CHRONIC OILING AND SEABIRD MORTALITY FROM THE SUNKEN VESSEL S.S. *JACOB LUCKENBACH* IN CENTRAL CALIFORNIA

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SUMMARY

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In 2002, the source of a mystery oil spill that killed large numbers of seabirds, especially Common Murres *Uria aalge*, in the Gulf of the Farallones, central California, was tracked to the vessel S.S. *Jacob Luckenbach* which sank after a collision in 1954. Matches of many oil samples have established that oil leaking from this vessel is responsible for the 2001-2002 and many earlier mystery oiling events in the 1990s, especially the 1997-1998 Point Reyes Tarball Incidents. This vessel has been a major source of chronic oil pollution in central California, although illegal offshore dumping of tank washing and bilge dumping also is implicated as a significant source of chronic oiling by non-matches of several oil samples. Recent efforts to investigate the source of oil, remove oil from the sunken vessel, and examine impacts to seabirds are summarized. A natural resource damage claim is being filed and seabird restoration efforts are envisioned.

Key words: oil, tar balls, California, mortality, restoration, Common Murre *Uria aalge*, Gulf of the Farallones, S.S. *Jacob Luckenbach*

INTRODUCTION

Mystery oil spills have plagued the central California coast for decades (Carter 2003). While recent oil fingerprinting techniques have assisted tracking of some mystery spills to specific vessels (e.g., *Apex Houston* oil spill; *Command* oil spill; Page *et al*. 1990; Carter *et al*. 2003a), the source of many mystery spills could not be determined. These spills usually shared the following characteristics: 1) they occurred in winter and were associated with large storms; 2) they manifested themselves in the appearance of oiled seabirds, primarily Common Murres *Uria aalge*, on beaches from Bodega Bay to Monterey Bay; and 3) very little oil was ever seen on the beaches or in the water. Various theories had been generated to explain the source of these oiling events, most commonly natural offshore oil seeps or oil from the vessel *Puerto Rican* which had exploded off the Golden Gate in 1984, was towed offshore to avoid coastal impacts, and broke up in rough seas. The stern half (with up to 8,500 bbls of bunker C oil and 11,725 bbls of other oil products) sank about 30 km south of the Farallon Islands (Herz & Kopec 1985, Dobbin *et al*. 1986). In 1985, oil was suspected of leaking from the sunken stern of the *Puerto Rican*. However, oil fingerprinting analyses since 1985 have often demonstrated that oil on seabirds was not consistent with *Puerto Rican* oil or California seep oil but did appear to be a bunker fuel. Illegal offshore tank washing and bilge dumping were generally blamed for the oil which was thought to come to shore when driven by strong winter storm winds.

When oiled birds washed ashore over an extended period in November-December 2001 during the San Mateo Mystery Spill, state and federal government agencies established a task force to determine the source of the oil. Oil fingerprinting analyses indicated the vast majority of the oil samples from birds were from the same source. Investigators obtained and examined oil samples from various vessels that repeatedly crossed the area, quickly ruling them out as possible sources. A review of Synthetic Aperture Radar (SAR) images from satellites and consultations with ornithologists regarding the behavior and beaching patterns of oiled birds suggested that the oil originated 15-30 km south of the Farallon Islands, near the location of the sunken *Puerto Rican*. At this point, leakage from another undersea wreck emerged as the dominant theory explaining the mystery oil spills (McCleneghan 2002). While hundreds of wrecks have been documented in the area, only a few were of large vessels. In January 2002, oil samples from the S.S. *Jacob Luckenbach*, a likely culprit based on location and type and amount of oil onboard when it sank, were matched to both oiled birds (Table 1) and oil collected on the surface of the ocean above the wreck. On 14 July 1953, the S.S. *Jacob Luckenbach*, a 148-meter freighter, had collided with its sister ship, the *Hawaiian Pilot*, and sank in 55 m of water about 27 km west-southwest of San Francisco (Fig. 1). Bound for South Korea with railroad parts, it had left San Francisco loaded with 10,880 barrels of bunker fuel.

Oil fingerprinting is the science of evaluating chromatographic signatures of crude oil and refined petroleum products. This involves interpreting patterns of biomarkers, which contain carbon, hydrogen, and other elements, in a qualitative or quantitative manner. Because these biomarkers are stable over long periods of time, this method has proven reliable for fingerprinting oil (Peters and Moldowan 1993). Once discovered as the source of the 2001-2002 mystery spill, government agencies checked for and found matches of *Luckenbach* oil samples with oil samples from another recent mystery oiling event in 1997-1998 (the Point Reyes Tarball Incidents), as well as with earlier samples from the winters of 1992-93 (n = 2 samples) and April 1999 (n = 1 sample). Table 1 presents the oil fingerprinting results from the Pt. Reyes Tarball Incidents (winter 1997-1998) and the San Mateo Mystery Spill (winter 2001-2002), the only two spills for which large numbers of sample results are currently available.

Based on these oil fingerprinting results, the *Luckenbach* has emerged as a major source of chronic oiling in central California. However, oil samples from seabirds that did not match *Luckenbach* oil were often refined products from a variety of sources, suggesting that illegal dumping also has contributed to chronic oiling of seabirds in central California. As part of the on-going assessment of seabird injuries, government agencies will be analyzing additional oil samples from birds collected over the years from time periods outside of the large oiling episodes. In this paper, we summarize available information on the potential impacts to seabirds from *Luckenbach* oil.

IMPACTS TO SEABIRDS

With various oil samples from the 1990s tied to *Luckenbach* oil, it is likely that many earlier mystery oil spills also were related to the leaking *Luckenbach*. However, prior to the mid-1990s, government response to mystery oiled bird events was limited and documentation sparse. Between 1971 and the mid 1990s, most information regarding oiled bird numbers on beaches in the Gulf of the Farallones from mystery spills was obtained by rehabilitation groups (e.g., International Bird Rescue and Research Center [IBRRC]) who recorded the numbers of live oiled birds brought in by the public (Carter 2003). In addition, relatively standardized data on numbers of oiled birds were available from three other sources: 1) numbers of dead oiled and non-oiled seabirds on beaches were recorded with standardized beached bird surveys by the Point Reyes Bird Observatory in 1972-1985 (Stenzel *et al*. 1988; Nur *et al*. 1997) and by the Gulf of the Farallones National Marine Sanctuary since 1993 (Roletto *et al*. 2000); 2) numbers of oiled birds have been monitored by the Point Reyes Bird Observatory (PRBO) at Southeast Farallon Island (SEFI) since

TABLE 1
Results of Oil Chemistry Analysis of Oiled Birds

Oiling event	Feather samples analyzed	Number that matched the *Luckenbach*	% that matched the *Luckenbach*
Pt. Reyes Tarball Incidents (winter 1997-98)	37	35	95%
San Mateo Mystery Spill (winter 2001-02)	52	38	73%

Fig. 1. The Location of the *Luckenbach*

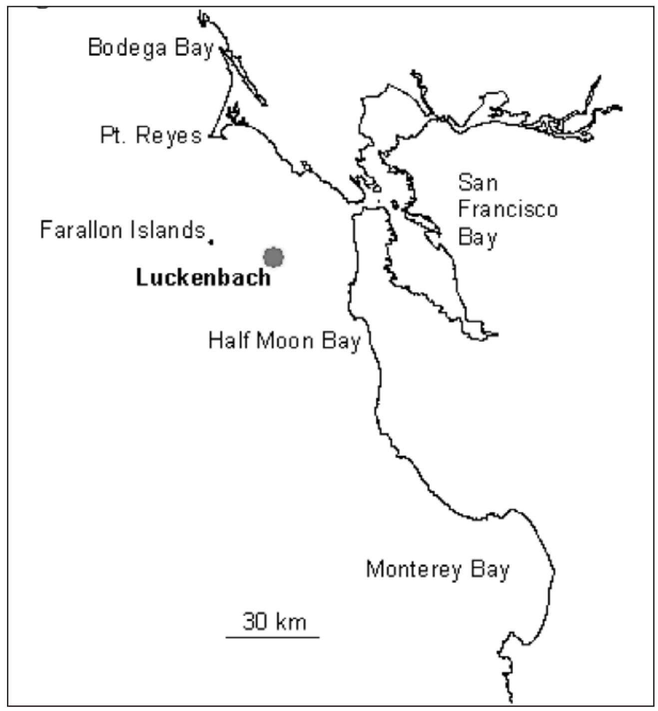


TABLE 2
Major Mystery Oil Spills off Central California or and Relationship to the *Luckenbach*

Date	Impacts (regardless of oil source)	Link to *Luckenbach**
Winter 1973-74	100+ live oiled birds found by public	Strongly suspected
Winter 1981-82	218 oiled birds observed on SEFI	Strongly suspected
August 1983	500+ live oiled birds found by public	Possible
Winter 1989-90	243 oiled birds observed on SEFI	Strongly suspected
Winter 1990-91	195 live oiled birds found by public; 127 oiled birds observed on SEFI	Strongly suspected
Winter 1992-93	163 live oiled birds found by public; 117 oiled birds observed on SEFI	Confirmed
Winter 1997-98	2,964 birds collected by agency response	Confirmed
Winter 2001-02	1,921 birds collected by agency response	Confirmed
Summer 2002	257 birds collected by agency response	Confirmed
Winter 2002-03	546 birds collected by agency response	Confirmed

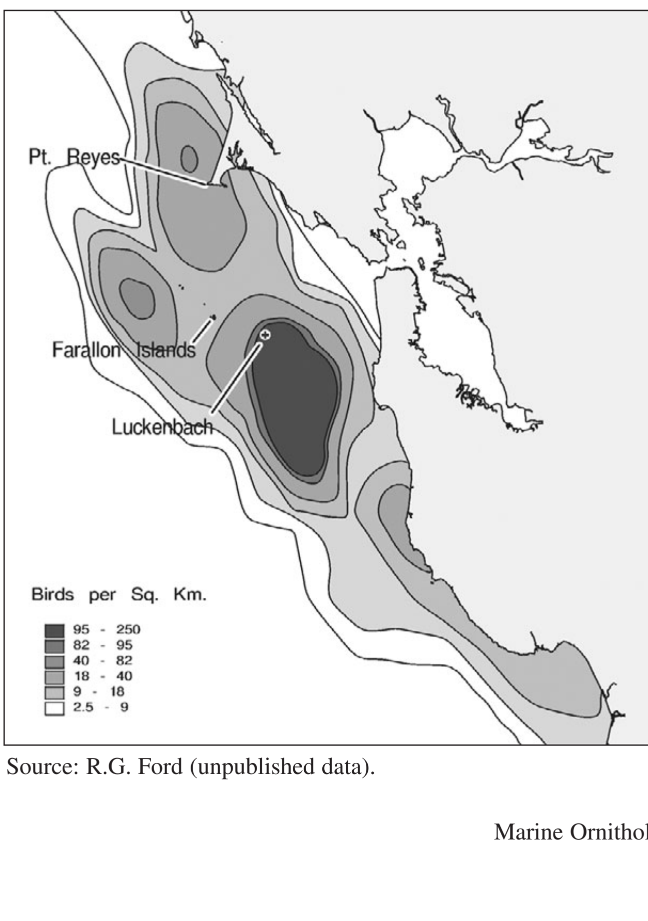
* Confirmation implies that oiled birds were matched to the Luckenbach through oil fingerprinting.

1977 (Nur *et al*. 1997); and 3) county park rangers at the Fitzgerald Marine Reserve, San Mateo County, recorded numbers of live oiled birds from 1968-1995 (Carter 1997). All major mystery spills since 1973 are summarized in Table 2, along with their relationship to the *Luckenbach*. Many events were associated with strong winter storms (Nur *et al*. 1997). However, many chronic oiling events may not have been documented and chronic oiling may have been much more continuous over the past few decades. Beached bird surveys from 1972-1985 found 15.1% of Common Murre carcasses to be oiled, with exceptional numbers in winter 1972-73 (45.1% oiled) and winter 1975-76 (32.8% oiled) (Nur *et al*. 1997). Beached bird surveys since 1993 have found 12.5% of all Common Murre carcasses to be oiled (Roletto *et al*. 2000).

The earliest documentation of a mystery spill event appears to be May 1973, when 8 live oiled birds were collected at Fitzgerald Marine Reserve in San Mateo County (Carter 1997). In December of the same year, 100 birds collected by the public were turned into IBRRC (Carter 2003), while 8 more were found at Fitzgerald Marine Reserve (Carter 1997). IBRRC received over 500 oiled birds from the Marin County coast in August 1983. However, the timing and location of this event are not typical of a *Luckenbach* event. Weather at that time of year is typically mild, and prevailing winds are more likely to carry oil and oiled birds south of San Francisco. Nevertheless, it may represent a sudden release from the vessel. IBRRC also received 195 birds in winter 1990-91 and 163 birds in winter 1992-93 (Carter 2003).

PRBO observations of oiled birds at SEFI documented pulses of 34 birds in winter 1977-78, 55 birds in winter 1979-80, 218 birds in winter 1981-82, 243 birds in winter 1989-90, 127 birds in winter 1990-91, and 117 birds in winter 1992-93. These events were usually associated with strong storms (Nur *et al*. 1997).

Fig. 2. Common Murre Densities December thru February



Source: R.G. Ford (unpublished data).

All mystery oil spills since (and including) 1992-93 have been matched to the *Luckenbach* through oil chemistry analysis (Table 2). Unfortunately, adequate oiled feather samples do not exist for the earlier events. Species composition has been fairly constant across episodes, with Common Murres accounting for the vast majority of birds found. Moderate numbers of Pacific Loons *Gavia pacifica*, Western Grebes *Aechmorphorus occidentalis*, Northern Fulmars *Fulmarus glacialis*, Brown Pelicans *Pelecanus occidentalis*, and Brandt's Cormorants *Phalacrocorax penicillatus* have also been recovered (Tables 3, 4). Winter concentrations of murres in central California are often centered over the *Luckenbach* (Fig. 2), making murres very susceptible to oiling from this source (Ainley & Boekelheide 1990; Briggs *et al*. 1983, 1987). Several major breeding colonies are located within 50 km of the *Luckenbach*. In 1995, over 50,000 pairs of murres bred at the South and North Farallon Islands combined and over 20,000 pairs at the Point Reyes National Seashore (Carter *et al*. 2001). Numbers have increased since 1995 (M.W. Parker, pers. comm.). These colonies represent over 95% of the central California breeding population. Murres in central California in winter appear to belong solely to the local breeding population although it is possible that small numbers of murres from northern populations do visit during winter (Manuwal & Carter 2001).

It is well documented that the number of birds collected on beaches represents a fraction of the total number of birds impacted (Ford *et al*. 1987, 1996; Page *et al*. 1990). At this time, total mortality has been estimated only for the 1997-98 Pt. Reyes Tarball Incidents. Himes Boor *et al*. (2003) estimated total mortality from that mystery spill (regardless of oil source) at 18,291 birds, not including an additional 191 birds that were considered to have possibly survived after rehabilitation and release. This estimate used a Beached Bird Model (see Ford *et al*. 1987), extrapolating from the beaches searched and adjusting for scavenging and search efficiency. Further adjustments were made to account for at-sea loss and natural mortality. Table 4 provides more details regarding the species composition of the estimated mortality. Note that the higher multiplier associated with smaller bodied birds is due to their lower retention rate on beaches due to scavenging and lower rate of observers finding carcasses.

TABLE 3
Total Mortality Estimates of
Pt. Reyes Tarball Incidents, 1997-98

Species	# Collected	# Estimated Dead
Common Murre	1,858	9,094
Brown Pelican	21	123
Other near-shore large species	542	2,334
Other offshore large species	463	2,946
Marbled Murrelet	3	122
Offshore small species	66	3,672
Other small land birds	6	Not included
TOTAL:	2,959	18,291

Note: "Small species" refers to small alcids and shorebirds that are easily removed from beaches by gulls and ravens. Source: Himes Boor et al. (2003).

TABLE 4: Numbers Collected Live & Dead During Recent Oiling Episodes

Species	Winter 1997-98	Winter 2001-02	Winter 2002-03
Red-throated Loon *(Gavia stellata)*	11	5	
Pacific Loon *(Gavia pacifica)*	54	43	10
Common Loon *(Gavia immer)*	14	4	1
Loon, sp.	2	1	
Pied-billed Grebe *(Podilymbus podiceps)*	3		
Horned Grebe *(Podiceps auritus)*	16		
Red-necked Grebe *(Podiceps grisegena)*	3		
Eared Grebe *(Podiceps nigricollis)*	13	2	
Western Grebe *(Aechmorphorus occidentalis)*	142	74	132
Clark's Grebe *(Aechmorphorus clarkii)*	9	3	10
Aechmophorus grebe sp.	40	13	5
Grebe, sp.	12	2	1
Northern Fulmar *(Fulmarus glacialis)*	335	5	11
Pink-footed Shearwater *(Puffinus creatopus)*	1		
Sooty Shearwater *(Puffinus griseus)*	7		1
Short-tailed Shearwater *(Puffinus tenuirostris)*	3		
Black-vented Shearwater *(Puffinus opisthomelas)*	3		
Shearwater, sp.	3		
Leach's Storm-Petrel *(Oceanodroma leucorhoa)*	1		
Ashy Storm-Petrel *(Oceanodroma homochroa)*		1	
Brown Pelican *(Pelecanus occidentalis)*	21	9	2
Brandt's Cormorant *(Phalacrocorax penicillatus)*	60	35	36
Double-crested Cormorant *(Phalacrocorax auritus)*	3	3	
Pelagic Cormorant *(Phalacrocorax pelagicus)*	12	3	2
Cormorant, sp.	2	1	
Brant *(Branta bernicla)*	1		
Lesser Scaup *(Aythya affinis)*		1	
Greater Scaup *(Aythya marila)*	1		
Surf Scoter *(Melanitta perspicillata)*	90	6	3
White-winged Scoter *(Melanitta fusca)*	22		
Black Scoter *(Melanitta nigra)*	1		
Scoter, sp.	4		
Bufflehead *(Bucephala albeola)*	5	1	
Ruddy Duck *(Oxyura jamaicensis)*	1	2	
Red-breasted Merganser *(Mergus serrator)*		1	
Duck, sp.	2		
American Coot *(Fulica americana)*	4		
Sanderling *(Calidris alba)*		1	
Red-necked Phalarope *(Phalaropus lobatus)*	1	1	
Red Phalarope *(Phalaropus fulicaria)*	35		7
Shorebird sp.		2	
Bonaparte's Gull *(Larus philadelphia)*	1	1	
Heermann's Gull *(Larus heermanni)*	15	5	
Mew Gull *(Larus [canus] brachyrynchus)*	1	1	
Ring-billed Gull *(Larus delawarensis)*	2	2	1
California Gull *(Larus californicus)*	5	33	2
Herring Gull *(Larus [argentatus] smithsonianus)*	4	6	1
Western Gull *(Larus occidentalis)*	38	48	2
Glaucous-winged Gull *(Larus glaucescens)*	8	34	1
Glaucous Gull *(Larus hyperboreus)*	2		
Black-legged Kittiwake *(Rissa tridactyla)*	12	3	
Gull, sp.	11	13	
Gull, Western x Glacous-winged		2	
Common Murre *(Uria aalge)*	1,858	1,487	312
Pigeon Guillemot *(Cepphas columba)*	3	1	
Marbled Murrelet *(Brachyramphus marmoratus)*	3		
Ancient Murrelet *(Synthliboramphus antiquus)*	6	15	
Cassin's Auklet *(Ptychoramphus aleuticus)*	23	9	4
Rhinoceros Auklet *(Cerorhinca monocerata)*	7	29	1
Horned Puffin *(Fratercula corniculata)*	1		
Alcid, sp.	1		
Bird, sp.	15	7	1
Falcon, sp. (falconer's hybrid)		1	
Burrowing Owl *(Athene cunicularia)*		1	
Exotic Goose		1	
Other small land birds	6	3	
TOTAL:	2,959	1,921	546

The level of estimated mortality to Common Murres (9,094 impacted) is significant given the relatively small size and depleted status of the affected local breeding population due to impacts from gill-net fishing, major oil spills, human disturbance, and other factors (Takekawa *et al*. 1990; Carter *et al*. 2001; Nevins & Carter 2003). Highest murre impacts occurred at the Drake's Bay colony complex where reduced numbers were still noted by 2000 (Carter *et al*. 2003b). In addition, impacts to threatened Marbled Murrelets *Brachyramphus marmoratus* (122 impacted) also are significant but less well documented since the recovery of these small-bodied seabirds is difficult (Table 3). The central California population of murrelets also is relatively small and declining from loss of old-growth forest nesting habitat, mortality in gill nets, and oil pollution (Carter & Erickson 1992; Carter & Kuletz 1995; Carter *et al*. 1995; USFWS 1997).

LUCKENBACH OILING EVENTS AND WINTER STORMS

Very little is known about the undersea currents that sweep past the *Luckenbach*. The area is subject to complex surface currents, partially influenced by tidal currents in and out of San Francisco Bay. During the oil removal efforts in the summer of 2002, divers noted that the undersea currents were often stronger than surface currents and would switch directions during the course of a day. Oiling events from the *Luckenbach* are correlated with strong storm events. Since 1996, when significant wave height (WVHT; i.e., average of the highest one-third of all of the wave heights during a 20-minute sampling period) measured by NOAA Buoy 46026 in the Gulf of the Farallones, reaches seven meters, a significant oiling event has always ensued. In the past, oiling events have occasionally been triggered by WVHT in the 5.5 range. Furthermore, once an oiling event is triggered, it may persist for several weeks or even months. WVHT has reached seven meters only five times in the past five years. These large waves appear to be correlated with strong bottom currents at the vessel. During oil removal operations, divers observed that, during strong swells, strong currents developed that caused oil to be wicked from various holes in the vessel (K. McCleneghan, pers. comm.).

CLEANUP OPERATIONS

In the summer of 2002, the National Pollution Funds Center (NPFC) of the United States Coast Guard spent over $19 million removing oil from the vessel (Kay 2002). Dive teams, breathing mixed gas and living in a pressurized chamber for up to a month, worked daily throughout the summer locating oil and pumping it out of the wreckage to a large barge stationed at the surface. The work was hampered by poor visibility and strong undersea currents and the fact that the *Luckenbach* contained over 30 different tanks and compartments containing oil. Small releases during the operation resulted in the oiling of several hundred birds (see Table 2). In the end, approximately 2,380 barrels (22% of the total originally on board) were removed and most of the remaining holes and vents were either sealed or buried. It was estimated that 690 barrels remained onboard but was not removable. Herz & Kopec (1985) noted that recovery of oil or plugging of leaks was considered for the sunken stern of the *Puerto Rican* but these actions were not conducted because of the estimated cost (millions of dollars) and little guarantee of success with available technology. Modern technology made such efforts practical and successful in the case of the *Luckenbach*, although long-term success needs to be monitored.

Unfortunately, the oil removal effort has not led to a complete end to the oiling events. Strong storms in November and December 2002 resulted in the collection of over 500 oiled birds. Oil chemistry analyses of oiled birds have again pointed to the *Luckenbach* (five of five samples matched). An analysis of the number of birds collected in the three weeks after a major storm event, where WVHT exceeds seven meters, suggests that some improvement has been made (Fig. 3). It does appear that oiling events are now limited to the time period immediately after large storms. Fig. 4 compares the total number of birds collected during recent winters (Table 3) with those collected only in the aftermath of large storms (Fig. 3), listing the number of birds collected during non-storm periods.

SEABIRD RESTORATION

No legally responsible party for the *Luckenbach* has been determined to exist. In such cases, the NPFC may authorize the use of the Oil Spill Liability Trust Fund to pay for clean-up and response costs and compensatory restoration. This fund, created under the Oil Pollution Act of 1990 (OPA 90) in the wake of the *Exxon Valdez* oil spill (Piatt *et al*. 1990), first received money from a five cents per barrel fee on imported and domestic oil. The fund is augmented by the collection of federal fines and penalties. The $19 million response action was paid for from this fund.

Compensatory restoration is any restoration action that seeks to compensate the public for injuries to natural resources. Under OPA 90 and various other state and federal laws, natural resource trustee

Fig. 3. Birds collected during 3 weeks following major storms

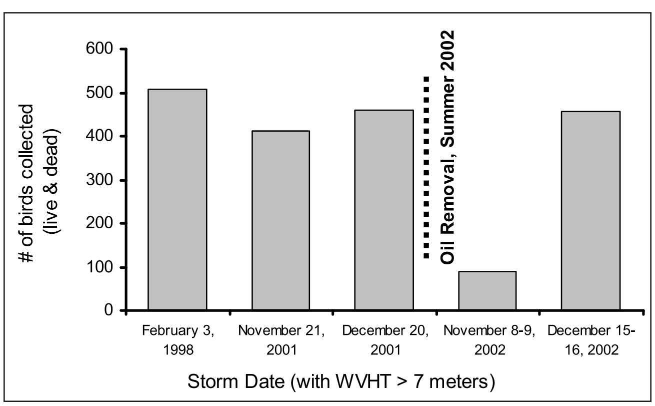
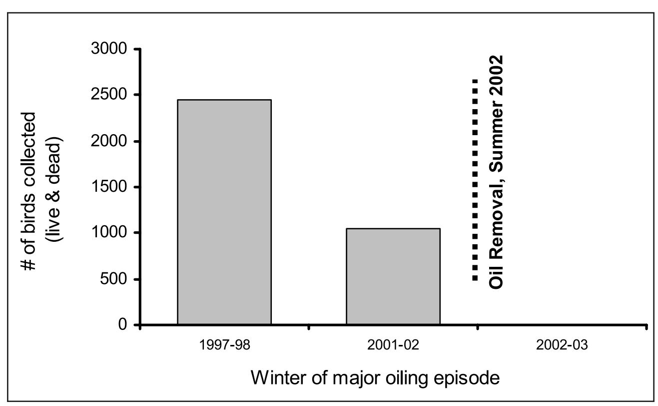


Fig. 4. Birds collected beyond 3 weeks of a major storm



agencies may pursue a natural resource damage claim for compensatory restoration. In the case of the *Luckenbach*, a claim will be made to the NPFC by the U. S. Fish and Wildlife Service, the Bureau of Land Management, the National Parks Service, the National Oceanic and Atmospheric Administration, and the California Department of Fish and Game. The natural resource damage assessment (NRDA) associated with this claim is currently seeking to quantify the injuries to seabirds and identify restoration actions that both restore the seabirds to pre-spill levels and further compensate the public for interim losses. The claim will be based on the cost to implement these restoration projects. Under OPA 90, only injuries that occurred after August 18, 1990 (the passing of OPA 90) may be addressed by this damage claim.

Past and proposed restoration projects for pelagic birds in California have included social attraction to reestablish a Common Murre colony (Apex Houston Trustee Council 1995); eradication of rats from Anacapa Island to improve seabird nest success (American Trader Trustee Council 2001); institution of a human disturbance reduction program to protect nesting grebes (American Trader Trustee Council 2001) and murres (Command Trustee Council 2003); acquisition of old growth redwoods to protect Marbled Murrelet breeding habitat (Command Trustee Council 2002, Apex Houston Trustee Council 1995); institution of a corvid management program to improve Marbled Murrelet nest success (Command Trustee Council 2003); and the development of artificial roosts to benefit Brown Pelicans (Command Trustee Council 2003, American Trader Trustee Council 2001). The restoration projects in this case will be focused on the species most heavily impacted, either in absolute numbers or in relation to their population status, and subject to feasibility limitations.

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