



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

2015 Annual Report

Natural Resource Report NPS/SFAN/NRR—2017/1516



ON THE COVER

Pacific harbor seals in Bolinas Lagoon, California.

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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. Long-term monitoring studies at the largest harbor seal colonies in Point Reyes National Seashore have been conducted intermittently since the mid-1970s by various groups. 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 2015 breeding and molting seasons (March-May and June-July, respectively) once to 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 253 surveys at eight Marin County sites, contributing approximately 450 hours of monitoring. During the breeding season, a peak count of 2,696 adult and immature seals was recorded at all Marin County monitoring sites, which is the same as the 15-year average. The Drakes Estero Complex had the most adult and immature seals (839), followed by Tomales Bay (460) and Double Point (442). During the breeding season, 1,051 seal pups were recorded at all Marin County sites, which is similar to the 15-year average. The Drakes Estero Complex and Double Point accounted for 59% (617) of pups at Marin County haul-outs. During the molting season, a peak count of 4,230 animals was recorded at Marin County sites, which is similar to the 15-year average. During surveys, 89 disturbances to seals were recorded. The most frequent causes were unknown source (25%) and humans on foot (18%). 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 62% of breeding season adult and immature animals (2,659 of 4,271), 76% of pups (1,193 of 1,613), and 66% of seals during the molting season (3,738 of 5,688), 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 J. Arce, J. Barcelon, N. Becker, G. Blumenthal, C. Cardosi, K. Carolan, R. Catlin, M. Cox, S. Dick, B. Felix, J. Ford, J. Forsell, G. Hanks, E. Kean, K. Khtikian, J. Khudyakov, M. King, J. Lamphier, S. Li, D. Loeffler, W. Ludan, R. McLemore, A. Pincetich, C. Pincetich, H. Rederer, C. Roundey, P. Scott, S. Shenoy, P. Sherry, B. Siegel, S. Snow, E. Sojourner, B. Somerday, K. Soroca, J. Thompson, S. Van Der Wal, S. Waber, D. Winters, and E. Wright.

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Finally, we are grateful for the generous contributions from the Point Reyes National Seashore Association and the San Francisco Bay Area Network Inventory and Monitoring Program.

All monitoring activities were conducted under the National Marine Fisheries Service Permit 17152-00.

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 meets 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 (Allen et al. 2011).

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.

The information presented in this report is a summary of the harbor seal data collected at PORE and GOGA during the 2015 breeding and molting seasons, March-July. SFAN surveys were also conducted in conjunction with other agencies and organizations in adjacent areas (San Francisco Bay, San Mateo County, and Sonoma County). 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, and 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 (Sydeman and Allen

1999). 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 2014). 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

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, using peer-reviewed methods, but not all of the current sites were surveyed until 2000. 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 protocol 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 Sanctuary¹, 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).

¹ Name changed from the Gulf of the Farallones National Marine Sanctuary in 2015.



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 (http://www.farallones.org/volunteer/beach_watch.php) or National Marine Fisheries Service (NMFS) stock assessments (<http://www.nmfs.noaa.gov/pr/pdfs/sars/po2011sehr-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 (Adams et al. 2009, Harvey and Goley 2011).

The sampling design 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). Mowry and Newark Sloughs in SFB were not surveyed during the 2015 molting season. Surveys at Fort Ross began again in 2013 after not being conducted since 2006.

Surveys

Volunteer observers were trained to monitor harbor seals at designated sites within PORE and GOGA during two classroom and one field session in February and March 2015. Many of the volunteers had been previously trained and returned to the 2015 season with several years of experience. New volunteers were required to be mentored by returning 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 to twice per week at each Marin County location. Surveys were conducted at medium to low tides (below 3 ft) during the day. Surveys were not conducted in heavy fog because of poor visibility or in the rain 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 within Point Reyes National Seashore (NPS/SAMANTHA FORD).

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).

Generally, volunteers surveyed for approximately 2 hours from fixed observation points with all subsites counted approximately every 30 minutes for a total of four counts each survey. Seal counts at each subsite were recorded separately on pre-formatted datasheets and then summed for site totals

every half hour. Tomales Point, Bolinas Lagoon, and Duxbury Reef often had only two counts each survey due to hiking/traveling time between subsites.

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, Fisher, Hiker, Horse rider, Kite flyer, Oyster worker, 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, 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. For example, 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 adult/immature and pup age categories. 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 2014 and compared to the 2015 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 actual disturbances, those that elicited a head-alert or flush reaction from the seals, were used for summary 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 2014 may differ slightly from data summaries published in previous harbor seal reports.

Results

Overall

In 2015, 41 volunteers and two NPS staff members completed 253 surveys at Marin County sites between March 1st and July 31st, with approximately 450 hours of monitoring. Each location had between 29 and 34 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 2,696 adults/immatures and 1,051 pups were observed during the breeding season (March-May) and 4,230 individuals were recorded during the molting season (June-July; Table 2).

Table 2. Summary data of harbor seal colonies for the 2015 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	460	115	431	29	14	0
Tomales Point	330	109	437	30	3	3
Point Reyes Headlands	93	36	383	12	2	0
Drakes Estero Complex	839	341	955	33	7	1
Double Point	442	276	957	29	6	2
Duxbury Reef	51	7	94	33	1	0
Bolinas Lagoon	330	159	772	34	13	2
Point Bonita	151	8	201	33	5	3
TOTAL	2,696	1,051	4,230	233	51	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 2015 breeding season was 2,696, which is a decrease from the previous year, but the same as the 15-year average (Figure 2). Drakes Estero Complex had the most adults/immatures (839), followed by Tomales Bay (460) and Double Point (442; Table 2).

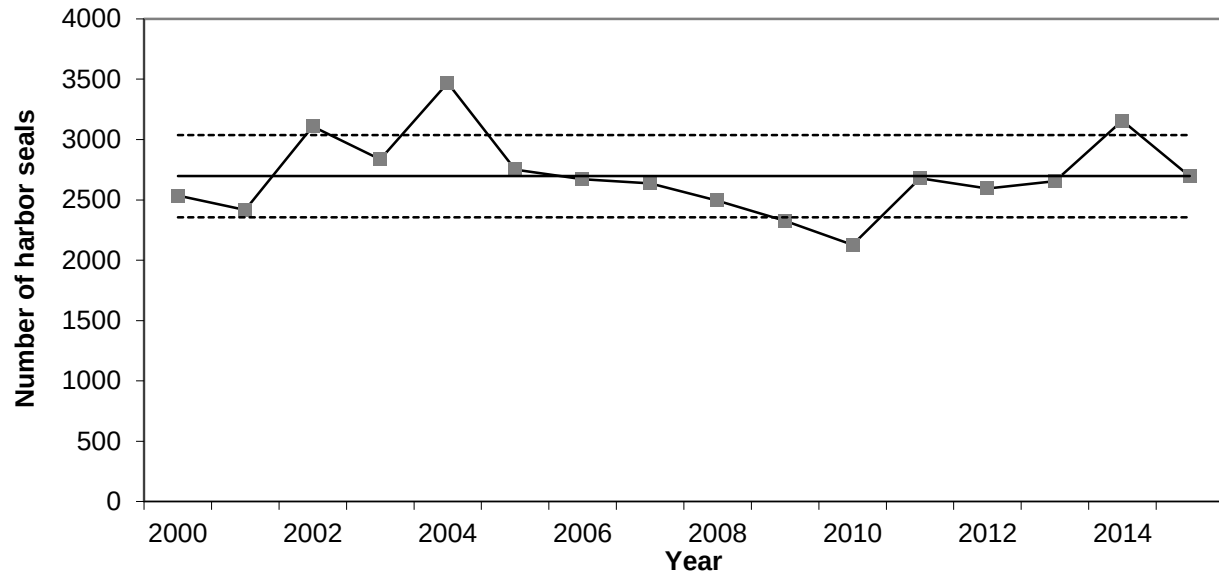


Figure 2. Maximum counts of harbor seal adults and immatures during the breeding season (March-May) for 2000-2015 at Marin County sites. The solid line on the graph represents the mean of the maximum adult counts from 2000-2014 (mean = 2,697) and the dashed lines represent one standard deviation from the mean (SD = 340.8).

Pups: The combined maximum pup count for all Marin County sites during the 2015 breeding season was 1,051 pups. The maximum count is a slight decline from the past four years, but within one standard deviation below the average for the past 15 years (Figure 3). Drakes Estero Complex and Double Point accounted for 59% (617) of pups at Marin County sites, which is consistent with the proportions of pups in the past.

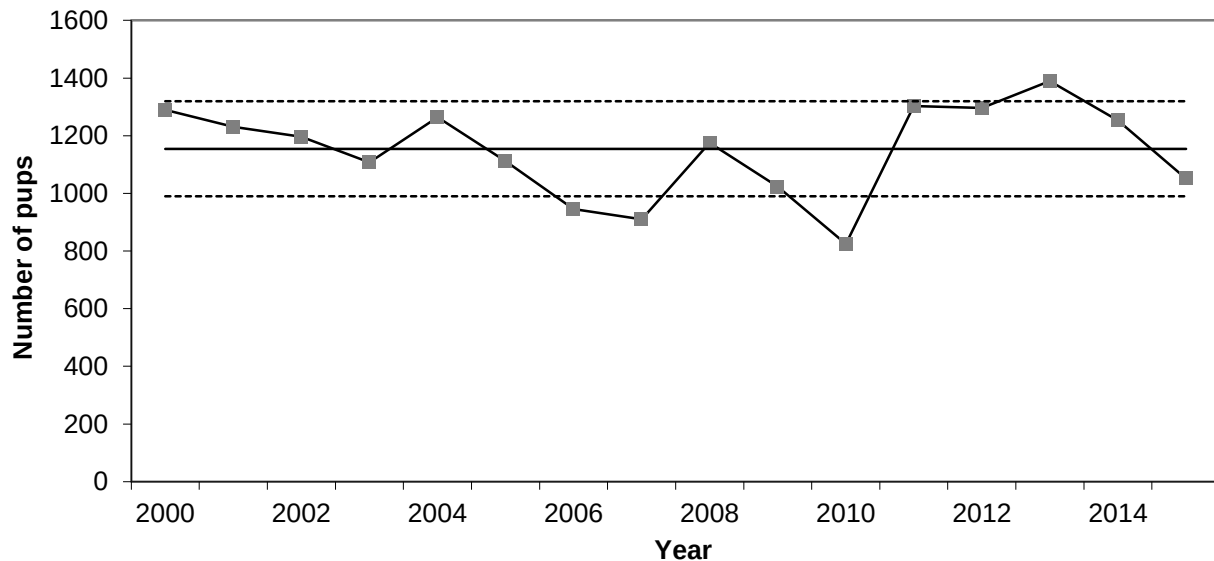


Figure 3. Maximum harbor seal pup counts for 2000-2015 at Marin County sites. The solid line on the graph represents the mean of the maximum pup counts from 2000-2014 (mean = 1,155), and the dashed lines represent one standard deviation from the mean (SD = 164.6).

The date of the first live pup observed has been documented since 2000, and there is no apparent trend in the date or location of the first pup observed from 2000 to 2015 (Figure 4). Single pups were seen at Double Point and Point Bonita in early February, but neither one was near an adult nor seen during the next survey and it is assumed they did not survive. The first reported viable pup of 2015 was seen on March 13 at Drakes Estero.

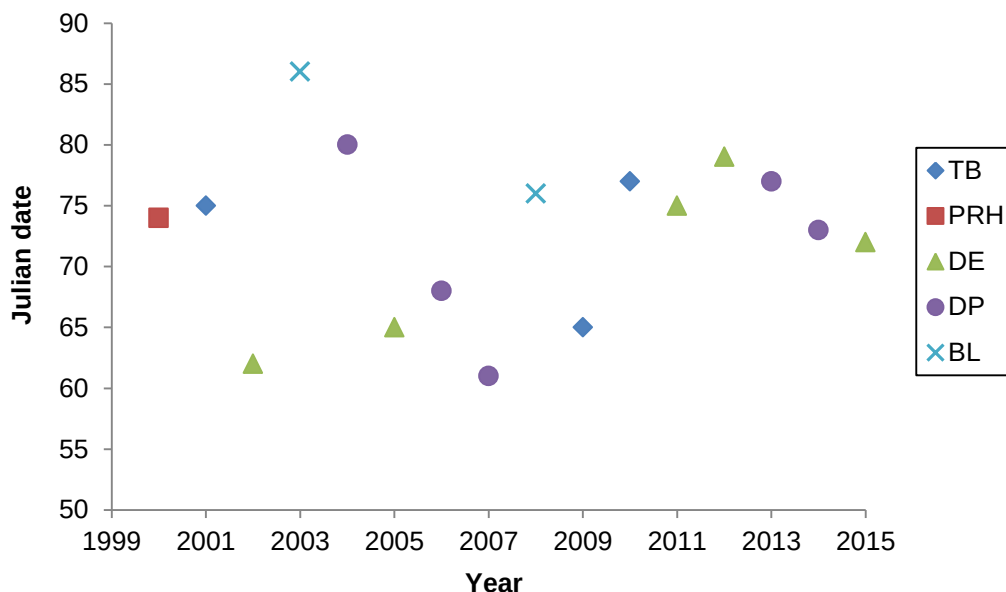


Figure 4. Date of first live pup observed in the season by location, 2000-2015.

The maximum pup numbers decreased by approximately 25% at three of the five primary pupping sites (Bollinas Lagoon, Double Point, and Tomales Bay) from 2014 to 2015 (Figure 5). The Drakes Estero Complex and Tomales Point pup numbers were similar to their respective 2014 counts. Point Bonita, although not a primary pupping site, is noteworthy since pup counts have increased following restrictions to the site by GOGA in 2007 (Figure 6). However, in 2014 there was a large decrease in the pup count at this site and the 2015 count remained the same.

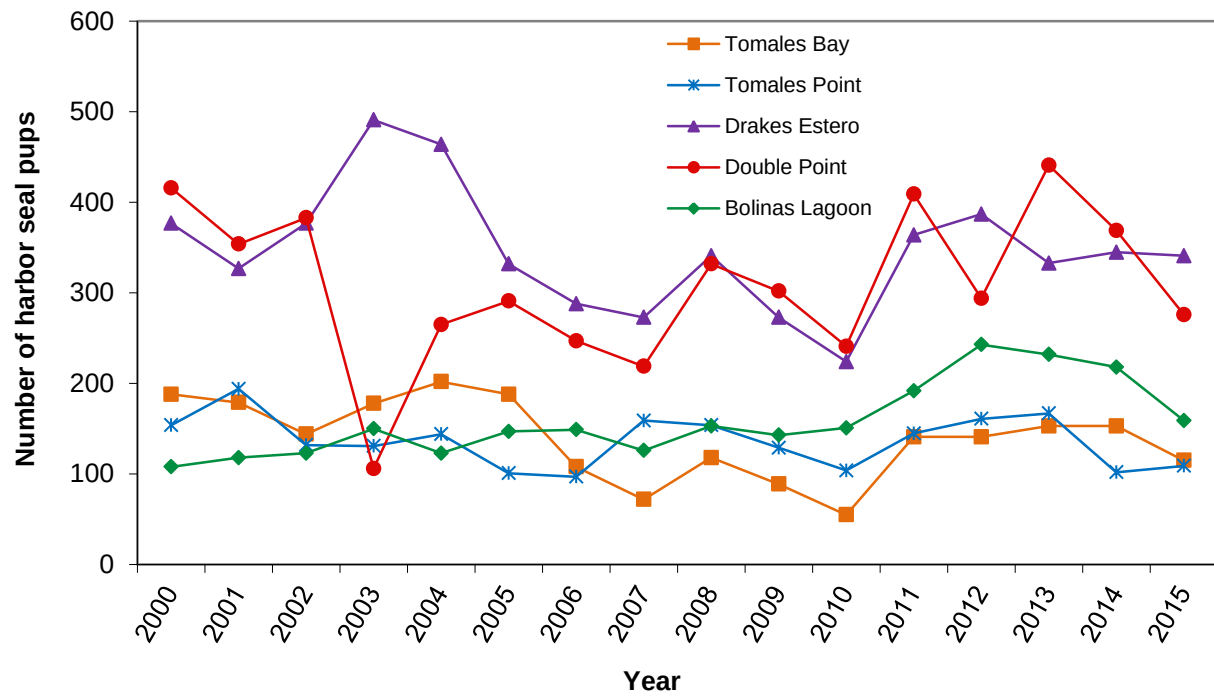


Figure 5. Maximum harbor seal pup counts at the dominant Marin County pupping locations during the breeding season (March – May), 2000-2015. The maximum counts of each site may have been observed on different days.

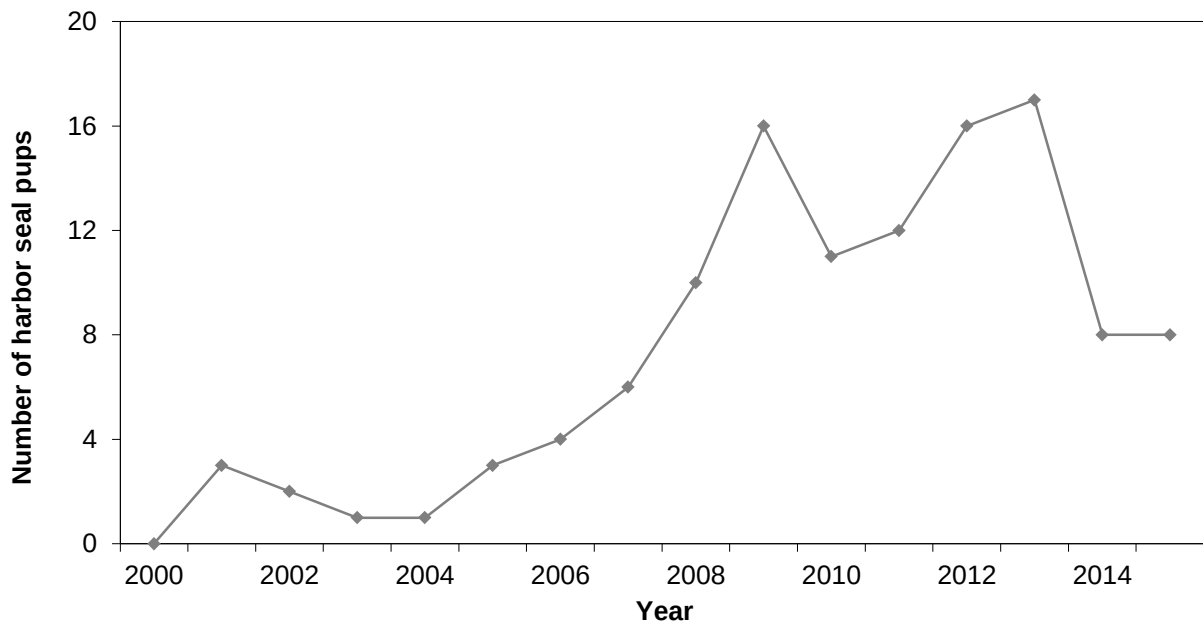


Figure 6. Maximum harbor seal pup counts at Point Bonita during the breeding season (March – May), 2000-2015.

Molt Counts

The maximum count of all seals during the 2015 molt season for all Marin County sites was 4,230 seals, which is similar to the 15-year average and almost identical to the counts from the past two years (Figure 7). Drakes Estero Complex and Double Point comprised 45% (1,912) of the total seals counted during the molt season (Table 2). This proportion is consistent with past years.

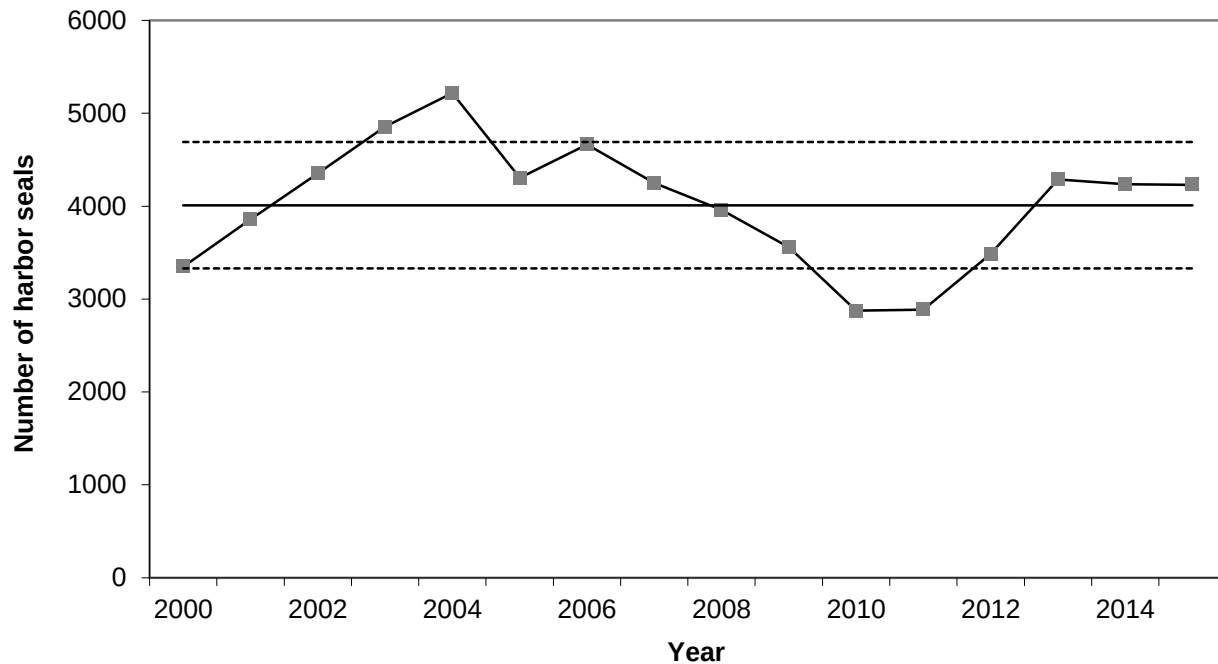


Figure 7. Maximum harbor seal counts during the molt season (June-July) for 2000-2015 at Marin County sites. The solid line on the graph represents the mean of the maximum molt counts from 2000-2014 (mean = 4,010) and the dashed lines represent one standard deviation from the mean (SD = 681.0).

Disturbances

At the Marin County sites in 2015, 89 disturbances were recorded that elicited a response from harbor seals (Table 3). This is the lowest number of disturbances recorded in the past 15 years. The most common disturbance sources were unknown (25%) and humans on foot (18%, Table 3). Aircraft accounted for 15% of the disturbances in 2015, with 13 disturbances recorded, which is higher than the 15-year average of 8 disturbances. Aircraft disturbances were recorded at all sites except Bolinas Lagoon, Duxbury Reef, and Point Reyes Headlands. The majority of the aircraft disturbances occurred at Point Bonita and were caused by helicopters. A lower percentage of disturbances caused by humans on foot occurred in 2015 due to fewer disturbances recorded at Bolinas Lagoon and the Drakes Estero Complex. At the Drakes Estero Complex, a seasonal closure during the breeding season was expanded to include Limantour Spit in 2014, which may have helped reduce the total number of disturbances. All Marin County sites had at least one disturbance recorded.

Table 3. Identified sources of disturbances (head alert, flush, flush into water) for Marin County sites. 2015 data is compared to the 2000 – 2014 mean $\pm$ 1 SD.

Year	Measure	Motorboat	Non-Motor Boat	Vehicle	Dog	Aircraft	Human	Bird	Unknown	Other	Total
2000-2014 mean	(#)	16.3 $\pm$ 6.79	11.1 $\pm$ 5.38	3.9 $\pm$ 3.67	0.6 $\pm$ 0.83	7.5 $\pm$ 4.09	38.3 $\pm$ 14.29	11.1 $\pm$ 4.43	30.9 $\pm$ 7.77	5.4 $\pm$ 3.40	125 $\pm$ 30.8
	(%)	13.3 $\pm$ 5.93	8.6 $\pm$ 3.17	3.0 $\pm$ 2.22	0.5 $\pm$ 0.64	5.9 $\pm$ 2.86	30.3 $\pm$ 7.69	9.1 $\pm$ 3.96	24.9 $\pm$ 4.26	4.5 $\pm$ 2.76	
2015	(#)	13	7	3	0	13	16	11	22	2	89
	(%)	14.6	7.9	3.4	0	14.6	18.0	12.4	24.7	2.2	

The rate of disturbances per hour in 2015 was highest in Tomales Bay (0.33 disturbances/hr), although the rate was lower than most previous years. Double Point, the Drakes Estero Complex, and Point Bonita each had 0.29 disturbances/hr (Figure 8). Increases in disturbance rates compared to 2014 were seen at Duxbury Reef, Point Bonita, and Tomales Point (Figure 9). Decreases in disturbance rates were seen at Bolinas Lagoon, the Drakes Estero Complex, and Tomales Bay. No change in disturbance rate was seen at Double Point. 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 clambers are in the vicinity of the seals (NPS/JIM FORSELL).

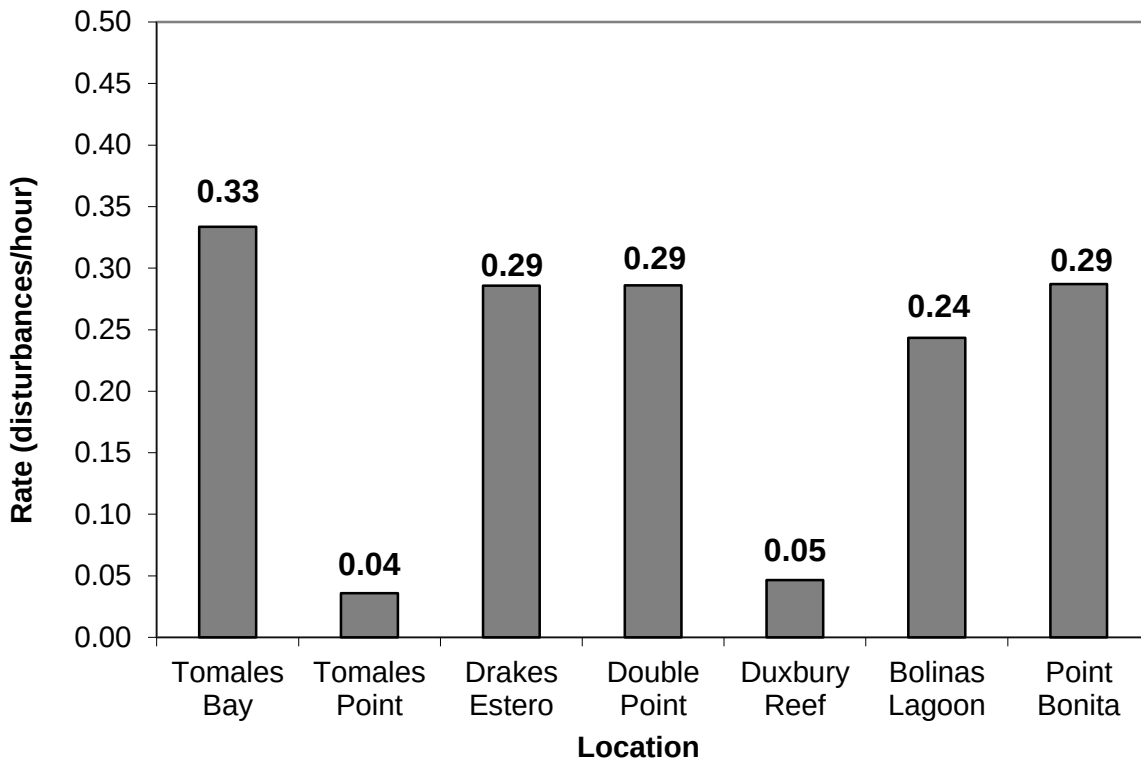


Figure 8. Rates of disturbances per hour at Marin County sites from March 1st through July 31, 2015. Only actual disturbances (head alert, flush, flush water) were used and survey time was based on observation time for all complete surveys (with or without disturbances).

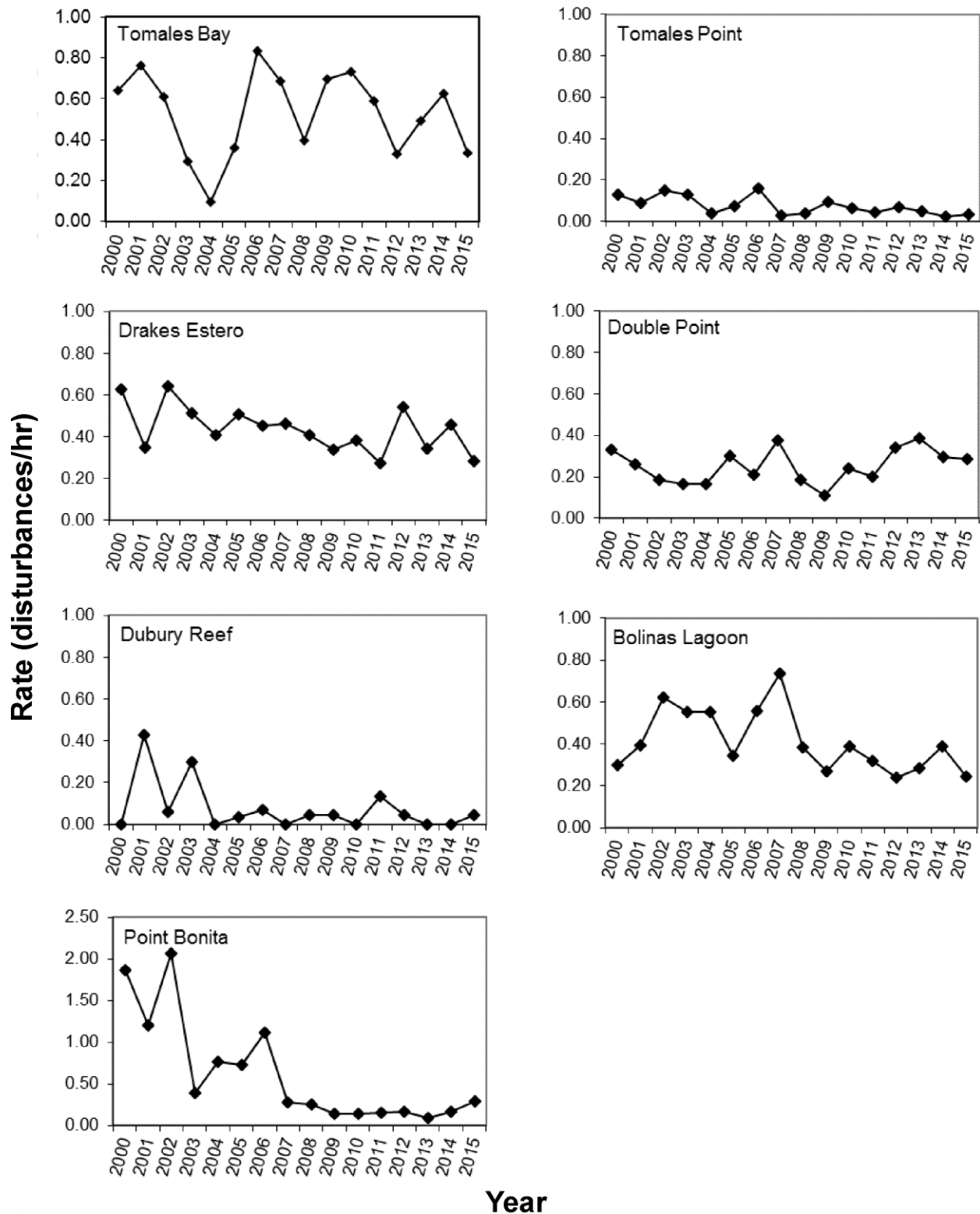


Figure 9. Rates of disturbances per hour at Marin County sites from March through July of 2000-2015. Only actual disturbances (head alert, flush, flush water) were used, and survey time was based on observation time for all complete surveys (with or without disturbances). Note different rate scale for Point Bonita.

Summaries by Site

Tomales Bay

Observers completed 29 high quality surveys at Tomales Bay between March 1 and July 31, 2015. The maximum breeding season adult/immature count (115 seals; Table 2) is a decrease from the previous year's highest count (579 seals) recorded at this site, but still higher than the 15-year average of 437 seals. The pup count of 115 is less than the average (141 pups). The first pup at this site was recorded on April 9. During the molting season, the maximum seal count was 431, which is similar to the average (407 seals). An increase in the number of seals hauling out on Hog Island occurred between the 2006 and 2009 monitoring seasons, but has since been steady at around 100 seals. The disturbances at Tomales Bay were primarily caused by motorboats traveling around the sandbars, as the bay is a very popular spot for fishing and clamming. The disturbance rate had a large decrease from 2014 (0.62 to 0.33; Figure 9), which may have been due to fewer disturbances by humans on foot.

Tomales Point

Observers completed 30 high quality surveys at Tomales Point between March 1 and July 31, 2015. During the breeding season, the maximum adult/immature count was 330 and the maximum pup count was 109 (Table 2). Both of which are less than their respective 15-year averages (359 adults/immatures and 138 pups). The first pup was recorded at this site on April 12. The maximum seal count during the molting season was 437, which is also less than the average of 480 seals. Tomales Point experienced a few disturbances mostly caused by aircraft. During mid-April, search and rescue efforts for missing boaters in the Tomales Point area and subsequent recovery efforts the following week probably caused multiple disturbances to seals that could not be recorded when surveys were not conducted. Due to its remoteness, the Tomales Point location is generally not frequented by visitors. However, due to the distance between the subsites, surveyors do not stay at one subsite long enough to see if other disturbances might occur.

Point Reyes Headlands

Observers completed 12 high quality surveys at Point Reyes Headlands between March 1 and July 31, 2015. Surveys at this site were only conducted during regional survey periods. During the breeding season, the maximum adult/immature count was 93 and the maximum pup count was 36, while during the molting season the maximum seal count was 383 (Table 2). The maximum breeding season adult/immature count is a decrease from the previous year's highest count (168 seals) recorded at this site, but similar to the 15-year average of 108 seals. Both the maximum pup and molt counts were less than their 15-year averages (48 and 348, respectively). The estimated date of the first viable pup is not reliable because of the low number of surveys completed at this site. One disturbance from an unknown source occurred during the 2015 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 33 high quality surveys in the Drakes Estero Complex, which includes Limantour Spit, between March 1 and July 31, 2015. The maximum counts during the breeding

season were 839 adults/immatures and 341 pups (Table 2). The maximum adult/immature count is the highest count at this site since 2004. The pup count is similar to the 15-year average (346 pups). The first viable pup of all Marin County sites was recorded at Drakes Estero on March 13. A high number of lone pups were seen on the main pupping sandbar in Drakes Estero and five lone pups were seen on Drakes Beach outside of the estuary, which is more than are usually seen in that area. Most of them looked healthy and had already lost their umbilical cord. It is possible that females left their pups alone in order to forage further away from the colony and then returned to them. The maximum molt count was 955 seals, which is less than this site's 15-year average of 1,081 seals, but within one SD of the mean. The majority of disturbances were caused by hikers on Limantour and Drakes Beaches, each of which are easily accessible, and by unknown sources. 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 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. The disturbance rate decreased from 2014 (0.46 to 0.29 disturbances/hr; Figure 9).



A lone harbor seal pup seen on Drakes Beach outside of Drakes Estero (NPS/SARAH CODDE).

Double Point

Observers completed 29 high quality surveys at Double Point between March 1 and July 31, 2015. The maximum counts during the breeding season were 442 adults/immatures and 276 pups (Table 2). The 2015 adult/immature and pup counts are the lowest counts at this site since 2010 and below their 15-year averages (549 and 311, respectively). A live pup was seen on February 26, but was alone and

is assumed to have not survived. Two dead pups were seen on March 5 and a third was seen on March 16. The first viable pup of the season was recorded on March 19. Due to a cliff collapse at another location at PORE, Double Point was not surveyed between March 20 and April 9 until a site safety evaluation could be completed. The molt season yielded a maximum count of 957 seals, which is similar to the 15-year average of 999 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. The disturbance rate in 2015 remained the same as 2014 (0.29 disturbances/hr; Figure 9).

Duxbury Reef

Observers completed 33 high quality surveys at Duxbury Reef between March 1 and July 31, 2015. During the breeding season, the maximum counts were 51 adults/immatures and 7 pups, which are both similar to their 15-year averages (69 and 5, respectively; Table 2). The first day a pup was recorded at this site was on April 23. Few pups are seen here, and they possibly come from nearby Bolinas Lagoon. During the molt season the maximum seal count was 94, which is the highest count since 2008. Duxbury Reef had the lowest number of seals and only one disturbance recorded. Disturbances are rarely recorded at Duxbury Reef, possibly due to the poor accessibility for humans at this location.

Bolinas Lagoon

Observers completed 34 high quality surveys at Bolinas Lagoon between March 1 and July 31, 2015. The maximum counts during the breeding season were 330 adults/immatures and 159 pups (Table 2). The maximum adult/immature count in 2015 is less than the count in 2014, but still above the 15-year average for the site (289 seals). After record high pup counts in 2012 – 2014, the 2015 maximum pup count declined and is the same as the 15-year average (158 pups). The first viable pup was recorded on April 7. During the molting season, the maximum count was 772 seals. This peak molt count is the highest count recorded in the past 16 years at this site and a large increase over the 15-year average of 457 seals. The primary causes of disturbances at this site were unknown sources, birds, and humans on foot, which included visitors along Highway 1. The 2015 disturbance rate for Bolinas Lagoon decreased from 2014 (0.39 to 0.24 disturbances/hr; Figure 9).

Point Bonita

Observers completed 33 high quality surveys at Point Bonita between March 1 and July 31, 2015. The maximum adult/immature count (151 seals; Table 2) is one of the highest counts in the past 16 years of monitoring. While Point Bonita is not a primary pupping site, the pup numbers have been increasing since 2008. However, the 2014 and 2015 maximum pup counts (8 pups) are the lowest counts since 2007. A pup was seen on February 28 trying to approach various adult seals and it is assumed to not have survived. Another lone pup was seen on March 19 and its outcome is unknown. The first viable pup was recorded on March 28. The maximum molt count was 201 seals, which is above the 15-year average (161 seals). The disturbances at Point Bonita were caused by various sources including aircraft, fishers onshore, motorboats, and unknown sources. The 2015 disturbance rate had a large increase from 2014 (0.16 to 0.29 disturbances/hr; Figure 9).

Regional Sites

Thirteen regional surveys occurred between February 26 and August 3, 2015 at 23 different locations. Not all sites were surveyed on all scheduled days due to weather conditions or scheduling conflicts. In 2015, there were multiple locations that had maximum counts in March: Fort Ross, Alcatraz, Castro Rocks, Mowry Slough, Cowell Ranch, Purisima Creek, and Pescadero. 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 2015 breeding season, a maximum of 4,271 adults/immatures and 1,380 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 5,688. Marin County sites accounted for 62% of the maximum adult and immature seal breeding count, 76% of the maximum pup count, and 66% 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 8,760 (95% CI = 6,598–10,920; Harvey and Goley 2011).

Table 4. Regional surveys of harbor seal numbers in central California, February 26 – August 3, 2015. Thirteen surveys were scheduled on alternating weekends, eight during the breeding season and five during the molt season. Values reported as number of surveys (N), mean, standard error (SE), and maximum (Max). ND = No data.

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	8	179.6	13.2	199	50	4	216.3	25.5	255
	Fort Ross	8	128.0	18.5	130	9	4	120.5	16.1	153
	Jenner	8	165.5	11.5	209	34	5	248.4	54.8	384
	Bodega Marine Reserve	7	62.7	6.1	81	13	5	64.2	8.6	83
Marin County	Tomales Bay ⁴	8	414.5	24.9	476	115	4	293.5	50.9	431
	Tomales Point	8	236.1	19.9	330	109	4	327.0	52.9	437
	Point Reyes Headland ⁴	7	75.7	4.5	93	36	5	244.8	47.3	383
	Drakes Estero Complex	8	427.9	66.7	839	341	5	601.8	106.9	955
	Double Point	7	264.8	36.5	418	276	5	245.8	88.1	579
	Duxbury Reef	8	61.0	10.4	44	7	4	53.8	8.6	82
	Bolinas Lagoon	8	221.5	17.9	308	159	5	442.0	79.4	670
	Point Bonita ⁴	8	109.3	19.6	151	8	5	121.8	23.9	201
San Francisco Bay	Alcatraz	8	3.9	1.8	6	0	5	1.4	1.0	5
	Castro Rocks	8	149.8	12.5	148	48	5	161.0	14.7	203
	Yerba Buena Island	8	74.9	11.5	81	27	5	150.6	13.9	190
	Newark Slough ⁴	5	20.0	6.0	37	11	0	ND	ND	ND
	Mowry Slough ⁴	5	41.0	8.9	42	15	0	ND	ND	ND
San Mateo County	Point San Pedro	8	5.0	2.0	13	2	3	12.3	3.0	18
	Cowell Ranch	8	55.3	5.8	71	19	4	54.0	8.6	68
	Purisima Creek	8	107.0	29.5	70	35	5	66.0	13.9	98
	Pescadero	8	47.9	5.9	40	13	5	38.8	6.8	64
	Pebble Beach	8	84.1	10.4	92	12	5	101.4	5.6	112
	Fitzgerald Marine Reserve	8	221.1	38.3	393	41	5	241.8	41.8	317
ALL SITES		–	–	–	4,271	1,380	–	–	–	5,688

¹Adults and immatures during the breeding season, February 26 – 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 – August 3.

⁴Includes surveys that occurred outside of regional weekend period.

Sonoma County

The 2015 maximum adult/immature and pup counts during the breeding season at Sonoma County sites were less than the previous year's counts (Figures 10 and 11). Among Sonoma County sites, Jenner and Sonoma Coast had the high counts of adults/immatures and the high count of pups occurred at Sonoma Coast (Table 4). In 2014, Jenner was not surveyed during the molt, so a comparison to that year cannot be made. The 2015 Sonoma County molt count decreased from the 2013 count (Figure 12). Jenner had the highest molt count among Sonoma County sites in 2015 (Table 4). Jenner was the only site in Sonoma County with recorded disturbances, which included two caused by photographers and one caused by a kayaker.

San Francisco Bay

The 2015 maximum adult/immature count at SFB is one of the lowest counts recorded in the past 11 years and this follows one of the highest counts recorded in 2014 (Figure 10). The 2015 pup count also decreased from 2014 (Figure 11). Within SFB, the high counts for adults/immatures and pups occurred at Castro Rocks (Table 4). During the molt season, Mowry and Newark Sloughs were not counted, which combined usually make up a substantial amount of the SFB seal population. However, even with this missing data the 2015 molt count was still higher than the count in 2014. During the molt season, Castro Rocks had the high count of seals among SFB sites, which is consistent with past years (Table 4).

In SFB, multiple disturbances occurred at Alcatraz, where very few seals haul out, and at Yerba Buena Island. Disturbance sources included aircraft, motorboats, non-motorboats, and unknown sources. An unrecorded disturbance at Yerba Buena Island most likely occurred when a car accident resulted in a vehicle being stranded at the seal haul-out during the peak of pupping in early May. However, this accident did not occur during a survey and no witnesses were reported. The vehicle was seen on the beach the next day during a regional survey and the seals were hauled out at a different location.

San Mateo County

The maximum adult/immature count during the breeding season at San Mateo County sites in 2015 and 2014 were both the largest counts recorded for this region in the past 11 years (Figure 10). Although, it should be noted there are many years where some sites were not surveyed and a new site was added in 2012. The 2015 maximum pup count declined from the counts of the past three years (Figure 11). There was a large decline in the 2015 molt count as compared to the count in 2014, which was the highest count recorded in this region in the past 11 years (Figure 12). Among San Mateo County sites, Fitzgerald Marine Reserve had the high counts of adults/immatures, pups, and molting seals (Table 4). Two disturbances by visitors at the Fitzgerald Marine Reserve were the only disturbances reported in San Mateo County. Four potential disturbances occurred at Pescadero, Pebble Beach, and Fitzgerald Marine Reserve when people were observed in the harbor seal haul-out areas and the surveyors were unsure if a disturbance had occurred prior to their arrival.

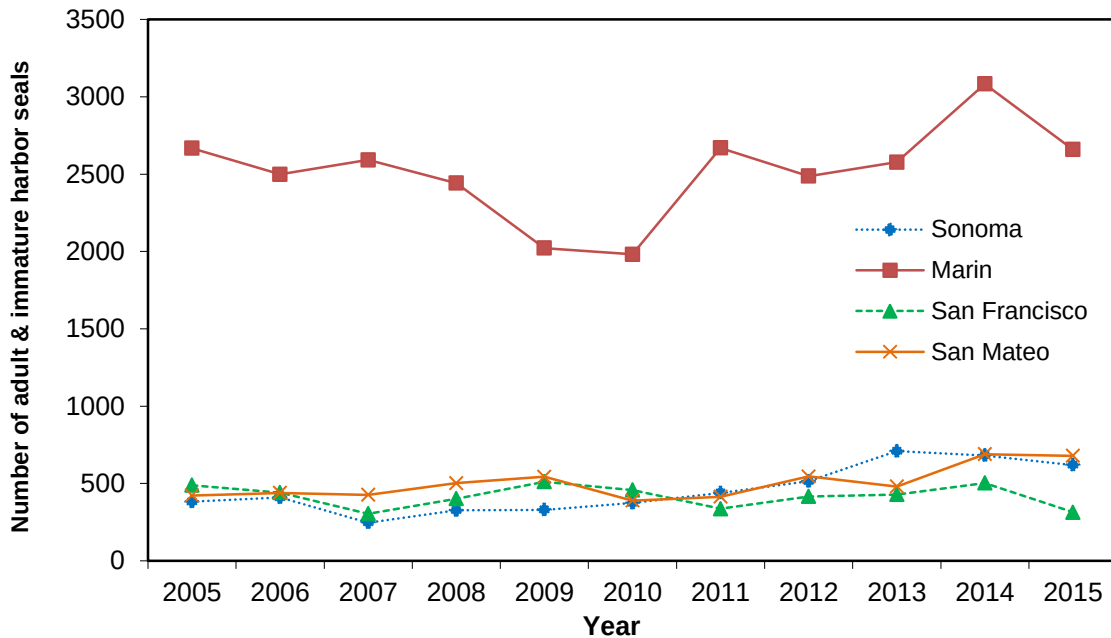


Figure 10. Maximum counts of harbor seal adults and immatures by region during the breeding season for the 2005-2015 regional surveys in central California. Bodega Marine Reserve was added to Sonoma County in 2010, Purisima Creek was added to San Mateo County in 2012, and Fort Ross was added to Sonoma 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 2005-2015 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.

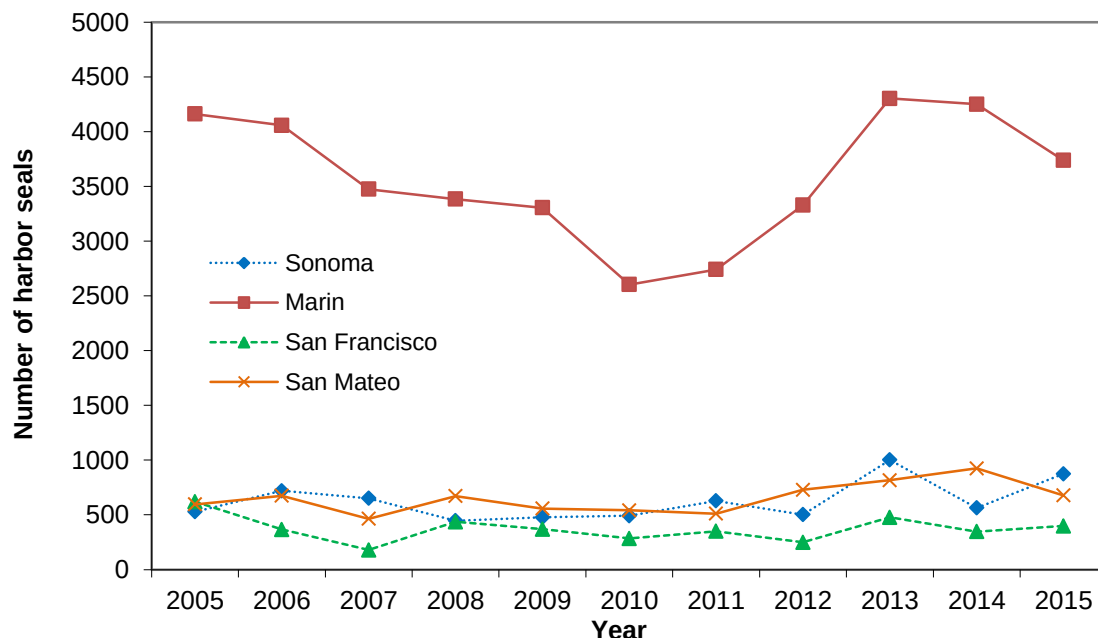


Figure 12. Maximum counts of all age classes of harbor seals by region during the molting season for the 2005-2015 regional surveys in central California. Bodega Marine Reserve was added to Sonoma County in 2010, Purisima Creek was added to San Mateo County in 2012, and Fort Ross was added to Sonoma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

All of the 2015 counts during the breeding and molting seasons were similar to their respective 15-year averages and within one standard deviation of the average. The molt season counts have been the same for the past three years and follow peak low counts in 2010 and 2011. From 2000 to 2015, the Drakes Estero Complex and Double Point annually produced the highest numbers of harbor seal pups and together are the primary breeding and molting sites for harbor seals of Marin County. In 2015, these two sites combined produced 59% of the pups observed during the breeding season and 45% of the seals recorded during the molting season at Marin County sites. The proportion of seals during the molting season at the Drakes Estero Complex and Double Point in 2015 was less than the 15-year average of 52%. This could be due in part to a higher proportion of seals at Bolinas Lagoon (18%) than previous years (15-year average is 12%). A higher proportion at Bolinas Lagoon has additionally been seen in 2010, 2011, and 2014. Bolinas Lagoon has had an increase in seal numbers the past few years during both the breeding and molting seasons. An increase in pups began in 2012; however, in 2015 the pup count decreased and was the same as the 15-year average.

The number of disturbances that occurred during the 2015 season was less than the 15-year average. Throughout the study area from 2000-2015, the primary sites that experienced disturbances were Tomales Bay, the Drakes Estero Complex, Bolinas Lagoon, and Double Point. In 2015, Point Bonita also had a higher number of disturbances, but still much reduced from 2006 when GOGA implemented protection measures. In 2015, Tomales Bay had the highest disturbance rate recorded

for the year, with the majority of disturbances caused by motorboats. In the past ten years, one of the highest disturbance rates consistently occurred at Tomales Bay as this is a popular recreational area for fishing, clamming, and boating (motorboats and kayaks). The most common source categories of disturbance for all Marin County sites in 2015 were unknown and humans on foot. These sources, along with motorboats, are consistently 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, Gible and Harvey. 2015). During 2014-2015, regional anomalies continued in the eastern Pacific Ocean including a warm water “Blob” that persisted off the north Pacific that affected the distribution of prey species of marine mammals, an unprecedented drought in California reducing freshwater flow into the Pacific Ocean, and the beginning of an El Niño that extended into 2016. 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. We have not analyzed the potential effects of these 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

- A maximum of 2,696 adult and immature seals were counted onshore during the breeding season.
 - The highest number of adults/immatures hauled out at Drakes Estero Complex (839), followed by Double Point (442).
- A maximum of 1,051 pups were observed at Marin County colonies.
 - The Drakes Estero Complex and Double Point accounted for 59% (617) of pups at Marin County colonies
- A maximum of 4,230 animals (all age classes) were counted during the molting season at Marin County haul-out sites.

- Drakes Estero Complex and Double Point accounted for 45% (1,912) of the total seals counted during the molt season.
- 89 disturbances were recorded during surveys.
 - This is the lowest number of disturbances recorded in the past 15 years.
 - The most frequent disturbance categories were unknown sources (25%) and humans on foot (18%).
 - The highest disturbance rate (0.33 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. Twenty-nine volunteers participated in these surveys.
 - Marin County sites accounted for 62% of breeding season adult and immature seals, 76% of pups, and 66% of seals during the molting season.
- 41 volunteers and two NPS staff members completed 253 surveys at Marin County sites between March 1 and July 31, 2015, with approximately 450 monitoring hours.

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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, 2000-2015. The mean includes disturbance sources from 2000 – 2014.

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
2000-2014 Mean	7.5	5.9	11.1	9.1	0.6	0.5	38.3	30.3	16.3	13.3	11.1	8.6	3.9	3.0	30.9	24.9	5.4	4.5	125

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