Marine Sanctuaries Conservation Series ONMS-11-02

Coastal Ocean Mammal and Bird Education and Research Surveys (BeachCOMBERS), 1997–2007: *Ten years of monitoring beached marine birds and mammals in the Monterey Bay National Marine Sanctuary*

U.S. Department of Commerce
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Coastal Ocean Mammal and Bird Education and Research Surveys (BeachCOMBERS), 1997–2007: Ten years of monitoring beached marine birds and mammals in the Monterey Bay National Marine Sanctuary

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Cover

Volunteer beach surveyors, Mike Orlando and Tish Conway-Cranos, examine a dead Common Murre (*Uria aalge*) suring a survey of Zmudownski State Beach, Monterey County, CA (Photo: Hannah Nevins).

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Abstract

Since May 1997, the volunteers of the Coastal Ocean Mammal and Bird Education and Research Surveys (BeachCOMBERS) have conducted systematic surveys in the Monterey Bay National Marine Sanctuary. The main goal of the program was to determine human and natural impacts to the Monterey Bay ecosystem. Marine birds and mammals are conspicuous top predators of the marine ecosystem, and the deposition of these dead organisms on beaches was used as an indicator of marine ecosystem health, including availability of prey resources, anthropogenic impacts, and natural die-offs. The specific objectives of the Beach COMBERS program were to: 1) obtain baseline information on rates of beach deposition of marine birds and mammals; 2) assess causes of seabird and marine mammal mortality; 3) assist resource management agencies in early detection of unusual rates of natural and anthropogenic mortality; 4) assess abundance of tar balls (oil patches) on beaches; 5) build a network of interacting citizens, scientists, and resource managers; and 6) disseminate information to the resource managers, public, and educational institutions. This long-term monitoring of beached marine birds and mammals enabled resource managers to determine trends in deposition to better identify significant events affecting wildlife including oil spills, fishery interactions, harmful algal blooms, and natural starvation events. During 1997 to 2007, we identified 28 unusual mortality events including 15 that were documented based on a significant increase in deposition greater than a baseline threshold level, and 13 other events where the main indicator was increased oiling (i.e., >2% of birds) or strandings of very rare species. Several documented events were of regional significance occurring along the west coast of North America (e.g., 1997-98 El Niño, 2003 fulmar die-off). The documentation of other events made important contributions to science (e.g., 1998 Domoic Acid Bloom, 2007 Mystery Foam or initiated resource protection actions (e.g., S/S *Luckenbach* oil spill, Gill-net bycatch). We recommend the continuance of this long-term program to increase stewardship and understanding of marine birds and mammals in the Monterey Bay National Marine Sanctuary.

Key Words

Beach survey, bycatch, El Niño, harmful algal bloom, marine mammal, monitoring, Monterey Bay National Marine Sanctuary, oil, seabird

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Dedication: We dedicate this report to the memory of Chuck Haugen, a dauntless volunteer who shared his great knowledge of the natural world in an unassuming manner.

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Introduction

The Monterey Bay National Marine Sanctuary (MBNMS) in central California (Fig. 1) was established in 1992 in part to protect the wildlife and beaches valued by local citizens from threats of oil pollution by proposed offshore drilling platforms. At a national level, the United States Congress determined the MBNMS had special significance relative to conservation, ecology, science education and aesthetics (MBNMS Management Plan 2008). The MBNMS has one of the most diverse and abundant assemblages of marine mammals in the world, including six species of pinnipeds, one species of mustelid, and 21 species of cetaceans (Harvey 1996). Monterey Bay is one of the most heavily utilized areas by seabirds worldwide, and hosts a rich seabird community with more than 94 species that occur regularly (Roberson 2001)[1]. Several threatened and endangered seabirds and marine mammal species inhabit Monterey Bay including the federally threatened and state-listed endangered Marbled Murrelet (*Brachyrhamphus marmoratus*), Brown Pelican (*Pelecanus occidentalis californicus*)[2] and the southern Sea Otter (*Enhydra lutris nereis*).

Marine birds and mammals are conspicuous top predators of the marine ecosystem, and the deposition of these dead organisms on beaches can be used as an indicator of marine ecosystem health, including availability of prey resources, anthropogenic impacts, and natural die-offs. Long-term monitoring of beached marine birds and mammals can enable resource managers to determine trends in deposition to better identify significant events detrimental to wildlife including oil spills, fishery interactions, harmful algal blooms, and disease outbreaks. The effects of mortality events can only be determined if adequate information on baseline deposition of beached organisms is available (Eguchi 2002). Well designed long-term beach monitoring programs provide consistent, reliable baseline data that can detect large-scale catastrophic events such as oil spills, but also can detect more subtle changes in environmental quality including increased frequency of harmful algal blooms and long-term chronic oiling, which may not be apparent with a short-term sampling design (Stenzel et al. 1988, Nur et al. 1997, Shumway et al. 2003, Jessup et al. 2009). Additionally, resource agencies can use baseline data from long-term monitoring programs to quantify natural resource damages and estimate restoration compensation following large-scale oil spills (Luckenbach Trustee Council 2006).

Various groups have conducted systematic Beached Bird Surveys (BBS) since the 1940-1950s in the Netherlands, Belgium, and Germany, and in the 1970-1980s throughout many other European countries, North America, and Russia to assess damages to marine bird populations from oil pollution and coastal fishery bycatch (reviewed by Camphuysen 1998). In California, BBS have been used to document mortalities incurred during catastrophic oil spills (Page et al. 1990), and continue to be useful to document chronic or low-level rates of oiling (Stenzel et al. 1988, Hampton et al. 2003, Roletto et al. 2003). Long-term beach survey programs enable researchers to detect regional trends in oil pollution and evaluate whether changes in laws to prevent marine pollution have been effective (Camphuysen 1998, Weise and Ryan 2003).

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[1] For a full description of the MBNMS habitats and species diversity, the Sanctuary Integrated Monitoring Network website is available to the public (http://www.sanctuarysimon.org).
[2] On 5 Feb. 2009, the Brown Pelican was removed from the state endangered species list and from the federal endangered species list on December 17, 2009.

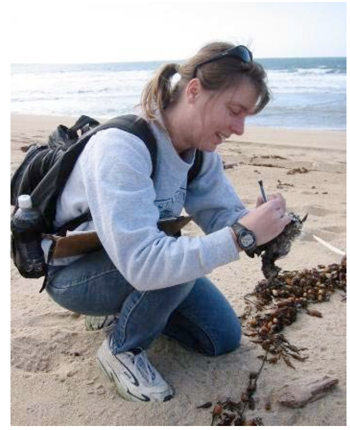
Documenting deposition rates of mammals and seabirds is essential for long-term monitoring of natural and human caused mortality to these important marine resources (Benson et al. 1999). Documenting species-specific rates of deposition enables resource managers to identify which seabird populations are most often affected by particular threats (e.g., diving birds and gill net bycatch, Speich and Wahl 1986), and aid in conservation and management plans for these species (Camphuysen 1998).

The Coastal Ocean Mammal and Bird Education and Research Surveys (BeachCOMBERS) program was established in 1997 to monitor natural and human-related mortality of marine birds, mammals, and turtles in the MBNMS (Benson et al. 1998, Benson et al. 1999, Benson 2000). Whereas previous studies in the Monterey Bay region were directed toward assessing human-related impacts to the marine environment, BeachCOMBERS differs from these and other west coast beach surveys by using standardized effort, frequency, and search areas that allows comparison of relative changes in the deposition rate of marine birds and marine mammals and provides a monthly index of ecosystem health in Sanctuary. Standardization of sampling effort was an important feature of the BeachCOMBERS study design and has allowed for effective comparisons of inter-annual trends.

BeachCOMBERS builds upon past beach surveys conducted in California: Dr. G. Victor Morejohn and graduate students at Moss Landing Marine Laboratories studied several beaches in inner Monterey Bay with a variety of methods during 1968 to 1972; Stenzel et al. (1988) surveyed southern, central, and northern CA beaches from 1974 to 1982; Julian and Beeson (1998) surveyed southern CA beaches during 1990 to 1995; Mason (1997) surveyed Monterey Bay beaches from 1992 to 1994; and the California Department of Fish and Game surveyed beaches from 1980 to 1998 (Wild 1990). Beach survey programs have also been developed elsewhere along the west coast of North America including the Gulf of the Farallones (1993 to present; "Beach Watch"; Roletto and Grella, 1995), Oregon (Bob Loeffel, Oregon Dept. of Fish and Wildlife, unpublished data), Washington, Alaska (Julia Parrish, Coastal Observation and Seabird Survey Team [COASST], University of Washington), and British Columbia (Alan Burger [1986 —1997], Bird Studies Canada [2002—present], Beached Bird Survey [O'Hara et al. 2009]). Although the frequency of sampling, methods of marking, and surveyor effort, varies among these studies, they provide important background for comparisons with the present study conducted by BeachCOMBERS. Justification for BBS also varies. Whereas Stenzel et al. (1998) and Beach Watch emphasized oil spill documentation as the main justification for monitoring, and Wild (1990) and Julian and Beeson (1998) focused on documenting bycatch, the main emphasis of BeachCOMBERS is ecosystem monitoring.

The specific objectives of the Beach COMBERS program were to: 1) obtain baseline information on rates of beach deposition of marine birds and mammals; 2) assess causes of seabird and marine mammal mortality; 3) assist resource management agencies in early detection of unusual rates of natural and anthropogenic mortality; 4) assess abundance of tar balls (oil patches) on beaches; 5) build a network of interacting citizens, scientists, and resource managers; and 6) disseminate information to resources agencies, the public, and educational institutions.

Methods



Volunteer Karin Forney inspects a beached bird, Marina State Beach

Sampling Design

The BeachCOMBERS protocol was developed from a pilot study in 1996 and a review of previous beach surveys to determine the proper number, distribution, and frequency of surveys and effort necessary to detect changes in beachcast organisms (Simons 1985, Jameson 1986, Stenzel et al. 1988, Bodkin and Jameson 1991, Roletto and Grella 1995, Benson et al. 1999, Beach Watch 2008). The BeachCOMBERS monitoring plan covers sandy beaches within the Monterey Bay National Marine Sanctuary (Figure 1). Most of the shoreline covered in the project is accessible by road or a trail less than 2 km from vehicular access. The basic method is similar to a strip transect, where all beachcast birds and mammals within the strip (i.e., the width of the beach) are counted and it is assumed that all new carcasses in the survey area are observed and recorded (Appendix A: Protocol). The survey effort was centered on the wrack line of the previous high tide, although the entire beach is surveyed with the help of binoculars to scan upper beach wrack and by walking in a zigzag fashion to ensure that most beached birds and mammals were located. Based on Ford (2006) and other studies, we know the survey is an *estimate of deposition* rather than a total census because not all animals will be visible to the observers (i.e. buried, missed) and the number of animals found will increase with effort, experience, beach type, and frequency of surveys (Byrd et al. 2009). Because of the need to obtain repeatable and comparable data, we standardized effort to reduce variation associated with this estimate. To standardize search effort among surveys and beaches, surveys were always conducted by a team of two trained volunteers. If others accompanied the team on a survey, they were not allowed to actively look for beachcast animals. Also, dogs were not allowed on surveys as this would bias the number of animals found. Usually, the volunteer teams used two cars: one parked at one end of the beach section and one driven to the other end of the beach. The team then surveyed the beach as they walked the distance back to the first car. Surveys were conducted during an ebb tide, and teams began surveys approximately 1 to 1.5 hours before low tide.

Surveys are conducted during the first week of each month, every month of the year. Ideally the time period between samples would be non-random (e.g., a survey conducted every 30 days); however, the logistics of organizing numerous volunteers is too great to expect this. Thus, we allow the survey team a seven-day window at the start of each month to complete a survey. Therefore, the time between surveys is not the same for each sampling period. For example, if a team conducts a survey on the last day of the seven-day window in one month, and then conducts the next survey on the first day of the following month, the time between surveys is 23 days. Similarly, the time between surveys could be as great as 38 days. The variability in time between surveys may allow a greater number of beached organisms to accumulate on the beach; however, we expect the impact on the number of beachcast organisms counted is small. Also because the timing of each beach survey is somewhat random within the 7-day window at the beginning of the month, through time the biases associated with various times are eliminated.

Data was recorded on two data forms using standardized four-letter species codes (Appendix B: Datasheets). A cover sheet contains sections to record the date of the survey, the names of the volunteers conducting the survey, the beach name and segment number, the northern and southern boundaries, the duration of survey (begin and end times), the weather conditions, and presence or absence of tar balls found, number collected, and size range. Also, a general comments field is provided on the cover sheet for any other unusual flotsam or jetsam (e.g., jellyfish, marine debris) that was observed. The second form is the main data sheet, where all of the data for beachcast organisms are recorded. For each carcass encountered, the following data are recorded: species code, decomposition state, age and sex (when possible), number of previous marks (toe clips or hemp twine), scavenging, cause of death (when evident), presence of oil, whether or not a photograph was obtained, and presence of identification tags or bands. A general notes section is used to document any tags present on the carcass, length measurements, photograph roll and frame numbers, or any comments that would aid in post-identification of an unidentified or unusual sighting.

After the carcass is identified, it is marked by either clipping a toe for seabirds, or attaching a piece of hemp twine around the rear flipper or fluke of marine mammals. Each time a marked bird is encountered on subsequent surveys, another toe is removed and recorded, or another piece of twine is attached. By noting the number of toes clipped or number of pieces of twine on the animal, we can track the duration that a carcass remains on the beach, and analyze deposition data for only "new" (first-observed) carcasses. Whereas other studies have estimated persistence from similar data (Byrd et al. 2009), the intent of this study was to focus on patterns in new deposition. This sequential marking method also helps us avoid double-counting carcasses when determining the number of newly beached individuals.

Volunteer Training

Providing proper training and data quality assessments are necessary when using volunteers to collect scientific information. It is equally important to maintain volunteer enthusiasm and participation to ensure consistency in the data and to build the expertise and conservation values of the group. Therefore, we developed a training program that consists of in-class lectures and discussions, laboratory-based learning, and field-based experiences (Appendix A: Protocol). During training, we discussed the philosophy of BeachCOMBERS, including the objectives and rationale for the sampling design. By explaining the sampling design, the volunteers learn the value of the data they collect, and the need for accuracy and consistency.

To ensure proper identification of beachcast animals, volunteers received 20 hours of instruction in the identification of marine birds, mammals and turtles using slides, handouts, study skins, skeletal preparations, guide books, and in-field identification. Training was led by Dr. Jim Harvey, Scott Benson, Hannah Nevins, and graduate students from Moss Landing Marine Laboratories (MLML), along with MBNMS personnel. Lecturers emphasized the use of diagnostic features for beachcast organisms (e.g., feet and bills for birds, skulls and body morphology for mammals), and provided each volunteer with resources, including a bird field guide (Scott 1998), and a beached bird, mammal, and turtle identification guide (Ainley et al. 1994). Thus, volunteers were introduced to the local fauna of central California, and provided with a variety of methods useful for identifying each specimen. In the laboratory they used study skins, live mounts, and skeletal preps at MLML to provide hands-on training in identification of various species. Volunteers were provided methods for identifying scavenged carcasses, determining sex and age when possible, and taking measurements to identify species and age class (e.g., plumage, wing chord). Volunteers were trained to collect basic stranding data for marine mammals (i.e., NOAA "level A") which included species identification, location, age, sex, and standard length. These data were forwarded to the NOAA-Fisheries Marine Mammal Health and Stranding Network and U.S. Fish and Wildlife Service. The final instruction was conducted in the field on selected beaches, where volunteers were tested for accuracy of identification skills in a simulated survey.

At the end of the training session, volunteers were provided a sampling kit which included a measuring tape, tide book, identification cards, clippers for removing toes of beached birds, string for marking marine mammals, reference guides, datasheets, collection permits and materials for oil samples and fresh animals, and contact numbers for various agencies including The Marine Mammal Center (TMMC), University of California Santa Cruz (UCSC), MLML, The Monterey Bay Aquarium (MBA), and the California Department of Fish and Game (CDFG). Protective gloves, bags, and labeling markers were provided to collect additional samples (e.g., toe clips, blubber biopsy) in the event of an unusual mortality event or for specific requests from collaborators. In 2003, in an effort to provide better location information of marine mammal strandings to the MLML stranding network, volunteer teams that survey beaches in Monterey County were provided with a portable global position system (GPS; Garmin Geko™ 201) to record accurate latitude and longitude for each marine mammal encountered.

In addition to instruction on species identification, marking animals, and filling out datasheets, volunteers were trained to recognize a variety of possible anthropogenic mortality factors, including oil on carcasses, tar balls on beaches, and evidence of fishery interactions (see Causes of Mortality). Before beginning surveys, volunteers signed NOAA Volunteer Service Agreements, discussed safety concerns, including the importance of assessing ocean swell height and wind patterns, avoiding toxic substances, disease transmission, and using protective gear (e.g., gloves).

Trends in Deposition

To obtain baseline information on rates of deposition of marine birds and mammals, trained volunteer teams conducted monthly surveys and identified and quantified all beached organisms on 24 pre-defined beach segments within the Monterey Bay National Marine Sanctuary (Figure 1). For deposition trend analysis, only the original 11 Monterey Bay "Core" beaches (Beaches 1-11, Fig. 1) were included due to greater duration of survey record (i.e., since 1997-98).

Deposition rate was calculated as the number of newly deposited animals per linear km surveyed. By standardizing data to effort (number of km walked), we compared deposition rates among months and years. For example, if 10 "new" birds were found on a 2 km segment, the resulting deposition would be 5 birds km^{-1} mo^{-1}. For monthly comparisons, beach segments were considered replicates. Because all beachcast organisms were marked monthly, newly deposited animals were defined as those without any markings from previous surveys (e.g., birds with no toes clipped or mammals with no twine were considered new). Two beaches were walked bi-monthly (Beach 5 and 8; Fig. 1), the data were adjusted to account for this increased sampling frequency (e.g., birds with one toe clip from of the mid-month survey were considered "new" for calculating new deposition in following first of the month sample).

Causes of Mortality

To determine the incidence of human-caused seabird and marine mammal mortality, volunteers examined each intact (not heavily scavenged) carcass for the presence of oil or entanglement in fishing gear. If observers found oiled birds, they determined the extent of oiling as the proportion of the body oiled: (1) < 2%; (2) 2–33%; (3) 34–66%; (4) 67–100% of body. Observers recorded where oil occurred on the body: dorsal only, ventral only, entire body, head only, feet only, wings only, or other. Volunteers collected and/or photo-documented oiled specimens opportunistically. Personnel from California Department of Fish and Game's Oil Spill Prevention and Response group (CDFG-OSPR) provided oil sampling protocols and instruction on how to properly collect samples. All oiled feather samples, tar balls, and oiled birds were deposited at CDFG-OSPR Marine Wildlife Veterinary Care and Research Center (MWVCRC), Santa Cruz and transferred to CDFG's Petroleum Chemistry Lab (PCL). A chain of custody and an intake log was maintained at MWVCRC. Results of PCL fingerprinting analyses were archived at MWVCRC and are not reported here.

We assumed the presence of fishing line, hooks, or net marks were indicative of a negative fishing interaction. When monofilament line, hooks, or other evidence of fishery interactions were observed, volunteers documented this on the datasheet, took photographs, and collected the animals for further examination when possible. Because other causes of mortality are more difficult to determine in the field, fresh seabird specimens were collected for post-mortem examination by collaborators including the Central Coast Marine Bird Health Study (MWVCRC). All fresh marine mammals were reported to collaborators to assist with post-mortem studies.

Documenting oiling and presence of tar balls on beaches

Volunteers recorded oiling on beaches by quantifying the number and diameter of tar balls found during each monthly survey. In general, tar balls or tar patties were discrete, thick oil globules and often had a weathered surface. Because of the variability in the observers' assessments of total number of tar balls encountered (e.g., "4,562" compared with "thousands"), we used the frequency of surveys with tar balls present and categories of numbers (i.e., 1-100, 100-1000, 1000-10000) as metrics for comparisons rather than an encounter rate such as the number of tar balls per km (Roletto et al. 2003). Fresh or newly deposited tar balls were collected following CDFG's recommended procedures for sample collection, storage, and chain of custody. Oil samples were then submitted to CDFG-PCL to determine the source of the oil (e.g., natural seeps or vessel traffic) based on chemical constituents (e.g., fingerprinting). In the case of a large deposition of oil, volunteers were instructed to immediately notify CDFG, the Office of Emergency Services and/or California State Parks dispatch. Oiling protocols were adapted from the Beach Watch program (Roletto et al. 2003).

Unusual Mortality Events

To assist resource management agencies in early detection of mortality events, we used BeachCOMBERS data from 1997-2007 to establish an 11-year baseline for comparison with current marine bird and mammal stranding records. Seven criteria, adapted from the NOAA- Fisheries "Criteria for Determining a Marine Mammal Unusual Mortality Event" by The Working Group on Marine Mammal Unusual Mortality Events (Federal Register 2006), were used to determine all mortality events. In this retrospective analysis, we determined particularly "Unusual Mortality Events" (UME) as those which exceeded a deposition Threshold Level (criteria 1, see below). We defined "Other Mortality Events" as those that fit one or more criteria 2-7. The criteria were:

1. A marked increase in the magnitude of strandings when compared with prior records;
2. A temporal or spatial change in mortality: within in a localized area, spreading geographically with time, or occurring throughout a species' range;
3. The species, age, or sex composition of the affected animals is different than that of animals that are normally affected;
4. Affected animals exhibit similar or unusual pathologic findings, clinical signs, or general body condition (e.g., fat layer);
5. Mortality event is accompanied by unusual behavior patterns observed among living individuals, such as abnormal patterns of swimming or feeding;
6. Potentially significant mortality is observed in species, stocks or populations that are particularly vulnerable (e.g., listed as depleted, threatened, endangered, or declining); and
7. Mortality is observed concurrent with, or as part of, an unexplained continual decline of a population, stock, or species.

Threshold Level

Specifically, UMEs were those that could be quantified by a significant increase in deposition of marine birds or mammals above a "threshold level". For example, using Criteria 1, we developed species-specific monthly mean deposition rates and calculated a threshold level (TL), defined as the long-term monthly mean deposition (new birds km^{-1}) plus two times the standard deviation. Thereafter, we defined an unusual event as one in which monthly deposition exceeded the TL. Assuming a normal distribution of monthly deposition, the TL included about 98% of values; therefore, unusual events were 2% of the extreme deposition values. We evaluated all mortality events that occurred between 1997 and 2007 based on the TL baseline established by the entire data set. "Other" events were classified based on criteria 2-7. For rare species, where too few data were available to determine trends with TL (e.g., storm-petrels), we considered that the event warranted further investigation when total number of animals reported was greater than twice that reported during any of the other years. We considered an oiling event to be significant if more than 2% of the birds encountered during monthly beach surveys were oiled based on long-term oiling rate. This oiling rate is slightly lower than that reported for the Sanctuary waters to the north (Gulf of Farallones, 3.2%, Roletto et al. 2003). Additionally, Criteria 2, 3, and 6 also were quantified using BeachCOMBERS and other BBS data. Criteria 4 and 5 were quantified using data collected by collaborators including the Monterey SPCA and Central Coast Marine Bird Health Study. Criterion 7 was quantified using background information on the species being impacted by the mortality event (e.g., breeding success, population counts), when this information was available.

> Standard Deposition Index (SDI) is a relative index of the proportion of deposition, which exceeds the threshold level (TL). For example the grand average for Common Murres in August was 1.8 ± 2.2 SD birds km^{-1} (n = 11 yr), so the TL = 1.8 + (2*2.2) = 6.2 birds km^{-1}. The highest monthly deposition measured was 8.1 birds km^{-1} in August 1997, compare this to the TL (i.e., 6.2 – 8.1 = 1.9) and we calculated it was 30% greater than baseline TL (i.e., 1.9/ 6.2 birds km^{-1}].

Standard Deposition Index

To further evaluate the relative magnitude of impacts among UMEs, we created a Standard Deposition Index (SDI) incorporating a variety of the seven criteria, including the number of species involved, the duration of the event, whether rare, threatened, or endangered species were involved, and anomalous demographics (abnormal age classes or sexes affected compared to normal for that time of year). The index allowed us to normalize our assessment of the importance of each UME relative to each other and track trends in the magnitude and frequency of UMEs.

The SDI was calculated as: $SDI = \sum(\% - TL) * \sum Dur_i * S_v * YOY_i$

where, for each species (i) exhibiting increased mortality relative to the monthly TL in each event,

[S_v] = Species vulnerability (1 for each species non-threatened species, 2 for classified as rare, threatened, or endangered);

[% - TL] = Percentage of deposition greater than threshold level;

[Dur_i] = duration in months where the deposition was >TL for each event;

[YOY_i]= age factor, proportion discounted by the young-of-year (i.e., proportion of adults) – for a mix of ages – assumed stable age structure (1.0), for ≥ 80% YOY (0.8), and for were skewed toward adults ≥ 80% (1.2).

TL = Threshold level, long-term mean (97-07) plus two standard deviations

The standard deposition index for an entire event (eSDI) was calculated as the sum of all individual species' SDI for that event. For other mortality events in which monthly deposition did not exceed the TL for any species, we used secondary criteria (2-7) to determine unusual events, and relied on reports from wildlife rehabilitators, general public, and NOAA marine mammal stranding network participants.

Developing a network of collaborators and information dissemination

In order to develop a working network of volunteers, scientists, pathologists, and resource managers within the MBNMS region, BeachCOMBERS developed an email listserve to keep all collaborators apprised of current events in the Sanctuary, and to disseminate important information. The BeachCOMBERS coordinator sent out monthly emails to volunteers with information on current species composition in the MBNMS, types of animals to expect on beach surveys, tide and weather predictions for the survey period, requests for samples and oil spill alerts.

Volunteers contributed reports of dead and live stranded, and tagged marine mammals to National Marine Fisheries Service - Marine Mammal Stranding Network participants in Monterey County (Moss Landing Marine Laboratories, California State Universities), Santa Cruz County (Long Marine Laboratories, UC Santa Cruz), and The Marine Mammal Center (Sausalito/Moss Landing). State Parks employees, the Monterey Dunes Colony, the Naval Post-Graduate School, the Monterey Bay Aquarium, and others gave assistance in reporting and collecting stranded mammals. This practice created a cooperative environment by reducing the amount of time volunteers from the various stranding networks needed to dedicate to relocating and confirming identification of animals already found by BeachCOMBERS.

Because of the extraordinary potential for sample collection created within the BeachCOMBERS survey framework, we often received requests for samples of beachcast seabirds and marine mammals. In many cases, the requested samples were easy to collect and volunteers were keen to participate in scientific studies. In 2001, we began a project to determine bio-geographic affinities of several migratory species in the MBNMS using genetic analyses. BeachCOMBERS collected toe clips for genetic analyses by Cheryl Baduini (Keck Science Center, Claremont Colleges, CA) to determine the sex ratio and colony affinities of Sooty and Short-Tailed Shearwaters. In 2002, BeachCOMBERS collected toe clips of Northern Fulmars for genetic studies by Scott Hatch (USGS-BRD, Alaska Science Center, Anchorage, AK). In 2005-2008, BeachCOMBERS collected toe clips for a genetic population study of grebes by graduate student Diana Humple (Sonoma State University, CA). Finally, BeachCOMBERS worked closely with the Central Coast Marine Bird Health Study at MWVCRC to collect intact seabird carcasses for necropsy to determine causes of mortality.

Results and Discussion

Survey Effort

The core beaches, including segments from New Brighton to Carmel (Beaches 1-10, Fig. 1), have been monitored monthly since May 1997 (Table 1). The survey area expanded from the original ten beaches to include Waddell and Scott's Creek (Beach 11) in September 1998, six beaches in the Cambria/San Simeon area (Beaches 12-17) in May 2001, Sand Dollar beach in Big Sur (Beach 23) in July 2003, four city beaches in Santa Cruz County (Beach 22 and 25, July 2003; Beach 27 and 28, June 2006), Del Monte Beach in Monterey County (Beach 24, June 2003), and one beach in Morro Bay (Beach 26, November 2003). Additionally, bi-monthly sampling began in October 1998 on beaches 5 and 8 to provide better temporal resolution of carcass deposition on these beaches with the greatest deposition rates. Beaches 12, 13, and 23 were surveyed bi-monthly to accommodate increased volunteers. Beach 11 was split into north (Waddell Creek, 11N) and south sections (Scotts Creek, 11S) to accommodate more volunteers in July 2003, although the combined survey area remained the same. Fort Ord (Beach 9) was discontinued for 11 months due to logistical difficulties and an increased risk of volunteer injury because the adjacent military base was in the process of being converted to state lands. Although new beach surveys were added to accommodate increased numbers of volunteers and to increase the geographic scope of the program, when the number of volunteers waned, the core beaches continued to be the priority for each monthly survey effort. Thus, the duration that some beaches were surveyed outside of the core area was only a few months (**Error! Reference source not found.**).

Volunteer Program

Volunteers were recruited from the local community via newspaper advertisements and email and paper flyers distributed to universities, state agencies, and other volunteer groups (e.g., Año Nuevo docent program). BeachCOMBERS volunteers tended to be well educated and a number of participants had advanced degrees or research experience. Volunteers included retirees from the local area, undergraduate or graduate students from local colleges and universities, personnel from state and federal agencies, and other interested citizens. Recent questionnaires filled out by prospective volunteers (n = 98) indicated that most had access to personal computers (91%) and cameras (94%) and were willing to contribute the use of these resources to the program. We recruited volunteers with experience in other programs (e.g., Long Marine Lab docents, Pt. Lobos docents, and Pt. Sur Lighthouse docents). When asked to rank their carcass identification skills before training on a scale of 0 to 10, volunteers averaged a self-score of 4.5 on birds and 6.1 on marine mammals (n = 98), and 39% scored themselves ≤ 3 for birds whereas only 19% scored ≤ 3 for mammals, indicating a general working knowledge of marine mammals in the region. Common reasons for wanting to participate in the program were, "love of the ocean", "connectedness with the ocean" and an interest in wanting to contribute to understanding sanctuary resources.

The number of volunteers active and trained in the BeachCOMBERS program increased steadily each year since the program started in 1997 (Figure 2). A total of 205 volunteers have been recruited to BeachCOMBERS since it began, including those interested in non-beach survey support and monitoring the email listserver. At least 104 individuals have accompanied a trained BeachCOMBERS volunteer on a single or a small number of walks, thus furthering local community exposure to the program. We have trained a total of 180 volunteers during the past 10 years to survey beaches, and currently 100 active BeachCOMBERS volunteers conduct 27 surveys on 24 beaches monthly (including bi-monthly surveys). Compared with other MBNMS programs, including TeamOCEAN (75 volunteers), BAYNET (approximately 35 volunteers), and the Citizen Watershed Monitoring Network (approximately 200 volunteers), BeachCOMBERS contributes approximately 40% of the volunteer effort to the Monterey Bay National Marine Sanctuary.

Retention of volunteers in the program was high (mean 65% year to year), and attributed to two unique features of the program: volunteers gained a sense of ownership or stewardship for a particular beach, and volunteers felt they contributed valuable data which contributed to protection of the sanctuary. Periodic efforts were made by program staff to reinforce the importance of data collection by providing examples of how the data were used. Past conservation successes, such as documenting leaking oil connected to the *S/S Luckenbach* (see Documenting oiling and presence of tar balls on beaches) served to instill a continued sense of the program's and individuals' achievements. A total of 80 volunteers have retired during the last 10 years, resulting in 7% loss per year. Reasons for leaving the program were attributed to external life changes (e.g., moving out of the area, getting a new job, leaving the country, having babies, getting old) rather than problems with the program itself.

Often the limiting factor to the number of active volunteers in the program was the number of beaches available in the local area to be surveyed. A team of three or four volunteers per beach was arranged so that monthly a team of two surveyors walk the beach and the individuals rotate among months. Alternately, a team of two walks the beach every month and when a substitute is needed, an email was sent to the COMBERS listserve or volunteer coordinator to find a substitute for that survey.

Volunteer Effort

During May 1997 to December 2007, volunteers conducted a total of 2,356 monthly surveys, walking a total of 17,177 kilometers (**Error! Reference source not found.**). Up to 32 surveys covering up to 25 beaches were conducted a month, including beaches walked weekly or bi-monthly. An average monthly beach survey is approximately 2.9 kilometers in length, and is 1.8 ± 0.8 hrs in duration, which is equivalent to 9,942 hours of survey time during the past 11 years (Table 1). When beach survey effort was combined with the time required to get to and from the beach and time to deliver data and samples to MLML, volunteers contributed an additional mean 1.4 ± 0.5 hours per month, and the total volunteer time increased to approximately 3.2 ± 1.1 hours per month, or 17,117 volunteer hours during the past 11 years (Figure 3)[3]. Additionally, approximately 5% of BeachCOMBERS volunteers spent 10-30 minutes per month entering their data online. A small number of BeachCOMBERS have volunteered additional time to help collaborators including the Central Coast Marine Bird Health Study, CDFG-OSPR, International Bird Rescue and the MLML Stranding Network during unusual mortality events, oil spills, or

[3] This is equal to a total contribution of $390,096 ($35,463 per year) to BeachCOMBERS program using the 2008 dollar value of volunteer time in CA of $22.79/ hour.

other times. Outside of survey and travel time, volunteers often transported live birds to rehabilitation centers, called in to stranding network participants, and made extra trips to transport samples — these activities were not easily captured in the volunteer time data.

Enrichments & Appreciation

We offered volunteers enrichment opportunities, such as participation in Dr. Harvey's graduate-level Marine Vertebrate course at Moss Landing Marine Laboratories and refresher classes to improve species identification skills, learn about the program's accomplishments and get acquainted with other volunteers. We showed appreciation for the work of the volunteers by providing opportunities to observe seabirds aboard day cruises in Monterey Bay, during shorebird surveys, and other field activities. Once a year, the Sanctuary held a volunteer appreciation event in conjunction with the Sanctuary Currents Symposium.

Long-term Trends in Deposition

Seabird Deposition

Species composition of beached seabirds in all years was dominated by six orders of birds: Anseriformes (sea ducks), Gaviiformes (loons), Podipediformes (grebes), Procellariiformes (tubenoses), Pelecaniformes (pelicans and cormorants), and Charadriiformes (gulls, alcids, others; Figure 5a). Of these, the first three groups migrate from inland terrestrial breeding habitats associated with lakes and ponds, and the latter three are more closely associated with marine habitats year round. In general, seasonal deposition patterns reflected the migratory cycles of these species (Henkel 2004, Henkel and Harvey 2008), and indicated a seasonal trend of increased deposition in summer and decreased deposition in winter (Figure 4). For the sake of clarity and space, here we describe the seasonal and inter-annual trends of the ten most abundant bird species found during beach surveys.

Anseriformes - Scoters

Surf scoters (*Melanitta perspicillata*) were the most often encountered sea ducks found on surveys during migratory pulses in January to July, and November to December (Figure 6a). During the 1997–98 El Niño, Surf Scoters represented a greater proportion of the recorded species and deposition relative to past years (20% compared with 3% average) and was slightly later (April to June) than during other years (Figure 7a). White-winged (*M. fusca*) and black scoters (*M. nigra*) were rarely documented. During the 1960-70s, G.V. Morejohn reported that *M. fusca* was an abundant species on beach surveys at Moss Landing State Beach (Monterey County) (MLML, unpublished data; Nevins and Harvey 2002). There is evidence that all species of North American sea ducks have undergone significant population decreases (Gouldie et al. 1994).

Gaviiformes – Loons

Pacific Loon (*Gavia pacifica*) occurred on beach surveys during spring (April to July) and fall migration (December to January), representing ~3 % of beached birds (Figure 6b). This seasonal deposition pattern is consistent with relatively low year-round abundance except during migration as described by nearshore shipboard surveys (Henkel 2004). Most Pacific Loons were likely immature (41%) based on subsequent necropsy (n = 17). Of historic records (1929-2002), only one band return was reported for this species; it was both banded and recovered in the same area in California (Mary Gustafson, USGS-Bird Banding Lab). During the past eight years, only the El Niño year of 1998 produced significant anomaly in deposition for this species (Fig. 7b). Given the low deposition of loons, it is interesting that we have documented Domoic Acid in the few cases examined by MWVCRC, suggesting this biotoxin may often affect this nearshore group (see Harmful algal blooms).

Podicipediformes – Grebes

Western (*Aechmophorus occidentalis*) and Clark's Grebes (*A. clarkii*) were treated together as they were only recently considered separate species. During beach surveys they were identified to species when the head was intact; otherwise they were recorded as a species-complex (i.e., CWGR). Grebes are medium-sized nearshore piscivorous birds, and represented a consistent proportion (~10%) of beached birds each year (Fig. 5a), but particularly during spring (Figure 6c).

In 2000, a die-off of grebes began in March, peaked in April to May, and extended into June and July (Table , Figure 7c). Birds killed during this event were young-of-the-year and were found in a relatively localized region, particularly Zmudowski and Moss Landing (Beach 5 and 6) and to lesser extent Salinas River and Marina (Beach 7 and 8) in inner Monterey Bay. The pattern of deposition during the die-off coincided with an increase in the abundance of live grebes in central Monterey Bay detected by nearshore shipboard surveys (Henkel 2004). Because little is known about the colonies of origin for wintering grebes in California, we have no basic information related to this deposition event that places it into context with the breeding population; however, a recent collaboration (2006 to present) on a genetics study with Diana Humple (Sonoma State University) may elucidate the origin of these birds.

Procellariiformes - Tubenoses

Sooty Shearwater (*Puffinus griseus*) represented ca. 9% of birds recorded during beach surveys during May to October (Figure 5a). Short-tailed Shearwater (*P. tenuirostris*) occurred primarily during the winter and in far fewer incidence than Sooty Shearwaters (<0.05 km^{-1}). It is most likely that most "unidentified shearwater species" (i.e., SHSP) were Sooty rather than the similar, but more rare Short-tailed Shearwater. The seasonal increase in deposition of Sooty Shearwaters occurred during the summer months when this species is most abundant in the Monterey Bay region (Figure 6d). In inter-annual comparisons, the most significant increase in deposition occurred during the El Niño years of 1997-98 and 2000 (Figure 7d). During 2001–2004, 15% of 55 entangled seabirds were Sooty Shearwaters.

Northern Fulmar (*Fulmarus glacialis*) was the dominant winter tubenose species represented on beach surveys, migrating from breeding colonies in Alaska and Canada (Hatch and Nettleship 1989). Fulmars occurred on beach surveys during November to January, and March to April (Figure 6e). During November 2003 to April 2004, we documented an unusual mortality event or "die-off" of fulmars (Table). This deposition was significantly greater than had been recorded previously (maximum 12 birds km^{-1} mo^{-1}, Figure 7e), and was accompanied by other reports from beach surveys from Baja California, Mexico to British Columbia (COASST, Beach Watch). The deposition event was unusual in magnitude, geographic extent, and coincided with abnormal occurrence of high densities of live and moribund fulmars at sea in Monterey Bay (14 ± 4 bird km^2, J. Harvey, unpublished data).

Because no band data were available for fulmars, we inferred the colony of origin based upon the ratio of color morphs and bill measurements of birds collected during the 2003-2004 die-off. In November and December 93% were dark morph, and 7% light (n = 415), which indicated an origin of Gulf of Alaska or Western Aleutian Is. (Hatch and Nettleship 1998). Morphometrics were not different from Semidi Is., and smaller than Chagulak Is. in the Aleutians. These birds were emaciated, had empty stomachs, and predominantly were young-of-the-year (96%) or immature sub-adults (4%, n = 186). We concluded that a large scale (i.e., ocean basin) environmental perturbation was responsible for the magnitude and extent of this morality (Nevins and Harvey 2005). It was likely food limitation occurring in the Gulf of Alaska as fledgling fulmars migrated south. The fact that many Red Phalaropes (*Phalaropus fulicaria*) also were found freshly dead during the 2003-04 die-off further support this hypothesis; phalaropes are another surface-feeder and arctic-breeding migrant that would be foraging in the same region post-breeding as fulmars.

Pelecaniformes – Pelicans, Cormorants, and Allies

Brown Pelican (*Pelecanus occidentalis*) were a common fall and winter resident in the sanctuary, and historically nested in lesser numbers at Bird Rock, Point Lobos, Monterey County (Baldridge 1973). This species was most often encountered on beach surveys during June to August, and December corresponding to the post-breeding dispersal of adults and young-of-the-year from colonies in southern California (Figure 6f). Because the occurrence of pelicans on beach surveys is generally minimal (i.e., < 0.5 birds km^{-1}) and greatly variable from year to year, inference about trends is limited. In 2001, a significant deposition was detected by beach surveys, when large numbers of pelicans were killed by entanglement in recreational fisheries (Figure 7f). This deposition was greater than that associated with the 1998 El Niño. Pelicans aggregated near two recreational fishing piers in Santa Cruz County, Seacliff Beach and Santa Cruz Municipal Wharf, where the overlap between forage fish abundance, pelican foraging, and fishing activities resulted in an increased level of interactions. California Department of Fish and Game increased warden patrols to help disentangle birds and advised fishers, but ultimately the city responded to wildlife concerns by closing these piers to recreational fishing. Rehabilitation centers treated more than 170 pelicans during this event (International Bird Rescue Center, unpublished data).

Brandt's Cormorant (*Phalacrocorax penicillatus*) is a resident species with colony areas loosely scattered on suitable habitat throughout the sanctuary (Sowls et al. 1980) and at the large colony at the Farallon Islands (Boekelheide et al. 1990a). Brandt's represented ~5% of beached birds each year (Figure 5a). They were found on surveys throughout the year, but at relatively low incidence (< 0.5 birds km^{-1}; Figure 6g). The months with the greatest deposition were April and May, and September to January. During the fall post-breeding season, fledgling young were expected to disperse from the largest colony at the Farallon Islands southward into the study area. This seasonal trend tracks the occurrence patterns of nearshore shipboard surveys (Henkel 2004), with the exception of the spring mortality. Since 1997, 26 banded birds have been recorded and all but one rehabilitated bird (recovered 3 years after release) were tagged as chicks on the Southeast Farallon Island (USGS Bird Banding Lab [BBL], unpublished data).

Inter-annual data indicate an increasing trend in annual deposition for this species (Figure 7g). Surprisingly, Brandt's Cormorants did not show an increase in deposition during the 1997-98 El Niño year, perhaps because reproductive activity was reduced and few young were produced (Boekelheide et al. 1990a). It is interesting that despite the 2005 Upwelling failure which created a severe food shortage and resulted in greater spring deposition of this species, by the end of the summer when ocean conditions improved Brandt's were successfully nesting (W. Sydeman pers. comm.).

Charadriiformes – Auks, Gulls and Shorebirds

Common murre (*Uria aalge*) was one of the most abundant species encountered during this study (25% of beached birds) as found in previous studies in central California (Stenzel et al. 1988, Mason 1997). Murres occurred most often during surveys May to October corresponding to the post-breeding dispersal (1.0 birds km^{-1}, Figure 6h). Adult males and their dependent chicks comprise a majority of the birds in Monterey Bay during July to October (Nevins 2004). Of the 7 band returns indicating colony of origin, three were from nearby Farallon Islands, three were rehabilitated birds from CA (International Bird Rescue), and one was banded as a chick on Triangle Island, British Columbia.

The inter-annual trend in the deposition of Common Murres has been significantly affected by human-related activities including oil spills, gill net bycatch, and recreational fishing entanglement. During the first years of this study (1997–1999), fishers using bottom-set gill nets in waters of 30 fm had significant impacts to this species (Forney et al. 2001, see Gillnet Fishery). Subsequent to regulation changes in 2000, there was a reduction in total fishing effort and a decrease in deposition of murres in the study area (Figure 7h). Increased deposition of murres during 1997-98 was likely caused by a combination of oil pollution, El Niño effects, and fishery bycatch (Boekelheide et al. 1990b). During winter of 1997-98, the Point Reyes Tarball Incident occurred in central California, oil killed ca. 3,000 birds of which 63% were murres (Hampton et al. 2003). During 1997-98 El Niño, ocean conditions reduced the availability of prey to murres. Prey reduction also may have resulted in a nearshore shift in distribution of murres seeking food and contributed to increased bycatch deposition as suggested by Croll (1990).

Western Gull (*Larus occidentalis*) is a locally breeding resident species, nesting on rooftops and cliffs throughout the sanctuary (Monterey Breeding Bird Survey, Roberson 2001). The beach deposition data indicates this year-round occupation of the area and matches results from nearshore shipboard surveys (Henkel 2004). Increased deposition occurred during fall and winter, August to December, which likely represents an influx of fledged juveniles into the study area (Figure 6i). Few band returns (5 of 5) indicate colonies of origin of Hatch Year (HY) birds at Farallones, however, as with other species, banding is not done systematically at all colony areas. Regional data indicate additional sources from Oregon, Washington, and Mexico (BBL, Penniman et al. 1990). Age data indicated that 48% are After Hatch Year (AHY), 39% HY, 11% Second Year (SY), 2% Third Year (TY); (2004, n = 140 birds, additional 36 not aged).

Inter-annual comparisons indicated that an increase in deposition of Western Gull was not observed during El Niño years, similar to Brandt's Cormorants. Overall, there was an increasing trend for this species (Figure 7i). This may reflect lower fledging success of Western Gulls during food poor years (Penniman et al. 1990), such as occurred during 1998. An alternative explanation is that Western Gulls have an opportunistic foraging mode that allows this species to make use of alternative prey resources (e.g., dumpsites) during food limited years.

California Gull (*Larus californicus*) is a common and abundant winter visitor in Monterey Bay. They represented ~3% of beached birds (Fig. 5a). Their migratory behavior is evident by their bi-modal seasonal occurrence in beach surveys during August to December, and April to May (Figure 6j). The seasonal occurrence in beach surveys coincides with occurrence patterns of nearshore shipboard surveys (Henkel 2004).

The inter-annual trend in deposition of California Gulls was similar to that of Western Gulls and Brandt's Cormorants; they showed an increasing trend throughout the study and a significant increase in depositiondeposition during 2004 (Figure 7j). This event remains unexplained, as few data from known source colonies were available to interpret these results. Band returns from COMBERS indicated Mono Lake as the primary source for birds found in the study area (3 of 5). However, the long-term band reports from California (1929-2002) indicate birds originate from diverse colony regions including Colorado, Idaho, Montana, North Dakota, Nevada, Oregon, Utah, Washington, Wyoming, and Alberta Saskatchewan, Canada (BBL, unpublished data).

Marine Mammal Deposition

Pinnipeds: Seals, sea lions and fur seals

California sea lion (*Zalophus californianus*) was the most frequently encountered marine mammal species found on surveys in all years (53% of mammals, Figure 5b). Sea lions were most often encountered during June to December, corresponding to the non-breeding season (a). Tag returns indicate Channel Islands breeding colonies were the source of animals found in Monterey Bay area. The only significant trend in annual deposition of sea lion was that during the 1999 La Niña year, deposition was less than in other years (Figure 9a). The majority of animals recovered were immature, and it is likely survivorship of this age class was increased during this productive year.

Harbor seal (*Phoca vitulina richardii*) is one of two phocid species which breed locally. These coastal seals are resident and make little migratory movements with the exception of juvenile dispersal period (Oates 2005). Harbor seals were the second most abundant (12%) marine mammal reported each year (Figure 5b). The seasonal pattern in deposition reflected the breeding season with the greatest deposition occurring May to November (b). There were no clear inter-annual differences, although a slight increase in deposition was evident during 2002 (Figure 9b).

Northern elephant seal (*Mirounga angustirostris*) is a phocid that breeds locally and migrates north during non-breeding. Elephant seals comprised up to 14% of new deposited marine mammals each year (Figure 5b). We detected most deposition during the spring (March to May), during post-breeding, when the young weanlings leave the colony and experience the greatest deposition (c). Most of elephant seals recorded in surveys were immature. The inter-annual trend indicated an increasing deposition of this species during the study period (Figure 9c). Increased deposition likely reflects an increasing local breeding population. Since the implementation of the 1972

Marine Mammal Protection Act, elephant seals have been increasing and established new breeding colonies in various sites in central California (Sydeman and Allen 1999).

Mustelidae: Sea otters

Southern sea otter carcasses represented an average 7% of reported marine mammals each year (Figure 5b). They were encountered frequently during March to May, and October to November (
d). Inter-annual comparisons indicated that 2001, 2003 and 2005 were years of increased otter deposition (Figure 9e). Timely reporting of sea otter carcasses benefited CDFG researchers interested in identifying and quantifying specific mortality factors for this endangered species.

Cetacea: Porpoises, dolphins, and whales

Harbor porpoise (*Phocoena phocoena*) was the most abundant cetacean found during surveys. Porpoise comprise ~3% of the yearly mammal deposition. Harbor Porpoise were most often reported during April to Oct, the period of calving, with few reported during winter (
d). An increased deposition of porpoise that occurred in 2004 (Figure 9d) remains unexplained. Too few carcasses were fresh enough to conduct thorough necropsies. As was found with the Common Murres, an increase in harbor porpoise deposition in 1997-1998 (Figure 5) was attributed to an increase in gillnet fishing activity and associated bycatch of porpoise during this time (Forney et al. 2001).

UnusualMortality Events

We identified a total of 28 mortality events involving seabirds and marine mammals indicated by increased deposition during the past 11 years. Overall, nine of these events were attributed to changes in environmental conditions, nine were attributed to oiling, three were due to harmful algal blooms, three were related to population increases, two were related to fishery interactions, one was due to natural predation, and one was due to unknown circumstances. Of these 28 mortality events, 15 were classified as Unusual Mortality Events because deposition of one or more species exceeded the threshold limit (Table 2,). The remaining 13 mortality events were identified based on criteria including an increase in oiling rate, a localized beaching of rare species, or unusual numbers of live birds (Table).

The majority of the mortality events were attributed to changing environmental conditions. This included prey reduction during the 1997-98 and 2001 El Niños (eSDI = 4760, 18; Figure 10), the 2005 upwelling failure (eSDI = 863), and the 2006-07 Alcid die-off (eSDI = 328). Based on our calculated eSDI, the 1997-98 El Niño was by far the most significant mortality event detected by BeachCOMBERS because ten species exceeded the TL and the event extended up to 7 months. It appears that migratory species were more greatly affected (Mean species SDI = 83) than resident species (Mean species SDI = 6). Deposition thresholds were exceeded in summer and winter migratory seasons for surf scoters and pacific loons during this protracted event. Whereas the two El Niño events had similar composition of species affected including Rhinoceros Auklets, a resident species, and two migratory species (Northern Fulmar, Sooty Shearwater), the more recent 2005 and 2006-07 events had the greatest effects on resident species, and no migratory species showed an increase in deposition. Although environmental variability was also attributed as the cause of the Red Phalarope Die-off and the Puffin Invasion, neither of these events was detected using the TL (Table 2). This is primarily due to the fact that both of these seabird species are so rarely encountered and the long-term threshold is not applicable.

Harmful algal blooms were responsible for three unusual mortality events. Two spring events in 1998 and 2007 were attributed to the diatom-produced biotoxin Domoic Acid (eSDI = 9, 175), whereas the November 2007 Mystery Foam was attributed to an indirect effect of plumage fouling by foamy surfactants produced by the dinoflagellate *Akashiwo sanguinea* (eSDI = 29). Nearshore-feeding species including California Sea Lions, Brandt's Cormorants, Surf Scoters, loons and grebes were particularly affected by these events (see Harmful algal blooms).

An increase in young-of-the-year seabirds, or a population "boom", was likely the cause of three documented mortality events. These events were characterized as Unusual Mortality Events and were likely related to food-limitation affecting the young-of-the-year, including the 2000 grebe die-off (SDI = 163), the 2003-04 Northern Fulmar die-off (SDI = 672), and the 2006 Common Murre Baby Boom (SDI = 53). The 2000 grebe die-off was an acute event, with increased deposition occurring for 2-3 months in a localized area (limited to beaches 1 to 5 in northern Monterey Bay). The 2003-04 Northern Fulmar Die-off, however, was exceptional because it encompassed a large geographic range (>10,000 km) that lasted for several months during the winter of 2003 (Nov to March, SDI = 432) and again in the following summer/fall (June to October, SDI = 240) of 2004 (see Deposition results: Procellariiformes for details). The other mortality event related to a population boom was the Brown Pelican die-off in 2006. This was not detected using the SDI because it primarily occurred south of the study area.

Two Unusual Mortality Events in 1997 and 2001 were attributed to fishery interactions, resulting in moderate increases in deposition above threshold levels (SDI = 66, 235). Although three seabird species had deposition greater than the TL, the endangered status of Brown Pelicans caused the 2001 event to rank greater than the 1997 event. Based on fishery observer data, the 1997 gillnet fishery event impacted several other species of marine mammals and potentially sea otters, but the only two species that exceeded the TL for this time period were seabirds: Common Murres (SDI = 30) and Brandt's Cormorants (SDI = 30).

Although eight mortality events were documented related to oiling, only one was considered an Unusual Mortality Event, the Point Reyes Tarball Event (eSDI = 9,Table). Based on the CDFG damage assessment (Luckenbach Trustee Council 2006), many other species of seabirds were affected, but this was not reflected in our deposition-based metric. The majority of oiling events (6 of 8) were detected by an increase in the oiling rate above 2%, however, and not detected by an increase in deposition above the TL (Table 2). Two of these were confirmed as being caused by oiling from leaking ships, including a shipwreck (*S/S Luckenbach*), and a historical landmark (*S/S Palo Alto*). In the case of the S/S Palo Alto, oil leakage had not been observed in the beach area because the oil was leaking into wells within the structure that harbor seals, cormorants and pelicans were able to access from above, but could not escape easily. During the 2006 clean-up operation, approximately 505 gallons of oil and 125 cubic yard so oily sand and residue and 173 bird, 2 harbor seal and ~50 unidentified carcasses were recovered from the vessel in addition to those reported on beach surveys. [4]Several other mystery spills were considered chronic (duration up to 10 months), occurring in 1999, 2004, 2005, 2006, and 2007 (Table 2). Although the majority of oil was removed in 2002, the leaking shipwreck *S/S Jacob Luckenbach* was a chronic source of oil-related mortalities throughout the duration of study, primarily impacting Common Murres but also fulmars, shearwaters, scoters, and grebes. A few live and dead oiled birds were recovered in the study area during the 2007 *Cosco Busan* oil spill, but this was not detected using the TL or oiling criteria, primarily because the event occurred outside of the study area.

Highlights

BeachCOMBERS data have been applied to several cases to understand threats to sanctuary resources and identify conservation solutions which merit further discussion. These findings in particular have contributed significantly to documenting and quantifying these impacts to marine wildlife, including entanglement mortality involving a nearshore gillnet fishery (Forney et al. 2001), harmful algal bloom-related mortalities (Scholin et al. 2000, Jessup et al. 2009), and oiled wildlife (Luckenbach Trustee Council 2006).

Gillnet Fishery

During the 1980s and early 1990s, the California halibut set gillnet fishery incurred increased levels of entanglement and mortality of Common Murre, and two sensitive species, southern sea otter, and harbor porpoise in Monterey Bay (Croll 1990, Wild 1990, Julian and Beeson 1998). The fishery also affected harbor seals, but the impact relative to population size for this species was not thought to be of concern. In 1994, fishery depth restrictions were initiated (to 30 fm) to reduce bycatch of these species, but thereafter fishing effort shifted towards southern Monterey Bay, where deeper waters were closer to shore, and potential interactions were greater. In 1997, BeachCOMBERS stranding data indicated an increase in Common Murre on beaches adjacent to the area of increased gillnet fishing effort. This prompted an assessment of bycatch mortality by Forney et al. (2001) incorporating factors such as water depth and geographic distribution of fishing effort. Forney et al. (2001) estimated fishery-related mortality of these three sensitive species using a combination of BeachCOMBERS data and other observer data collected between 1990 and 1994, information between 1990 and 1998 on fishery distribution and magnitude, and mortality estimates between 1994 and 1998. BeachCOMBERS data indicated that Common Murre deposition in the summers of 1997 and 1998, were distinctly greater than those observed in similar surveys conducted in 1992 and 1993 by Mason (1997), when there was no fishing activity in the area. In 1997, 82% of the Common Murres that BeachCOMBERS volunteers found were within a 14 km stretch of beaches surveyed in the southern part of Monterey Bay, adjacent to the area of increased gillnet fishing effort. Similarly, Forney et al. (2001) also showed increased deposition of harbor porpoise and sea otters, in part from BeachCOMBERS volunteer effort. Necropsies of murres at Moss Landing Marine Laboratories indicated the fishery disproportionately affected reproductively adult males (8:1) and their attendant young chicks (Nevins 2004). During 1980 to 2000, based on Forney et al. (2001) cumulative mortalities of murres were estimated at 42,000 birds; these data were used to support an emergency change in depth regulations (to > 60 fm) enacted by California Department of Fish and Game in 2000

[4] CA State Parks and CDFG Press Release, "Old Oil Removed from SS Palo Alto: Historic Cement Ship Now Save for Wildlife", dated October 26, 2006. See: www.dfg.ca.gov/ospr for SS Palo Alto project page.

based on take of sensitive species and the likelihood of significant negative impact to the nearby murre breeding population at Big Sur, Monterey County. This temporary depth restriction was extended several times until it became finalized in April 2002. The BeachCOMBERS data thus were instrumental in determining changes in beachcast deposition of marine mammals and birds leading to changes in fishery regulations to protected vulnerable species.

Harmful algal blooms

Harmful algal blooms (HABs) and the biotoxins they produce impact organisms in coastal marine ecosystems, including benthic invertebrates, fishes, birds, and whales (Lefebvre et al. 2002). More importantly, HABs can affect human health via contamination of aquaculture or harvested seafood. Therefore, indicators of HABs, which can signal threats to human and marine ecosystem health, are important to monitor (Aguirre et al. 2002). Typically, the best indicator species are those having a narrow dietary range and those that feed on planktivorous fishes. Species including the Brown Pelican and California sea lions feed extensively on northern anchovy (*Engraulis mordax*) in Monterey Bay, are commonly affected by HABs, and serve as good ecosystem monitors. Because it is thought that increased human activities and nitrification of coastal watersheds can promote conditions for algal blooms, the frequency and intensity of HABs is expected to increase in coming years (Shumway et al. 2003). Beach surveys provide important data and samples to researchers documenting trends in HABs.

Diatom Bloom: Domoic Acid

BeachCOMBERS have documented mortality events associated with the biotoxin Domoic Acid (DA) and have contributed valuable scientific understanding of its effects—including the first study to examine the effects of DA in sea lions (Scholin et al. 2000) and sea otters (Krueder et al. 2003). DA is produced by the pinnate diatom *Pseudonitzchia australis* and was first identified in 1986 as the cause of a human outbreak of gastrointestinal illness called Amnesiac Shellfish Poisoning. Monterey Bay was one of the first areas where seabird impacts were detected (Work et al. 1992). In 1998, BeachCOMBERS documented an acute mortality event affecting California sea lions related to this biotoxin (Gulland 2000, Scholin et al. 2000). During this event between May 18 and June 19, 1998, more than 70 live and 400 dead California sea lions were documented on beaches within Monterey Bay. Live animals treated at the Marine Mammal Center showed signs of neurological toxicity including head weaving, seizing, and ataxia. Urine, serum, and fecal samples taken from the animals indicated increased levels of DA in their body. *Pseudo-nitzschia australis* was the dominant algal species during this bloom. The neurotoxin was detected in planktivorous fish including the northern anchovy and in sea lion body fluids, demonstrating conclusively that DA was concentrated as it was transferred from one trophic level to the next. Scholin et al. (2000) established an unambiguous connection between this HAB and marine mammal mortality by using species-specific DNA probes and DA-receptor binding assays to identify *P. australis* and detect DA in the cells, in combination with liquid chromatography-mass spectrometry (LCMS) to confirm the presence of DA in plankton, fish, and sea lion samples. Additionally, histopathology confirmed that animals showing neurological toxicity also had lesions in their brains and hearts consistent with DA intoxication.

Since the 1998 DA mortality event, BeachCOMBERS has contributed to quantify the impact of this biotoxin on marine birds and mammals in the Sanctuary. Volunteers have continued to report and, when possible, collect fresh dead animals for post-mortem examination at

MWVCRC. During 2005-2007, BeachCOMBERS volunteers collected 628 birds for post-mortem exam for the Seabird Health Study. These collections have helped document DA in sea otters for the first time (Krueder et al. 2003) and detect the prevalence of smaller-scale DA events in seabirds that would have otherwise gone unreported. For example, during January to early August 2007, BeachCOMBERS and other local rehabilitation centers submitted 271 freshly dead seabirds to the Central Coast Marine Bird Health Study. A small portion of examined birds (4%) were identified as potential biotoxin cases as they were in good health, with moderate to abundant body fat, and stomachs containing partially digested fish. These birds included Brandt's Cormorants, Red-Throated Loons, Pacific Loons, and Brown Pelicans. In some cases, observers reported live birds displaying neurological or behavioral abnormalities consistent with biotoxin intoxication such as decreased coordination, depression, and odd behavior such as walking on city streets. These neurological symptoms prompted testing of a subset of birds for DA. Samples from these birds were submitted to two laboratories for DA testing (California Animal Health and Food Safety [CAHFS] and University of California Santa Cruz [UCSC]). Of nine birds tested, four were confirmed positive for DA, including 2 Brandt's cormorants, 1 Red-throated loon, and 1 Pacific loon. As coastal ecosystems are modified through increasing human impacts, we expect an increase in the frequency and intensity of HABs –quantifying these impacts is a key management issue that beach surveys can help to understand.

Dinoflagellate Bloom: Santa Cruz Mystery Foam

In November 2007, an anomalous beaching of live birds in Monterey Bay, called the "Santa Cruz Mystery Spill" (later called Mystery Foam) occurred in three distinct waves: 8 to 14 November 50 grebes and scoters, 20 and 21 November 135 live and 50 dead fulmars, and 26 to 29 November 150 grebes, scoters, loons and pelicans. In total, 632 live and dead birds were recovered. Although the birds were thought to be oiled as they exhibited plumage fouling and loss of waterproofing similar to oiled birds and the event occurred coincident with the 7 November *Cosco Busan* spill in San Francisco Bay, the plumage-fouling was later determined to be caused by surfactants produced by an algal bloom rather than a petroleum product. The birds had apparently been fouled along the waterline by a mildly fishy-smelling and clear substance and lost waterproof capabilities. Feathers were analyzed and the agent was determined not a petroleum or other chemical but rather of algal origin, likely produced by the breakdown of cells of *Akashiwo sanguinea*, a dinoflagellate (Jessup et al. 2009). It is thought that the by-product of the breakdown of the algal bloom caused a foamy surfactant that fouled the birds. This is the first time plumage fouling by algal surfactants affecting seabirds has been noted.

Documenting oil on beaches & oiled wildlife

Tar balls

A total of 2423 surveys were completed for which tar ball information was available, this includes monthly and mid-monthly surveys. Tar balls were recorded on average at a frequency of 16 ± 8 % of surveys beaches in each year (n = 11). The frequency of tar balls encountered on surveys exhibited a seasonal trend with greater frequencies February to April than during other months (Figure 12). The monthly mean frequencies of oiling from the southern Sanctuary beaches (Cambria/San Simeon area) were significantly greater than that of northern (Monterey Bay area) beaches ($X^2 = 86.03$, df = 11, $p < 0.001$). The southern beaches showed the reverse trend with relative low frequencies during January and greater frequencies of oiling throughout the year.

Oiled birds

Oiled birds showed a seasonal variability in occurrence similar to the frequency of tar on northern MBNMS beaches. Oiled birds were found more frequently November to May (3 - 7%), whereas fewer birds were documented oiled (<2%) during other months (Figure 13). Oil spills affected mainly diving seabirds including Gaviiformes, Podipediformes, and Alcids but also some Procellariiformes (particularly Sooty Shearwaters). A pulse in oiling rate was associated with 1997-1998 Point Reyes Tarball Incident, which occurred in central California oiling ca. 3,000 birds of which 63% were murres (Hampton et al. 2003). We documented increased oiling rates (>2%) in "mystery spill" events that have occurred each winter since that time (Figure 11).

Discussion

Volunteers as Citizen Scientists

BeachCOMBERS was based on the concept that well-trained citizen volunteers can conduct standardized surveys and collect valuable scientific data that helps assess the health of the marine environment in the sanctuary. Over 200 volunteers have contributed more than 18,000 hours to BeachCOMBERS during the past 10 years. This entire project would not be possible without the integral support and effort of these citizen scientists. However, because volunteers collected all data, it was necessary to invest to a large amount of time and energy in training and managing volunteers to ensure accurate and consistent monthly data collection. In return volunteers were provided with enrichment activities (e.g., field trips, talks) and given sanctuary-related gifts (e.g., patches, hats) in appreciation for their efforts. The high recruitment and retention rate of volunteers in the program indicate a continuing interest in the community for this program.

Deposition Rate is an Index of Mortality

As with any beach sampling program, there were limitations to using the BeachCOMBERS data to infer trends in absolute mortality for all species in the MBNMS. First, beach deposition is an index rather than an absolute measure of mortality rate. To estimate mortality rate, it would be necessary to have known population size for each species and also correct for factors such as rarity, body size, movement, environmental conditions, depredation, and scavenging. For example, pelagic, rare, and small-bodied birds are under-represented in beach surveys (e.g., < 450g, small alcids, phalaropes, and storm-petrels). We found that medium and large-bodied seabirds (e.g., 450 to 1200 g, murres, grebes, loons) and all pinnipeds, which occur regularly in the sanctuary, were adequately represented in our surveys and interannual comparisons were possible. Second, despite well-experienced beach observers, carcasses will be missed (Ford 2006, Byrd et al. 2009). Third, the depositional environment influences the number of birds detected, and storms and large swells can wash carcasses off beaches or bury specimens or increase deposition at other beaches. We did not make a correction factor for storm intensity, beach slope or other potential environmental conditions which may affect deposition, but this would be a requisite for estimating total mortality in future analyses. Finally, depredation at sea and scavenging on the beach can influence detection rates. Several studies have addressed these issues with regard to obtaining estimates of birds killed in oil spill events (i.e., Natural Resource Damage Assessment [NRDA], Hampton and Zafonte 2005, Ford 2006), but it was not an objective of this program to estimate actual mortality in terms of total numbers of animals killed during a specific event.

One of the persistent problems encountered when interpreting BeachCOMBERS data was measuring deposition during major oil spills. During large oiling events, crews responding with CDFG-Office of Spill Prevention and Response (OSPR) remove some or all of the carcasses from the beaches as evidence, and to limit public exposure and further wildlife impacts, thus deposition rates measured during these times can be artificially reduced. However, because of the nature of the response activities needed, it is not possible to control for this in the data, but rather understand it is a limitation of the data. For example, during the 1997-1998 Point Reyes Tarball Event, deposition rates documented by Beach COMBERS for October 1997 thru March 1998 were severely underestimated due to CDFG-OSPR beach response (Figure 11; Hampton and Zafonte 2005). Despite these limitations, the event was still evident in the SDI, there was an increase in percentage of oiled seabirds recorded for this time. To resolve this issue, BeachCOMBERS held a meeting with CDFG-OSPR personnel in May 2004, and they agreed to provide us with the location, number, species, and condition of carcasses (e.g., toe clippings, amount of oil, etc.) removed from MBNMS beaches during oil spill response. The incorporation of CDFG-OSPR data is an important consideration for interpreting beach survey data in the event of future spills.

Standardized Effort

The program benefited from initiating a survey protocol designed to maximize standardization and consistency in effort so that trends could be more easily tracked, and we could quickly determine anomalies based on our long-term baseline of calculated species-specific threshold limits. We established baseline information for the incidence of unusual and other mortality events and by working with MWVCRC Seabird Study we have identified novel diseases (e.g., renal coccidosis) and age- and sex-related mortality factors, important for understanding population-level impacts.

Baseline Parameters for Ecosystem Monitoring

We found several parameters useful in quantifying ecosystem impacts to sanctuary resources based on beach surveys conducted by BeachCOMBERS, including (*i*) deposition rate standardized by effort, used to determine a threshold level by which mortality events were identified and the SDI by which events compared; and (*ii*) oiling rate, and (*iii*) frequency of tar deposition on beaches, which were used to evaluate oil-related threats. The threshold level criterion and SDI were useful to quantify and compare unusual mortality events in 54% of cases. For oil events, oiling rates were a better method of detection than deposition for 89% of events because of the effects of spill-related response (i.e., carcass removal) on deposition. Events involving few individuals of rare or uncommon species in a localized area (e.g., 2004 Orca Kills, 2007 Puffin Invasion) were the most difficult to quantify with any parameter, so total number reported was the best descriptor of these rare species events for future comparisons. Several events that occurred outside the study area may have been significant for the population involved (e.g., 2007 *Cosco Busan* oil spill, 2006 Brown Pelican), but could not be assessed with these data given the spatial extent of surveys. Cooperation with local wildlife rehabilitation centers also was useful to identify events involving live stranded animals (e.g., 1998 DA Bloom, 2007 Mystery Foam). There was only one event to our knowledge not recorded by BeachCOMBERS that was documented by a Fish and Game biologist involving “hundreds” of California Gulls at Marina Beach that was apparently fishery-related, which was not detected on the subsequent beach survey. This indicates at least some small localized events may go undetected by our survey design. Any events of significance and a geographic scope greater than one beach, however, were likely detected by our TL analysis.

Our analysis of species-specific mortality patterns indicated that it was necessary to monitor at least 10 common bird and 5 marine mammal species to detect trends in human-related and environmentally-driven perturbations such as HABs, oil spills, and el Niños in the Monterey Bay region. By monitoring all species and optimizing communication with partners such as resource agencies, rehabilitation centers, and research institutions, BeachCOMBERS has documented finer-scale events with accuracy that may have been missed by only focusing on 10 seabird species (e.g., 2006 Red Phalarope). Acute events of short duration (several days to a week) were more difficult to detect with our depositional threshold levels, whereas prolonged events (several months or more) were more easily captured in the data, primarily due to monthly frequency of surveys.

Pilot studies by MLML to test the ability to conduct surveys more frequently (daily, weekly) indicated that increased frequency caused greater variability in duration between surveys, missed surveys, and greater effort required to organize substitute volunteers, which also resulted in use of less experienced volunteers who missed more birds and made incorrect identifications. Given these results, our monthly sampling and threshold level approach was the most straightforward, repeatable, and easily measured index to provide timely assessment and response to perturbations in the sanctuary. Marine health monitoring programs are needed to determine if ocean health is deteriorating, remaining stable, or getting better (Gulland and Hall 2007).

Identifying die-offs or stochastic mortality events, particularly those involving indicator species, are important components of monitoring marine ecosystem health (Aguirre et al. 2002). New approaches to measure complex, multi-species ecosystem components such as disease, contaminants, and population demographics are developing, and beach survey programs provide essential information about the biological impacts to upper trophic level organisms. We found that collaboration with the veterinary expertise of the Seabird Health Study at MWVCRC allowed us a greater ability to compare the variable demographic composition of events (i.e., young vs. adult), which increased our ability to compare relative importance of one mortality event with another. Because no other regional center exists to coordinate these different aspects of studying mortality, the BeachCOMBERS program has served this role during many events, particularly those occurring at the regional spatial scales such as the 2004 Fulmar die-off, 2005 upwelling failure, and 2007 Mystery Spill events (Nevins and Harvey 2004, Parrish et al. 2007, Jessup et al. 2009).

The event index (eSDI) allowed for comparisons among events differing greatly in species composition. For example, the 2004 fulmar die-off (one species, mostly young-of-year, SDI = 672) compared with the 2005 upwelling failure (multiple species, many adults, SDI = 863) indicated that the 2005 event had a greater ecosystem impact than did the 2004 event. Whereas the 2005 upwelling failure had multi-species impacts similar to the 1997-98 and 2001 El Niños[5], differences in species composition (i.e., resident vs. migratory) and timing of the event indicated that this was not an El Niño. For example, one of the best indicator species for the two El Niños was Sooty Shearwater deposition, but we did not see significant increases in deposition for this species in 2005. These results were corroborated by fishery-oceanographic assessments indicating a "lack of a clear ENSO signal in the tropics… and indicates that equatorial processes did not play a significant role in creating ENSO-like anomalies in the California Current System" and instead the "warmer than normal SSTs were driven by a weak North Pacific High that reduced upwelling-favorable winds during the spring of 2005, resulting in weaker than normal upwelling along the entire west coast ([CalCOFI 2005-06] Peterson et al. 2006).

Oil pollution is a significant source of mortality for marine birds in the North Pacific and is recognized as a global problem for marine wildlife (Camphuyusen et al. 2002). Thousands of seabirds have been killed by catastrophic oil spills in central California, including the 1971 San Francisco Spill (~10,000), the 1986 *Apex Houston* (~12,000; Page et al. 1990), the 1996 *Cape Mochican* (12,220) and the 1998 *Command* (~1,500) reviewed by Carter et al. (2001, 2003). Chronic oil pollution, originating from leaking shipwrecks, urban runoff, and other non-point sources, was a continual source of mortality for seabirds in this study. For example, the source of winter "mystery spills" that have occurred in central California periodically throughout the last 20 years was finally identified as the *S/S Luckenbach*, a leaking shipwreck that sank offshore of San Francisco Bay in 1953 (Hampton et al. 2003). BeachCOMBERS played an integral role in documenting these oiling events and collecting samples, and because the core study area was 51 km, we likely attained adequate sampling for oiling rate and species richness according to guidelines set forth by Seys et al. (2002) of a minimum study region of 25 to 40 km for assessing oil spill impacts.

Documenting oiling and presence of tar balls on beaches

The regular frequency of tar ball occurrence on beaches in the Monterey Bay National Marine Sanctuary indicates a persistent source of oiling in the region.
In general, tar ball transport was caused by a combination of wind, currents, and nearshore tides, and Shanks (1987) found tar balls also could be transported up to 8 km shoreward by the propagation of internal waves. The seasonal pulse of tar balls in January to March coincided with increased percentage of oiled birds but an overall reduced seabird deposition (< 3 birds km^{-1}) indicating that the oiling was not just a reflection of an increased depositional environment, but rather an increase in chronic oiling in sanctuary waters during winter.

Chronic oiling may originate from ship operations and tank washing, historic shipwrecks, natural seeps, and pipeline leaks (Hampton et al. 2003). It should be noted that even under the International Conference on Marine Pollution: Convention for the Prevention

[5] The "el Niño" is the warm water phase along the west coast of North America of the El Niño/Southern Oscillation (ENSO), a periodic ~4-5 year climatic cycle driven by the air pressure changes in the tropical western Pacific. The "La Nina" is the cool water phase (anomalously cooler than normal) of ENSO.

of Pollution from Ships and adopted protocol (MARPOL 1978), vessels may discharge oil into the sea at a rate of 30 liters per nautical mile (16 L km^{-1}) provided they are 80 km from shore. Given this loophole in the legislation, it is likely vessels will continue to commonly make discharges at sea. Two historic vessels, the shipwrecked S/S *Luckenbach* and the grounded *Palo Alto* provide examples for significant impacts that can be expected from this type of source. Hundreds of shipwrecks of varying size and potential cargo scattered throughout the sanctuary waters (The Resources and Undersea Threats [RUST] Database, Overfield and Symons 2009) and these should probably be re-assessed periodically to determine risks associated with leakage as these vessels deteriorate. For example, in 2003 MBNMS surveyed the *Montebello*, a 139 m tanker sunk by a Japanese submarine in 1941, in the southern Monterey Bay Sanctuary and determined it was intact (de Marignac and Burton 2003). While direct impacts of oil leakage were not reported, derelict fishing nets entangled on the superstructure had resulted in ghost fishing (de Marignac and Burton 2003).

Oiled Birds

The baseline percentage of oiled birds reported monthly by BeachCOMBERS during non-spill times (2%) was similar to that reported by beach survey programs in GFNMS (3.2%, Roletto et al. 2003) and COASST (2.2%, Parrish and Hass, unpublished data). While this low-level of oiling was not of immediate concern, it highlights the importance of using oil rate as a monitoring tool for determining changes in impacts to marine birds (Camphuysen 1998, Camphuysen and Heubeck 2001). Low-levels of oil exposure may cause detrimental sub-lethal effects to seabirds —oil exposure may affect immunology, plumage waterproofing and insulation, digestion, nutritional state, and depress blood chemistry (Burger and Gochfeld 2002), thus affecting the survival of seabirds in a number of ways. Past oil exposure can have long-term impacts on seabird populations by depressing reproductive abilities, prey resources, and ultimately seabird populations may take decades to recover (e.g., 1989 *Exxon Valdez* oil spill, Alaska; Piatt et al. 1990). Future studies to determine the source of oiling by detailed chemical fingerprinting analysis may help elucidate sources of and determine trends in chronic oiling affecting sanctuary beaches and wildlife.

BeachCOMBERS has documented both catastrophic known-source and chronic mystery-source oiling events based on the monthly oiling rate increasing to >2%. Several of these events were associated with oil seepage from the 1953 shipwrecked S/S *Jacob Luckenbach*; these included the 1997-98 Pt. Reyes Tarball Incidents and mystery spills in 1999, 2001/02 and 2003. Two catastrophic spills occurred outside of the core survey area during the study period, the September 1998 T/V *ommand* spill off Pacifica, San Mateo County (to the north of the study area) resulting a single month increase in oiling rate (to 3% of new birds encountered) in the MBNMS and the November 2007 *Cosco Busan* crash inside the San Francisco Bay (>5%). These reports were provided to state agencies and sanctuary resource managers for damage assessments and resulted in mitigation funding amounting, in the case of the Luckenbach, to $21 million (Luckenbach Trustee Council 2006). While several of Pt. Reyes Tarball and other winter mystery spills were eventually connected to the *Luckenbach*, several events documented in recent years have yet to be resolved (March 2004, January – April 2005, April 2006, and January-February

2007). In 2006, BeachCOMBERS reports helped to identify the source of oil affecting cormorants at Seacliff State Beach as coming from the grounded *S/S Palo Alto*, a historic and tourist point of interest. These two oiling sources have subsequently been mediated by clean-up efforts. Because oil was located in over 30 different compartments on the vessel, complete oil removal was difficult, and approximately 29,000 gallons that were not removable remain onboard. The remaining holes in the vessel were sealed at the completion of the clean-up (Luckenbach Trustee Council 2006). Recent oil fingerprinting of chronic oil by CDFG Petroleum Chemistry Lab indicate small number of mortalities were attributed to Luckenbach-sourced oil as recently as 2008, and this shipwreck may continue to plague wildlife in coming years (Nevins et al. 2011).

Fishery Bycatch

These results highlight the ability of beach surveys to document bycatch when other fishery dependent data are lacking or sporadic, especially for coastal fisheries with small fleets. The data contributed by BeachCOMBERS in documenting the bycatch of murres and other species in the coastal halibut set gillnet fishery offers a unique example of how beach surveys have provided important information for resource management and conservation. The initial documentation of the increased deposition by BeachCOMBERS and the reassessment of fishing bycatch by Forney et al. (2001) led to subsequent changes in fishery regulations and protected the local population of Common Murres, Harbor Porpoise and other marine mammals from a significant threat. The nearby Big Sur breeding colonies, at the southern end of the range for this species, require recruitment of immature birds from larger colonies to the north (i.e., Farallon Islands, Point Reyes). Given the demographics of the catch reported by Nevins (2004), it was likely that stagnating population growth at these breeding locations reported by Carter et al. (2001) during the time of the fishery was due to the loss of potential recruits (immature birds) being killed during winter and reproductively active adults (chick-rearing males) killed during summer. A significant management effort has been underway to restore several murre colonies along the central California coast (e.g., McChesney et al. 2007), and reduction or elimination of mortality factors such as bycatch are likely to contribute to population growth in these areas.

Harmful Algal Blooms

BeachCOMBERS data has been used successfully to determine large acute UMEs, and subtler small-scale mortality events of marine mammals and birds caused by harmful algal blooms (HABs), particularly *Pseudo-nitzchia australis* exuding the neurotoxin Domoic Acid (DA, Scholin et al. 2000). *P. australis* blooms are patchy and episodic in nature and DA-related mortality has the potential to go undetected if a small number of animals are affected by a relatively small, localized bloom. The timing and species composition of the 2007 DA event occurred in two episodes (e.g., March - cormorants, May- loons) indicated that these were likely two separate events. These mortalities did not appear to have been a result of a large-scale DA-associated mortality event, but rather may represented multiple small-scale blooms affecting a small numbers of birds and marine mammals (Bargu et al. 2010). Bargu et al. (2010) indicated that increased DA and *P. australis* abundance coincided with live strandings of DA-poisoned sea lions strandings in events in 1998, 2000 and 2007; however in other years of high toxin concentration, the predicted pattern was not found suggesting a more complex relationship.

Generally, proving a mortality event was HAB-related was difficult, as species' sensitivities to toxins are often unknown. Further, ascribing a definitive cause of death was difficult, and obtaining proper samples can be challenging in the field without concurrent algal bloom data. We are just now discovering that although DA was a quick-acting toxin, it does not always impact a large group of animals. We have documented HAB events since the inception of BeachCOMBERS, but recent increased interest in documenting these mortalities (e.g., seabird health study 2005-2007) has likely increased the number of events documented in this category. Until a systematic approach is taken to developing a monitoring program for HAB-related mortality in the area, many small-scale acute events are likely to go undocumented, and inferring trends in these data may be misleading (Shumway et al. 2003). The novel occurrence of a previously undocumented source of mortality by the dinoflagellate *Akashiwo sanguinea* via plumage fouling by surfactants from the breakdown of cells during a bloom was a noteworthy example of how important BeachCOMBERS data were to understanding biological impacts at upper trophic levels (Jessup et al. 2009). Dinoflagellates have increased in the phytoplankton community in recent years (F. Chavez, pers. comm.), and we expect future events related to these blooms to have similar consequences and characteristics (i.e., highly localized stranding of nearshore birds fouled along the waterline by a clear substance). Unlike DA, the detection of another *A. sanguinea* event is likely to be reported due to the greater numbers of live birds affected (Phillips et al. 2011)[4].

[4] In October and November 2009, a similar *Akishiwo* event occurred in Oregon, resulting in the live stranding and death of more than 700 birds, including loons, scoters, grebes and murres.

Management Recommendations

Given the past accomplishments of the BeachCOMBERS program, we offer the following recommendations towards furthering the use of marine birds and mammals as sentinels of ecosystem indicators in the Monterey Bay and other National Marine Sanctuaries:

- **Continue long-term standardized surveys** with standard effort in the core study area of the MBNMS. We have established baselines for deposition of the most abundant resident and migratory seabirds and marine mammals, rates of oiling and entanglement, oiling on beaches, HABs and related impacts to wildlife. Although this 11-year baseline has incorporated environmental stochasticity including two El Niños events and one La Nina, given changing global climate, it is even more important to continue to build on this baseline by continuing monthly surveys. This baseline also will allow for comparisons after major regulatory or legislative changes (e.g., offshore drilling, fishing management plans).
- **Continue to provide opportunities to engage citizen scientists in ecosystem monitoring** through BeachCOMBERS and other Sanctuary-supported volunteer programs (e.g., Team Ocean kayak naturalist, water quality sampling). The amount of consistent effort required for maintaining a long-term study is too cost-prohibitive to do this type of study without volunteers. Local communities also benefit from this work by increased connection to sanctuary and stewardship of resources, and understanding of seasonal and catastrophic events.
- **Monitor changes in Chronic Oil in the MBNMS.** This will require continued collaboration with CDFG-OSPR for both oil fingerprinting (by submitting samples to the Petroleum Chemistry Laboratory) and natural resource damage assessment to effectively determine new sources of oil and the quantify the impacts to wildlife. This is feasibly and reliably done through incorporating beach sampling metrics for oil pollution (i.e., number of tar balls, number of live and dead oiled birds) and a regular, systematic reporting of oil pollution to inform response activities.
- **Foster collaborative networks** among management agencies and other research institutions to assist in response to oil spills, HABs and other emerging issues. BeachCOMBERS has been integral to the collaboration of regional wildlife and pathology experts (OSPR-MWVCRC, National Wildlife Health Center), rehabilitation centers (International Bird Rescue, SPCA), and other beach survey programs (e.g., Beach Watch, COASST, Canada BBS) to understand disease and other causes of mortality.

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Table 1. Summary of BeachCOMBERS survey effort by beach. Beach information includes beach segment number, beach name, county, timing of survey, duration of survey effort at beach (in years), and beach length during 1997-2007. Volunteer effort includes total number of surveys, average survey time per month, average travel time per month, and total monthly volunteer time, cumulative kilometers walked, survey time and volunteer time.

Beach #[a]	Beach Name	County[b]	Timing of survey	# of surveyors	Duration (yr)	Beach length (km)	Total # surveys	Ave. monthly survey time (hr)	Ave. monthly travel time (hr)[2]	Ave. monthly volunteer time (hr)	Cumulative distance walked (km)	Cumulative survey time (hr)	Total Cumulative volunteer time (hr)	Cumulative survey time (hr) per surveyor
1	New Brighton	SC	First week	2	11	3.7	126	2.0	1.1	3.0	932.4	495.0	763.0	247.5
2	Aptos	SC	First week	2	11	4.8	128	2.2	1.5	3.7	1236.5	566.5	950.5	283.3
3	Manresa	SC	First week	2	11	5.2	127	2.6	1.2	3.8	1308.1	654.0	966.9	327.0
4	Sunset	SC	First week	2	11	5.3	129	2.1	2.1	4.2	1370.0	548.3	1078.5	274.1
5A	Zmudowski	MTY	First week	2	11	4.4	128	2.7	2.3	5.0	1113.6	685.4	1279.7	342.7
5B	Zmudowski	MTY	Third week	2	11	4.4	111	2.7	2.0	4.8	965.7	602.0	1056.7	301.0
6	Moss Landing	MTY	First week	2	11	5.0	128	2.4	1.5	3.9	1277.4	623.2	1007.2	311.6
7	Salinas River	MTY	First week	2	11	5.2	129	2.7	2.0	4.7	1328.7	698.3	1214.3	349.2
8A	Marina	MTY	First week	2	11	4.2	128	2.5	1.3	3.9	1070.1	651.8	995.7	325.9
8B	Marina	MTY	Third week	2	10	4.2	111	2.2	1.9	4.1	928.0	487.0	910.2	243.5
8C	Marina [d]	MTY	Second week	2	0.30	4.2	4	1.8	1.3	3.2	33.4	14.7	25.3	7.3
8D	Marina [d]	MTY	Fourth week	2	0.25	4.2	3	1.8	1.3	3.1	25.1	10.8	18.8	5.4
9	Fort Ord	MTY	First week	2	11	5.2	118	2.5	1.5	4.0	1215.4	590.2	944.2	295.1
10	Carmel	MTY	First week	2	11	4.2	128	2.5	1.1	3.6	1070.1	645.7	927.3	322.9
11N	Waddell	SC	First week	2	10	3.1	79	3.8	1.3	5.2	496.1	605.0	813.9	302.5
11S	Scott's Ck	SC	First week	2	5	1.0	81	0.7	1.4	2.1	157.1	112.7	342.2	56.3
12A	Moonstone	SLO	First week	2	7	2.0	80	1.6	1.5	3.1	320.0	256.3	496.3	128.1
12B	Moonstone	SLO	Third week	2	5	2.0	28	1.2	0.8	2.0	112.0	66.8	113.4	33.4
13A	San Simeon Creek	SLO	First week	2	7	2.0	74	1.1	0.8	1.9	296.0	165.0	288.3	82.5
13B	San Simeon Creek	SLO	Third week	2	5	2.0	22	1.5	1.5	3.0	88.0	64.5	130.5	32.3
14	San Simeon Cove	SLO	First week	2	7	2.4	77	2.1	1.5	3.6	369.6	324.5	555.5	162.3
15	Arroyo Laguna	SLO	First week	2	4	1.0	21	1.1	1.1	2.2	42.0	46.6	92.1	23.3
16	Arroyo de la Cruz	SLO	First week	2	7	2.5	75	1.4	2.8	4.2	375.0	217.2	629.7	108.6
17	San Carpoforo	SLO	First week	2	7	2.2	79	0.8	1.2	2.0	347.6	121.5	314.5	60.8
22	Castle Rock	SC	First week	2	4	1.0	23	1.0	2.0	3.0	46.0	45.5	137.5	22.8
23A	Sand Dollar	MTY	First week	2	5	1.0	51	1.7	1.5	3.2	102.0	176.2	329.2	88.1
23B	Sand Dollar	MTY	Third week	2	5	1.0	42	1.9	0.5	2.4	84.0	155.5	197.5	77.8
24	Del Monte	MTY	First week	2	3	2.5	23	2.3	1.2	3.5	115.0	104.5	160.9	52.3
25	4-mile Beach	SC	First week	2	5	0.7	34	0.9	0.9	1.9	47.6	64.4	126.7	32.2
26	Morro Bay	SLO	First week	2	5	3.0	48	1.4	0.9	2.3	288.0	136.3	219.0	68.2
27	Davenport Landing	SC	First week	2	2	0.4	19	0.1	0.6	0.7	14.8	5.3	27.5	2.7
28	3-mile Beach[e]	SC	First week	2	0.17	0.4	2	0.3	0.7	0.9	1.6	1.1	3.7	0.5
	TOTALS:					94.1	2356	1.8	1.4	3.2	17176.9	9941.8	17116.8	4970.9

[a] A = First week, B = Second week; N = North segment, S = South segment
[b] County = MTY (Monterey); SLO (San Luis Obispo); SC (Santa Cruz).
[c] Travel time = Estimated from 2007 data
[d] Weekly survey conducted in 2002, discontinued
[e] Beach discontinued

Table 2. Chronological summary of 15 Unusual Mortality Events (UMEs) recorded by BeachCOMBERS 1997-2007. Events were quantified based on UME criterion 1 – an unusual increased deposition for one or more species (SDI), and for the entire event (eSDI). Relative magnitude is expressed as percentage points exceeding expected threshold (%>TL) calculated for each species. Species vulnerability (S_v): if species affected were threatened or endangered (2) or not a species of concern (1).

Year	Name	Event Index (eSDI)[a]	Individual Index (SDI)[a]	Species-affects detected	Start	Sv	%>TL	Dur[b]	Age Factor	Ages classes affected	Other species affected but not >TL	Probable cause of death[c]	Reference[d]
1997	Gill net by-catch	**66**	36	Common Murre	Aug	1	30	1	1.2	More adults (60) and males (8:1) in summer; more young-of-year in winter (76)	Harbor Seal, Elephant Seal, Harbor Porpoise, Sea Otter	HUM-human-related, incidental fishery bycatch	Forney et al. 2001, Nevins 2004
			30	Brandt's Cormorant	Aug	1	30	1	1.0				
1997-98	El Nino	**4760**	1792	Surf Scoter (spring/summer 98)	Mar	1	256	7	1.0	adult and young	Other seabirds and marine mammals	ENV- reduced prey range-wide	Benson 1999
			786	Sooty Shearwater	Apr	1	131	5	1.2				
			730	Brown Pelican	Mar	2	73	5	1.0				
			516	Cassin's Auklet	Apr	1	129	4	1.0				
			266	Pacific Loon (winter 98-99)	Dec	1	74	3	1.2				
			227	Surf Scoter (winter 97)	Nov	1	63	3	1.2				
			165	Rhinoceros Auklet	Apr	1	55	3	1.0				
			120	Northern Fulmar	May	1	40	3	1.0				
			96	Common Murre	Jun	1	48	2	1.0				
			42	Pacific Loon (spring/summer 98)	Apr	1	7	6	1.0				
			16	California Sea Lion	Jun	1	16	1	1.0				
			4	Brandt's Cormorant	Mar	1	2	2	1.0				
1997-98	Pt. Reyes Tarball Event	**9**	7	Common Murre	Oct	1	1	6	1.2	all: more adult and subadult males	55+ spp. of seabirds, waterbirds & others	OIL-chronic signal from shipwreck *Luckenbach*	Hampton et al. 2003, Nevins and Carter 2003, Roletto et al. 2003, PSG 2004
			2	Clark's/Western Grebe	Nov	1	2	1	1.0				
1998	Domoic Acid bloom	**9**	9	California Sea Lion	May	1	9	1	1.0	adult and young	Sea otter (?), seabirds (?)	HAB- offshore environment	Scholin et al. 2000
2000	Grebe die-off	**163**	163	Clark's/Western Grebe	Mar	1	68	3	0.8	young-of-year (100)	None	YOY-breeding area (inland)	TWS 2004
2001	El Nino	**18**	13	Northern Fulmar	Mar	1	13	1	1.0	all	Other seabirds, California sea lions	ENV- reduced prey range-wide	
			3	Rhinoceros Auklet	Mar	1	3	1	1.0				
			2	Sooty Shearwater	May	1	2	1	1.2	all adult			
2001	Entanglement Issue	**235**	235	Brown Pelican	Aug	2	49	3	0.8	young-of-year (100)	Gull spp., esp. Heerman's and Western Gulls	HUM-human-related, shore fishery interaction	N. Rojek, unpublished

Table 2. continued

2003	Surf Scoter	**44**	44	Surf Scoter	Oct	1	44	1	1.0	unknown	None	HAB - possible	Henkel 2005
2003-04	Fulmar Die-off	**672**	432	Northern Fulmar (winter 03-04)	Nov	1	108	5	0.8	young-of-year (96) and subadult (4)	Red Phalarope (n = 14, Nov 2003)	ENV- reduced prey range-wide	Nevins et al. 2004
			240	Northern Fulmar (summer 04)	Jun	1	48	5	1.0				
2004-05	Upwelling failure	**863**	448	Cassin's Auklet	Nov	1	112	4	1.0	all	Other seabirds and marine mammals	ENV- starvation	Nevins and Harvey 2005
			240	Rhinoceros Auklet	Nov	1	60	4	1.0				
			135	Brandt's Cormorant	May	1	45	3	1.0				
			25	Harbor Seal	Feb	1	25	1	1.0				
			15	Common Murre	May	1	15	1	1.0				
2006	Grebe event	**18**	18	Clark's/Western Grebe	Sep	1	22	1	0.8	unknown	None	UNK - has not been determined	
2006	COMU baby boom	**53**	53	Common Murre	Nov	1	33	2	0.8	young-of-year (first winter)	None	YOY-breeding increase	McChesney et al. 2007
2006-07	Alcid die-off	**328**	258	Common Murre (spring 07)	Feb	1	86	3	1.0	all	Rhinoceros Auklet, other alcids	ENV- starvation	SSEP unpublished data
			66	Common Murre (winter 06)	Feb	1	33	2	1.0				
			4	Cassin's Auklet	Jun	1	1	4	1.0				
2007	Mystery Foam	**29**	29	Brandt's Cormorant	Nov	1	29	1	1.0	all	Clark's/Western Grebe, Pacific Loon, Surf Scoter	HAB- nearshore environment, plumage fouling	Jessup et al. 2009
2007	Domoic Acid bloom	**175**	141	Brown Pelican	May	2	44	2	0.8	all	California Sea Lion	HAB- nearshore environment	Nevins and Phillips, unpublished
			20	Clark's/Western Grebe	Jun	1	20	1	1.0				
			14	Brandt's Cormorant	Jun	1	14	1	1.0				

[a]Seabird Depostion Index (SDI) for each species, cumulative SDI for event (eSDI)
[b]Duration in months.
[c]Signal: HAB = Harmful algal bloom, OIL= Petroleum plumage fouling resulting in death, YOY-young of the year mortality, ENV= environmental, reduced prey availability, NAT- other natural mortality factor (e.g. depredation)
[d]Reference includes a significant resulting report, publication, article, poster, or presetation (see Appendix C).

Table 2. Summary of 13 other mortality events recorded by BeachCOMBERS, 1997-2007, not detected with >TL (see Table 2). Baseline data were not available due to the rarity of species but quantified based on other criteria including duration, number and species of animals reported, and ages affected, or other unusual findings (e.g., oiling). Species vulnerability (Sv): if species affected were threatened or endangered, then S =2, if not S = 1.

Year	Name	Species-affects detected	Start	Dur[b]	Sv	Number of Animals reported	Ages affected (%)[c]	Other species affected	Criteria used to classify event	Probable cause of death[d]	Reference[e]
1999	Mystery Spill	Common Murre	Feb	3	1	12	all	Other seabirds (number reported includes all species)	Oiled birds >2%	OIL-chronic signal from shipwreck *Luckenbach*	BeachCOMBERS unpublished data
2001-02	San Mateo Mystery Spill	Common Murre	Nov	10	1	73	adult (58), hatch-year (42)	10+ spp. of seabirds	Oiled birds >2%	OIL-chronic signal from shipwreck *Luckenbach*	Hampton et al. 2003, SSEP unpublished data
2004	Mystery Spill	seabirds	Mar	1	1	?	all	?	Oiled birds >2%	OIL-chronic signal, source unknown	BeachCOMBERS unpublished data
2004	Orca kills	Gray Whale	May	2	2	11	calves (100)	None	Unusual number of rare species in localized area	NAT-predation by killer whales	Perryman 2005
2005	Mystery Spill	Common Murre	Jan	10	1	21	adult (92), immature (2)	17 spp. of seabirds[f]	Oiled birds >2%, tarballs	OIL-chronic signal, source unknown	BeachCOMBERS unpublished data
		Rhinoceros Auklet	Jan	10	1	17	ASY (100)				
		Northern Fulmar	Jan	1	1	5	ASY (100)				
		Brandt's Cormorant	Jan	5	1	6	ASY (100)				
		Cassin's Auklet	Jan	1	1	4	ASY (100)				
		Sooty Shearwater	Aug	2	1	4	AHY(100)				
		Short-tailed Shearwater	Jan	1	1	2	AHY (100)				
2005	Cement Ship/ Seacliff Oil	Brandt's Cormorant	Jun	6	1	4	all	Harbor Seals, Brown Pelicans entraped in hull	Oiled birds >2% in localized area, shore-resting species	OIL-chronic signal from landmark historic ship *SS Palo Alto*	
2006	Brown Pelican event	Brown Pelican	Apr	1	2	31	young-of-year (100)	None	Localized distribution, more to south of study region	YOY-breeding increase	Zabka et al. 2006a
2006	Mystery Spill	Common Murre	Mar	4	1	?	unknown	other seabirds	Oiled birds	OIL-chronic signal, source unknown	
2006	Red Phalaropes	Red Phalarope	Nov	3	1	41	adult (87), female (7:1)	None	Localized beaching of live birds, rare species to detect	ENV-starvation during migration, likely related to storm events	Zabka et al. 2006b
2006-07	Mystery Spill	Western/Clark's Grebes	Apr	2	1	~750	all	Nearshore birds: Surf Scoters, Western/Clark's Grebes	Oiled birds >2%; non-petroleum fouling of plumage	HAB - surfactant from algal bloom	Jessup et al. 2009
2007	Fulmar Die-off	Northern Fulmar	Nov	1	1	250	young-of-year (100)	None	Localized massive influx of live stranded birds	ENV- starvation	SSEP unpublished data
2007	Cosco Busan oil spill[a]	Clark's Grebe	Nov	1	1	2	all	Other waterbirds, mostly in SFO Bay, ~50 collected live in area (only 2 by Combers)	Oiled birds	OIL-catastrophic spill in SFO from collision	BeachCOMBERS unpublished data
2007	Puffin invasion	Horned Puffin	Mar	4	1	41	immature/sub-adult (73)	None	Very rare species, and unusual timing	ENV- starvation as a result of foraging area shift (?)	Phillips et al. 2007
		Tufted Puffin	Jun	1	1	3					

[a] Likely deposition was affected by increased collection effort during spill response, so there was no significant anomally detected.
[b]Duration in months.
[c]Data from H. Nevins unpublished, post-litigation examination of carcasses (n = 164).
[d]Signal: HAB = Harmful algal bloom, OIL= Petroleum plumage fouling resulting in death, YOY=young of the year mortality, ENV= environmental, reduced prey availability, NAT= other natural mortality factor (e.g. depredation)
[e]Reference includes a significant resulting report, publication, article, poster, or presetation (see Appendix D: List of products for complete details).
[f]Includes one oiled individual for each of the following species (see AOU species list): ANMU, BRPE, BVSH, COLO, CORM, MEGU, PALO, PIGU, SHOR, SUSC, WEGR, WEGU.

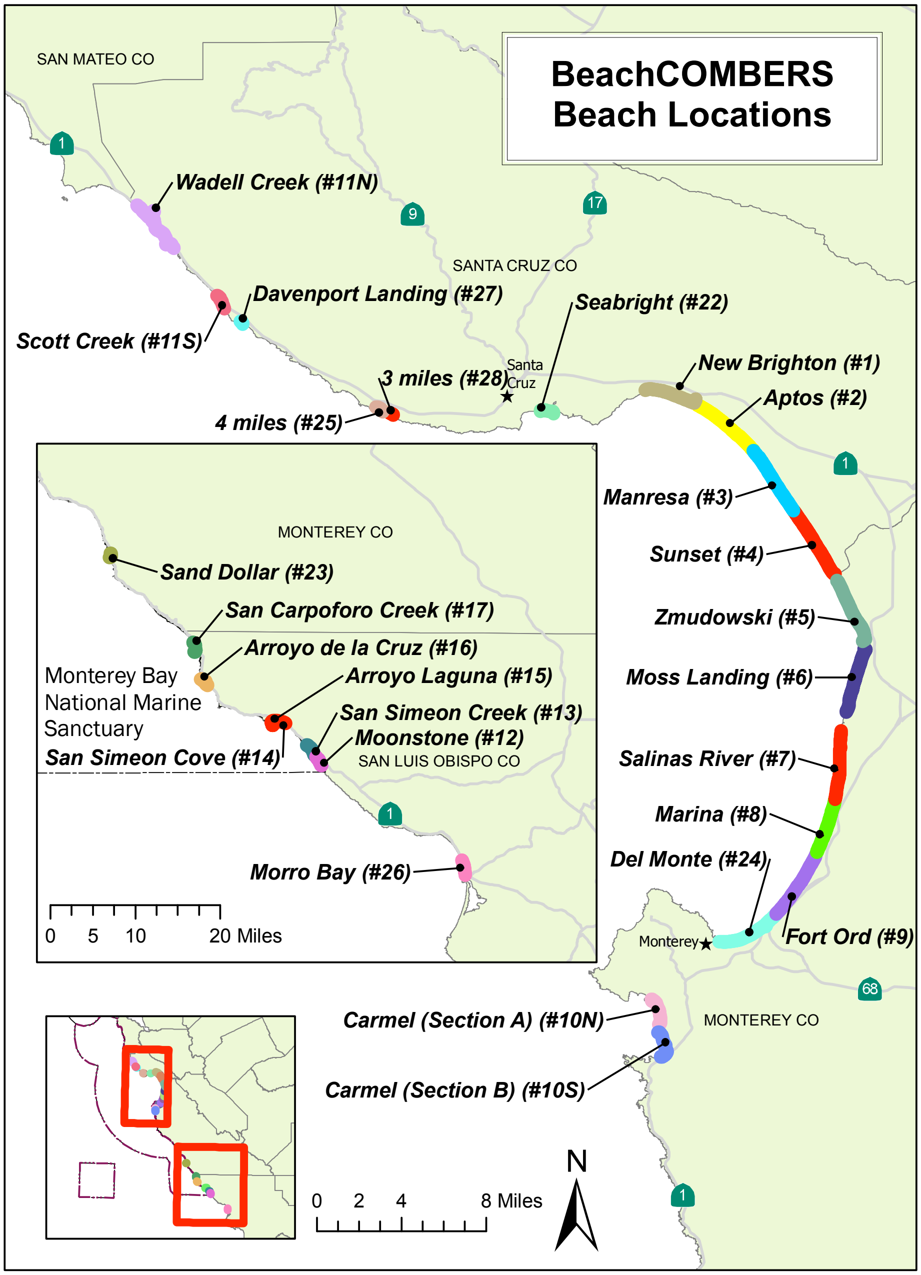


Figure 1. Map of Beach COMBERS survey segments in northern and southern [large inset] regions of the Monterey Bay National Marine Sanctuary. Survey segments are shown in relation to the Sanctuary boundary in the small inset. Core study beaches are beaches 1-11 in the northern part of MBNMS. Refer to Table 1 for specific beach lengths and survey details.

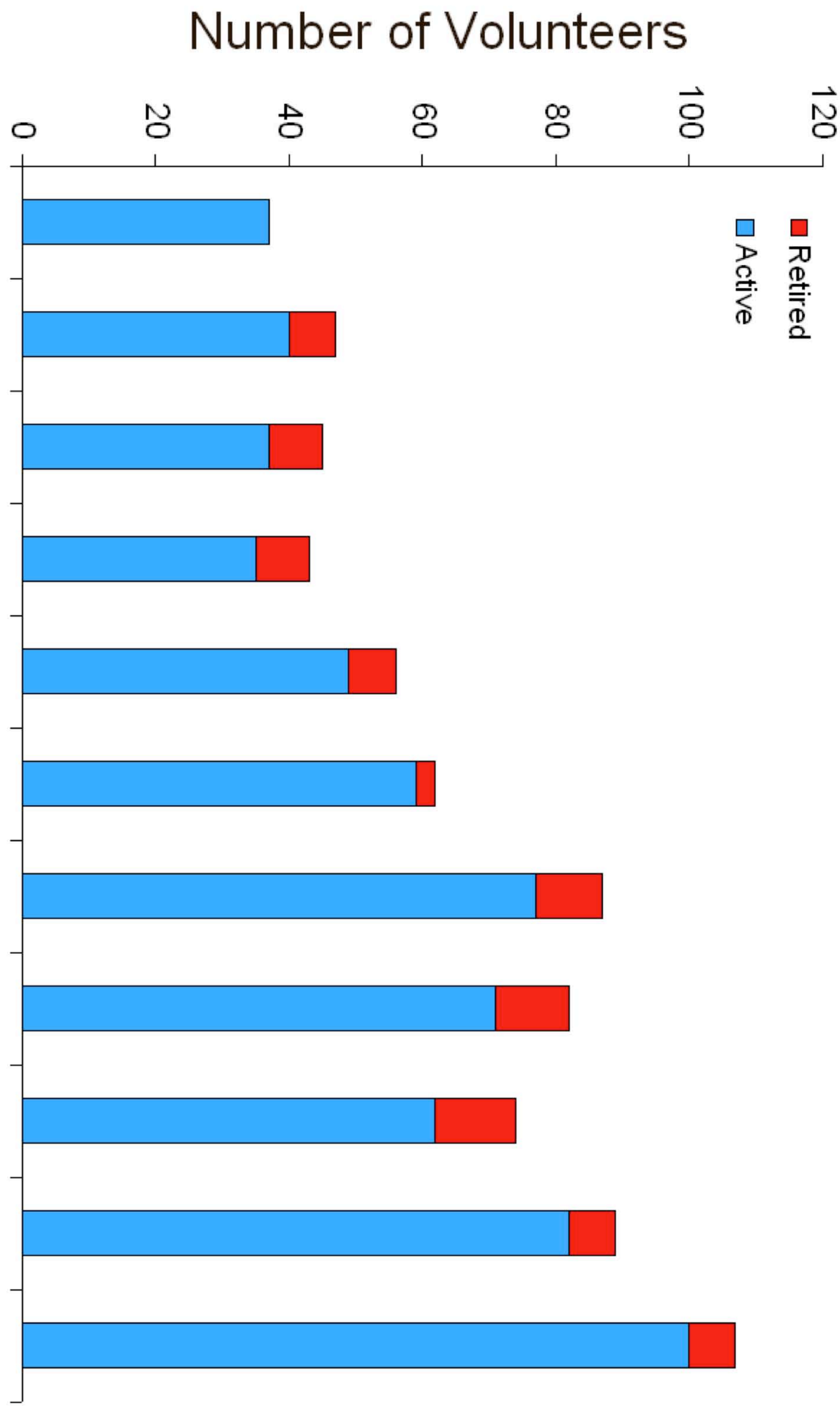


Figure 2. Cumulative number of active (including both new recruits and retained) and retired BeachCOMBERS volunteers: 1997–2007.

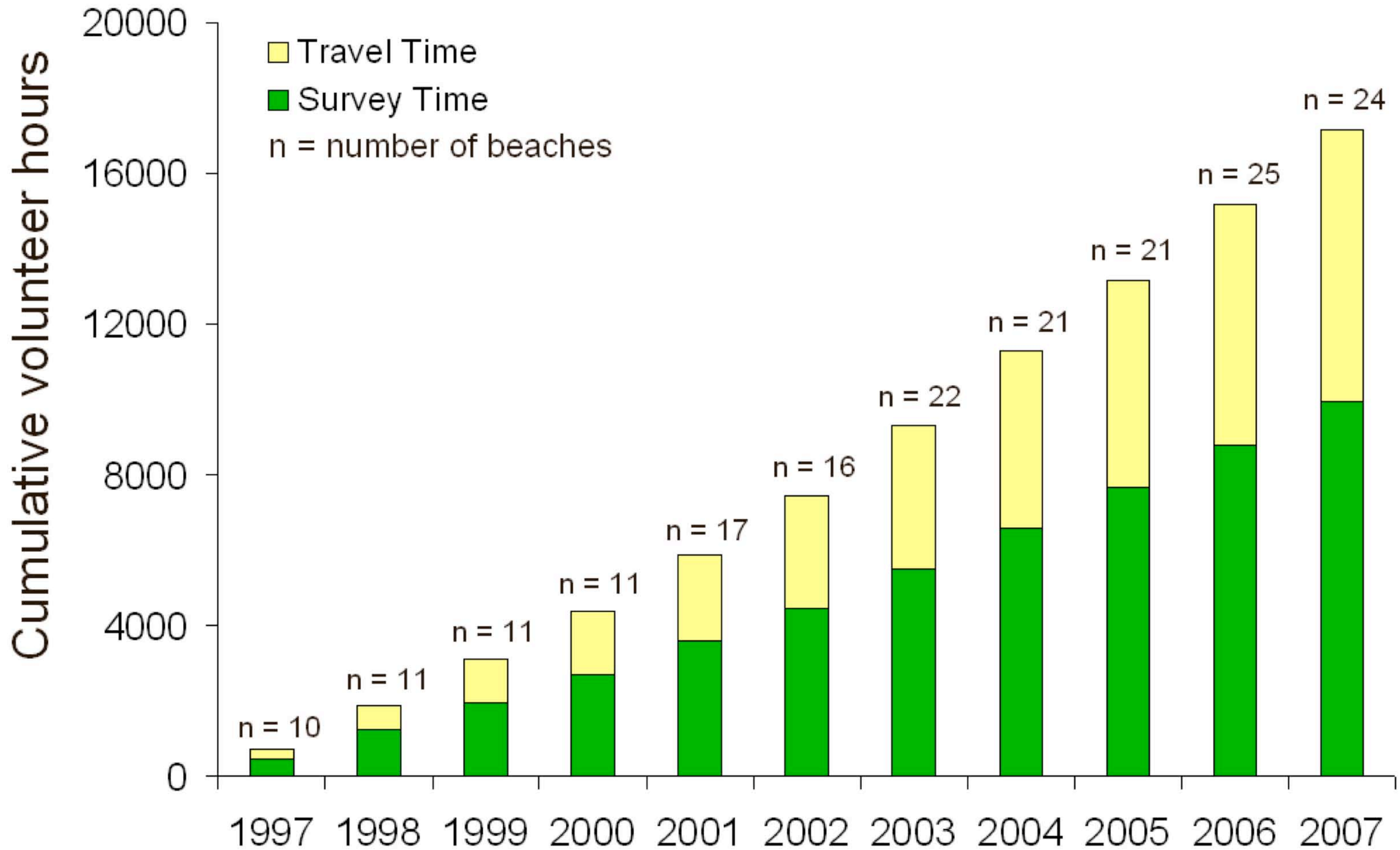


Figure 3. Cumulative BeachCOMBERS volunteer hours including survey time and travel time: 1997–2007. Number of beaches surveyed are indicated (n).

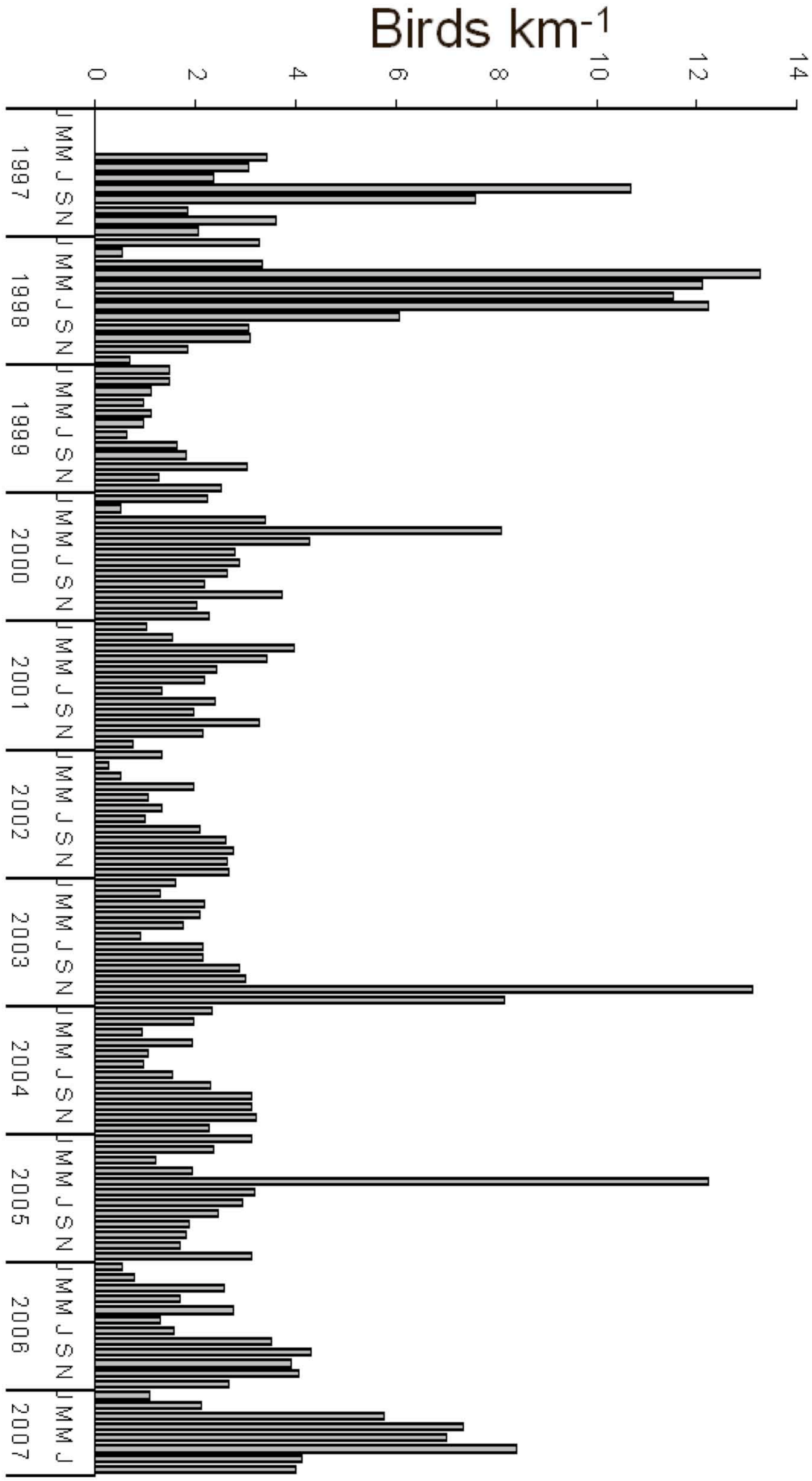
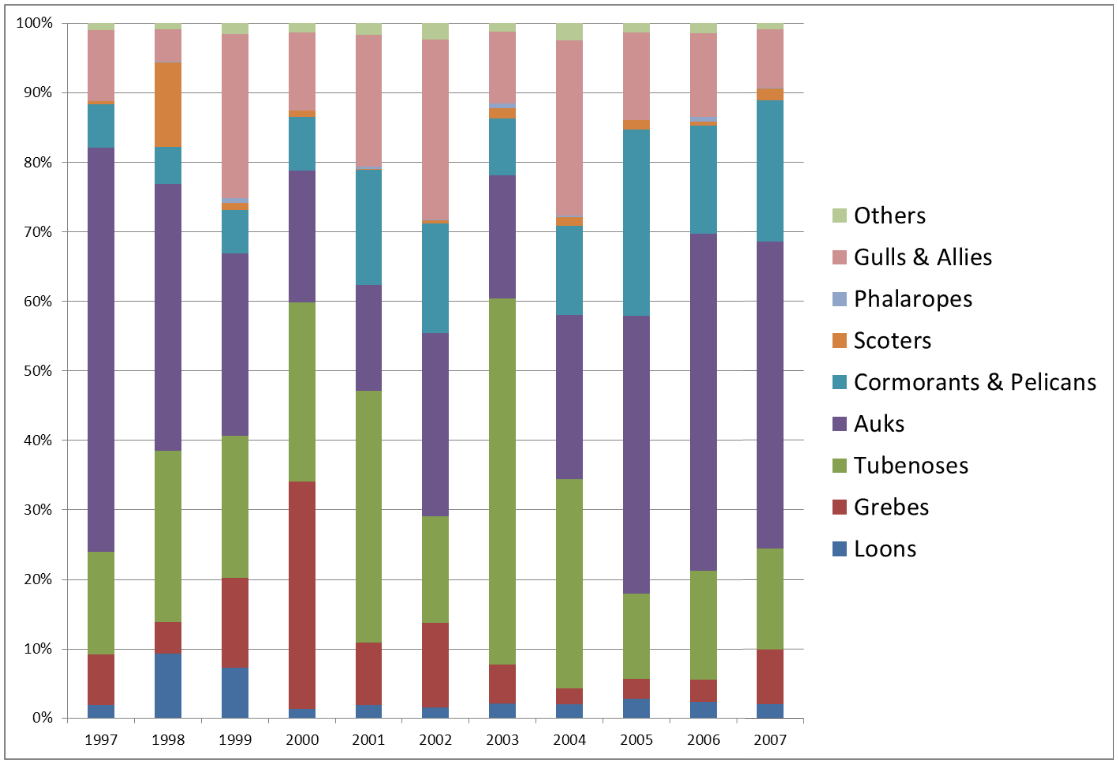


Figure 4. Long-term overall new deposition of all seabird species (birds km^{-1}): 1997–2007.

A



B

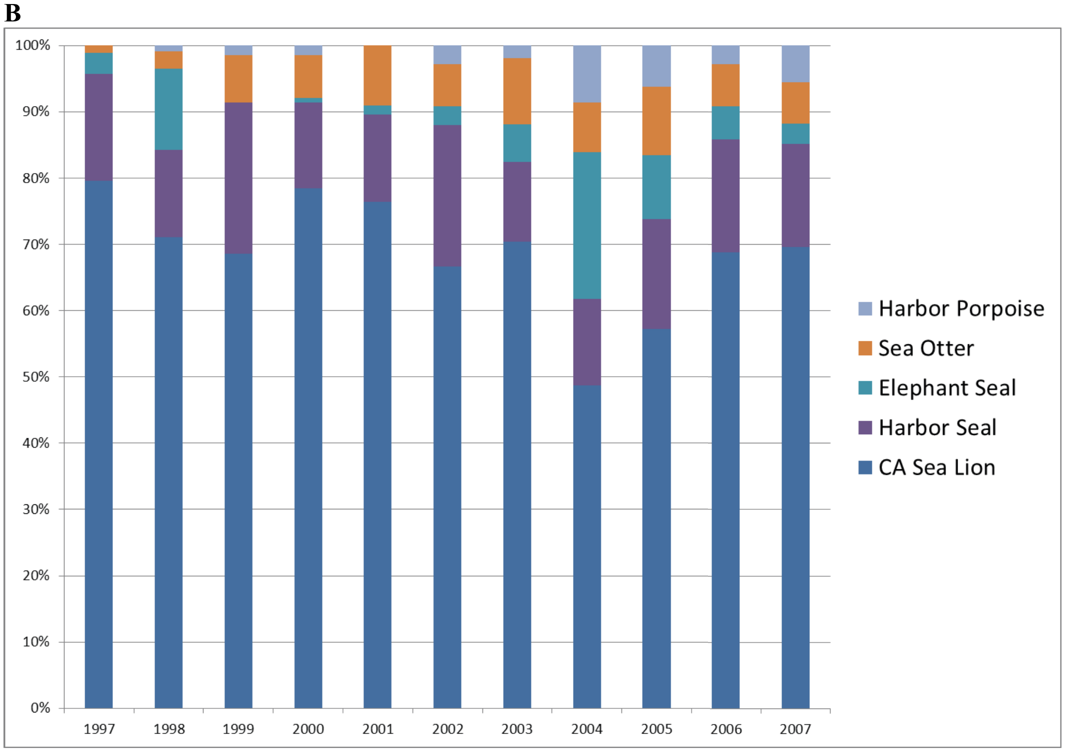


Figure 5. Annual composition of beachcast a) seabirds and b) marine mammals by taxonomic group, 1997–2006. "Other species" includes those individuals not identified to species level.

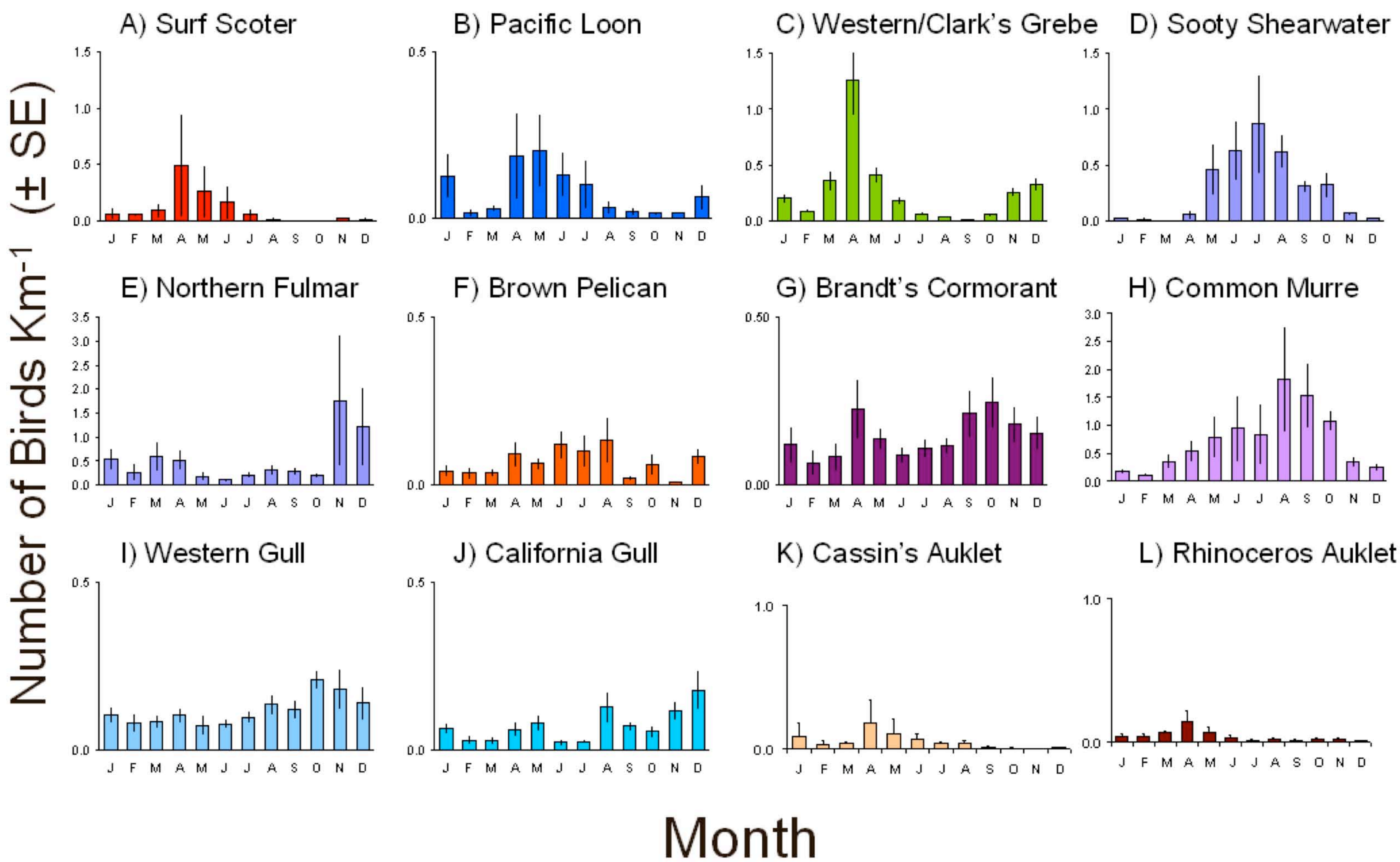


Figure 6. Monthly mean deposition of ten most abundant seabirds, 1997-2007. Data shown are for new deposition on 11 core beaches in northern Monterey Bay National Marine Sanctuary (#1-11, Figure 1). Bars represent one standard error (SE, n = 11 yrs.).

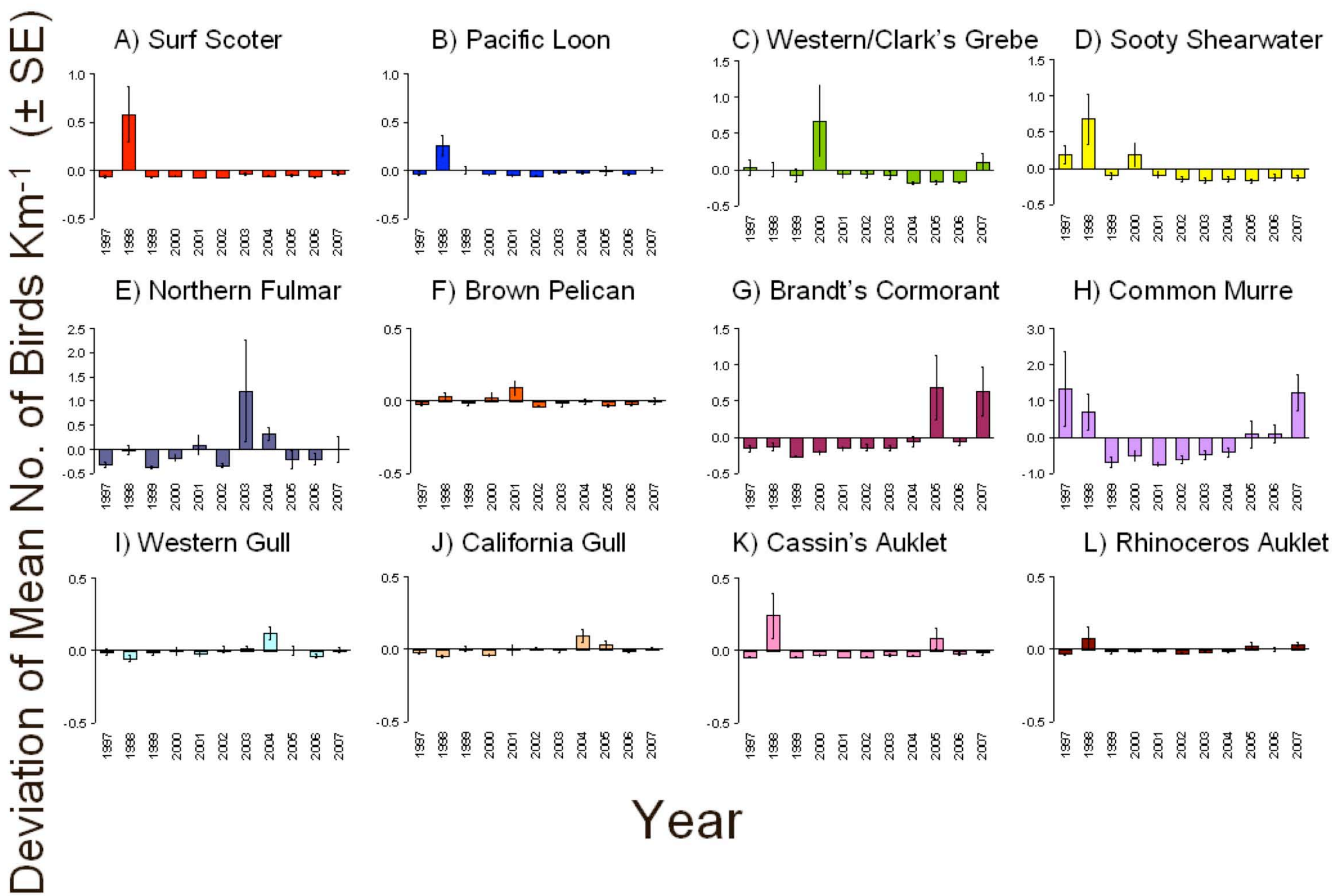


Figure 7. Inter-annual comparison of mean new deposition of ten most abundant seabirds, 1997-2007. For each species data represent deviation of species mean deposition from long-term species mean deposition (1997-2007). Data shown are for 11 core beaches in northern Monterey Bay National Marine Sanctuary (beaches #1-11, Figure 1). Bars represent one standard error (SE, n = 11 yrs.).

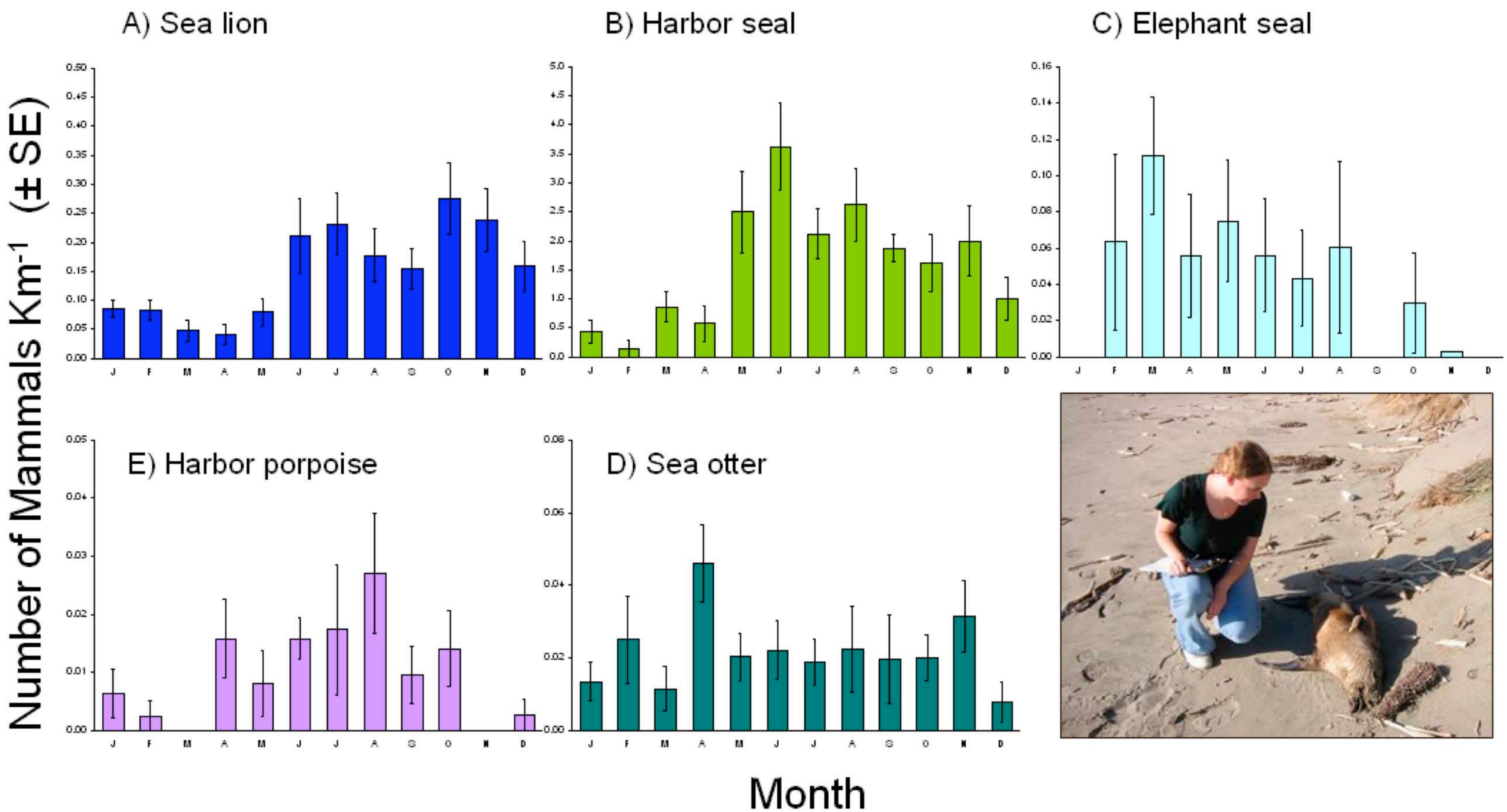


Figure 8. Monthly mean deposition of the most common marine mammals, 1997–2007. See text in Results for description of species-specific depositional patterns.

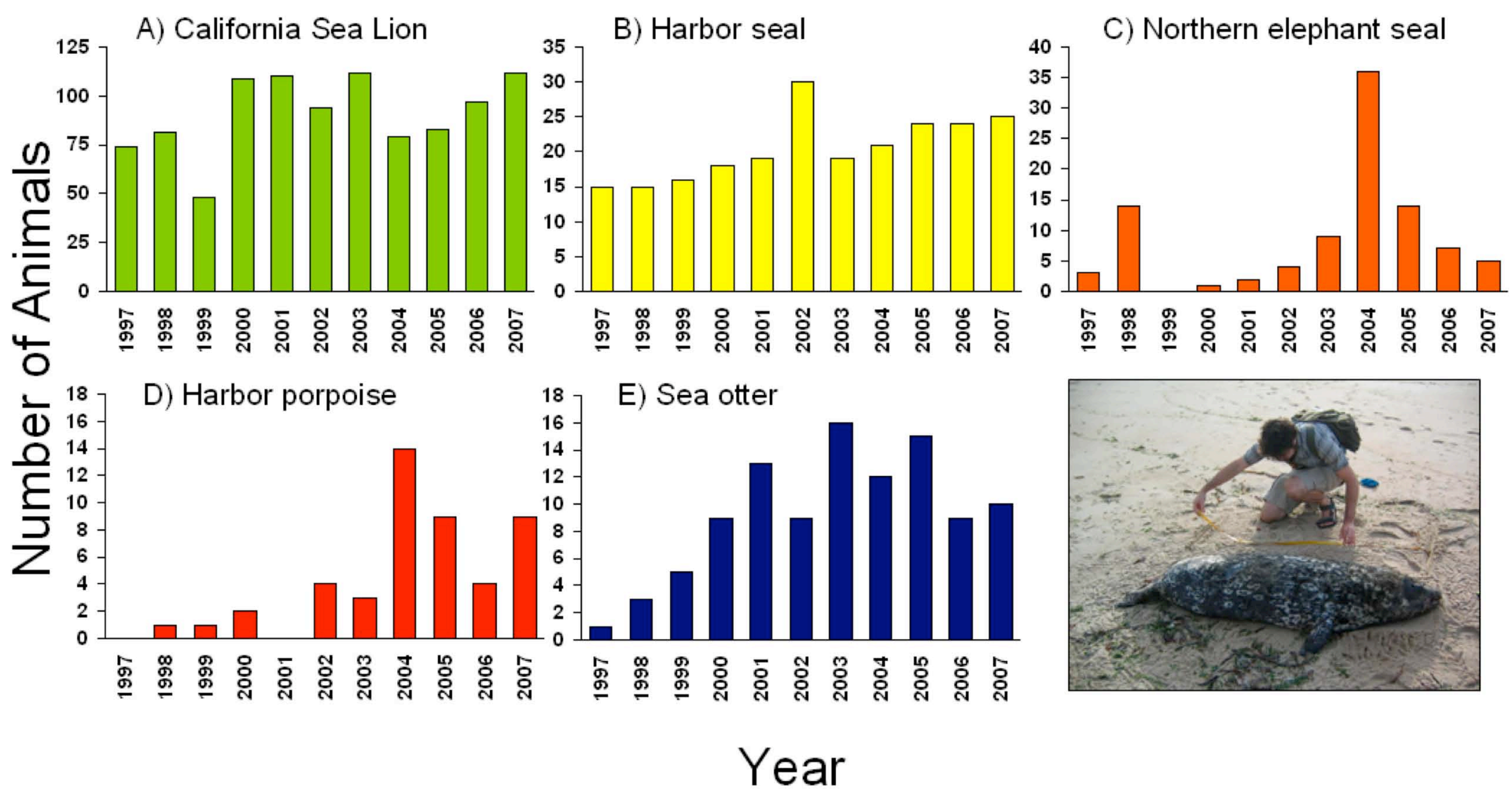


Figure 9. Inter-annual deposition of the most common marine mammals reported within core study area, 1997–2007. See map (Fig. 1) and text for description of 11 core beaches.

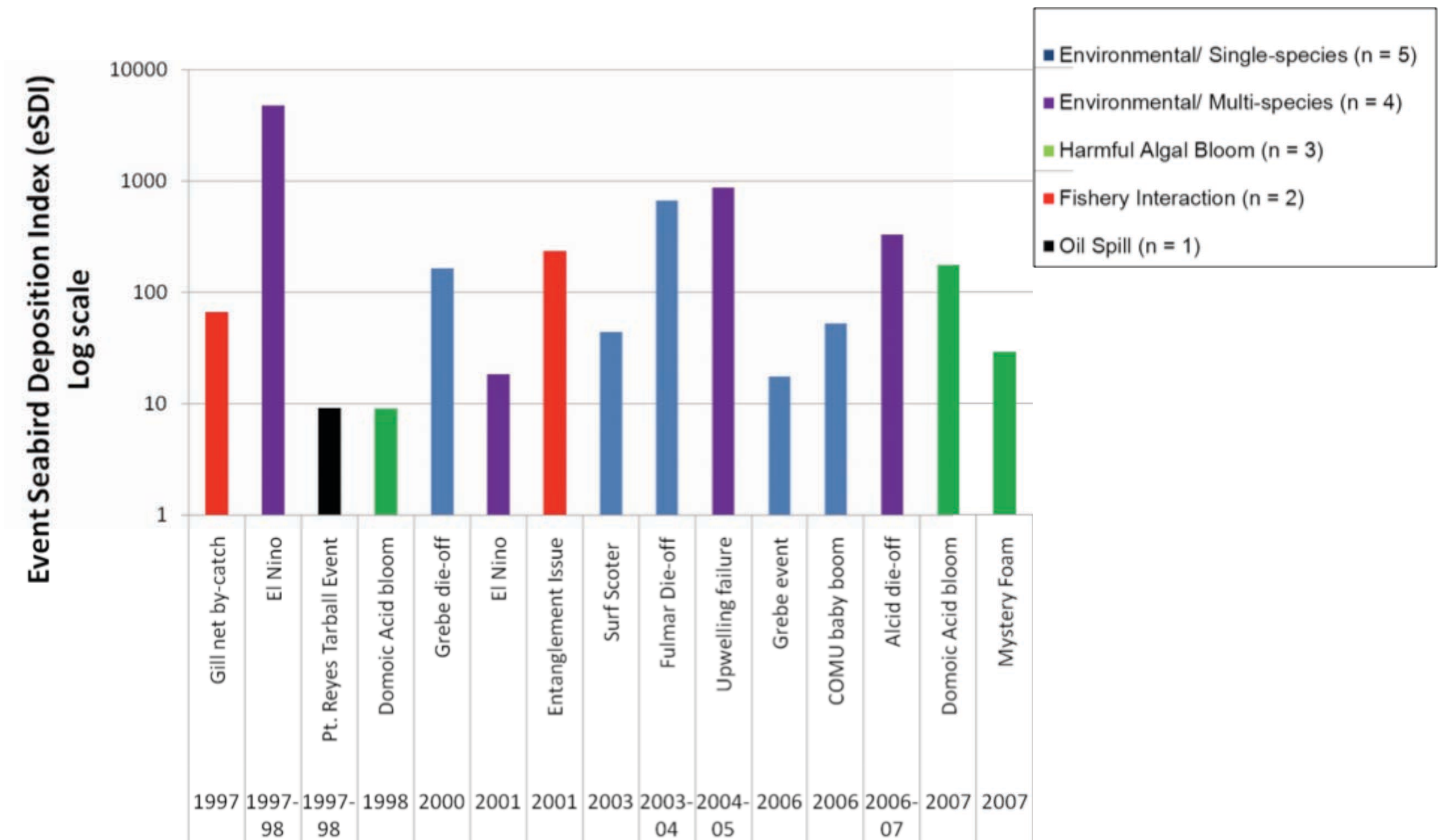


Figure 10. Event Standard Deposition Index (log scale) for 15 Unusual Mortality Events defined by one or more species exceeding the threshold limit, 1997-2007. See text and Table 2 for description of specific events detected using this method.

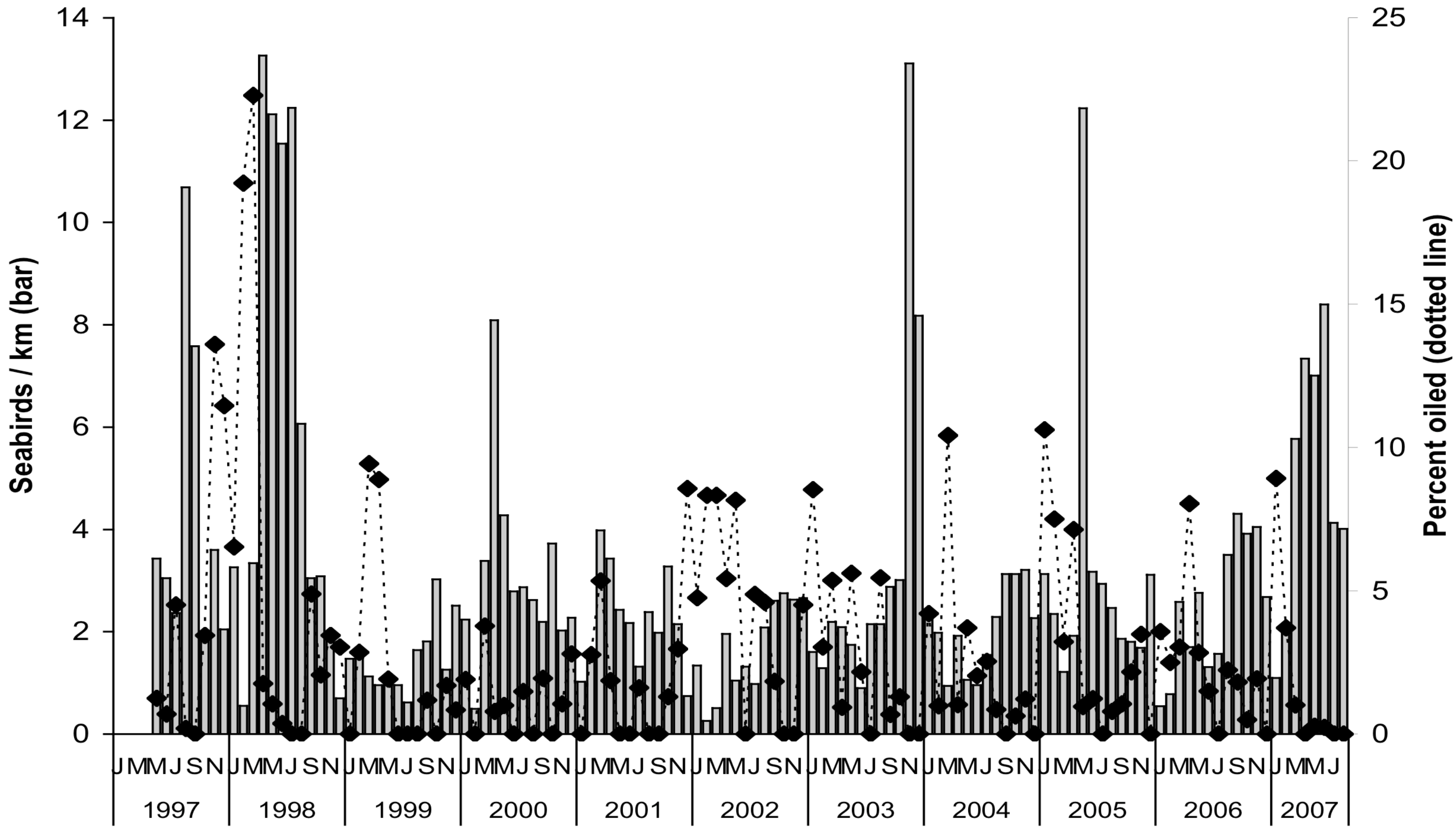


Figure 11. Oiled seabird deposition (seabirds/km) and percent oiled, 1997-2007. Significant oiling events were identified when the percent of oiled birds exceeded two percent monthly (see Table 2 for summary of events).

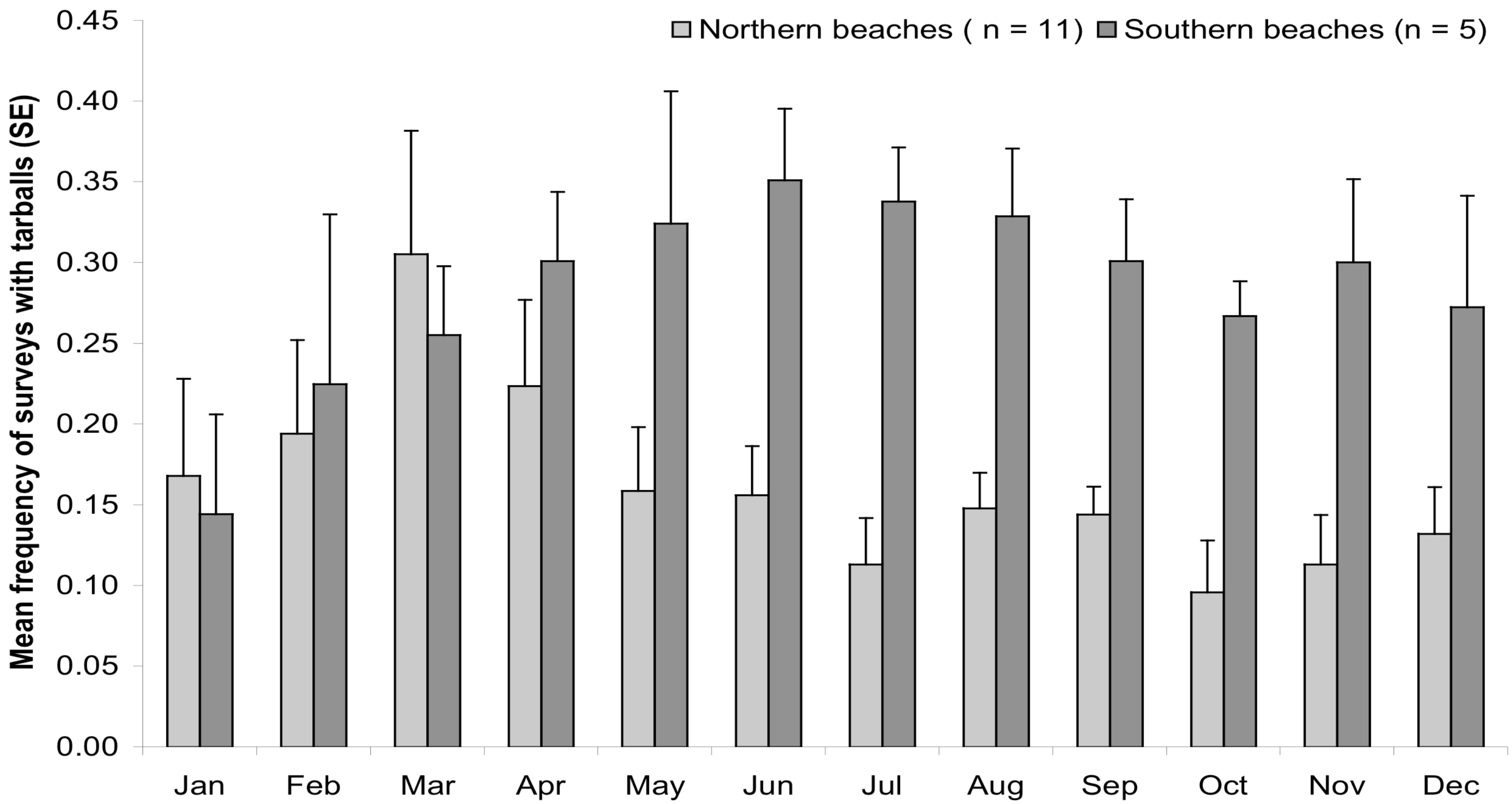


Figure 12. Mean frequency of surveys with tarballs for the northern (beaches #1–11) 1997-2007 and southern (#12–17) survey areas, 2001–2007.

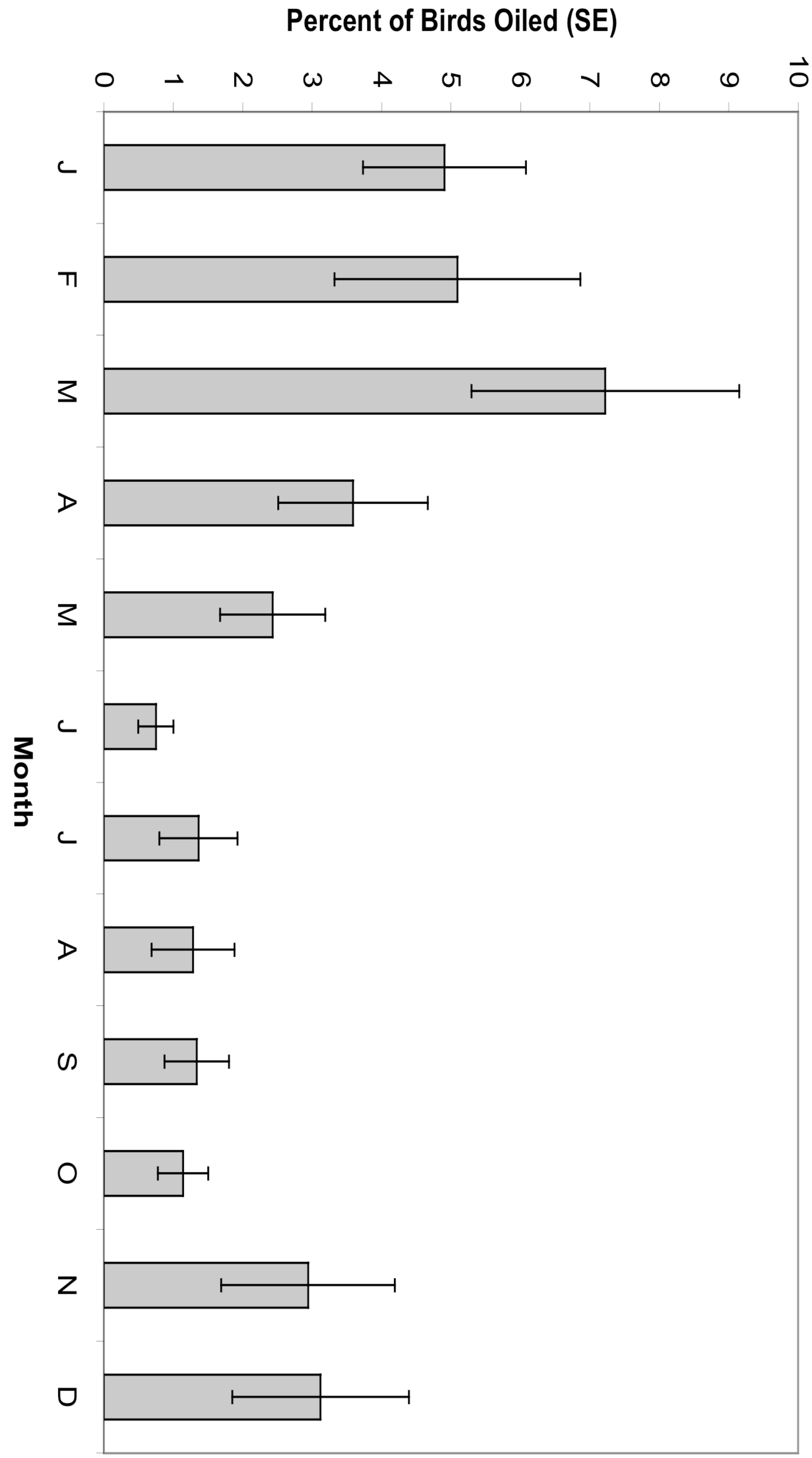


Figure 13. Monthly mean percent of oiled birds 1997–2007.

Appendix A: Protocol

Introduction
This protocol is for volunteers to follow while conducting systematic beach surveys for as part of the Coastal Ocean Mammal/ Bird Research & Education Survey program (a.k.a. Beach COMBERS) in the Monterey Bay National Marine Sanctuary (MBNMS). Beach surveyors should consult field guide to aid in identification of the common species of marine birds and mammals. The primary reference is “Beached Marine Birds and Mammals of the North American West Coast: A revised guide to their identification” (Ainley et al. 1986) and “Birds of North America” (National Geographic Society).

Data Collection
There are two data forms to fill out on each survey. The **header** sheet will include the beach segment number, names of surveyors, date, time, start and end times, weather, number and size of tarballs, and general notes or findings during survey. The beached **organism datasheet** will include detailed description of each animal encountered during your survey. It is important that for each beached animal every field in the survey datasheet is completed or filled with a dash to indicate that you have checked each carcass for scavenging, oiling, and tags. Descriptions of each field in the datasheet are listed below.

Species (code)
Identify the animal to the best of your ability, using your field guides, training materials, and Beached Bird and Mammal book. Consult your partner to agree on the most conservative taxonomic level. For example, if it is a phalarope, but the carcasses is heavily scavenged and your partner thinks it to be a red, but you a red-necked, record PHAL for unidentified phalarope in the Species code field. Use the species code list provided which uses the four-letter abbreviation for the standardized common names. If you then decide to key out the species using the Beached bird book and now know that in fact it is a red phalarope, then record the species as REPH. Include details of how you identified the animal when you have used the key, such as record the wing chord and bill measurements and coloration of bill, feet, or other characters you may have used to identify to species. If you take photos to identify an animal, please include digital or hard copies with your monthly data submission.

If you are not able to identify a bird use UNID or lowest taxonomic level, and put comments in the notes field, if you have other description, but questionable identification. For example, you could put PINN for unidentified seal or sea lion, and in notes, it might read “possible ZACA, skull missing”.

Condition (1-4)
The condition of the carcass can often tell you how long it has been on the beach and whether it is in good enough condition to determine probable cause of death or collect for necropsy. Condition **1** indicates a live injured, dying, sick or oiled animal. Please note location and condition to relay to appropriate wildlife rehabilitation center. Condition **2** is considered fresh dead, a carcass that has just washed in from the sea. Although a condition 2 carcass may be scavenged, it will have fresh blood and tissue exposed. Only collect condition 2 animals for necropsy, unless it is a rare or endangered species or a cetacean of any kind. Condition **3** is a decomposing animal, often has bugs and/or deteriorating tissue. Condition **4** indicates that the animal is no longer decomposing at a fast rate because it has dried out and become mummified. Condition 3 and 4 differ in that the tissue is no longer soft, but is hard, the condition 4 carcasses are generally stiff.

Sex (M/F/U)
You will not be able to distinguish the sex of many seabirds because they are *monomorphic* (sexes look alike) and therefore sex will be “U” for unknown. The exceptions are ducks which have different male and female plumages (i.e., surf scoters), and gulls and grebes in which the sexes have different sized or shaped bills. You should try to examine all pinnipeds and cetaceans to determine the sex of the animal. Using a

stick, roll the animal onto its back, so that the central ventrum (belly) is exposed. The sex of the animal can mainly be determined on fresher (condition 1- 2) carcasses. Scavenging at the orifices is common, and makes it difficult to sex heavily scavenged carcasses. Male pinnipeds will have a penile opening posterior (toward tail end) of the umbilicus (belly-button), whereas female pinnipeds will only have one ventral mark for the umbilicus. Cetaceans differ in the presence (females) or absence (males) of two mammary slits on both sides of the central genital slit. Consult the pg. 172 (pinnipeds) and pg. 187 (cetaceans) for illustrations of differentiating among sexes in marine mammals. If you are unsure of the sex, record "U" in this field.

Age (Birds: HY, AHY, FY, SY, TY; Mammals: PC, IM, AD)
Birds are difficult to age; most seabirds can only be differentiated into juvenile or hatch-year (HY) and after-hatch-year (AHY) plumages. Gulls may have a series of two or three plumages after the first year, corresponding to the second-year (SY), third year (TY), before reaching the adult (AD) plumage. Consult your field guide to distinguish age by plumage, bill and foot coloration. Often there is little difference in bill or wing length among age classes.

Mammals are primarily aged based on size. Using rings of enamel in the teeth, researcher will be able to obtain a specific age, but for the purposes of the beach survey, we are only recording broad age classes. Mammal pups or calves (PC) are the smallest age class, followed by sexually immature or subadult (IM), and the oldest, largest animals are considered adults (AD). In some species there are other characters which distinguish the males as adults, such as the sagittal crest of the adult male California sea lions and the pronounced, billowing nose of the adult male Northern elephant seal.

Toe Clipping (0 – 6, 8, 9)
To determine how long a beached animal has been on the beach, we use a toe-clipping system to mark bird carcasses and twine to mark mammals. Each time a carcass is encountered, one toe is clipped off or a piece of twine is tied around the rear flipper. Because cetaceans and sea otters always will be collected, there is no need to mark these animals. There are two columns for coding this; "**previous**" refers to the number of toes that were clipped previously, before your present survey, and "**post**" refers to how many have been clipped after you leave the animal. So the first time a new animal washes up on the beach it will be coded as "0/ 1" corresponding to no toes clipped and then one clipped. The second month if it is encountered again, it will be "1/2", then "2/3" on the third survey, and so on, "3/4, 4/5, 5/6, and 6/6". We stop clipping toes after 6 toes of both feet or 3 on a bird with one foot (because not all species have 4 toes, but all have 3). If a bird only has one foot, then it will be coded as "0/1, 1/2, 2/8", indicating that all toes have been clipped on bird with one foot only, code "**8**". If the carcass only has **no feet** or **one foot**, please record this in the notes. Twine on mammals is coded similarly, with no limit to the number of pieces that are placed on a carcass. If an animal is collected, please indicate "**9**" in the post field and record this in the notes. If a wildlife agency has been notified of the occurrence of a dead protected or rare species (sea otters, turtles, cetaceans, snowy plovers or brown pelicans), please record this in the notes.

Scavenged (Y/N/U)
Most carcasses are scavenged when they are fresh and newly deposited on the beach. Typical scavengers include gulls, coyotes, turkey vultures and shore crabs. Scavengers target the breast of birds and eyes and other orifices of marine mammals. If the carcass has been scavenged, skin will be torn or ripped, exposing the underlying tissue. Record "**Y**" (yes) in this field if there is evidence of scavenging and "**N**" (no) if there hasn't been scavenging (i.e., the carcass is intact). Record "**U**" (unknown) if the carcass is too old and mummified to determine scavenging.

Cause of Death (1- 4)
Try to determine probable cause of death, such as **1**) shot, look for both entry and exit wound as scavenger pecks can look very similar (sometimes an x-ray is necessary to see bullet fragments, **2**) tangled in fishing line or net, make sure that the line didn't wrap around animal after it died, look for signs of wearing of skin or feathers near entanglement site, **3**) tangled in plastic, **4**) unknown, if other, write in notes field. Describe in notes and take photos to document cause of death. Generally, you will not be able to determine cause of death during your beach survey unless the carcass is really fresh. Collect fresh (condition 2) specimens for necropsy to determine other causes.

Oiled (Y/N/U)
Check each bird and mammal for oiling. You will only be able to determine oiling of carcasses in relatively good condition and that have not been scavenged extensively. Record "**Y**" (yes) if oiled, and continue to describe extent and where oiled in next two fields. If the animal is not visibly oiled, record "**N**" (no), and write dashes in the next two fields. If the carcass is not intact enough to determine if it is oiled or not, record "**U**" (unknown) in this field. Be conservative and careful, dried blood, and diatom growth on feathers can be mistaken for oil. Oil tends to make the tiny barbules of the feather stick together, whereas diatoms will grow along these structures, making it look frayed. If a bird was oiled for a while before dying, it may also have oil on its bill from preening oiled feathers.

Oil Extent (1-4)
Estimate the percentage of the surface of the body that is covered by the oil. The codes are **1**) small globules, <2% of the body, **2**) 2-33% of the body, **3**) 34-66% of the body, **4**) 67-100% of body. If it is covering the entire ventrum, this is considered 50%. Take a photo of the oiled area and another of the head to verify the identity of the animal for documentation. Continue description in next field.

Where oiled (1-7)
Examine the animal to determine which parts have been exposed to oil. Code as **1**) dorsal only (back), **2**), ventral only (belly), **3**) entire body, **4**) head only, **5**) feet only, **6**) wings or flippers only, **7**) other, please record description in notes if oiling does not fit into any of the other categories. Most often, birds are oiled on the ventrum when they roost on the water, whereas pinnipeds tend to be oiled on the head and shoulders when they surface.

Photo (Y/N)
Take a photo of animals which are oiled, entangled or show other evidence of human-related activities (i.e., six-pack plastic rings around body). Photograph banded or tagged animals, especially if cause of death is evident. Also take photos of interesting finds, such as sharks, unusual flotsam or jetsam. Indicate "**Y**" (yes) if a photo was taken and record roll and frame number in notes column. Record "**N**" (no) if no photo was taken. Photographs are optional. Please send in your photos via email or regular mail with your monthly data submission.

Tag (Y/N)
Tag refers to tags or other markings (brands, bands) applied by other researchers. Check both legs of birds for bands and all flippers of pinnipeds for tags, if none, record "**N**" (no) in this field. If the animal is tagged or marked in any way, such as a metal leg band, brand mark, or plastic flipper tag, indicate "**Y**" (yes) in the Tag field. Describe color, location, and number of tag in notes field. For example, you would record "TAG = Y, NOTES = #1209-23478 metal leg band (on right leg), collected". All tags are reported by the data manager to the national bird banding lab (birds), National Marine Fisheries Service (marine mammals), California Department of Fish and Game (sea otters), or U. S. Fish and Wildlife Service (endangered species).

Notes
Use this field to record more detailed information from any of the other data, such as unusual species (not on list), measurements (standard length = nose to tip of tail), tag number, location and description, Photo roll and frame number, disposition of animal if it has been removed from beach (i.e., collected for necropsy, Moss Landing Marine Lab)

Appendix B: Datasheets

Page 1 of ___

Beach COMBERS Data Form

(please use pencil)

Date__________________ **Surveyor Names** ________________________________ ________________________________	**Time dedicated to the survey (h:mm)** Survey ____ Travel ____ Online Data entry ____ Other ____ ____ ____ ____ ____

Beach segment: Segment number_____

Segment name____

Northern boundary____

Southern boundary____

Start time________ End time________

Weather: sunny__, overcast__, drizzle__, or rain__ **Wind:** calm__, light__, moderate__, or strong__	**Tar balls:** Number found _____ (count to 10; 11 to 50; 51 to 100; 101 to 1,000; more than 1,000) Number collected _____ Size range (Diameter inches)_________
Marine mammals: Number Called in ____	**Data entered on line:** Yes ____ No___

General comments (oiled wildlife, sampled collected, unusual sighting, additional surveyors, etc.)**:**

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Return to: Beach COMBERS-MLML, 8272 Moss Landing Road, Moss Landing, Ca 95039
Telephone: (831) 771-4422

Version 2. May 2010

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Name: ______________________ **Date:** ____________

Beach COMBERS Data Form (please use pencil)

				Toe Clipping			Cause of		Oil	Where			
Species	Condition	Sex	Age	previous	post	Scavenged	Death	Oiled	Extend	Oiled	Photo	Tag	Comments

Codes for Beached Organisms Categories

Condition:	**1** (live dying). **2** (fresh dead), **3** (decomposing, **4** (dried, mummified), **U** (unknown)
Sex:	**F** (female), **M** (male), **U** (unknown
Age:	**HY** (hatch year), **AHY** (after hatch year), **FY** (1^{st} year), **SY** (2^{nd} year), **TY** (3^{rd} year), **IM** (immature), **AD** (adult), **PC** (pup, newly hatched chick/egg, or calf), **U** (unknown)
Toe Clipping:	Previous indicates number of toes clipped or twine for marine mammals when you encountered animal. Leave blank if one foot is missing and note in comments, Post indicates number of toes clipped when you left. Leave blank if no toe to clip. Indicate "6" if all toes have been clipped on bird with two feet. Indicate "8" if all toes have been clipped on bird with one foot. Indicate "9" if animal removed from beach. Use comments if necessary.
Scavenged:	**Y** (yes), **N** (no), **U** (unknown)
Cause of Death:	**1** (shot), **2** (tangled in fishing net/line), **3** (tangled in plastic), **4** (unknown)
Oiled:	**Y** (yes), **N** (no), **U** (unknown)
Oil Extend:	**1** (small globule, <2% of body), **2** (2-33% of body), **3** (34-36% of body), **4** (67-100% of body)
Where Oiled:	**1** (dorsal only), **2** (ventral only), **3** (entire body), **4** (head only), **5** (feet only) **6** (wings/flippers only) **7** (other)
Photo:	**Y** (yes), **N** (no)
Tag:	**Y** (yes), **N** (no)
Comments:	Indicate number, color, and location of any tag present; photo information; and bird with any missing feet. If marine mammal, include length measurements, location and if called in. Note disposition and label of removed animal.

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Version 2. May 2010

BeachCOMBERS Species Code List

Marine birds	Code
Loons - Gaviidae	
Arctic Loon	ARLO
Common Loon	COLO
Pacific Loon	PALO
Red-throated Loon	RTLO
Yellow-billed Loon	YBLO
Unidentified Loon	LOON
Grebes - Podicipedidae	
Clark's Grebe	CLGR
Western Grebe	WEGR
Clark's/Western Grebe	CWGR
Eared Grebe	EAGR
Horned Grebe	HOGR
Pied-billed Grebe	PIGR
Red-necked Grebe	RNGR
Unidentified Grebe	GREB
Tubenoses - Procellariidae	
Black-footed Albatross	BFAL
Laysan Albatross	LAAL
Black-vented Shearwater	BVSH
Buller's Shearwater	BUSH
Flesh-footed Shearwater	FFSH
Pink-footed Shearwater	PFSH
Short-tailed Shearwater	SHOS
Sooty Shearwater	SOSH
Unidentified Shearwater	SHSP
Northern Fulmar	NOFU
Ashy Storm-petrel	ASSP
Black Storm-petrel	BLSP
Fork-tailed Storm-petrel	FTSP
Leach's Storm-petrel	LHSP
Least Storm-petrel	LTSP
Unidentified Storm-petrel	SPSP
Unidentified Procellarid	PROC
Auks - Alcidae	
Cassin's Auklet	CAAU
Ancient Murrelet	ANMU
Marbled Murrelet**	MAMU
Xantus's Murrelet	XAMU
Craveri's Murrelet	CRMU
Common Murre	COMU
Horned Puffin	HOPU
Tufted Puffin	TUPU
Rhinoceros Auklet	RHAU
Pigeon Guillemot	PIGU
Unidentified Alcid	ALCD
Cormorants & Pelicans - Pelacaniformes	
Brandt's Cormorant	BRAC
Double-crested Cormorant	DCCO
Pelagic Cormorant	PECO
Unidentified Cormorant	CORM

Marine birds (cont.)	Code
Brown Pelican	BRPE
White Pelican	WHPE
Scoters	
Black Scoter	BLSC
Surf Scoter	SUSC
White-winged Scoter	WWSC
Unidentified Scoter	SCOT
Phalaropes	
Red Phalarope	REPH
Red-necked Phalarope	RNPH
Unidentified Phalarope	PHAL
Gulls, Terns, Jaegars - Lariidae	
Bonaparte's Gull	BOGU
California Gull	CAGU
Glaucous Gull	GLGU
Glaucous-winged Gull	GWGU
Heerman's Gull	HEEG
Herring Gull	HERG
Laughing Gull	LAGU
Mew Gull	MEGU
Ring-billed Gull	RBGU
Sabine's Gull	SAGU
Thayer's Gull	THGU
Western Gull	WEGU
Black-legged Kittiwake	BLKI
Unidentified Gull	GULL
Caspian Tern	CATE
Elegant Tern	ELTE
Forester's Tern	FOTE
Common Tern	COTE
Royal Tern	ROTE
Least Tern	LETE
Unidentified Tern	TERN
Parasitic Jaeger	PAJA
Pomarine Jaeger	POJA
Long-tailed Jaeger	LTJA
South Polar Skua	SPSK
Unidentified Jaeger	UNJA
Unidentified/Others	
Unidentified non-marine	NPSS
Unidentified bird	UNID
Unidentified dove/pigeon	DOVE
Unidentified raptor	RAPT
Unidentified shorebird	SHOR
Unidentified duck/goose	DUCK

Marine Mammals	Code
Baleen Whales - Mysticetes	
Blue Whale	BAMU
Fin Whale	BAPH
Gray Whale	ESRO
Humpback Whale	MENO
Minke Whale	BAAC
Sei Whale	BABO
Unidentified Whale	WHAL
Toothed Whales - Odontocetes	
Bottlenose Dolphin	TUTR
Long-beaked Common Dolphin	DECA
Short-beaked Common Dolphin	LIBO
Unidentified Common Dolphin	UNDE
Northern Right Whale Dolphin	LAOB
Pacific White-sided Dolphin	KOBR
Risso's Dolphin	DEDE
Killer Whale	OROR
False Killer Whale	PSCR
Unidentified Dolphin	DOLH
Harbor Porpoise	PHPH
Dall's Porpoise	PHDA
Unidentified Porpoise	PORP
Baird's Beaked Whale	BEBA
Cuvier's Beaked Whale	ZICA
Hubb's Beaked Whale	MECA
Unidentified Beaked Whale	BEAK
Sperm Whale	PHMA
Unidentified Toothed Whale	ODON
Seals and Sea Lions - Pinnipedia	
California Sea Lion	ZACA
Guadalupe Fur Seal	ARTO
Steller's Sea Lion	EUJU
Northern Fur Seal	CAUR
Unidentified Otariid	OTAR
Elephant Seal	MIAN
Harbor Seal	PHVI
Unidentified Phocid	PHOC
Unidentified Pinniped	PINN
Otters - Mustelidae	
Sea Otter***	ENLU
River Otter***	LUCA

Other Vertebrates	Code
Sea Turtles	
Eastern Pacific Green Turtle	PGTR
Hawksbill Turtle	HBTR
Leatherback Turtle	LBTR
Loggerhead Turtle	LHTR
Pacific (Olive) Ridley Turtle	PRTR
Unidentified Turtle	UNTR
Unidentified & Others	
Unid. Not marine mammal	NMMA
Unid. Marine mammal	UNMM
No birds or mammals on survey	NNNN
Fish or Shark	FISH

*** If code is not on list, please spell out name in notes**

**** Please collect all Marbled Murrelets, even if you are not sure of ID**

***** Report all live or dead otters to MB Aquarium or CDFG**

Contacts:

	CA Dept. Fish and Game -831-469-1719	Sample drop-off, oiled wildlife
	Marine Mammal Center 831-633-6298	Marine mammals - LIVE
***	Monterey Bay Aquarium 831-648-4840	Sea Otters - live or dead
	Moss Landing Marine Lab 831-771-4422	Marine mammals - dead - MTY County
	Long Marine Lab - UCSC 831-212-1272	Marine mammals - dead - SC County
	Native Animal Rescue 831-462-0726	Birds - live - Santa Cruz County
	SPCA Monterey Bay 831-373-2631	Birds - live - Monterey County
	State Park Dispatch 831-429-2851	Emergencies or Oil on the beach

Appendix C: Timeline of products, posters, presentations and accomplishments

2008
Contributed to paper: "Entanglement of marine birds and mammals and seabirds in central California and north-west coast of the United States 2001 -2005" by E. Moore et al. *in press.* Marine Pollution Bulletin
Contributed to Poster: C. Gibble, Monterey Bay National Marine Sanctuary Currents Symposium 2008, Oceans of Change: Our Climate, Our Sanctuary, Our Future, April 5, 2008.
Contributed to Poster: E. Phillips, Monterey Bay National Marine Sanctuary Currents Symposium 2008, Oceans of Change: Our Climate, Our Sanctuary, Our Future, April 5, 2008.
Contributed to Presentation: "Plastic Ingestion by Seabirds Used to Quantify and Evaluate Trends in Pollution" H. Nevins, et al. NOAA Marine Debris Forum, April 1-3, 2008, Bethesda, MD
Presentation: "A decade of BeachCOMBERS: 1997-2007" Santa Cruz Bird Club, May 2008
Training: Bird identification in the field, Team Ocean, May 10, 2008

2007
Paper: "Beached birds and physical forcing in the California Current" by Parrish, J.K., N. Bond, H. Nevins, N. Mantua, R. Loeffel, W. T. Peterson, and James T. Harvey. 2007. Marine Ecology Progress Series 352: 275-288.
Contributed to MS thesis: "Entanglement of marine species: a case study in central California" by Emma Moore, Imperial College, Univ. of London, London, UK, Oct 2006.
Contributed to Poster: "Bird entanglements observed during beach monitoring surveys", E. Moore, S. Lyday, J. Roletto, K. Litle, H. Nevins, and J. Harvey. Pacific Seabird Group Meeting, 7-11 February, Asilomar, CA.
Training: 22 new volunteers were trained, MLML.
Training: Team Ocean, MBNMS, May 2007.

2006
Poster: "BeachCOMBERS: using surveys of beached marine birds to monitor natural and human-related mortality in the Monterey Bay National Marine Sanctuary", MBNMS Currents Symposium, March, 2006
Presentation: "BeachCOMBERS: using surveys of beached marine birds to monitor natural and human-related mortality in the Monterey Bay National Marine Sanctuary", Ecology and Management of Seabirds, The Wildlife Society, Western section annual meeting 2006.
Training: "Life Beneath the Surface" presentation of sanctuary research, H. Nevins August 16, 2006.
Training: Moss Landing Marine Laboratories
Training: Team Ocean, MBNMS, April 2006.
Volunteer appreciation: Association of Monterey Bay Area Governments and Monterey Bay National Marine Sanctuary, Reflection awards, Monterey Marriott, March 3, 2006.Volunteers of the year: Glen Seiler & Pamela Kearby

2005
Report: "BeachCOMBERS: Coastal Ocean Mammal & Bird Education and Research Surveys in central California, 1997-2004" Moss Landing Marine Laboratories, March 3, 2005. 32 pp.
Preliminary Report: "Report on CA Seabird Mortality Event, January – March, 2005" by H. Nevins, J. Harvey, M. Miller, D. Jessup, S. Lyday, and J. Roletto. June 20, 2005.
Presentation: "Seabirds as indicators of plastic pollution in the North Pacific", Nevins et al. Plastic Debris: Rivers to Sea Conference, September 7-9, 2005, Redondo Beach, CA
Presentation: BeachCOMBERS: Coastal Ocean Mammal & Bird Education and Research Surveys in central California, 1997-2004. Pacific Seabird Group Meeting, Portland, OR, January 21, 2005
Poster: "BEACHCOMBERS: Using surveys of beached marine birds to investigate natural and human-related the Monterey Bay National Marine Sanctuary, 1997 – 2004", Currents Symposium, CSUMB, March 2005

Article: “BeachCOMBERs update” by H. Nevins and J. Harvey. Ecosystem Observations 17:18-19
Contribution to article: “Winter mortality of surf scoters” L. Henkel and H. Nevins, J. Harvey, and S. Benson Ecosystem Observations 2005:19-20.
Award: MBNMS volunteer of the year award – Glenn Seiler & Pam Kerby, March 3, 2005
Training: Volunteer refresher course, Moss Landing Marine Laboratories, June 4-5, 2005.
Outreach/Education: Migration Festival, Seacliff State Park, February 12, 2005, Aptos, CA

2004
Article: “Mortality of Northern Fulmars in Monterey Bay” H. Nevins and J. Harvey. Ecosystem Observations, 2004.
Poster: “An unusual mortality of Northern Fulmar (*Fulmarus glacialis*)”, Harvey et al. Currents Symposium “Clean Waters, Healthy Oceans”, California State University Monterey Bay, March 6, 2004.
Presentation: “An unusual mortality of Northern Fulmar (*Fulmarus glacialis*)”, Pacific Seabird Group Meeting, La Paz, Mexico, January 2004.
Presentation: “An unusual mortality of Northern Fulmar (*Fulmarus glacialis*)”, The Wildlife Society Meeting, Rohnert Park, CA, February 28, 2004.
Award: NOAA Environmental Hero, April 2004
Award: Certificate of Congressional Recognition, Senator Sam Farr, April 25, 2004
Meeting: Beach Survey Program (BeachCOMBERS) and oil spill response (OSPR): data sharing and communication, Moss Landing Marine Laboratories, January 9, 2004.
Meeting: CDFG Oiled Wildlife Response Plan, Yolo Wildlife Area, Davis, CA, May 3, 2004.
Training: NOAA B-WET Teacher Enhancement Workshop, Moss Landing Marine Laboratories, July 27, 2004.
Presentation: “When to call a die-off unusual: documenting stranding rates with systematic beach surveys”, CA Marine Mammal Stranding Network Symposium” by T. Brookens, H. Nevins & J. Harvey, Santa Barbara, CA, March 18-20, 2004.
Presentation: “An unusual mortality of Northern Fulmar (Fulmarus glacialis)”, California Council for Wildlife Rehabilitators, Tenaya Lodge, Yosemite, CA September 18, 2004.
Presentation: “Tale of two seabirds: life on wing and under waves” H. Nevins 7 J. Adams, American Cetacean Society, Hopkins Marine Lab, Monterey, CA, Sept. 30, 2004.
Contributed to thesis: “Diet, demography, and diving behavior of the common murre (*Uria aalge*) in central California.” H. Nevins, Moss Landing Marine Laboratories and San Francisco State University, Oct. 24, 2004.
Training: Team Ocean, Monterey Bay Sanctuary, Monterey, CA, May 25, 2004.

2003
Preliminary Report: Mortality of Northern Fulmar (*Fulmarus glacialis*) in Monterey Bay during winter 2003. H. Nevins & J. Harvey, Moss Landing Marine Laboratories, 3 pp.
Poster: "Monitoring changes in oiling rates of beached marine birds in the Monterey Bay National Marine Sanctuary" Currents Symposium, CSUMB, March 15, 2003.
Meeting: CDFG-OSPR regarding oiled wildlife response plan, Moss Landing Marine Laboratories, December 29, 2003.
Article: ”Unusual debris: glass fishing floats and whisky bottles”
Training: “Murre aging & sexing” with BeachWATCH program, 17 participants, Marine Wildlife Veterinary Care & Research Center, Santa Cruz, CA. Nov. 15, 2003
Training: refresher course 3 Cambria volunteers, Moss Landing Marine Laboratories, December 3, 2003
Enrichment: 6^{th} Anniversary Potluck, Moss Landing Marine Laboratories, August 14, 2003
Training: Team Ocean, Monterey Bay Sanctuary, Monterey, CA, May 2003

2002
New Beaches (5): Sand Dollar, Big Sur; Castle Rock, Santa Cruz; 4-mile, Santa Cruz, spilt beach 11 (11N-Waddell/11S-Scott’s); Del Monte, Monterey is resumed
Article: “Monitoring Mortality Events and Oiling of Seabirds and Marine Mammals Using Beach COMBERS Data“ by H. Nevins and J. Harvey, MBNMS Ecosystem Observations, 2002.
Newsletter Article: “Beached Bird Surveys, Dead Birds Do Tell Tales.” Ely, E. 2002. The Volunteer Monitor, the National Newsletter of Volunteer Watershed Monitoring 14(1) 10-13.

Poster: "Detecting Oiled Seabirds in the Monterey Bay" at the 29th Annual Meeting of the Pacific Seabird Group, Santa Barbara, California, February 20-23, 2002
Poster: "Detecting Oiled Seabirds in the Monterey Bay" at the MBNMS Currents Symposium 2002, March 9, CSUMB.
May 2002: Completed training class for 22 new + 4 sanctuary volunteers.
Outreach/Recruitment: 10^{th} Anniversary Celebration Ocean's Fair, Monterey
Outreach/Recruitment: 10^{th} Anniversary Celebration, San Simeon, CA Table (volunteers P. & C. Adams) Sept. 5, 2002.
Outreach/Education: "Seabird Ecology" unit of Explorations in Marine Science – MLML & John Hopkins University, 44 students. November 2, 2002.
Monterey Bay National Marine Sanctuary Volunteer Appreciation Event. Star of the Sea certificate "In great appreciation for your generous contribution of time and dedication to the Monterey Bay National Marine Sanctuary, preserving it for future generations. We, at NOAA's National Marine Sanctuaries, extend our thanks and gratitude." Presented to the Beach COMBERS June 8, 2002.

2001
May 2001: Added 6 new beaches to the program in the southern region of MBNMS. Two day training class for 17 new volunteers.
Draft Report: "Beach COMBERS (Coastal Ocean Mammal / Bird Education and Research Surveys) May 1997 - December 2000." Submitted to the Monterey Bay National Marine Sanctuary, September 2001
Presentation: "Beach COMBERS a Beach Monitoring Program to Assess Natural and Anthropogenic Changes in Populations of Birds and Mammals in the Monterey Bay National Marine Sanctuary" Sixth Biennial Workshop on Research in the Gulf of the Farallones National Marine Sanctuary October 25, 2001

2000
Contribution to paper: "Central California gillnet effort and bycatch of sensitive species, 1990-98." Proceedings of an International Symposium of the Pacific Seabird Group, Semi-Ah-Moo, Washington, February, 1999.
Contribution to article: "Mortality of sea lions along the central California coast linked to a toxic diatom bloom." Scholin et al. 2000 NATURE 403(6) 80-84.
Poster: "Can we distinguish between natural and anthropogenic beach deposition events?" at the MBNMS Currents Symposium 2000, March 18, Santa Cruz, California. Awarded Best Thematic Poster.

1999
Article: Ecosystem Observations, Annual Report for the MBNMS, Article: "Seabirds within Monterey Bay - Observations of the quick and the dead."
Poster: "Monitoring Beachcast Marine Birds And Mammals In Monterey Bay" at the MBNMS Currents Symposium 1999, March 20, Seaside, California.
Report: "Establishing a Beach Monitoring Program to Assess Natural and Anthropogenic Changes in Populations of Birds, Mammals, and Turtles in the Monterey Bay National Marine Sanctuary." Moss Landing Marine Laboratories Technical Publication 99-03.

1998
Award: Volunteer Recognition Award, presented to Beach COMBERS by Under Secretary of Commerce for Oceans and Atmosphere, at the National Oceans Conference, Monterey, California.
Article: Ecosystem Observations, Annual Report for the MBNMS, Article: "Deposition of marine birds and mammals on Monterey Bay beaches."
Poster: "Monitoring beachcast seabirds in Monterey Bay" at the 25th Annual Meeting of the Pacific Seabird Group, Monterey, California.
Poster: "Monitoring beachcast seabirds in Monterey Bay" at MBNMS Currents Symposium 1998, March 7, Santa Cruz, California.
Newspaper article: "Beached creatures tell tales: counters keep grim but vital tally." February 5, Californian, Salinas, California.
Newspaper article: "Combing the beach a learning experience." February 1, Press Democrat, Santa Rosa, California.

Newspaper article: "Beach COMBERS record beaches' dead." February 1, The Bryan-College Station Eagle, Texas.
Newspaper article: "Walking a grisly patrol: BeachCOMBERS record beaches' dead." January 9, Monterey County Herald, Monterey, California.
MBNMS Newsletter: "Beach COMBERS take to the sands!"

1997
Newspaper article: "Survival fight for ocean foul: Volunteers scramble to save hundreds of birds from oily residue in Monterey Bay." October 27, San Jose Mercury News, San Jose, California.
Newspaper article: "Seabird deaths mystify wildlife experts." August 13, San Jose Mercury News, San Jose, California.
Beach COMBERS monitoring program begins in May.