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PACIFIC HARBOR SEAL CENSUS IN CALIFORNIA DURING MAY-JULY 2002 AND 2004

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ABSTRACT

An aerial photographic census of Pacific harbor seals, *Phoca vitulina richardsi*, was conducted in California from May to July in 2002 and 2004 to document the number of seals hauled out during the molt period. To compensate for latitudinal differences in the timing of the molt, the state was divided into three strata. Surveys began in the southernmost stratum in May of each year and progressed north in June and July. Aerial photographic surveys at the Channel Islands and the mainland coast of southern California occurred during the afternoon high-low tide cycle. Surveys in central and northern California generally occurred after 0800 hours during the morning low-low tide cycle at tide levels of +0.5 m (re: MLLW) or less. Color transparency photographs of harbor seals were taken from an aircraft flying at an altitude of about 213 m with a 126-mm-format camera equipped with image motion compensation and the geographical position of each photograph was recorded by linking the camera to a computer and Global Positioning System (GPS). In 2002, there were 3,878 harbor seals counted onshore at the Channel Islands, 17,555 along the mainland coast and San Francisco Bay estuary, and 21,433 harbor seals statewide. In 2004, there were 4,344 harbor seals counted onshore at the Channel Islands, 21,989 along the mainland coast and San Francisco Bay estuary, and 26,333 statewide. In southern California, approximately 70% of seals were found at Santa Cruz, Santa Rosa, and San Miguel islands. After dividing the mainland counts by 0.5° latitude segments to document distribution of seals, segment 37.50° to 37.99° N latitude had the highest number of seals. No seals were found along the mainland along the section of coastline that included Los Angeles and Orange counties, and north San Diego County. The population of harbor seals in California during 2004 was estimated to be 43,449 individuals using a factor of 1.65 to correct for the fraction of seals not hauled out during overflights.

INTRODUCTION

Pacific harbor seals, *Phoca vitulina richardsi*, are widely distributed along the mainland coast, islands and bays of California. Previous aerial photographic surveys of harbor seals in California during the June through July pre-molt and molt period (when the greatest number of seals are expected to be hauled out) indicated that the California population was increasing at an average annual growth rate of 3.5% between 1982 and 1995 (Hanan[3] 1996, Fluharty[4] 1999). The population in California in 1995 was estimated at 30,293 individuals (Barlow et al.[5] 1997).

During 1982-1995, seals were counted from near-vertical color-transparency photographs taken with a 70-mm-format Hasselblad camera from an aircraft as it flew along the coastline at an altitude of 183-213 m (Hanan[3] 1996, Fluharty[4] 1999). Various methodologies for censusing harbor seals were reviewed at a workshop on methods and timing of harbor seal surveys in California (Barlow[6] 2002), and participants recommended that a new camera system be used which automatically recorded time, latitude, and longitude of each photograph. A 126-mm-format military reconnaissance camera, equipped with image motion compensation and the capability of automatically recording time, latitude, and longitude of each photograph had been used successfully to census northern elephant seals, *Mirounga angustirostris*, Steller sea lions, *Eumetopias jubatus*, and California sea lions, *Zalophus californianus*, (Lowry et al. 1996, Westlake et al. 1997, Lowry 1999). This report describes methods and results of harbor seal censuses conducted in May-July of 2002 and 2004 in California with a vertically-mounted 126-mm-format camera.

[3]Abundance and distribution for Pacific harbor seals, *Phoca vitulina richardsi*, on the coast of California. Ph.D. Dissertation, University of California, Los Angeles. 158 pp.

[4]Fluharty, M. J. 1999. Summary of Pacific harbor seal, *Phoca vitulina richardsi*, surveys in California, 1982-1995. California Department of Fish and Game, Marine Region Administrative Report 99-1. 49 pp.

[5]Barlow, J., K. A. Forney, P. Scott Hill, R. L. Brownell Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, R., and R. Reeves. 1997. U.S. Pacific marine mammal stock assessments: 1996. NOAA Technical Memorandum NMFS, NOAA-TM-NMFS-SWFSC-248. 223 pp.

[6]Barlow, J. 2002. Report of the California harbor seal workshop, March 28-29, 2002, Southwest Fisheries Science Center. *Can be obtained from:* Jay Barlow, National Marine Fisheries Service, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

METHODS

Field Methods

Aerial surveys to photograph seals were scheduled during the peak molt period when the greatest fraction of seals would be ashore (Stewart and Yochem 1994). California was divided into three strata (Fig. 1) to account for latitudinal gradient in the timing of the molt by harbor seals (inferred from latitudinal timing of the reproductive period [Tempte et al. 1991]): (1) southern California, (2) central California, and (3) northern California. The southern California stratum included the Channel Islands and mainland coast of southern California from the U.S./Mexico border (32.533°N, 117.117°W) to Pismo Sand Dunes (35.000°N, 120.640°W). The central California stratum included the coastline from Pismo Sand Dunes to Point Reyes (37.995°N, 123.023°W), Drakes Estero, and San Francisco Bay estuary. The northern California stratum included the coastline from Point Reyes to the California/Oregon border (42.000°N, 124.212°W). Seals molt earlier in the southern stratum and by as much as a month later in the northern stratum.

Photographic surveys were scheduled at the Channel Islands and the mainland coast of southern California during the lowest tide cycle in the afternoon (high-low tide) in late-May through mid-June. Previous studies at the Channel Islands have shown that the greatest numbers of harbor seals are hauled out during this period (Stewart and Yochem 1994).

Photographic surveys in central and northern California were scheduled during the low-low tide cycle at tide levels of 0.31 m or less during mid-to-late June and late-June through July, respectively (Allen et al. 1985, Barlow[4] 2002). However, in 2004 the maximum allowable tide level was raised from 0.31 m to 0.46 m due to persistent fog, and at four sites that tide level was also exceeded because of additional weather and logistical constraints: portions of Point Buchon [0.46 m to 0.49 m], Humboldt Bay [0.49 m to 0.52 m], the Eel River [0.89 m], and Cape Mendocino [0.98 m]. The program WTides (freeware obtained at http://www.mdr.co.nz/) was used to schedule surveys, determine tide height at each haulout site after the survey was completed, and for referencing the mean lower low water datum reference (MLLW). A Garmin GPSMAP 76 Global Positioning System (GPS) was used to monitor tide levels while in flight. Central and northern California surveys were scheduled after 0800 hours when light conditions were optimal for locating and photographing seals. For several sites, ground counts were conducted in lieu of aerial surveys because persistent fog prevented photographic overflights.

In 2002, aerial surveys were conducted from 22 May to 1 July, and ground surveys were conducted on 12 June (by an aerial survey team member [M. Lowry]) and 18 June (Deborah E. Green, San Francisco State University, personal communication) (Table 1). In 2004, aerial surveys were conducted from 18-20 May to 19 July, and ground surveys were conducted on 24 June, 6 July (Russ Bradley, PRBO Conservation Science, personal communication), 25 June, 4 July, and 23 July (Brook Sommerfeldt, Point Reyes National Seashore, personal communication), and 19 July (by

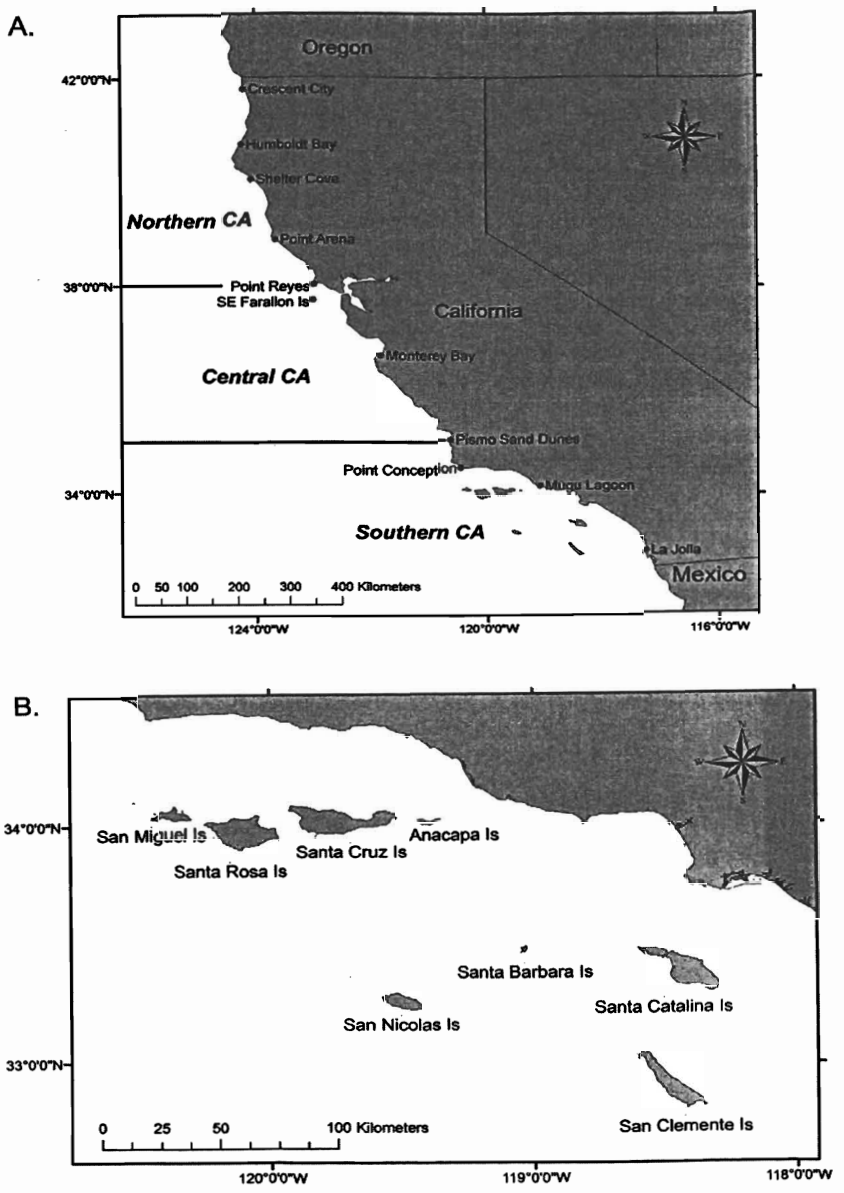

Figure 1. Maps of (A) California depicting the three strata used in this study and (B) the Channel Islands.

Table 1. Dates and areas surveyed for harbor seals within three strata of California during 22 May through 1 July 2002.

Survey area	Date
Southern California:	
Port Hueneme to Point Conception	22 May 2002
Mugu Lagoon, Anacapa Is., Santa Cruz Is., Santa Rosa Is., and San Miguel Is.	23 May 2002
Santa Barbara Is., San Nicolas Is., San Clemente Is., and Santa Catalina Is.	24 May 2002
Mainland coast from Point Loma to La Jolla, Seal Beach and vicinity, Palos Verdes Peninsula, and Pacific Palisades to Point Mugu	25 May 2002
Purisima Point	12 June 2002
Point Mugu to Pismo Beach	16 June 2002
Central California:	
Pismo Beach to Monterey	16 June 2002
Monterey to Point Reyes, and San Francisco Bay estuary	17 June 2002
Yerba Buena Island	18 June 2002
Northern California:	
Point Reyes to Fort Ross Point	28 June 2002
Fort Ross Point to Jug Handle State Reserve (6 km south of Fort Bragg)	29 June 2002
Jughandle State Reserve to California/Oregon border	30 June 2002
S. E. Farallon Islands	1 July 2002

aerial survey team) (Table 2).

A twin-engine, high-wing Partenavia P68-observer aircraft (offering excellent forward and downward visibility) was flown at a ground speed of 185 km/h (100 kts) and at an altitude of 213 m (700 ft) above sea level. In 2002, the altitude was raised at Elkhorn Slough to 305 m (1000 ft) and to 427 m (1400 ft) at Southeast Farallon Islands due to permit restrictions, to 366 m (1200 ft) at Castro Rocks (San Francisco Bay) due to Federal Aviation Administration restrictions, and to 274 m (900 ft) at Humboldt Bay after we observed that seals at this location were disturbed. In 2004, the altitude was raised to 244 m (800 ft) at Humboldt Bay (seals were not affected by the aircraft at this altitude). Although the altitude was higher than normal at those areas, seal counts were not compromised because they could still be detected in the high resolution photographs.

Harbor seals were photographed with a 126-mm-format Chicago Aerial Industries, Inc. KA-76 camera (mounted vertically inside the belly of the aircraft) equipped with image motion compensation and operated at a cycle rate that achieved 67% overlap between adjacent frames. A 152 mm focal-length lens was used on the camera, except at the Farallon Islands in 2002 where a 305 mm focal-length lens was used. The latitude and longitude of each photograph was recorded by linking the camera

Table 2. Dates and areas surveyed for harbor seals within three strata of California during 18 May through 23 July 2004.

Survey area	Date
Southern California:	
Point Mugu to Pismo Beach	18 May 2004
Santa Barbara Is., San Nicolas Is., Santa Catalina Is., and mainland coast from Point Loma to Point Mugu (except at Camp Pendleton, and Redondo Beach to Pacific Palisades)	19 May 2004
Anacapa Is., Santa Cruz Is., Santa Rosa Is., and San Miguel Is.	20 May 2004
San Clemente Is.	1 June 2004
Santa Rosa Is. and San Miguel Is.	2 June 2004
Anacapa Is. and Santa Cruz Is.	3 June 2004
Central California:	
Pismo Beach to Point San Luis	22 June 2004
Point Buchon to Cayucos Point, Point Piedras Blancas to Ragged Point, and Point Lopez to Needle Rock Point	23 June 2004
Needle Rock Point to Bolinas, and San Francisco Bay estuary	24 June 2004
Bolinas to Point Reyes, Yerba Buena Island, Point Lopez to Point San Luis	25 June 2004
Southeast Farallon Islands	24 June 2004
Southeast Farallon Islands	6 July 2004
Northern California:	
Punta Gorda to California/Oregon border	5 July 2004
Punta Gorda to Shelter Cove, and Rockport to Jug Handle State Reserve	7 July 2004
Shelter Cove to Rockport, Jug Handle State Reserve to Manchester State Beach	9 July 2004
Duncans Point to Bridgeport Landing, and Bodega Rock	18 July 2004
Bodega Head	19 July 2004
Tomales Bay and Tomales Point	25 June 2004
Tomales Bay and Tomales Point	4 July 2004
Tomales Bay and Tomales Point	23 July 2004

to a computer and GPS. Kodak Aerochrome HS Film SO-359, a very fine-grained, high-speed, color transparency film, was used. The camera was set at an aperture of f/4 or f/5.6 with a shutter speed between 1/400 and 1/2000 second.

The survey team consisted of two or three observers and the pilot, who were in constant communication via headsets. The observer in the right front seat 1) looked for seals in front and to the right of the aircraft, 2) directed the pilot to locations of seals, 3) operated a computer that was linked to a Garmin GPSMAP 76 GPS unit to track the aircraft on a topographic map displayed on the computer screen (National Geographic Topographic Maps of California, overlaid with all known harbor seal haulout sites), and 4) checked tide level displayed by the Garmin GPSMAP 76 GPS. The second observer 1) looked for seals under the aircraft from the belly viewing

port located behind the camera, 2) operated the camera when seals were sighted, and 3) recorded notes onto a second computer that was linked to a GPS and the camera. The third observer (when available) was seated behind the pilot on the left side of the aircraft and looked for seals to the left and below the aircraft, and operated the second computer. During each survey, the aircraft was flown directly over the coastline or slightly offshore, and seals were photographed as they passed underneath. The aircraft doubled back to photograph seals that were out of camera range or sighted too late to be photographed on the first pass. Multiple photographic passes were made over large rocks or islands to ensure that the entire area was photographed.

Count Methods

Harbor seals on each image were counted through a 7-70X zoom binocular microscope as the photographs were illuminated on a light table. Locations of animals on each image were marked on a clear acetate overlay as each was counted. Marks on the acetate were compared and verified with overlapping photographs. If not all animals could be counted in one photograph, the overlay was placed on the adjacent photograph at the exact location where the count ended previously and the count continued. Seals were counted in this manner until all were counted. One count was made for each rock, island, or haulout site. Seals in the water were not included in our counts because correction factors to estimate total population size are based only on seals that are hauled out on land.

For some areas, two or more counts were obtained on different days. In these cases, we selected (a) counts from the lower tide level, (b) the flights that included the longest stretch of coastline coverage, or, (c) for ground counts, the date that was closest in time to flights completed in that region. Although some repeated survey areas or haulout sites may have had a higher count of seals, the higher count was not deliberately chosen.

Counts were tabulated separately for San Francisco Bay estuary, each of the Channel Islands (Fig. 1), and by 0.5° latitude segments for mainland sites to document distribution of seals. The following exceptions were made in order to keep the count contiguous for a coastal segment: (1) Southeast Farallon Islands and Drakes Estero are included in latitude segments 37.50° to 37.99°, and (2) San Francisco Bay estuary is excluded in latitude segments 37.50° to 37.99° and 37.00° to 37.49° and presented separately.

The total population size of California harbor seals was estimated by dividing the total count obtained in this study by the proportion hauled out, p, during concurrent telemetry studies of 120 tagged seals (Harvey and Goley[7] 2005). Individual radio-tagged seals that were known to have functioning transmitters during the study (n=114) were treated as binomial random variables to estimate variance and a normally-distributed 95% confidence interval (CI) of the proportion hauled out. The correction factor for abundance estimation was estimated as $1/p$.

[7]Harvey, J. T. and D. Goley. 2005. Determining a correction factor for aerial surveys of harbor seals in California. Final Report to National Marine Fisheries Service and Pacific States Marine Fisheries Commission, PSMFC Contracts No. 03-19 and 04-33, NOAA Grant No. NA17FX1603. 35 pp.

RESULTS

Within California, we counted 21,433 harbor seals in 2002 and 26,333 in 2004 (Table 3, Fig. 2). At the Channel Islands, 3,878 seals were counted in 2002 and 4,344 in 2004 (Table 4). Along the mainland coast of California and in the San Francisco Bay estuary, 17,555 seals were counted in 2002 and 21,989 in 2004 (Table 5).

In 2002, 8,418 harbor seals were counted in the northern California stratum (39.28% of the statewide total), 7,744 in the central California stratum (36.13% of the statewide total), and 5,271 in the southern California stratum (24.59% of the statewide total) (Table 3, Fig. 3). In 2004, 9,591 harbor seals were counted in the northern California stratum (36.42% of the statewide total), 10,954 in the central California stratum (41.60% of the statewide total), and 5,788 in the southern California stratum (21.98% of the statewide total) (Table 3, Fig. 3). The 2002-2004 average statewide percentage of the total count for each stratum was 23.3% for southern California, 38.9% for central California, and 37.8% for northern California.

Along the mainland coast of California (including San Francisco Bay estuary), segment 37.50° to 37.99° N latitude had the most seals during both survey years (n = 2,988 and n = 3,360 for 2002 and 2004, respectively; Table 5). No seals were found along the mainland coast between Mugu Lagoon (11 km ESE of Port Hueneme) and La Jolla (in San Diego) which included Los Angeles and Orange counties and North San Diego County.

Of all the Channel Islands in the southern California stratum, Santa Cruz Island had the most seals in 2002 (n =1,055) and 2004 (n =1,102) and Santa Barbara Island the fewest in 2002 (n = 15) and 2004 (n = 12; Table 4). Santa Cruz Island, Santa Rosa Island, and San Miguel Island had 69.5% and 70.9% of the Channel Island population in 2002 and 2004, respectively.

Table 3. Total number of harbor seals hauled out within three California strata, and for California statewide, during surveys conducted May-July 2002 and 2004.

Stratum	Number of Seals Counted 2002	2004
Northern CA Total	8,418	9,591
Central CA Total	7,744	10,954
Southern CA Total	5,271	5,788
California Total	21,433	26,333

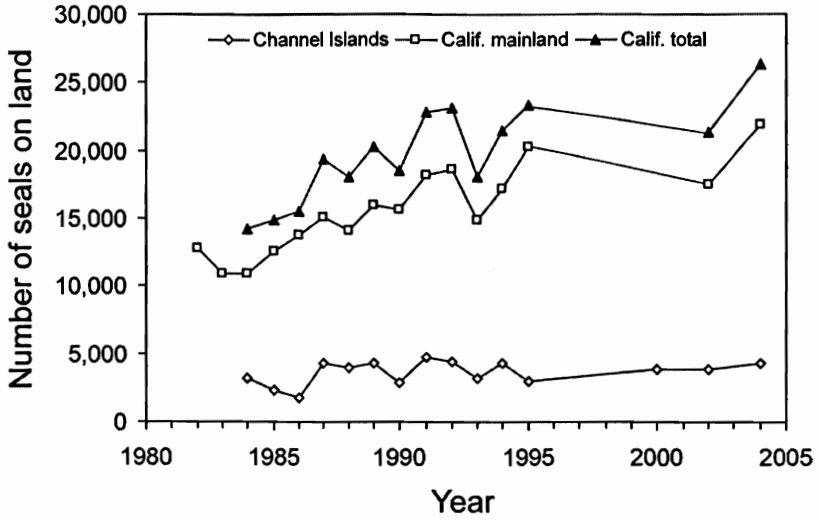

Figure 2. Counts of harbor seals on land during late-molt period in California for 1982-2000 (Hanan[1] 1996, Fluharty[2] 1999, Read and Roberts[7] 2001) and for 2002-2004 (this study).

Table 4. Total number of harbor seals hauled out at the Channel Islands during surveys conducted May-June 2002 and 2004.

Island	Number of Seals Counted 2002	2004
Anacapa Island	231	173
Santa Cruz Island	1,055	1,102
Santa Rosa Island	911	972
San Miguel Island	731	1,004
San Nicolas Island	584	784
Santa Barbara Island	15	12
Santa Catalina Island	236	193
San Clemente Island	115	104
Channel Islands Total	3,878	4,344

Table 5. Total number of harbor seals counted within each 0.5 degree latitude segment along the mainland coast of California, and separately for San Francisco Bay estuary (S F Bay estuary), during surveys conducted May-July 2002 and 2004.

Segment	Sum of seals from all haulouts 2002	2004
41.50° to 42.00°	883	1,047
41.00° to 41.49°	514	416
40.50° to 40.99°	1,553	2,141
40.00° to 40.49°	403	525
39.50° to 39.99°	730	740
39.00° to 39.49°	1,141	1,522
38.50° to 38.99°	1,736	1,905
38.00° to 38.49°	1,458	1,295
37.50° to 37.99°[a, b]	2,988	3,360
S F Bay estuary[b]	558	621
37.00° to 37.49°[b]	994	1,557
36.50° to 36.99°	1,291	2,127
36.00° to 36.49°	455	778
35.50° to 35.99°	806	1,292
35.00° to 35.49°	652	1,219
34.50° to 34.99°	432	50
34.00° to 34.49°	806	1,273
33.50° to 33.99°	0	0
33.00° to 33.49°	0	0
32.50° to 32.99°	155	121
Mainland Total	17,555	21,989

[a]SE Farallon Islands and Drake's Estero are included in latitude segments 37.50° to 37.99°.
[b]San Francisco Bay estuary is excluded from latitude segments 37.50° to 37.99° and 37.00° to 37.49°.

DISCUSSION

The population of harbor seals in California appears to be increasing (contrary to indications from the 2002 survey [see Lowry and Carretta[8] 2003]), but the rate of increase appears to be lower than it was during the 1980's and 1990's (Fig. 2). However, since the 1990's, the 2002 and 2004 harbor seal counts in southern California, as

[8]Lowry, M. S. and J. V. Carretta. 2003. Pacific harbor seal, *Phoca vitulina richardsi*, census in California during May-July 2002. NOAA Technical Memorandum NMFS NOAA-TM-NMFS-SWFSC-353. 48p.

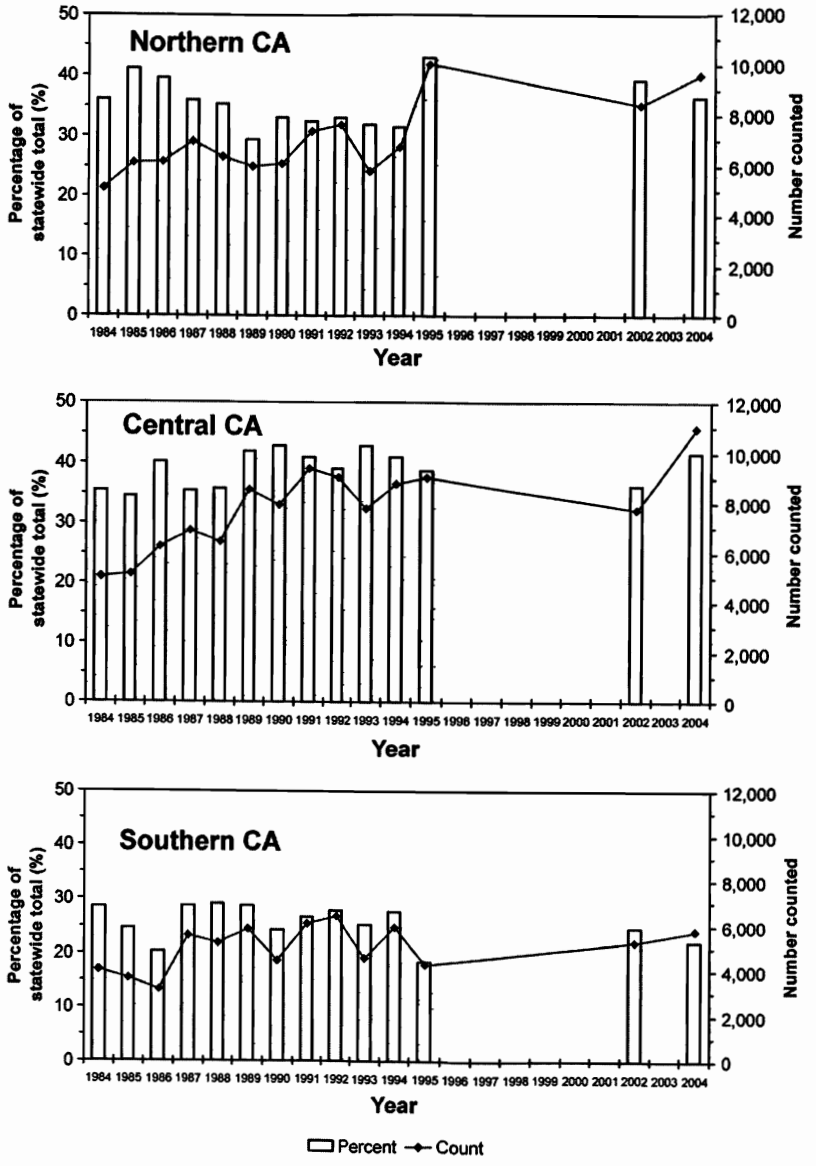

Figure 3. Percentage of harbor seals from the total statewide count and counts of harbor seals on land during late-molt period for three strata (Southern CA, Central CA, and Northern CA) for 1982-2000 (Hanan[3] 1996, Fluharty[4] 1999, Read and Roberts[9] 2001) and for 2002-2004 (this study).

well as at the Channel Islands, show no noticeable increase, while the 2004 counts in central California and the 2002 and 2004 counts in northern California show increases (Hanan 1996[3], Fluharty 1999[4], Read and Roberts[9] 2001) (Fig. 3).

Census methodology differs between surveys conducted during the 1980's and 1990's with those we conducted in 2002 and 2004. Differences between the two survey periods are the following: (1) stratification of the state into two strata (Channel Islands and mainland) in the earlier surveys and into three strata in our surveys (southern, central, and northern California), (2) differences in timing that each strata was surveyed (strata were surveyed several weeks apart in the earlier surveys and approximately ten to fourteen days apart in our surveys), and (3) bays and estuaries were surveyed between high and low tide in earlier surveys and during low tide in our surveys. Harbor seals are known to have strong site fidelity, move short distances (mean = 24.2 km, SE = 4.3 km) during pupping and molting periods, move in any direction along the coast when they do, and have no age-sex differences in movement patterns (Torok 1994[10], Harvey and Goley[7] 2005). Given that, we feel that differences in overall seal counts would be negligible between the two survey methods.

Within California, approximately three quarters of the harbor seals were counted within central and northern California and 60% of the state total were counted between Fort Bragg and Pismo Beach (i.e., between 39.5° and 35.0° N latitude). Segment 37.50° to 37.99° N latitude (just north of San Francisco), which includes haulouts at Bolinas Lagoon, Double Point, Drakes Estero, and Point Reyes Headland (most of which are within Point Reyes National Seashore), had the highest concentration of seals in 2002 and 2004. The lack of any harbor seal haulout sites along the mainland coast of southern California between Point Mugu and La Jolla (in San Diego) can be attributed to extensive urban development and beach use by humans in this area.

Haulout counts are not a complete census of the population during the peak molt season because some seals are foraging at sea or moving to other sites at the time of the survey. Radio tag studies have been used to estimate the proportion of animals on land (Yochem et al. 1987, Harvey[11] 1987). Unfortunately, the majority of these studies (reviewed in Boveng[12] 1988) documented the proportion of seals on land for extended periods of time during the day, not at an instantaneous rate (as would occur when an aircraft flies over during aerial surveys), and some proportions were

[9]Read, R. and E. Roberts. 2001. Final report: Census/survey of harbor seals in California. Report submitted to Pacific States Marine Fisheries Commission. Available from Robert Read, California Department of Fish and Game, Marine Region, San Diego Field Office, 4949 Viewridge Avenue, San Diego, CA 92123.

[10]Torok, M.L. 1994. Movements, daily activity patterns, dive behavior, and food habits of harbor seals (*Phoca vitulina richardsi*) in San Francisco Bay, California. M.S. Thesis, California State University Stanislaus and Moss Landing Marine Laboratories. 88 pp.

[11]Harvey, J.T. 1987. Population dynamics, annual food consumption, movements, and dive behaviors of harbor seals, *Phoca vitulina richardsi*, in Oregon. Ph.D. Dissertation, Oregon State Univ., Corvallis. 177 pp.

[12]Boveng, P. 1988. Status of the Pacific harbor seal population on the U.S. west coast. Administrative Report LJ-88-06, Southwest Fisheries Center, La Jolla, California. 43 pp.

estimated during months that seals were not molting. Boveng[12] (1988) deduced that 70% of seals would be at sea during molt-season surveys (giving a correction factor of 1.4). Since then, three studies have estimated the proportion of seals on land during aerial surveys (Hanan[1] 1996, Huber et al. 2001, and Harvey and Goley[7] 2005). The estimated correction factor (1.53) in Huber et al. (2001) is probably not appropriate for California counts because that study was done during the pupping season and was north of this study area. For the California stock of harbor seals, a correction factor of 1.3, derived from data of radio tagged seals at Point Conception and San Miguel Island (in southern California) has been used for estimating total abundance of harbor seals in California from counts obtained at haulouts (Doyle Hanan personal communication in Carretta et al.[13] 2001). Concurrent with our 2004 census, a separate study was conducted to derive a correction factor from 120 seals radio-tagged in central and northern California (Harvey and Goley[7] 2005). The 1.65 correction factor estimated in that study, based on a proportion hauled out of 0.605 (CV=0.076), is more appropriate for estimating total population size from the seal counts presented in this paper because it overlapped temporally and spatially with our survey. Applying the 1.65 (95% CI 1.44 - 1.94) correction factor to the 2004 California harbor seal count of 26,333 (including southern California) yields an estimated population size of 43,449 (95% CI: 37,920-51,086) harbor seals in California in 2004. The lower 20th percentile of this estimate, or N_{min} as used in the U.S. Pacific Marine Mammal Stock Assessment reports, is 40,816 harbor seals, based on a lower 20th percentile correction factor of 1.55. Potential biases for the correction factor include 1) environmental effects such as weather or latitudinal cline, 2) biological effects such as age or sex, or 3) anthropogenic factors such as human disturbance, although efforts were made by Harvey and Goley[5] (2005) to minimize each of these effects.

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[13]Carretta, J. V., J. Barlow, K. A. Forney, M. M. Muto, and J. Baker. 2001. U.S. Pacific marine mammal stock assessments: 2001. NOAA Technical Memorandum: NOAA-TM-NMFS-SWFSC-307. 280 pp.

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