



Pacific Harbor Seal (*Phoca vitulina richardii*)

Monitoring at Point Reyes National Seashore and Golden Gate National Recreation Area

2016 Annual Report

Natural Resource Report NPS/SFAN/NRR—2018/1719



ON THE COVER

Pacific harbor seals hauled out on rocks at Point Bonita in the Marin Headlands, California.

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Golden Gate National Recreation Area
*2016 Annual Report***

Natural Resource Report NPS/SFAN/NRR—2018/1719

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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).

Harbor seal surveys were conducted throughout the 2016 breeding and molting seasons (March-May and June-July, respectively) once or twice per week at the largest Point Reyes National Seashore and Golden Gate National Recreation Area harbor seal colonies, collectively referred to as Marin County sites. Members of the Harbor Seal Monitoring Volunteer Program assisted NPS staff in completing 265 surveys at eight Marin County sites, contributing approximately 465 hours of monitoring. During the breeding season, a peak count of 2,126 adult and immature seals was recorded at all Marin County monitoring sites, which is less than the 16-year average and one of the lowest counts recorded. The Drakes Estero Complex had the most adult and immature seals (473), followed by Tomales Bay (437). During the breeding season, 951 seal pups were recorded at all Marin County sites, which is also less than the 16-year average. The Drakes Estero Complex and Double Point accounted for 58% (552) of pups at Marin County haul-outs. During the molting season, a peak count of 3,722 animals was recorded at Marin County sites, which is similar to the 16-year average. During the 2016 monitoring seasons, 101 disturbances to seals were recorded. The most frequent causes were humans on foot (26%), unknown sources (23%), and motor boats (21%). Thirteen regional surveys were conducted throughout the breeding and molting seasons at locations in Sonoma, Marin and San Mateo counties, and San Francisco Bay. Of these areas, Marin County sites accounted for 55% of breeding season adult and immature animals (2,080 of 3,759), 71% of pups (908 of 1,274), and 65% of seals during the molting season (3,606 of 5,580), all of which are similar proportions to past years.

Acknowledgments

Volunteers are the backbone of the harbor seal monitoring program. We thank all the volunteers who hiked many miles to survey harbor seals, including F. Booker, C. Cardosi, T. Carney, K. Carolan, R. Catlin, M. Cox, D. Donnenfield, B. Felix, D. Ford, J. Ford, J. Forsell, E. Kean, K. Khtikian, J. Khudyakov, J. Lamphier, K. Liang, W. Ludan, C. Maloney, T. McHale, R. McLemore, H. Nelson, A. Nordstrom, W. Pettus, H. Rederer, J. Robinson, C. Roundey, A. Segal, S. Shenoy, B. Siegel, S. Snow, E. Sojourner, J. Thompson, S. Van Der Wal, S. Waber, M. Weiss, J. Winer, D. Winters, and S. Young.

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All monitoring activities were conducted under the National Marine Fisheries Service Permit 17152.

Introduction

The San Francisco Bay Area Network (SFAN) Inventory and Monitoring Program includes National Park Service (NPS) sites such as 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, have protected status through 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). Also, pinnipeds, including harbor seals, are good indicators of the potential effects of changes in climate such as sea level rise and variations in timing and magnitude of coastal upwelling (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, but not all of the current sites were surveyed until 2000.

Harbor seals were also identified as a marine mammal species most likely to benefit from the establishment of marine protected areas (MPAs) in the north central California coast region under the Marine Life Protection Act (CDFG 2009). Five MPAs were designated within PORE as well as three special closure areas that while primarily designed to protect marine birds, may also benefit harbor seals. The MPAs were implemented in 2010 by the California Department of Fish and Wildlife in cooperation with the NPS. 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 2016 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 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 commonly present at Point Reyes 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 mainland 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 seals' terrestrial resting and pupping periods; 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 (Sydemann and Allen 1999, Carretta et al. 2015). NOAA statewide surveys of harbor seals have noted long-term recovery of the population since the 1980s with a peak in 2004, but that subsequent counts in 2009 and 2012 have been lower (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 2017). The NPS may implement visitor management actions to reduce disturbance to seals at colonies, if appropriate.



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 as a whole are to:

- detect changes in population size
- detect changes in reproductive success as indicated by pup production
- identify sources, frequency and level of effects of natural and anthropogenic disturbances on harbor seal haul out use and productivity

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 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 Sonoma County coastline at 38°44'29" N latitude south to the San Mateo County coastline at 37°31'58" N latitude, and 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. These include tidal mud flats, offshore and onshore rocky tidal ledges, islets, and sandy beaches. Coastal embayment sites include Tomales Bay, Drakes Estero Complex, Bolinas Lagoon, and San Francisco Bay. 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 subsite 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 Sonoma, Marin, and San Mateo counties, California. Map does not present 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.

Sampling Design

The current distribution of the harbor seal breeding/molting population allows surveyors to monitor all sites in PORE and GOGA. Thus, spatial stratification or other sampling techniques were not needed to decide which haul-outs to include for monitoring. SFAN is also reliant upon other monitoring, such as the Greater Farallones National Marine Sanctuary Beach Watch program (<https://farallones.noaa.gov/science/beachwatch.html>) or National Marine Fisheries Service (NMFS) stock assessments (http://www.nmfs.noaa.gov/pr/sars/pdf/stocks/pacific/2014/po2014_harbor_seal-ca.pdf) that include aerial surveys, and reports from park visitors, including boaters, kayakers and the birding community, to locate new haul-outs in remote areas of the parks. 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 ability to detect meaningful population changes over time (Adams et al. 2009). The main parameters monitored are reproductive success (defined as the number of pups counted at each site), population size, distribution, phenology, and disturbances (Adams et al. 2009). Not all seals will be onshore during the surveys; 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).

The monitoring approach enables the data to be integrated with other regional surveys, allowing for the interpretation of results in a regional context. Annually, 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 include colonies in Sonoma County (Sea Ranch, South Sonoma sites, Fort Ross, Jenner, and Bodega Marine Reserve), SFB (Castro Rocks, Alcatraz, Yerba Buena Island, Mowry Slough, and Newark Slough), 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

Surveys were conducted by two NPS staff members and 39 trained volunteers. Volunteer observers were trained to monitor harbor seals at designated sites within PORE and GOGA during two classroom sessions and one field trip in February and March 2016. Many of the volunteers were previously trained and returned to the 2016 season with several years of experience. New volunteers were required to be mentored by seasoned volunteers at a site one to three times before they conducted a survey on their own.

Harbor seal surveys were conducted throughout the breeding (March 1st through May 31st) and molting (June 1st through July 31st) seasons once or twice per week at each Marin County location. Surveys were conducted at medium to low tides (below 3 ft) during the day for an average of 2 hours. Surveys were not conducted in heavy fog, winds over 30 mph, or rain because of poor visibility and because harbor seals haul out in lower numbers in the rain (Jemison and Pendleton 2001).

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. 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) all animals were counted as adults or immature seals because of the difficulty in distinguishing large pups from immature seals.



Volunteer training at Drakes Estero in Point Reyes National Seashore (NPS).

Disturbances and potential disturbances were also recorded as they occurred. Disturbances included any events that caused the seals to lift their head (head alert), flush (move towards the water), or flush 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 with an unknown source. Disturbances were recorded by fixed categories to assist with summary analyses (Table 1). Due to the distance between subsites, Tomales Point and Point Reyes Headlands surveyors are not at any one subsite long enough to generally see disturbances occur. However, due to the remoteness of these sites, very few visitors frequent these locations.

At most sites, volunteers 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. Seal counts at each subsite were recorded separately on pre-formatted datasheets and then summed for site totals every half hour.

Table 1. Categories used to record disturbance sources on field datasheets.

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

On alternating weekends (March – July), regional surveys were conducted at all sites included in the regional counts (see Figure 1). Participants in the region-wide surveys included various organizations and volunteers. Regional counts could be conducted at any time between Thursday and Monday over the selected regional survey weekends.

Data Management and Analysis

All count and disturbance datasheets from Marin County sites were entered into a relational Microsoft Access database during the course of the field season. At the end of the season, the database records were error-checked against the paper datasheets for accuracy. All records were reviewed to ensure that only accurate and complete count data were used for analysis and are defined as high quality data. Incomplete counts or counts that may have been hampered by poor weather conditions were noted in the database as poor quality surveys and excluded from population count analysis. Collection of disturbance data, though, was not affected by weather conditions or surveying all sites, and was summarized regardless of the quality of associated seal count data (see also Becker et al. 2011). Nevertheless, high and poor quality count data were retained in the database.

Although harbor seal data were collected according to subsites within each monitoring location, subsite data are not reported or analyzed within this report. By summing the subsite counts for each survey time interval, the maximum site total was identified for each survey and used for data summaries and analyses. During the breeding months of March, April, and May, the maximum total site count for each survey included the age categories: adult/immature and pup. Live and dead pups were included in the maximum pup count.

The maximum number of seals counted at a site over the course of the entire season is often used for comparisons between years and sites. Because there is little movement of harbor seals between sites during both the pupping and molting seasons (Lowry et al. 2001, Nickel 2003, Cordes and Thompson 2015), it was assumed that individual animals were not counted at more than one site. Additionally, only surveys that occurred during the expected range of the peak breeding season (mid-April through

mid-May) were used to determine the maximum counts for adult/immature seals and pups at each site. The maximum total count for each year within the study area was determined by taking the sum of the maximum count at each location. The maximum total count was determined separately for the breeding and molting seasons. Maximum counts at each location may have occurred on separate days (Barlow 2002). When compiling count summaries from the harbor seal data, only records noted as high quality counts were included. During the regional survey weekends, it was not uncommon for a site to be surveyed more than once. In these cases, the survey with the higher seal count was used for any regional summaries. A regional population estimate was derived from 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 is not used to estimate the population of individual Marin County sites because there is not enough information to determine if the correction factor can be used at an individual site level.

The total maximum counts of breeding season adult and immature seals, pups, and molting season harbor seals were averaged across survey years 2000 to 2015 and compared to the 2016 data. For comparisons of past regional surveys, complete data sets for the locations outside of Marin County are only available since 2005. Surveys at Bodega Marine Reserve (Sonoma County) were added in 2010, at Purisima Creek (San Mateo County) in 2012, and at Fort Ross (Sonoma County) in 2013.

When examining disturbance events, only those that elicited a head-alert or flush reaction from the seals were used for analysis. Disturbance tallies were based on disturbance sources rather than the number of subsites or seals affected. Disturbance rates were calculated from the number of disturbance events that occurred during the time period from the first observation to the end of the final observation period. Because the disturbance data were not analyzed for effects on the seal count data in this report, all actual disturbance data were used for analysis regardless of the quality of the associated seal count data. Potential disturbances (events that could potentially elicit a reaction from seals) were recorded by volunteers to quantify any given type of disturbance recurring at a particular site, but this information is not analyzed in this report. These data may be used to understand potential emerging disturbance issues at each location.

The harbor seal monitoring data may change over time as errors are corrected, and as data analysis procedures are improved. For this reason, summary data reported here for 2000 to 2015 may differ slightly from data summaries published in previous harbor seal reports.

Results

Overall

In 2016, 39 volunteers and two NPS staff members completed 265 surveys at Marin County sites between March 1st and July 31st, with approximately 465 hours of monitoring. Each location had between 25 and 37 high quality surveys, except for Point Reyes Headlands, which is on the regional survey schedule and only had 12 surveys. At Marin County sites, a maximum of 2,126 adults/immatures and 951 pups were observed during the breeding season (March-May) and 3,722 individuals were recorded during the molting season (June-July; Table 2).

Table 2. Summary data of harbor seal colonies for the 2016 season. All reported numbers reflect the maximum number seen during a single census.

Location	Max # adults in breeding season ¹	Max # pups in breeding season	Max # seals in molting season ²	# Surveys ³	Max # reds ⁴	Max # shark bites ⁴
Tomales Bay	437	83	363	33	11	1
Tomales Point	305	113	518	27	2	1
Point Reyes Headlands	102	26	291	12	1	2
Drakes Estero Complex	473	298	933	25	10	1
Double Point	335	254	544	34	8	1
Duxbury Reef	49	4	145	33	2	1
Bolinas Lagoon	307	166	692	37	16	1
Point Bonita	118	7	236	37	4	3
TOTAL	2,126	951	3,722	238	54	11

¹ Adults and immatures during the peak of the breeding season, mid-April to mid-May.

² All age classes during the molt season, June - July.

³ Only surveys deemed as high quality (see methods)

⁴ The maximum number observed during a single census in March - July.

Adult and Pup Counts During the Breeding Season

Adults: The maximum count of adult and immature seals during the 2016 breeding season was 2,126, which is less than one standard deviation below the 16-year average and, along with the count in 2010, is the lowest count recorded in the time series 2000-2016 (Figure 2). Drakes Estero Complex had the most adults/immatures (473), followed by Tomales Bay (437; Table 2).

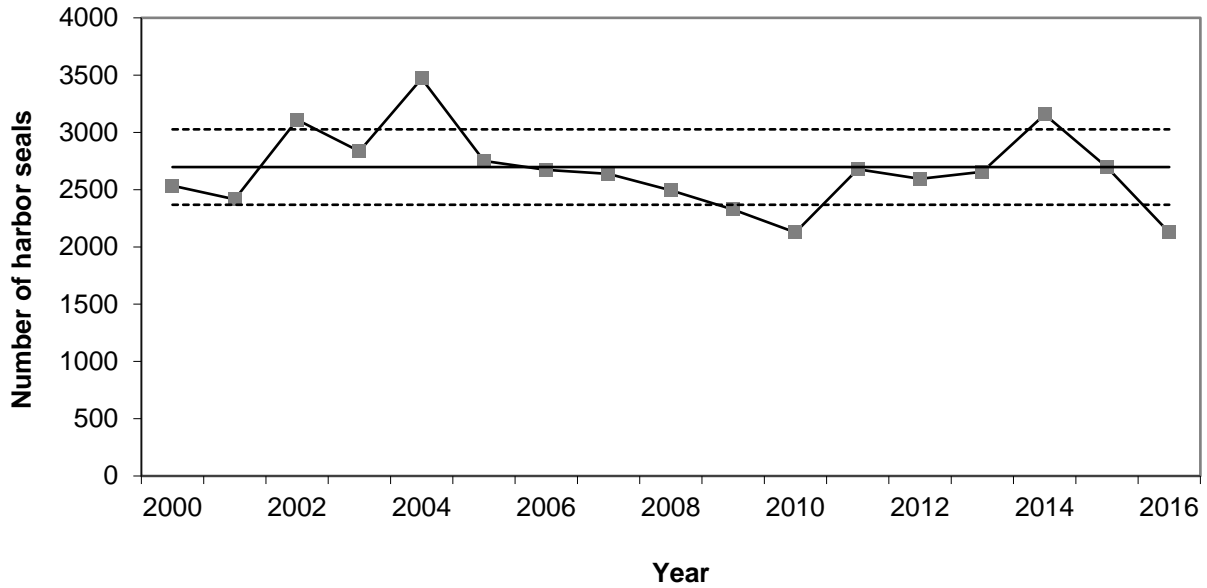


Figure 2. Maximum counts of harbor seal adults and immatures during the breeding season (March-May) for 2000-2016 at Marin County sites. The solid line on the graph represents the mean of the maximum adult counts from 2000-2015 (mean = 2,697) and the dashed lines represent one standard deviation from the mean (SD = 329.3).

Pups: The combined maximum pup count for all Marin County sites during the 2016 breeding season was 951 pups. The maximum count is less than one standard deviation below the average for the past 16 years (Figure 3). Drakes Estero Complex and Double Point accounted for 58% (552) of pups at Marin County sites, which is consistent with the proportions of pups in the past.

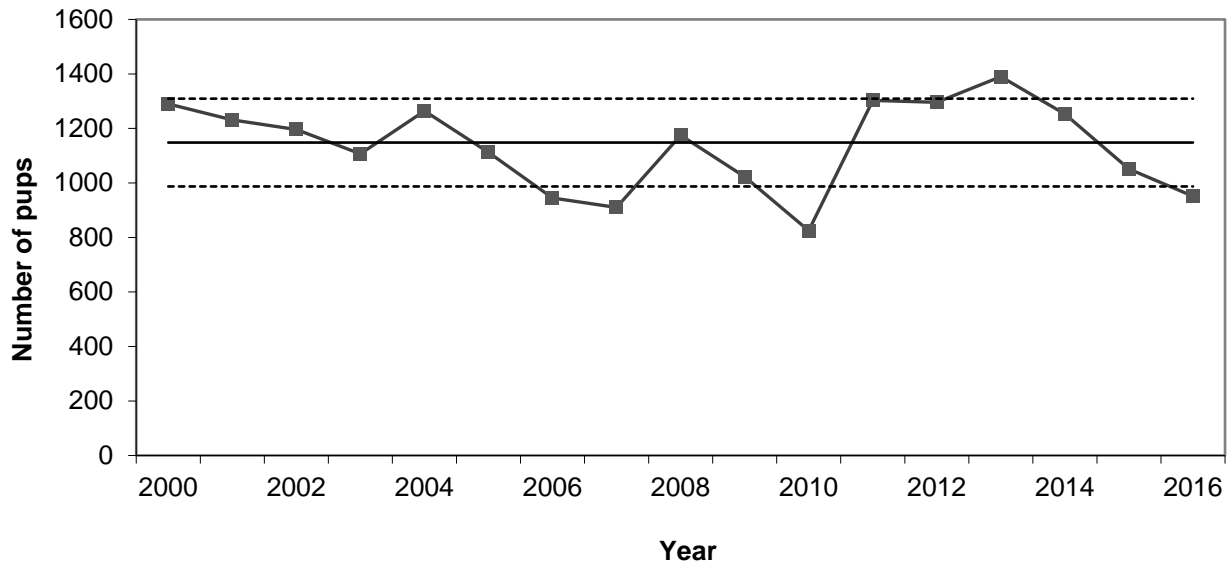


Figure 3. Maximum harbor seal pup counts for 2000-2016 at Marin County sites. The solid line on the graph represents the mean of the maximum pup counts from 2000-2015 (mean = 1,148), and the dashed lines represent one standard deviation from the mean (SD = 161.1).

The primary pupping locations within the Marin County sites are Tomales Bay, Tomales Point, Drakes Estero, Drakes Estero, Double Point, and Bolinas Lagoon. The maximum pup numbers at three of the five primary pupping sites in 2016 remained similar to their respective counts from 2015 (Bolinas Lagoon, Double Point, and Tomales Point; Figure 4). The exceptions were Drakes Estero Complex and Tomales Bay which had decreases of 13% and 28%, respectively (Figure 4). Point Bonita, although not a primary pupping site, is noteworthy since pup counts increased following restrictions to the site by GOGA in 2007 (Figure 5). However, counts at this site have remained low since 2014, which follows the trend seen for the total maximum pup counts in Marin County.

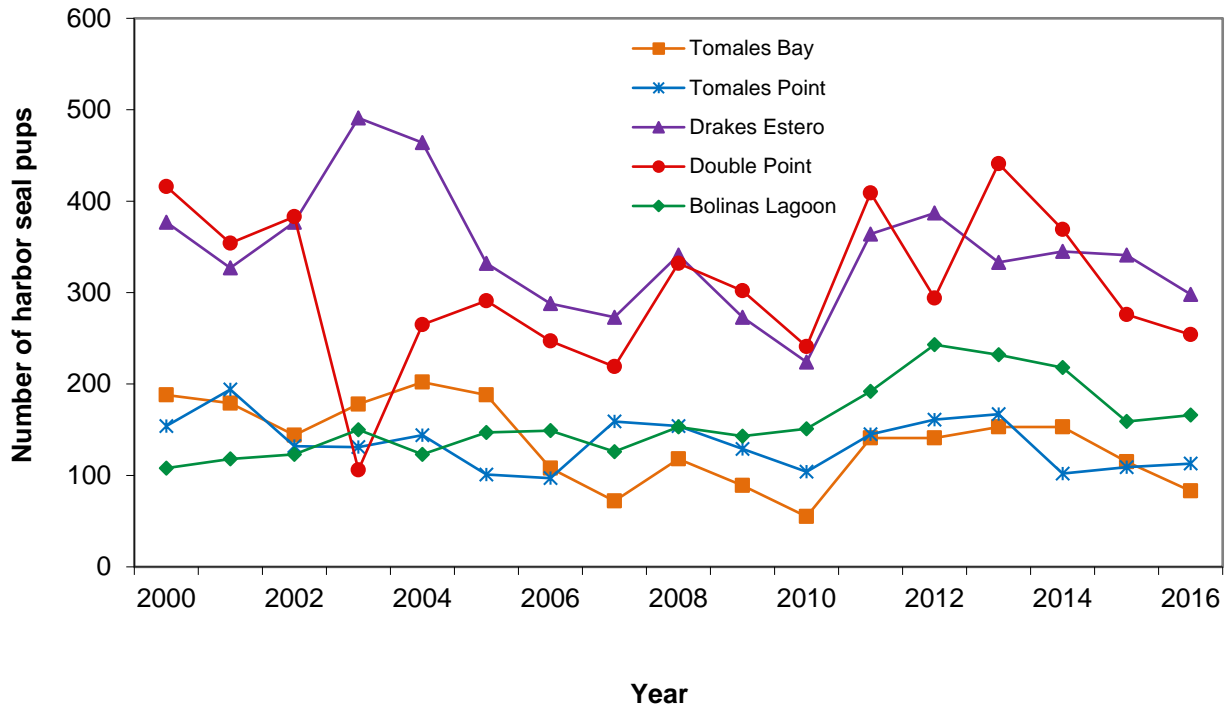


Figure 4. Maximum harbor seal pup counts at the dominant Marin County pupping locations during the breeding season (March – May), 2000-2016. The maximum counts of each site may have been observed on different days.

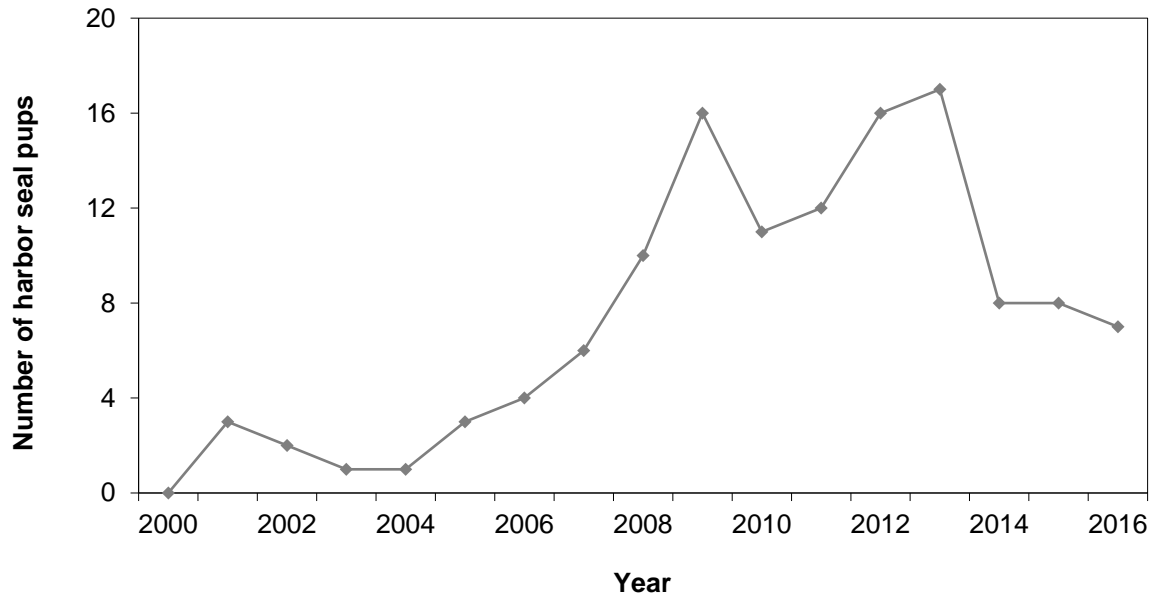


Figure 5. Maximum harbor seal pup counts at Point Bonita during the breeding season (March – May), 2000-2016.

Typically, the first viable pup is seen in mid-March at either Drakes Estero or Double Point (Figure 6). The first reported pup of 2016 was seen on March 6 at Double Point. A downward trend in phenology over the past five years is suggestive but when including data over 17 years, there is no apparent trend. More sophisticated analyses are required to determine if the recent trend is linked to other factors such as changes in the environment.

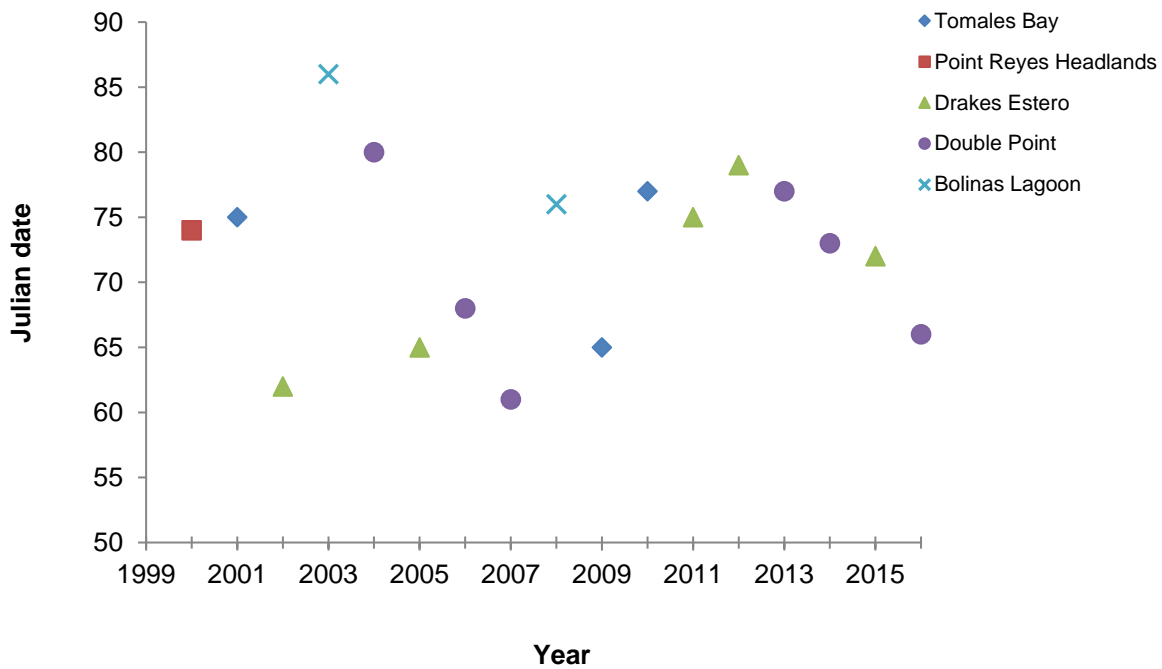


Figure 6. Date of first live pup observed in the season by location, 2000-2016.

Molt Counts

The maximum count of all seals during the 2016 molt season for all Marin County sites was 3,722 seals, which is similar to the 16-year average (Figure 7). Drakes Estero Complex and Double Point comprised 40% (1,477) of the total seals counted during the molt season (Table 2). This proportion is a decrease compared to past years (2000 – 2015 mean = 51%) and is due to a decrease in the proportion of seals at Double Point and an increase in the proportion of seals at Bolinas Lagoon. In 2016, Bolinas Lagoon had a peak count of molting seals (692) greater than that at Double Point (544; Table 2). The Drakes Estero Complex and Bolinas Lagoon combined made up 44% of the total seals counted during the molt season (Table 2).

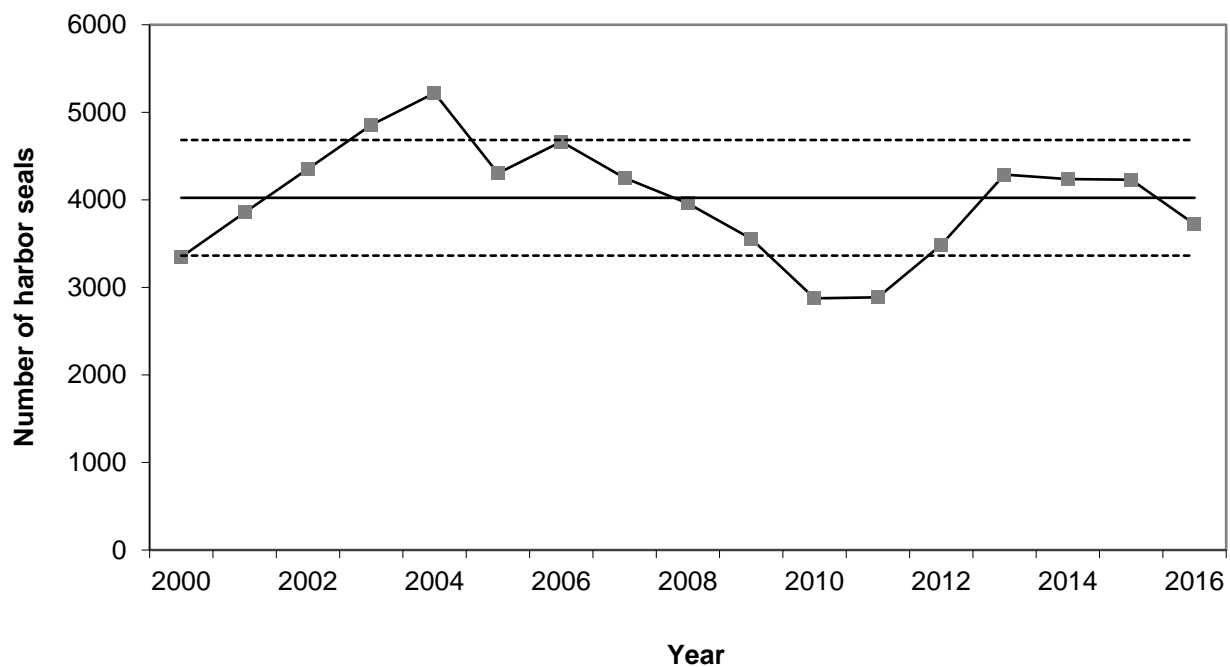


Figure 7. Maximum harbor seal counts during the molt season (June-July) for 2000-2016 at Marin County sites. The solid line on the graph represents the mean of the maximum molt counts from 2000-2015 (mean = 4,023) and the dashed lines represent one standard deviation from the mean (SD = 660.2).

Disturbances

At the Marin County sites in 2016, 101 disturbances were recorded that elicited a response from harbor seals, which is less than the 16-year average of 123 disturbances (Table 3). The most common disturbance sources were humans on foot (26%), unknown (23%) and motorboats (21%, Table 3). Fewer disturbances have been recorded at the Drakes Estero Complex since a seasonal closure during the breeding season was expanded to include Limantour Spit in 2014. Tomales Bay had the highest number of disturbances recorded at this site in the 16-year monitoring period with 48 disturbances, which is almost half of all disturbances recorded at Marin County sites. Clammers and motor boats were the main sources of disturbance on Tomales Bay.

Table 3. Number and percentage of identified sources of disturbances (head alert, flush, flush into water) for Marin County sites. 2016 data is compared to the 2000 – 2015 mean \pm 1 SD.

Year	Measure	Motorboat	Non-Motor Boat	Vehicle	Dog	Aircraft	Human	Bird	Unknown	Other	Total
2000 - 2015 mean	(#)	16.1 \pm 6.61	10.9 \pm 5.30	3.9 \pm 3.56	0.6 \pm 0.81	7.9 \pm 4.18	36.9 \pm 14.88	11.1 \pm 4.28	30.4 \pm 7.83	5.2 \pm 3.39	123 \pm 31.12
	(%)	13.3 \pm 5.74	8.6 \pm 3.07	3.0 \pm 2.15	0.4 \pm 0.63	6.4 \pm 3.52	29.5 \pm 8.04	9.3 \pm 3.91	24.9 \pm 4.12	4.4 \pm 2.72	–
2016	(#)	21	4	1	2	9	26	8	23	7	101
	(%)	20.8	4.0	1.0	2.0	8.9	25.7	7.9	22.8	6.9	–

The rate of disturbances per hour in 2016 was highest in Tomales Bay (0.69 disturbances/hr, Figure 8). The Drakes Estero Complex, Double Point, Bolinas Lagoon, and Point Bonita all had similar disturbance rates (0.24, 0.21, 0.21, and 0.17 disturbances/hr, respectively; Figure 8). Decreases in disturbance rates compared to 2015 were seen at all sites except Tomales Bay (Figure 9). The rates of disturbances vary from year to year depending on activities at each location, but trends have not been analyzed.



Human activity on Seal Island in Tomales Bay. Harbor seals are hauled out on the tip of the sandbar in the middle of the image. Numerous boats and recreational clammers are in the vicinity of the seals (NPS/JIM FORSELL).

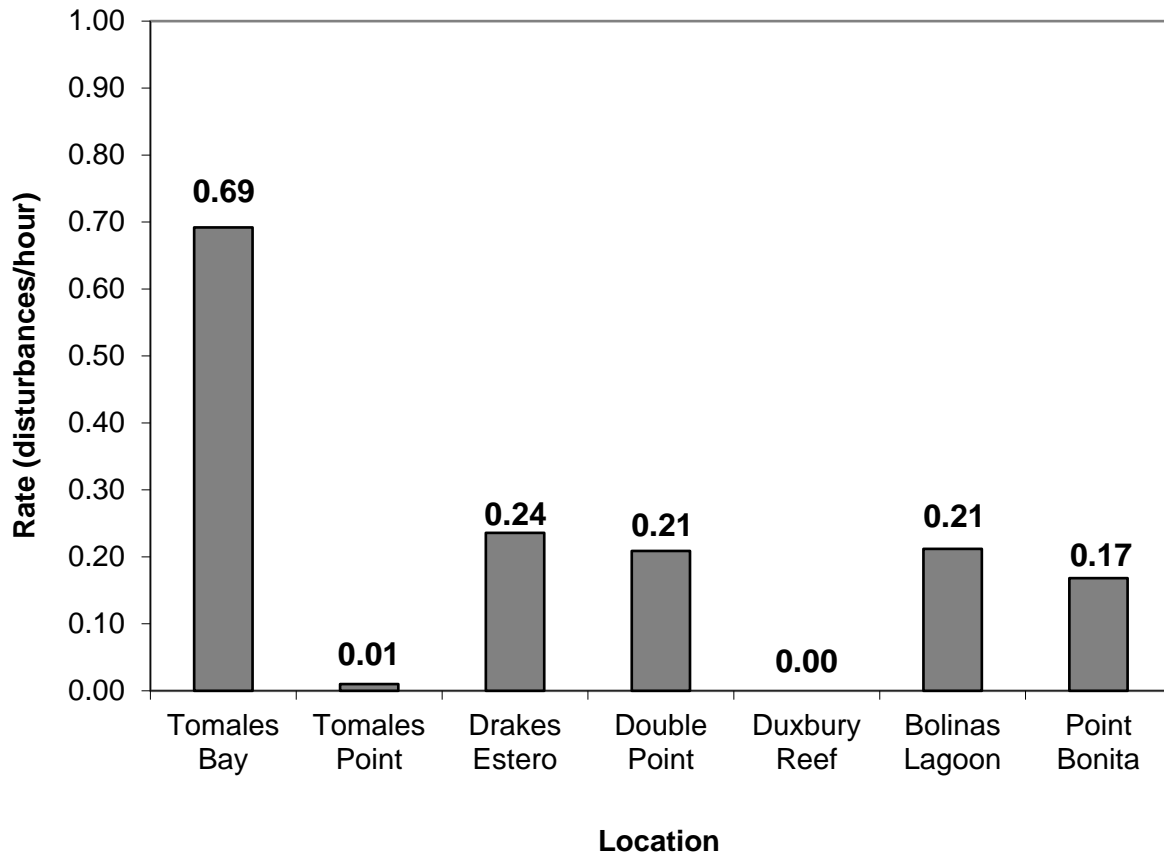


Figure 8. Rates of disturbances per hour at Marin County sites March 1 - July 31, 2016. Only actual disturbances (head alert, flush, flush water) were used and survey time was based on observation time for all complete surveys (with or without disturbances).

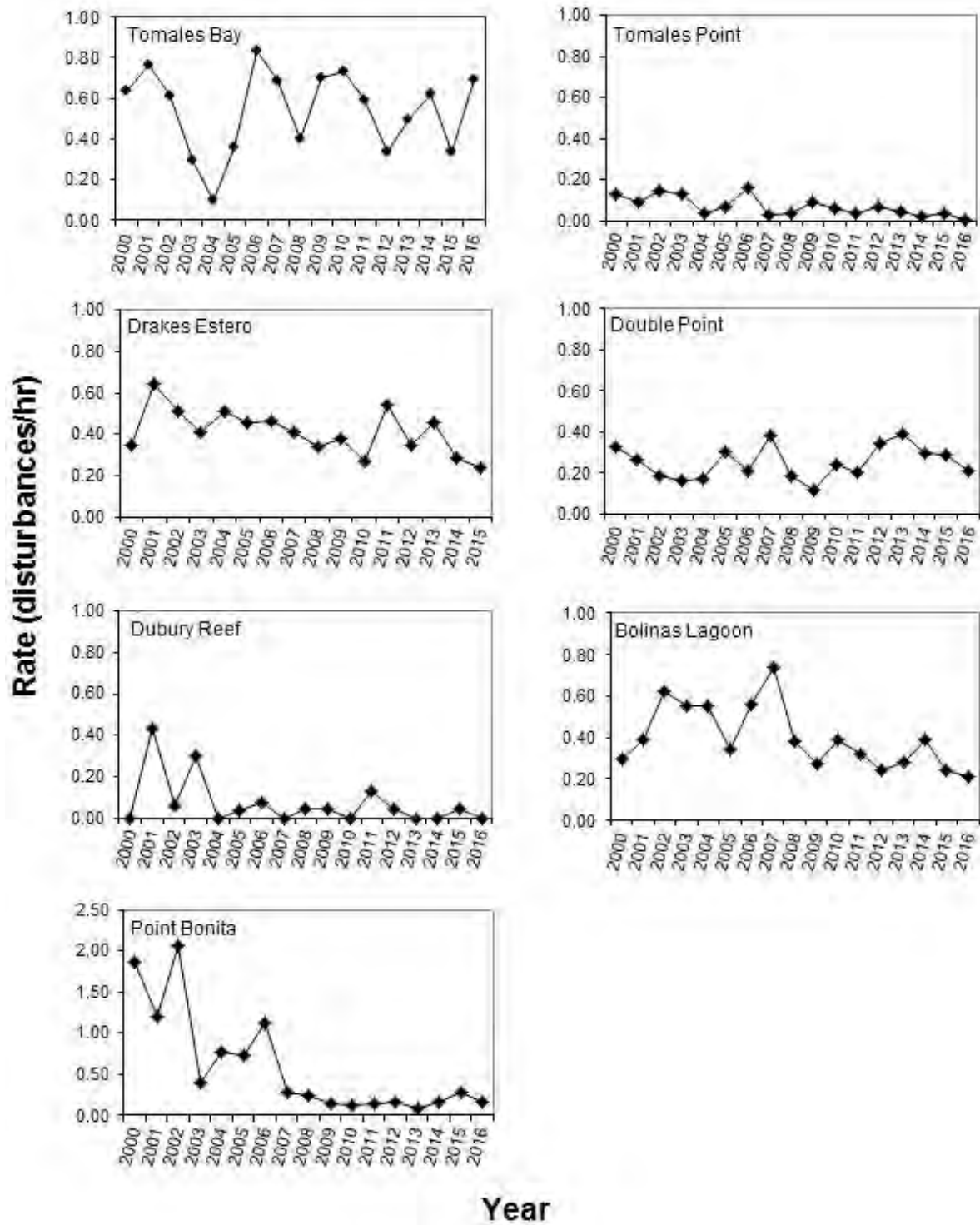


Figure 9. Rates of disturbances per hour at Marin County sites from March through July of 2000-2016. Only actual disturbances (head alert, flush, flush water) were used, and survey time was based on observation time for all complete surveys (with or without disturbances). Note different rate scale for Point Bonita due to high disturbance rates in previous years.

Summaries by Site

Tomales Bay

Observers completed 33 high quality surveys at Tomales Bay between March 1 and July 31, 2016. The maximum breeding season adult/immature count (437 seals; Table 2) is the same as the 16-year average of 438 seals. The pup count of 83 is less than the average (139 pups) and is the lowest count since 2010. The first pup at this site was recorded on March 25. During the molting season, the maximum seal count was 363, which is less than the average (409 seals). The disturbances at Tomales Bay were primarily caused by motorboats and clambers on the sandbars, as the bay is a very popular spot for fishing and clamming. There were multiple incidents of boats landing directly on the sandbar where seals were hauled out and of clambers walking towards seals causing them to flush in the water. The disturbance rate had a large increase from 2015 (0.33 to 0.69 disturbances/hr; Figure 9) and was greater than the 16-year average (0.53 disturbances/hour).

Tomales Point

Observers completed 27 high quality surveys at Tomales Point between March 1 and July 31, 2016. During the breeding season, the maximum adult/immature count was 305 and the maximum pup count was 113 (Table 2). Both of which are less than their respective 16-year averages (358 adults/immatures and 136 pups). The first pup was recorded at this site on March 29. The maximum seal count during the molting season was 518, which is greater than the average of 477 seals. Only one disturbance was recorded at Tomales Point. Due to its remoteness, the Tomales Point location is generally not frequented by visitors. However, because of the distance between the subsites, surveyors are not at any one subsite long enough to generally see disturbances occur.

Point Reyes Headlands

Observers completed 12 high quality surveys at Point Reyes Headlands between March 1 and July 31, 2016. Surveys at this site were only conducted during regional survey periods. During the breeding season, the maximum adult/immature count was 102 and the maximum pup count was 26, while during the molting season the maximum seal count was 291 (Table 2). The maximum breeding season adult/immature count is similar to the 16-year average of 107 seals. Both the maximum pup and molt counts are less than their 16-year averages (47 and 350, respectively). The 2016 pup count is the lowest count recorded in the past 16 years and is almost half of the site's average. The estimated date of the first viable pup is not reliable because of the low number of surveys completed at this site. No disturbances were recorded during the 2016 season. This site rarely has human disturbances because of its remoteness and inaccessibility. Most of the harbor seals were seen at a large northern elephant seal colony pocket beach.

Drakes Estero Complex

Observers completed 25 high quality surveys in the Drakes Estero Complex, which includes Limantour Spit, between March 1 and July 31, 2016. The maximum counts during the breeding season were 473 adults/immatures and 298 pups (Table 2). The maximum adult/immature count is the lowest count recorded at this site during the 16-year monitoring period and much lower than the average of 780 seals. The pup count is less than the 16-year average (346 pups). The first pup at Drakes Estero was recorded on March 22. The maximum molt count was 933 seals, which is less

than this site's 16-year average of 1,073 seals. The majority of disturbances were caused by hikers on Limantour and Drakes Beaches, each of which are easily accessible. A seasonal closure during the breeding season at Limantour Spit was started in 2014. Hikers were still documented in the closure area this year, although fewer disturbances were noted. The closure of an oyster farm located in Drakes Estero occurred on December 31, 2014. Motor boats associated with the oyster farm were the only motorized vessels allowed in this estuary up until this closure. As a result, there are no longer motor boats operating near the harbor seal haul-outs in Drakes Estero, unless permitted by the NPS. The estuary is seasonally closed to kayaking from March 1 through June 30 during the critical pupping period and no kayaks were reported during this time. Two sightings of a coyote near harbor seal haul-outs in the estuary are part of an increasing trend the last few years of more coyote caused disturbances. The disturbance rate decreased from 2015 (0.29 to 0.24 disturbances/hr; Figure 9).

Double Point

Observers completed 34 high quality surveys at Double Point between March 1 and July 31, 2016. The maximum adult/immature count during the breeding season was 335 seals (Table 2), which is the second lowest count at this site in the 17-year monitoring period. The 2016 pup count of 254 is less than the 16-year average of 309 pups. The first viable pup of all Marin County locations in 2016 was recorded at Double Point on March 2. The molt season yielded a maximum count of 544 seals, which is the lowest count recorded in the site's 17-year monitoring period and much lower than the 16-year average of 1,000 seals. Disturbances to seals at Double Point were primarily caused by unknown sources. Unknown disturbances may have been caused by small rockslides from the eroding cliffs above the beaches, which observers could not see or hear. Double Point is a remote site that is difficult to access by humans and terrestrial wildlife. However, there was one disturbance recorded this year of people walking on the beach. Additionally, a couple of disturbances were caused by coyotes, which along with Drakes Estero, is an increasing trend being seen throughout Point Reyes. The disturbance rate decreased from 2015 (0.29 to 0.21 disturbances/hr; Figure 9).

Duxbury Reef

Observers completed 33 high quality surveys at Duxbury Reef between March 1 and July 31, 2016. During the breeding season, the maximum counts were 49 adults/immatures and 4 pups (Table 2). The adult/immature count is less than this site's 16-year average of 68 seals and the pup count is similar to the average of 5 pups. The first day a pup was recorded at this site was on April 10. Few pups are seen here, and they possibly come from nearby Bolinas Lagoon. During the molt season, the maximum seal count was 145, which is the highest count since 2004 and much larger than the 16-year average of 78 seals. Duxbury Reef had the lowest number of seals and no disturbances recorded. Disturbances are rarely recorded at Duxbury Reef, possibly due to the poor accessibility for humans at this location.

Bolinas Lagoon

Observers completed 37 high quality surveys at Bolinas Lagoon between March 1 and July 31, 2016. The maximum counts during the breeding season were 307 adults/immatures and 166 pups (Table 2), both of which are similar to their 16-year averages (291 and 158, respectively). The first viable pup was recorded on March 16. During the molt season, the maximum count was 692 seals. This peak molt count is a large increase over the 16-year average of 476 seals and continues the trend of higher

than average molt counts since 2014. The primary cause of disturbances at this site was humans on foot, which included visitors along Highway 1 and road construction workers. The 2016 disturbance rate for Bolinas Lagoon was similar to 2015 (0.24 to 0.21 disturbances/hr; Figure 9).

Point Bonita

Observers completed 37 high quality surveys at Point Bonita between March 1 and July 31, 2016. The maximum adult/immature count was 118 seals (Table 2) and is similar to the 16-year average (114 seals). The 2016 pup count was 7 seals, which is the same as the 16-year average. The first pup was recorded on March 19, although it was not seen during the next few surveys and no other pups were recorded until April 11. The maximum molt count was 236 seals, which is greater than the 16-year average (163 seals) and the second largest count in the time series. The disturbances at Point Bonita were primarily caused by motorboats and unknown sources. The 2016 disturbance rate had a large decrease from 2015 (0.29 to 0.17 disturbances/hr; Figure 9).

Regional Sites

Thirteen regional surveys occurred between March 3 and July 25, 2016 at 23 different locations. Not all sites were surveyed on all scheduled days due to weather conditions or scheduling conflicts. In 2016, there were multiple locations that had maximum counts in March: Bodega Marine Reserve, Alcatraz, Castro Rocks, Purisima Creek, Pescadero, and Fitzgerald Marine Reserve. These counts were not included in determining the maximum breeding season count since they did not fall within the expected range of the peak breeding season (mid-April to mid-May). These early peaks most likely included seals that were still moving in and out of areas prior to the breeding season.

During the 2016 breeding season, a maximum of 3,759 adults/immatures and 1,274 pups were observed, although the maximum counts may have occurred on different days for each location (Table 4). During the molt season, the combined maximum count of all seals from each site was 5,580. Marin County sites accounted for 55% of the maximum adult and immature seal breeding count, 71% of the maximum pup count, and 65% of the maximum molt count. Using a correction factor of 1.54 (95% CI = 1.16–1.92), a regional harbor seal population estimate calculated during the molt season was 8,593 (95% CI = 6,473-10,714; Harvey and Goley 2011).

Table 4. Regional surveys of harbor seal numbers in central California, March 3 – July 25, 2016. Thirteen surveys were scheduled on alternating weekends, nine during the breeding season and four during the molt season. Values reported as number of surveys (N), mean, standard error (SE), and maximum (Max).

Regional Area	Location	Breeding Season					Molting Season			
		N	Adult Mean ¹	SE	Adult Max ²	Pup Max	N	Mean ³	SE	Max ³
Sonoma County	Sonoma Coast ⁴	9	130.3	14.2	187	63	4	171.8	20.1	239
	Fort Ross	9	99.1	14.0	146	17	3	153.5	24.8	206
	Jenner	9	203.4	22.4	311	34	4	194.8	29.7	246
	Bodega Marine Reserve	7	62.2	8.5	76	8	4	69.4	11.8	96
Marin County	Tomales Bay ⁴	9	365.8	21.2	437	79	4	258.6	36.1	296
	Tomales Point ⁴	9	162.4	22.6	228	74	3	332.8	76.1	518
	Point Reyes Headland	9	63.4	8.2	102	26	3	207.0	45.5	291
	Drakes Estero Complex	7	384.0	44.5	469	298	3	702.0	164.2	933
	Double Point	9	259.1	35.0	378	254	4	353.6	84.6	500
	Duxbury Reef	9	41.0	8.0	49	4	4	77.2	24.0	145
	Bolinas Lagoon	9	219.8	20.0	299	166	4	497.6	100.7	687
	Point Bonita	8	93.0	11.2	118	7	4	135.2	41.0	236
San Francisco Bay	Alcatraz	8	3.7	1.4	3	0	3	1.3	0.6	2
	Castro Rocks	9	187.1	12.8	197	41	4	198.6	17.1	235
	Yerba Buena Island	8	98.0	14.9	155	30	3	121.3	22.2	150
	Newark Slough ⁴	4	24.5	5.3	36	12	3	3.7	3.7	11
	Mowry Slough ⁴	4	64.0	17.5	112	33	3	49.0	4.4	56
San Mateo County	Point San Pedro	9	7.6	1.2	12	1	2	19.0	5.1	25
	Cowell Ranch	9	39.3	5.5	60	17	4	42.2	13.9	78
	Purisima Creek	9	55.5	6.2	68	29	4	83.4	10.5	101
	Pescadero	9	34.5	5.3	41	10	4	49.2	8.5	68
	Pebble Beach	9	50.5	4.7	63	16	4	89.8	9.3	109
	Fitzgerald Marine Reserve	9	180.3	11.8	212	55	4	252.6	41.7	352
ALL SITES		–	–	–	3,759	1,274	–	–	–	5,580

¹Adults and immatures during the breeding season, March 3 – May 31.

²Adults and immatures during the peak of the breeding season, mid-April to mid-May.

³All age classes during the molt season, June 1 – July 25.

⁴Includes surveys that occurred outside of regional weekend period.

Sonoma County

The 2016 maximum adult/immature and pup counts during the breeding season at Sonoma County sites were greater than the previous year's counts (Figures 10 and 11). Among Sonoma County sites, Jenner had the high count of adults/immatures and Sonoma Coast had the high count of pups (Table 4). The 2016 Sonoma County molt count decreased from the 2015 count (Figure 12). Jenner and the Sonoma Coast had the highest molt counts among Sonoma County sites in 2016 (Table 4). Jenner was the only site in Sonoma County with recorded disturbances, which were primarily caused by visitors walking on the beach.

San Francisco Bay

The 2016 maximum adult/immature count at SFB is one of the highest counts recorded, along with the counts in 2014 and 2010, and this comes after one of the lowest counts recorded in 2015 (Figure 10). The 2016 pup and molt counts also increased from 2015 (Figure 11). Within SFB, the high counts for adults/immatures, pups, and molting seals occurred at Castro Rocks (Table 4). The molt count at Castro Rocks is the largest count recorded at this site in the twelve years of monitoring.

In SFB, multiple disturbances occurred at all sites except Newark and Mowry Sloughs. Disturbance sources included aircraft, motorboats, birds, and unknown sources. A possible disturbance at Castro Rocks most likely occurred when a boat grounded on the rocks near the harbor seal haul out before the harbor seal monitors arrived. When observers arrived, seals were more abundant than normal at a different location.

San Mateo County

The maximum adult/immature count during the 2016 breeding season at San Mateo County sites decreased from 2015, but is similar to the counts in other years (Figure 10). Higher than normal adult/immature counts were seen in 2014 and 2015. Although, it should be noted there are many years where some sites were not surveyed and a new site, which contributes substantial numbers to the county totals, was added in 2012. The 2016 maximum pup count was similar to the counts of the past two years (Figure 11). There was a small increase in the 2016 molt count after the large decrease in 2015 (Figure 12). Among San Mateo County sites, Fitzgerald Marine Reserve had the high counts of adults/immatures, pups, and molting seals (Table 4). Very few disturbances were recorded at the San Mateo County sites in 2016, with only one disturbance at Cowell Ranch and one disturbance at Pebble Beach. A possible disturbance occurred at Pebble Beach when fishermen were observed in a known harbor seal haul out area, but no seals were present.

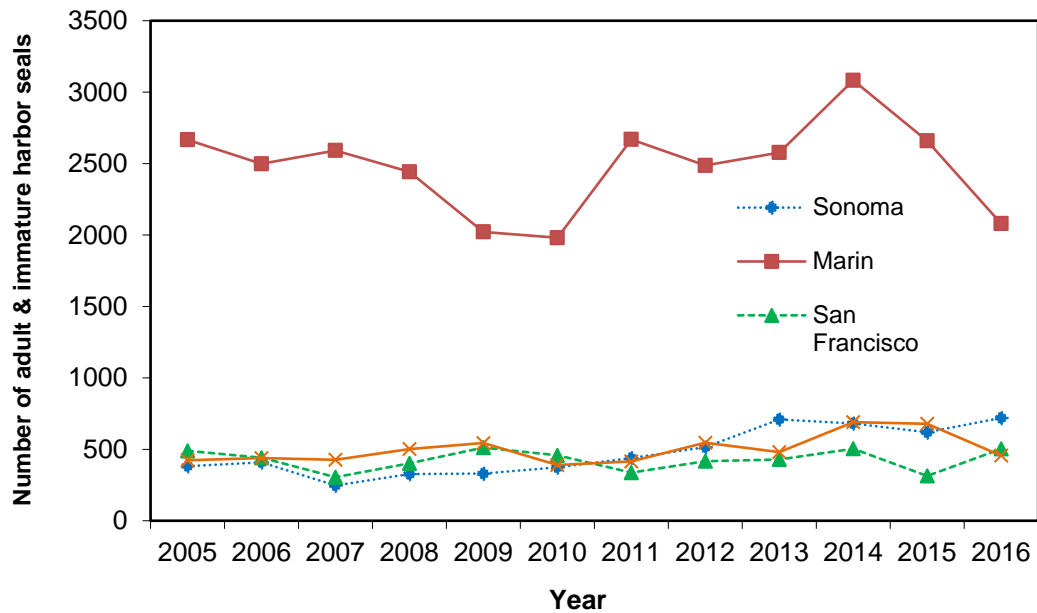


Figure 10. Maximum counts of harbor seal adults and immatures by region during the breeding season for the 2005-2016 regional surveys in central California. Bodega Marine Reserve was added to Sonoma County in 2010, Purisima Creek was added to San Mateo County in 2012, and Fort Ross was added to Sonoma County in 2013. Incomplete surveys occurred in San Mateo County in 2006 and 2013 and San Francisco Bay in 2007.

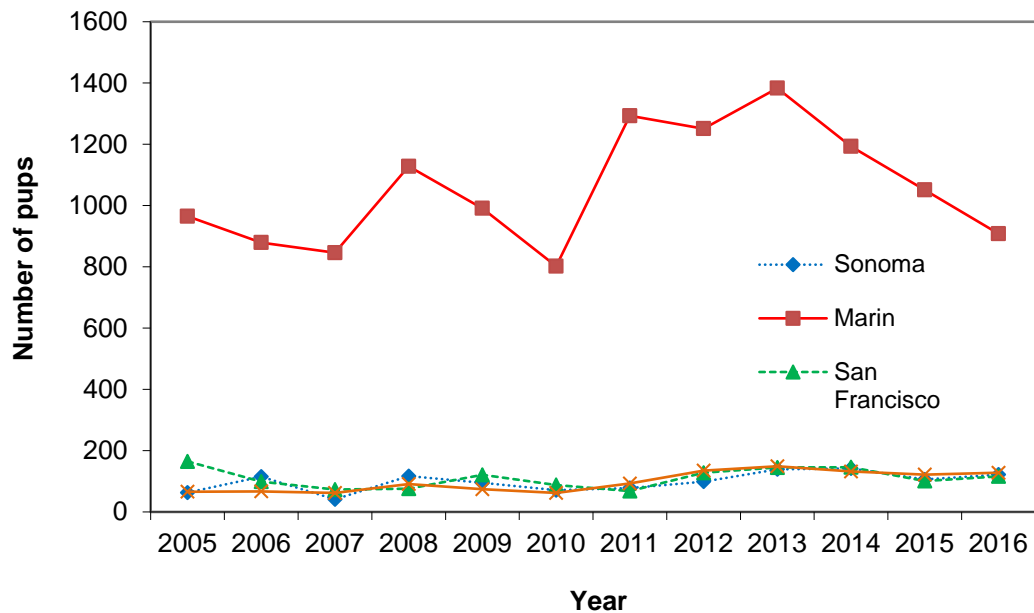


Figure 11. Maximum counts of harbor seal pups by region during the breeding season for the 2005-2016 regional surveys in Central California. Bodega Marine Reserve was added to Sonoma County in 2010, Purisima Creek was added to San Mateo County in 2012, and Fort Ross was added to Sonoma County in 2013. Incomplete surveys occurred in San Mateo County in 2006 and 2013 and San Francisco Bay in 2007.

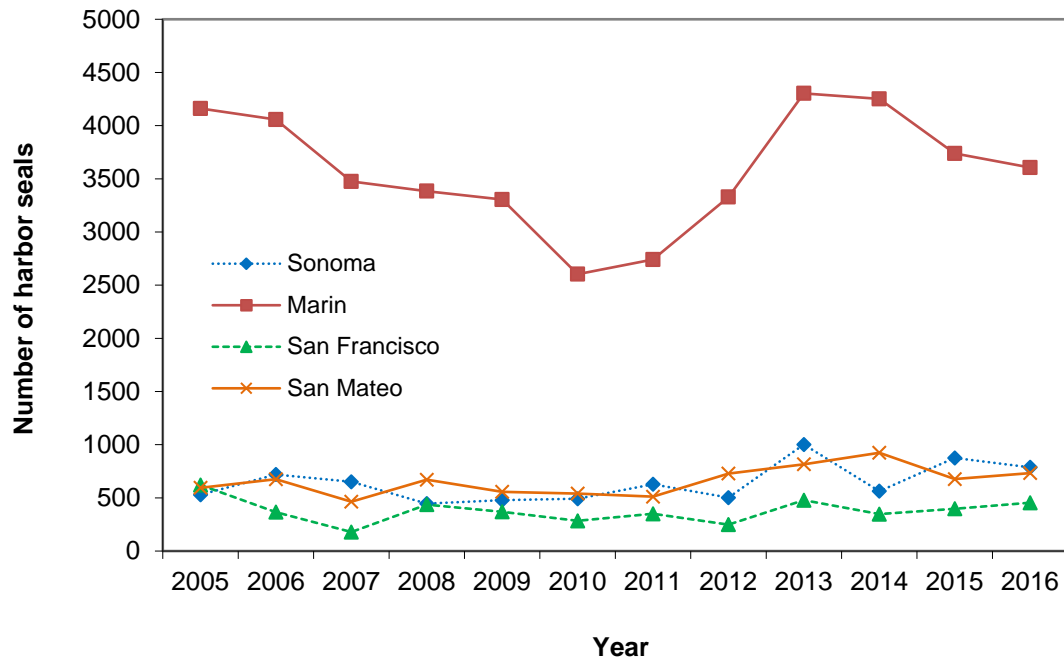


Figure 12. Maximum counts of all age classes of harbor seals by region during the molting season for the 2005-2016 regional surveys in central California. Bodega Marine Reserve was added to Sonoma County in 2010, Purisima Creek was added to San Mateo County in 2012, and Fort Ross was added to Sonoma County in 2013. Incomplete surveys occurred in San Mateo County in 2006 and 2013, San Francisco Bay in 2007, 2012, and 2015, Marin County in 2010, and Sonoma County in 2014.

Discussion

The adult/immature and pup counts during the 2016 breeding season were less than their respective 16-year averages. The adult/immature count was one of the lowest counts of the time series and this is related to declines at both the Drakes Estero Complex and Double Point, which account for >50% of the number of seals in the region. The Drakes Estero Complex count in 2016 was the lowest count recorded in the past 16 years and the Double Point count was the second lowest count. The molt season count for Marin County sites was similar to the 16-year average. The low breeding season counts could have been correlated to the effects of the regional anomalies in the eastern Pacific Ocean, which included one of the strongest El Niños on record and a warm water Blob that persisted off the north Pacific since 2013 and affected the distribution of prey species of marine mammals (Jacox et al. 2016, Gentemann et al. 2017). Each of these weather patterns may have contributed to a reduction in prey for harbor seals and indirectly affected their reproduction and time resting at haul out sites, as has been reported in previous years (Sydeman and Allen 1999, Keiper et al. 2005, Becker et al. 2011). With multiple years of the warm water Blob, it is possible that the upwelling periods did not result in upwelling cold water that was as nutrient rich, which could have had cascading effects throughout the marine food web (Gentemann et al. 2017).

The Drakes Estero Complex and Double Point annually produce the highest numbers of harbor seal pups and together are typically the primary breeding and molting sites for harbor seals of Marin County and the region. However, in 2016, the peak molt count at Double Point was approximately 45% lower than the site's average and only made up 15% of the seals at Marin County sites. Bolinas Lagoon made up a higher proportion of seals in 2016 with 19%, and Drakes Estero had the highest proportion with 25%. A higher proportion of molting seals at Bolinas Lagoon also was documented in 2010, 2011, 2014, and 2015 (see previous annual reports Codde et al. 2011 and 2012, Codde and Allen 2015 and 2017). During the breeding season, Double Point and Drakes Estero produced 58% of the pups, which is similar to previous years.

Throughout the study area from 2000-2016, the primary sites that experienced disturbances were Tomales Bay, the Drakes Estero Complex, Bolinas Lagoon, and Double Point. Tomales Bay had the highest disturbance rate recorded for the year (0.69 disturbances/hour), and the rate was much higher than all other survey sites (range 0.01 – 0.24 disturbances/hour). The disturbance sources at Tomales Bay were primarily motorboats and clambers. In the past ten years, 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 launching site. The most common source categories of disturbance for all Marin County sites in 2016 were humans on foot, unknown sources, and motorboats. These sources are regularly the major causes for disturbance at Marin County sites over the past decade.

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, Gibble and Harvey. 2015). We have not analyzed the potential effects of the recent climate anomalies on harbor seals but will do so when we conduct more in depth analyses. Information gained at PORE and GOGA contributes to understanding how recovered populations may influence regional marine ecosystems. Studying trends and alterations in habitat also may provide insights into the potential or real effects of climate change on harbor seal distribution and abundance.

Collaborations

NPS staff assisted with training of volunteers monitoring harbor seals for the Stewards of the Coast and Redwoods Seal Watch program in Sonoma County. SFAN staff continued to coordinate the central California coast regional surveys, which include collaborations with multiple government agencies, universities, and non-profit groups including US Fish and Wildlife Service, Greater Farallones National Marine Sanctuary, UC Davis Bodega Marine Laboratory, Greater Farallones National Marine Sanctuary Association, Fort Ross Conservancy, Stewards of the Coast and Redwoods Seal Watch program, and other volunteers.

Season Highlights

- 39 volunteers and two NPS staff members completed 265 surveys at Marin County sites between March 1 and July 31, 2016, with approximately 465 monitoring hours.
- A maximum of 2,126 adult and immature seals were counted onshore during the breeding season.
 - The highest number of adults/immatures hauled out at Drakes Estero Complex (473), followed by Tomales Bay (437).
 - Record low counts were reported at the Drakes Estero Complex and Double Point.
- A maximum of 951 pups were observed at Marin County colonies.
 - The Drakes Estero Complex and Double Point accounted for 58% (552) of pups at Marin County colonies
- A maximum of 3,722 animals (all age classes) were counted during the molting season at Marin County haul-out sites.
 - This is the third year in a row that Bolinas Lagoon has had counts that are higher than the 16-year average.
 - Double Point had the lowest count recorded in the past 16 years.
- 101 disturbances were recorded during surveys.
 - The most frequent disturbance categories were humans on foot (26%), unknown sources (23%) and motorboats (21%).

- The highest disturbance rate (0.69 disturbances/hour) occurred in Tomales Bay.
- Regional surveys occurred 13 times throughout the breeding and molt seasons (March-July), and include San Francisco Bay and Sonoma, Marin, and San Mateo counties.
 - Marin County sites accounted for 55% of breeding season adult and immature seals, 71% of pups, and 65% of seals during the molting season.

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Appendix A

Table A1. Identified sources of disturbances (head alert, flush, flush into water) for Marin County sites from March through July, 2000-2016. The mean includes disturbance sources from 2000 – 2015.

Year	Aircraft		Bird		Dog		Human		Motorboat		Non-Motor Boat		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
2000-2015 Mean	7.9	6.4	11.1	9.3	0.6	0.4	36.9	29.5	16.1	13.3	10.9	8.6	3.9	3.0	30.4	24.9	5.2	4.4	123

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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