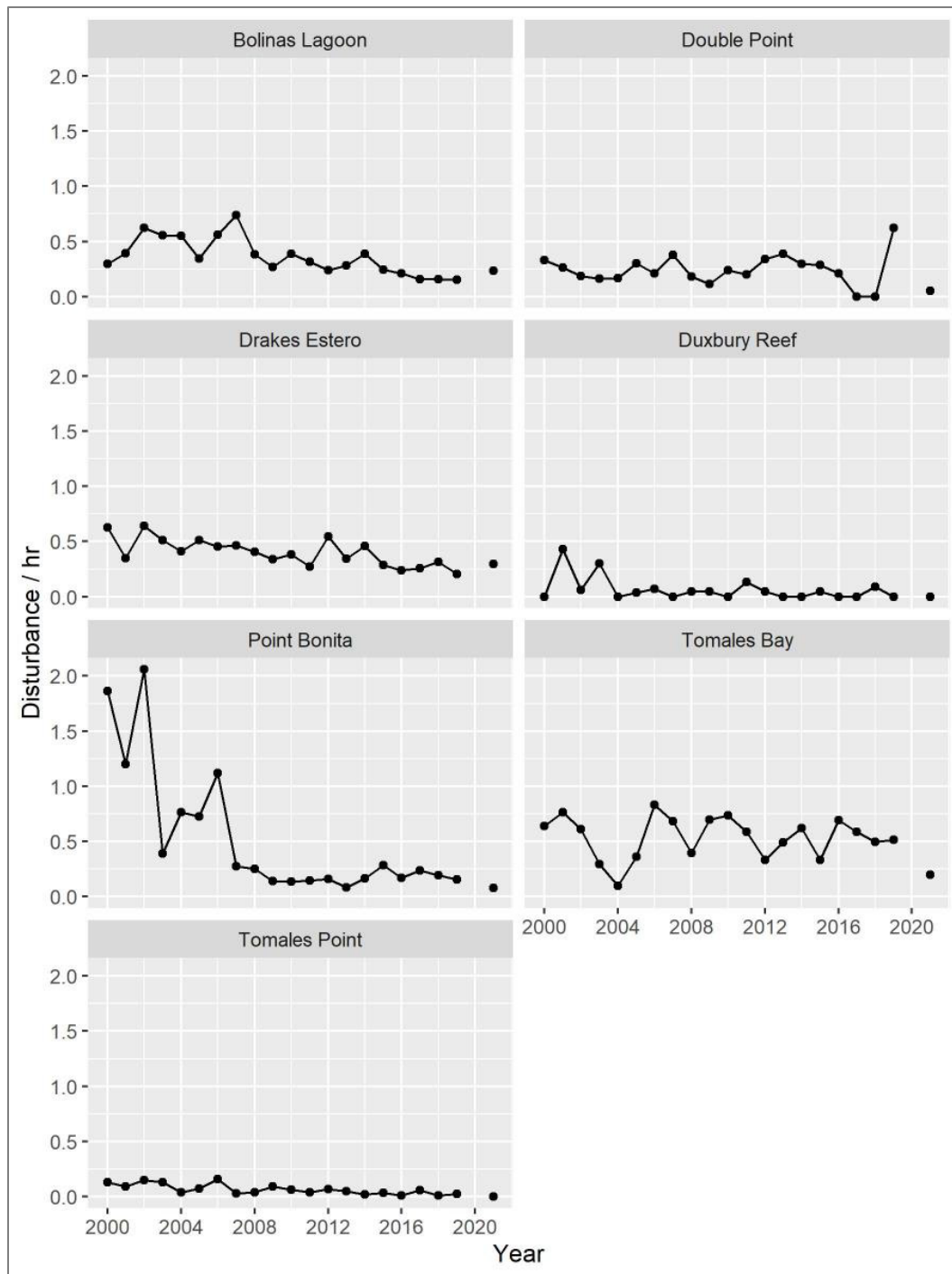


Figure 7. Rates of disturbances per hour at Marin County sites from March through July of 2000–2021. Only actual disturbances (head alert, flush, flush water) were used, and survey time was based on observation time for all complete surveys (with or without disturbances). Note there were no surveys conducted in 2020.

NPS



Coyote approaching a harbor seal pup on a sandbar within Drakes Estero.

NPS / SUE VAN DER WAL

Regional Sites

Thirteen regional surveys occurred between March 1 and July 31, 2021, at 21 different locations throughout the central coast of California. Not all sites were surveyed on all scheduled days due to weather conditions or scheduling conflicts. During the 2021 breeding season, we counted a maximum of 3,399 adults/immatures and 1,365 pups, although the maximum counts may have occurred on different days for each location (Table 4). During the molt season, we recorded a maximum count of 3,970 seals (all age classes). Of these areas, Marin County sites accounted for 62% of breeding season adult and immature animals (2,093 of 3,399), 71% of pups (972 of 1,365), and 60% of seals during the molting season (2,369 of 3,970), all of which are similar proportions to past years. Using a correction factor of 1.54 (95% CI = 1.16–1.92), we calculated a regional harbor seal population estimate during the 2021 molt season of 6,114 seals (95% CI = 4,605–7,622; Harvey and Goley 2011).

Table 4. Regional surveys of harbor seal numbers in central California, March 1–July 26, 2021. Thirteen surveys were scheduled, nine during the breeding season and four during the molt season. Values reported as number of surveys (N), maximum (Max), mean, and standard deviation (SD). ND = No data.

Regional Area	Location	Breeding Season					Molt Season		
		N	Adult Max ^A	2005–2019 Adult Mean (SD) ^B	Pup Max	2005–2019 Pup Mean (SD) ^B	N	Max ^C	2005–2019 Mean (SD) ^B
Mendocino County	Point Arena Lighthouse	9	77	–	31	–	4	147	–
Sonoma County	Sonoma Coast	8	148	186.5 (29.3)	54	61.6 (16.6)	3	132	223.9 (48.7)
	Fort Ross	5	146	153.4 (54.6)	32	17.0 (8.6)	1	44	174.6 (36.9)
	Jenner	9	134	176.5 (48.9)	25	21.3 (10.7)	4	351	292.2 (77.6)
	Bodega Marine Reserve	0	ND	60.9 (15.4)	ND	11.4 (3.9)	0	ND	81.0 (25.5)
Marin County	Tomaes Bay	9	355	422.2 (77.8)	118	105.9 (28.0)	3	344	353.3 (143.3)
	Tomaes Point	9	272	311.5 (69.9)	62	111.9 (32.6)	2	221	424.1 (120.4)
	Point Reyes Headland	7	94	101.1 (28.6)	48	41.7 (10.1)	3	184	335.3 (124.4)
	Drakes Estero Complex	9	536	662.1 (110.9)	231	315 (42.2)	4	598	930.3 (198.7)
	Double Point	6	341	471.4 (108.0)	228	278.4 (85.5)	2	253	703.1 (266.7)
	Duxbury Reef	9	52	51.3 (24.7)	3	5.3 (4.7)	4	69	72.3 (37.3)
	Bolinas Lagoon	9	326	338.7 (69.5)	270	178.1 (52.3)	4	619	515.2 (131.2)
	Point Bonita	8	117	123.3 (31.8)	12	9.1 (4.1)	4	81	175.3 (56.1)
San Francisco Bay	Alcatraz	8	8	7.1 (4.2)	0.0 (0.0)	0.0 (0.0)	4	3	3.1 (2.9)
	Castro Rocks	8	199	176.7 (38.0)	60	47.5 (16.7)	4	250	179.7 (54.6)
	Yerba Buena Island	9	186	120.8 (36.3)	42	19.0 (10.6)	4	257	139.6 (45.0)
	Newark Slough	0	ND	38.5 (14.9)	ND	16.2 (10.0)	0	ND	11.9 (8.5)
	Mowry Slough	0	ND	105.3 (26.6)	ND	40.8 (24.6)	0	ND	88.8 (54.4)

^A Adults and immatures during the peak of the breeding season, mid-April to mid-May, except for Mendocino County which has a peak until early June.

^B Average of the annual maximum counts between 2005 and 2019, except for the following sites: Fort Ross started in 2013, Bodega Marine Reserve started in 2010, and Purisima Creek started in 2012. Point Arena does not have an average since counts started in 2019. Additionally, other sites sometimes skip a year of monitoring.

^C Maximum counts occurring between June 10 and July 26.

Table 4 (continued). Regional surveys of harbor seal numbers in central California, March 1–July 26, 2021. Thirteen surveys were scheduled, nine during the breeding season and four during the molt season. Values reported as number of surveys (N), maximum (Max), mean, and standard deviation (SD). ND = No data.

Regional Area	Location	Breeding Season					Molt Season		
		N	Adult Max ^A	2005–2019 Adult Mean (SD) ^B	Pup Max	2005–2019 Pup Mean (SD) ^B	N	Max ^C	2005–2019 Mean (SD) ^B
San Mateo County	Point San Pedro	9	9	20.6 (15.6)	3	1.5 (1.7)	1	16	31.9 (19.0)
	Cowell Ranch	8	62	89.9 (29.7)	25	18.9 (3.5)	4	60	103.5 (37.8)
	Purisima Creek	8	60	79.0 (22.3)	32	29.8 (6.9)	4	36	94.3 (25.8)
	Pescadero	9	34	43.8 (12.5)	17	9.8 (3.4)	4	32	51.8 (13.6)
	Pebble Beach	9	60	74.5 (17.9)	22	15.0 (5.7)	4	76	118.7 (41.0)
	Fitzgerald Marine Reserve	9	183	224.7 (55.0)	50	41.4 (19.3)	4	197	280.7 (78.6)
ALL SITES	–	–	3,399	–	1,365	–	–	3,970	–

^A Adults and immatures during the peak of the breeding season, mid-April to mid-May, except for Mendocino County which has a peak until early June.

^B Average of the annual maximum counts between 2005 and 2019, except for the following sites: Fort Ross started in 2013, Bodega Marine Reserve started in 2010, and Purisima Creek started in 2012. Point Arena does not have an average since counts started in 2019. Additionally, other sites sometimes skip a year of monitoring.

^C Maximum counts occurring between June 10 and July 26.

Mendocino County

We added Point Arena to the regional survey sites in 2019, but this is the first time it has been reported in an SFAN annual report. This is the only location surveyed in Mendocino County, and it consists of four subsites around the Point Arena Stornetta unit of the US Bureau of Land Management California Coast National Monument. The Point Arena volunteer recorded maximum counts of 77 adults/immatures and 31 pups during the 2021 breeding season and 147 total seals during the 2021 molt season (Table 4). The only disturbance recorded by the volunteer was a U.S. Coast Guard helicopter that caused the seals to head alert.

Sonoma County

Sonoma County volunteers did not survey the Bodega Marine Reserve in 2021, and that site typically makes up approximately 10% of the Sonoma County harbor seal population. The Sonoma County adult/immature count in 2021 was lower than 2019 (Figure 8), with the biggest declines seen at Fort Ross and Jenner. The 2021 pup count is lower than 2019, but that year had an especially high pup count at Jenner (Figure 9). The other three sites are either similar to their long-term average (Sonoma Coast and Jenner) or greater than their long-term average (Fort Ross). Among Sonoma County sites, Sonoma Coast and Fort Ross had the high counts of adults/immatures and Sonoma Coast had the high count of pups (Table 4). During the molt season, the 2021 maximum count was only slightly less than 2019 (Figure 10). However, volunteers recorded large declines compared to the long-term averages at both Sonoma Coast and Fort Ross, while an above average count was recorded at Jenner (Table 4). Volunteers observed the highest molt count among Sonoma County sites in 2021 at Jenner (Table 4). In Sonoma County, volunteers only recorded a disturbance at Fort Ross, and it was caused by a beach walker.

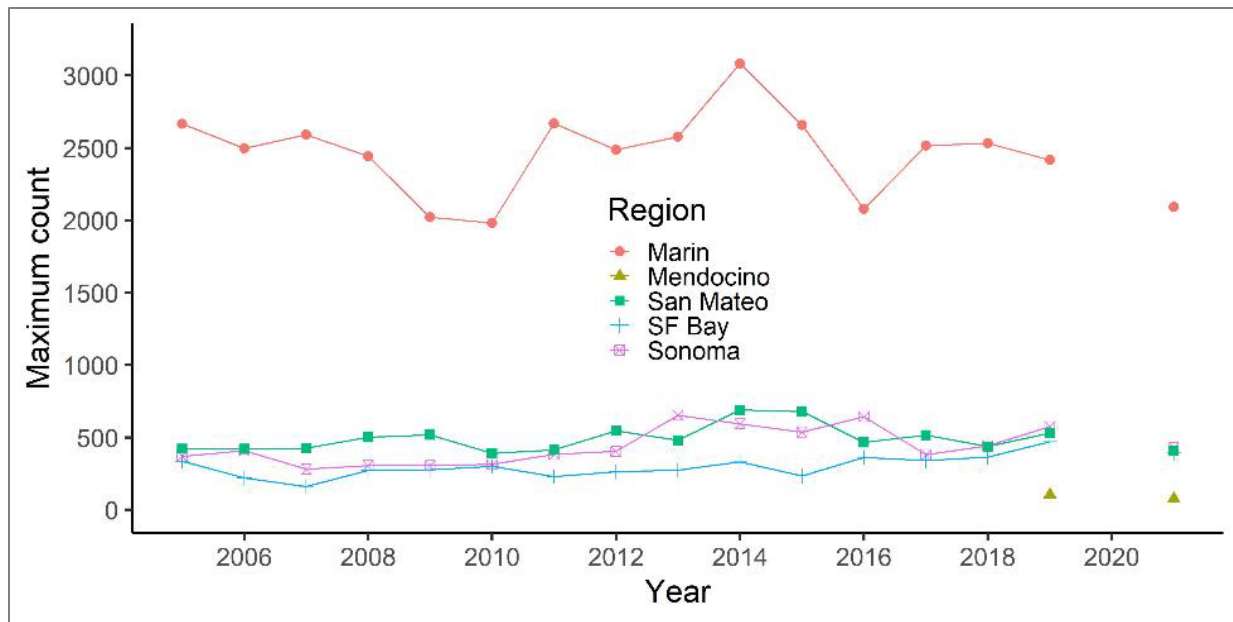


Figure 8. Maximum counts of harbor seal adults and immatures by region during the breeding season for the 2005–2021 regional surveys in central California. Bodega Marine Reserve was added to Sonoma County in 2010, Purisima Creek was added to San Mateo County in 2012, Fort Ross was added to Sonoma County in 2013, and Mendocino County was added in 2019. Incomplete surveys occurred in San Mateo County in 2006 and 2013 and San Francisco Bay in 2007. No surveys were conducted in 2020.

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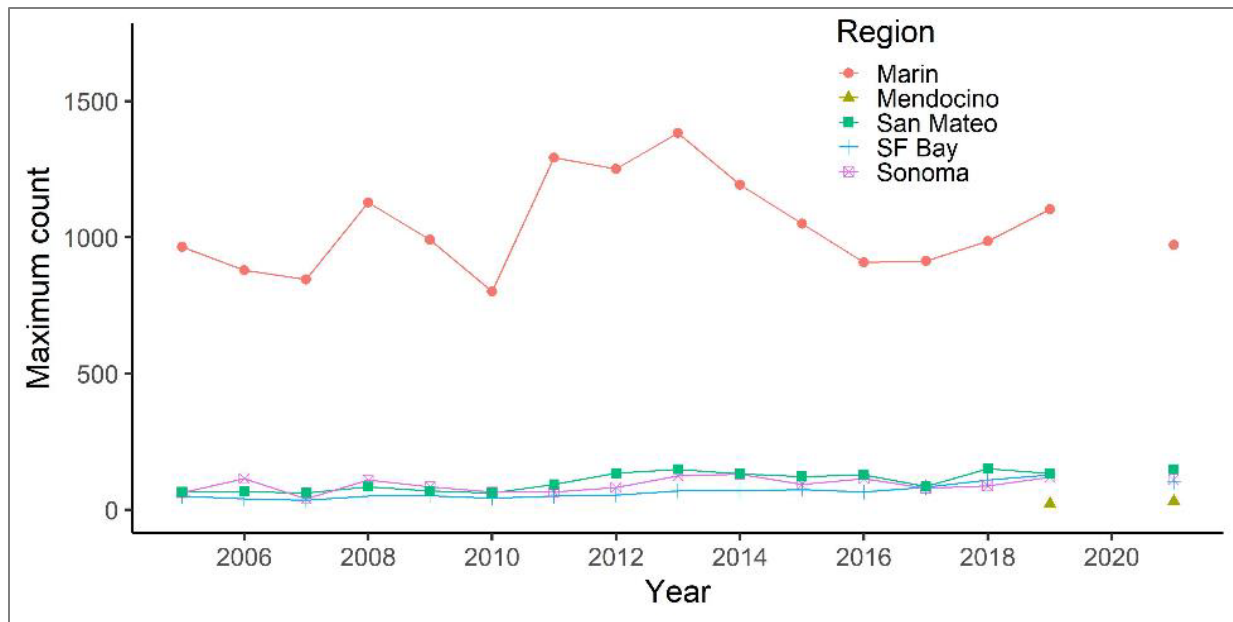


Figure 9. Maximum counts of harbor seal pups by region during the breeding season for the 2005–2021 regional surveys in Central California. Bodega Marine Reserve was added to Sonoma County in 2010, Purisima Creek was added to San Mateo County in 2012, Fort Ross was added to Sonoma County in 2013, and Mendocino County was added in 2019. Incomplete surveys occurred in San Mateo County in 2006 and 2013 and San Francisco Bay in 2007. No surveys were conducted in 2020.

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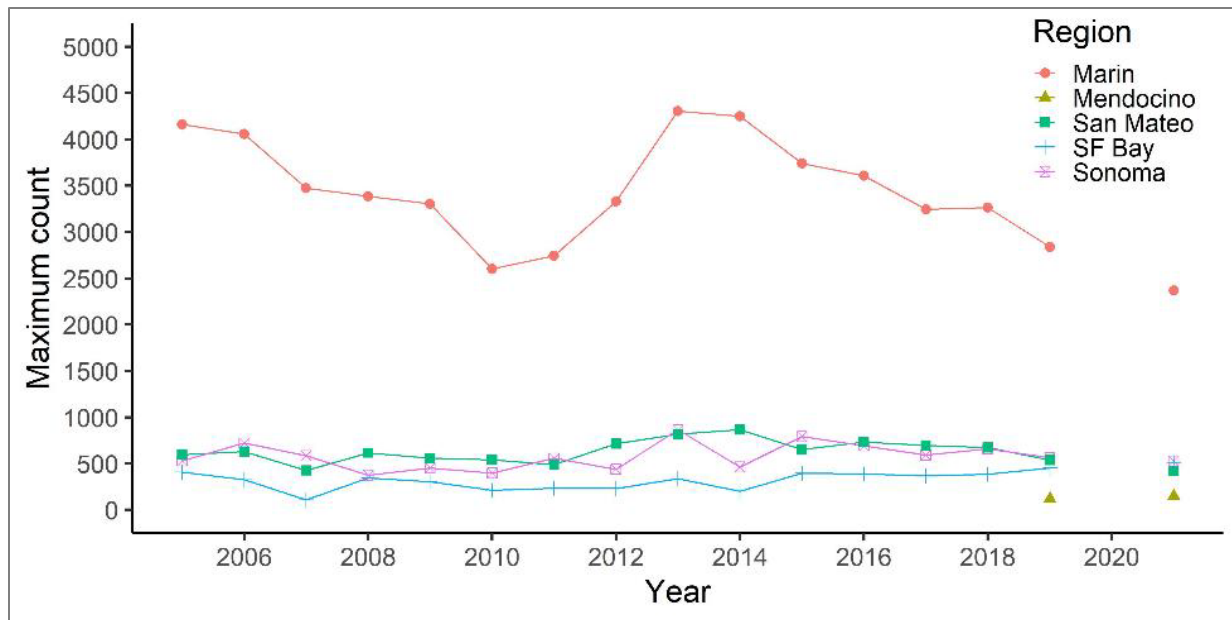


Figure 10. Maximum counts of all age classes of harbor seals by region during the molting season for the 2005–2021 regional surveys in central California. Bodega Marine Reserve was added to Sonoma County in 2010, Purisima Creek was added to San Mateo County in 2012, Fort Ross was added to Sonoma County in 2013, and Mendocino County was added in 2019. Incomplete surveys occurred in San Mateo County in 2006 and 2013, San Francisco Bay in 2007, Marin County in 2010, and Sonoma County in 2014. No surveys were conducted in 2020.

NPS

San Francisco Bay

Volunteers have not surveyed Mowry and Newark Sloughs since 2018. The SFB breeding season counts in 2021 had small declines compared to 2019 (Figures 8 and 9). However, the two main locations surveyed (Castro Rocks and Yerba Buena Island) had above average counts compared to their long-term averages. The pup count at Yerba Buena Island was the largest count at that site during the 16-year study period. Within SFB, the high counts for adults/immatures and pups occurred at Castro Rocks (Table 4). The maximum molt count in 2021 was slightly greater than 2019 and is the largest count on record for SFB during this monitoring study (Figure 10). The high count during the molt season occurred at both Castro Rocks and Yerba Buena Island, and both sites had counts that were greater than their long-term averages. The monitoring teams recorded disturbances during many of the surveys at Yerba Buena Island and only a few surveys at Alcatraz and Castro Rocks. At Yerba Buena Island, the sources of disturbance included motorboats (including large ferries), a sailboat, a gardener using a leaf blower, vehicle noise, other harbor seals, and unknown sources, and primarily resulted in seals flushing into the water. At Alcatraz, the sources of disturbance included motorboats and birds, and primarily resulted in head alerts. At Castro Rocks, the sources of disturbance included another harbor seal and an unknown source.

San Mateo County

The maximum adult/immature count during the 2021 breeding season at San Mateo County sites was less than counts from recent years, but the pup count was one of the highest counts in the past 17

years of monitoring at these sites (Figures 8 and 9). All sites in San Mateo County had either pup counts similar to their long-term averages or above average. We saw a large decrease in the maximum molt count in 2021, and it was the lowest count for the past 17 years of monitoring. This continues the trend of declining molt counts that we have observed since the high count in 2014 (Figure 10). The monitoring teams recorded lower than average counts at all sites in San Mateo during the molt season. Among San Mateo County sites, Fitzgerald Marine Reserve had the high counts of adults/immatures, pups, and molting seals (Table 4). The monitoring teams did not record any disturbances at San Mateo County sites in 2021. However, the teams noted potential disturbances at Pedro Point, Fitzgerald Marine Reserve, and Cowell Ranch Beach when people were seen in known harbor seal haul-outs, but no seals were present when observers were there.

Discussion

The adult/immature harbor seal count for Marin County sites during the 2021 breeding season was less than the long-term average and one of the lowest counts on record during the 21 years of NPS monitoring. We attributed this large decline to low counts at nearly all sites including Drakes Estero Complex, Double Point, Tomales Bay, and Tomales Point. However, the 2021 pup count was only slightly less than the long-term average and was still within one standard deviation of the average. We saw major declines in the pup counts at the Drakes Estero Complex and Tomales Point this year compared to their long-term averages (−33% and −51%, respectively), and this year's counts were among some of the lowest counts at the two sites. Conversely, the pup count at Double Point increased compared to 2019 but was still lower than the long-term average, and counts at this site have been lower than average since 2015. Throughout most of the 21-year study period, Drakes Estero and Double Point comprised the majority of seals counted in Marin County. In recent years, however, Bolinas Lagoon pup numbers increased while Double Point decreased, and this year the pup count at Bolinas Lagoon was the highest count we have recorded at this site. This was the first time in the study's history that neither Drakes Estero nor Double Point had the highest pup count.

The maximum count of all seals during the molt season for Marin County sites was far below the 20-year average and is the lowest molt count in the history of the NPS monitoring program. Seal counts during the molt season in Marin County have been declining since 2016. All Marin County sites had lower than average counts in 2021 except Bolinas Lagoon. We recorded a major decline at the Drakes Estero Complex this year, and Double Point continued to have seal counts that are below the long-term average. In fact, seal counts at Double Point have ranged from 37% to 79% below the long-term average since 2016. As such, 2021 marked five consecutive years of below-average seal counts there and a potential cause for concern. In contrast, 2021 marked only the second observation of an extremely low count at Drakes Estero throughout the study period, with the first time being in 2011. This year's molt count at Drakes Estero was approximately 43% below the long-term average. Monitoring teams also recorded low molt-season counts at most sites in Sonoma County and all of San Mateo County.

To date, there are no known studies explaining the increase in coyote observations in the area. However, the decline in all counts at Drakes Estero in 2021 coincided with an increase in coyote sightings and attacks on pups at this site. During the 2021 breeding season, we recorded one to three coyotes on the main pupping sandbar in Drakes Estero during most surveys. On two different days we saw a coyote preying on a live harbor seal pup, and on a third day two coyotes were seen eating a dead adult harbor seal when the observer arrived, so we cannot confirm if the coyotes killed the seal or were simply scavenging the carcass. The main pupping sandbar had previously been unreachable by coyotes because of the channel of water surrounding it. However, in 2021, natural changes in sandbar morphology allowed predator access. We did not conduct surveys in 2020, so it is possible this also occurred undetected in 2020. We assumed that due to the constant presence of coyotes on this main sandbar, many of the seals that usually haul out there moved to nearby sandbars that were completely surrounded by deeper water. A similar displacement of seals in Drakes Estero occurred in

2004 when the main pupping sandbar at that time became connected to the mainland and coyotes were able to access it (Becker et al. 2011). The seals then moved to the sandbar that they have been using in recent years. Future monitoring will show if the seals move to different sandbars to avoid the coyotes or if the sandbar connection to the mainland changes. We installed a wildlife camera at this site in early May to take a photo once a minute during daylight hours, but we did not detect any more coyote occurrences at Drakes Estero in 2021. This non-detection may have been due to our installation of the camera after the peak of pupping season. That timing meant that there were very few young pups which likely are more of a draw for coyotes than older pups because they are easier to prey upon than quicker, more agile, older pups. We also noted fewer seals hauling out on the sandbar that was accessible to coyotes, which may indicate that such sandbars have become ineffective habitat due to coyote avoidance by seals. Additional evidence to support that conclusion included photos that revealed seals using the main pupping sandbar at higher tide heights (when it was more difficult for coyotes to access the sandbar) and then moving to a smaller sandbar (surrounded by deep water) as the tide receded.

In recent years, we have recorded major changes in the number of seals at Bolinas Lagoon and Double Point. The maximum pup counts at Double Point have been below average since 2017, whereas the pup counts at Bolinas Lagoon have increased since 2017. During the molt season, the number of seals at Double Point started to decline in 2016, but the counts at Bolinas Lagoon dramatically increased as early as 2014. Between 2000 and 2015, the combined counts of the Drakes Estero Complex and Double Point comprised the majority of the seals recorded during the molt season. Since 2016 we saw a shift with Bolinas Lagoon and the Drakes Estero Complex comprising the majority of the seals during the molt season; however, with this year's low count at Drakes Estero, the two sites comprised only about 47% of the total seals in Marin County. The molt counts at Double Point, since 2016, have ranged between 37% and 79% below the site's long-term average. We are not certain why this site is declining, but the decreasing seal counts could be due to an increase in coyotes as well as changes in habitat from large storms in 2017. For example, coyote sightings at Double Point have increased in recent years, and large landslides in 2017 appear to have allowed easier access for coyotes to this site. Changes in beach morphology from large storms also may have created a less-desirable haul-out site, thereby affecting how the seals used the beach. We have not been tracking individual seals, so it is not possible to determine if some seals leaving Double Point are now using Bolinas Lagoon.

Throughout the 21-year study period, the primary sites that experienced disturbances were Tomales Bay, Drakes Estero Complex, Bolinas Lagoon, and Double Point. Although, in 2021, we detected only one disturbance at Double Point. We were able to conduct only a small number of surveys at Double Point in 2021, so we likely missed some disturbances—especially from coyotes—as we did see coyote tracks on the beach during some surveys. Drakes Estero had the highest disturbance rate in 2021, which we mostly attributed to coyotes and unknown sources. Throughout most of the long-term study period, Tomales Bay consistently experienced the highest disturbance rate because it is a popular recreational area for fishing, clamming, and boating (motorboats and kayaks), and is adjacent to a boat launch site. However, in 2021, we recorded fewer disturbances in Tomales Bay. This may reflect undetected disturbances due, in part, to very few surveys conducted on weekends when more

people typically recreate on the water, but we also saw fewer clammers than normal on the sandbars during the weekdays. The primary boat launch site near the harbor seal haul-out in Tomales Bay was not renting boats in 2021 due to COVID-19 precautions and thereby may have led to fewer people clamming on the sandbars.

The most common sources of disturbance for all Marin County sites in 2021 were unknown sources and motorboats. These sources, along with humans on foot, were regularly the major causes of disturbance at Marin County sites over the past decade (see Table 6 in Appendix B). The number of disturbances caused by humans on foot was low in 2021 due to reduced presence of both clammers in Tomales Bay and beachgoers on Limantour and Drakes Beach. Some of these reductions were related to the closure of Drakes Beach to visitors for most of the 2021 monitoring season due to construction work at the parking lot. Moreover, despite the presence of some beachgoers on Limantour Spit, there were no seals hauled out at that location in 2021. In fact, we have observed very few seals using Limantour Spit over the past few years.

Harbor seals are high trophic-level predators in the marine ecosystem, and numerous dynamic processes have the potential to affect their abundance and distribution. Harbor seals are sensitive to changes in the marine ecosystem, especially El Niño events, and respond quickly to changes in prey abundance and distribution, and to human disturbance (Allen et al. 1985; Thompson and Miller 1990; Trillmich and Ono 1991; Thompson et al. 1998; Sydeman and Allen 1999; Gible and Harvey 2015). Despite productive ocean conditions in 2020 (Harvey et al. 2021), we observed relatively low harbor seal counts at PORE and GOGA in 2021. Longterm, information gained at PORE and GOGA contributes to understanding how recovered populations may influence regional marine ecosystems. Studying trends and alterations in habitat and habitat use may also provide insights into the potential or real effects of climate change on harbor seal distribution and abundance. For example, storm events, increasing wave height, and rising sea levels may change sandbar formation and locations for seals to haul out at Drakes Estero.

Collaborations

SFAN staff continued to coordinate the central California coast regional surveys, which included collaborations with multiple government agencies, universities, and non-profit groups including California Department of Transportation, US Fish and Wildlife Service, Greater Farallones National Marine Sanctuary, UC Davis Bodega Marine Laboratory, Greater Farallones Association, Fort Ross Conservancy, Stewards of the Coast and Redwoods Seal Watch program, Sea Ranch Coastal Stewardship Task Force, the Sea Ranch Harbor Seal Docent Program, and other volunteers (see Appendix C).

Changes to Data Collection

Due to safety concerns about the observation site for Double Point, we identified a new location. This site is farther from the cliff edge and is on more stable ground. We conducted fewer surveys than described in the protocol, as we assessed the new location for safety and limited which volunteers could go to the site. We anticipate increasing the number of surveys to the typical level in 2022.

The Point Reyes Headlands colony has two observation sites since not all seals can be seen from one location. One of the observation locations had become unsafe for staff and volunteers to access due to increased erosion and risk of landslides, and we had to limit our survey effort to only the safer observation spot. Going forward, and including 2021, the harbor seal counts at the Point Reyes Headlands will be partial counts as not all seals can be seen from the single observation site.

Season Highlights

- In 2021, 22 volunteers and one NPS staff member completed 172 surveys at eight Marin County sites between March 1 and July 31, with approximately 285 monitoring hours.
- We counted a maximum of 2,107 adult and immature seals onshore during the 2021 breeding season at Marin County locations.
 - The total count was below the 20-year average and was one of the lowest counts recorded during the study period.
 - The highest number of adults/immatures hauled out at Drakes Estero Complex (550).
- We recorded a maximum of 972 pups in 2021 at Marin County colonies. This count is similar to the long-term average.
 - The highest number of pups we recorded was at Bolinas Lagoon (270), and this is the first time Bolinas has ever had the highest number of pups of all Marin County sites.
 - We saw a major decline in pups at Drakes Estero. The 2021 count was one of the lowest counts recorded during the 21-year monitoring period at this site. Coyote presence is likely the cause of this decline.
- During the 2021 molt season, we counted a maximum of 2,581 seals (all age classes) at Marin County haul-out sites. This is the lowest count on record during the 21-year study period.
 - The highest number of seals hauled out at Bolinas Lagoon (619), and this is the first time in the 21-year monitoring period that this site has had the highest number of seals of all Marin County sites.
 - We recorded extremely low counts at the Drakes Estero Complex and Double Point.
- In 2021, we observed 38 disturbances during surveys.
 - The most frequent causes in 2021 were unknown sources (29%) and motorboats (26%).
 - The highest disturbance rate (0.29 disturbances/hour) occurred at Drakes Estero and the primary cause was coyotes.
- Regional surveys occurred 13 times throughout the breeding and molt seasons (March–July) in 2021. The sites include locations in San Francisco Bay and Mendocino, Sonoma, Marin, and San Mateo counties.

- The regional harbor seal population estimate calculated during the 2021 molt season was 6,114 (95% CI = 4,605–7,622).
- Marin County sites accounted for 62% of breeding season adult and immature seals, 72% of pups, and 60% of seals during the molting season.
- We added Point Arena (Mendocino County) to the regional surveys in 2019, but this is the first year the site was included in this annual monitoring report.

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Appendix A. Summary Data for the 2021 Monitoring Seasons

Summary count data from harbor seal monitoring in the 2021 breeding and molt seasons are presented in Table 5, and weekly maximum counts for each Marin County site are shown in Figure 11.

Table 5. Summary count data for harbor seal colonies during the 2021 monitoring seasons. Values reported as number of surveys (N), minimum (min), maximum (max), mean, and standard deviation (SD).

Location	Breeding Season ^A						Molt Season ^B			
	N	Adult Min	Adult Max	Adult Mean (SD)	Pup Max	Pup Mean (SD)	N	Min	Max	Mean (SD)
Tomales Bay	16	146	355	273.3 (59.9)	118	50 (32.2)	8	179	414	282.4 (74.5)
Tomales Point	14	44	272	130 (71.3)	62	34 (21.1)	5	116	339	225 (82.7)
Point Reyes Headlands	7	10	95	52 (32.0)	48	29 (19.9)	3	98	184	140 (43.0)
Drakes Estero	16	122	550	307 (135.8)	231	108 (80.3)	8	313	749	484 (147.8)
Double Point	6	60	341	211 (92.5)	228	168 (41.4)	5	40	297	191 (98.2)
Duxbury Reef	14	23	71	35 (13.7)	3	2 (0.8)	8	16	90	46 (24.5)
Bolinas Lagoon	13	102	326	203 (84.2)	270	118 (93.1)	8	253	619	396 (124.5)
Point Bonita	18	7	117	46 (33.9)	12	5 (3.6)	9	25	105	64 (23.7)

^A Breeding season values include all surveys conducted March 1–May 30. The maximum count may differ from what is reported in the main report if it occurred early or late in the season and included seals that may be travelling between sites.

^B Molt season values include all surveys conducted June 1–July 31. The maximum count may differ from what is reported in the main report if it occurred early in the season and included seals that may be travelling between sites.

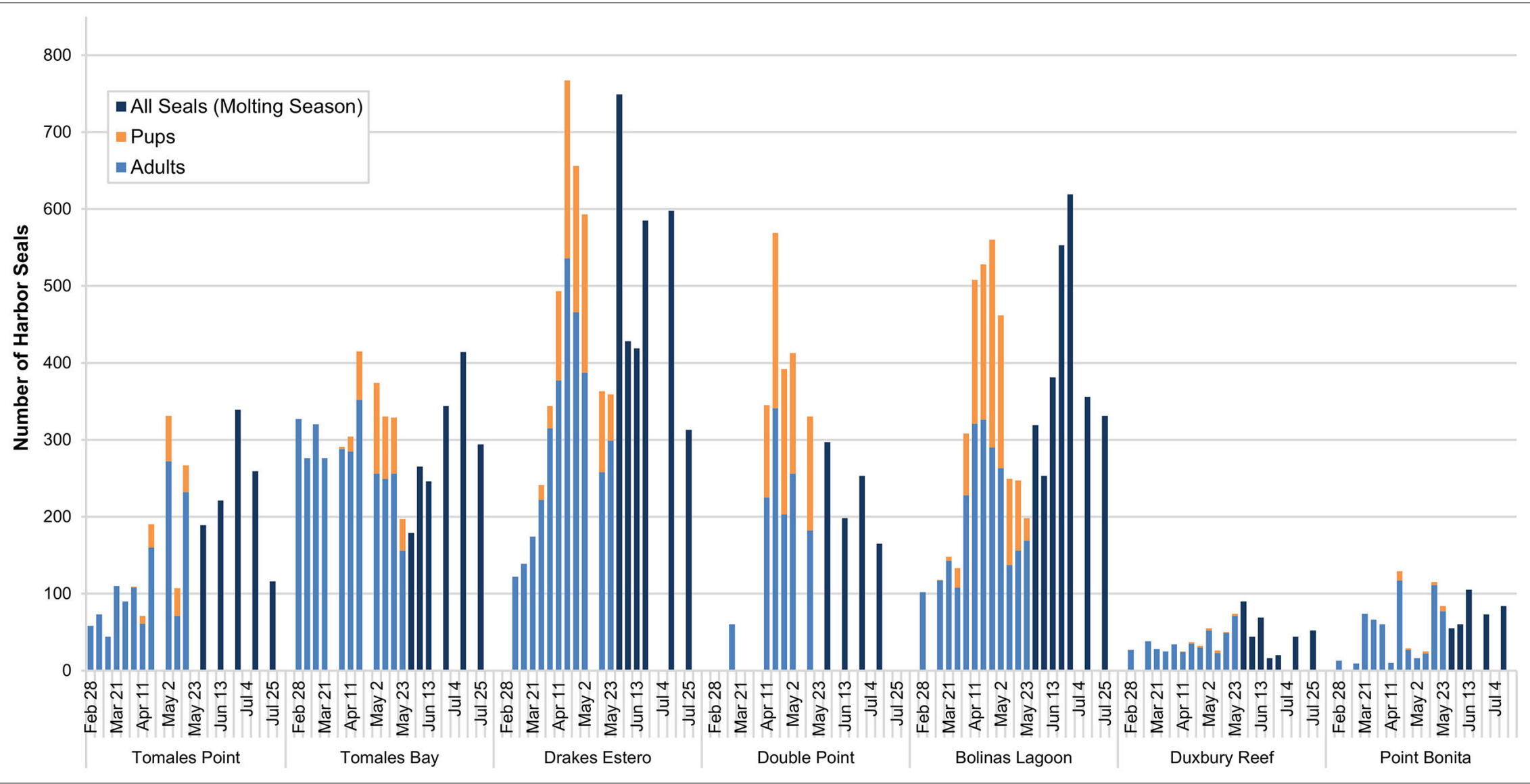


Figure 11. Weekly maximum counts of each Marin County site from March through July 2021. Dates with missing columns indicate no high-quality surveys took place at that site during that week.
NPS

Appendix B. Identified Sources of Disturbances for Marin County Sites from March Through July, 2000–2021

We present the sources of seal disturbance observed at Marin County sites during the monitoring seasons (March through July) for 2000 through 2021 in Table 6.

Table 6. Identified sources of disturbances (head alert, flush, flush into water) for Marin County sites from March through July, 2000–2021. The mean includes disturbance sources from 2000–2019.

Year	Aircraft		Bird		Dog		Human		Motorboat		Non-Motorboat		Vehicle		Unknown		Other		Total
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
2000	14	11.3	19	15.3	0	0.0	23	18.5	14	11.3	9	7.3	0	0.0	43	34.7	2	1.6	124
2001	4	3.1	9	6.9	1	0.8	45	34.6	14	10.8	12	9.2	2	1.5	28	21.5	15	11.5	130
2002	9	5.7	11	7.0	0	0.0	48	30.6	19	12.1	15	9.6	9	5.7	39	24.8	7	4.5	157
2003	10	7.5	10	7.5	0	0.0	38	28.6	13	9.8	20	15.0	3	2.3	32	24.1	7	5.3	133
2004	2	2.2	7	7.5	1	1.1	35	37.6	2	2.2	9	9.7	7	7.5	23	24.7	7	7.5	93
2005	10	8.1	10	8.1	2	1.6	43	35.0	9	7.3	14	11.4	1	0.8	31	25.2	3	2.4	123
2006	8	5.1	13	8.3	1	0.6	57	36.3	14	8.9	16	10.2	5	3.2	35	22.3	8	5.1	157
2007	14	6.7	13	6.2	2	1.0	70	33.3	29	13.8	21	10.0	14	6.7	45	21.4	2	1.0	210
2008	4	3.7	5	4.6	0	0.0	51	47.2	11	10.2	10	9.3	5	4.6	18	16.7	4	3.7	108
2009	3	3.1	6	6.3	0	0.0	21	21.9	22	22.9	11	11.5	2	2.1	27	28.1	4	4.2	96
2010	5	4.4	5	4.4	2	1.8	35	30.7	27	23.7	5	4.4	3	2.6	30	26.3	2	1.8	114
2011	5	5.3	11	11.7	0	0.0	27	28.7	20	21.3	3	3.2	3	3.2	19	20.2	6	6.4	94
2012	3	2.9	15	14.4	0	0.0	28	26.9	16	15.4	4	3.8	2	1.9	29	27.9	7	6.7	104
2013	12	11.0	19	17.4	0	0.0	19	17.4	18	16.5	7	6.4	1	0.9	30	27.5	3	2.8	109
2014	10	8.0	13	10.4	0	0.0	34	27.2	16	12.8	11	8.8	2	1.6	35	28.0	4	3.2	125
2015	13	14.6	11	12.4	0	0.0	16	18.0	13	14.6	7	7.9	3	3.4	22	24.7	2	2.2	89
2016	9	8.9	8	7.9	2	2.0	26	25.7	21	20.8	4	4.0	1	1.0	23	22.8	7	6.9	101
2017	12	12.4	6	6.2	0	0.0	16	16.5	29	29.9	4	4.1	1	1.0	27	27.8	2	2.1	97
2018	11	12.2	2	2.2	1	1.1	20	22.2	26	28.9	8	8.9	1	1.1	18	20.0	3	3.3	90
2019	6	9.7	2	3.2	1	1.6	15	24.2	16	25.8	2	3.2	2	3.2	13	21.0	5	8.1	62
2021	1	2.6	5	13.2	0	0.0	5	13.2	10	26.3	1	2.6	0	0.0	11	28.9	5	13.2	38
2000–2019 Mean (SD)	8.2 (3.9)	7.3 (3.7)	9.8 (4.8)	8.4 (4.1)	0.7 (0.8)	0.6 (0.7)	33.4 (15.2)	28.1 (7.9)	17.5 (6.9)	15.9 (7.6)	9.6 (5.5)	7.9 (3.3)	3.4 (3.3)	2.7 (2.0)	28.4 (8.5)	24.5 (4.0)	5.0 (3.2)	4.5 (2.7)	116 (32.0)

Appendix C. Lead Organizations for Regional Sites

We list the organizations that led data collection at regional sites during the 2021 monitoring season in Table 7.

Table 7. List of lead organizations responsible for data collection at each regional site in 2021.

Regional Area	Location	Organization
Mendocino County	Point Arena	Sara Bogard ^A
Sonoma County	Sonoma Coast	Sea Ranch Coastal Stewardship Task Force and the Sea Ranch Harbor Seal Docent Program
	Fort Ross	Fort Ross Conservancy
	Jenner	Stewards of the Coast and Redwoods
San Francisco Bay	Alcatraz	Golden Gate National Recreation Area
	Castro Rocks	California Department of Transportation
	Yerba Buena Island	D. Greig ^A , K. High ^A
Marin County	Tomales Bay	Point Reyes National Seashore
	Tomales Point	Point Reyes National Seashore
	Point Reyes Headlands	Point Reyes National Seashore
	Drakes Estero Complex	Point Reyes National Seashore
	Double Point	Point Reyes National Seashore
	Duxbury Reef	Point Reyes National Seashore
	Bolinas Lagoon	Point Reyes National Seashore
	Point Bonita	Point Reyes National Seashore
San Mateo County	Point San Pedro	Greater Farallones National Marine Sanctuary (GFNMS) and Greater Farallones Association (GFA)
	Cowell Ranch	GFNMS and GFA
	Purisima Creek	GFNMS and GFA
	Pescadero	GFNMS and GFA
	Pebble Beach	GFNMS and GFA
	Fitzgerald Marine Reserve	GFNMS and GFA

^A Individual not affiliated with an organization.

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