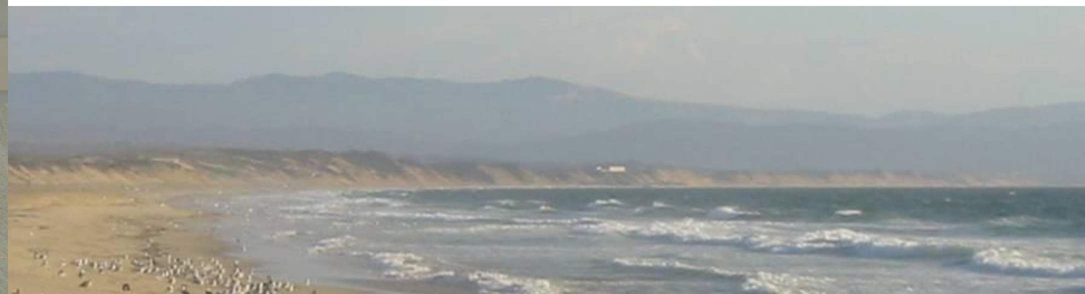

Chronic Oil and Seabirds

Scientific Study and Evaluation Program (SSEP)
Of the California Department of Fish & Game, Office of Spill Prevention and Response (CDFG-OSPR)

FINAL REPORT

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Cover: Birds affected by chronic oiling contrasting types of oil and season. Chronic oiling is often not attributable to a known source, despite considerable wildlife damages. An oiled Common Murre (top) was killed when it was undergoing flight feather molt and was not able to fly prior to being oiled by an unknown source (MWVCRC# 06-0102, Coll. 1/27/2006). During tarball events, small pieces of weathered oil are scattered along the wrackline (Morro Bay, photo: Melissa Boggs, CDFG). Common Murre in adult breeding plumage (bottom) was killed by mystery spill later attributed to the shipwreck S.S. *Jacob Luckenbach* (MWVCRC#10-0885). Background Salina River State Beach, Monterey Bay, CA (photo: H. Nevins, MWVCRC).

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Abstract

The goal of this study was to determine trends and sources of chronic oiling and other mortality factors affecting marine birds in central California, provide this information to California Department of Fish and Game Office of Spill Prevention and Response (CDFG-OSPR) to determine the species and populations affected by oil, and to help guide appropriate mitigation and restoration actions. This information is central to CDFG-OSPR's mission "*to provide best achievable protection of California's natural resources by preventing, preparing for, and responding to spills of oil and other deleterious materials, and through restoring and enhancing affected resources.*" Specifically, our objectives were to 1) quantify and document trends in chronic oiling and other mortality factors by conducting necropsies of seabirds collected by beach survey programs, rehabilitation centers, and state and federal resource agencies, 2) identify sources of oil by analyzing oiled feather samples and comparing them to known specimens at the CDFG-OSPR Petroleum Chemistry Lab (PCL), and 3) increase understanding of the population-level affect of oil spills on marine birds by examining post-litigation specimens.

Our results indicate chronic oiling is the cause of 1 to 4% of annual mortality of marine birds in central CA. Species groups most affected by chronic oiling were alcids, loons, grebes, cormorants, pelican, procellarids, phalaropes, and gulls; these same species are also those most affected by catastrophic oil spills. We found several other mortality factors which continue to affect CA seabirds, including fishery entanglement, trauma, biotoxins, and to a lesser extent, plastic ingestion. We found that demographic impacts of oiling events depend upon the season in which the oil spill occurs. Winter events such as *Luckenbach* spills affected first year birds more than adults whereas late summer and fall spills (e.g, *Kure*, *Stuyvesant*) affected more adults than expected. These results may be useful in determining population-level impacts of both chronic and catastrophic oiling events in the future and designing appropriate mitigation plans.

1.0 Background

Oil pollution is a significant source of mortality for marine birds in central California (Carter 2003) and is recognized as a problem for seabirds worldwide (Heubeck et al. 2003). To date most reports of wildlife impacts are limited to *catastrophic spills* of sufficient geographic scope and large numbers of casualties to warrant natural resource damage claims for litigation (i.e., responsible party can be identified and held financially responsible). *Mystery spills* occur and have been well documented in California, often affecting large numbers of animals, but cannot be readily attributed to a known source or responsible party. Mystery spills have been attributed to fouling from petroleum leaking from shipwrecks (e.g. *T.V. Luckenbach*, *S.S. Palo Alto*) and other fouling agents such as harmful algal bloom events (e.g. 2007 Monterey Bay Mystery Spill, Jessup et al. 2009). By contrast, *chronic oil pollution* is defined as oiling of wildlife not associated with a particular spill event or responsible party. Chronic oiling is caused by small or undetected spills, such as spilled diesel from small boats, runoff from streets and parking lots, and natural seep oils, or from illegal discharges at sea. Cumulative chronic impacts to individual oiled birds or to specific breeding colonies can be hundreds to thousands of birds per year —equivalent to damages incurred during a small-scale spill. Documenting chronic oiling impacts requires long-term beach survey monitoring (Camphuysen and Huebeck 2001, Roletto et al. 2003).

The goal of this study was to determine trends and sources of chronic oiling and other mortality factors affecting marine birds in central California. By better quantifying seabird mortality factors, this study was to provide information to California Department of Fish and Game, Office of Spill Prevention and Response (CDFG-OSPR) to determine the annual impact to species and populations, and to help to inform appropriate mitigation and restoration actions. This information is central to CDFG-OSPR's mission:

> *"The mission of Office of Spill Prevention and Response (OSPR) is to provide best achievable protection of California's natural resources by preventing, preparing for, and responding to spills of oil and other deleterious materials, and through restoring and enhancing affected resources."*

Specifically, our objectives were to 1) quantify trends in chronic oiling and other mortality factors by conducting necropsies of seabirds collected by beach survey programs, rehabilitation centers, and state and federal resource agencies, 2) identify sources of oil by analyzing oiled feather samples at the CDFG-OSPR Petroleum Chemistry Lab (PCL), and 3) increase understanding of seasonal affects of oil spills on marine bird populations by examining post-litigation specimens collected during winter and summer.

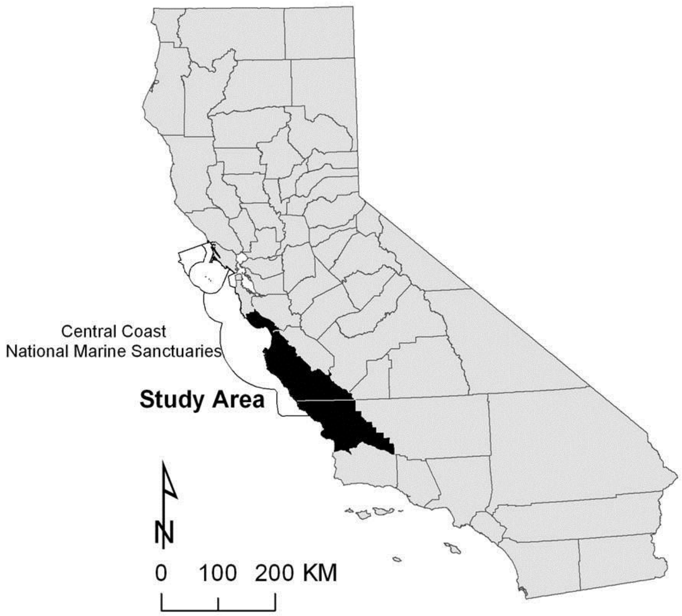

Figure 1. Study area includes Santa Cruz, Monterey and San Luis Obispo Counties (black) and adjacent to waters of Monterey Bay, Gulf of the Farallones, and Cordell Bank National Marine Sanctuaries (line).

2.0 Methods

2.1 Quantify Mortality Factors affecting marine bird populations

The study area included beaches of Santa Cruz, Monterey and San Luis Obispo Counties and coastal areas adjacent to waters of the central coast National Marine Sanctuaries (Figure 1). To quantify the number of species affected and document trends in chronic oiling, we examined dead stranding records from the beach survey program in Monterey Bay National Marine Sanctuary (Coastal Ocean Marine Mammal and Bird Education and Research Surveys [BeachCOMBERS]) and the main rehabilitation center in the area (Society for the Prevention of Cruelty to Animals of Monterey County [MSPCA]). We compared oiling rates from beach survey records and MSPCA intake records from 2005-2009 to estimate a minimum number of birds killed by chronic oil in the Monterey Bay area in an average year.

To verify and quantify other mortality factors staff at the CDFG-OSPR Marine Wildlife Veterinary Care and Research Center, Santa Cruz (MWVCRC) conducted systematic necropsies of all seabirds submitted during 2005 – 2007. Carcasses were collected opportunistically by beach survey volunteers (BeachCOMBERS and Beach Watch in Gulf of the Farallones and Cordell Bank National Marine Sanctuaries), by central coast rehabilitations organizations (MSPCA, International Bird Research and Rescue Center) and other Oiled Wildlife Care Network (OWCN) participants and state and federal resource agencies (CDFG, State Parks, Fish and Wildlife Service. In 2005-2009, disease investigations were conducted by experienced biologists (E. Donnelly, C. Gibble, H. Nevins, E. Phillips, C.Young), a veterinarian (A. Wells) and veterinary pathologists (T. Zabka, M. Miller) at MWVCRC. Gross examinations were performed to determine probable sources of mortality, and factors contributing to injury. All necropsies were performed in a systematic manner using standard datasheets (Appendix A). Case reports, database and tissue samples were archived at MWVCRC.

For all species, we placed mortality factors into one of nine categories adapted from Newman et al. (2007) including: *Fishery Interaction* (gill net, drownings, entanglement in recreational or commercial gear); *Trauma/broken bones* (human-related boat-strikes, collisions, and “natural” causes such as predator interactions); *Environmental* which included starvation and emaciation evidenced by severely depleted body, fat and muscle mass; *Infectious* which included any identified fungal, bacterial, or viral pathogen; *Pathology with no Etiology* defined as lesions or other abnormalities on gross exam, pending pathological review or no diagnosis made; and *Toxicosis* which included chemical, metal poisoning (e.g. lead sinker); for *Oil*, (we assumed any external oiling was the primary cause of death of that individual (*sensu* Oka and Okuyama 2000)); and *Biotoxin* (e.g. Domoic Acid) based on by internal organ damage and confirmed with laboratory testing; *Plastic* limited to cases where the plastic ingestion had created gastrointestinal blockage which caused mortality; and *Undetermined* for cases where the carcass was too decomposed or scavenged to determine cause of death.

2.2 Identify sources of oiling on feathers

MWVCRC staff sampled feathers from a subset of birds collected from various programs using similar protocols to those used during oil response (OWCN 2000). For all oiled birds, we followed standard evidence sampling protocols established by the OWCN Wildlife Processing Unit (OWCN 2000). All oiled birds were examined externally to determine the extent (% of body), oiling depth, and description of oiling. Birds were then photographed and a sample of oiled feathers taken. Data from each bird was entered in an “individual oiled bird” intake log and all samples were labeled with a unique number (i.e. D100, D101, etc.). We selected a sub-sample of oiled birds for feather analysis based on year and species. We limited our retrospective analysis to birds collected after winter 2003 since a previous study had looked at chronic oil sources prior to that time (Hampton et al. 2003). We also limited petroleum analysis to two of the most oiled-affected species, Common Murre (*Uria aalge*) and Rhinoceros Auklet (*Cerorhinca monocerata*). We chose these species because they were resident in shelf waters – the area of interest – and we expected these samples to have less variability in the source of oiling compared with feather samples from more migratory and offshore species such as Northern Fulmars (*Fulmarus glacialis*). Samples were analyzed and interpreted by Susan Sugarmann, Shane Stahl, and Marida Martin at CDFG Petroleum Chemistry Laboratory (PCL). PCL personnel verified petroleum content and compared hydrocarbon signatures or “fingerprints” with those of reference samples from known sources in their library. Reference library samples at PCL including samples of Alaska North Slope crude, Monterey Formation crude, refined products, and *Luckenbach*, Seacliff Mystery Spill, and San Simeon samples. Those feather samples which were not analyzed were archived at PCL. Many tarball samples were collected during beach surveys; however, since these samples were not tied to wildlife damages, we did not analyze these samples, but archived them at PCL for future studies.

2.3 Post-litigation specimen investigations

We examined marine birds that had been held for litigation from past oil spills to increase population level understanding of specifies affected, demographics and geographic origin of the affected populations. Once the OSPR natural resource damage assessment (NRDA) and litigation processes were completed, specimens were made available for this study. We documented morphometrics, sex, and age (Nevins and Carter, 2003). Specimens were classified into one of three age/reproductive categories based upon bill and wing size, plumage, and gonad maturity, bursa size, and skull ossification and when necessary this was confirmed by histopathology. We classified individuals into three age categories: 1) adult - reproductively active (enlarged testes/ ripe ova) or non-active; 2) subadult/immature – >1yr, immature gonads; and 3) hatch-year/first year - born within the calendar year or first winter birds.

In addition, tissue samples (bone, feather, muscle) from these specimens were archived at MWVCRC and made available for use by collaborators at UC Santa Cruz and UC Berkeley for stable isotope analyses to address community-level or species-specific questions (Kena Fox-Dobbs, UCSC; Allison Moody, UCB). Muscle and liver samples were collected for a population genetics study (Diana Humple, Sonoma State University). Additional samples of muscle were submitted to a study on the prevalence of protozoal infections in marine animals (Robin Miller and Michael Grigg, National Institute of Health). The results of these studies are reported elsewhere.

Based on post-litigation examinations, we developed a web-based photo collection of seabirds, including photos of beaks, feet, carina, and other identifying parts from which dead, oiled and scavenged birds could be identified in the future. This image library will provide a reference tool for OSPR staff and other trustees which can be easily accessed in future oil spills, using personal computers, during wildlife processing to provide more accurate identification for NRDA analysis[1].

3.0 Results & Discussion

3.1 Quantify Mortality Factors affecting marine bird populations

3.1.1 Mortality Factors

We examined a total of 849 birds collected during 2005-2007. Birds were collected by rehabilitation centers (51 – 62%) and beach survey programs (19 – 21%), by the general public (12%), state and federal resource agencies (7%), and others (2%) in central CA (Monterey, Santa Cruz and San Luis Obispo Counties). Of the cases submitted for necropsy in 2005 (n = 157), 2006 (n = 302), and 2007 (n = 390), we found that most seabird deaths in each year (40 – 70%) were attributed to emaciation/ starvation. During the years of this study, we ranked diseases; both unidentified pathologies with no etiology (21 – 32%) and identified infectious diseases (5 – 10%) as the second most important source of mortality. The proportion of cases for which

[1] Link to image gallery: http://shutterbug.ucsc.edu/gallery/

diagnosis were undetermined (6 – 12%) decreased each year, indicating an increase in our ability to resolve disease factors. Oil (5 – 8%) and biotoxins (1 – 4%) ranked as the third and fourth most important sources of mortality. We found natural and human-related trauma in several species (5 – 9%). We also identified fishery interactions (2 – 6%) and plastic ingestion (1%) as causes of mortality to seabirds in these years (Figure 1).

We made comparisons between intake records for seabirds from MSPCA (1 January to 19 November; n = 283) with those from BeachCOMBERS in 2005 to determine if these data were suitable for comparisons in trends of mortality factors. We found at MSPCA a greater proportion of rehabilitation birds were determined to be oiled (6%) than reported by the beach survey program in 2005 (3%, n = 2141).

3.1.2 Oiling

Species composition
We examined 15,918 records of 53 coastal and marine bird species among 11 taxonomic groups using data combined from BeachCOMBER surveys and MSPCA rehabilitation records during 2005-2009 (Table 1). We found that chronic oiling affected 24 of 53 species (45%) and 7 of 11 groups. The taxa most affected by number of oiled individuals were alcids (182), procellariids (41), grebes (34), loons (23), larids (15), cormorants (12), pelicans (5), sea ducks (2) and phalaropes (2). We did not detect external oiling of any terns, kittiwakes, jaegers, shorebirds, or any non-marine species. By number, the top five species affected by chronic oil in descending order were: Common Murre, Rhinoceros Auklet, *Aechmophorus* grebes, Northern Fulmar and Pacific Loon. By percent oiled (number of oiled individuals relative to the total), loons (6%), phalaropes (3.5%) and alcids (3%) were the groups with the highest proportions affected. Among alcids, the three most pelagic species within this group - Rhinoceros Auklets and Ancient Murrelets, and Tufted Puffins – had the greatest percentages oiled. In general, the proportions oiled were greater for live strandings than for dead strandings for all taxa except the procellariiforms, where this pattern was reversed (Table 1). Of the four endangered species examined – Brown Pelican[2], Marbled Murrelet, Least Tern, Snowy Plover – only pelicans (1%) were documented as oiled.

Annual trends
A total of 196 dead oiled birds were documented by beach surveys during 2005 (n = 56), 2006 (35), 2007 (26), 2008 (54) and 2009 (25). A total of 121 live oiled birds were documented by the rehabilitation center during 2005 (17), 2006 (24), 2007 (37), 2008 (33) and 2009 (10). The combined average number of oiled birds recorded in the Monterey Bay area was 63 ± 11 birds per year (n = 5 yrs). This was a minimum number of birds affected by chronic oiling because carcass recovery is known to be a fraction of those killed.

Based on annual systematic beach surveys 2000-2009, trends in the overall annual proportion of birds oiled increased until 2003 and thereafter decreased, indicating a reduction in the background chronic oiling overall (Figure 2). From a longer time series, BeachCOMBERS have documented a continuing decrease in oiling rates since 2003

[2] In November 2009, Brown Pelicans were removed from the endangered species list.

(Figure 5). By taxonomic group, the alcids (60 – 74%) were most affected by oiling in all years, followed by procellarids (15 – 16%), and cormorants (4 – 9%), with fewer gulls (2 – 5%) and others (~2 %) affected. The composition of species oiled has changed in recent years indicated by the difference in the relative proportion oiled of Common Murres and Northern Fulmars (Figure 3). We found a monthly pattern to chronic oiling in Monterey Bay indicated by relatively low oiling rates June to September compared with greater oiling rates November through May, and the peak in March (Figure 4).

3.1.3 Entanglement

We found entanglement in recreational fishing gear (e.g. nets and or line, hooks, lures) occurred at a low-level in the study area based on beach surveys and rehabilitation data. BeachCOMBER data indicated there were a total of 72 dead beached birds entangled in fishing gear during 2005-2010 (Table 2); equal to 0.5 – 0.6% of new carcasses reported annually. Of the birds affected, all murres and loons were adults whereas most gulls were immature. MSPCA recorded an average of 17 ± 9 live stranded birds per year during 2005-2009 (n = 5 yrs). The combined average number of entangled birds recorded by BeachCOMBERS and MSPCA is 30 ± 10 birds per year (n = 5 yrs). Whereas both datasets indicated larids were the most affected taxa (31-53%), MSPCA collected more live stranded pelicans than COMBERS, who found a greater percentage of comorants affected. It should be noted that MSPCA treated and successfully released 22% of the entangled birds recovered. An additional 28% of entangled birds were transferred to International Bird Rescue Center, Cordelia.

3.1.4 Disease

To test for emerging zoonotic diseases in wild seabirds, we submitted cloacal swab samples in viral transport media for Avian Influenza testing. We also submitted cases for West Nile Virus testing, particularly among land-roosting birds (i.e., Brandt's Cormorants) when exposure was considered a possibility by the MWVCRC pathologists. All results to date for both diseases have all been negative. Results of a regional genetic quantification of protozoal parasites are reported elsewhere (R. Miller and M. Grigg, unpublished data).

3.1.5 Unusual Mortality Events

During 2005-2009, we responded to several oiling and unusual mortality events. Using data from BeachCOMBERS, we defined an"unusual" event as one for which the baseline deposition rate on beaches (carcasses per km) was *more than* the long-term mean plus two times the standard deviation. For rare species, where too little data was available to determine trends, we considered that an event warranted further investigation when total deposition was greater than that reported during the last ten years. We considered an oiling event to be significant if more than 2% of the birds encountered during a monthly beach survey were oiled (based on long-term BeachCOMBER data). We summarized the unusual mortality events during 2005-2009:

2005

- A January – February 2005 oiling event affected 30+ individual seabirds in the Monterey Bay National Marine Sanctuary from Santa Cruz to Carmel. BeachCOMBERS documented many tarballs and coincidentally dead oiled birds, but did not document any live oiled birds during this event. The tarballs were noted as "numerous" to "3 to 10 per square meter", weathered and thick, from 2 to 6 inches or more in diameter. Tarballs and oiled feather samples were submitted to the CDFG - PCL[3], the source was determined to be Monterey Formation.
- May to June 2005, we documented an unusual mortality event affecting resident species including Common Murres, Brandt's Cormorants, Cassin's and Rhinoceros Auklets. We examined 157 specimens during this time and attributed the primary cause of death to be starvation caused by a reduction in upwelling-driven primary productivity. We presented the results of this mortality event at the Pacific Seabird Group Meeting in 2005[4], and in two published articles (Nevins and Harvey 2006, Parrish et al. 2006).
- September to November 2005, Brandt's Cormorant and other oiled birds were found in a highly localized area of Seacliff State Beach in Santa Cruz Co. The source of the oil was the grounded historical landmark, *S.S. Palo Alto*. This source was linked to a previous event in September 2004. The *Palo Alto* was built in 1919 as an oil tanker by the San Francisco Shipbuilding Company in Oakland, California. It was mothballed and used for a casino, a fishing pier, and is currently closed to the public because of its deteriorating condition. By October 2006, OSPR, State Parks and contractors successfully cleaned out 505 gallons of oil, 125 cubic yards of oily sand and residue in the main hold in the ship where 173 bird remains (mostly Brandt's Cormorants, HMN pers. obs.). Two harbor seals carcasses were recovered and the wreck sealed to prevent further wildlife damage.

2006

- A January 2006 die-off of Red Phalaropes (*Phalaropus lobatus*) was documented along the central coast from Monterey Bay to the Gulf of the Farallones. Rehabilitation centers reported live stranded birds November 2005 to January 2006 which were described as "thin, cold and weak"[5] condition. MWVCRC examined 41 birds collected dead on beaches or that died in rehab centers, but the event probably affected hundreds of birds (IBRRC, *unpublished data*). The birds we examined were predominantly adults (87%), and mostly female (1 M: 7 F). The Red Phalarope is a highly pelagic, arctic breeder which migrates along the California coast in flocks numbering in the hundreds to thousands. Although not much is known about demographics of flocks, our results indicate there may be some difference in the timing of migration among different age and sex groups related to the timing of arrival and departure to/from Artic breeding sites. The majority of birds had ingested plastic (67% of 41). Based on the cases we examined, however, we determined that starvation likely related to a reduction in food availability was the primary cause of this mortality (Zabka et al. 2006).
- Two Brown Pelican (*Pelecanus occidentalis*) mortality events occurred during April and May 2006. The first was a die-off of young-of-the-year which was attributed to

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[3] PCL Accession #: RHAU 004-05-05, RHAU 004-05-06, SOSH 004-05-07, RHAU 004-05-08
[4] Parrish et al., Seabirds as indictors of marine ecosystems symposium, 15-19 February 2005, Girdwood, Alaska.
[5] Sue Campbell, Monterey SPCA reports, unpublished data.

starvation. The latter event included many adults and was attributed to Domoic Acid (DA). The DA event occurred to the south of the core study area, in Santa Barbara and Orange Counties. Information from gross necropsies was entered into a searchable database and disseminated to appropriate parties shortly after the event.

- A diesel spill occurred in a localized area in Moss Landing harbor during November 2006. Four Western Gulls were brought to MWVCRC for necropsy and samples were submitted to OSPR-PCL. Results indicated that, although these birds had prior debilitating conditions (e.g. broken wing), they were able to make a living in the harbor using offal as evidenced by good to excellent body condition until they were killed by the diesel spill.

2007

- An unusual increase in beached alcids of various species, including murres, Rhinoceros Auklets and Cassin's Auklets was detected in February and extended through much of the spring of 2007. Necropsies found that many birds were in poor body condition and this mortality may have been related to a reduction in prey availability for these species.
- During March to June 2007 an "invasion" of Horned Puffin (*Fratercula corniculata*), was detected by beach surveys, rehabilitation centers and bird watchers along the central California region (Phillips et al. 2006a). This is an unusually rare species in the area and many samples were retained by MWVCRC for museum collections.
- Domoic Acid toxicity was detected in several species of loons, cormorants, and pelicans during May and June 2007 (Phillips et al. 2006b).
- A "Mystery Spill" red tide event occurred in three pulses during November 2007 affecting mainly nearshore foraging birds. The first and third pulses involved mostly grebes, surf and white-winged scoters and the second pulse, Northern Fulmars. A total of ~700 birds were affected in this event which was attributed to a previously unreported type of dinoflagellate bloom (Jessup et al., 2009).

2008

- BeachCOMBERS detected a small signal of chronic oiling during January – February, and April to June 2008 which coincided with an increased deposition in oiled birds in rehab centers in southern CA (L. Henkel, unpublished data).

2009

- A catastrophic reduction in the availability of forage fish (northern anchovy) in May 2009 in central CA resulted in complete breeding failure at many colony areas and significant mortality of Brandt's Cormorants and other nearshore feeding loons and grebes (Nevins et al. unpublished data).
- A harmful algal bloom similar to the 2007 Mystery Spill (see above) occurred in Oregon and Washington in September and October 2009. This event affected many grebes, loons and sea ducks (Phillips et al. *in press*).
- During the winter of 2009-2010, an increased deposition of Brown Pelicans occurred throughout CA. The details of this event are reported elsewhere (Nevins et al. in prep.)

3.2 Sources of oiling on feathers

MWVCRC obtained oiled feathers from a subset of BeachCOMBER and Monterey SPCA birds and tarballs collected off beaches in the Monterey Bay National Marine Sanctuary in addition to samples collected by CDFG wardens, the public and other beach survey programs during 2005 (n = 49 bird, 67 tarballs) and 2006 (n = 32 birds, 38 tarballs), and 2007 (n = 31 birds, 19 tarballs; Table 3). In 2007, an additional 6 Horned Puffins were sampled at the request of OSPR. All of these samples were sent to PCL for fingerprint analysis and archiving.

A total of 30 samples were submitted to PCL prospectively in this study. The majority of samples were identified as Monterey Formation (21) and four samples had insufficient material to fingerprint. Of the Monterey Formation type samples, 7 of 21 could be clustered with the “Pismo Otter” (S-029-08-5) and 6 (28%) matched a common sample (S-036-09), for 13 of 21 (62%) there was no match found (Table 4). Many of the Monterey Formation types were likely related to seep activity, such as the *Pismo Otter* group which maybe related to a Pt. Conception seep (L. Henkel and M. Martin, pers. comm.) The last group likely represents non-seep oil pollution and could potentially be originating from a variety of sources. Note: the total number does not reflect the actual number of birds oiled, but rather a subset of those documented by BeachCOMBERS and others.

When the long-term BeachCOMBERS data (1997 to 2010) was synthesized with PCL results, the major sources of increased oiled seabird deposition during this period included two ships – the wrecked *Luckenbach*, the grounded vessel S.S. Palo Alto – both of which have been cleaned up in recent years (Figure 6). We documented a significant chronic oiling event in winter and spring 2008 and coincided with increased seep activity and oiled bird strandings in southern CA (L. Henkel, unpublished data). The probable source of this event is likely to be from seep activity. We identified a mystery event in 2006 for which we were unable to match to known source; of the samples analyzed, 8 were Monterey Formation source and 6 others did not match library samples (unknown; Table 4).

3.3 Examination of post-litigation specimens

We examined four sets of oil spill specimens released from litigation by OSPR including the 1997 Kure Spill, 1999 Stuyvesant Oil Spill, 2001-2002 San Mateo Mystery Spill, and the 2002-2003 *Luckenbach.* The first two spills occurred in Humboldt Bay and the later two spills were from the same origin, the *Luckenbach* shipwreck.

3.3.1 Kure Oil Spill 1997

We examined 602 carcasses collected during 7 to 22 November 1997; species examined included Common Murres (249), grebes (27), fulmars (104), and other species (222). We contacted a variety of museums and interested researchers to provide samples for their studies. Diana Humple (Sonoma State) obtained molt data and tissue samples from the grebes to examine connectivity between coastal wintering and breeding lakes using genetic markers (Humple, 2009). Of the murres we examined, were more adults (63%) than juveniles (37%; Humple et al. *in press*). Whereas the sex ratios for fulmars (n = 47) and grebes (n = 26) were not different from 1 M: 1 F, the ratio for murres was significantly skewed toward males (4 M: 1 F, df = 1, p<0.001, n = 175).

3.3.2 Stuyvesant Oil Spill 1999

We examined 334 seabirds of various species, including 231 Common Murres and 24 Marbled Murrelets collected during the *Stuyvesant* Oil Spill in Humboldt Bay in September 1999. This spill occurred during the late chick-rearing period and thus had very different demographics than the two winter spills (below). We assumed that the sample of birds we examined was representative of the population affected by the spill. From this collection, 50% were after hatch year (AHY/ASY), 50% were first year birds (HY/SY). This proportion of adults and immatures is significantly different than what one would predict based on a Leslie matrix post-breeding census (expected 87% and 13%; Chi-square = 5.91, df = 1, p = 0.018). The adult sex ratio (15 M: 1 F) was significantly skewed toward males (n = 113; p<0.001), whereas the sex ratio for immature birds (1.3 M: 1 F) was not significantly different from 1:1 (n = 113, p = 0.37). For five birds sex could not be determined.

3.3.3 San Mateo Mystery Spill 2001-2002 (SMMS) — We examined 177 Common Murres of 1,921 birds collected of all species killed by the SMMS during May 2005. This oil spill was later matched to the 1954 shipwrecked S.S. *Jacob Luckenbach* based on oil fingerprinting (Hampton et al. 2003). From this collection, 172 murres were in good enough condition to measure; of these 60% were AHY/ASY, 36% were HY/SY (first winter), and 4% could not be aged nor gender determined. This proportion of adults and immatures was significantly different than predicted based on a Leslie matrix post-breeding census (expected 87% and 13%, respectively; Chi-square = 5.91, df =1, p = 0.018). The sex ratio was 1.3:1, and 1.0:1 males to females for adult (n = 104) and immature (n = 62) age classes, respectively. Neither sex ratio was significantly different from 1:1 (p>0.05).

3.3.4 Luckenbach 2002-2003 — During November and December 2002 and January 2003, as a result of an additional release of oil from the shipwrecked *Luckenbach, more* dead oiled birds were collected and archived. We examined 166 birds, of which the majority were Common Murres (n = 163), and the remaining three were Clark's Grebes (*Aechmorphorus clarkii*, n = 2) and a Brown Pelican (n = 1). Among the murres there was a male-biased sex ratio (2 M: 1F; n = 157, p < 0.001). For the remaining 6 birds we were unable to determine the sex because the carcasses had been previously necropsied and the gonads were no longer present or intact.

4.0 Discussion & Management Implications

In this study, we assumed that any detectable external oiling of the plumage of a dead seabird was responsible for that death. This assumption is based on work by Oka and Okuyama (2000) who indicated that even a small amount of oiling can result in mortality as oiled birds consume energy rapidly due to loss of thermoregulatory ability as a result of plumage oiling.

Chronic oiling from unidentified sources was documented in the 1980s as affecting 6% of marine birds beached in central California (Bodkin and Jameson 1991). Prior to the *Luckenbach* clean-up in 2002, beach survey programs in central CA reported 2 to 3% of birds recorded each month are oiled (Roletto et al. 2003). The results of this study indicate that a low level of oiling continues to affect wildlife in central California at a rate of 2% per annum. Based on BeachCOMBERS data, we did not find a difference in the annual rate prior (2000-2003) or post *Luckenbach* clean-up (2004-2009). Samples matching the shipwreck in 2004-2009 indicated continuing low level impacts, but the species composition changed. The relative oiling rate of Common Murres decreased after 2003, but the relative oiling rate of an offshore indicator species, Northern Fulmar, increased. If we assume the distribution of these two species has not changed throughout the study period, this suggests a shift in the distribution of this chronic oiling source –to more offshore locations in more recent years.

The cumulative impacts of individual oiled birds can be equivalent to the damages incurred during a small scale spill (Nur et al. 1997, Hampton et al. 2003). The expense of routine sampling, without a responsible party, however, has prevented a consistent effort to document sources of chronic oiling of wildlife. This project has used existing beach survey data to obtain reference samples for fingerprint analysis and make comparisons with known references from the PCL library. Excluding those samples which were related to known sources (i.e. shipwrecks, vessels) it appears that the occurrence of Monterey Formation type oiling is persistent in central CA as it occurs in all years. In contrast, unknown oil types have a more sporadic occurrence among years indicating more transient or ephemeral sources (transiting vessels).

Chronic oiling can affect large numbers of individual birds or species at vulnerable life stages or locations and can be from a variety of sources (Hampton et al. 2003). In this study found that time of year (i.e., winter vs. summer) can greatly affect the age composition and sex ratio of murres and grebes (Humple et al., in press) based on the the post-litigation spill samples. Our results indicated that the winter *Luckenbach* spills in 2001-2003 affected more young of the year birds than expected given the population having an equal probability of oiling, whereas the late summer *Stuyvesant* spill affected more chick-rearing males and their attendant chicks in greater proportion than adult females. We suggest that this may be indicative of further dispersal of adults during the non-breeding (November to March) as compared with immature birds in winter and coastal dispersal of chick-rearing adults during summer which aggregate in protective waters (Briggs et al. 1987). For murres there was no indication of a sex-related difference in dispersal pattern and subsequent susceptibility to oiling in winter, but in summer breeding males are particularly susceptible to oil spills. We assumed that the sample of birds we examined was representative of the population affected by the spill.

Demographic impacts varied among mortality factors. For example, we found that entanglement in recreational fishing gear affected primarily adult murres but more often immature gulls. The episodic nature of chronic mortality makes understanding population level impacts difficult, without a long-term dataset (i.e., 5 to 10 years). It is expected that mortality directed at the adult portion of the population will be significantly more detrimental to population growth than mortality of immature animals. A modeling exercise to determine the population-level impacts of such age-specific chronic mortality may be useful to understanding how seabird populations are affected, and how damages may be mitigated through the NRDA process. It was our intent to identify mortality factors and the current level of severity; we leave it to future researchers to address trends and design appropriate actions to mitigate these factors.

Results from this investigation of chronic oiling and seabird health provides important information to determine appropriate mitigation measures for effective wildlife restoration. First, in cooperation with beach survey programs and rehabilitation centers, we have described a comprehensive summary of species affected by chronic oiling, entanglement and other mortality factors; and through band recovery information we identified those local colony areas which were source populations of the for individuals. Thus potential restoration activities at these local colony areas (i.e., Farallones, Año Nuevo) are expected to benefit populations which are damaged in the central coast study region. Second, we found through systematic assessment of mortality factors and response to episodic mystery spills and events, that several factors continue to affect Common Murres and other seabirds, including loons, grebes, cormorants, pelican, procellarids, alcids and gulls; the same species often affected by catastrophic oil spills. These factors included prey-based starvation/emaciation, oiling, fishery interactions, trauma, biotoxins, and to a lesser extent, plastic ingestion. Human-related factors are particularly important to identify because mitigation of these impacts are possible through NRDA (e.g. education and public awareness campaigns). As human populations increase in coastal regions, we expect the impacts of anthropogenic changes on coastal areas will increase the intensity and impacts of biotoxins and plastics ingestion for seabirds. Finally, these data serve as baseline measure of these impacts from which change (positive, negative, or neutral) can be assessed in future studies.

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Table 1. Numbers of marine birds recorded during study by beach surveys (BeachCOMBERS) and rehabilitation centers (MSPCA) and combined (BC/MSPCA) in the Monterey Bay area during 2005-2009. Reported are total new records for each program (total) and number of oiled, and percent of total oiled for each species and taxonomic group (% oiled). All birds recorded by beach surveyors were dead strandings, birds recorded by the rehabilitation center were live strandings.

	COMBERS			**MSPCA**			**BC/MSPCA Combined**		
Species	Total	Oiled	% Oiled	Total	Oiled	% Oiled	Total	Oiled	% Oiled
Alcids									
Auklet, Cassin's	166	4	2.4	10	1	0.0	176	5	2.8
Auklet, Rhinoceros	170	33	19.4	8	2	25.0	178	35	19.7
Guillemot, Pigeon	112	0	0.0	9	1	11.1	121	1	0.8
Murre, Common	4521	72	1.6	602	65	10.8	5123	137	2.7
Murrelet, Ancient	8	2	25.0	2	1	50.0	10	3	30.0
Murrelet, Marbeled	3	0	0.0	0	0	0.0	3	0	0.0
Murrelet, Unidentified	0	0	0.0	1	0	0.0	1	0	0.0
Puffin, Horned	43	0	0.0	9	0	0.0	52	0	0.0
Puffin, Tufted	13	1	7.7	2	0	0.0	15	1	6.7
Alcid, Unidentified	60	0	0.0	0.0	0	0.0	60	0	0.0
	5096	**112**	**2.2**	**643**	**70**	**10.9**	**5739**	**182**	**3.2**
Cormorants									
Cormorant, Brandt's	2332	12	0.5	136	0	0.0	2468	12	0.5
Cormorant, Double-crested	41	0	0.0	10	0	0.0	51	0	0.0
Cormorant, Pelagic	45	0	0.0	14	0	0.0	59	0	0.0
Cormorant, Unidentified	114	0	0.0	8	0	0.0	122	0	0.0
	2532	**12**	**0.5**	**168**	**0**	**0.0**	**2700**	**12**	**0.4**
Pelicans									
Pelican, Brown	228	1	0.4	293	4	1.4	521	5	1.0
Pelican, White	0	0	0.0	2	0	0.0	2	0	0.0
Pelican, Unidentified	0	0	0.0	1	0	0.0	1	0	0.0
	228	**1**	**0.4**	**296**	**4**	**1.4**	**524**	**5**	**1.0**
Sea Ducks									
Scoter, Black	1	0	0.0	1	0	0.0	2	0	0.0
Scoter, Surf	108	1	0.9	65	1	1.5	173	2	1.2
Scoter, White-winged	3	0	0.0	1	0	0.0	4	0	0.0
Scoter, Unidentified	12	0	0.0	0	0	0.0	12	0	0.0
	124	**1**	**0.8**	**67**	**1**	**1.5**	**191**	**2**	**1.0**
Grebes									
Grebe, *Aechmophorus* spp.	1535	18	1.2	192	12	6.3	1727	30	1.7
Grebe, Eared	20	1	5.0	17	1	5.9	37	2	5.4
Grebe, Horned	5	0	0.0	2	1	50.0	7	1	14.3
Grebe, Pied-billed	8	0	0.0	6	0	0.0	14	0	0.0
Grebe, Unidentified	139	1	0.7	2	0	0.0	141	1	0.7
	1707	**20**	**1.2**	**219**	**14**	**6.4**	**1926**	**34**	**1.8**
Larid									
Gull, California	296	0	0.0	120	0	0.0	416	0	0.0
Gull, Glaucous-winged	82	0	0.0	2	0	0.0	84	0	0.0
Gull, Heermann's	64	0	0.0	26	2	7.7	90	2	2.2
Gull, Western	443	2	0.5	694	11	1.6	1137	13	1.1
Gull, Uncommon[1]	51	0	0.0	27	0	0.0	78	0	0.0
Gull, Unidentified	456	0	0.0	19	0	0.0	475	0	0.0
	1392	**2**	**0.1**	**888**	**13**	**1.5**	**2280**	**15**	**0.7**
Other Larids									
Jaeger, Parasitic	5	0	0.0	0	0	0.0	5	0	0.0
Kittiwake, Black-legged	7	0	0.0	1	0	0.0	8	0	0.0
Tern, Caspian	3	0	0.0	1	0	0.0	4	0	0.0
Tern, Elegant	6	0	0.0	2	0	0.0	8	0	0.0
Tern, Forster's	3	0	0.0	0	0	0.0	3	0	0.0
Tern, Least	0	0	0.0	1	0	0.0	1	0	0.0
	24	**0**	**0.0**	**5**	**0**	**0.0**	**29**	**0**	**0.0**

Table 1. Continued.

	COMBERS			MSPCA			BC/MSPCA Combined		
Species	Total	Oiled	% Oiled	Total	Oiled	% Oiled	Total	Oiled	% Oiled
Loons									
Loon, Common	45	0	0.0	22	5	22.7	67	5	7.5
Loon, Pacific	210	8	3.8	52	9	17.3	262	17	6.5
Loon, Red-throated	20	0	0.0	6	0	0.0	26	0	0.0
Loon, Unidentified	20	0	0.0	5	1	20.0	25	1	4.0
	295	**8**	**2.7**	**85**	**15**	**17.6**	**380**	**23**	**6.1**
Phalaropes									
Phalarope, Red	17	0	0.0	19	2	10.5	36	2	5.6
Phalarope, Red-necked	8	0	0.0	9	0	0.0	17	0	0.0
Phalarope, Unidentified	2	0	0.0	2	0	0.0	4	0	0.0
	27	**0**	**0.0**	**30**	**2**	**6.7**	**57**	**2**	**3.5**
Procellariids									
Albatross, Black-footed	8	0	0.0	0	0	0.0	8	0	0.0
Fulmar, Northern	1212	26	2.1	229	2	0.9	1441	28	1.9
Procellariiform, Unidentified	2	0	0.0	0	0	0.0	2	0	0.0
Shearwater, Black-vented	2	1	50.0	0	0	0.0	2	1	50.0
Shearwater, Bullers	3	0	0.0	0	0	0.0	3	0	0.0
Shearwater, Pink-footed	8	0	0.0	0	0	0.0	8	0	0.0
Shearwater, Short-tailed	29	2	6.9	0	0	0.0	29	2	6.9
Shearwater, Sooty	460	9	2.0	9	0	0.0	469	9	1.9
Shearwater, Unidentified	14	0	0.0	0	0	0.0	14	0	0.0
Storm-Petrel, Fork-tailed	12	1	8.3	4	0	0.0	16	1	6.3
Storm-Petrel, Leach's	0	0	0.0	11	0	0.0	11	0	0.0
Storm-Petrel, Unidentified	2	0	0.0	0	0	0.0	2	0	0.0
	1752	**39**	**2.2**	**253**	**2**	**0.8**	**2005**	**41**	**2.0**
Shorebirds									
Plover, Snowy	1	0	0.0	37	0	0.0	38	0	0.0
Other Shorebirds[2]	29	0	0.0	20	0	0.0	49	0	0.0
	30	**0**	**0.0**	**57**	**0**	**0.0**	**87**	**0**	**0.0**
Grand Total	**13207**	**195**	**1.5**	**2711**	**121**	**4.5**	**15918**	**316**	**2.0**
Other, Non-Marine Bird Species[3]	62	0	0.0	0	0	0.0	62	0	0.0

[1]Uncommon species are Bonaparte's, Glaucous, Herring, Mew, Ring-Billed, Thayer's Gulls.
[2]Other Shorebirds includes killdeer, black-bellied plover, least sandpiper, black-necked stilt, whimbrel, willet, and unidentified shorebird.
[3]Non-Marine Bird Species includes dove, great egret, non-passerine bird species, and undentifiable birds (i.e., extensively scavenged).

Table 2. Annual summary of entanglement cases documented by BeachCOMBERS encountered during 2005-2010 by BeachCOMBERS and 2005-2009 by Monterey SPCA.

	COMBERS								MSPCA						
Species	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Subtotal**	**%**	**2005**	**2006**	**2007**	**2008**	**2009**	**Subtotal**	**%**
Alcids							**13**	18						**7**	8
Guillemot, Pigeon			1				1							0	
Murre, Common	4		3	1	4		12			1	2	3	1	7	
Cormorants							**19**	26						**4**	5
Cormorant, Brandt's	2	1	1	1	6	1	12				2			2	
Cormorant, Double-crested	1	1					2							0	
Cormorant, Pelagic	1						1			1		1		2	
Cormorant, Unidentified		2	2				4							0	
Pelicans							**2**	3						**21**	25
Pelican, Brown			1		1		2			2		7	11	20	
Pelican, White													1	1	
Sea Ducks							**1**	1						**2**	2
Scoter, Surf			1				1			1	1			2	
Grebes							**6**	8						**4**	5
Grebe, *Aechmophorus* spp.			3	3			6		1			2	1	4	
Larid							**22**	31						**44**	53
Gull, California			2	1			3			1		2	1	4	
Gull, Heermann's		1	1				2							0	
Gull, Western	1	2	3	1	2	1	10		2	15	5	5	12	39	
Gull, Unidentified	1		1	1	1	3	7				1			1	
Loons							**4**	6						**1**	1
Loon, Common			1				1		1					1	
Loon, Pacific	1				2		3							0	
Procellariids							**5**	7						**0**	0
Fulmar, Northern	1		1				2							0	
Shearwater, Sooty		1			1	1	3							0	
Grand Total	**12**	**8**	**21**	**8**	**17**	**6**	**72**	**100**	**4**	**21**	**11**	**20**	**27**	**83**	**100**

Table 3. Total number of oiled feather samples and tarballs collected by source: Coastal Ocean Mammal and Bird Education and Research Surveys (BeachCOMBERS), Monterey Society for the Prevention of Cruelty to Animals (MSPCA), Pacific Wildlife Care (PWC), state (CDFG) and federal agencies (USFWS, USGS) and other sources (public, etc.). Note: the samples are a subset of the total numbers of birds documented oiled by these groups.

	Source				
Species	**Beach COMBERS**	**MSPCA**	**PWC**	**USGS/ DFG/ Other Agency**	**Other**
Loon, Common		1		1	3
Loon, Pacific	5	5			3
Loon, Red-throated			1		
Loon, Unidentified	1				
Grebe, *Aechmorphus* spp.	7	3	9		2
Cormorant, Brandt's	7	1	1		
Pelican, Brown	3	1			5
Scoter, Surf			1		
Merganser, Red-breasted	1				
Auklet, Cassin's	6				
Auklet, Parakeet	1				
Auklet, Rhinoceros	20	1	1	12	12
Murre, Common	31	27	5	19	13
Murrelet, Ancient	1	1			1
Puffin, Horned					6
Puffin, Tufted	1				
Gull, Western	1	4			
Fulmar, Northern	22	3	1	2	10
Shearwater, Sooty	6				
Phalarope, Red	1		1		1
Total Oiled Birds	**114**	**47**	**20**	**34**	**56**
Tarballs	119			10	31

Table 4. Summary of oil sources identified by the PCL from a subset of samples of oiled birds collected during 2003 – 2009.

Year	*Luckenbach*	*Palo Alto* (Cement ship)	Monterey Formation	Unknown (not Monterey)	Unknown	Grand Total
2003	2		2			4
2004	7	10	2			19
2005		7	5		1	13
2006			8		6	14
2007	1		8	1	4	14
2008	1		7	2		10
2009			4	1		5
Total	**11**	**17**	**36**	**4**	**8**	**79**

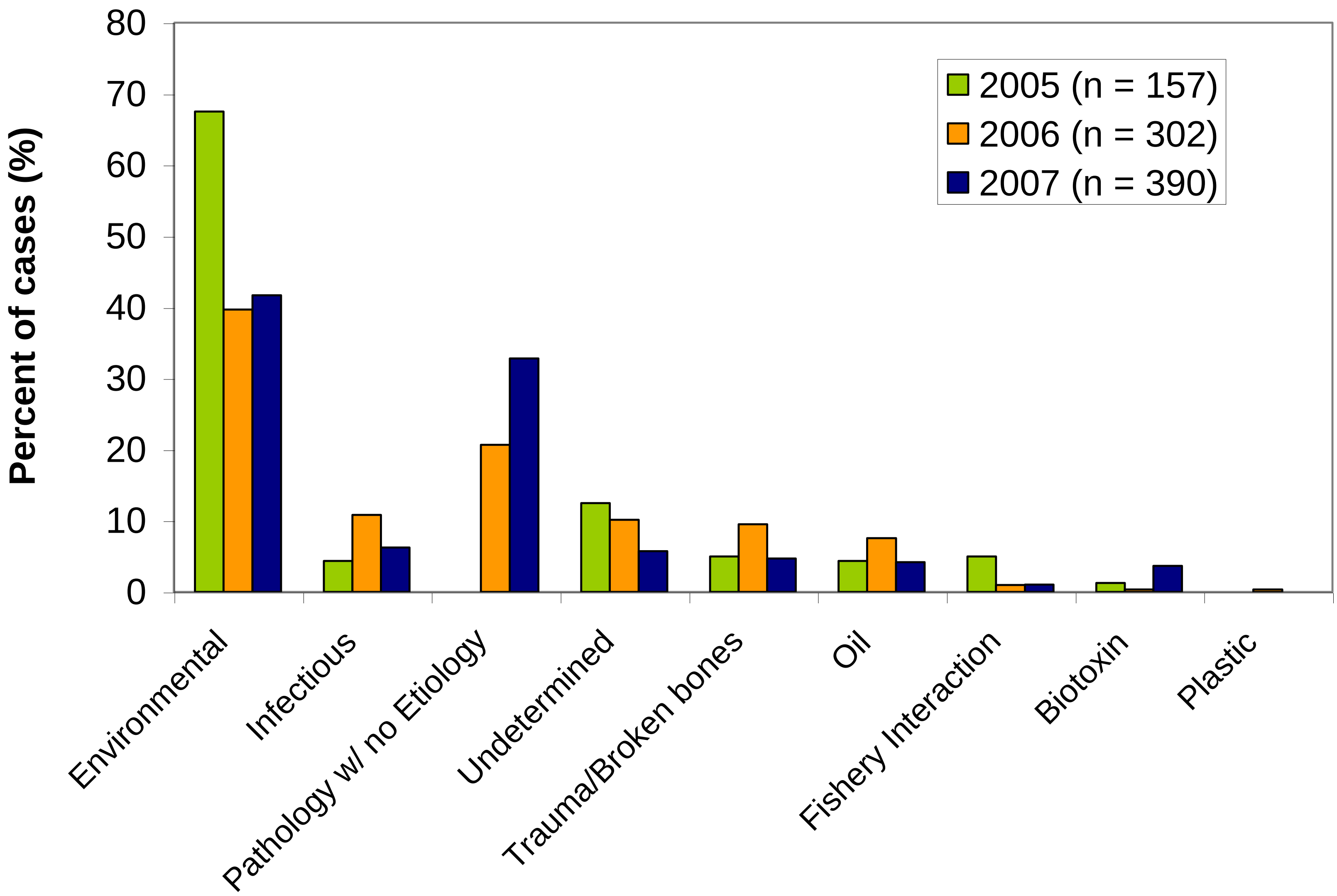

Figure 1. Summary of relative mortality by category in three years (2005-2007) identified by the Seabird Health Study at the CDFG-OSPR, Marine Wildlife Veterinary Care and REsearch Center.

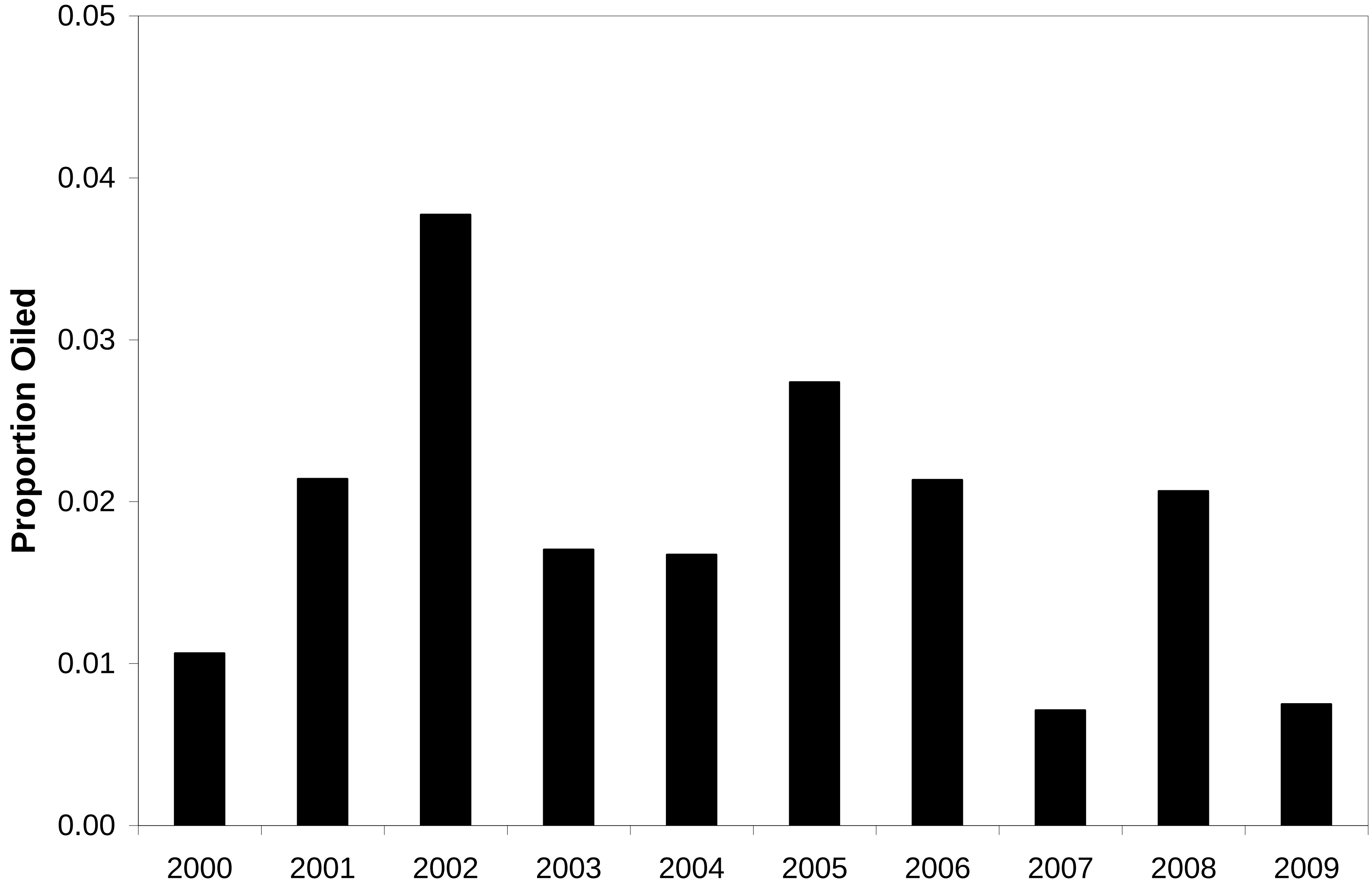

Figure 2. Inter-annual trends in the proportion of seabirds recorded oiled (number of oiled/total "new birds recorded) by systematic beach surveys by BeachCOMBERS in the Monterey Bay area, 2000-2009 (11 beaches per month, 51 km).

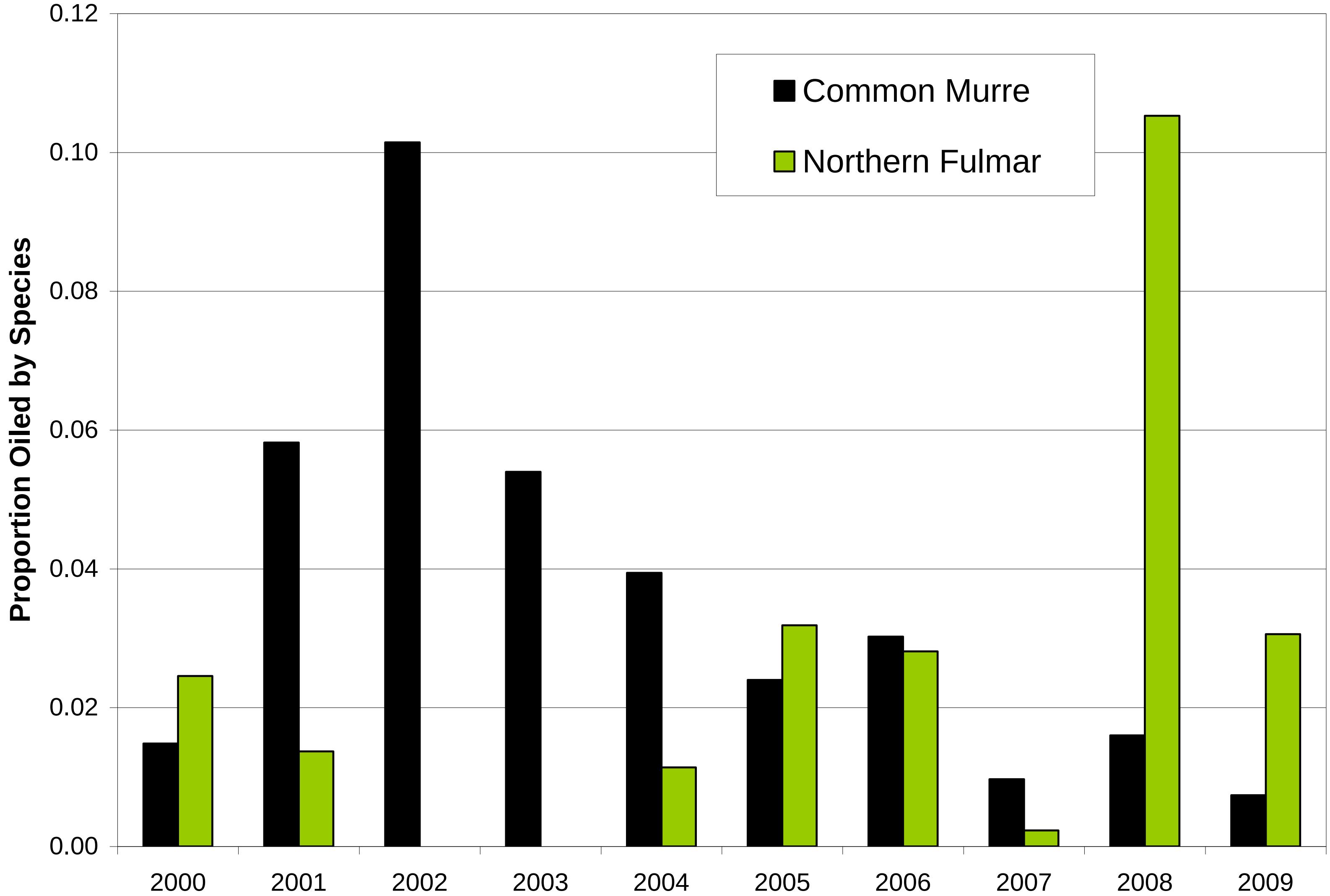

Figure 3. Changes in the species-specific oiling rates of the most commonly oiled nearshore (Common Murre) verses offshore (Northern Fulmar) species. Data from systematic BeachCOMBERS surveys in Monterey Bay, CA 2000-2009. Note major chronic oiling sources, shipwreck *SS Luckenbach*, was cleaned up in 2003.

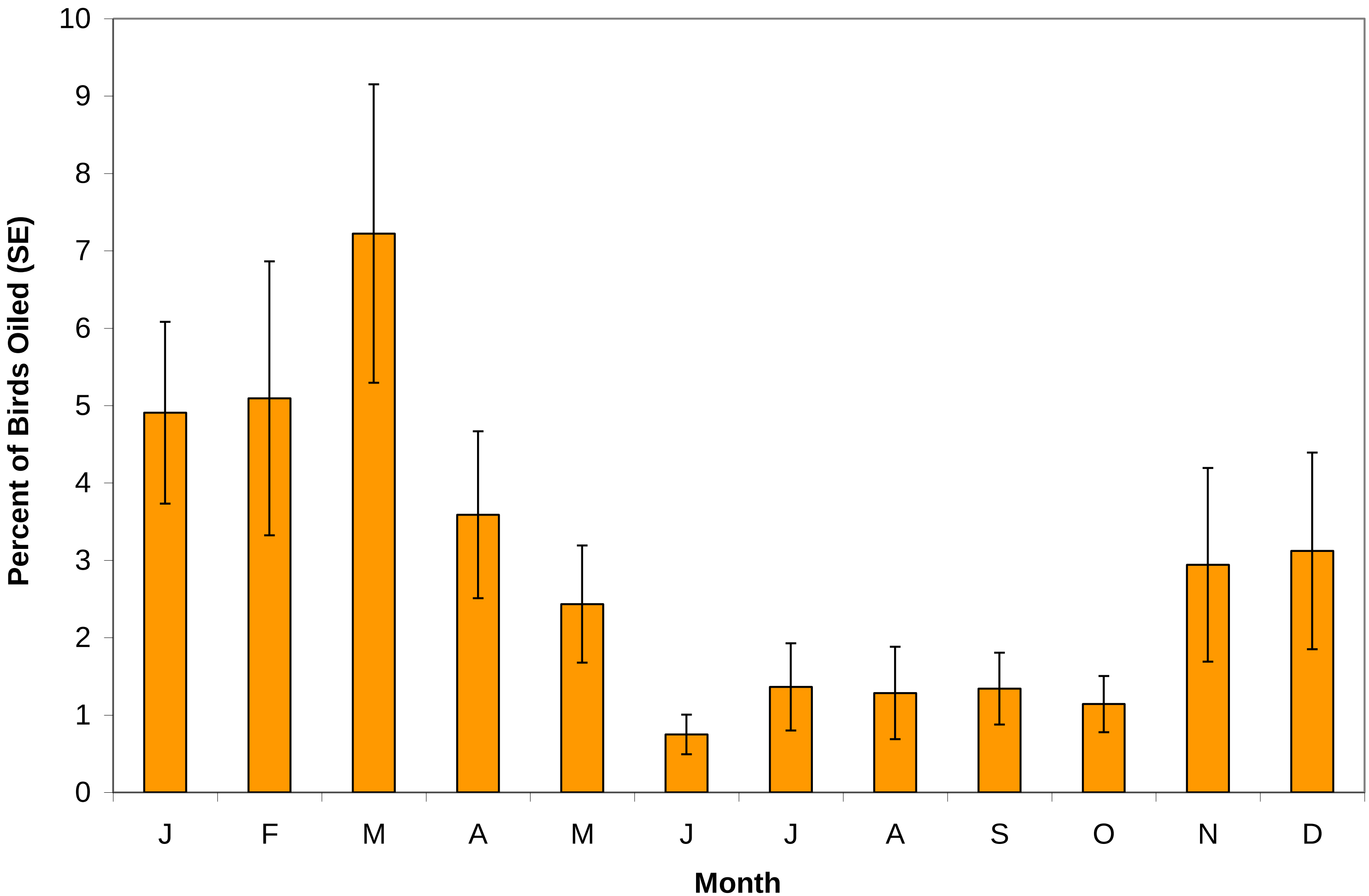

Figure 4. Monthly mean percent oiled seabird reported on beach survey, Montery Bay, CA, May 1997 to December 2002. Error bars represent± standard error (n = 11 years, 11 beaches per month, 51 km).Data from BeachCOMBERS, 1997-2007.

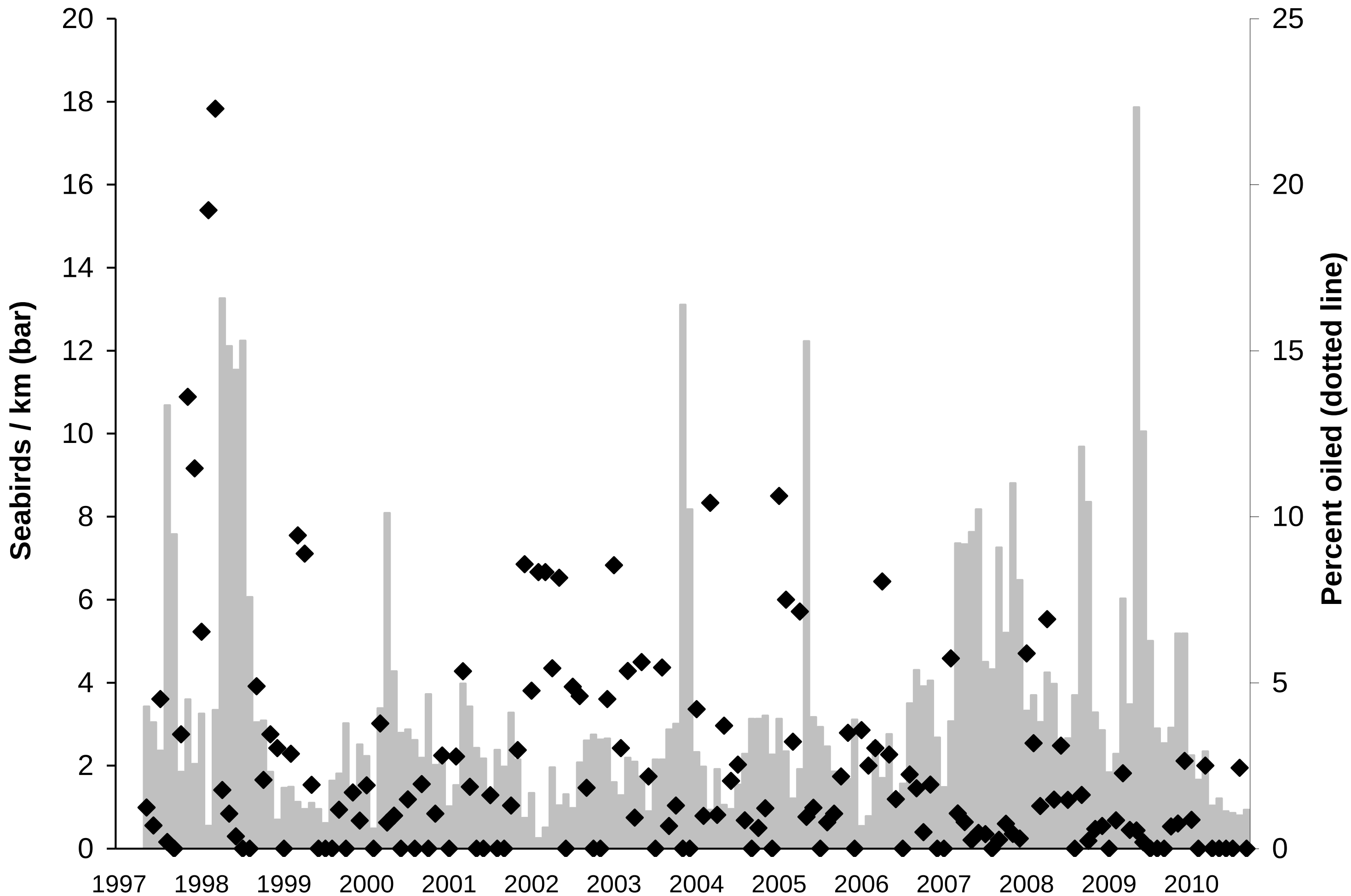

Figure 5. Long-term trend in monthly new deposition of marine birds km^{-2} (bars) and percent oiled (dots) reported by BeachCOMBERS. Significant oiling events were marked by oiling rates greater than 2%, such as during the 1997-98 Pt. Reyes Tarball event (October 1997 to March 1998), the San Mateo Mystery Spill (October 2001 to May 2002), and various "mystery oil events" during spring 1999, March 2004, January to May 2005, and winter 2005-2006, spring 2008. Note that a reduction in deposition often occurs with significant oil events due to OSPR response-related clean-up efforts on beaches.

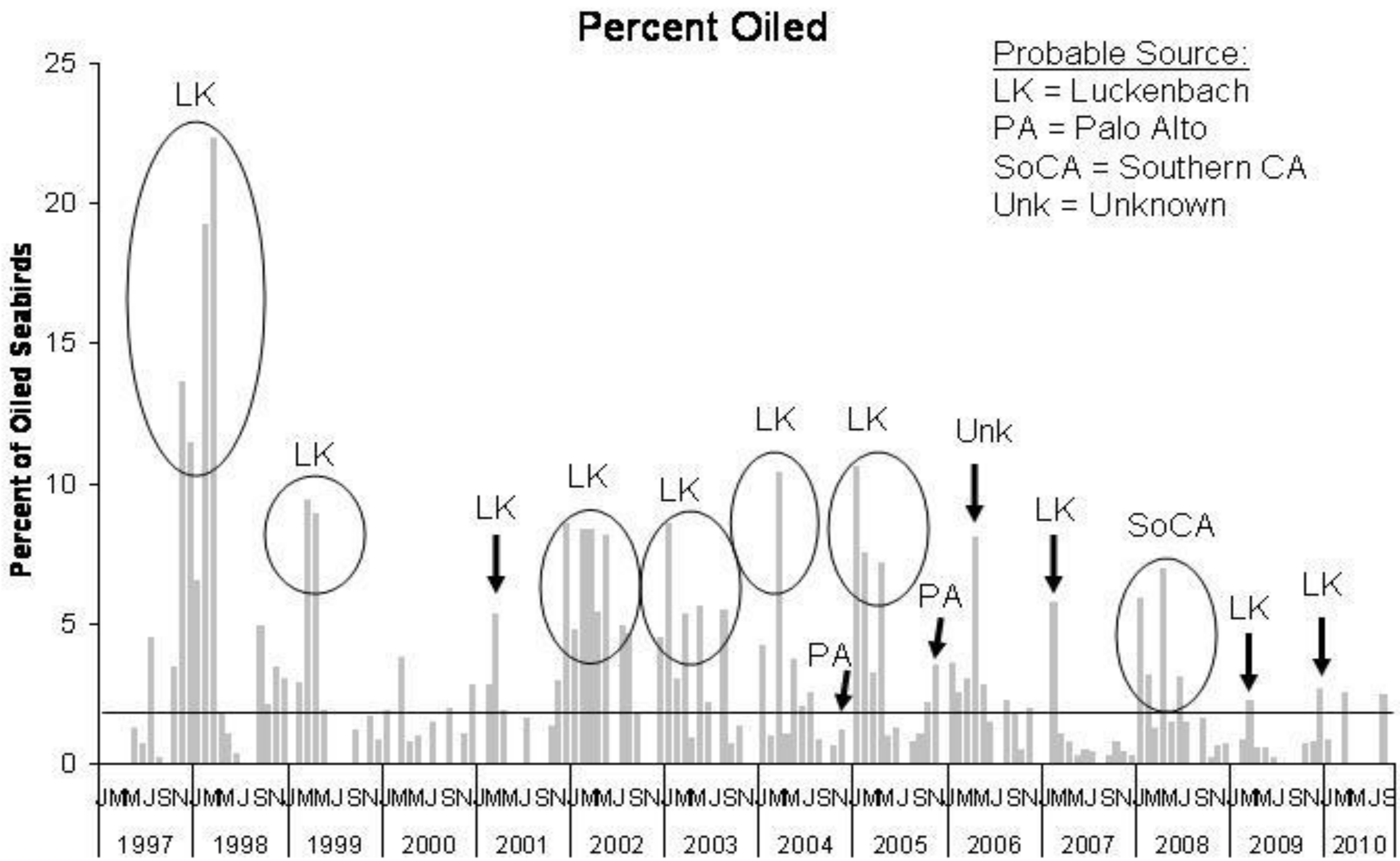

Figure 6. Probable sources of increased oiling seabird deposition during 1997 to 2010. Line indicates 2% baseline above which an oiling event is considered significant. Sources include: Luckenbach (LK), the grounded vessel S.S. Palo Alto (PA), oiling coinciding with seep activity in southern CA (SoCA), and unknown sources (Unk).

7.0 Appendix A: Seabird Health Study Datasheet

AVIAN GROSS NECROPSY SHORT FORM
INSTITUTION: MWVCRC, CALIFORNIA FISH AND GAME

MWVCRC Acc# | **Species**
Path#: | **Band#:**
Other#:

Collector: Date: | **Necropsy by:** **Date:**
Location (city, county):
Admit Date: **Death Date/Time:** **Euthanasia?** Y / N / U | **Photograph?** Y / N **Radiograph?** Y / N **Abnormal?** Y / N / NA

History (weather; terrain; number found - same/other species):

Clinical (signs; treatment – type/duration; lab results):

Human Interaction (describe, evidence saved):

Oil: Y / N / U **Chain of custody form completed and feathers saved?** Y / N
Oil Extent: 1 (<2% of body) 2 (2-33%) 3 (34-66%) 4 (67-100%) **Where oiled**: dorsal / ventral // entire body / head / feet / wings (*Describe/photograph*)
Notes:

Carcass (note: assess after opening the coelomic cavity): 2-Fresh / 3-Fair, decomposed, organs intact / 4-Poor, advanced decomposition / 5-Macerated
Scavenged? Y / N **Describe**: **Previously Frozen?** Yes / No **Disposition**: saved / discarded
Plumage: Juvenile / Nuptial / Adult / Eclipse / Winter / NA / Unk **Molt (%):** Body: Wing: Head: Tail:
Body Mass (g): ______________ (actual / estimate) (wet / sand / dry) **Notes:**
External parasites? Y / N **Morph**: (*e.g. fulmars*):
Measurements (mm): Culmen: ___________ **Nares (length):** ________ **Width at anterior nares**: ____________ **Depth at gonys**: ____________
Tarsus: ___________ **Maximum flattened wing chord**: _____________ **Curved wing chord:** _________
***(For Common murres only): Supraorbital width**: ______ **Interorbital width**: ______ **SOR Score**:_______*

Subcutis Fat: Depth (mm): ________ marked / moderate / fair / none / serous **Internal Fat:** marked / moderate / fair / none / serous
Pericardial Fat: marked / moderate / fair / none / serous **Subjective Body Condition** obese / good / thin / emaciated
Internal weights (g): Pectoral muscle complex: ________ (above / even / mildly, moderately, markedly below keel)
Liver: _________ **Spleen**: _________ **Heart**: __________ **Other: (note)**

Sex: M / F / U | **Age**: HY SY ASY IMM AHY AD Unk
Gonad Length: ______ **Width**: _______ **Diameter Largest Follicle**: ____ | **Bursa** : prominent / apparent / not apparent / NF **Size:** ____ x_____
Oviduct: prominent / apparent / thin, straight / NA / NE | **Thymus:** prominent / apparent / not apparent / NF

GI Content (empty/amount&appearance) Crop: | **Proventriculus :**
Ventriculus: | **Small intestine**:
Cecum/Colon: | **Cloaca**:
Parasites (precise location, number: +1 = 0-10; +2 = 10-20; +3 = 20-50; +4 > 50, associated lesion?):

Gross Findings:

Cytology: lung / liver / spleen / kidney / intestine/ other:
Tissue: Normal (N) / Abnormal (A) / Unknown (U) / Not found (NF) / Not examined (NE) // Histology (H) / Saved -70 or -20 (S) / Molecular diagnostic (M)

	N	A	U	NF	NE	H	S_{-20}	S_{-80}	M		N	A	U	NF	NE	H	S_{-20}	S_{-80}	M		N	A	U	NF	NE	H	S_{-20}	S_{-80}	M
Feather:										Esophagus										Proventriculus									
Uropygial gland										Crop										Ventriculus									
Skin										Trachea										Duodenum									
Fat (site):										Air sacs										Pancreas									
Pectoral muscle										Lung										Jejunum									
Muscle:										Heart										Ileum									
Sciatic nerve										Aorta										Cecum									
Tibiotarsus/joint										Spleen										Colon									
Bone marrow										Liver										Cloaca									
Bone:										Gall bladder										Bursa									
Choana										Kidney										Brain									
Tongue										Ureter										Eye (L/R)									
Parathyroid										Adrenal gland										Conjunctiva (L/R)									
Thyroid										Gonad										Spinal cord									
Thymus										Oviduct										Other tissue:									

Search Terms: Organ System	Location	Morphology	Etiology

Preliminary Cause(s) of Mortality: