BEACHED BIRD SURVEYS AND CHRONIC OIL POLLUTION IN CENTRAL CALIFORNIA

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SUMMARY

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This report summarises beached bird and oil pollution data gathered from September 1993 through August 2002 by Beach Watch, a long-term shoreline monitoring program. Surveys were conducted at 32 beach segments ranging from southern San Mateo County to southern Sonoma County. Beached birds were most commonly found in August and September, and most birds at this time were local nesting marine species. During the 1997/98 El Niño-Southern Oscillation (ENSO) event, the annual encounter rate for all beached birds more than doubled, and the encounter rate for oiled birds increased more than six-fold. Also during the 1997/98 ENSO the encounter rate for tarballs (hardened patties of oil) was more than twenty times that observed for the preceding year. Periodic increases of oiled birds and tarballs may have reflected the corresponding releases of heavy fuel oil from long submerged vessels, such as the SS *Jacob Luckenbach*, as well as illegal discharges from merchant and tank vessels. The percentage of beached birds found oiled was lower than that reported in the southern North Sea (1977-1997) and in Newfoundland (1984-1999). Comparison with an earlier beached bird dataset from central California from 1971 to 1981 (Stenzel *et al*. 1988) suggests that oiling rates have declined since that decade. The observations recorded by Beach Watch have contributed to the discovery, identification and prosecution of sources of pollution.

Keywords: California, oil, seabirds, mortality, tarballs, beached-birds

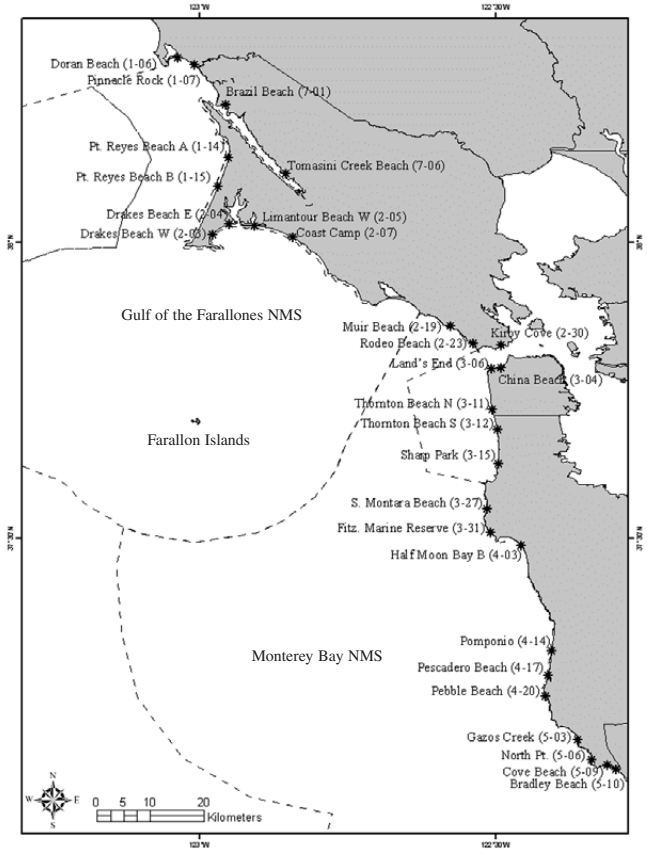
INTRODUCTION

Systematic shoreline surveys for beached birds have been conducted since the middle of the twentieth century (Bull & Boeson 1961, Veitch 1976, Page *et al*. 1982, Stenzel *et al*. 1988, Powelsland & Imber 1988, Carter & Page 1989, Bayer *et al*. 1991, Heubeck 1995, Benson *et al*. 1999, Camphuysen & Heubeck 2001). In 1993, the Gulf of the Farallones National Marine Sanctuary (GFNMS) began Beach Watch, a long-term shoreline monitoring program, in north-central California. The program records baseline data on beachcast and live marine organisms, assists sanctuary management in the early detection of natural and human-caused environmental perturbations such as epizootic outbreaks, El Niño-Southern Oscillation (ENSO) events and oil spills, and provides a network of skilled shoreline surveyors to respond during oil spills. Since 1996, the Beach Watch program has also counted tarballs (small patties of oil) found on survey beaches, as a secondary indicator of chronic oil pollution.

Beach Watch was originally derived from a beached bird survey program begun in California by Point Reyes Bird Observatory during the 1970s (Stenzel *et al*. 1988; Carter & Page 1989). From this program, Carter and Page developed protocols to standardize oil spill response surveys for the Gulf of the Farallones shoreline. Later the GFNMS tailored the response protocols to monitor spatial and temporal deposition patterns of coastal bird and marine mammals.

We review temporal patterns in encounter rates for beached birds, oiled birds, and tarballs along the Gulf of the Farallones shoreline. We contrast these encounter rates with those from other beached

Fig. 1. Location of shoreline surveys for beached birds and oil, September 1993 through August 2002.



bird survey programs and illustrate the use of encounter rate data in obtaining legal redress for pollution damage to marine birds.

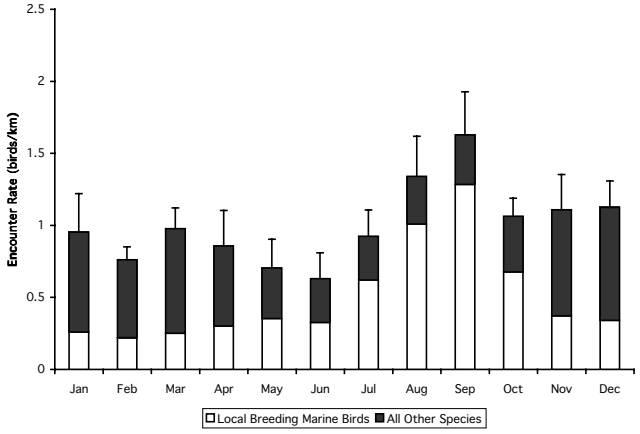
METHODS

We collected data from 32 beach segments between Bodega Head, latitude 38° 18.492', longitude 123° 4.024', in Sonoma County south to Año Nuevo in southern San Mateo County, latitude 37° 6.422', longitude 122° 17.589' (Fig. 1). Surveys for each beach were conducted at either two or four week intervals, depending on surveyor availability. Teams of 1-4 people surveyed beaches in a zigzag fashion and scanned the edges of any upper dunes, recording the species and number of dead birds and presence of oil. Tarballs were counted and analyzed for verification of hydrocarbons, beginning in 1996. Other data collected but not discussed in this paper included: live birds, live and dead marine mammals, age and sex of dead birds and mammals, state of decomposition, presence of scavenging, apparent cause of death, presence of bands or tags, human activities, beach slope, beach wrack deposition, number of live oiled birds, as well as a number of other measures (Roletto *et al*. 2003). Surveyors photographed each carcass encountered for later species, age and sex verification by an expert ornithologist. California State Office of Spill Prevention and Response processed oil samples for verification of petroleum hydrocarbons.

Data were also analysed in relation to the proportion of birds oiled (the oiling fraction; Furness & Camphuysen 1997, Camphuysen 1998, Camphuysen & Heubeck 2001, Seys *et al*. 2002 a, b). To control for variations in the encounter rate for beached birds, data were compared on the basis of the fraction of the beached birds that were found oiled relative to the total of all beached birds. For trend analysis, these fractions were subjected to a logit transformation.

Analyses presented here were based on 3,972 surveys, representing 8576 km of survey effort, made from September 1993 through August 2002. To compare data among different parts of the coastline, numbers of birds recorded were quantified as encounter rates (i.e. number of birds per kilometer surveyed). Analyses did not include data collected by oil spill response efforts because response surveys included increased search effort and survey techniques were variable, e.g. searches conducted on foot, horseback, all terrain vehicles, search of the wrack line only, etc.

Fig. 2. Mean monthly encounter rates (number of birds per km) for local breeding marine birds and for all other beached birds, from September 1993 through August 2002. Bars represent standard error for all birds.



RESULTS

Monthly Patterns

We encountered beached birds throughout the year at an average rate of 0.99 birds/km. In all, 100 bird species were found beached. The Common Murre *Uria aalge* was most frequently encountered, representing 26.2% (0.260 per km) of the total (Table 1). The highest encounter rates for all beached birds were in August and September, when most of those found were local breeding marine species (Fig. 2). Marine species that breed in the Gulf of the Farallones sanctuary comprise: Leach's Storm-petrel *Oceanodroma leucorhoa*, Ashy Storm-petrel *Oceanodroma homochroa*, Brandt's

Fig. 3. Mean monthly encounter rates for Common Murres, Western Gulls, Brandt's Cormorants and for all other local breeding marine birds, from September 1993 through August 2002. Bars represent standard error for all local marine breeding birds.

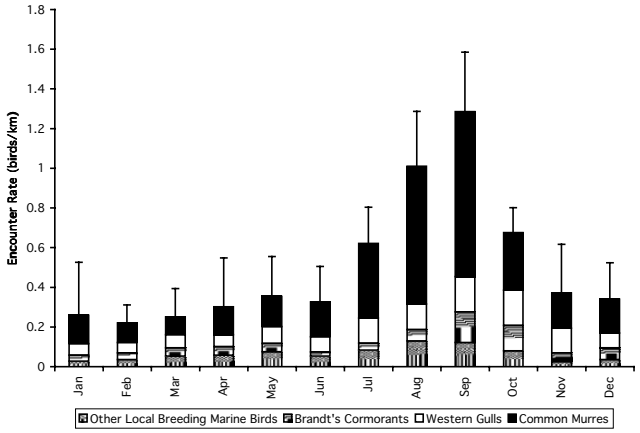
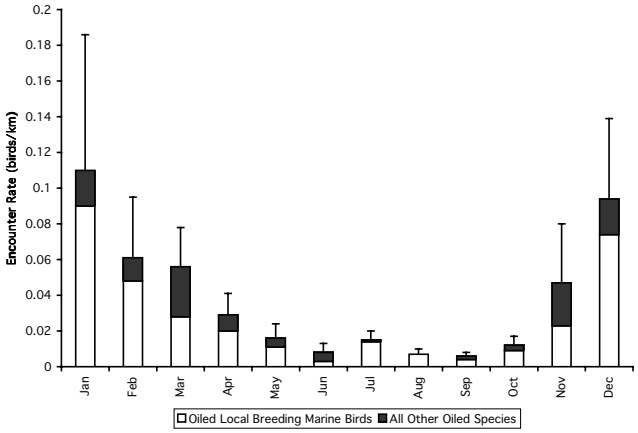


Fig. 4. Mean monthly encounter rates of oiled local breeding marine birds and other oiled birds, from September 1993 through August 2002. Bars represent standard error for all birds.



Cormorant *Phalacrocorax penicillatus*, Double-crested Cormorant *Phalacrocorax auritus*, Pelagic Cormorant *Phalacrocorax pelagic*, Western Gull *Larus occidentalis*, Common Murre, Pigeon Guillemot *Cepphus columba*, Marbled Murrelet *Brachyramphus marmoratus*, Cassin's Auklet *Ptychoramphus aleuticus*, Rhinoceros Auklet *Cerorhinca monocerata*, and Tufted Puffin *Fratercula cirrhata* (Ainley & Boekelheide 1990).Common Murres represented 54% of all local breeding marine species found beached. Although the monthly encounter rate for local breeders was greatest in August and September, peak encounter rates for all other species occurred from November through April (Fig. 3).

We recorded the highest encounter rates of oiled beached birds, both local breeders and others, from November through March (Fig. 4). Common Murres were the most frequently oiled species (9.6%) and comprised 63% of the total oiled seabirds.

Inter-year variation

During the nine years considered here, the annual encounter rate of all birds combined varied from 0.600 to 1.967 birds/km (Fig. 5). From October 1997 through August 1998, the overall encounter rate more than doubled over the previous sample year. Similarly, the encounter rates of both oiled local breeding seabirds (0.147) and all other oiled birds (0.042) increased more than six-fold during the 1997/98 year (Fig. 6).

The percentage of birds oiled was highest in the sample year 1997/98 (Fig. 7). We found no significant linear trend in a logit analysis of the oiled bird encounter rates (R= 0.063, R2 = 0.04, P= 0.872).

Within-year variation

The monthly encounter rates for all birds on all beaches appeared as a series of pulses, with annual peaks during the late summer and early fall months (Fig. 8). Furthermore, oiling rates produced a

Fig. 5. Mean encounter rates of local breeding marine birds and all other species during nine years of Beach Watch; each year beginning in September and ending the following August. Bars represent standard error for all birds.

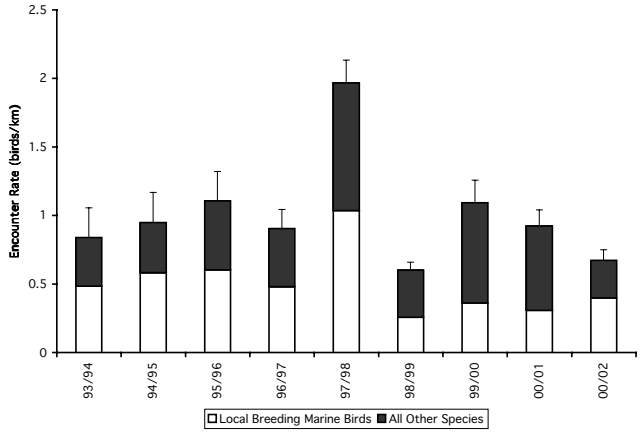


Fig. 6. Mean encounter rates of all oiled local breeding marine birds and all other oiled species for the nine years of Beach Watch; each year beginning in September and ending the following August. Bars represent standard error for all birds.

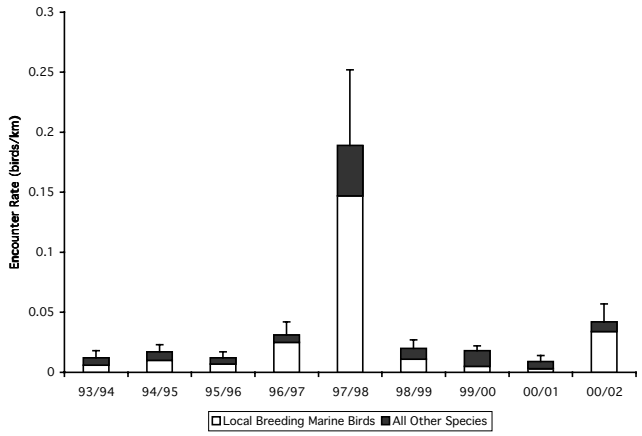


Fig. 7. Percentage of all beached birds found oiled during the nine years of Beach Watch, from September 1993 through August 2002. Bars represent standard error for all birds.

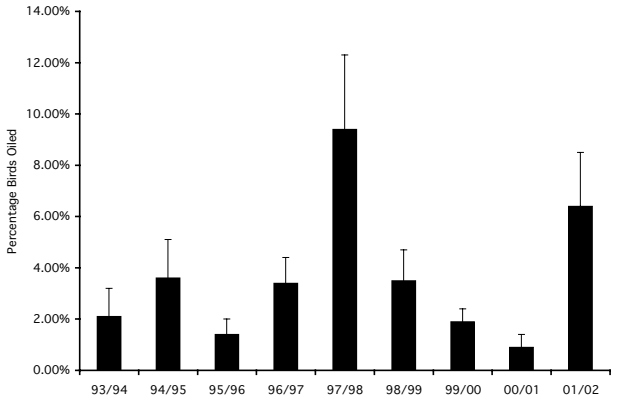
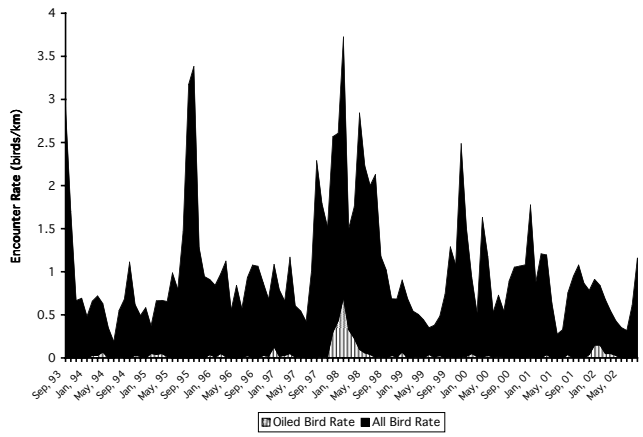


Fig. 8. Mean encounter rate of all beached birds and of oiled birds for the sequential months of Beach Watch, September 1993 through August 2002.



series of smaller peaks, with an exceptional 8-month increase beginning in October 1997. The peak of unoiled birds during the summer and fall of 1995 was in part attributed to a domoic acid die-off that affected many marine species off central California (Scholin *et al*. 2000). Domoic acid is a biotoxin produced by diatoms *Pseudo-nitzchia* spp. It is suspected that domoic acid effected murres, pelicans and cormorants along the central California coast. The peak in both oiled and unoiled birds during the 1997/98 winter and 1998 spring was attributed to both the Point Reyes Tarball Events (Carter & Golightly 2003) and the strong ENSO event (McPhaden 1999). The peak of oiled birds during the 2001/02 winter may have been caused by sporadic releases of oil from the sunken vessel *SS Jacob Luckenbach* (Kelly *et al*. 2002).

Tarballs

Tarballs were most frequently encountered in January when 100 tarballs/km were recorded. February and November had the next highest encounter rates (23 tarballs/km and 15 tarballs/km, respectively; Fig. 9). In the year from September 1997 through August 1998, the mean annual tarball rate reached its highest level of 71 tarballs/km, a more than twenty-fold increase from the preceding year (3 tarballs/km; Fig. 10).

DISCUSSION

Monthly Patterns

Compared with results from the Netherlands, where dead birds occur mostly during the winter (Camphuysen & Heubeck 2001), the highest level of beached seabirds in the Gulf of the Farallones occurred in the late summer months (August and September). The elevated level of beached birds occurred after local breeding species, such as Common Murres and cormorants, fledged their chicks. Similar die-offs of breeding birds such as Common Murres have long been noted on the West Coast of North America (e.g., Bayer *et al*. 1991, Bodkin & Jameson 1991).

Our study and the work in the southern North Sea (Camphuysen & Heubeck 2001), found highest encounter rates for oiled beached birds during the winter and spring months (November through March). However, the proportion of oiled birds found in our study (3.2%) was less than that recorded in the southern North Sea (Camphuysen 1998, Seys *et al*. 2002a, b, 46% oiled and 37% oiled, respectively) and in Newfoundland (Weise & Ryan 2003, 62% oiled; Table 2). The low incidence of oiling seen in the Gulf of the Farallones resembles oiling rates reported from other studies along the West Coast of North America. For example, in Monterey Bay, California, <2% of seabirds found in surveys of ten beaches from March 1997 through December 2001 were oiled (H. M. Nevins and J. T. Harvey pers. comm. 2003). On beaches in the outer coast and inland waters in Washington and the coast of Oregon < 2% of all beached birds were found oiled (Table 2).

Inter-year variation

Encounter rates for all beached birds, for oiled birds, and for tarballs all more than doubled during the period from September 1997 through August 1998. These increases followed the beginning of the intense ENSO that began in March 1997 (McPhaden 1999) and the associated decline in marine productivity (Chavez *et al*. 1999). Also during the winter of 1997/98, there were reported releases of oil from the submerged vessel *SS Jacob Luckenbach* (Kelly *et al*. 2002), which may account for the higher oiled bird and tarball encounter rates. During this period, both the overall beached bird encounter rate and the oiled bird rate remained elevated for months. In the following year (1998/99), the beached bird encounter rate was lower than normal, possibly because reproductive failure following the ENSO and oiling events of the preceeding year led to a lower than normal number of first year birds in the populations at risk. A similar increase in carcass deposition rate was observed in central California during the previous strong ENSO event of 1982-1983 (Bodkin & Jameson 1991), with a similar reduction in encounter rates in 1984.

Within-year variation

As relatively few birds are found oiled on the Pacific coast of North America, monthly encounter rates for oiled birds, or oiling fractions, may act as a sensitive indices of spills from individual vessels and sunken ships such as the *SS Jacob Luckenbach*. In terms of information theory, signals are more easily detected

Fig. 9. Mean monthly tarball encounter rate; each year beginning in September and ending the following August. Bars indicate standard error.

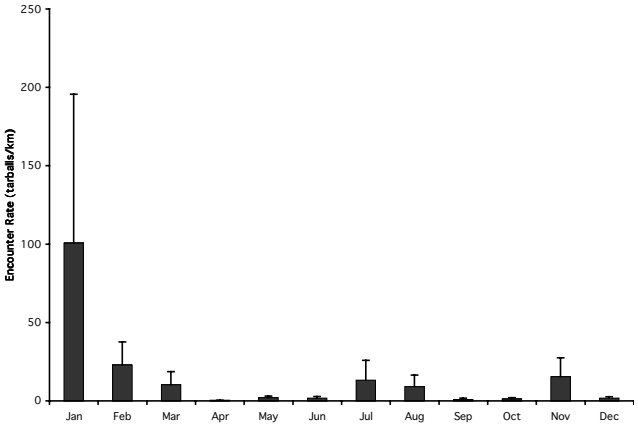
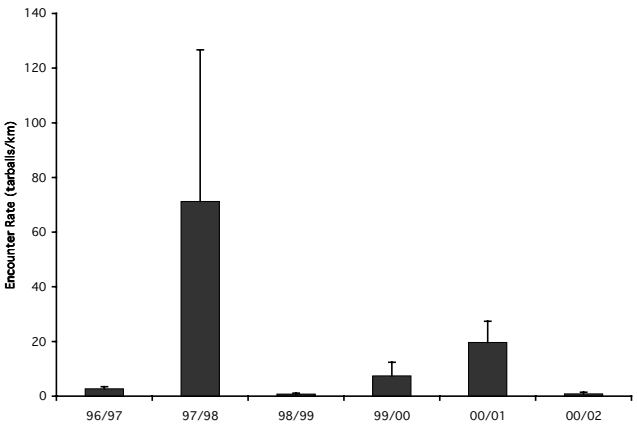


Fig. 10. Mean annual tarball encounter rates for the sample years of Beach Watch; each year beginning in September and ending the following August. Bars indicate standard error.



against a low background level. Where background rates are higher, as found in the North Sea (Furness & Camphusen 1997, Camphuysen 1998, Camphuysen & Heubeck 2001, Seys *et al*. 2002a), and Newfoundland (Weise & Ryan 2003) it may be more difficult to locate specific sources of chronic oil pollution. The low oiling rates and fractions observed by this survey program and by others along the West Coast of North America also may make it easier to detect other kinds of environmental perturbations, such as domoic acid toxicities (e. g., Schollin *et al*., 2000), which might be masked by higher oiling encounter rates and fractions.

Finally, the consistent monitoring protocols, wide geographical search effort and relative intensity of the Beach Watch database has provided a baseline data set against which to compare the mortality rates and species composition during known oil spills (Camphuysen & Heubeck 2001, Ford 2002). The Beach Watch baseline data set helped to evaluate damages and determine settlements for four recent spills in the Gulf of the Farallones.

1) On 28 October 1996 the SS *Cape Mohican* released an estimated 96,000 gallons of oil into the San Francisco Drydock Company drydock facility. During this spill, an estimated 42,000 - 50,000 gallons were released into San Francisco Bay and by 30 October 1996 reached the Gulf of the Farallones and Monterey Bay National Marine Sanctuaries. The Beach Watch baseline data set was used to help determine the level of impacts from this spill and resulted in a restoration settlement of over $3.6 million for seabirds and impacted habitats.
2) During the fall and winter of 1997 and 1998, another oil incident unfolded, designated as the Point Reyes Tarball Events. Numerous oiled birds and tarballs washed up on the shores of these sanctuaries and over 1,900 oiled birds were found (Kelly *et al*. 2002, Nevins & Carter 2002). Damage assessment for this spill is still underway. Beach Watch baseline data set is being used for natural resource damage assessment and determination of impacts from the spill.
3) On 27 September 1998, the *T/V Command*, spilled approximately 3,000 gallons of oil resulting in a 10 to 15 mile oil slick off of Half Moon Bay. More than 75% (estimated 11,193) of the seabirds killed in this spill were Common Murres. The *Command* case was settled December 1999 for $4.05 million to be used for seabird restoration and $98,100 in civil penalties to each of the sanctuaries damaged by the spill (Gulf of the Farallones and Monterey Bay National Marine Sanctuaries).
4) During the spring and summer of 2001 through 2002, elevated numbers of oiled birds were collected from beaches as far north as Bodega Head and as far south as Monterey. It was determined that oil was leaking from the sunken vessel the *SS Jacob Luckenbach*. Damage assessment for this spill is underway. Beach Watch baseline data set is being used for natural resource damage assessment and determination of impacts from the spill.

During each of these incidents the Gulf of the Farallones National Marine Sanctuary was able to provide experienced wildlife reconnaissance surveyors and quickly survey local beaches, collect oil and oiled wildlife, aid in the direction of response and clean-up efforts, and assess the change in use of the beaches by many marine organisms and by humans (Ford 2002). This illustrates the importance of this long-term beach bird survey program and gives support for the value of continuing beach survey programs along the west coast and elsewhere (Camphuysen & Heubeck 2001, Ford 2002).

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Table 1. Encounter and oiling rates for all species with encounter rates >0.001 birds/km during September 1993 through August 2002. Species in bold are local breeding species. The following species were also recorded: Red-necked Grebe Podiceps grisegena, Eared/Horned Grebe Podiceps nigricollis/auritus, Pied-billed Grebe *Podilymbus podiceps*, Black-footed Albatross *Phoebastria nigripes*, Pink-footed Shearwater *Puffinus creatopus*, Flesh-footed Shearwater *Puffinus carneipes*, Buller's Shearwater *Puffinus bulleri*, Black-vented Shearwater *Puffinus opisthomelas*, Manx Shearwater *Puffinus puffinus*, Leach's Storm-Petrel *Oceanodroma leucorhoa*, Ashy Storm-Petrel *Oceanodroma homochroa*, Petrel Species Unknown, Snowy Egret *Egretta thula*, Black-crowned Night-Heron *Nycticorax nycticorax*, Turkey Vulture *Cathartes aura*, Greater White-fronted Goose *Anser albifrons*, Ross's Goose *Chen rossii*, Canada Goose *Branta canadensis*, Brant *Branta bernicla*, Tundra Swan *Cygnus columbianus*, Gadwall *Anas strepera*, American Wigeon *Anas americana*, Mallard *Anas platyrhynchos*, Northern Pintail *Anas acuta*, Green-winged Teal *Anas crecca*, Greater Scaup *Aythya marila*, Lesser Scaup *Aythya affinis*, Scaup Species Unknown, Black Scoter *Melanitta nigra*, Long-tailed Duck *Clangula hyemalis*, Red-breasted Merganser *Mergus serrator*, Ruddy Duck *Oxyura jamaicensis*, Duck Species Unknown, Red-tailed Hawk *Buteo jamaicensis*, Peregrine Falcon *Falco peregrinus*, Virginia Rail *Rallus limicola*, Black-bellied Plover *Pluvialis squatarola*, Black Oystercatcher *Haematopus bachmani*, Whimbrel *Numenius phaeopus*, Black Turnstone *Arenaria melanocephala*, Surfbird *Aphriza virgata*, Sanderling *Calidris alba*, Red-necked Phalarope *Phalaropus lobatus*, Pomarine Jaeger *Stercorarius pomarinus*, Parasitic Jaeger *Stercorarius parasiticus*, Bonaparte's Gull *Larus philadelphia*, California Gull *Larus californicus*, Thayer's Gull *Larus thayeri*, Glaucous Gull *Larus hyperboreus*, Sabine's Gull *Xema sabini*, Elegant Tern *Sterna elegans*, Common Tern *Sterna hirundo*, Arctic Tern *Sterna paradisaea*, Marbled Murrelet B*rachyramphus marmoratus*, Xantus's Murrelet *Synthliboramphus hypoleucus*, Craveri's Murrelet *Synthliboramphus craveri*, Ancient Murrelet *Synthliboramphus antiquus*, Parakeet Auklet *Aethia psittacula*, Horned Puffin *Fratercula corniculata*, Tufted Puffin *Fratercula cirrhata*, Auklet Species Unknown, Murrelet Species Unknown, Band-tailed Pigeon *Columba fasciata*, Barn Owl *Tyto alba*, Great Horned Owl *Bubo virginianus*, Owl Species Unknown, Pacific-slope Flycatcher *Empidonax difficilis*, Western Scrub-Jay *Aphelocoma californica*, Clark's Nutcracker *Nucifraga columbiana*, American Crow *Corvus brachyrhynchos*, Corvid Species Unknown, Song Sparrow *Melospiza melodia*, Red-winged Blackbird *Agelaius phoeniceus*.

TABLE 1

Species	Encounter Rate (birds/km)	Oiling Rate (birds/km)
Red-throated Loon *Gavia stellata*	0.007	0.0001
Pacific Loon *Gavia pacifica*	0.020	0.001
Common Loon *Gavia immer*	0.009	0.0003
Loon Species Unknown	0.002	0.0001
Horned Grebe *Podiceps auritus*	0.004	0
Eared Grebe *Podiceps nigricollis*	0.002	0.0003
Western Grebe *Aechmophorus occidentalis*	0.051	0.002
Clark's Grebe *Aechmophorus clarkii*	0.011	0.0001
Western/Clark's Grebe	0.046	0.001
Grebe Species Unknown	0.004	0.0002
Northern Fulmar *Fulmarus glacialis*	0.108	0.002
Sooty Shearwater *Puffinus griseus*	0.022	0.0003
Short-tailed Shearwater *Puffinus tenuirostris*	0.005	0.0001
Fork-tailed Storm-petrel *Oceanodroma furcata*	0.003	0
Brown Pelican *Pelecanus occidentalis*	0.017	0.0001
Brandt's Cormorant *Phalacrocorax penicillatus*	**0.054**	**0.0001**
Double-crested Cormorant *Phalacrocorax auritus*	**0.004**	**0**
Pelagic Cormorant *Phalacrocorax pelagicus*	**0.010**	**0.0002**
Cormorant Species Unknown	0.005	0.0002
Surf Scoter *Melanitta perspicillata*	0.040	0.0001
White-winged Scoter *Melanitta fusca*	0.006	0
Bufflehead *Bucephala albeola*	0.002	0
American Coot *Fulica americana*	0.002	0.0001
Shorebird Species Unknown	0.002	0.0001
Willet *Catoptrophorus semipalmatus*	0.004	0
Marbled Godwit *Limosa fedoa*	0.003	0
Red Phalarope *Phalaropus fulicarius*	0.003	0.0001
Heermann's Gull *Larus heermanni*	0.013	0.0001
Mew Gull *Larus canus*	0.002	0.0001
Ring-billed Gull *Larus delawarensis*	0.004	0
Herring Gull *Larus argentatus*	0.004	0
Western Gull *Larus occidentalis*	0.099	0.001
Glaucous-winged Gull *Larus glaucescens*	0.029	0.0002
Western x Glaucous-winged Gull hybrid	0.005	0
Black-legged Kittiwake *Rissa tridactyla*	0.005	0.0006
Gull Species Unknown	0.017	0.0001
Common Murre *Uria aalge*	**0.260**	**0.025**
Pigeon Guillemot *Cepphus columba*	**0.016**	**0.0002**
Rhinoceros Auklet *Cerorhinca monocerata*	**0.008**	**0.0007**
Cassin's Auklet *Ptychoramphus aleuticus*	**0.019**	**0.0007**
Alcid Species Unknown	0.004	0
Common Raven *Corvus corax*	0.002	0
Bird Species Unknown	0.012	0.0002
Seabird Species Unknown	0.003	0.0001

TABLE 2
Summary of oiled birds (percent of total encountered) recorded by beach survey programs in the Atlantic and Pacific Oceans.

Year	Site	Oiling Fraction	Study
1977-1997	Holland	46%	Camphuysen, 1998
1984-1999	Newfoundland	62%	Wiese & Ryan, 2003
1978-1979	Inland Washington	< 1%	Speich & Wahl 1986
1980-1986	Central California	6.3 %	Bodkin & Jameson 1991
1990-1999	Belgium	44.7 %	Seys *et al*. 2002a, b
1993-2002	Central California	3.2 %	This report
1997-2001	Central California	<2 %	Nevins & Harvey unpublished
2000-2003	Oregon and Washington	2.2%	Hass & Parrish unpublished