Final Report

Central Coast Marine Bird Health Study: Year 3 (2005-2007)

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

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Background

The Scientific Study and Evaluation Program (SSEP) of the Department of Fish & Game Office of Spill Prevention and Response (CDFG-OSPR) was initiated to investigate and evaluate applied response programs, best achievable technologies and potential adverse effects of oil spills. The program also supports natural resource damage assessments as well as projects that develop baseline biological and chemical information and establish reference sites for environmental concentrations of petroleum products.

Summary

The Central Coast Marine Bird Health Study (hereafter, Seabird Health Study) enhanced response capabilities during unusual mortality events in support of OSPR oil spill response and established a regional information center for federal, state, and local resource managers for issues regarding marine bird health. During three years of the CDFG-OSPR SSEP sponsored Seabird Health Study, we systematically quantified human-related and natural causes of mortality based on field studies and lab necropsies (2005, n = 157; 2006, n = 302; 2007, n = 390) and found that although natural mortality factors comprised a significant proportion of determined cases (68%), anthropogenic causes of morbidity and mortality such as chronic oiling, trauma, and fishery interactions continue to be considerable (~15%). Nearshore species (grebes, loons, surf scoters) were more frequently impacted by harmful algal blooms compared with offshore species (murres, shearwaters). We characterized the demography of several unusual mortality events increasing the understanding of causes behind seabird wrecks in the area, including those affecting phalaropes, puffins, fulmars and others. In addition to routine necropsies, we examined post-litigation samples from three past oil spill events: 1997 Kure (n = 602), 1999 Stuyvesant (n = 334), and the 2001-02 San Mateo Mystery Spill (n = 169, aka Luckenbach). We found demographic differences among Common Murres collected during these spill events related to the season and phenology of this species. Winter spills affected mainly adults (60 to 63%) and late summer spill affected significantly more chick-rearing males (15:1 sex ratio). These results provide important information to determine appropriate mitigation measures for effective wildlife restoration. We also provided the CDFG- Petroleum Chemistry Lab with 109 oiled feather samples to help identify non-point source spills and aid in OSPR's natural resources damage assessment (NRDA) process.

Objectives

Initiated in 2005, the primary goal of the Seabird Health Study was to develop a comprehensive program to monitor the health and mortality of marine bird populations that are most often affected by oil spills within the central California coast region[1] (Fig. 1). Specific objectives were to (1) conduct field investigations to measure baseline health and survivorship, chronic oiling and entanglement of wild seabirds, (2) provide quantitative assessment of mortality factors by conducting necropsies of specimens

[1] The core study area includes Santa Cruz, Monterey, and San Luis Obispo Counties. Specimens from peripheral areas were included during unusual mortality events or at the request of state or local agencies.

collected from beach survey programs[2], rehabilitation centers, and state and federal resource agencies, and (3) derive an understanding of the affect of oil spills on marine birds at the population-level by examining post-litigation specimens.

Further, we documented types of anthropogenic factors affecting seabirds upon which to recommend appropriate mitigation actions. In addition to the primary objectives, we provided samples to collaborators working to detect the presence of emerging zoonotic diseases in seabirds, including avian influenza virus (AI) and West Nile virus (WNV).

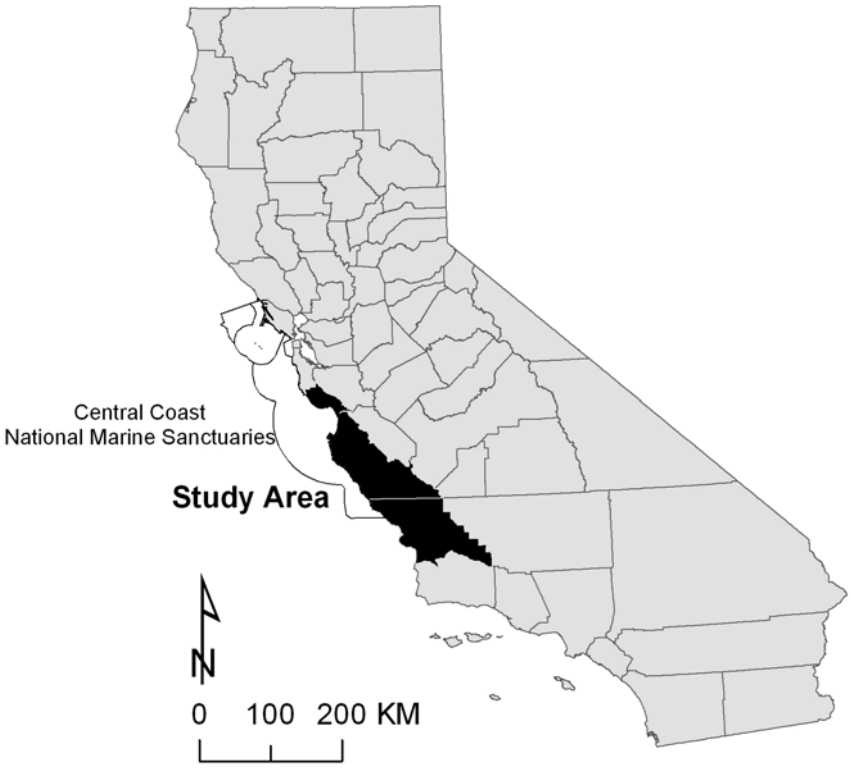

Figure 1. Study area includes Santa Cruz, Monterey and San Luis Obispo Counties (black) and adjacent to waters of Monterey Bay, Gulf of the Farallones, and Cordell Bank National Marine Sanctuaries (line).

Methods & Experimental Plan

Objective (1): Baseline health and survival of seabirds in California

We conducted live-capture field investigations in Monterey Bay using boats and trained personnel from both OSPR and Moss Landing Marine Laboratories (MLML). Our goal was to sample up to 100 adult and chick Common Murres each month from June to October. Birds were captured using a spotlight and dip-net from a small boat. This study augments previous work[3] by establishing a systematic program to sample for disease and to document chronic oiling and entanglement[4]. When possible, we collected cloacal swabs to help determine prevalence of potentially zoonotic avian

[2] The Moss Landing Marine Laboratories - Monterey Bay National Marine Sanctuary COMBERS program surveys beaches monthly in Monterey and Santa Cruz, and San Luis Obispo counties and Gulf of the Farallones - Beach Watch volunteers survey beaches in San Mateo, San Francisco, and Marin counties.

[3] Previous OWCN-funded studies have proven the feasibility of at-sea capturing methods for murres and shearwaters, and demonstrated the ability to effectively sample hematology, body condition, and diet, and incidental oiling and entanglement (S. Newman, unpublished data; J. T. Harvey and H. M. Nevins, unpublished data; J. Adams and J. T. Harvey, unpublished data).

[4] Oiled and entangled birds were captured during sampling trips in 2001 (1 of 20 murres oiled), and 2003 (2 of 18 murres were entangled, 1 of 18 murres oiled; 1 of 63 shearwaters oiled).

influenza virus in wild seabirds. We recovered banded birds for post-mortem examination through regional beach monitoring programs and rehabilitation centers.

Birds were captured, weighed, banded, and released over a very short time period (< 5 min) to prevent disassociation from foraging groups or attending parents. Ideally, this provides a sample of known-aged birds for estimating first-year survival, which is a vital parameter to determine population demography (Ainley et al. 2002). Banded birds recovered on systematic beach surveys received gross necropsy and histopathologic examination (dependent upon carcass condition) in order to document life history status, to establish baseline information on "background" conditions and infections that if detected in the future could be considered insignificant relative to overall seabird health, and to diagnose causes of morbidity and mortality. This information was entered into a searchable computer database to facilitate analysis and retrospective investigations.

Objective (2): Species-specific disease factors

Disease investigations were led by experienced biologists and veterinary pathologists at CDFG-MWVCRC. As outlined under objective 1 we documented life history and pathology findings from gross and histopathologic examination of birds obtained from beach survey programs, rehabilitation centers, and state and federal resource agencies throughout the central California coast (Monterey, Santa Cruz and San Luis Obispo Counties). This pathology service included response to unusual mortality events. We used intake records from a rehabilitation center (Monterey SPCA) to describe and summarize potential disease factors; data that often are currently collected, but not systematically evaluated. Information was entered into a searchable database, disseminated to appropriate parties when necessary, and will be published in a peer-reviewed journal when findings from 2007 are complete.

The Seabird Health Study provided coordination and expertise on wildlife pathology, and established a framework for a systematic demographic and health assessment program. CDFG-MWVCRC holds an image archive[5], tissue and specimen bank, and searchable computer database for seabirds, and will continue to refine avian- and species-specific protocols for necropsy and disease assessment, which were created in 2005. The annotated image library can be used as a reference guide for wildlife response and NRDA wildlife processing groups. Information in the database and obtained from necropsies can be used to help support graduate student research. Reference pathology slides will be valuable for training and understanding of background and significant conditions, such as the potential emerging diseases of avian influenza virus and West Nile Virus in seabirds. Using available genetic technology and existing screening programs, AI infection rates of seabirds, viral type, potential exposure rates and risks can be evaluated and information made available to OSPR and its contractors. Significant findings were summarized and disseminated to appropriate parties in a timely manner.

Objective (3): Post-litigation specimen investigations

Demographic information derived from oil spills and other mass mortality events provide insight to factors affecting local marine bird populations. We also can use archived tissue to augment our understanding of the geographic origins of migratory seabirds (e.g., genetic structure or isotope analyses) that are killed during oil spills.

[5] http://shutterbug.ucsc.edu/gallery/albums.php

To increase population level understanding of the demographics of marine birds affected by oil spills we examined, measured, and photographed marine birds that had been held for litigation. Once the litigation processes were completed, specimens being held by OSPR NRDA were made available for research and museum collections. We used released seabird carcasses to increase our understanding of the demographics of different mortality factors by documenting morphometrics, sex, and age (Nevins & Carter, 2003). Specimens were classified into one of three age/reproductive categories based upon bill and wing size, plumage, and internal examination, and when necessary confirmed by histopathology. We assessed gonad maturity, bursa size, and skull ossification to classify individuals into categories which included 1) adult - reproductively active (enlarged testes/ ripe ova) or non-active, 2) subadult/Immature – >1yr, immature gonads, and 3) hatch-year - born within the calendar year.

In addition, tissue samples (bone, feather, muscle) from these specimens were archived for use by cooperators at UC Santa Cruz and UC Berkeley for stable isotope analyses to address community-level or species-specific questions (K. Fox-Dobbs, UCSC; A. Moody, UCB). Muscle and liver samples were collected for a population genetics study (D. Humple, Sonoma State University). Additional samples of muscle were submitted to a study on the prevalence of protozoal infection in marine animals (M. Grigg, National Institute of Health).

Subsequent to an oil spill event and to scavenging, it can be difficult for natural resource trustee agencies to determine the number and type of species and life stages that have been killed. We developed a web-based photo collection of seabirds, including photos of beaks, feet, carina, and other identifying parts from which dead birds and scavenged, oiled birds can commonly be identified. This image-based format will provide an image library as a reference tool for contract experts, OSPR staff, and other trustees to easily access using personal computers during carcass collection and analysis in future oil spills.

Results & Discussion

(1) Baseline health and survival of seabirds in California

We conducted several field capture events in Monterey Bay using boats and trained personnel from both OSPR and MLML. In 2005 we captured 18 birds and in 2006 we collected an additional 3 birds (Table 1). Captures were conducted in coordination with the seabird satellite tracking study by Josh Adams (USGS). None of the birds captured and released were oiled or entangled. During these two years, unfavorable oceanographic conditions resulted in record low reproductive output at both the Farallones (W. Sydeman, pers. comm.) and the nearby Big Sur colonies (G. McChesney, USFWS) which significantly hindered our ability to meet the objective of banding 100 young-of-the-year murres.

However, we were able to recover 9 Common Murres and 37 banded birds of various species through collections by beach monitoring and rehabilitation centers. Species recovered with bands included Brandt's Cormorants (24), Rhinoceros Auklets (1), Common Murres (9), Surf Scoter (2), Brown Pelican (1), Snowy Plover (2), Common Loon (1) and Sooty Shearwater (1; Table 2). These band records indicate that most birds collected in the study area are from local breeding colonies, predominantly SE Farallon Island. Four of the returns were from birds rehabilitated at the IBRRC center in Cordelia (Table 2).

Oiling — Using data from BeachCOMBER surveys, we found that chronic oiling continued to be a factor affecting survivorship of Common Murres and 22 other seabird species in the region. We assumed that any detectable external oiling of the plumage of a 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. A total of 157 oiled birds were documented by beach surveys during 2005 (n = 76), 2006 (n = 46) and 2007 (n = 35). In general, the greatest proportions of oiled birds were alcids (60-74%), procellarids (15-16%), and cormorants (4-9%), and fewer gulls (2-5%) and others (~2 %) were affected. Of the alcids, the Common Murres and Rhinoceros Auklets were most often affected by oiling (Table 4). We examined the 2005 intake records for seabirds from Monterey SPCA to determine if these data were suitable for comparisons in trends of mortality factors (1 Jan to 19 Nov; n =283). We found that although most often the diagnosis was undetermined (62%), a greater proportion of rehabilitation birds were determined to be oiled (6%) than reported by the beach survey program in 2005 (3%, n = 2141) and 2006 (2%, n = 1777). The 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). In 2007, and additional 6 Horned Puffins were sampled at the request of OSPR. All of these samples were sent to the Petroleum Chemistry Lab for fingerprint analysis and archiving (Shane Stahl, PCL).

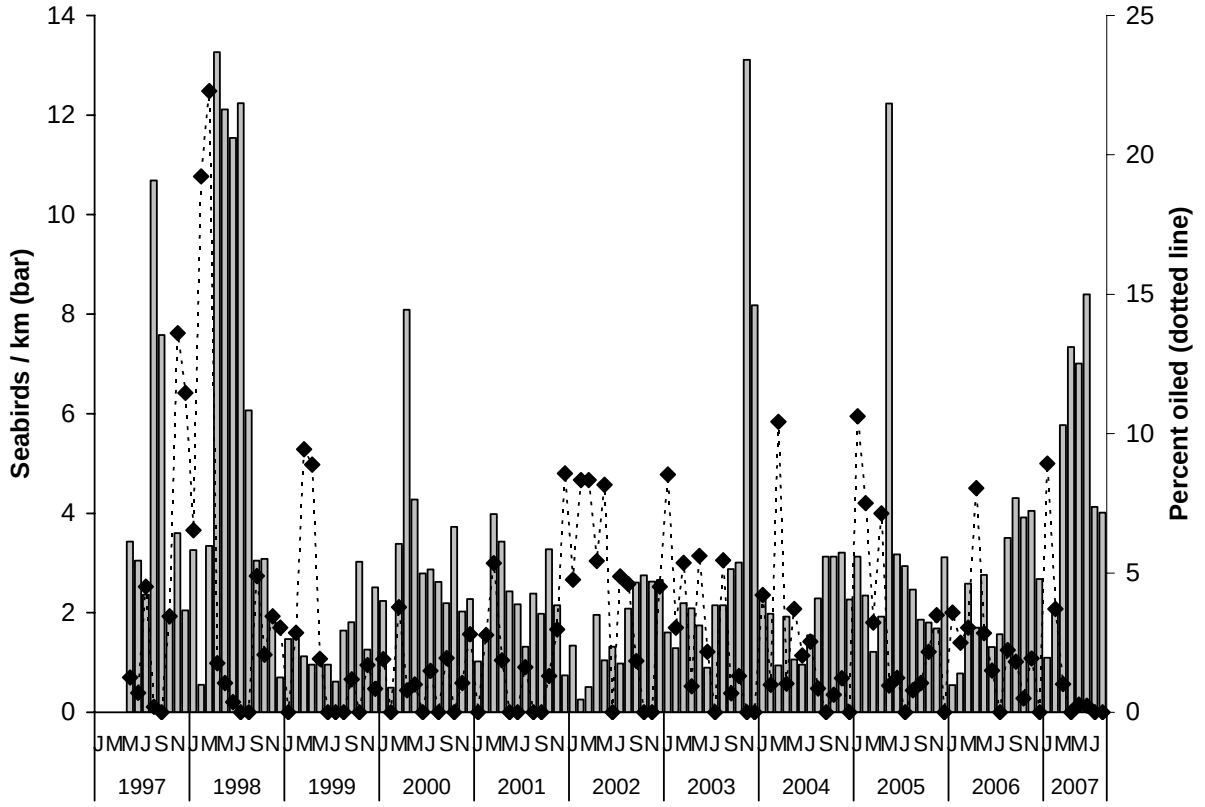

Figure 2 Long-term trend in monthly new deposition of marine birds (bars) and percent oiled (dotted line) reported by BeachCOMBERS. Significant oiling events were marked by oiling rates greater than 2%, such as during the 1997-98 Pt. Reyes Tarball event (Oct 97 to Mar 98), the San Mateo Mystery Spill (Oct 2001 to May 2002), and various “mystery oil events” during spring 1999, March 2004, Jan to May 2005, and winter 2005-06. Note that a reduction in deposition often occurs with significant oil events due to OSPR response-related clean-up efforts on beaches.

Table 1. Seabirds captured for Central Coast Marine Bird Health Study in 2005 and 2006 (IACUC protocol #874 Harvey and Nevins). Species codes follow AOU convention combining the first two letters of the first and last name (i.e. Red Phalarope = REPH). Age codes refer to hatch-year (HY) and after-hatch-year (AHY). Associations are between the bird captured and attending adults (A) or chicks (C), or group of birds (group).

No.	Date	Location	time	Species	Band No.	Leg (L/R)	Age	Plumage	Mass (g)	Oiled?	Diet?	Blood?	Molt	Assoc.	Notes
1	9/1/2005	Moss Landing, offshore	21:26	COMU	1106-01201	L	HY	Juv	900	N	N	N	p1-10 = 90%	C/A	chick adult size; adult not captured
2	9/1/2005	Moss Landing, offshore	22:08	COMU	1106-01202	U	AHY	Winter	1110	N	N	N	10%	A1/C1	
3	9/1/2005	Moss Landing, offshore	22:08	COMU	1106-01203	U	HY	Juv	1090	N	N	N	100%	C1/A1	white-tipped underwing coverts, all
4	9/1/2005	Moss Landing, offshore	22:19	COMU	1106-01204	U	AHY	Winter	1130	N	Y	N	10%	A/A	ret's old, weight after puking
5	9/1/2005	Moss Landing, offshore	22:32	COMU	1106-01205	U	HY	Juv	1190	N	N	N	100%	C2/A2	2-in-1 net, white-tipped secondaries
6	9/1/2005	Moss Landing, offshore	22:32	COMU	1106-01206	U	AHY	Winter	980	N	N	N	p1=old, p2-1	A2/C2	picked feathers in a patch near ven
7	9/1/2005	Moss Landing, offshore	22:47	COMU	1106-01207	R	AHY	Transitior	1060	N	N	N	0%	A3/C3	
8	9/1/2005	Moss Landing, offshore	22:47	COMU	1106-01208	R	HY	Juv	1000	N	N	N	100%	C3/A3	coverts slightly white-tipped
9	9/1/2005	Moss Landing, offshore	23:03	COMU	1106-01209	R	AHY	Winter	990	N	N	N	0%	A	rets worn to rachis, few diatoms on
10	9/1/2005	Moss Landing, offshore	23:24	COMU	1106-01210	R	AHY	Transitior	1120	N	N	N	yes	A5/C5	p10=old, p1-9 = 0%
11	9/1/2005	Moss Landing, offshore	23:24	COMU	1106-01211	R	HY	Juv	1140	N	Y	N	100%	C5/A5	white-tipped underwing coverts, chi
12	9/2/2005	Moss Landing, offshore	0:08	COMU	1106-01212	R	AHY	Transitior	1100	N	N	N	30%	A1/Group 4A	
13	9/2/2005	Moss Landing, offshore	0:12	COMU	1106-01213	R	AHY	Mottled	1020	N	N	N	30%	A2/Group 4A	clean belly
14	9/2/2005	Moss Landing, offshore	0:16	COMU	1106-01214	R	AHY	Transitior	980	N	N	N	yes	A3/Group 4A	<10%, all pins
15	9/1/2005	Moss Landing, offshore	0:36	COMU	1106-01215	R	AHY	Transitior	1090	N	N	N	60%	A1/Group	clean brest, all rets gone; captured
16	9/1/2005	Moss Landing, offshore	0:39	COMU	1106-01216	R	AHY	Mottled	920	N	N	N	50%	A2/Group	yellowish feet; captured from string
17	9/1/2005	Moss Landing, offshore	0:53	COMU	1106-01217	R	HY	Juv	1000	N	N	N	100%	C/A	
18	9/1/2005	Moss Landing, offshore	1:03	COMU	1106-01218	R	HY	Juv	960	N	N	N	100%	C/A	
1	8/17/2006	Moss Landing, offshore	21:36	SOSH	1055-07129	R	AHY	NA	1025	N	Y	N	yes		p1-2 = 50%; P3-10 = 70%
2	8/17/2006	Moss Landing, offshore	22:10	COMU	1106-01219	R	HY	Juv	1250	N	N	N	90%	C/A	AI swab 06-08-17-61 DJ
3	8/17/2006	Moss Landing, offshore	22:25	COMU	1106-01220	R	AHY	BR	1100	N	N	N	20%	A/C	AI swab 06-08-17-62 DJ

Table 2. Band recoveries in study area reported to USGS Bird Banding Lab during Central CA Marine Bird Health Study during May 2005 to June 2008.

Date Recovered	Species	Beach	County	Leg (1)	Band No.[a]	Leg (2)	Color Band	Color Code	Collector(s), Group	Location banded[b]
5/1/2005	Brandt's Cormorant	Zmudowski	Monterey		0778-21597		Red	AJE	M. Yoklavich/ J. Harvey (COMBERS)	SE Farallon Is, CA
5/2/2005	Brandt's Cormorant	Sunset	Santa Cruz		0778-11975		Green	A48	COMBERS	Farallon Is., CA
5/17/2005	Brandt's Cormorant	Marina	Monterey	R	0778-21124	L	Green	E67	COMBERS	Farallon Is., CA
7/1/2005	Brandt's Cormorant	New Brighton	Santa Cruz	R	XXX-22537	L	Red	KTE	COMBERS	Farallon Is., CA
9/26/2005	Brandt's Cormorant	Seabright	Santa Cruz		0778-22726		White/black	LAL	Milton Abbott (Public)	Farallon Is., CA
10/1/2005	Brandt's Cormorant	Fort Ord	Monterey	R	XXX-23227	L	White/black	TXU	COMBERS	Farallon Is., CA
10/3/2005	Brandt's Cormorant	Marina	Monterey	R	XXX-23511	L		XNC	COMBERS	Farallon Is., CA
11/18/2005	Brandt's Cormorant	Zmudowski	Monterey		XXX-09902		Black		COMBERS	Farallon Is., CA
12/3/2005	Brandt's Cormorant	Fort Ord	Monterey	L	XXX-22783	R		LZT	COMBERS	Farallon Is., CA
7/28/2005	Common Murre	Seacliff	Santa Cruz		1066-80282				Jan Leppe (State Parks)	IBRRC, Suisun, CA (rehab)
5/10/2005	Rhinocerous Auklet	Limantour Beach	Marin		0875-16253				Peter de Jung (Beach Watch)	Farallon Is., CA
10/20/2005	Snowy Plover	Zmudowski	Monterey		no metal band		right leg-red/orange, left leg-baby blue band		COMBERS	Montery Bay
7/15/2005	Sooty Shearwater	Marina	Monterey		1035-20212				COMBERS	Montery Bay (rehab)
11/7/2006	Black Brant	Carmel	Monterey	L	3617-31466	R	Black	28Z	Pamela Vily	Chevak, Alaska
5/1/2006	Brandt's Cormorant	Sunset	Santa Cruz		0778-2113X				COMBERS	Farallon Is., CA
6/5/2006	Brandt's Cormorant	New Brighton	Santa Cruz		0778-23139			PZN	COMBERS	Farallon Is., CA
10/1/2006	Brandt's Cormorant	Waddell Creek	Santa Cruz	L	XXX-23802	R	yellow	AXK	COMBERS	Farallon Is., CA
6/6/2006	Brown Pelican	Moss Landing Harbor	Santa Cruz		0669-20125				E. Phillips/J. Burrows (MLML)	
6/30/2006	Common Loon	Morro Bay	San Luis Obispo	L	0938-30802	R-Blue/Orange; L-Silver/Blue			Mike Harris (CDFG)	Loon Study - SLO
9/6/2006	Common Murre	Zmudowski	Monterey	L	75-302	L	Green		COMBERS	
1/1/2007	Brandt's Cormorant	Manresa	Santa Cruz		no metal band		yellow	JPE	COMBERS	
5/3/2007	Brandt's Cormorant	Moss Landing	Monterey	L	0778-24098	R	Yellow	EPZ	J. Ames/ B. Lea(COMBERS)	SE Farallon Is, CA
5/6/2007	Brandt's Cormorant	Salinas River	Monterey		0778-24195		yellow/black	HAC	L. Otterby(COMBERS)	SE Farallon Is, CA
5/6/2007	Brandt's Cormorant	Zmudowski	Monterey	L	0778-24664	R	yellow/black	ZTC	L. Wertz/J. Webb (COMBERS)	SE Farallon Is, CA
5/15/2007	Brandt's Cormorant	Zmudowski	Monterey	L	0778-24616	R	yellow/black	ZPZ	C.Miller/L. Hall (COMBERS)	SE Farallon Is, CA
5/16/2007	Brandt's Cormorant	Marina	Monterey	L	0778-23857	R	yellow/black	CHP	B. Phillips (COMBERS)	SE Farallon Is, CA
6/4/2007	Brandt's Cormorant	Del Monte	Monterey		0778-22834		white/black	NKP	COMBERS	California
6/4/2007	Brandt's Cormorant	Sunset	Santa Cruz	L	XXX-23774	R	yellow	ALC	COMBERS	
6/4/2007	Brandt's Cormorant	Sunset	Santa Cruz	L	XXX-24525	R	yellow	ZKC	COMBERS	
9/29/2007	Brandt's Cormorant	Del Monte	Monterey	L	0778-24296	R	yellow	HNN	Monterey Resident	Farallon Is., CA
2/4/2007	Clark's/Western Grebe	Waddell Creek	Santa Cruz		1757-17337				W. Heady/K. Kusic (COMBERS)	
3/6/2007	Common Murre	New Brighton	Santa Cruz		1066-80142				L. Jordan (COMBERS)	San Francisco, CA
5/1/2007	Common Murre	Del Monte	Monterey		1096-58672				J. Pizzo (COMBERS)	California
9/2/2007	Common Murre	Marina	Monterey		0996-82774		Brown	CWS	Benson/Forney (COMBERS)	British Columbia

9/2/2007	Common Murre	Marina	Monterey		MOO-898				Benson/Forney (COMBERS)	
11/1/2007	Common Murre	Moss Landing	Monterey	L	1096-58658				J. DeMarignac (COMBERS)	
11/28/2007	Common Murre	East Cliff Beach 41st	Santa Cruz		1096-59009				E. Phillips (COMBERS)	
12/8/2007	Northern Fulmar	Monterey City	Monterey		1136-01002				Monterey SPCA	MWVCRC, Santa Cruz, CA
2/7/2007	Short-Tailed Shearwater	San Carpoforo	San Luis Obispo		162-70460				Jeff & Sue Kwasny (COMBERS)	Australia
1/14/2007	Snowy Plover	Sunset	Santa Cruz	L	8021-16600	R	blue/yellow	white/green	K. Neuman/B. Wolcott (St. Parks)	California
4/5/2008	Brandt's Cormorant	Zmudowski	Monterey		0778-21772		Red	CKU	Wertz/Webb (COMBERS)	California
4/5/2008	Brandt's Cormorant	Fort Ord	Monterey	R	0778-25114	L	grey/yellow	NPP	C. Young/B. Hoover (COMBERS)	California
1/22/2008	Common Murre	Del Monte	Monterey		MOO-337				Tom (Monterey SPCA)	
2/22/2008	Surf Scoter	Aquatic Park, San Francisco	San Francisco		1697-63273				Mary Cantini	IBRRC, Suisun, CA (rehab)
5/24/2008	Surf Scoter	Asilomar	Monterey	L	1697-63226				Ranger Jacobs (St. Parks)	California
2/17/2008	Western Gull	Zmudowski	Monterey		2406-04822				S. McGuire/ C. Miller (COMBERS)	Farallon Is., CA

[a] Band numbers recorded as "X" indicate missing number (e.g., number not read, worn off or otherwise illegible)
[b] Data provided by USGS Bird Banding Lab. Where blank, data has not been returned by bander.

Table 3. Cases of entanglement documented by BeachCOMBERS by date encountered during 2005 (n = 13), 2006 (n = 8) and 2007 (n = 20). All individuals are unique animals. Counties are Santa Cruz (SC), Monterey (MTY) and San Luis Obispo (SLO). Species codes follow AOU convention (see table 1).

Year	Date (YYMMDD)	Beach	County	Species	Condition[a]	Sex	Age	Scavenged	Comment
2005	20050102	2	SC	DCCO	1	U	AD	N	fishing interaction, choked on perch
	20050201	1	SC	WEGU	3	U	IM	Y	body wrapped in fishing line
	20050206	7	Mty	GULL	4	U	U	Y	tangled in heavy monofilament line
	20050402	7	Mty	COMU	3	U	AD	Y	entangled in herring (?) net, collected MLSB#1089
	20050418	5B	Mty	PALO	4	M	AD	Y	one foot, fishing line around wing
	20050501	5A	Mty	BRAC	2	U	IM	N	fish hook through bill
	20050501	9	Mty	WEGU	3	U	AD	Y	
	20050507	8a	Mty	DOVE	3	U	U	Y	wrapped in fishing line
	20050520	5B	Mty	COMU	3	U	AD	N	badly tangled in fishing line with bird above
	20050520	5B	Mty	COMU	3	U	AD	Y	badly tangled in fishing line with bird below
	20050701	1	SC	BRAC	4	U	IM	Y	collected MLSB#1160, tagged #778-22537
	20050801	7	Mty	PECO	2	U	AHY	Y	hooked on feet, fishing line around wing
	20050820	8b	Mty	COMU	3	U	AHY	Y	breeding plumage
2006	20060603	3	SC	DCCO	4	U	AHY	N	entanglement in fishing line with small wire box
	20060605	1	SC	BRAC	4	U	FY	Y	hook and line attached around neck
	20060803	26	SLO	HEEG	4	U	AD	Y	fish hook through bill
	20061003	4	SC	WEGU	2	U	IM	N	fish hook in nostril
	20061005	26	SLO	CORM	4	U	U	Y	fish hook in bill
	20061101	2	SC	CORM	3	U	U	N	fishing line on left wing
	20061104	5A	Mty	WEGU	3	U	IM	Y	monofilament, hook and weight
	20061104	8a	Mty	WEGU	4	M	IM	Y	hooked on line through lower jaw
2007	20070107	24	Mty	BRPE	3	U	U	Y	fish hook at base of neck
	20070220	8b	Mty	SUSC	3	F	AD	Y	line around neck, removed hooks from line
	20070306	1	SC	BRAC	3	U	AD	N	choked on fish?
	20070306	1	SC	COMU	2	U	AD	N	choked on fish?
	20070319	5b	Mty	WEGU	3	U	IM	Y	3-pronged hook through leg & nares, entangled in line
	20070418	5b	Mty	CWGR	4	U	AD	Y	hook and line around both feet, imbedded in leg MLSB#1665
	20070501	24	Mty	HEEG	3	U	AD	N	hook-swallowed w/ line out of mouth
	20070603	5a	Mty	COMU	3	U	AD	N	wrapped in fishing line; cut off
	20070604	4	SC	COLO	3	U	U	U	in gill net, photos 1 and 2
	20070604	24	Mty	PIGU	2	U	AD	N	breeding plumage

Year	Date (YYMMDD)	Beach	County	Species	Condition[a]	Sex	Age	Scavenged	Comment
2007									
	20070703	4	SC	GULL	4	U	IM	Y	
	20070704	5a	Mty	CAGU	2	U	IM	N	fishing lure/hook in mouth and wing
	20070707	23a	Mty	CWGR	4	U	U	Y	MLSB1783 feet wrapped in fish line/clipped toe
	20070802	9	Mty	CORM	3	U	AD	Y	Fishing line
	20070802	9	Mty	CORM	3	U	AD	Y	Entangled with fish hook
	20070907	6	Mty	WEGU	2	U	IM	N	fishing plug (lure) in wing and bill
	20070919	8b	Mty	WEGU	4	U	U	Y	fishing line with 2 hooks wrapped around wing
	20071101	6	Mty	COMU	3	U	U	Y	balloon line attached
	20071104	4	SC	CAGU	3	F	U	N	fishing line around both feet, wing chord 40cm
	20071205	24	Mty	NOFU	2	U	U	N	hook in mouth

Table 4. Number of individual oiled birds encountered dead each month on beaches by BeachCOMBERS in the Monterey Bay National Marine Sanctuary during 2005, 2006 and 2007. Species codes follow AOU convention combining the first two letters of the first and last name (i.e. Ancient Murrelet = ANMU).

		ANMU	BRAC	BRPE	BVSH	CAAU	CAGU	CLGR	COMU	CORM	FTSP	GULL	NOFU	PALO	PIGU	REPH	RHAU	SHOR	SHOS	SOSH	SUSC	TUPU	WEGR	WEGU	Total
2005	Jan		1	1	1	4			1			1	5				4		2						20
	Feb								1	1							7						1		10
	Mar	1															2				1				4
	Apr								5								2								7
	May		1						4					1			2			1					9
	June		1				1		2												1			1	6
	July								3																3
	Aug																			2					2
	Sep								5						1			1		1				1	9
	Oct								2								1								3
	Nov		3																						3
	Dec																								
subtotal		1	6	1	1	4	1	0	23	1	0	1	5	1	1	0	18	1	2	4	2	0	1	2	76
2006	Jan								1																1
	Feb								1																1
	Mar											1	4				1								6
	Apr								4				1				3								8
	May								3							1	2								6
	June																			1			1		2
	July																								0
	Aug		1						7											1		1			10
	Sep								5																5
	Oct								2	1															3
	Nov								4																4
	Dec																								0
subtotal		0	1	0	0	0	0	0	27	1	0	1	5	0	0	1	6	0	0	2	0	1	1	0	46
2007	Jan																								0
	Feb								5				1				2				1				9
	Mar								5																5
	Apr								3								1								4
	May													2											2
	June								2		1														3
	July																			1					1
	Aug								1																1
	Sep								3														1		4
	Oct								1											1					2
	Nov							2																	2
	Dec								1				1												2
subtotal		0	0	0	0	0	0	2	21	0	1	0	2	2	0	0	3	0	0	2	1	0	1	0	35
Grand total		**1**	**7**	**1**	**1**	**4**	**1**	**2**	**71**	**2**	**1**	**2**	**12**	**3**	**1**	**1**	**27**	**1**	**2**	**8**	**3**	**1**	**3**	**2**	**157**

Entanglement — We found entanglement in recreational fishing gear (e.g. nets and or line, hooks, lures) continued at a low-level in the study area based on beach surveys and rehabilitation data. BeachCOMBER data indicated there were a total of 21 birds entangled in fishing gear during 2005 (n = 13), 2006 (n = 9), and 2007 (n = 20), equal to 0.6% to 0.5%, and 0.5% of new carcasses reported in each of these years. By comparison, during 2005, 1% of 283 cases reported at Monterey SPCA were entangled. Species affected in both datasets included gulls (34%), cormorants (27%), alcids (20%), loons (5%), grebes (5%), scoters, pelican, fulmar and non-seabirds (<5%) (Table 3). Of the birds affected, all murres and loons were adults whereas most gulls were immature.

Disease – To test for emerging zoonotic diseases in wild seabirds, we submitted cloacal swab samples in viral transport media for AI testing. We also submitted cases for WNV, particularly for land-roosting birds (i.e., Brandt's Cormorants) when the case was considered a possibility by the MWVCRC pathologists. Thus far all tests for both diseases have all been negative. Pectoral muscle samples submitted for a regional genetic quantification of protozoal parasites are pending analysis.

(2) Species-specific disease factors

In 2005-2006, disease investigations were conducted by experienced biologists (E. Phillips, H. Nevins), a veterinarian (A. Wells) and veterinary pathologists (T. Zabka, M. Miller) at MWVCRC. In 2005, we examined 157 birds collected from May to December 2005 and 302 and 390 birds in 2006 and 2007 respectively. Overall, birds were primarily collected by rehabilitation centers (51-62%) and beach survey programs (19-21%), and additionally by state and federal resource agencies (7%), the general public (12%) and others (2%) in central California (Monterey, Santa Cruz and San Luis Obispo Counties). When possible, we documented life history and disease findings from gross and histopathologic examination of birds obtained. All necropsies were performed in a systematic manner using standard datasheets (Appendix A). Case reports, database and tissue samples were archived at MWVCRC.

Unusual Mortality Events — During 2005-2007, we responded to several unusual mortality events. Using data from BeachCOMBERS, we defined a significantly "unusual" event as one which the baseline deposition rate on beaches (carcasses per km) was *more than* the long-term mean plus 2 times the standard deviation. For rare species where too little data was available to determine trends, we considered that the event warranted further investigation when total deposition was greater than that reported during the last 10 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 these three years:

2005

- A Jan – Feb 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 2-3 inches to 6 or more in diameter. Tarball and oiled feather samples were submitted to the CDFG - Petroleum Chemistry Lab, but as yet the source has not yet been determined.

- 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 (See full report Appendix B). We presented the results of this mortality event at the Pacific Seabird Group Meeting in 2005[6], and in an article in *Ecosystem Observations* (Nevins and Harvey 2006).

2006

- A Jan 2006 die-off of Red Phalaropes (*Phalaropus lobatus*) was documented along the central coast from Monterey Bay to the Gulf of the Farallones. Most birds that stranded live Nov. to Jan 2006 were reported as "thin, cold and weak"[7]. We examined 41 birds collected dead on beaches or 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 (1:7). 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, however, our results indicate there maybe some differences 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 reduced food availability was the primary cause of this mortality (Appendix C)
- Two Brown Pelican mortality events occurred during April and May 2006. The first was a die-off of young-of-the-year which was attributed to starvation while 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, but our contributions were necessary for investigating these cases. Information from gross necropsies was entered into a searchable database and disseminated to appropriate parties shortly after the event (Appendix D).
- Diesel spill occurred in a localized area in Moss Landing harbor during Nov 2006. Four gulls were brought in for necropsy and samples were submitted to OSPR. Results indicate that although these birds had prior debilitating conditions (e.g. broken wing), but 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 (Appendix E).

2007

- An unusual increase in beached alcids of various species, including murres, Rhinoceros Auklets and Cassin's Auklets was detected starting in Feb 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 reduced prey availability for these species.

[6] Parrish et al., Seabirds as indictors of marine ecosystems symposium, 15-19 February 2005, Girdwood, Alaska.
[7] Sue Campbell, Monterey SPCA reports.

- During March to June an “invasion” of Horned Puffins, an unusually rare species in the area was detected by beach surveys, rehabilitation centers and bird waters along the central California region (Appendix F).
- Domoic Acid toxicity was detected in several species of loons, cormorants, and pelicans during May and June 2007 (Appendix G).
- A “Mystery Spill” red tide event occurred during November 2007 affecting mainly nearshore foraging birds in one pulse (grebes, surf and white-winged scoters) and in another pulse, northern fulmars (Jessup et al., *in prep.*).

Mortality Factors— For all species examined (Table 5), we placed mortality factors into one of six categories adapted from Newman et al. (2007) including: **Fishery Interactions** (gill net, drownings, entanglement in recreational or commercial gear), **Trauma** (both human-related boat-strikes, collisions and those determined “natural events”); **Environmental** which includes starvation, and natural species interactions (e.g. predation); **Infectious** which includes any fungal, bacterial, or viral pathogen; **Pathology with no Etiology** is defined as lesions or other abnormalities on gross exam, pending pathological review or no diagnosis made; and **Toxicosis** which includes chemical, metal poisoning (e.g. lead sinker), oiling, biotoxin (e.g. Domoic Acid); and **Undetermined** where the carcass was too decomposed to determine cause of death. In these cases, we assumed any external oiling was the primary cause of death.

Of the cases submitted for necropsy in 2005 (n = 157), 2006 (n = 302), and 2007 (n = 390) we found that most mortality (40 to 70%) could be attributed to environmental conditions (i.e. food shortage leading to starvation). During these years, identified infectious diseases (5-10%) and those pathologies with no etiology (21-32%) combined ranked disease as the second most important source of mortality. We identified the occurrence of several novel diseases in several species of seabirds (fig. 5). The proportion of cases for which diagnosis were undetermined (6-12%) decreased each year (Fig. 4). Toxicosis from oil (5-8%) and biotoxins (1-4%) ranked as the third most import source of mortality. We found natural and human-related trauma in several species (5-9%). Individual oiled birds defined as oil-related mortalities not specifically identified as related to a designated oil event were documented affected several species each year (Table 4). We also identified fishery interactions (2-6%, Table 3) and plastic ingestion (1%) as causes of mortality to seabirds.

Table 5. Composition of species examined each year for the Central CA Marine Bird Health Study, May to December 2005, January to December 2006 and 2007. Birds were sampled opportunistically from various federal, state, and local sources (see text) with the exception of gulls, which were not a major focal group for this study. Post-litigation samples are not included in these totals as those sample sizes are reported elsewhere.

Species	2005	2006	2007	Grand Total
Common Murre	41	106	135	282
Brandt's Cormorant	29	28	41	98
Brown Pelican		65	13	78
Red Phalarope		45	3	48
Northern Fulmar	3	16	28	47
Horned Puffin		2	41	43
Western Grebe	7	3	21	31
Red-Necked Phalarope	2	11	9	22
Cassin's Auklet	4	12	5	21
Pacific Loon	2	6	11	19
Rhinoceros Auklet	3	6	5	14
Pigeon Guillemot	3	6	5	14
Clark's Grebe	1	1	12	14
Common Loon	2	3	6	11
Sooty Shearwater	4	5	1	10
Western Gull	2	7		9
Surf Scoter	1		8	9
Double crested Cormorant		3	5	8
Pelagic Cormorant	1	3	4	8
Forked-tailed Storm-petrel		4	3	7
Least Tern			7	7
Red-Throated Loon		1	5	6
California Gull	1	1	4	6
Tufted Puffin		1	4	5
Eared Grebe		1	4	5
Ancient Murrelet	2	1	1	4
Heermann's Gull		1	2	3
Glaucous-Winged Gull	2		1	3
Glaucous Gull			2	2
Marbled Murrelet	1		1	2
Black-Legged Kittiwake		1	1	2
Black-footed Albatross	1		1	2
Caspian Tern		2		2
Short-tailed Shearwater	1			1
Pied-billed Grebe		1		1
Bonaparte's Gull			1	1
Buller's Shearwater	1			1
Forster's Tern	1			1
Horned Grebe		1		1
Grand Total	**115**	**343**	**390**	**848**

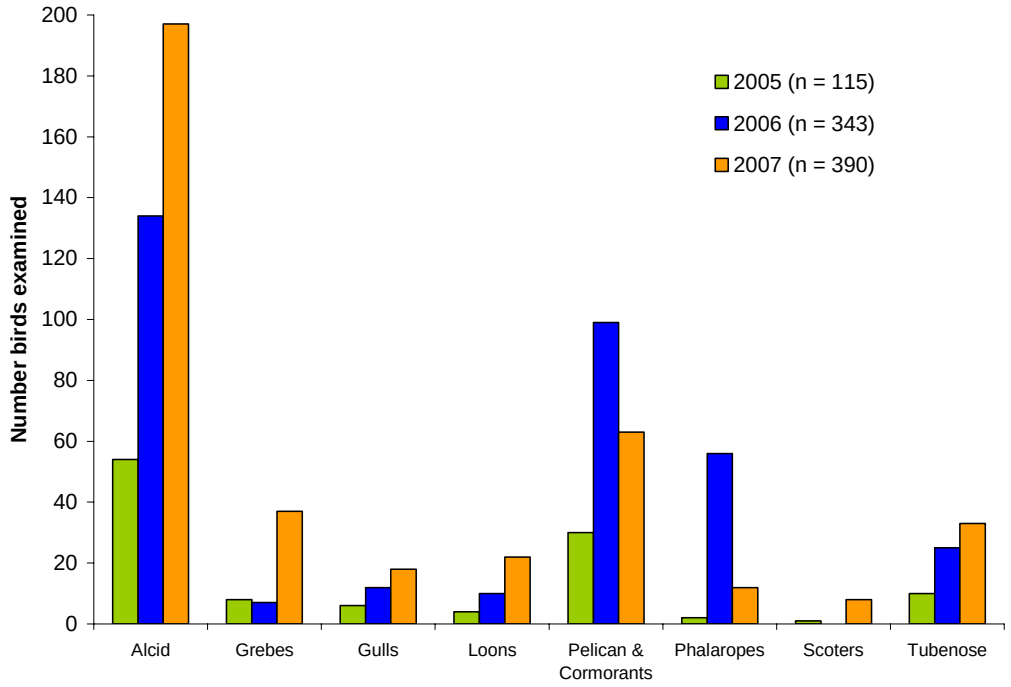

Figure 3. Number of birds examined in the Seabird Health Study by taxonomic grouping. Birds were sampled opportunistically from various federal, state, and local sources (see text) with the exception of gulls, which were not a major focal group for this study.

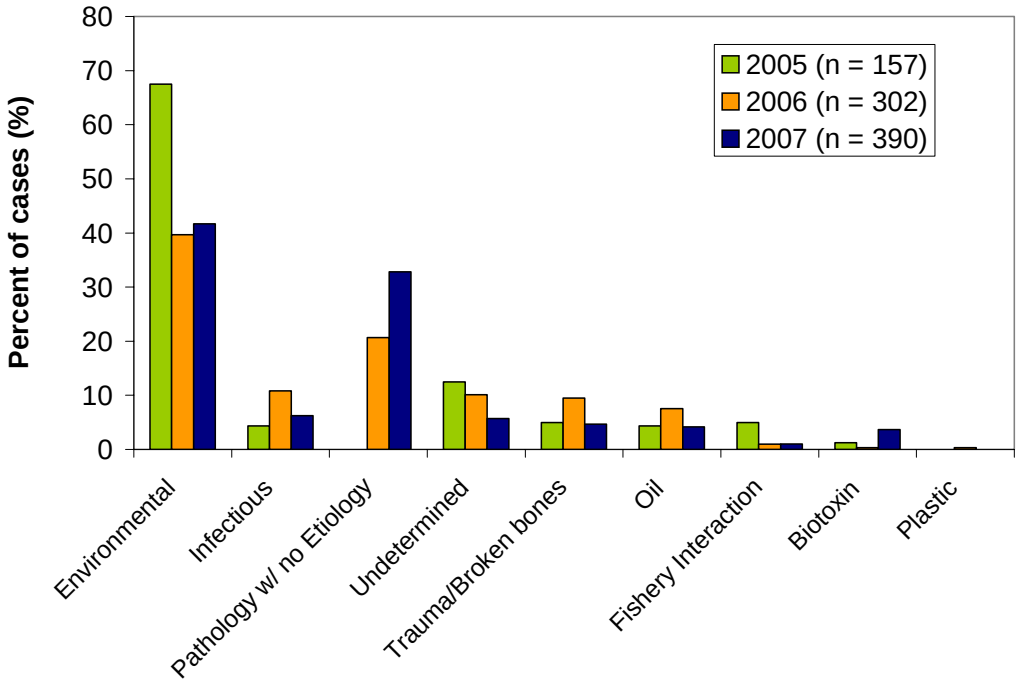

Figure 4. Percent of cases examined by the Seabird Health Study for all categories of mortality factors. The one potential plastic case was a fulmar which had ingested a party balloon which obstructed the gastrointestinal tract. See text for descriptions of categories.

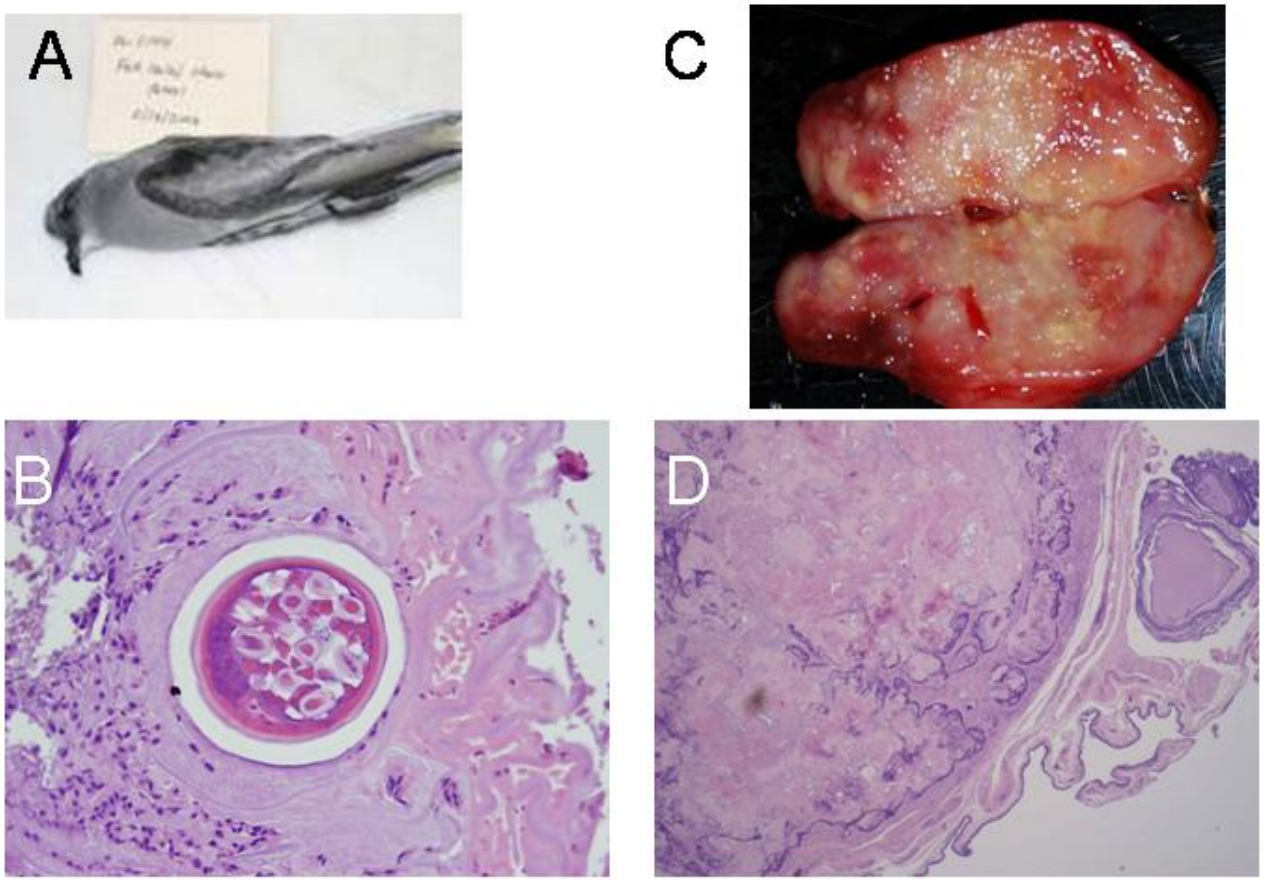

Figure 5. Two examples of novel diseases affecting seabirds: (A) Forked-tailed Storm-petrel 06-0365 with (B) parasite-induced gastritis (inflammatory response to nematode) causing an acute systemic bacterial infection and an adult female Common Murre 07-0479 with (C) gross and histo-section of a (D) mineralized carcinoma.

(3) Post-litigation specimen investigations

We examined three sets of specimens released from litigation by OSPR and one from NOAA-Fisheries including i) 1997 Kure Spill, ii) 1999 Stuyvesant Oil Spill, iii) 2001-2002 San Mateo Mystery Spill, and iv) 2005 Alaska Fishery by-catch birds. We quantified the demographics of each of these three mortality events by documenting morphometrics, sex, and age. Specimens were classified into one of three age/reproductive categories based upon bill and wing size, plumage, and internal examination, and when necessary confirmed by histopathology. We used gonad maturity, bursa size, and skull ossification to classify individuals into categories which include; 1) Adult - reproductively active (enlarged testes/ ripe ova) or non-active, 2) Subadult – >1yr, immature gonads, 3) Hatch-year - born within the calendar year.

Kure Oil Spill 1997 — We examined 602 carcasses collected during November 7-22, 1997, including 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. For example, Diana Humple (Sonoma State) was very keen to obtain molt data and tissue samples from these grebes to examine connectivity between coastal wintering and breeding lakes using genetic markers. Of the murres we examined, more were adults (63%) compared with juveniles (37%). Whereas the sex ratios for fulmars (n = 47) and grebes (n = 26) were not different from 1:1, the ratio for murres was significantly skewed toward males (3.7:1, df = 1, $p<0.001$, n = 175).

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 during September 1999. This spill occurred within Humboldt Bay during the late chick-rearing period and thus had very different demographics than the winter SMMS. As with the SMMS, we assumed that the sample of birds we examined was representative of the population affected by the spill. From this collection 50% were AHY/ASY, 50% were 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 (15:1) was significantly skewed toward males (n = 113; $p<0.001$), whereas the sex ratio for immature birds (1.3:1) was not significantly different from 1:1 (n = 113, p = 0.37). For five birds sex could not be determined. These results indicate that the *Stuyvesant* affected adult chick-rearing males and their attendant chicks in greater proportion than adult females given the population having an equal probability of oiling. We suggest that this maybe indicative of further dispersal of adult females post-breeding as compared with these male-chick pairs which aggregate in protective waters (Briggs et al. 1987). This clearly shows a shift in the demographics of the population of murres affected by oil spills depending upon season.

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). These results indicate that the SMMS affected more first winter birds than expected given the population having an equal probability of oiling. We suggest that this may be indicative of further dispersal of adults during the non-breeding (Nov to March) as compared with immature birds. There was no indication of a sex-related difference in dispersal pattern and subsequent susceptibility to oiling. We assumed that the sample of birds we examined was representative of the population affected by the spill.

Alaska Fishery by-catch birds 2005 — We examined 385 seabirds of various species, particularly Northern Fulmars collected by NOAA fishery observers in the Bering Sea during summer 2005. Other species we examined included Black-legged Kittiwake, Glaucous-winged Gull, Glaucous and Slaty-backed Gulls, Short-tailed Shearwater, and Laysan Albatross. Because the fulmars caught in the Bering Sea and Gulf of Alaska during summer are thought to be part of the same population that winters offshore of the California coast (Nevins & Harvey 2004, Scott Hatch, *personal communication*), we hoped to obtain morphometric and genetic samples to investigate population dynamics of this population. Second, we were interested in determining the incidence of plastic ingestion as compared to those birds collected in CA during winter. We found that most fulmars killed as bycatch in Alaska trawl fisheries contained at least one piece of plastic (62%). This is slightly less than the incidence measured in beached fulmars recovered in California during a die-off in winter 2003-04 (71%, n = 190, Nevins et al. 2005).

Management Implications

Results from the Seabird Health Study provide important information to determine appropriate mitigation measures for effective wildlife restoration as part of natural resource damage assessment (NRDA). First, in cooperation with beach survey programs and rehabilitation centers, we have described a comprehensive view of species affected by chronic oiling and other mortality factors; and through band recovery information we identified those local colony areas which are source populations for individuals in this study area. 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 that several factors continue to affect Common Murres and other seabirds, including loons, grebes, cormorants, pelican, procellarids, alcids and gulls; these same species are also often affected by catastrophic oil spills. These factors included oiling, fishery interactions, trauma, biotoxins, and to a lesser extent, plastic ingestion. Human-related factors are important to identify specifically since 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 change on coastal waters will increase the intensity and impacts of biotoxins and plastics ingestion for seabirds. These data serve as baseline measures of these impacts from which future change (positive,

negative, or neutral) can be assessed. Third, we found through post-litigation investigations, that demographic impacts can vary depending upon season when an oil spill occurs (e.g. Stuyvesant vs. San Mateo Mystery Spill). These impacts also vary among mortality factors. For example, we found that primarily adult murres become entangled in recreational fishing gear. 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 more so 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.

Acknowledgments

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Appendix A: Standard datasheet – Seabird Health Study

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

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

Collector: **Date:**
Location (city, county):

Necropsy by: **Date:**

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
Feather:									
Uropygial gland									
Skin									
Fat (site):									
Pectoral muscle									
Muscle:									
Sciatic nerve									
Tibiotarsus/joint									
Bone marrow									
Bone:									
Choana									
Tongue									
Parathyroid									
Thyroid									
Thymus									

	N	A	U	NF	NE	H	S_{-20}	S_{-80}	M
Esophagus									
Crop									
Trachea									
Air sacs									
Lung									
Heart									
Aorta									
Spleen									
Liver									
Gall bladder									
Kidney									
Ureter									
Adrenal gland									
Gonad									
Oviduct									

	N	A	U	NF	NE	H	S_{-20}	S_{-80}	M
Proventriculus									
Ventriculus									
Duodenum									
Pancreas									
Jejunum									
Ileum									
Cecum									
Colon									
Cloaca									
Bursa									
Brain									
Eye (L/R)									
Conjuctiva (L/R)									
Spinal cord									
Other tissue:									

Search Terms: Organ System	Location	Morphology	Etiology

Preliminary Cause(s) of Mortality:

Appendix B: Seabird Mortality Summary – May 2005

Report on California Seabird Mortality Event, January - May 2005

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June 20, 2005

This report summarizes ongoing studies to identify and quantify species-specific mortality factors affecting marine birds in California. Our specific objectives are to: 1) identify mortality factors, 2) quantify the mortality (using standardized beach surveys), and 3) create a reference library of necropsy images and tissue samples for future investigations of species-specific disease. We continue to seek coordination with rehabilitation centers, researchers, and resource agencies, to increase our understanding of populations of marine birds in central California.

Emaciated Cassin's Auklet, skin is clear of fat and pectoral muscle is wasted away from keel, giving hatchet shape to breast. Photo: H. Nevins

During January to February 2005, beached bird survey programs in central California reported increased deposition of several pelagic seabird species including Cassin's and Rhinoceros Auklets in the Monterey Bay area (MBNMS Beach Combers) and Common Murres and Brandt's Cormorants north of Monterey Bay (GFNMS Beach Watch). Tufted and Horned Puffins which are typically rare species were also encountered during Monterey Bay area surveys during this time. The timing of this mortality of these species was earlier than usual, and the magnitude of deposition was greater than in other years surveyed, with the exception of the 1997–1998 El Niño (1997 to 2004; Fig. 1). Typically a post-breeding/fledging mortality peak occurs for murres and cormorants August through October (Roletto et al. 2004). This spring time mortality event is 4 times higher than in previous years.

Necropsies of 15 Cassin's, 3 Rhinoceros Auklets, 1 Ancient and 1 Marbled Murrelet indicated that most individuals were in poor condition as they had no remaining fat reserves and severe muscle wasting (Table 1). The concordance in mortality trends in these pelagic species indicated a biological response to reduced prey resources in the offshore ecosystem during January to February.

During April to May 2005, beach surveys reported increased numbers of Common Murres and Brandt's Cormorants. State, federal and local agencies collected seabird carcasses to

determine the cause of this mortality. Brandt's Cormorants comprised the greatest proportion (67%, n = 39) of seabirds submitted for necropsy (Table 1). The majority of those examined were immature (56%, n = 22), and fewer sub-adult (10%, n = 4), and adult (33%, n = 13). There were no significant differences in sex ratios among age groups. Six banded cormorants were recovered which had been marked as fledglings on the Farallon Islands in 2003 (3) and 2004 (3). All immature cormorants were characterized by a buffy colored breast plumage, immature gonads, and absence of breeding plumes. Sub-adults were distinguished from breeding adults by the length and completeness of nuptial plumage (iridescent body plumage, a blue gular pouch, and long nuptial plumes) and differences in gonad maturity. With the exception of one specimen, all examined birds were moderately to severely emaciated, had no subcutaneous fat, low body masses, atrophied livers, atrophied pectoral muscles, and empty stomachs. The exception was one bird with a stomach full of fresh anchovies; this specimen has been submitted for domoic acid biotoxin testing. Several individuals had increased internal and external parasite loads; however, this finding was not consistent among all birds and was considered secondary to starvation.

Emaciation was a consistent finding among 38 of 39 cormorants examined.

Most of the Common Murres necropsied were mature adults (5 of 7) in breeding plumage; four of these were female. The three murres collected in Bodega Bay area, were females which had recently laid eggs. This was apparent on dissection; ruptured follicles, distended oviducts and cloacas. These birds were in severely emaciated condition, with body masses at approximately 70% of normal. Perhaps the energetic requirements of producing an egg decreased their overall body condition and made them vulnerable to reduced prey availability.

Table 1. Species, sex, and age of specimens necropsied at OSPR-MWVCRC during January to May, 2005. Preliminary necropsy findings and number of individuals involved indicated in parentheses.

Species	Total	Sex (F:M:U)	Age (AD:SA:IMM:U)	Ave. Mass *g* (n)	Necropsy Gross Findings (number of individuals)
Pacific Loon	2	(2:0:0)	(1:0:1:0)	1468 (2)	emaciation (2); positive intestine: *Plesiomonas shigelloides* (1)
Brandt's Cormorant	39	(16:21:2)	(13:4:22:0)	1571 (39)	emaciation (38), incl. unid. mites (2); potential Domoic Acid (1; [good body condition, stomach full of anchovies)
Pelagic Cormorant	2	(0:1:1)	(0:0:2:0)	732 (2)	emaciation; unid. mites (1)
California Gull	1	(1:0:0)	(0:0:1:0)	720 (1)	emaciation
Surf Scoter	1	(1:0:0)	(0:0:0:1)	615 (1)	emaciation, intestinal peritonitis secondary to acanthacephalan parasite
Snowy Plover	1	(0:0:1)	(0:0:0:1)	23 (1)	undetermined [autolyzed]
Common Murre	7	(5:1:1)	(5:0:2:0)	697 (6)	emaciation (7); entangled (1)
Marbled Murrelet	1	(1:0:0)	(0:0:0:1)	192 (1)	emaciation; [note: bird in winter plumage]
Ancient Murrelet	2	(1:0:1)	(0:0:1:1)	159 (1)	undetermined (1); oiled (1)
Cassin's Auklet	15	(6:9:0)	(0:0:1:0)	127 (15)	emaciation (15)
Rhinoceros Auklet	3	(2:1:0)	(1:0:2:0)	345 (3)	emaciation (3)
Total	74				

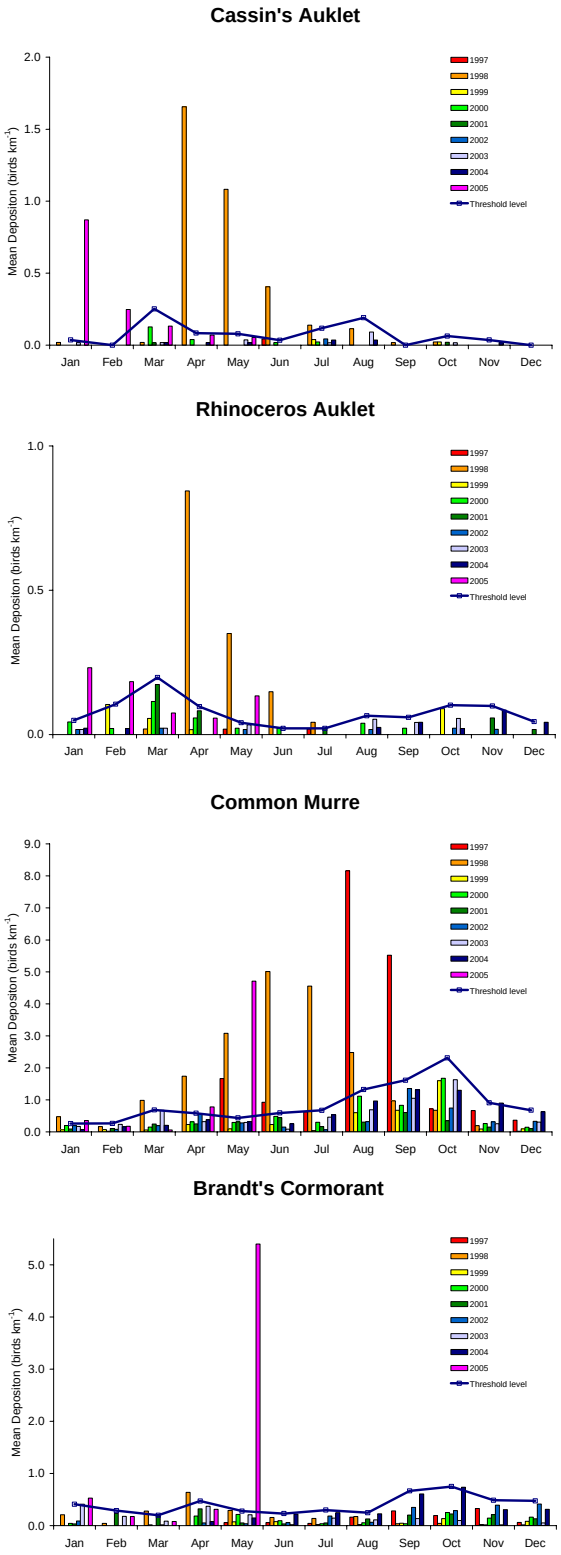

Figure 1. Four seabirds showing increased monthly mean deposition (birds km^{-1}) in 2005 relative to baseline reported by BeachCOMBERS in the Monterey Bay area (beaches 1 to 11; May 1997 to May 2005). Threshold level indicated by line is used to determine "unusual" mortality events. Threshold level is estimated as long term mean plus 2 SD (excluding 1997-98 El Niño). Note difference in scale of y-axis among graphs.

Summary —The combined results from long-term beach surveys and recent necropsies indicated an unusual increase in the mortality of several species of pelagic alcids and neritic cormorants in central California during January to May 2005. Starvation was found to be the primary cause of death in the majority of birds examined. Mature, breeding-aged adult cormorants and murres were affected as well as immature individuals suggesting severe food limitation. Ultimately, physical environmental factors, such as reduced upwelling favorable winds and resulting reduction in oceanographic conditions are likely responsible for the reduced productivity in the region. Fishery oceanographers indicate recruitment of juvenile rockfish was low in the spring of 2005 (NMFS, Santa Cruz Lab) and colony-based studies suggest reduced breeding success for many of these species (PRBO). Thus it seems likely that reduced availability of prey is the ultimate cause of seabird mortalities reported during this period.

Acknowledgements This work was made possible by the dedicated volunteer beach surveyors of BeachCOMBERS and Beach Watch programs. We especially thank the following individuals for responding quickly to collect specimens for necropsy during this unusual mortality event: Sharon McGuire and Chris Miller, Scott Benson and Karin Forney, Linda Jordan and Dave Evans, Kathy and Gene Pfeifer, Pam Kearby and Glenn Seiler, Marti Ainsworth and Margo Hober, J. Adams and J. Hubbard, and T. Brookens (BeachCOMBERS); Jeff Price (CA State Parks), Branner Solano, M. Finney, Peter de Jung Jamie Hall and Dru Devlin (Beach Watch); Kristen Arkush (UCD, Bodega Marine Laboratory); Jenny Erbes (PRBO); Itchung Cheung (UCSC) and Stacey Tatman (MWVCRC). We also thank volunteers who helped with necropsies: Kim Starbuck, Elizabeth Phillips, Corinne Gibble, Melinda Nakagawa (MLML); and Sandrine Hazan, Elizabeth Wheeler, Eva Berberich, Elene Dorfmeier, Lexi Fisher, and Adam Schneider (MWVCRC).

This work was supported in part through a grant from the Monterey Bay National Marine Sanctuary Foundation, Science Integrated Monitoring Network. Substantial in-kind support was provided by Moss Landing Marine Laboratories and California Dept. of Fish and Game, Marine Wildlife Veterinary Care and Research Center. Future investigations will benefit from timely data collection, summary, and the continued efforts for systematic beach surveys. If you have questions or comments regarding this or other mortality events in the area please contact Hannah Nevins (831-771-4422, hnevins@mlml.calstate.edu).

Appendix C: Red Phalarope Wreck – Jan 2006

Summary of Red Phalarope (*Phalaropus fulicaria*) wreck based on gross examination

Tanja Zabka[1], Hannah Nevins[1,2], and Elizabeth Phillips[1,2]

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[2]Moss Landing Marine Laboratories, 8272 Moss Landing Road, Moss Landing, CA 95039

Dated: 25 January 2006

A wreck of live and dead stranded Red Phalaropes (*Phalaropus fulicaria*) occurred along the central and northern California coast during heavy storms in late November 2005 through early January 2006. All birds presented at rehabilitation centers were cold, weak, and starving. Many responded to supportive care and were released (see inset photo, © IBRRC), and others, were too compromised and did not respond favorably. These small (60g), pelagic birds are rarely found intact on beach surveys, and this wreck provided unique opportunity to gather basic information about the species, such as the sex ratio at sea, state of molt, and age. As of January 20, 2006, a total of 33 birds were submitted for necropsy from rehabilitation centers and beach survey programs to the Marine Wildlife Veterinary Care and Research Center. We measured and necropsied all birds submitted, took cytology of the lung, saved tissues in formalin for histology, and banked liver and skeletal muscle at -20 degrees. A subset of approximately 7 birds will be submitted for histological evaluation to help screen for an underlying condition to predispose to starvation and death. As a general summary, all birds were in winter plumage, not molting, and the majority (27 of 31, 87%) were adult females with quiescent reproductive tracts. All birds examined were emaciated, without subcutaneous body fat, often with liver atrophy, and anemic. Most birds had urate stasis evident in the kidneys, ureters and cloaca, which is suggestive of dehydration. We commonly found gastrointestinal hemorrhage, which is indicative of stress. The majority of birds (18 of 27, 67%) also had plastic in the ventriculus (also proventriculus in one case), which was not a great enough burden to cause gastrointestinal dysfunction but is reflective of ingestion of plastic fragments in the marine

environment prior to rehabilitation. Because phalaropes are opportunistic surface-feeding birds they likely ingest plastic indiscriminately while at sea. Infrequently, birds had early respiratory aspergillosis, which likely is secondary to debilitation and rehabilitation. FInal histopathology reports are pending.

Acknowledgements – Thanks to the many staff and volunteers of rehabilitation centers for their efforts to rehabilitate birds and provide specimens for necropsy including Michelle Belizzi, Jay Holcomb and Susan Kaveggia other folks at International Bird Rescue and Research Center, Cordelia and San Pedro, Sue Campbell at Monterey SPCA, and the Peninsula Humane Society of San Mateo. Additional specimens were provided by BeachCOMBERS program supported through a research grant by Monterey Bay National Marine Sanctuary SIMoN project. Further funding was provided for pathology by special investigation funds by Oil Spill Prevention and Response - California Department of Fish and Game.

Appendix D: Summary of Brown Pelican Mortality 2006

Brown Pelican Mortality Update
6/20/2006
Jessup, Phillips, Nevins, Zabka

Beach surveys in the Cambria and Morro Bay area indicated a small increase in numbers of pelicans (6 on six beaches surveyed), but only 2 were found in beach surveys of 11 beaches from Carmel to Scott's Creek in the Monterey Bay area.

Beginning in early May 2006 unusual mortalities of Brown Pelicans have been noticed at various locations along the California coast. Initial reports centered on the Ventura county area and involved both adult and immature pelicans. Some showed signs of incoordination, depression and many were in good flesh, a situation that in the past has been the result of domoic acid intoxication (a toxin produced by blooms of diatoms often referred to erroneously as "red tide" or harmful algal bloom). However, post mortem examinations and laboratory testing for toxin were inconclusive. This event involved several dozen birds.

Since the beginning of June dozens to perhaps a hundred pelicans have been picked up both alive and dead in the Pismo Beach, Morro Bay and more recently in the Monterey Bay area. These birds have been almost exclusively juveniles in poor body condition. In the last few days 31 dead pelicans have been delivered to the California Department of Fish and Game (CDFG), Marine Wildlife Veterinary Care and Research Center in Santa Cruz where they are being examined by biologists and veterinary pathologists. So far starvation and malnutrition are the most common findings, but 1 had a broken wing and 1 was heavily oiled.

Over the next few days additional pelicans will be examined and a report will be issued when significant findings and summary information have been collected.

Brown pelicans lay their eggs in winter, most of them in Mexico but some on the Channel Islands. The eggs hatch in early spring and chicks usually begin to fledge in the May and June. Nesting was very successful this year, including the first successful fledgings at Prince Island in recent history, so some level of mortality of the large numbers of recently fledged birds may be expected.

CDFG is working with the UC Davis Wildlife Health Center and International Bird Rescue Research Center (IBRRC) on these events and work at the MWVCRC is being coordinated by Hannah Nevins. Several rehabilitation organizations have contributed specimens including Monterey SPCA, Penninsula Humane, and The Morro Bay Bird Center.

Appendix E: Summary of Findings from Diesel Spill – Nov 2006

Summary findings from gross necropsy of four gulls recovered from diesel spill, Nov 2006
T. Zabka

Signalment: 3 western gulls (1 adult female, 1 adult male, 1 immature male)
1 Heerman's gull (adult female)

Diagnostics: (1) Gross necropsy; (2) saved select tissues in formalin should addition information be required (wing pathology, spleen, liver, lung, kidney, heart, pectoral muscle); (3) cytology from the lung; (4) cytology from the air saculitis

Disposition: Carcasses placed in lock-up in freezer CDFG-MWVCRC

SUMMARY

1) Euthanasia was elected because of poor prognosis for recovery and release due to presence of "acute" to chronic wing fractures. The suspected fracture of the left shoulder of the Heerman's gull, actually was a dislocation due to ligament/tendon avulsion from the dorsal tubercle of the humerus. All wing pathology was chronic (weeks to months) or subacute (4-21 days) (none were acute); therefore, none was due to handling of the birds during recovery.

2) All birds had feathers oiled by what smelled like diesel fuel, located ventrally in three birds (ranging from 2-66% body surface area) and all over the body in one bird (67-100% body surface area).

3) Body condition (based on internal and subcutis adipose tissue) was good in three birds and thin in one bird, and all birds had a moderate amount of ingesta in at least in small and large intestine. Thus, the mild to marked muscle atrophy of the pectoral muscle was due to disuse atrophy associated with wing pathology and not due to malnutrition. Therefore, the wing fractures did not result in an inability to forage and sustain nutritional status at the time of euthanasia. Secondly, it suggests that the birds could not fly, which may explain why they were found in association with the spill (ie. they could not fly to avoid it).

4) One bird with the most chronic wing fracture and in good body condition also had an acute to subacute bacterial infection confined to the air sacs that did not seem extensive enough to be significantly debilitating at the time of euthanasia. Whether it would have progressed cannot be discerned. (note: this diagnosis was confirmed by cytology)

5) One bird had a subacute, open fracture, which eventually may have lead eventually to a local or even systemic infectious process.

Appendix F:
Puffin Invasion 2007: Summary of Horned Puffin (*Fratercula corniculata*) mortality event based on gross examination

Elizabeth Phillips[1, 2], Hannah Nevins[1, 2], Corinne Gibble[1, 2], Jim Harvey[2] and Dave Jessup[1]

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[2]Moss Landing Marine Laboratories, 8272 Moss Landing Road, Moss Landing, CA 95039

Update: Sept. 6, 2007

During late March to late June 2007, the Monterey Bay National Marine Sanctuary's BeachCOMBERS documented increased numbers of Horned Puffins (*Fratercula corniculata*) washing up dead on beaches in Monterey, Santa Cruz, and San Luis Obispo counties. This event provided the Central California Marine Bird Health Study with a unique opportunity to gather basic information about the species. To date, 41 Horned and 3 Tufted Puffins (*F. cirrhata*) have been found dead or stranded liveon beaches within the sanctuary.

Horned Puffins are distinguished by white belly and bi-colored yellow and orange bill.

Unlike the related Tufted Puffin, which breeds locally at the Farallon Islands off San Francisco, the Horned Puffin is a "very rare" visitor to Monterey Bay[8]. There are an estimated 1 million Horned Puffins worldwide, but they exclusively breed to the north on islands in the Gulf of Alaska, Aleutian Is., Bering Sea and Russia[9]. They nest in earthen burrows along cliffs or crevices among boulders. Typically puffins winter far offshore throughout the central North Pacific and the majority of observations of this species along this coast are limited to summer (June-Sept) [1]. However, during "invasion" years, more than 200 have been reported in state waters such was the case in 1975 [1]. Unusual invasions have occurred as far south as the northwestern Hawaiian Islands[10]. BeachCOMBERS recorded Tufted Puffins in four of the last ten years (1997-1, 2002-1, 2005-4, 2006-2), whereas they have only recently detected Horned Puffins, in 2005 (2) and 2006 (2).

Beachcast Tufted Puffin in non-breeding plumage lacks the white face patch.

Because little is known about the non-breeding range and dispersal of this species, we collected data to determine the sex ratio at sea, state of molt, and age. BeachCOMBER volunteers collected all

[8] Don Roberson, Monterey Bay Birds, Published by Monterey Peninsula Audubon Society, 2002.
[9] Piatt, J. F., and A. S. Kitaysky. 2002. Horned Puffin (*Fratercula corniculata*). In The Birds of North America, No. 603 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
[10] Clapp, R. B. 1986. A summary of alcid records from Hawaii. Colonial Waterbirds 9: 104–107.

puffin carcasses they encountered during monthly beach surveys (35). Carcasses also were submitted by Monterey County SPCA (5), Native Animal Rescue in Santa Cruz (1), Monterey Bay Aquarium (1), Pacific Wildlife Care in Morro Bay (1), and Año Nuevo State Park (1). Puffins which were brought to rehabilitation centers died 1-3 days after arrival.

Most of the puffins were moderately to extremely scavenged, however we were able to obtain a minimum of bill and tarsus measurements, in addition to molt patterns from all carcasses. Molt was assessed at the primaries, secondaries, tertiaries, retrices, and throughout the body once the subcutis was exposed upon necropsy. Additionally, 11 carcasses were intact enough for a thorough necropsy to determine sex, nutritional state, age, stomach content analysis and other demographic characteristics. Two of the birds were oiled[11].

All of the Horned Puffins examined were in non-breeding (basic) plumage, showing a white belly, and variations of whitish grey to smoky grey cheek patches. The bills were pale yellow-orange, with darker red-orange on the distal third. Of those with intact sheaths, they showed 2-3 grooves. Wing molt patterns were variable—of the 24 examined for molt, 13 were not molting (all old feathers), 7 were partially molting (<50% re-grown), and 4 were in near completion of molt (70-100% re-grown). Of the 3 Tufted Puffins collected in June, all were in non-breeding plumage and one was undergoing primary molt.

Upon necropsy, we found an equal sex ratio of 9 males to 7 females. Most of the male birds were immature (4 of 7, 57%), and the remaining were classified as adults based on gonads. Of the female birds, all were non-breeding adults (4 of 4). All of the birds showed moderate to severe signs of emaciation, including atrophy of the pectoral muscle mass and liver, anemia, and no body fat. The average mass (355 ± 65g, n = 17) was 64-69% of that reported for breeding birds[2], indicative of severe food limitation. Most birds also showed signs of urate stasis in the kidneys, ureters, and cloaca, suggestive of dehydration. None of the birds examined had any prey remains within the gastrointestinal tract. However, the majority of the birds (9 of 16, 56%) had plastic pieces of varying shape and size in their proventriculus and/or ventriculus. The amount of plastic found in the gastrointestinal tract was not enough to cause dysfunction or blockage, but is reflective of ingestion of plastic fragments in the marine environment prior to stranding. Because puffins are known to feed on squid and bathypelagic lanternfishes, which often migrate to the sea surface at night, it is likely they ingested the plastic incidentally as they consumed these surface-feeding fish. Additionally, six birds examined had internal parasites – five with tapeworms throughout the intestines, and one case of roundworms in the esophagus. Final histopathology results are pending. Carcasses and skeletal remains were accessioned into the vertebrate collection at Moss Landing Marine Laboratories, 8272 Moss Landing Road, Moss Landing, CA 95039.

[11] (1) HOPU 07-0565, 6/2/07, Sunset State Beach, SC Co., (2) HOPU 07-0540, 6/4/07, Pfiefer Beach, Big Sur, Mty. Co.

Acknowledgements:

Thanks to the BeachCOMBERS volunteers and local public for collecting and bringing birds to local agencies for rehabilitation, Sue Campbell and volunteers at the Monterey SPCA, Lisa Wertz and Joelle Sweeney for helping process the birds and data. This work was supported in part through a grant from the Monterey Bay National Marine Sanctuary Foundation, Science Integrated Monitoring Network. Substantial in-kind support was provided by Moss Landing Marine Laboratories and California Dept. of Fish and Game Office of Spill Prevention and Response, and the Marine Wildlife Veterinary Care and Research Center. Future investigations will benefit from timely data collection, summary, and the continued systematic beach surveys. If you have questions or comments regarding this or other mortality events in the area please contact Hannah Nevins (831-469-1745, hnevins@mlml.calstate.edu).

Photo gallery: http://shutterbug.ucsc.edu/gallery/view_album.php?set_albumName=album377

Appendix G: Spring 2007 Domoic Acid Mortality of Seabirds in Monterey Bay, California

Elizabeth Phillips[1, 2], Hannah Nevins[1, 2], Jim Harvey[2], Melissa Miller[1], and Dave Jessup[1]

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Dated: 08-31-07

During January to early August 2007, the Central Coast Marine Bird Health Study examined 271 freshly dead seabirds recovered by rehabilitation centers, beach survey programs, and the public. We conducted thorough postmortem examinations on seabirds, and documented nutritional state, age, and sex, in addition to any significant lesions or other changes indicative of disease, oiling, or toxicity.

Red-Throated Loon collected for necropsy

A large proportion of the birds (46%) examined were moderately to severely emaciated, which is a typical finding for many seabirds in the springtime in Monterey Bay. However, a smaller portion of examined birds (4%) were in good health, with moderate to abundant body fat and stomachs containing partially digested fish. These birds included Brandt's Cormorants, Red-Throated Loons, Pacific Loons, and Brown Pelicans. In some instances, observers reported live birds displaying neurological or behavioral abnormalities such as incoordination, depression, and odd behavior such as walking down city streets, consistent with biotoxin intoxication. These findings prompted us to test a subset of birds to determine if the neurotoxin domoic acid (DA) was causing seabird mortality in this region. DA is a potent neurotoxin produced by blooms of coastal phytoplankton diatoms called *Pseudo-nitzschia australis*. Once the toxin is produced, filter feeding organisms such as anchovies and sardines can sequester the toxin. When these fish are consumed by seabirds and marine mammals, the toxin can cause neurological disorders and death. Prior reports indicate recovery of live birds with neurological disease and freshly dead birds in good nutritional condition often are reliable indicators of significant local DA events affecting seabirds.

We collected a range of samples from these seabirds and submitted them to two laboratories: The California Animal Health and Food Safety laboratory in Davis (CAHFS) and Dr. Mary Silver's laboratory at UC Santa Cruz (UCSC) for DA testing. Of 9 seabirds tested, 4 were confirmed positive for DA, including 2 Brandt's cormorants, 1 Red-throated loon, and 1 Pacific loon (Table 1). The two cormorants were collected alive and brought to Monterey SPCA, but died during transport. The two loons were found dead on the beach by the BeachCOMBERS program, and were part of a group of five loons found within this time period. We tested four other birds that were brought to

Monterey SPCA for rehabilitation that exhibited neurological disease, but none of those birds tested positive at the time of necropsy.

Table 1. Summary of test results for presence of domoic acid (DA) in seabirds from two laboratories using two methods: (A) CAHFS uses liquid chromatography-mass spectrometry, and (B) UCSC uses high performance liquid chromatography. Species codes listed are: Brandt's Cormorant (BRAC), Brown Pelican (BRPE), Clark's Grebe (CLGR), Common Loon (COLO), Red-throated Loon (RTLO), and Pacific Loon (PALO). Results are presented in parts per million (ppm). Also indicated are minimum detection limits for each run of the sampling device (MDL). N.D. = Not detected.

Collection Date	Collection Location	MWVCRC#	Species	Age	DA?	Rehab?	Sample	Sample type	Result (ppm)	MDL	Lab
3/4/2007	Jetty Road, Moss Landing	07-0445	BRAC	Immature	Yes	No	A-1	Stomach contents	13	0.1	B
							A-2	Stomach contents	4	0.1	B
							A-3	Stomach contents	4	0.1	B
3/4/2007	Jetty Road, Moss Landing	07-0446	BRAC	Immature	Yes	No	A	Stomach contents	29	0.1	B
4/23/2007	Pismo Beach	07-0377	CLGR	Adult	No	No	A	Cloacal contents	N.D.	2.5	A
4/26/2007	Del Monte Beach, Monterey	07-0390	BRAC	Adult	No	1 day	A	Cloacal contents	N.D.	1.7	A
4/27/2007	San Luis Obispo	07-0394	COLO	Adult	No	2 day	A	Cloacal contents	N.D.	0.5	A
4/28/2007	San Carlos Beach, Monterey	07-0414	BRAC	Adult	No	1 day	A	Cloacal contents	N.D.	8.3	A
4/29/2007	Pebble Beach	07-0413	BRPE	Adult	No	1 day	A	Bile	N.D.	1.0	A
							B	Cloacal contents	N.D.	3.0	A
5/2/2007	Sunset State Beach	07-0472	RTLO	Immature	Unk	No	A	Stomach contents	*Pending*		B
5/5/2007	Marina State Beach	07-0475	PALO	Immature	Yes	No	A	Cloacal contents	43	0.5	A
5/6/2007	Salinas River State Beach	07-0409	BRAC	Adult	No	No	A	Cloacal contents	N.D.	5.0	A
5/6/2007	Salinas River State Beach	07-0410	RTLO	Adult	Yes	No	A	Cloacal contents	46.1	2.5	A
							B	Cecal contents	150.6	2.5	A
							C	Intestinal contents	14.6	2.5	A
							D-1	Stomach contents	4.5	3.5	A
							D-2	Stomach contents	3.0	0.1	B

The average interval between stranding and necropsy for rehabilitated birds was 1 day, so DA may have been cleared from the excretory and digestive tracts of these birds before they died in rehabilitation, leading to false negative tests for DA. Unfortunately, no samples were collected for DA testing while the birds were alive in the rehabilitation center. We are awaiting results of histopathology from these same birds, to determine if there are any DA-associated lesions in the brain or other organs.

Domoic Acid blooms are patchy and episodic in nature and DA-related mortality such as the four cases we documented have the potential to go undetected if a small number of animals are affected by a relatively small, localized bloom. In this study, 2 of the 4 confirmed, DA-positive birds were collected in early March, while the other two died in early May. These mortalities don't appear to have been a result of a large-scale DA-associated mortality event, as was documented in Southern California earlier this year[12] and occurred in the past in Monterey Bay[13, 14], but rather may represent multiple small-scale blooms affecting a small number of seabirds. The long-term BeachCOMBERS dataset indicates that both of seabird types that tested positive for DA (cormorants and loons), normally exhibit increased deposition during springtime, April to July (Figs. 1, 2). Each spring, increased cormorant and loon abundance occurs locally during seasonal migration. Most of the beachcast birds found dead during this time of year are emaciated. In 2007, both seabird types showed an increased deposition of live and dead, beach-cast birds during the period when the DA toxicity was detected in the subset of necropsied birds. We suspect that underlying mortality related to DA may have been masked by more significant mortality due to starvation. Because systematic sampling is cost-prohibitive, we were not able to determine the total proportion of birds affected by DA. In the future, we hope to collect more specimens during high deposition periods, coupled with systematic DA testing to better document small-scale harmful algal blooms causing mortality of seabirds.

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[12] "Dead birds appear by river", Orange County Register (Santa Ana, CA). By Pat Brennan. February 14, 2007; "Troubled Waters For Our Sea Creatures: Poisonous Ocean-Borne Algae Are Spreading Into Coastal Regions, Hurting Sea Lions And Pelicans" by Bill Whitaker, CBS Evening News, Los Angeles, Jan. 30, 2007

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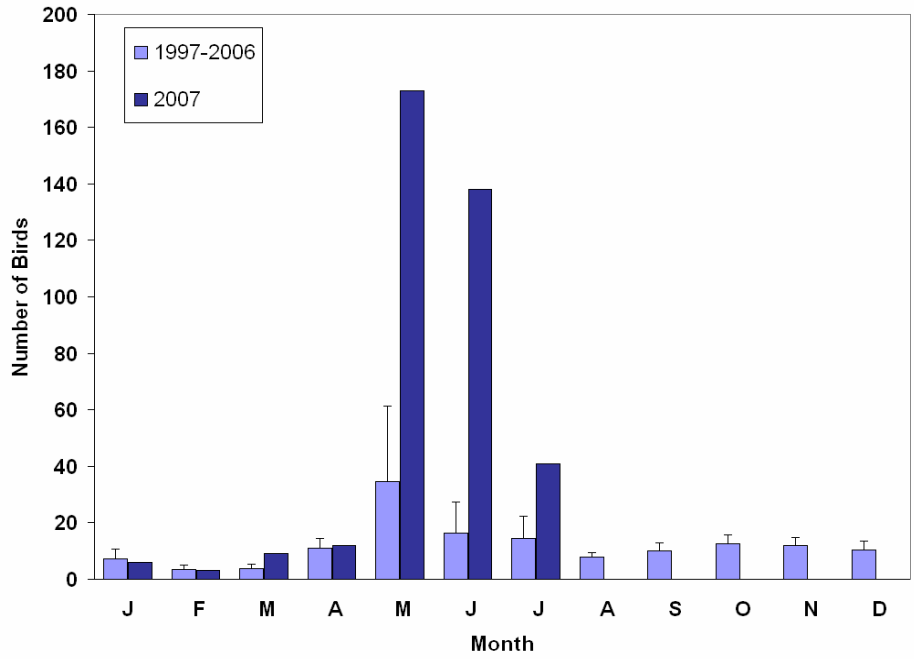

Figure 1. Long-term deposition of cormorants (mean number of birds per month) measured by BeachCOMBERS in Monterey Bay, CA for 1997-2006, compared with deposition during spring 2007.

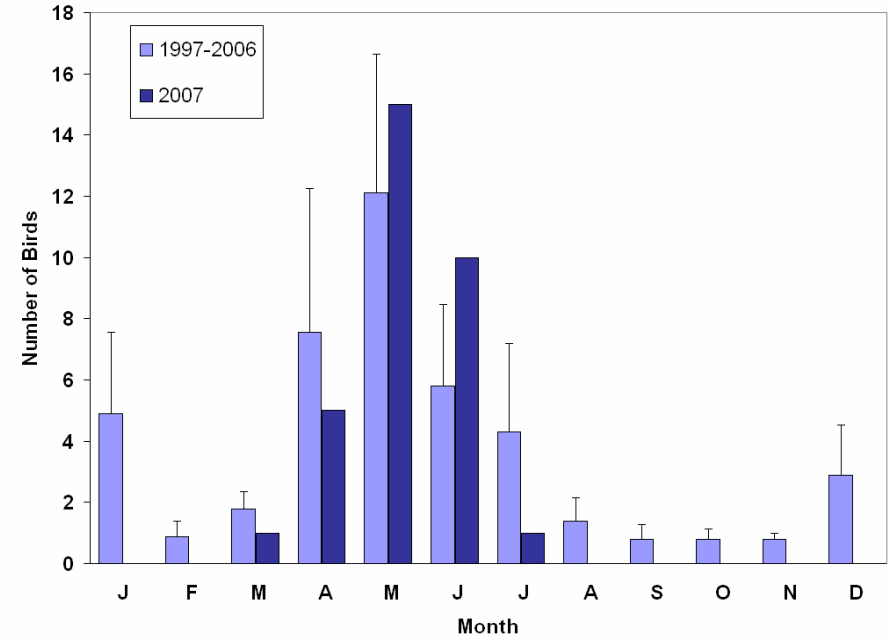

Figure 2. Long-term deposition of loons (mean number of birds per month) measured by BeachCOMBERS in Monterey Bay, CA during 1997-2006, compared with deposition during spring 2007.