Mortality of Seabirds Assessed from Beached-bird Surveys in Southern British Columbia

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Results are reported from 738 monthly beached-bird surveys, performed between October 1989 and March 1993, and covering 1468 km at 38 sites in British Columbia. The mean density of beached carcasses was 0.42 km^{-1}, with marked differences between sites. Carcass deposition was highest in autumn and winter in most sites, and this was attributed to high densities of wintering birds, increased mortality among juveniles and post-breeding adults, and possibly wind and oceanic factors. A total of 823 water birds from 53 species was reported. Common Murres, *Uria aalge* (21%), Glaucous-winged Gulls, *Larus glaucescens* (20%), and Rhinoceros Auklets, *Cerorhinca monocerata* (7%), were the only species to exceed 5% of the total count. At least 6 % of the beached-birds were oiled, but the mean density of oiled birds (0.02 km^{-1}) was among the lowest reported from beach surveys around the world.

Key Words: Beached-bird surveys, seabird mortality, British Columbia, oiled seabirds, pollution.

The coastal waters of British Columbia support some of the highest densities of seabirds, waterfowl and shorebirds in the eastern North Pacific. These seas are also used by thousands of vessels, including oil-bearing tankers and barges. Marine shipments of crude oil and refined petroleum products in southern British Columbia exceed 40 million cubic metres (>250 million barrels) every year (Shaffer and Associates 1990). There is clearly a high risk that spills might affect large numbers of seabirds. These risks became reality with the *Nestucca* spill in the winter of 1988/89 and the sinking of the *Tenyo Maru* in the summer of 1991. Both events created extensive oil slicks off British Columbia and northern Washington and killed thousands of seabirds (Rodway et al. 1989; Ford et al. 1991; Burger 1992, 1993). Birds are also affected by hundreds of smaller spills of petroleum and vegetable oils (Vermeer and Vermeer 1975; McKelvey et al. 1980; Burger 1992; Burger and Fry 1993). The cumulative mortality of seabirds due to such chronic oiling can, in some situations, exceed the more publicized deaths which follow large, catastrophic spills (Piatt et al. 1985; Camphuysen 1989; Chardine et al. 1990).

The risk of oiling and the paucity of baseline information on chronic oiling and natural mortality patterns of seabirds prompted the initiation of systematic beached-bird surveys in British Columbia. Surveys were started at several beaches in 1989, under the auspices of the Royal British Columbia Museum and the Emergency Services Branch of B.C. Environment, and has grown to include regular surveys at 38 beaches. The primary aims of the program are to provide baseline information on the rates of mortality of seabirds through the seasons and in a variety of coastal regions, and to monitor oiling from both large catastrophic and small-scale chronic spills. This report analyzes the data available from surveys made in southern British Columbia between October 1989 and March 1993.

Materials and Methods

Surveys were made by volunteer naturalists on foot, once a month at approximately the same date each month at each beach, following Ainley et al. (1980). Details on all dead or incapacitated birds were recorded on standardized field sheets. Carcasses not retained for identification or museum purposes were thrown well above the tideline to avoid them being counted twice. Identification of carcasses was sometimes difficult, but was aided by the use of a field guide to beached-birds (Ainley et al. 1980) and through comparisons with museum specimens. Surveyors reported the presence of any oiled birds, oil on the beaches, storms or other relevant phenomena.

Data were stored on two databases (Microsoft Excel): one summarising each beach survey, and one for information on each bird found. Data on about 35 beached carcasses found outside systematic surveys were also included in the latter database, but were not included in calculations of carcass densities. Copies of the databases have been archived at the Biological Collections, Royal British Columbia Museum. Victoria, B.C.

Surveys were grouped into four regions:
i) The west coast of Vancouver Island (WCVI), between Tofino and Port Renfrew, encompasses beaches facing the open Pacific. Virtually all of the beaches were predominantly sandy, with occasional rocky shelves or boulders, and exposed to high energy waves.

ii) Southern Vancouver Island (SVI), between China Beach and Sidney, faces the Strait of Juan de Fuca and Haro Strait. Tidal currents in this region are strong, but most beaches are exposed to low wave action except during storms.

iii) Strait of Georgia and the Gulf Islands (SGGI), includes beaches on both sides of the strait, from Campbell River and Powell River southwards, including the Gulf Islands in the south of the strait. These marine areas are very sheltered but are sometimes exposed to strong tidal currents. Wave action is usually very light.

iv) White Rock and Boundary Bay (WRBB) lies just north of the U.S. border. These surveys were made along the shores at White Rock, in Mud Bay and on the west of Boundary Bay. Beaches are sandy or muddy, are often covered in dense eelgrass wrack and are exposed to moderate to light wave action.

Results

Carcass density

Data from 738 monthly surveys covering 1468 km at 38 sites are summarized in Table 1. The mean carcass density (giving each site equal weighting regardless of the frequency of surveys) was 0.42 carcasses km^{-1}.

There were striking differences in carcass densities between the four major regions (Table 1). An analysis of variance using the mean carcass density per beach, indicated that the variation among beaches within each region was less than the variation among regions ($F_{3,34} = 6.466$, $P<0.01$). The average density was highest on the west coast of Vancouver Island and the White Rock-Boundary Bay regions (0.67 and 0.87 birds km^{-1}, respectively), relatively low on the south of Vancouver Island (0.31), and very low (0.08) in the Strait of Georgia and Gulf Islands where no carcasses at all were found at two-thirds of the sites in 99 surveys.

Data from sites which had one or more years of continuous coverage were selected to show monthly variations (Figure 1). The west coast of Vancouver Island showed a strong, seasonal trend, with 76% of carcasses found in a four-month period in late summer and autumn (August through November). There was high mortality during this period in all other areas too, although the pattern was less striking. Very few carcasses were found during late spring through mid-summer (May through July).

Species composition

Information was obtained on 840 beached-birds, of which 17 were terrestrial or domesticated birds and were not considered further. The 823 water birds included 53 species, dominated by waterfowl (21% of the carcasses), gulls (31%) and alcids (34%) (Table 2; see Appendix for species list). The Common Murre, *Uria aalge* (21%), Glaucous-winged Gull, *Larus glaucescens* (20%) and Rhinoceros Auklet, *Cerorhinca monocerata* (7%) were the most common species, and the only species to exceed 5% of the total count .

There were striking differences among the four regions, reflecting the differences in marine habitat (Table 2). Tube-nosed seabirds made up 7% of the carcasses from the west coast of Vancouver Island, where beaches face the open Pacific, but were insignificant elsewhere. Conversely, waterfowl (ducks and geese) made up only 2% of the carcasses on the WCVI beaches, but 17–47% in other regions with more sheltered water. Gulls were common in all regions (28–52%). Alcids were the most common birds found on the west coast of Vancouver Island (54%) and southern Vancouver Island (44%), but were rare elsewhere.

There was insufficient material to detect seasonal trends among most species, but trends in families were often obvious. Loons and grebes, which winter in coastal waters, were found only between September and May (Figure 2). All three species of cormorants are resident in British Columbia, although their numbers are supplemented in winter by northward movements from the United States Most cormorants appear to die in summer or autumn (Figure 2). The vast majority of waterfowl use the coastal waters only as wintering grounds and this is reflected in the strong seasonal pattern found in all areas. The peak of mortality in January is partly due to an unseasonably cold period in 1993, when much of the fresh water was frozen and many starved dabbling ducks were found in the White Rock-Boundary Bay region.

Glaucous-winged Gulls are common breeding residents in most coastal areas, but the bulk of carcasses (70%) were found in autumn and winter (September through January) and very few during the breeding season (Figure 3). First-year (22%) and immature gulls (16%, including some first-years) occurred disproportionately more often among the carcasses, particularly in autumn.

Dead Common Murres, Cassin's Auklets, *Ptychoramphus aleuticus,* and Rhinoceros Auklets were most common in late summer through early winter (Figure 4). This pattern was partially due to the seasonal presence of these species off the west coast of Vancouver Island, although large numbers of murres and Cassin's Auklets tend to remain there through the winter. This pattern also reflected high mortality among newly-fledged juveniles. The age of 125 Common Murres was reported, and 61 (49%) were partly-grown juveniles found dead in August through October. Forty-six (85%) of the 54 Rhinoceros Auklets were juveniles found between August and November. Few Cassin's Auklets were reliably aged.

TABLE 1. Summary of carcass densities reported from beached bird surveys in southern British Columbia (October 1989 through March 1993) . In each region, the beaches are arranged in sequence from north to south, except for southern Vancouver Island (arranged west to east).

Region and beach site	No. of surveys	Total carcasses	Total distance (km)	Mean birds per km	No. of person-days
1. West coast Vancouver Island (WCVI)					
Chesterman's Beach, Tofino*	37	45	70.3	0.64	41
Cox Bay, Tofino *	34	32	34.0	0.94	36
Schooner Cove, Tofino *	29	22	20.5	1.07	34
Long Beach, Ucluelet *	24	149	164.4	0.91	41
First Beach, Bamfield	4	1	6.0	0.17	8
Pachena Beach, Bamfield *	56	112	67.2	1.67	82
Dead End Beach, Pachena Point	8	3	3.2	0.94	12
Mile Half Beach, Pachena Point	9	3	9.0	0.33	12
Michigan Creek Beach	8	1	8.0	0.13	10
Carmanah Crib Creek *	16	15	40.0	0.38	21
Carmanah Creek *	16	5	21.0	0.24	20
Total for WCVI:	241	388	443.6	0.87	317
(Unweighted mean, N = 11 sites)				[0.67]	
2. Southern Vancouver Island (SVI)					
China Beach *	27	4	28.5	0.14	29
French Beach *	12	1	16.0	0.06	17
Gordon's Beach	10	1	5.8	0.17	13
Whiffin Spit Inner, Sooke *	21	31	29.4	1.05	27
Whiffin Spit Outer, Sooke *	21	11	21.0	0.52	28
Witty's Lagoon/Taylor Point *	11	5	11.0	0.45	17
Chatham & Discovery Islands *	26	0	26.0	0.00	27
Cordova Bay Central *	22	4	22.0	0.18	22
Cordova Bay North *	25	7	40.0	0.18	25
Bazan Bay, Sidney *	34	14	85.0	0.16	34
Island View, Sidney *	21	19	42.0	0.45	20
Total for SVI:	230	97	326.7	0.30	259
(Unweighted mean, N = 11 sites)				[0.31]	
3. Strait of Georgia & Gulf Islands (SGGI)					
Storries Beach, Campbell River *	14	0	21.5	0.00	26
Palm Beach, Powell River *	18	0	16.6	0.00	18
Mission Point, Sechelt *	23	8	23.0	0.35	43
Sergeant's Bay, Sechelt *	26	24	78.0	0.31	24
Wace Creek, Mill Bay *	11	4	22.0	0.18	46
Fulford Harbour, Saltspring Island	4	0	10.0	0.00	5
Menhinick, Saltspring Island *	25	0	50.0	0.00	25
North Beach, Saltspring Island *	29	1	42.4	0.02	29
Hamilton Beach, Pender Island	10	0	5.0	0.00	18
Medicine Beach, Pender Island *	18	0	14.4	0.00	28
East Point, Saturna Island	10	0	10.0	0.00	12
Total for SGGI:	188	37	292.9	0.13	274
(Unweighted mean, N = 11 sites)				[0.08]	
4. White Rock and Boundary Bay (WRBB)					
Boundary Bay West	3	18	12.0	1.50	3
White Rock Area 6 (Mud Bay)*	21	107	61.7	1.73	52
White Rock Area 4 *	25	58	75.0	0.77	28
White Rock Area 2*	20	56	199.4	0.28	35
White Rock Area 1*	10	4	57.0	0.07	20
Total for WRBB:	79	243	405.1	0.60	138
(Unweighted mean, N = 5 sites)				[0.87]	
TOTAL (All sites)	738	765	1468.3	0.52	988
(Unweighted mean, N = 38 sites)				[0.42]	

*Data from these beaches were used for seasonal analyses (Figure 1).

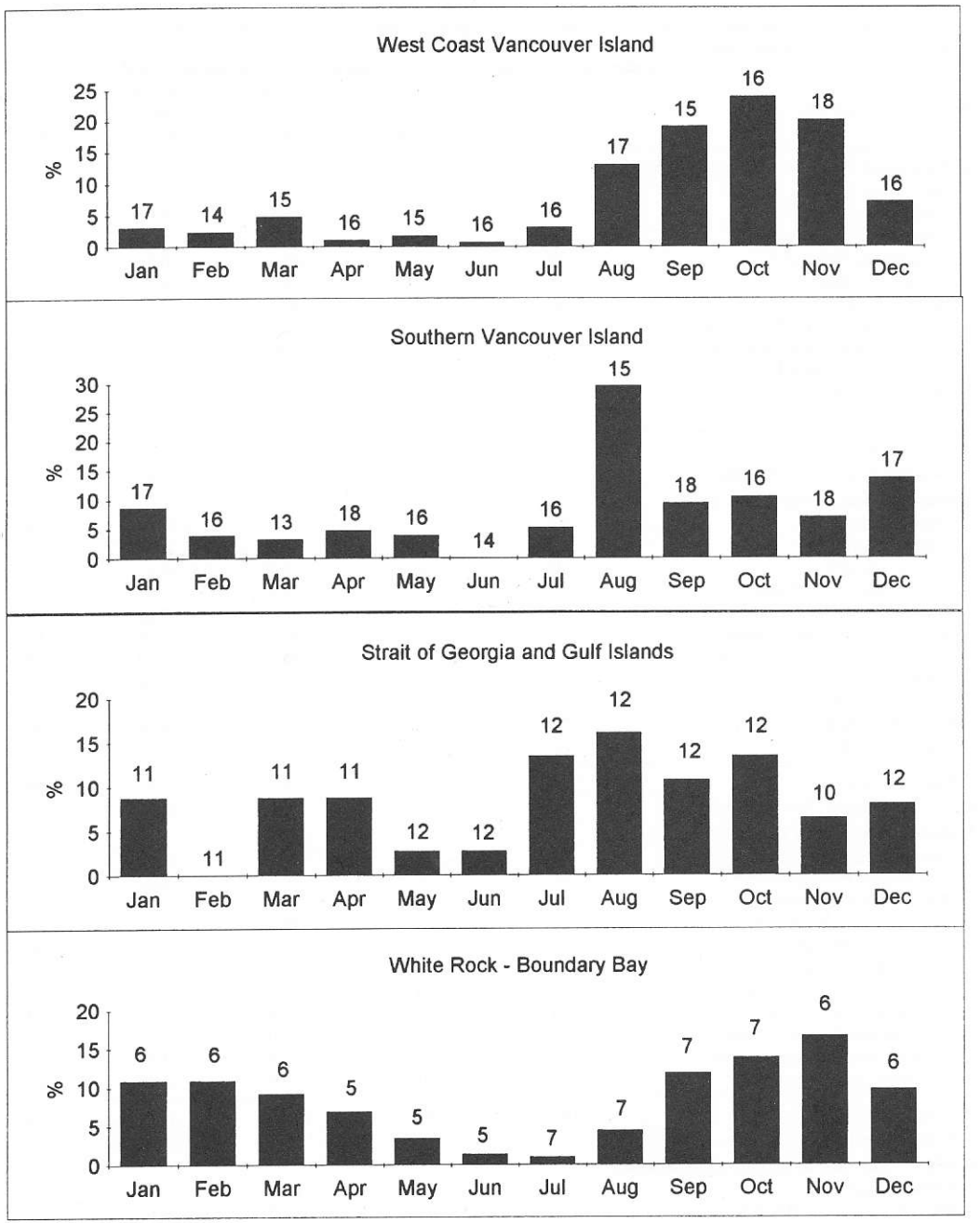

FIGURE 1. The monthly percentage of the total carcass count found in each region during beached-bird surveys in British Columbia. Sample sizes show numbers of surveys per month.

Causes of mortality

Many of the beached-birds were either decomposed or partially eaten by scavengers, making assessment of the causes of death difficult. Furthermore, most causes of mortality, such as disease, starvation, internal injuries, and poisoning were not apparent from external examination. Surveyors were asked to estimate the state of decomposition and time since death. They estimated that 29% were fresh (average five days since death), 34 slightly

TABLE 2. Numbers (and percentages in parentheses) of carcasses of each family found in beached-bird surveys on the West Coast of Vancouver Island (WCVI), southern Vancouver Island (SVI), the Strait of Georgia and Gulf Islands (SGGI), and the White Rock - Boundary Bay area (WRBB) in British Columbia. See the appendix for species composition.

Families	WCVI	SVI	SGGI	WRBB	Total
Loons (Gaviidae)	4 (1.0)	2 (1.8)	0	9 (3.2)	15 (1.8)
Grebes (Podicipedidae)	4 (1.0)	3 (2.8)	1 (3.0)	23 (8.0)	31 (3.8)
Tube-noses (Procellariidae and Hydrobatidae)	28 (7.1)	1 (0.9)	0	0	29 (3.5)
Cormorants (Phalacrocoracidae)	20 (5.0)	3 (2.8)	0	1 (0.4)	24 (2.9)
Herons (Ardeidae)	1 (0.3)	1 (0.9)	1 (3.0)	3 (1.1)	6 (0.7)
Waterfowl (Anatidae)	8 (2.0)	18 (16.7)	13 (39.4)	133 (46.7)	172 (20.9)
Shorebirds (Charadriidae and Scolopacidae)	5 (1.3)	0	0	7 (2.5)	12 (1.5)
Gulls and jaegers (Laridae and Stercoraridae)	112 (28.2)	33 (30.6)	17 (51.5)	94 (33.0)	256 (31.1)
Alcids (Alcidae)	215 (54.2)	47 (43.5)	1 (3.0)	15 (5.3)	278 (33.8)
Total for all water birds	397	108	33	285	823

decomposed (average 13 days dead) and 37% very decomposed (average 21 days dead).

Causes of death were assumed for only 118 carcasses (Table 3). Natural causes, primarily starvation, were assigned to 25% , and oiling (30%) and shooting (35%) were the most frequent human-induced causes. Oiling was most frequent on the west coast of Vancouver Island, and shooting was most common on southern Vancouver Island and at White Rock.

Thirteen species were included in the 35 oiled birds, of which 28 came from the west coast of Vancouver Island (Table 4). Glaucous-winged Gulls (9) and Common Murres (9) were the most common oiled birds. Oiled birds were found in most months, with no apparent seasonal peak. Most were covered with relatively little oil: 66% of the birds had 10% or less of their plumage affected, and only three (9%) were nearly completely covered in oil (Table 4). The oiled birds included 12 affected by thick bunker or crude oil, two by light fuel oil and two by creosote from pilings.

The oiled birds represented 4.3 % of the 823 water birds found. However, at least 241 carcasses were known to be too decomposed or eaten to allow oiling to be detected, and there were undoubtedly additional carcasses in similar states which were not reported. At least 6.0% of the carcasses (35 out of 582) were therefore oiled. Broken down into regions this represents 10.2% (28/275) on the west coast of Vancouver Island, 4.4% (3/68) on southern Vancouver Island, 13.3% (4/30) in the Strait of Georgia and Gulf Islands, but none (0/209) at White Rock-Boundary Bay.

The mean density of oiled carcasses per km of beach was 0.06 on the WCVI, 0.01 on SVI, 0.01 in the SGGI area, 0 for the WRBB area, and 0.02 for all surveys pooled together. In the 22 surveys that reported oiled birds, only six (27%) reported other types of oil (usually small tar-balls) on the beach at the same time. The sample period overlapped with the Tenyo Maru oil spill of July and August 1991, but very little of the spilled oil and fewer than 20 oiled birds (none in routine beach surveys) were reported ashore in Canada.

Discussion

Comparisons with other beached-bird surveys

Beached-bird surveys have been conducted in several countries and regions (Table 5). The mean density of carcasses in British Columbia (0.42 km^{-1}) is among the lowest recorded anywhere. Only the inland waters of Washington State (Puget Sound and the San Juan Islands) had a lower density (0.26 km^{-1}) which was very similar to the adjacent areas in British Columbia; i.e., southern Vancouver Island (0.31 km^{-1}) and the Strait of Georgia and Gulf Islands (0.08 km^{-1}). The west coast of Vancouver Island (0.67 carcasses km^{-1}) had lower densities than comparable exposed beaches in California, Oregon and Washington (Table 5). This low rate of carcass deposition in British Columbia is surprising because the marine bird populations are comparable to, if not higher than, those off most of the lower United States (Atlantic and Pacific). Several reasons can be advanced to explain the low rates, including: low wave action in sheltered waters resulting in few dead birds being washed ashore; large amounts of beached debris, including huge piles of logs or kelp typical on more exposed beaches which make it more difficult to locate carcasses; high densities of scavenging birds (eagles, gulls, ravens, crows) and mammals (bears, wolves, coyotes, raccoons, dogs) which eat or remove beached carcasses. Other topographical and physical factors, such as the slope of the beach, local currents and wind directions, all are likely to influence deposition rates and require further investigation.

Seasonal and geographical variations

The highest carcass densities were reported during late summer through early winter, particularly on the

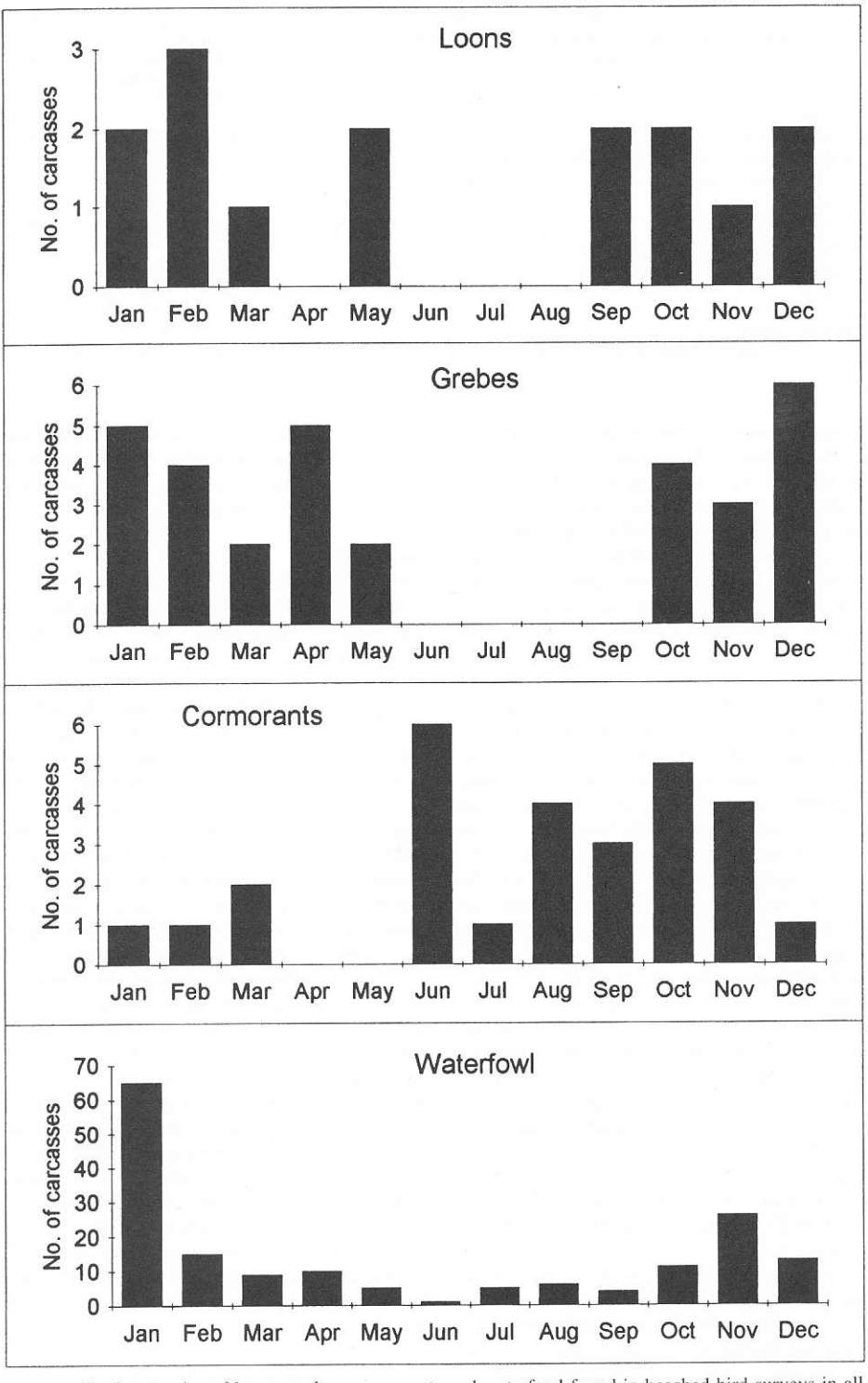

FIGURE 2. Monthly frequencies of loons, grebes, cormorants and waterfowl found in beached-bird surveys in all areas in British Columbia.

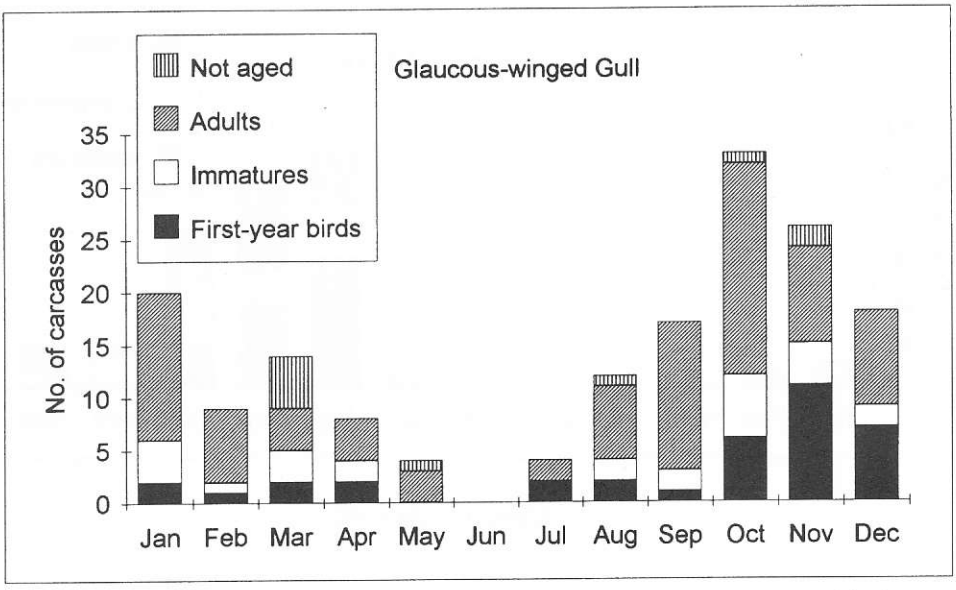

FIGURE 3. Age composition of Glaucous-winged Gulls found in each month in beached-bird surveys. The immature category includes 2- and 3-year olds, as well as some incompletely classified first-year birds. Some birds classified as adults might have been 3-year olds.

west coast of Vancouver Island and in the White Rock-Boundary Bay area, which had the highest overall densities. There are several reasons for the seasonal peak in beached-bird depositions.

First, all of the coastal areas sampled here experience a massive influx of birds in late summer and fall. Many, such as shorebirds or California Gulls, *Larus californicus*, move away as winter sets in, but huge populations of loons, grebes and waterfowl overwinter in British Columbia's coastal waters (Vermeer et al. 1983, 1992; Vermeer and Butler 1989; Campbell et al. 1990). This cannot explain all of the fall and winter mortality, however. Some species, such as Glaucous-winged Gulls, Common Murres, Cassin's Auklets, and Rhinoceros Auklets are present year-round and population densities at sea are not necessarily highest in fall and winter (Morgan et al. 1991). A second reason for the seasonal peak is that high mortality of newly-fledged juveniles occurs at this time and, in the case of the gulls, murres and Rhinoceros Auklets, contributes substantially to the peak. Adult birds, which might be stressed after breeding or while moulting, are more likely to die at this time too.

A third reason for the fall-winter peak is that carcasses are more likely to be deposited on beaches by storms in those seasons than in spring or summer. Again this doesn't fully explain the pattern because days on which many carcasses were found did not always follow stormy weather, and conversely, many intense storms did not bring carcasses ashore. The low wave action and sheltered waters of the Strait of Georgia and Gulf Islands, and at several of the beaches on southern Vancouver Island are obviously major reasons for low carcass deposition there, because many of these sites are adjacent to important feeding grounds of water birds. On the west coast of Vancouver Island, the prevailing winds are more likely to bring carcasses ashore in winter than in summer. The winter winds tend to be from the south or south-west (Thomson et al. 1989), which, in combination with the clock-wise Coriolis forces, will bring floating objects closer to shore. Summer winds tend to be from the northwest and hence have the opposite effect.

There are clearly a variety of topographical, physical and biological processes underlying the marked seasonal and geographical variation in carcass deposition within the areas sampled. This study has demonstrated the importance of some of these, but a longer series of surveys is needed for more rigorous analysis.

Causes of mortality and the impact of chronic oiling

The causes of death could be assumed for very few of the beached-birds. A thorough study will require detailed (and expensive) autopsies, toxicological sampling and microscopic investigations. The effects of industrial effluents, such as dioxins, which are known to affect herons in the Strait of Georgia (Whitehead 1989), could be monitored using fresh material from beached-birds.

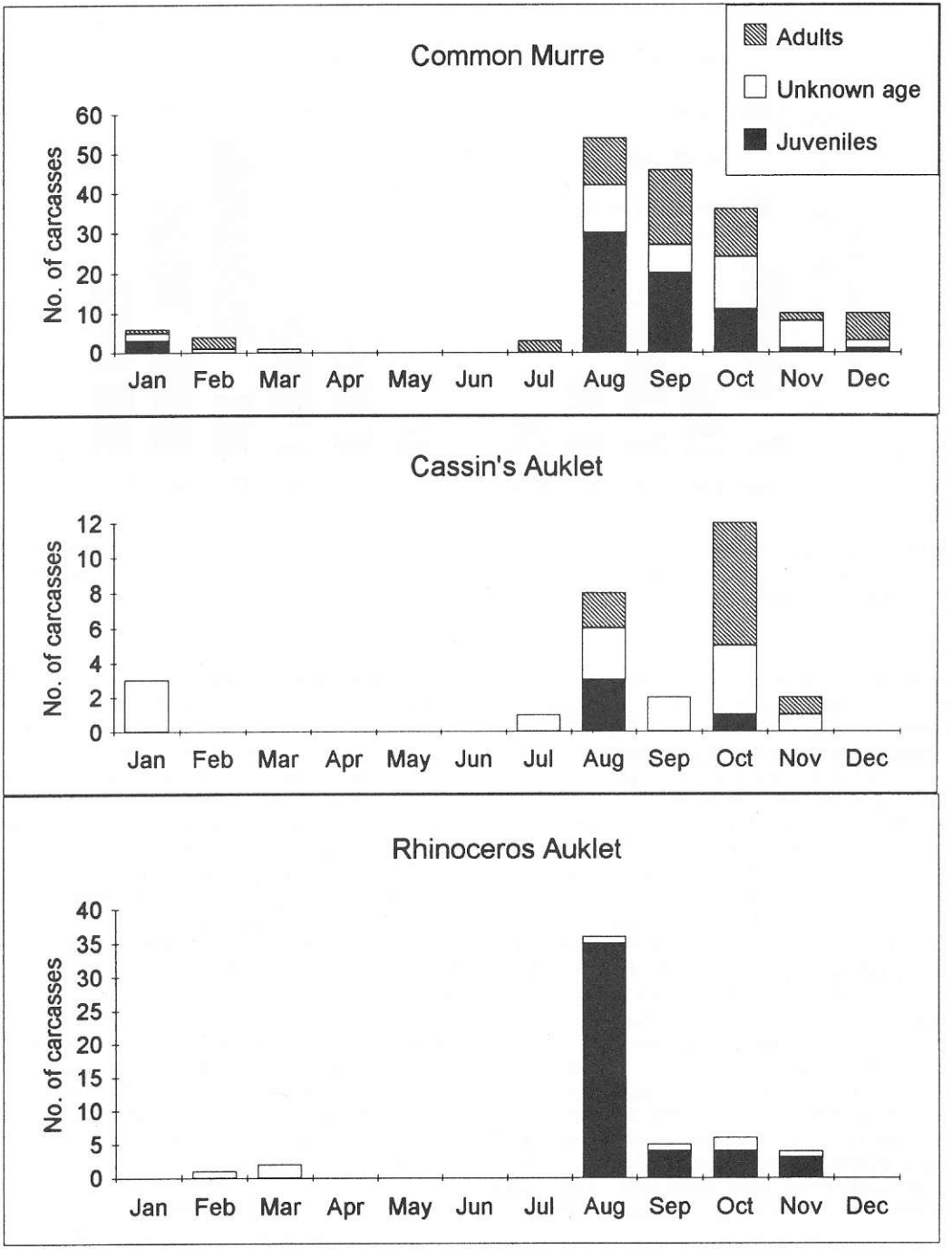

FIGURE 4. Age composition of three species of alcids found in each month in beached-bird surveys.

TABLE 3. Assumed causes of death for beached birds in southern British Columbia. The numbers of birds are shown for each category.

Assumed cause of death	Area within British Columbia				Total No.	Total %
	WCVI	SVI	SGGI	WRBB		
Natural causes						
Storms	2				2	1.7
Starvation	10	2		1	13	11.0
Predators	3	1		5	9	7.6
Broken wing	1		3		4	3.4
Choked on food				1	1	0.8
Human-related causes						
Oiling	28	3	4		35	29.7
Tangled in net or line	1	2	1	5	9	7.6
Shot	2	13	2	24	41	34.7
Injured by dog			3		3	2.5
Possible poisoning			1		1	0.8
Total	47	21	14	36	118	100

Oiling was a conspicuous cause of death among the beached-birds, and most of the victims were killed by small amounts of oil fouling their plumage. Oiling occurred year-round and affected many types of water bird. The overall estimate that 6% of mortality was due to oiling is clearly a minimum value, and the true value may be several times higher. Small amounts of oil on carcasses could easily be overlooked, particularly since the majority of carcasses were scavenged or partly disintegrated.

The 6% estimate of oiled birds is similar to estimates obtained from beach surveys in Washington, the Atlantic U.S., Shetland and Portugal, but lower than estimates from California, Newfoundland, Britain, the Netherlands and Belgium (Table 5). These comparisons are problematic, however, because some reports refer only to birds with known causes of death, whereas others refer to all carcasses found. The mean density of oiled birds per km of beach in British Columbia (0.02) is clearly very low relative to other parts of the world (Table 5). At face value this indicates that mortality due to chronic oiling is less serious in British Columbia than elsewhere. The problem certainly appears less serious here than in Newfoundland or the North Sea, where high shipping volumes, frequent spills and deliberate tank-flushing or bilge-pumping continue to be significant problems (Chardine et al. 1990; Chardine 1991; Camphuysen and Franeker 1991).

TABLE 4. Numbers of birds of each species found oiled, and the percentage of their plumage covered with oil.

Species	Percentage of plumage oiled					Total oiled
	1 - 5	6 - 10	11 - 50	51 - 90	>90	
Pacific Loon			1		1	2
Western Grebe			1			1
Sooty Shearwater		1				1
Cormorant sp.		1				1
Red-breasted Merganser		1				1
California Gull		1				1
Glaucous-winged Gull	3	4	1	1		9
Gull sp.		1				1
Common Murre		4	3	2		9
Pigeon Guillemot		1				1
Cassin's Auklet	2					2
Ancient Murrelet					1	1
Tufted Puffin	1	1				2
Rhinoceros Auklet	2					2
Auklet sp.					1	1
Total	8	15	6	3	3	35

TABLE 5. Summary of beached-bird surveys around the world.

Country or region	Years of coverage (#)	Mean distance per year (km)	Mean corpses per km	Proportion oiled corpses (%)	Approx. oiled corpses per km	References
British Columbia	1989-1993 (4)	367	0.42	6	0.02	This study
California	1971-1985 (14)	(91 beaches)	2.72	83% of known causes	–	Stenzel et al. (1988)
Oregon	1978-1984 (7)	(1 beach)	2.4-7.5	Not known	–	R. Loeffel, *quoted in* Speich and Wahl (1986)
Washington (Inland marine)	1978-1979 (2)	48	0.26	<1	<0.01	Speich and Wahl (1986)
Washington (Open shores)	1981-1984 (4)	Not known	6.64	4.5	0.30	Speich and Wahl (1986)
Atlantic U.S.	1975-1983 (8)	202	1.17	6.6	0.08	Simons 1985
Newfoundland	1980 -1984 (4)	68	7.1	52	3.68	Piatt et al. (1985)
Newfoundland	1984 -1988 (5)	144	4.7	23	0.57	Chardine et al. (1990)
New Zealand	1960-1990 (30)	4347	3.1	Not known	–	Powlesland and Imber (1988); Powlesland (1989)
South Africa	1978-1990 (12)	1678	1.45	Not analyzed	–	Avery (1983, personal communication)
Britain	1971 - 1979 (8) (autumn and winter only)	8890	0.57	47	0.27	Stowe (1982)
Shetland, U.K.	1979-1990 (10)	618	4.24	9.1	0.39	Heubeck (1987, personal communication)
Netherlands	1969-1990 (21)	1282	4.5	68.4	3.08	Camphuysen (1989, personal communication)
Belgium	1962-1977 (15)	63	3.7	70	2.59	Kuyken (1978)
Portugal	1982-1990 (9)	1359	2.4	7.8	0.19	(Teixeira 1986, personal communication)

It is not clear, however, whether the low density of oiled birds is due to the overall low rate of carcass deposition due to the factors outlined above. Experiments with bird-sized drift blocks off the west coast of Vancouver Island in summer and winter showed that only half the blocks released 1-2 km offshore were found on beaches, and only 10% of those launched 35-116 km off were found (Hlady and Burger 1993). Many oiled birds which die at sea are never found on beaches. This obviously also applies to other parts of the world, but there is insufficient information to judge whether oiled birds off British Columbia are more or less likely to be found on beaches than elsewhere.

About 10% of the surveys reported some oil on the beaches, with beaches on the west coast of Vancouver Island having a higher incidence (19%, Burger unpublished data). This suggests that there is a continual low level of small-scale oil pollution in British Columbia waters. Most of the reports referred to relatively small volumes of small tar-balls or oily sheens, but it is certain that the majority of such oil is overlooked on British Columbia beaches, which tend to be littered with large volumes of kelp, logs and other debris. No oil was reported on beaches in 72% of the surveys in which oiled birds were found, confirming that monitoring of seabird carcasses is essential for detecting evidence of the many slicks which do not come ashore (Piatt et al. 1985; Chardine 1991; Camphuysen 1989).

Chronic oiling on beaches and marine ecosystems in British Columbia may be less severe than in highly polluted waters elsewhere. Likewise, the impact of chronic oiling on seabirds off British Columbia might be less severe than that of a major spill, such as the *Nestucca* event, which killed about 56 000 seabirds (Ford et al. 1991). Nevertheless, the presence of oiled birds and oil on the beaches are indicators of a continuing problem which requires attention.

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APPENDIX. Species composition of carcasses found in beached bird surveys on the West Coast of Vancouver Island (WCVI), southern Vancouver Island (SVI), the Strait of Georgia and Gulf Islands (SGGI), and the White Rock-Boundary Bay area (WRBB) in British Columbia.

Species	WCVI	SVI	SGGI	WRBB	Total
Red-throated Loon, *Gavia stellata*				2	2
Common Loon, *Gavia immer*	1	2		6	9
Pacific Loon, *Gavia pacifica*	3			1	4
Horned Grebe, *Podiceps auritus*		1	1	7	9
Red-necked Grebe, *Podiceps grisegena*	1	1		2	4
Eared Grebe, *Podiceps nigricollis*		1			1
Western Grebe, *Aechmophorus occidentalis*	3			13	16
Grebe sp.				1	1
Northern Fulmar, *Fulmarus glacialis*	22	1			23
Sooty Shearwater, *Puffinus griseus*	4				4
Short-tailed Shearwater, *Puffinus tenuirostris*	1				1
Fork-tailed Storm-petrel, *Oceanodroma furcata*	1				1
Double-crested Cormorant, *Phalacrocorax auritus*	1	1		1	3
Brandt's Cormorant, *Phalacrocorax penicillatus*	9	1			10
Pelagic Cormorant, *Phalacrocorax pelagicus*	6	1			7
Unidentified Cormorant	4				4
Great Blue Heron, *Ardea herodias*	1	1	1	3	6
Trumpeter Swan, *Cygnus buccinator*	1				1
Canada Goose, *Branta canadensis*		1	4	1	6
Green-winged Teal, *Anas crecca*				40	40
Mallard, *Anas platyrhynchos*		1	6	17	24
Northern Pintail, *Anas acuta*				30	30
American Wigeon, *Anas americana*		1		4	5
Greater Scaup, *Aythya marila*				5	5
Lesser Scaup, *Aythya affinis*				1	1
Scaup sp.				1	1
Surf Scoter, *Melanitta perspicillata*	3			5	8
White-winged Scoter, *Melanitta fusca*	1	3	1	12	17
Scoter sp.		1		5	6
Goldeneye sp., *Bucephala* sp.		1		1	2
Bufflehead, *Bucephala albeola*	1	6		8	15
Common Merganser, *Mergus merganser*				1	1
Red-breasted Merganser, *Mergus serrator*		2			2
Ruddy Duck, *Oxyura jamaicensis*				1	1
Unidentified duck	2	2	2	1	7
Black-bellied Plover, *Pluvialis squatarola*				2	2
Surfbird, *Aphriza virgata*	2				2
Dunlin, *Calidris alpina*				3	3
Semi-palmated Sandpiper, *Calidris pusilla*				1	1
Long-billed Dowitcher, *Limnodromus scolopaceus*				1	1
Red-necked Phalarope, *Phalaropus lobatus*	1				1
Red Phalarope, *Phalaropus fulicaria*	1				1
Unidentified Shorebird	1				1
Parasitic Jaeger, *Stercorarius parasiticus*	1				1
Heerman's Gull, *Larus heermanni*	1				1
Mew Gull, *Larus canus*	2	1		1	4

APPENDIX: *CONTINUED*

Species	WCVI	SVI	SGGI	WRBB	Total
Ring-billed Gull, *Larus delawarensis*	1			4	5
California Gull, *Larus californicus*	30	2			32
Herring Gull, *Larus argentatus*	5			1	6
Thayer's Gull, *Larus thayeri*			2	2	4
Western Gull, *Larus occidentalis*	1				1
Glaucous-winged Gull, *Larus glaucescens*	45	27	10	79	161
GWGU x WEGU hybrid				2	2
Black-legged Kittiwake, *Rissa tridactyla*	2				2
Unidentified Gull	24	3	5	5	37
Common Murre, *Uria aalge*	127	34	1	13	175
Pigeon Guillemot, *Cepphus columba*		3		1	4
Marbled Murrelet, *Brachyramphus marmoratus*	4	1			5
Ancient Murrelet, *Synthliboramphus antiquus*	2				2
Cassin's Auklet, *Ptychoramphus aleuticus*	28				28
Rhinoceros Auklet, *Cerorhinca monocerata*	44	9		1	54
Tufted Puffin, *Fratercula cirrhata*	4				4
Unidentified auklet	4				4
Unidentified alcid	2				2
TOTAL ALL WATER BIRDS	**397**	**108**	**33**	**285**	**823**