BEACHED BIRD SURVEYS IN BRITISH COLUMBIA, 1986-1997

REPORT TO THE NESTUCCA TRUST FUND

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ABSTRACT

Beached bird survey data from 1986-1997 were analysed from 49 beaches, mostly in southern British Columbia. A total of 1431 surveys covering 2640 km (mean 1.8 km per beach) was included. Most surveys were done in 1990-1995. Density of beached carcasses (carcasses per km surveyed) varied considerably among the seven regions in the province:

- West Coast Vancouver Island (WCVI): 0.42 ± SD 0.51 (14 beaches);
- Southern Vancouver Island (SVI): 0.27 ± 0.28 (12 beaches);
- Southern Gulf Islands (SGI): 0.003 ± 0.008 (6 beaches);
- Strait of Georgia (STG) 0.13 ± 0.12 (7 beaches);
- White Rock/Boundary Bay (WRBB): 0.82 ± 0.46 (5 beaches);
- Central and Northern Coast (CNC): 1.25 ± 1.55 (3 beaches);
- Haida Gwaii/Queen Charlotte Islands (QCI): 0.02 ± 0.03 (2 beaches); and
- for all beaches in BC: 0.37 ± SD 0.56 (49 beaches).

Carcasses included 64 species (16 families) of water birds and 20 species of land birds. Alcids (32%), larids (32%, mainly gulls), and waterfowl (19%, mainly ducks) were the most common families. Common Murres (*Uria aalge*, 22%) and Glaucous-winged Gulls (*Larus glaucescens*, 18%) were the most common species. Most mortality (79% of carcasses) occurred from August through January, and often involved newly fledged juveniles. Surveys from WCVI showed a significant decline in carcass density in 1990-1995, but other regions and the pooled data for all BC showed no annual trends. There were no obvious changes in mortality associated with the 1987 and 1992 El Niño events which affected the BC coast. Only 24% of the 1260 carcasses in the database had notes on the possible cause of death. Of these 36% were thought to be natural causes and 64% due to human activities. The major causes of death recorded were gillnets (29% of carcasses, nearly all in the WRBB region), starvation (19%, several regions), hunting (17%, mainly WRBB and SVI), and oiling (12%, mainly WCVI). Oiled plumages were reported for 14 species, dominated by alcids (54%) and gulls (28%). Density of oiled carcasses averaged 0.014 oiled carcasses per km for all BC beaches, and was highest in

the WCVI region (0.041 per km). Small quantities of oil were reported on the beaches in 8% of all surveys in BC and for 17% of surveys in WCVI. Annual mean oiled carcass density declined on WCVI between 1990-1995, but showed no trend in other regions or for BC as a whole. The percentage of oiled birds showed no changes over the years in any region. The incidence of oiled birds in BC is low compared to most other coasts surveyed in North America and Europe. Oiled birds occurred less frequently on beaches in BC than in Newfoundland where mortality from oil was estimated to be 300,000 seabirds annually. The main concern in BC is the relatively high frequency of oiling on the west coast of Vancouver Island and possibly also for Haida Gwaii/Queen Charlotte Islands (which was not adequately sampled). Recommendations for improved monitoring of seabird mortality and rates of oiling include the following:

- improved recording of age classes in beach surveys to more accurately assess demographic impacts of gillnets, oiling and other causes of mortality;
- greatly increased monitoring in the northern areas of BC, particularly those areas likely to be affected if offshore exploration and extraction of oil proceeds;
- improved identification of oiled birds to get a better estimate of the true impacts of chronic oiling in BC;
- research into the factors affecting carcass deposition on BC beaches, in order to get a better estimate of the numbers of birds killed by oil and other causes.

Research and monitoring efforts in Europe and Newfoundland provide useful guidance on what could be done in BC to monitor seabird mortality and chronic oil pollution.

INTRODUCTION

Regularly repeated beached bird surveys have been widely used around the world to monitor mortality of seabirds (Burger 1993a). They are useful for assessing the timing, distribution and annual variations in mortality and are particularly valuable for determining the extent and changes in chronic oiling of seabirds (Camphuysen and Heubeck 2001, Camphuysen and Van Franeker 2002). Chronic oil spills are those which result from accidental or deliberate release of oil or oily bilge-water and which occur in all waters heavily used by shipping or close to shoreline industries. The quantities of oil are generally small and are often not reported to the environmental authorities. Nevertheless, chronic oil spills are responsible for killing thousands of seabirds in many parts of the world, and their cumulative effects are often far greater than the effects of the more widely publicized major spills such as the *Nestucca* or *Exxon Valdez* spills. The numbers of birds killed by oiling is not correlated with the volume of oil released (Burger 1993b). Beached bird surveys are the only effective method for monitoring the occurrence, distribution and trends in chronic oil pollution (Camphuysen and Heubeck 2001, Camphuysen and Van Franeker 2002, Wiese 2002).

Data from beached bird surveys in British Columbia between 1986 and 1997 are summarised and analysed in this report. Most of the data were from 1990-1995, when routine surveys were conducted under the author’s supervision at more than 40 beaches in BC, concentrated in the southern part of the province. This project was funded by the Royal British Columbia Museum and the Emergency Services Branch of the former BC Ministry of Environment, Lands and Parks. Data gathered by this program up to March 1993 were analysed and published (Burger 1993a). Survey effort dropped off after funding ended in 1994 and relatively few surveys were done between 1995 and 2000. Only one site was regularly surveyed between 1997 and 2000.

There has been renewed interest in beached bird surveys in British Columbia, prompted by several recent events. The BC government has proposed lifting the moratorium on oil exploration in the coastal waters of BC, which has raised concerns for increased chronic oil spills from drilling rigs and exploration vessels. Intensive recent research in Newfoundland showed that hundreds of thousands of seabirds were killed annually by chronic oil spills off eastern Canada (Wiese and Ryan 1999, Wiese 2002). This research highlighted the paucity of comparable information for the Pacific coast of Canada. A new beached bird survey program was initiated in British Columbia in August 2002, run by Bird Studies Canada (Delta, BC office) and the Canadian Wildlife Service. The data collected by this new program will be added to the existing beached bird data. A large program of beached bird surveys has been running for several years in Washington (Hass and Parrish 2000). A new post-doctoral research post was created at the University of Victoria, funded by Environment Canada, beginning in September 2002 to investigate the risks of oil pollution to seabirds off the British Columbia coast. Data on rates of oiling in beached birds are central to this research. Funding was available for this analysis from the Nestucca Trust Fund, established to investigate and mitigate the effects of oil spills off the BC coast.

The main goals of the present project were:

1. To update the 1993 databases to include all the data available in 2002 (effectively new data from March 1993 to the end of 2000);
2. To analyse these data in order to confirm and modify the results of the earlier analysis (Burger 1993a);
3. To include additional analyses using the longer time series of data now available, focusing on the extent, distribution and trends in chronic oiling;
4. To provide information which will guide the implementation of the new beached bird program in BC.

During the period 1987-1997 two major oil spills occurred, which together killed tens of thousands of seabirds off BC and northern Washington (Burger 1992). The *Nestucca* spill in late December 1988 was the most damaging and killed an estimated 56,000 birds (Rodway et al. 1989, Ford et al. 1991, Burger 1993c). Oil from this spill affected most beaches on southwestern Vancouver Island and traces of oil were found beyond Cape

Scott at the northern tip of the island. In July 1991, the sinking of the vessel *Tenyo Maru* in the mouth of the Strait of Juan de Fuca also killed many seabirds, but most of the oil moved into Washington, and Vancouver Island was relatively unscathed (Burger 1992). Birds known to be killed by these spills were not included in the beached bird databases, although a few which died weeks after the *Tenyo Maru* spill might have been inadvertently included. Oil from these spills persisted for many months on the beaches, and, as discussed below, contributed to some of the oil reported on beaches.

METHODS

Volunteer naturalists walked the designated beaches once a month on approximately the same day of the month, and reported any dead or incapacitated birds, and the presence of any oil on the beach. Surveyors followed a tested protocol (Ainley et al. 1980, Burger 1993a) and submitted data on standard data sheets (Appendix 1). Surveyors were asked to report the following for each bird carcass, where possible:

- species;
- age class;
- sex;
- the condition or state of decomposition;
- estimated days or weeks since death;
- evidence of oiling and the proportion of the body covered with oil;
- evidence of post-mortem scavenging and the proportion of the body eaten;
- notes on the likely cause of death; and
- other information relevant to the monitoring project.

See Appendix 1 for the ranks and codes used for each category. Each surveyor was given an identification guide to beached bird carcasses (Ainley et al. 1980). Identification of carcasses was sometimes difficult, especially for decomposed or dismembered carcasses and accurate species identification was not always possible. Many specimens were frozen and sent to the author for identification. Some specimens were preserved in the Royal BC Museum and in the biology teaching collection at the University of Victoria.

Data were entered into two Excel spreadsheets: one included summary data for each survey at all beaches (one row per survey day); the other included data for all carcasses found (one row per bird carcass). Samples of each are given in Appendices 2 and 3, respectively. A few beached carcasses (fewer than 20) from surveys not included in the beach analysis were included in the carcass database and in the analysis of carcasses presented here. The complete databases were archived with the new beached bird survey program at the Canadian Wildlife Service office in Delta, BC. Statistical analysis was done with SPSS 10.0 and tests were considered significant if $P<0.05$.

Carcass densities from the beach surveys were compared with indicators of El Niño conditions to see if these events caused significant changes in mortality of local birds. Two indicators of El Niño conditions were used, both obtained from the Institute of Ocean Sciences (IOS), Sidney BC (Department of Fisheries and Oceans website: http://www.pac.dfo-mpo.gc.ca/sci/). The Southern Oscillation Index is a standard index of parameters linked with El Niño – Southern Oscillations (ENSO). Negative values indicate El Niño events. I included the year-round mean of the index, as well as a mean for December and January, when most El Niños have their strongest effects. I also included sea surface temperature data from Amphitrite Point, on the west coast of Vancouver Island. This light-station has one of the longest series of temperature measurements in BC (1934-present). Monthly mean temperatures obtained from the IOS website were converted into temperature anomalies (mean for the month minus the 50-year mean for that month); positive anomalies therefore indicate warmer than average conditions (found during El Niños), and negative anomalies indicate colder than average conditions (see results).

To analyse geographic variations in the data, the surveys were grouped into 7 regions. These followed the regions described in Burger (1993a), except that the Gulf Islands and Strait of Georgia, previously grouped together, were separated in the present analysis. For consistency, the number codes used for the regions in the database and in Burger (1993a) were maintained, and the newly split regions were coded 3a and 3b (see below). This analysis also includes two regions not covered by Burger (1993a) in the northern parts of the province. The 7 regions were:

1. West Coast Vancouver Island (WCVI) – This included surveys from Cape Scott in the north to Carmanah Creek, in the south. Most surveys were done in the southwestern coast between Tofino and Carmanah Creek. Most of these beaches were exposed to the open Pacific and the bird species found here subsequently differed from those in the more sheltered beaches of most other regions. Onshore wind and waves frequently create conditions favourable for deposition of carcasses on beaches.

2. Southern Vancouver Island (SVI) – This region covered China Beach in the west to Sidney in the east. These beaches face the Strait of Juan de Fuca which is relatively sheltered but experiences occasional storms and onshore winds.

3a. **Southern Gulf Islands (SGI) –** This included beaches on Pender, Saltspring and Saturna islands. These beaches face sheltered inland seas, subjected to relatively little wave action and therefore do not have high rates of carcass deposition even though there are sometimes large populations of birds wintering on the adjacent ocean.

3b. **Strait of Georgia (STG) –** This region included beaches on both sides of the strait, between Campbell River and Mill Bay on the Vancouver Island shore, and Powell River and Sechelt on the mainland. The rates of deposition of carcasses were substantially higher than those on the Southern Gulf Islands, which is the reason these two regions were separated in the present analysis.

4. **White Rock and Boundary Bay (WRBB) –** This region included beaches facing Boundary Bay, with four of the five beaches on the eastern shore around White Rock. These beaches experienced relatively high rates of carcass deposition and strong influences of human activity.

5. Central and Northern Coast (CNC) – The sparsely populated coast of the central and northern mainland was not adequately sampled in this program. Three survey sites were regularly surveyed, all by light keepers living on small islands in this region. These data were not included in the earlier analysis (Burger 1993a) but there are now more data that warrant preliminary analysis.

6. Haida Gwaii/Queen Charlotte Islands (QCI) – This archipelago was represented only by Langara Island in the north and a few surveys from a beach near Massett. Obviously this is an inadequate sample for the region, but the data were included where possible. This region was not included in Burger (1993a).

RESULTS

Survey effort and regional summaries

Surveys were performed at 61 beaches in BC between 1987 and 2000, of which 49 yielded data included in this analysis (Table 1). The other 12 sites were surveyed for fewer than five months and were omitted. This analysis included data from 1431 surveys, involving 1967 person-days, covering a total of 2640 km (Table 2). The mean distance per survey was 1.8 km (Table 2). Most (90%) of the surveys were done in 1990-1995 (Figure 1) and this period was used to analyse annual variations in carcass deposition.

Carcass density was measured as the number of carcasses per km of survey for each day of survey, and mean density was calculated for each site and region (Table 2). To avoid bias because of the large variation in survey effort among the sites, unweighted mean densities in each region were calculated using the mean density from each site and not from each survey day. Unweighted regional mean densities are shown within square brackets in Table 2. Among the well-sampled regions, the highest carcass densities were in the White Rock/Boundary Bay region (0.82 ± SD 0.46 carcasses per km), followed by West Coast Vancouver Island (0.42 ± 0.51), Southern Vancouver Island (0.27 ± 0.28), and Strait of Georgia (0.13 ± 0.12). Only one carcass was reported from 155 regular surveys covering 215 km in the Southern Gulf Islands. The high mean carcass density from the Central and Northern Coast is biased by the high densities in few surveys at Egg Island. Carcass density was low in Haida Gwaii/Queen Charlotte Islands, but as explained above, this is not a representative sample for the region. The unweighted mean of all 49 beaches in BC was 0.37 ± SD 0.56 carcasses per km (Table 2).

Species and families of birds found

Sixty-four species of water- and shore-birds from 16 families were represented in the beached carcasses, plus a further 10 species of land birds (Table 3). Waterfowl (ducks and geese), larids (mostly gulls with a few terns and jaegers), and alcids (auks) made up the bulk of the carcasses (19%, 32% and 32% of the BC total, respectively).

Common Murre (22% of BC total) and Glaucous-winged Gull (18%) were by far the most common species among the carcasses (Table 3). Both species occur year-round in BC in a wide range of coastal and offshore habitats. Mallard, Green-winged Teal, Northern Pintail, California Gull, Cassin's Auklet, and Rhinoceros Auklet were the only other species to exceed 2% of the BC total carcass count.

Age classes of carcasses

Age classes could be reliably reported for larids (nearly all were gulls) and alcids. In both families a disproportionately large number of immature birds were found dead (Figure 2). Among larids 44% of carcasses were reported as immatures, including 22% first-year gulls. In the alcids, only immatures in their first year (i.e., juveniles) were separable from adults. First-year alcids made up a minimum of 41% of all the carcasses (some of the juveniles were undoubtedly erroneously reported as adults). A detailed comparison with the age composition of living bird populations was impossible because the local age compositions of the various species are not known.

Most of the immature larids and alcids died in August through October, within a few months of fledging (Figure 2).

Monthly variations in mortality

The monthly counts of carcasses in each family are shown in Table 4. Overall, 79% of the carcasses were found from August through January. Variations among the families is partly due to the migration and breeding schedules (e.g., loons, grebes, and waterfowl are present in large numbers in coastal waters only from late fall through spring; procellariiforms, gulls and alcids are most common in summer and early fall), but there are additional seasonal causes of mortality. Disproportionately more procellariiforms died in November and December when their numbers offshore were lower than in early fall. Mortality of gulls and alcids was exceptionally high after the breeding season in late summer and early fall when many newly-fledged juveniles perished, and adults undergoing moult were also apparently vulnerable (Figure 2).

Annual trends in carcass densities

Sufficient surveys were made in 1986-1995 to analyse annual variations during this decade. Only the West Coast Vancouver Island region was sampled through 1986-1995, and the first three years covered only a single beach (Table 1). Carcass densities in this region showed a significant decline from 1987 through 1995 (Figure 3; Pearson correlation $r = -0.80$, $N = 10$, $P = 0.005$), and this trend persisted when only the well-sampled years 1990-1995 were considered ($r = -0.914$, $N = 6$, $P = 0.011$). None of the other regions showed any significant trends over the years that they were sampled (Figure 3; Pearson correlation, $P>0.05$ in each case). The pooled data for all of BC were dominated by the West Coast Vancouver Island for 1986-1989, but in the pooled data from 1990-1995, when several regions contributed data (Figure 1), there was a significant decline in carcass densities (Figure 3; $r = -0.918$, $N = 6$, $P = 0.010$).

The period 1986-1995 included two significant El Niño events, in 1987 and 1992 as indicated by the Southern Oscillation Index (Figure 4). Sea temperatures at Amphitrite Point (and many other light stations) indicated warmer than average conditions through most of the sample period (related to the longer-term Pacific Decadal Oscillations which maintained generally warm conditions from 1977-1999 for the eastern North Pacific). The 1987 El Niño evidently had a relatively minor effect on sea surface temperatures on the outer coast of BC, but the stronger 1992 El Niño had a noticeable effect on local temperatures (Figure 4). Carcass densities in the beach surveys did not show any obvious effects of the El Niño events (Figure 3). Mean carcass density was somewhat higher in the West Coast Vancouver Island region in 1987, but this was similar to the mean density in 1989, which was a relatively cool year (Figure 4). Mean carcass densities during the strong 1992 El Niño were not higher than other years in any of the regions sampled (Figure 3).

Causes of mortality

Surveyors reported an apparent cause of death for only 24% of all carcasses (Table 5). Of these, 36% were apparently natural causes, dominated by starvation, predation, broken limbs and other obvious injuries, and the effects of severe storms and freezing weather. The remaining 64% of attributed causes were linked with human activities, especially drowning in gillnets, shooting by hunters, and oiling.

There were marked differences in the reported causes of mortality among the regions (Table 5), bird families (Table 6), age classes (Table 7) and seasons (Table 8). Suspected predation was reported from most regions (but most often in White Rock/Boundary Bay) scattered throughout the year, and affected mostly ducks, gulls, and shorebirds. Broken limbs and other injuries were most common among gulls and ducks and many reports came from the Strait of Georgia. Starvation was common among ducks in White Rock/Boundary Bay which was largely due to a prolonged cold period which froze many foraging areas used by waterfowl in this region in January 1993. Starvation was also common among alcids in the West Coast Vancouver Island region, many of which were inexperienced juvenile murres, Rhinoceros Auklets and Cassin's Auklets (see Burger 1993a).

Nearly all gillnet mortality was reported from White Rock/Boundary Bay and restricted to alcids (88 Common Murres and 1 Rhinoceros Auklet), 1 Western Grebe and 1 unidentified duck (Tables 5-8). Most gillnet mortality (87 of the 91 carcasses) was reported between August and October 1993 and was attributed to the salmon gillnet fishery across the US border at that time. Many hundreds of other bird carcasses were removed from the White Rock and Boundary Bay beaches by other people at this time and the beach surveys therefore included only a fraction of the hundreds of carcasses which washed up after that fishery. There were several articles in the local news media about this by-catch killing.

Carcasses showing evidence of shooting were most common on Southern Vancouver Island, Strait of Georgia and White Rock/Boundary Bay (Table 5). As expected, shooting was reported most often for ducks, but also for a surprising number of gulls, shorebirds, and alcids which are not legally game birds (Table 6). Furthermore shooting was not restricted to the normal fall-winter hunting season but was also reported in April, July and August (Table 8).

Occurrence of oiled birds

A total of 39 carcasses from at least 14 species were reported with oiled plumage (Table 9). Oiled birds comprised 12.3% of the 198 carcasses with reported causes of mortality (Table 5). This is undoubtedly an underestimate of the actual number of oiled birds because evidence of oiling might be easily missed in carcasses that had been partly scavenged or were partly decomposed. Most (77%) of the oiled birds were from West Coast Vancouver Island (9 beaches), with 10% each from Southern Vancouver Island (2 beaches) and Strait of Georgia (1 beach), and a single bird (3%) from Langara Island, Haida Gwaii/Queen Charlotte Islands (Table 9). Oiling was the most common cause of death reported for West Coast Vancouver Island and was attributed to 56% of the 54 carcasses with reported causes of death (Table 5). Oiling was responsible for 13% and 12% of carcasses with known causes of death in Southern Vancouver Island and Strait of Georgia, respectively, and was the sole cause of death reported for Haida Gwaii/Queen Charlotte Islands (Table 5). Taking all years into account, the density of oiled birds was highest for West Coast Vancouver Island (0.041 oiled birds per km), followed by Haida Gwaii/Queen Charlotte Islands (0.015), Strait of Georgia (0.010), and Southern Vancouver Island (0.007). All other regions reported no oiled birds and the mean for BC as a whole was 0.014 oiled birds per km.

Alcids (54%) and gulls (28%) made up the bulk of the oiled birds, with two loons and a single grebe, shearwater, cormorant, heron and merganser also reported oiled (Table 9). Most of the oiled birds that had been aged were adults (Table 7). Oiled birds were reported in all months except May, with no obvious seasonal pattern (Table 8).

Oil on the beaches

Surveyors reported evidence of oil on the beaches in 7.8% of all surveys (Table 10). Exceptionally high frequencies of oil (70% of surveys) was reported for Haida Gwaii/Queen Charlotte Islands, but the sample was small (20 surveys on 2 beaches) making it difficult to assess whether this accurately reflects the incidence of oil there. Oil was found on 17% of surveys in the West Coast Vancouver Island region and since this was the most intensely surveyed region, this is probably an accurate reflection of the high incidence of oil on beaches there. All other regions reported fewer than 6% of surveys with oil.

In most cases the oil seen on the beaches was in the form of a few small blobs (54% of the surveys reporting oil) or oily sheen (16% of surveys with oil; Table 10). Oiled birds, either dead and included in the carcass tally, or living and reported separately, were reported on 33 surveys (29% of the surveys with oil) and in most of these cases (27 surveys) the oiled birds were the only evidence of oil in the area.

Annual variations in oiled birds and oil on beaches

Oiled birds were found in 7 of the 12 years included in the analysis and the highest count (18 oiled carcasses) was in 1990. The incidence of oiled birds appears to have declined from the late-1980s through the 1990s (Figure 5), but only data from 1990-1995 were sufficient for statistical analysis. In 1990-1995 the frequency of oiled birds per km declined significantly for West Coast Vancouver Island (Pearson correlation; $r = -0.89$, $N = 6$, $P = 0.019$) but not in the pooled data from other regions ($r = -0.71$, $N = 6$, $P = 0.117$), or in pooled data from all of BC (r = -0.75, N = 6, P = 0.085). The percentages of carcasses reported oiled showed no significant correlations with year in 1990-1995 for any region or for the pooled data from all BC (P>0.05 in each case).

The annual variations in the percentage of surveys reporting oil on beaches fluctuated greatly (Figure 5). The high proportion in the West Coast Vancouver Island region in 1989 is due to the persistence of oil from the very large *Nestucca* oil spill of December 1988. The oiled birds from this catastrophe were not included in the beached bird database, but the oil persisted for many months after the spill in the form of oily blobs and oily sheens seeping through the sand from buried clumps of oil. Apart from the 1989 peak, there does not appear to be any trend across the years in this region. Data from 1990-1995 showed no significant correlation with years for West Coast Vancouver Island, in pooled data from other regions, or in pooled data from all BC surveys (Pearson correlation, P>0.05 in each case).

DISCUSSION

Regional variations in carcass densities and causes of mortality

There were striking differences in the densities of carcasses and types of birds found dead on beaches in the seven regions in BC. The differences in species composition among the regions (Table 3) largely reflect the type of ocean habitat adjacent to the beaches. For example, the pelagic fulmars, shearwaters and storm-petrels were largely restricted to the West Coast Vancouver Island beaches, and gulls and alcids were also common there. Carcasses from the more sheltered waters were dominated by waterfowl, gulls and the ubiquitous Common Murre. The species found in each region were also affected by the factors causing their deaths. Oiling, which affects alcids more than other species is partly responsible for the high alcid counts on the West Coast Vancouver Island beaches. Alcids are also most susceptible among the waterbirds to being caught in gillnets, which partly explains their abundance in the White Rock/Boundary Bay area. Similarly, the high incidence of waterfowl carcasses in that region is a combination of high wintering densities of these birds plus the effects of hunting there.

Densities of carcasses on beaches are affected by winds, currents and waves. Beaches in very protected waters, such as on the Gulf Islands, tend to receive relatively few carcasses even though there might be large populations of wintering birds on the waters nearby. Beaches on more exposed shores such as on the west coast of Vancouver Island receive more debris and carcasses than those in sheltered waters. Ocean currents and upwelling over the continental shelf tend to move surface water (and floating carcasses) seaward during summer off Vancouver Island, whereas winter conditions tend to favour onshore drift (Thomson 1981, Thomson et al. 1989). A more detailed analysis of the seasonal shifts in winds and currents coupled with data on densities and distributions of seabirds in nearby waters would no doubt explain much of the regional variations seen in the beached data, but that was beyond the scope of this analysis.

Densities of carcasses compared with other parts of the world

Carcass densities calculated from the 1986-1997 data did not differ greatly from those reported by Burger (1993a) for the partial data set, although the mean values in most regions were slightly lower than in the earlier analysis. The unweighted mean for all beaches in BC (0.37 ± SD 0.56 carcasses per km, N = 49 beaches) was similar to the mean calculated earlier (0.42 ± SD 0.48, N = 38 beaches; Burger 1993a). Burger (1993a) reviewed comparable data from 14 other parts of the world and showed that carcass densities in BC were among the lowest, matched only by the rates from inland waters in Washington State. This conclusion is supported by the analysis of the complete data set.

The reasons for the low carcass densities on BC beaches are not clear. Populations of seabirds on both sheltered and exposed seas are high. The shelf waters are important foraging areas for very large migrant populations of seabirds, especially in summer and fall (Morgan et al. 1991, Burger 2002). As mentioned above, winds and currents during these seasons might not bring floating carcasses towards shore. Drift-block experiments off southwest Vancouver Island showed that relatively high proportions of blocks released close to shore (1-2 km offshore) came ashore (43% in summer and 53% in winter), but blocks released 35-116 km offshore were seldom found (10% in winter, no data for summer; Hlady and Burger 1993). Additional drift-block experiments and detailed analysis of currents would help to estimate the proportion of carcasses which might come ashore within each region. A series of drift-block experiments done in southern Newfoundland allowed a more refined estimate of seabird mortality at sea and the effects of chronic oiling on the birds (Wiese 2002).

Other factors might partly explain low densities on BC beaches. The large amounts of debris and large logs typically found on BC beaches might obscure some of the carcasses. Scavengers which eat or remove carcasses (including eagles, ravens, coyotes, wolves, dogs) are frequently found on many beaches.

Annual variations, trends and effects of El Niños

Several beaches in BC have now been surveyed for five or more years allowing some preliminary analyses of annual variations. All beaches showed high variability in carcass densities (compare SD with means for each beach in Table 2). This is due to a variety of factors, including the generally low densities and high frequency of surveys with zero carcass counts, seasonal variations, and the variable effects of winds, currents and wave action. This variability for data from each beach makes it difficult to detect significant changes and trends and the current data set are insufficient for detailed statistical treatment. The data do, however, provide a baseline for tracking long-term changes (over a decade or more) if beach surveys are resumed and continued for several years.

The data from 1986-1997 do indicate a decline in carcass densities in the West Coast Vancouver Island region, and there was a statistically significant decline in the 1990-1995 period with intensive sampling. There are several possible explanations for the trend, including reduced mortality rates, reduced local populations, and changes in ocean currents and winds affecting carcass deposition. Resolving these effects with only 5-12 years of data is not feasible. None of the other regions showed any significant increasing or decreasing trends in carcass density.

The beached bird data showed no significant changes in carcass densities during the two El Niño events included in the years sampled. Widespread mortality of seabirds sometimes occurs in the tropical regions during El Niño events (e.g., Schreiber and Schreiber 1984, 1989). In the temperate eastern Pacific the effects are generally more subtle, and restricted to lower colony attendance, fewer breeding attempts, and lower breeding success at colonies (Hodder and Greybill 1985, Bayer 1986, Hatch 1987, Wilson 1991), and the influx of birds typically found in warmer areas (Burger et al. 1998).

The beach survey data analysed here all fell within the "warm" phase of the Pacific Decadal Oscillation which lasted from 1977 to 1999 and had negative effects on several fish-eating seabirds in the northeast Pacific (McGowan et al. 1998, Anderson and Piatt 1999). Continued beached bird surveys in the next decade, during the anticipated "cool" phase of the oscillation should reveal if these processes result in changes in mortality at sea.

Evidence and extent of chronic oiling of seabirds in BC

One of the major reasons for beached bird surveys is to monitor the extent and impacts of chronic oil pollution on seabirds. Routine beach surveys in several countries in Europe, for example, have been instrumental in identifying significant impacts of frequent, low-volume spills of oil, usually from vessels (Camphuysen and Heubeck 2001, Camphuysen and Van Franeker 1992). In some countries, e.g., Germany, the surveys have also revealed a decline in the proportions of oiled birds on beaches resulting from improved policing of oil spills at sea (Camphuysen and Van Franeker 1992). In other situations the beach surveys clearly revealed lack of compliance with existing laws curtailing the release of oil at sea.

Multi-year beached bird surveys, coupled with intensive research and modeling of factors affecting carcass deposition, have revealed that chronic oil spills from vessels kill about 300,000 seabirds each year off southeastern Newfoundland (Wiese and Ryan 1999, Wiese 2002). The cumulative effects of chronic small oil spills might have greater impacts on seabird populations in some areas than the highly publicized large spills (Furness and Monaghan 1986). Wiese's (2002) research indicates that this is clearly true for Newfoundland where the number of birds killed each year by chronic oil spills is similar to the mortality resulting from the *Exxon Valdez* spill in Alaska.

Based on preliminary analysis of beach survey data from BC, Burger (1993a) concluded that rates of oiling (oiled birds per km and percentage of carcasses showing evidence of oiling) were low in BC relative to Newfoundland and most other coastal areas in North America and Europe that had been investigated. The present analysis indicates that the extent of oiling has remained similar to that reported in Burger (1993a), and perhaps declined somewhat on the west coast of Vancouver Island.

Table 11 summarizes data from this study and Wiese (2002) allowing comparisons of carcass deposition rates and extent of oiling on Canada's Atlantic and Pacific coasts. The Newfoundland data covered the period of highest carcass deposition (winter) and the BC data are shown both for the year-round sample and for the period of highest carcass deposition (August-January). There was little difference in the rates of oiling in BC year-round or in August-January. The total rates of all carcasses, deposition rates of oiled carcasses, and percentage of carcasses which were oiled were all considerably higher in Newfoundland than in BC. This might be partly due to differences in the populations of seabirds found off the BC and Newfoundland coasts and the ocean processes bringing seabird carcasses ashore. This requires further investigation.

The main cause for concern in BC is that the percentage of carcasses which were oiled in the West Coast Vancouver Island region was only slightly lower than that of Newfoundland. This BC region also showed the highest frequency of oil on the beaches during surveys among the well-sampled regions (Table 10). There are also hints in the sparse data from Haida Gwaii/Queen Charlotte Islands that there might be somewhat higher incidence of oiling in that region. Perhaps oiling has a greater effect on the exposed open coast, where there are major shipping lanes, less supervision and regulation of shipping, and a greater opportunity for the illegal release of oily bilge water or other sources of oil?

In conclusion, the available data from the beached bird surveys suggests that the problem of chronic oiling affecting seabirds in the 1990s was considerably lower in the sampled beaches in BC than in Newfoundland. Chronic oiling was more prevalent on the outer exposed Pacific coast and this requires more detailed investigation and monitoring. The available beach survey data will be useful for indicating changes in oiling of seabirds if offshore exploration and extraction go ahead, although the areas most likely to be affected on the northern BC coast have not been adequately sampled. Addressing this data gap should be a priority for the beached bird program in the next few years.

RECOMMENDATIONS FOR FUTURE BEACH MONITORING

Given the increased interest in beached bird surveys and oil pollution in BC (see introduction), this seems a timely opportunity to make some suggestions based on the present analysis. The new beached bird survey program run by Bird Studies Canada and the Canadian Wildlife Service was initiated in August 2002 for a two-year period. Most of the procedures used in the new program have been tested in BC and elsewhere and require only fine-tuning. The following are a few suggestions to facilitate continued beached bird surveys and related research and monitoring of the mortality of seabirds and the effects of oil spills.

Details on age of birds are valuable

Many surveyors in the 1990s did not regularly attempt to age the carcasses they found. Aging of gulls using plumage characteristics is relatively easy for experienced birders and feasible for a novice with a field guide willing to take the time. In many species of alcids, juveniles in their first fall and winter can be separated from adults on the basis of smaller body size, plumage differences and other external characteristics (Gaston and Jones 1998). Juvenile Common Murres, for example, have smaller inter-orbital bones (between the eyes) than adults and this feature is evident throughout the first winter. Aging characteristics are given for several seabird species in the beached bird identification guide (Hass and Parrish 2000). For more experienced surveyors, other methods for aging birds are available in the North American Bird Banding Manual (regular updates from Canadian Wildlife Service). These include identifying immature birds from the presence of the Bursa of Fabricius (a fleshy internal sac extending from the cloaca). Presence or absence of the Bursa of Fabricius is routinely reported as an aging character in some European beached bird programs (Camphuysen and Van Franeker 1992).

The advantages of identifying age classes are that the impacts of gillnets, oiling and shooting, that affect adults can be more clearly assessed. Population models of long-lived birds clearly show that factors which affect the survival of adults have potentially greater impacts on bird populations than those that affect immatures (Nur and Sydeman 1999). If the bulk of birds killed by some human activity are adults, the population is likely to decline and take longer to recover than if immature birds are killed.

Even if birds are not reliably aged, surveyors should be encouraged to report a bird as an adult only if they can clearly determine that it is not immature. Otherwise they should report the age as unknown, so that the proportion of adults is not artificially inflated.

Paucity of data from northern BC

The data presented in this report reveal the glaring scarcity of beached bird data from the northern parts of the BC coast. Few sites were surveyed in the 1990s, despite efforts to recruit beach surveyors in some of the remote coastal communities. The new survey program should try to get more beaches surveyed in the more remote areas of northern

BC. Light-keepers in these areas would be particularly valuable as beach surveyors, and efforts are being made to recruit as many as possible into the new program.

The paucity of data from Haida Gwaii/Queen Charlotte Islands, Hecate Strait, Queen Charlotte Strait and surrounding areas is particularly disturbing, because these areas would likely be the most heavily affected by exploration for and extraction of offshore oil. The present data do not provide an adequate baseline for comparisons with conditions that might occur should offshore exploration commence in a few years time. A much larger sample of beaches is needed to take into account the natural variations in all measures of mortality and oil contamination of seabirds.

Improved identification of oiled birds

The presence of oil on the plumage is usually the only evidence that a bird has been in contact with oil. Unfortunately a large proportion of the carcasses encountered on beaches are partly scavenged or decomposed making it difficult to determine the cause of death (Stephen and Burger 1994). The proportion of mortality attributed to oiling was similar in a sample of 140 carcasses examined by beached bird surveyors in southern BC (24% oiled and 4% possibly oiled) and in a sample of 73 carcasses from the same area subjected to detailed necropsy by a veterinarian (19% oiled and 7% possibly oiled; Stephen and Burger 1994). Nevertheless, small quantities of oil on the plumage or ingested by the bird might easily be missed in both types of examination. Research has shown that even a few millilitres of oil on a birds plumage can affect its thermoregulation and if the oil is ingested during preening it can kill the bird or lead to long-term debilitation (Kahn and Ryan 1991, Leighton 1991).

It would therefore be valuable to investigate what proportion of the carcasses reported as un-oiled are in fact contaminated. A sample of carcasses taken from representative beaches could be tested for the presence of hydrocarbons. Sensitive chemical tests, ultraviolet flouresence, and gas chromatography have been used for this purpose using beached birds from the Netherlands, Germany and Denmark (Camphuysen and Van

Franeker 1992). Boersma (1986) suggested that routine testing for hydrocarbons in storm-petrels, which ingest floating bits of oil, might be a useful method for monitoring the presence of oil at sea. Something similar might be done using the carcasses deposited on beaches in BC.

Research on factors affecting carcass deposition

It is not known how representative beached bird surveys are of the occurrence of seabirds in nearby waters, rates and causes of mortality, and occurrence of oil spills. Similarly the effects of currents, tides, and wind on carcass deposition are not well understood. The recent research by Wiese (2002) provided valuable insights into factors affecting carcass depositions and estimates of oiling mortality in southeastern Newfoundland. This work combined routine beached bird surveys, experiments to determine the persistence and detectability of carcasses on beaches, improved design of drift blocks to better mimic floating carcasses, use of these drift blocks to estimate the movements of carcasses at sea and the proportion likely to come ashore, experiments to determine the sinking rates of carcasses at sea, and finally using these parameters in a mathematical model to predict the numbers of birds killed by oil each year. Similar procedures have become routine during the investigation of the impacts of major oil spills, such as the *Apex Houston* (Page et al. 1990), *Nestucca* (Ford et al. 1991, Burger 1993c), and *Exxon Valdez* (Ford et al.1996, Piatt and Ford 1996) oil spills, but had not previously been used to assess rates of chronic oiling of seabirds.

Some preliminary research has been done in BC and adjacent waters, including a drift block study (Hlady and Burger 1993) and experiments to determine persistence of carcasses on beaches and sinking rates of oiled carcasses (Ford et al. 1991, Burger 1992, Burger and Fry 1993). These are probably not sufficient to allow the type of mortality modeling undertaken by Wiese (2002) in Newfoundland, and additional research is needed.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Ainley, D. G., G. W. Page, L. T. Jones, L. E. Stenzel, and R. L. LeValley. 1980. Beached marine birds and mammals of the North American west coast: a manual for their census and identification. U.S. Fish and Wildlife Service Publication No. FWS/OBS -80/03, Department of Interior, Washington, D.C.

Anderson, P. J. and J. F. Piatt. 1999. Community reorganization in the Gulf of Alaska following ocean climate regime shift. Marine Ecology Progress Series 189:117-123.

Bayer, R. D. 1986. Breeding success of seabirds along the Mid-Oregon coast concurrent with the 1983 El Niño. Murrelet 67:23-26.

Boersma, P. D. 1986. Ingestion of petroleum by seabirds can serve as a monitor of water quality. Science 231:373-376.

Burger, A. E. 1992. The effects of oil pollution on seabirds off the west coast of Vancouver Island. Pp. 120-128 *in* The ecology, status and conservation of marine and shoreline birds on the west coast of Vancouver Island (K. Vermeer, R. W. Butler and K. Morgan, eds.). Canadian Wildlife Service Occasional Paper No. 75, Ottawa.

Burger, A. E. 1993a. Mortality of seabirds assessed from beached bird surveys in British Columbia. Canadian Field-Naturalist 107:164-176.

Burger, A. E. 1993b. Estimating the mortality of seabirds following oil spills: effects of spill volume. Marine Pollution Bulletin 26: 140-143.

Burger, A. E. 1993c. Effects of the *Nestucca* oil spill on seabirds along the coast of Vancouver Island in 1989. Technical Report Series No. 179. Canadian Wildlife Service, Pacific and Yukon Region, Delta BC.

Burger, A. E. (ed.) 2002. Distribution and abundance of seabirds off southwest Vancouver Island. Final report to Nestucca Trust Fund, Victoria, BC.

Burger, A. E., J. E. Etzkorn, B. Gisborne and R. Palm. 1998. Influx of Brown Pelicans off southwest Vancouver Island during the 1997 El Niño. Pacific Seabirds **25**: 61-64.

Burger, A. E. and D. M. Fry. 1993. Effects of oil pollution on seabirds in the northeast Pacific. Pp. 254-263 *in* The status, ecology, and conservation of marine birds of the North Pacific (K. Vermeer, K.T. Briggs, K.H. Morgan and D. Siegel-Causey, eds.). Canadian Wildlife Service Special Publication, Ottawa.

Camphuysen, C. J., and M. Heubeck. 2001. Marine oil pollution and beached bird surveys: development of a sensitive monitoring instrument. Environmental Pollution 112:443-461.

Camphuysen, C. J., and J. A. van Franeker. 1992. The value of beached bird surveys in monitoring marine oil pollution. Technisch Rapport Vogelbescherming 10, Zeist, Netherlands.

Ford, R. G. , J. L. Casey, C. H. Hewitt, D. B. Lewis, D. H. Varoujean, D. R. Warrick and W. A. Williams. 1991. Seabird mortality resulting from the *Nestucca* oil spill incident, winter 1988-89. Report for Washington Dept. Wildlife. Ecological Consulting Inc., Portland, Oregon.

Ford, R. G. et al. 1996. Total direct mortality of seabirds from the Exxon Valdez oil spill. American Fisheries Society Symposium 18:684-711.

Furness, R. W., and P. Monaghan. 1986. Seabird ecology. Blackie, Glasgow and London, UK.

Gaston, A. J., and I. L. Jones. 1998. The auks: Alcidae. Oxford University Press, Oxford, UK.

Hass, T., and J. K. Parrish. 2000. Beached birds: a COASST field guide. Wavefall Press, Seattle, WA.

Hatch, S. A. 1987. Did the 1982-1983 El Niño - Southern Oscillation affect seabirds in Alaska? Wilson Bulletin 99: 468-474.

Hlady, D. A. and A. E. Burger. 1993. Drift-block experiments to analyse the mortality of oiled seabirds off Vancouver Island, British Columbia. Marine Pollution Bulletin 26:495-501.

Hodder, J. and M. R. Graybill. 1985. Reproduction and survival of seabirds in Oregon during the 1982-1983 El Niño. Condor 87: 535-541.

Khan, R. A., and P. Ryan. 1991. Long term effects of crude oil on Common Murres (*Uria aalge*) following rehabilitation. Bulletin of Environmental Contamination and Toxicology 46: 216-222.

Leighton, F. A. 1991. The toxicity of petroleum oils to seabirds: an overview. Pp. 43-57 *in* J. White (ed.). The effects of oil on wildlife. Sheridan Press, Hanover, PA.

McGowan, J. A., D. R. Cayan, and L. M. Dorman. 1998. Climate-ocean variability and ecosystem response in the northeast Pacific. Science 281:210-217.

Morgan, K. H, K. Vermeer and R.W. McKelvey. 1991. Atlas of pelagic birds of Western Canada. Occasional Paper No. 72, Canadian Wildlife Service, Ottawa.

Nur, N. and W. J. Sydeman. 1999. Demographic processes and population dynamic models of seabirds. Pp. 149-188 *in* Current Ornithology, Vol. 15 (V. Nolan, E. D. Ketterson, and C. F. Thompson, eds.). Kluwer Academic/Plenum Press, New York.

Page, G. W., H. R. Carter, and R. G. Ford. 1990. Numbers of seabirds killed or debilitated in the 1986 *Apex Houston* oil spill in Central California. Studies in Avian Biology 14:164-174

Piatt, J. F., and R. G. Ford. 1996. How many seabirds were killed by the Exxon Valdez oil spill? American Fisheries Society Symposium 18:712-719.

Rodway, M. S., J. F. Lemon, J.-P. Savard and R. McKelvey. 1989. Nestucca oil spill: impact assessment on avian populations and habitat. Technical Report Series No. 68, Canadian Wildlife Service, Pacific and Yukon Region, Delta, BC.

Schreiber, E. A. and R. W. Schreiber. 1989. Insights into seabird ecology from a global “natural experiment”. National Geographic Research 5:64-81.

Schreiber, R. W. and E. A. Schreiber. 1984. Central Pacific seabirds and the El Niño Southern Oscillation: 1982 to 1983 perspectives. Science 225:713-716.

Stephen, C. and A. E. Burger. 1994. A comparison of two methods for surveying mortality of beached birds in British Columbia. Canadian Veterinary Journal 35:631-635.

Thomson, R. E. 1981. Oceanography of the British Columbia Coast. Canadian Special Publication of Fisheries and Aquatic Sciences No. 56, Ottawa.

Thomson, R. E., B. M. Hickey and P. H. LeBlond. 1989. The Vancouver Island coastal current: fisheries barrier and conduit. Pp. 265-296. *in* Effects of ocean variability on recruitment and an evaluation of parameters used in stock assessment models (R. J. Beamish and G. A. McFarlane, eds.). Canadian Special Publication of Fisheries and Aquatic Sciences No. 108, Ottawa.

Wiese, F. K. 2002. Estimation and impacts of seabird mortality from chronic marine oil pollution off the coast of Newfoundland. PhD thesis, Memorial University of Newfoundland, St. John’s, NF.

Wiese, F. K. and P. C. Ryan. 1999. Trends of chronic oil pollution in southeast Newfoundland assessed through beached-bird surveys, 1984-1997. Bird Trends 7:36-40.

Wilson, U. W. 1991. Responses of three seabird species to El Niño events and other warm episodes on the Washington coast, 1979-1990. Condor 93: 853-858.

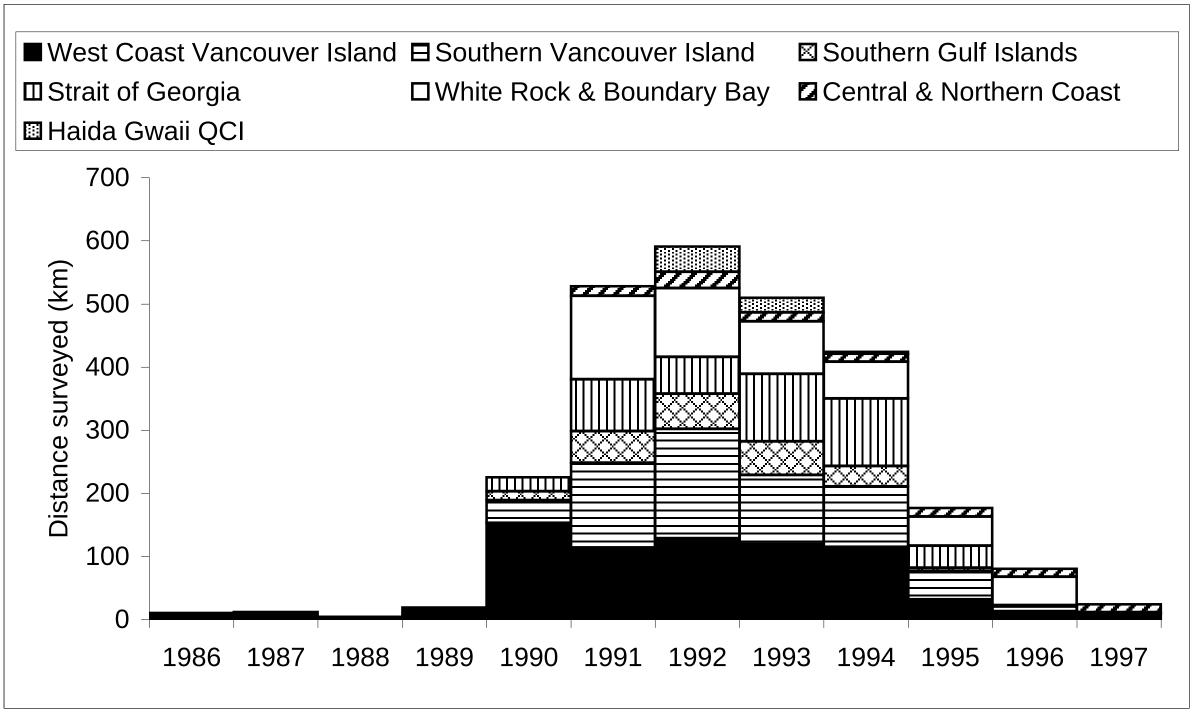

Figure 1. Total length of beach surveys (km) in each year in each region of British Columbia.

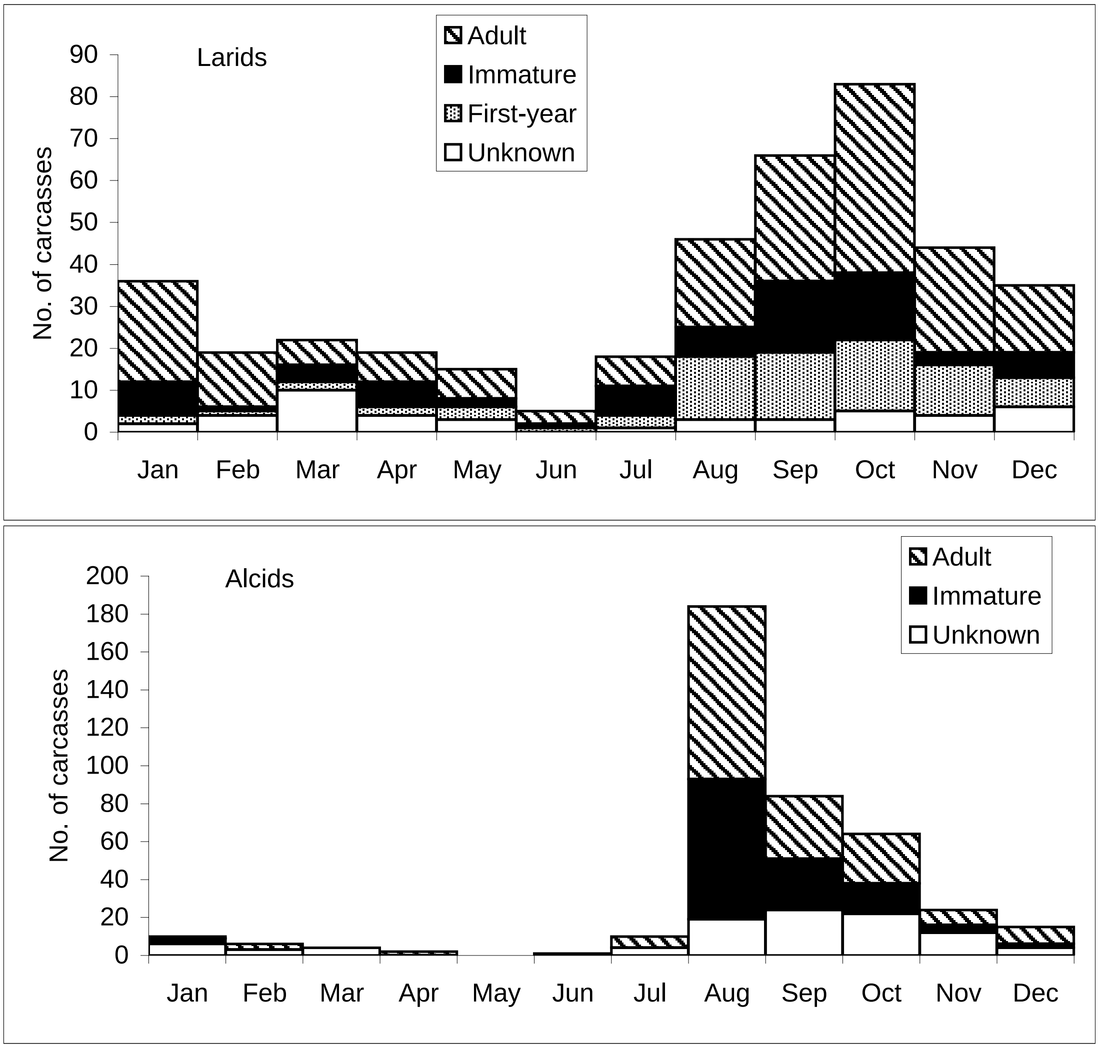

Figure 2. Numbers of larids (gulls, terns and jaegers) and alcids (murres, auklets, guillemots, murrelets and puffins) of each age class found in each month. In both families the proportions of adult birds are probably overestimated because some birds were probably incorrectly aged as adults. In the Larids (nearly all gulls), immature birds included second- and third-year birds, and those classified only as immature and not aged to year.

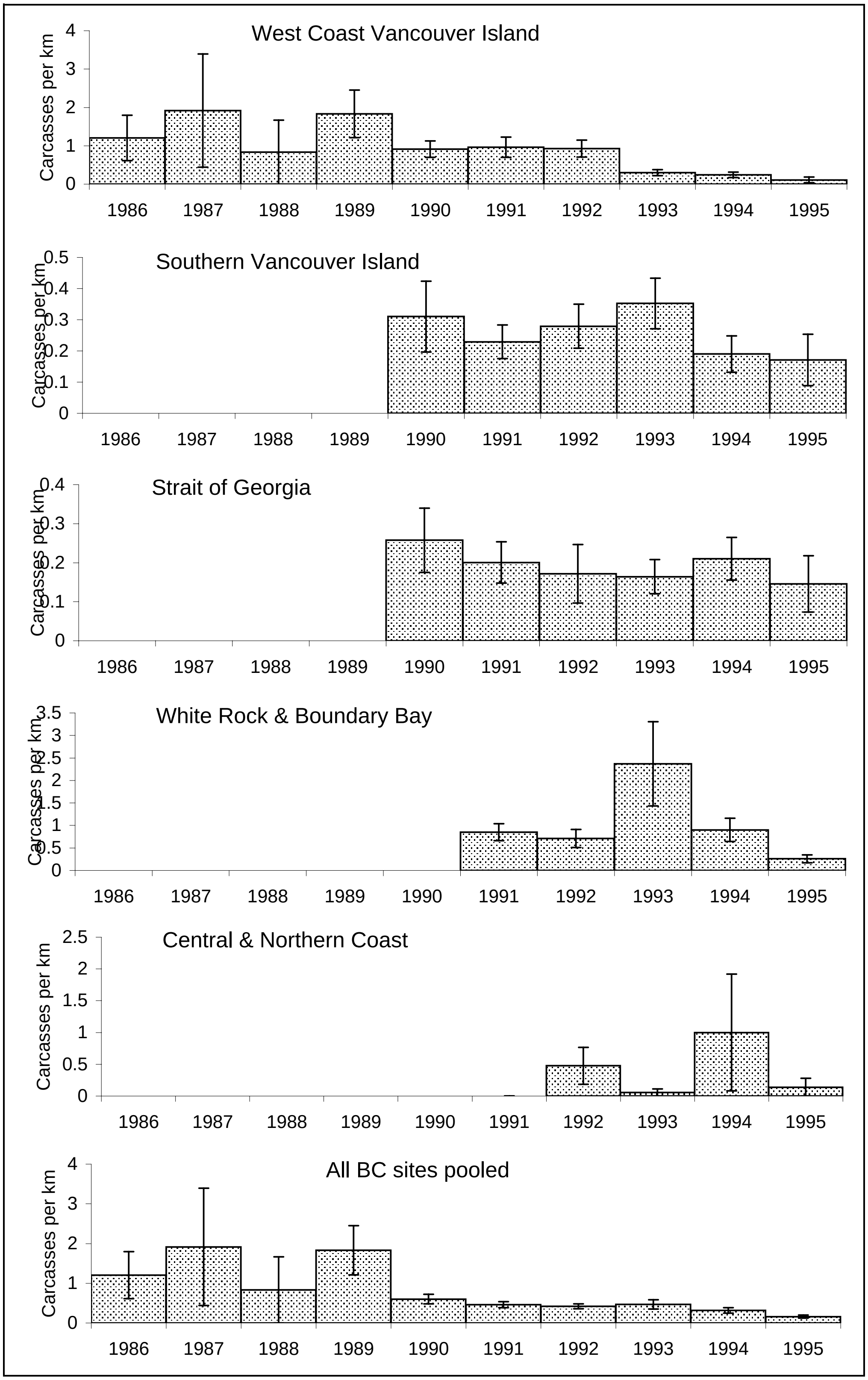

Figure 3. Annual mean (± SE) densities (carcasses per km surveyed) of beached bird carcasses in the various regions and in pooled data from all BC surveys. See Tables 1 and 2 for sample sizes. Note that the y-axis scale varies among the regions.

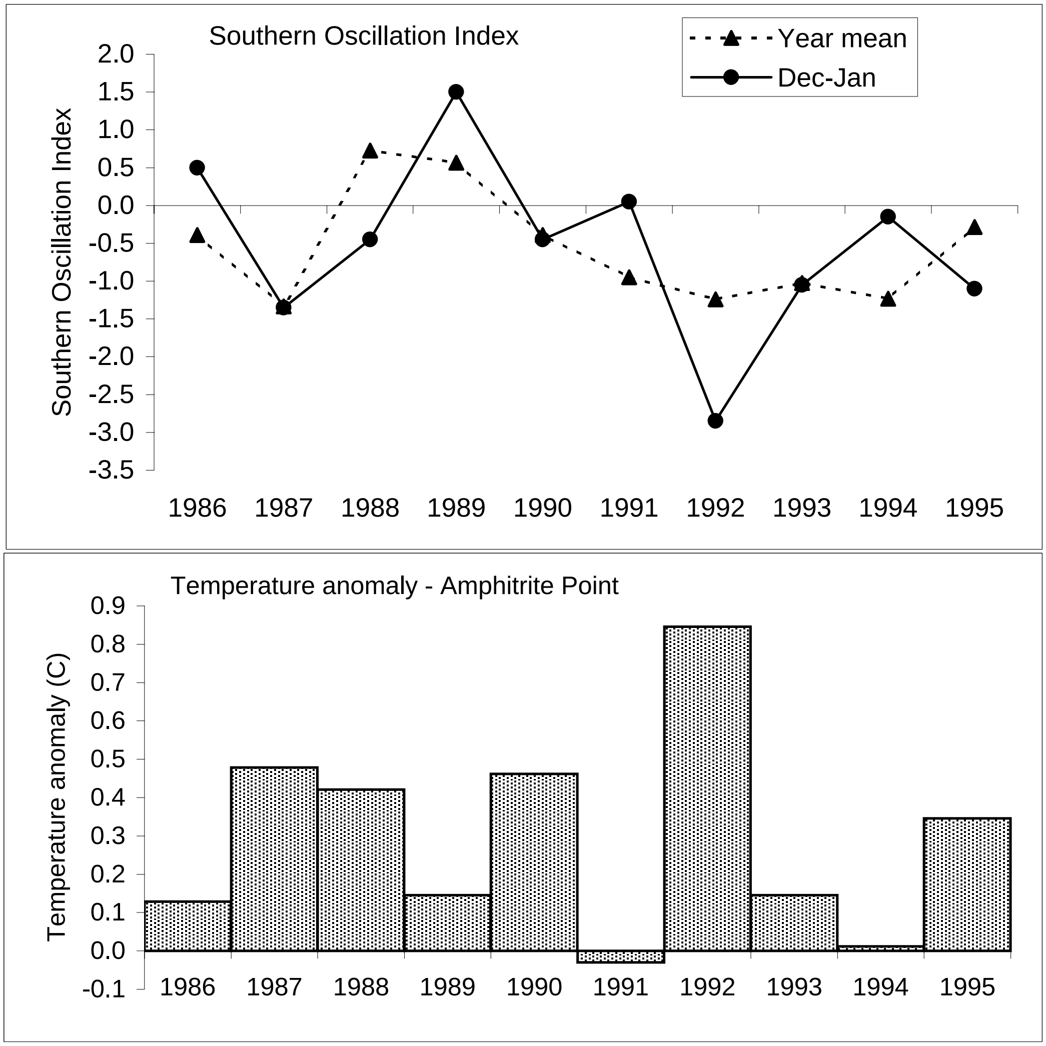

Figure 4. Evidence of El Niño events on the British Columbia coast. The upper graph shows the Southern Oscillation Index, where negative values are indicators of El Niño events. The lower graph shows the temperature anomalies (deviations from the long-term averages) measured at the Amphitrite Point light station on the west coast of Vancouver Island. Positive temperature anomalies indicate warmer than average temperatures. Both sets of data indicate El Niño events in 1987 and 1992.

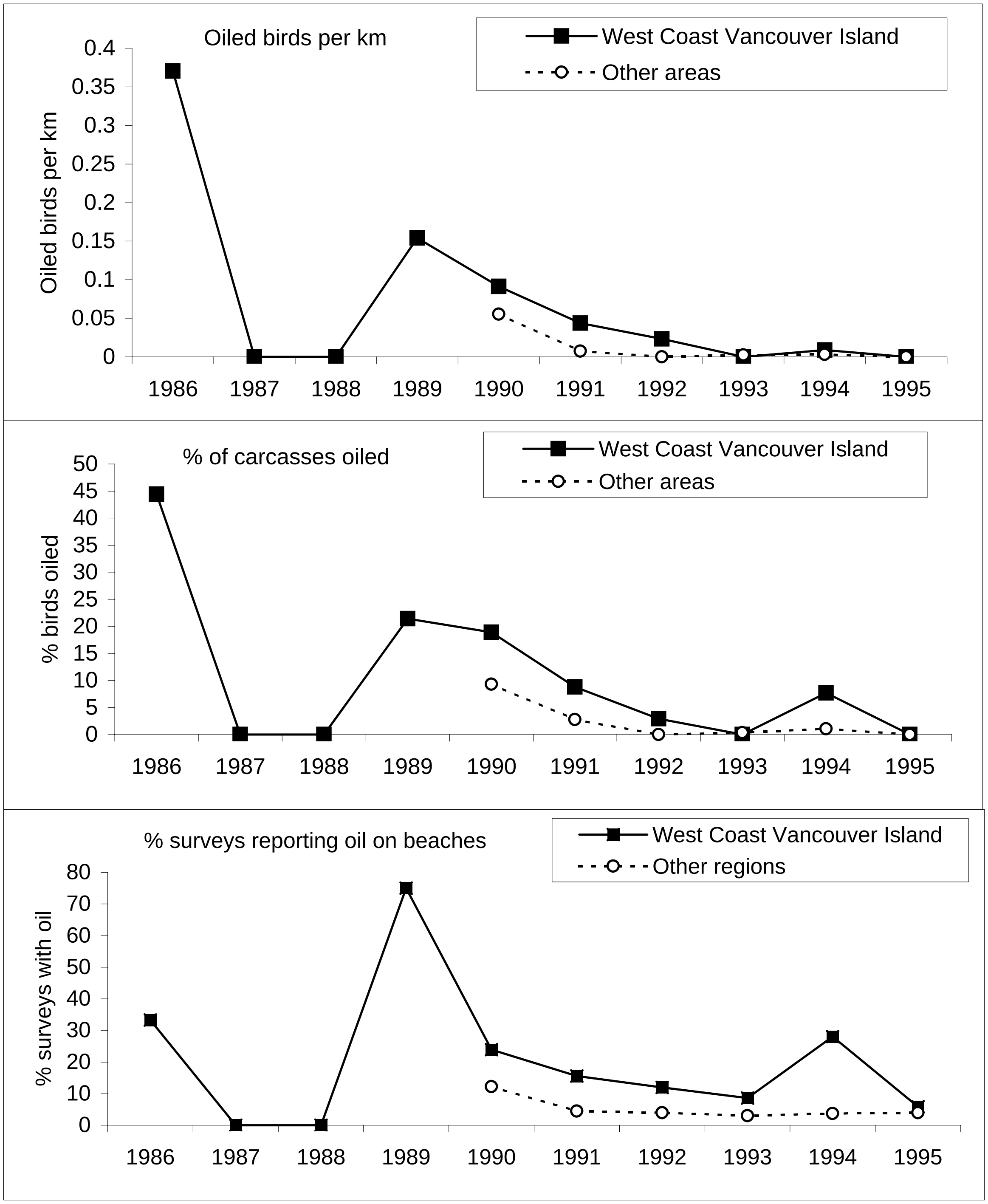

Figure 5. Annual variations in the evidence of oil pollution at sea off the West Coast Vancouver Island and other regions in BC based on beached bird surveys. The upper graph shows the number of oiled birds per km surveyed. The middle graph shows the percentage of carcasses found with obvious oiling. The bottom graph shows the percentage of surveys reporting some form of oil on the beach, including oiled birds, oily sheens, blobs and pancakes.

Table 1. Beaches surveyed in each region and the number of surveys completed in each year.

Region and beach site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total
1. West coast Vancouver Island (WCVI)																
Carmanah Creek						2	12	11	12	6						43
Carmanah Crib Creek						2	12	12	12	8						46
Chestermans, Tofino				1	12	12	12	11	13	1						62
Cox Bay, Tofino					9	12	12	12	12	1						58
Dead End Beach, Pachena Point						8					6	5				19
Experimental Bight, Cape Scott								3	5							8
First Gravel, Cape Scott								1	5							6
Guise Bay, Cape Scott								3	5							8
Long Beach				2	10	5	3	2								22
Michigan Beach, Pachena Point						8					6	3				17
Mile Half Beach, Pachena Point						9					4	4				17
North Beach, Cape Scott								1	5							6
Pachena Beach, Bamfield	9	10	4	1	8	11	12	6	7	1						69
Schooner Cove, Tofino					7	8	12	8	6							41
Total for WCVI	9	10	4	4	46	77	75	70	82	17	16	12				422
2. Southern Vancouver Island (SVI)																
Bazan Bay, Sidney					8	12	11	12	10	2						55
Chatham/Discovery Islands						12	12	11	5							40
China Beach					3	12	11	9	5	10	3					53
Cordova Bay Central						10	12	12	12							46
Cordova Bay North						12	10	12	5							39
French Beach					3	6	3									12
Gordon's Beach					3	4	3									10
Island View Beach						9	11	11	11	9	1					52
Trial Island, Victoria									10	9	3					22
Whiffin Spit Inner					3	6	10	5								24
Whiffin Spit Outer					3	6	10	5								24
Witty's Lagoon/Taylor Beach						1	11									12
Total for SVI					23	90	104	77	58	30	7					389
3.1 Southern Gulf Islands (SGI)																
East Point, Saturna Island						1	12	4								17
Fulford Harbour, Saltspring						4		9	5							18

Table 1 page 2

Region and beach site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total
Hamilton, Pender Island						4	6									10
Medicine, Pender Island						5	11	7		4						27
Menhinick, Saltspring					1	12	10	12	9							44
North Beach, Saltspring					6	10	12	3	5	1	1	1				39
Total SGI					7	36	51	35	19	5	1	1				155
3.2 Strait of Georgia (STG)																
Davis Bay, Sechelt									2	3						5
Mission Point, Sechelt						10	12	11	10	1						44
Mitlenatch Island						3		5								8
Palm Beach, Powell River					4	12	2									18
Sargeants Bay, Sechelt					6	12	7	12	11	6						54
Storries Beach, Campbell River					1	12	2									15
Wace Creek, Mill Bay							10	6								16
Total STG					11	49	33	34	23	10						160
4. White Rock and Boundary Bay (WRBB)																
Boundary Bay West						4										4
White Rock Area 1						9	1									10
White Rock Area 2						10	9	9	6	6	9					49
White Rock Area 4						10	12	9	4							35
White Rock Area 6						7	12	12	12	12	9					64
Total WRBB						40	34	30	22	18	18					162
5. Central and Northern Coast (CNC)																
Egg Island								2	2							4
Green Island						1	12	1								14
Ivory Island						7	9	12	11	12	12	12	12	12	6	105
Total CMC						8	21	15	13	12	12	12	12	12	6	123
6. Haida Gwaii/Queen Charlotte Islands (QCI)																
Langara Island							6	7	1							14
MacIntyre Bay, Massett							6									6
Total QCI							12	7	1							20
Total all areas	9	10	4	4	87	300	330	268	218	92	54	25	12	12	6	1431

Table 2. Summary of distances surveyed, carcasses found and mean carcass density at the surveyed beaches.
The mean carcass density is calculated treating each survey as an independent sample, but the unweighted mean density is calculated from the mean of each site in each area (each site is an independent sample).

Region and beach site	No. of surveys	No. of person-days	Mean distance per survey (km)	Total distance covered (km)	Total carcasses	% surveys with carcasses	Mean (± SD) carcass density (per km)
1. West coast Vancouver Island (WCVI)							
Carmanah Creek	43	55	2.1	90	8	16.3	0.09 ± 0.23
Carmanah Crib Creek	46	65	2.2	102.5	28	19.6	0.25 ± 0.90
Chestermans, Tofino	62	66	1.9	116.4	55	35.5	0.48 ± 0.92
Cox Bay, Tofino	58	61	1.0	57.8	39	27.6	0.68 ± 1.37
Dead End Beach, Pachena Point	19	27	0.5	8.7	4	15.8	0.50 ± 1.30
Experimental Bight, Cape Scott	8	17	1.0	8	0	0.0	0.00 ± 0.00
First Gravel, Cape Scott	6	12	0.5	3	0	0.0	0.00 ± 0.00
Guise Bay, Cape Scott	8	17	1.0	8	0	0.0	0.00 ± 0.00
Long Beach	22	41	7.7	168.4	149	72.7	0.84 ± 1.45
Michigan Beach, Pachena Point	17	21	1.0	17	1	5.9	0.06 ± 0.24
Mile Half Beach, Pachena Point	17	23	1.0	17	3	5.9	0.18 ± 0.73
North Beach, Cape Scott	6	15	0.5	3	1	16.7	0.00 ± 0.00
Pachena Beach, Bamfield	69	101	1.2	82.8	128	46.4	1.69 ± 2.97
Schooner Cove, Tofino	41	48	1.2	50.1	31	29.3	1.11 ± 2.54
All beaches WCVI	422	569	1.7	732.7	447	28.4	0.66 ± 1.73
[Unweighted mean ± SD, n = 14 sites]							[0.42 ± 0.51]
2. Southern Vancouver Island (SVI)							
Bazan Bay, Sidney	55	58	2.5	137	22	30.9	0.16 ± 0.27
Chatham/Discovery Islands	40	41	1.0	40	0	0.0	0.00 ± 0.00
China Beach	53	70	1.1	59.5	4	3.8	0.07 ± 0.42
Cordova Bay Central	46	70	1.3	58	18	23.9	0.33 ± 0.66
Cordova Bay North	39	39	1.6	61.8	9	20.5	0.13 ± 0.27
French Beach	12	17	1.5	17.5	1	8.3	0.06 ± 0.19
Gordon's Beach	10	13	0.6	6	1	10.0	0.20 ± 0.63
Island View Beach	52	52	1.7	89	37	42.3	0.44 ± 0.73
Trial Island, Victoria	22	27	1.0	22	5	22.7	0.23 ± 0.43
Whiffin Spit Inner	24	33	1.4	33.6	34	79.2	1.05 ± 1.00
Whiffin Spit Outer	24	34	1.1	26.4	12	29.2	0.45 ± 1.00
Witty's Lagoon/Taylor Beach	12	18	4.2	50.5	8	33.3	0.16 ± 0.29
All beaches SVI	389	472	1.5	601.3	151	24.9	0.26 ± 0.60
[Unweighted mean ± SD, n = 12 sites]							[0.27 ± 0.28]
3.1 Southern Gulf Islands (SGI)							
East Point, Saturna Island	17	21	0.9	16	0	0.0	0.00 ± 0.00
Fulford Harbour, Saltspring	18	18	1.7	30.5	0	0.0	0.00 ± 0.00
Hamilton, Pender Island	10	18	0.5	5	0	0.0	0.00 ± 0.00
Medicine, Pender Island	27	40	0.8	21.6	0	0.0	0.00 ± 0.00
Menhinick, Saltspring	44	44	2.0	88	0	0.0	0.00 ± 0.00
North Beach, Saltspring	39	39	1.4	54	1	2.6	0.01 ± 0.08

Region and beach site	No. of surveys	No. of person-days	Mean distance per survey (km)	Total distance covered (km)	Total carcasses	% surveys with carcasses	Mean (± SD) carcass density (per km)
All beaches SGI	155	180	1.4	215.1	1	0.6	0.00 ± 0.04
[Unweighted mean ± SD, n = 6 sites]							[0.003 ± 0.008]
3.2 Strait of Georgia (STG)							
Davis Bay, Sechelt	5	38	3.0	15	0	0.0	0.00 ± 0.00
Mission Point, Sechelt	44	72	3.3	143	26	40.9	0.26 ± 0.44
Mitlenatch Island	8	8	2.5	20	3	25.0	0.19 ± 0.37
Palm Beach, Powell River	18	21	0.9	16.6	0	0.0	0.00 ± 0.00
Sargeants Bay, Sechelt	54	54	3.0	161	44	55.6	0.27 ± 0.30
Storries Beach, Campbell River	15	31	1.6	23.5	0	0.0	0.00 ± 0.00
Wace Creek, Mill Bay	16	60	2.0	32	5	25.0	0.16 ± 0.30
All beaches STG	160	284	2.6	411.1	78	33.8	0.19 ± 0.33
[Unweighted mean ± SD, n = 7 sites]							[0.13 ± 0.12]
4. White Rock and Boundary Bay (WRBB)							
Boundary Bay West	4	4	4.0	16	18	25.0	1.13 ± 2.25
White Rock Area 1	10	20	3.0	30	4	20.0	0.07 ± 0.16
White Rock Area 2	49	85	3.4	165.4	182	59.2	1.11 ± 3.70
White Rock Area 4	35	41	3.0	106.7	63	51.4	0.70 ± 2.12
White Rock Area 6	64	126	2.4	155.7	190	56.3	1.12 ± 1.55
All beaches WRBB	162	276	2.9	473.8	457	53.1	0.96 ± 2.48
[Unweighted mean ± SD, n = 5 sites]							[0.82 ± 0.46]
5. Central and Northern Coast (CNC)							
Egg Island	4	9	0.3	1	3	25.0	3.00 ± 6.00
Green Island	14	14	1.0	14	10	35.7	0.71 ± 1.59
Ivory Island	105	125	1.2	124.8	5	2.9	0.03 ± 0.20
All beaches CNC	123	148	1.1	139.8	18	7.3	0.21 ± 1.23
[Unweighted mean ± SD, n = 3 sites]							[1.25 ± 1.55]
6. Haida Gwaii/Queen Charlotte Islands (QCI)							
Langara Island	14	31	3.2	45.4	2	14.3	0.05 ± 0.12
MacIntyre Bay, Massett	6	7	3.5	21	0	0.0	0.00 ± 0.00
All beaches QCI	20	38	3.3	66.4	2	10.0	0.03 ± 0.10
[Unweighted mean ± SD, n = 2 sites]							[0.02 ± 0.03]
All beaches in BC	1431	1967	1.8	2640.2	1154	25.8	0.41 ± 1.38
[Unweighted mean ± SD, n = 49 sites]							[0.37 ± 0.56]

Table 3. Number of carcasses of each species and family found in beached bird surveys in British Columbia, 1987-2000.

		Region*								% of BC
Family and species		WCVI	SVI	SGI	STG	WRBB	CNC	QCI	All areas	total
Loons - Gaviidae										
Red-throated Loon	*Gavia stellata*	0	0	0	0	2	0	0	2	0.2
Pacific Loon	*Gavia pacifica*	4	1	0	0	1	0	0	6	0.5
Common Loon	*Gavia immer*	1	5	0	0	11	0	0	17	1.3
Unspecified loon		0	1	0	0	1	0	0	2	0.2
Total loons		*5*	*7*	*0*	*0*	*15*	*0*	*0*	*27*	*2.1*
Grebes - Podicipedidae										
Horned Grebe	*Podiceps auritus*	0	7	0	1	8	0	0	16	1.3
Eared Grebe	*Podiceps nigricollis*	0	1	0	0	1	0	0	2	0.2
Red-necked Grebe	*Podiceps grisegena*	1	5	0	0	2	0	0	8	0.6
Western Grebe	*Aechmophorus occidentalis*	4	2	0	1	15	0	0	22	1.7
Unspecified grebe		0	0	0	0	2	0	0	2	0.2
Total grebes		*5*	*15*	*0*	*2*	*28*	*0*	*0*	*50*	*4.0*
Petrels & Shearwaters - Procellariidae and Hydrobatidae										
Northern Fulmar	*Fulmarus glacialis*	23	1	0	0	0	0	0	24	1.9
Sooty Shearwater	*Puffinus griseus*	5	0	0	0	0	0	0	5	0.4
Short-tailed Shearwater	*Puffinus tenuirostris*	1	0	0	0	0	0	0	1	0.1
Unspecified shearwater		0	0	0	0	0	1	0	1	0.1
Fork-tailed Storm-petrel	*Oceanodroma furcata*	1	0	0	0	0	0	0	1	0.1
Unspecified procellariiform		1	0	0	0	0	0	0	1	0.1
Total procellariiforms		*31*	*1*	*0*	*0*	*0*	*1*	*0*	*33*	*2.6*
Cormorants - Phalacrocoracidae										
Double-crested Cormorant	*Phalacrocorax auritus*	1	1	0	0	1	0	0	3	0.2
Brant's Cormorant	*Phalacrocorax penicillatus*	9	1	0	0	0	0	0	10	0.8
Pelagic Cormorant	*Phalacrocorax pelagicus*	6	1	0	0	0	0	0	7	0.6
Unspecified cormorant		8	0	0	1	2	0	0	11	0.9
Total cormorants		*24*	*3*	*0*	*1*	*3*	*0*	*0*	*31*	*2.5*
Herons - Ardeidae										
Great-blue Heron	*Ardea herodias*	1	2	0	5	3	0	0	11	0.9
Total herons		*1*	*2*	*0*	*5*	*3*	*0*	*0*	*11*	*0.9*
Waterfowl - Anatidae										
Trumpeter Swan	*Cygnus buccinator*	1	0	0	0	0	0	0	1	0.1
Mute Swan	*Cygnus olor*	0	0	0	1	0	0	0	1	0.1
Brant	*Branta bernicla*	0	0	0	0	0	2	0	2	0.2
Canada Goose	*Branta canadensis*	0	1	0	7	2	0	0	10	0.8
Domestic goose	*Anser anser*	0	1	0	0	0	0	0	1	0.1
Green-winged Teal	*Anas crecca*	0	0	0	0	43	0	0	43	3.4
Mallard	*Anas platyrhynchos*	0	6	0	17	24	0	0	47	3.7
Northern Pintail	*Anas acuta*	0	0	0	0	33	0	0	33	2.6
Eurasian Wigeon	*Anas penelope*	0	0	0	0	1	0	0	1	0.1
American Wigeon	*Anas americana*	0	4	0	0	4	0	0	8	0.6

Family and species		Region* WCVI	SVI	SGI	STG	WRBB	CNC	QCI	All areas	% of BC total
Greater Scaup	*Aythya marila*	0	0	0	0	9	0	0	9	0.7
Lesser Scaup	*Aythya affinis*	0	0	0	0	2	0	0	2	0.2
Unspecified scaup		0	0	0	0	2	0	0	2	0.2
Long-tailed Duck	*Clangula hyemalis*	0	1	0	0	0	0	0	1	0.1
Surf Scoter	*Melanitta perspicillata*	5	2	0	0	5	0	0	12	1.0
White-winged Scoter	*Melanitta fusca*	1	8	1	0	12	0	0	22	1.7
Unspecified scoter		0	1	0	0	6	0	0	7	0.6
Unspecified Goldeneye	*Bucephala sp.*	0	1	0	2	1	0	0	4	0.3
Bufflehead	*Bucephala albeola*	1	12	0	1	8	0	0	22	1.7
Common Merganser	*Mergus merganser*	0	1	0	0	1	0	0	2	0.2
Red-breasted Merganser	*Mergus serrator*	0	2	0	0	0	0	0	2	0.2
Unspecified merganser		0	0	0	1	0	0	0	1	0.1
Ruddy Duck	*Oxyura jamaicensis*	0	1	0	0	2	0	0	3	0.2
Unspecified duck		2	0	0	1	1	0	0	4	0.3
Total waterfowl		*10*	*41*	*1*	*30*	*156*	*2*	*0*	*240*	*19.0*
Raptors - Accipitridae										
Bald Eagle	*Haliaeetus leucocephalus*	0	0	0	0	0	1	0	1	0.1
Cooper's Hawk	*Accipiter cooperi*	0	0	0	0	1	0	0	1	0.1
Total raptors		*0*	*0*	*0*	*0*	*1*	*1*	*0*	*2*	*0.2*
Rails - Rallidae										
American Coot	*Fulica americana*	0	1	0	0	0	0	0	1	0.1
Total rails		*0*	*1*	*0*	*0*	*0*	*0*	*0*	*1*	*0.1*
Shorebirds - Haematopodidae, Charadriidae and Scolopacidae										
Black-bellied Plover	*Pluvialis squatarola*	0	0	0	0	3	0	0	3	0.2
Black Oystercatcher	*Haematopus bachmani*	0	0	0	0	0	1	0	1	0.1
Surfbird	*Aphriza virgata*	2	0	0	0	0	0	0	2	0.2
Semipalmated Sandpiper	*Calidris pusilla*	0	0	0	0	1	0	0	1	0.1
Western Sandpiper	*Calidris mauri*	0	0	0	0	1	0	0	1	0.1
Dunlin	*Calidris alpina*	0	0	0	0	4	0	0	4	0.3
Long-billed Dowitcher	*Limnodromus scolopaceus*	0	0	0	0	1	0	0	1	0.1
Red-necked Phalarope	*Phalaropus lobatus*	1	0	0	0	0	0	0	1	0.1
Red Phalarope	*Phalaropus fulicaria*	1	0	0	0	0	0	0	1	0.1
Unspecified shorebird		1	0	0	0	0	0	0	1	0.1
Total shorebirds		*5*	*0*	*0*	*0*	*10*	*1*	*0*	*16*	*1.3*
Laridae - Gulls, Jaegers and Terns										
Parasitic Jaeger	*Stercorarius parasiticus*	1	0	0	0	0	0	0	1	0.1
Heermann's Gull	*Larus heermanni*	1	0	0	0	0	0	0	1	0.1
Mew Gull	*Larus canus*	4	2	0	0	3	0	0	9	0.7
Ring-billed Gull	*Larus delawarensis*	1	0	0	0	11	0	0	12	1.0
California Gull	*Larus californicus*	42	3	0	2	0	0	0	47	3.7
Herring Gull	*Larus argentatus*	8	0	0	2	1	0	0	11	0.9
Thayer's Gull	*Larus thayeri*	3	0	0	2	2	0	0	7	0.6
Western Gull	*Larus occidentalis*	2	0	0	0	0	0	0	2	0.2

Family and species		WCVI	SVI	SGI	STG	WRBB	CNC	QCI	All areas	% of BC total
		Region*								
Glaucous-winged Gull	*Larus glaucescens*	49	42	0	13	118	7	0	229	18.2
Glaucous-winged x Western Gull hybrid		0	0	0	0	3	0	0	3	0.2
Black-legged Kittiwake	*Rissa tridactyla*	2	0	0	0	0	0	0	2	0.2
Unspecified gull		27	4	0	25	25	1	0	82	6.5
Common Tern	*Sterna hirundo*	0	0	0	0	2	0	0	2	0.2
Total larids		*140*	*51*	*0*	*44*	*165*	*8*	*0*	*408*	*32.4*
Alcidae - alcids or auks										
Common Murre	*Uria aalge*	127	38	0	1	113	0	0	279	22.1
Pigeon Guillemot	*Cepphus columba*	0	6	0	0	1	0	0	7	0.6
Marbled Murrelet	*Brachyramphus marmoratus*	4	1	0	0	2	0	0	7	0.6
Ancient Murrelet	*Synthliboramphus antiquus*	2	0	0	0	0	0	1	3	0.2
Cassin's Auklet	*Ptychoramphus aleuticus*	34	0	0	0	0	0	0	34	2.7
Rhinoceros Auklet	*Cerorhinca monocerata*	50	10	0	0	2	1	0	63	5.0
Tufted Puffin	*Fratercula cirrhata*	4	0	0	0	0	0	0	4	0.3
Unspecified alcids		7	0	0	0	0	0	0	7	0.6
Total alcids		*228*	*55*	*0*	*1*	*118*	*1*	*1*	*404*	*32.1*
Owls - Strigiformes										
Barn owl	*Tyto alba*	0	0	0	0	1	0	0	1	0.1
Northern Saw-whet Owl	*Aegolius acadicus*	2	0	0	0	0	0	0	2	0.2
Snowy Owl	*Nyctea scandiaca*	0	0	0	0	0	1	0	1	0.1
Total owls		*2*	*0*	*0*	*0*	*1*	*1*	*0*	*4*	*0.3*
Other birds										
Rock Dove	*Columba livia*	0	0	0	0	1	0	0	1	0.1
Belted Kingfisher	*Ceryle alcydon*	0	1	0	2	0	0	0	3	0.2
Northern Flicker	*Colaptes auratus*	0	0	0	0	1	0	0	1	0.1
Common Raven	*Corvus corax*	0	1	0	0	0	0	0	1	0.1
Northwestern Crow	*Corvus caurinus*	1	3	0	1	1	0	0	6	0.5
European Starling	*Sturnus vulgaris*	0	0	0	0	1	0	0	1	0.1
Total other birds		*1*	*5*	*0*	*3*	*4*	*0*	*0*	*13*	*1.0*
Unidentified birds		8	4	0	0	4	4	0	20	*1.6*
Total all birds		**460**	**185**	**1**	**86**	**508**	**19**	**1**	**1260**	**100.0**

* Region codes: WCVI - West Coast Vancouver Island; SVI - Southern Vancouver Island; SGI - Southern Gulf Islands; STG - Strait of Georgia; WRBB - White Rock and Boundary Bay; CNC - Central and Northern Coast: QCI - Haida Gwaii/ Queen Charlotte Islands.

Table 4. Number of carcasses in each family found in each month in beached bird surveys.

Family	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Loons	4	5	2	5	3	0	0	1	2	2	1	2	27
Grebes	6	6	2	7	3	0	0	0	5	7	6	8	50
Procellariiforms	2	0	0	0	1	1	2	2	0	1	18	6	33
Cormorants	1	3	2	0	4	2	1	5	3	5	4	1	31
Herons	2	0	0	0	1	0	0	2	0	2	3	1	11
Waterfowl	75	23	11	14	5	3	9	10	6	20	38	26	240
Shorebirds	3	0	0	0	2	0	0	2	1	3	1	4	16
Larids	36	19	22	19	15	5	18	46	66	83	44	35	408
Alcids	10	6	4	2	0	1	10	184	84	64	24	15	404
Other birds	2	1	11	2	2	1	5	4	4	1	2	5	40
Total	141	63	54	49	36	13	45	256	171	188	141	103	1260
% of total	11.2	5.0	4.3	3.9	2.9	1.0	3.6	20.3	13.6	14.9	11.2	8.2	100

Table 5. Apparent causes of death of beached birds found in each region in BC.

Cause of death reported	West Coast Vancouver Island	Southern Vancouver Island	Southern Gulf Islands	Strait of Georgia	White Rock & Boundary Bay	Central & Northern Coast	Haida Gwaii QCI	Total	% of known causes
Apparently natural causes									
Avian pox disease	0	1	0	0	0	0	0	1	0.3
Choked by fish	0	0	0	0	1	0	0	1	0.3
Broken limbs and other injuries	2	0	0	9	1	0	0	12	3.9
Suspected predation	3	3	0	1	14	7	0	28	9.0
Starved	12	3	0	0	44	0	0	59	19.0
Effects of severe storms	4	5	0	2	0	0	0	11	3.5
Total natural causes	21	12	0	12	60	7	0	112	36.1
% of known causes for the region	38.9	37.5	-	36.4	33.0	87.5	0.0	36.1	
Related to human activities									
Collision with cable	0	0	0	0	0	1	0	1	0.3
Likely drowned in gillnet	0	0	0	1	90	0	0	91	29.4
Entangled in fishing gear or hooked	1	2	0	4	2	0	0	9	2.9
Oiled	30	4	0	4	0	0	1	38	12.3
Poisoned	0	0	0	1	0	0	0	1	0.3
Predation by dog	0	0	0	4	0	0	0	4	1.3
Shot by hunters	2	14	0	6	30	0	0	52	16.8
Slingshot	0	0	0	1	0	0	0	1	0.3
Total human related causes	33	20	0	21	122	1	1	198	63.9
% of known causes for the region	61.1	62.5	-	63.6	67.0	12.5	100	63.9	
Total known causes	54	32	0	33	182	8	1	310	100
Unknown causes	406	153	1	53	326	11	0	950	-
Total	460	185	1	86	508	19	1	1260	-

Table 6. Apparent causes of death reported by beach surveyors in British Columbia, broken down by bird family using pooled data from all surveys in BC.

Cause of death reported	Loons	Grebes	Procell-ariiforms	Cormorants	Herons	Anatids	Shorebirds	Larids	Alcids	Other birds*	Unknown	Total all birds	% of known causes
Apparently natural causes													
Avian pox disease	0	0	0	0	0	0	0	0	1	0	0	1	0.3
Choked by fish	0	0	0	1	0	0	0	0	0	0	0	1	0.3
Broken limbs and other injuries	1	0	1	0	1	3	0	6	0	0	0	12	3.9
Suspected predation	1	1	2	0	0	8	4	9	0	3	0	28	9.0
Starvation	0	1	0	0	0	43	0	3	12	0	0	59	19.0
Effects of severe storms	0	2	2	1	0	3	0	2	1	0	0	11	3.5
Total natural causes	2	4	5	2	1	57	4	20	14	3	0	112	36.1
Related to human activities	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Collision with cable	0	0	0	0	0	1	0	0	0	0	0	1	0.3
Likely drowned in gillnet	0	1	0	0	0	1	0	0	89	0	0	91	29.4
Entangled in fishing gear or hooked	1	1	0	0	1	1	0	4	1	0	0	9	2.9
Oiled	2	1	1	1	1	1	0	11	21	0	0	39	12.6
Poisoned	0	0	0	0	0	1	0	0	0	0	0	1	0.3
Predation by dog	0	0	0	0	0	4	0	0	0	0	0	4	1.3
Shot by hunters	1	1	0	0	0	23	3	12	11	1	0	52	16.8
Slingshot	0	0	0	0	0	0	0	1	0	0	0	1	0.3
Total human related causes	4	4	1	1	2	32	3	28	122	1	0	198	63.9
Unknown causes	21	42	27	28	8	151	9	360	268	16	20	950	-
Total	27	50	33	31	11	240	16	408	404	20	20	1260	-

* Includes 1 pigeon, 1 owl and 1 Belted Kingfisher apparently killed by predators, and 1 woodpecker apparently shot.

Table 7. Age and apparent cause of death in beached birds, broken down by bird family, using pooled data from all BC.

		Apparently natural causes of mortality						Apparently human-related mortality							
Family	Age	Predation	Injury	Starved	Storm	Other natural	Total natural	Gillnet	Fishing gear	Oiled	Shot	Other human	Total human	Cause of death unknown	Total all carcasses
Loons	Adult		1				1			1			1	8	10
	Immature	1					1						0	1	2
	Unknown						0		1	1	1	0	3	12	15
	Total loons	*1*	*1*	*0*	*0*	*0*	*2*	*0*	*1*	*2*	*1*	*0*	*4*	*21*	*27*
Grebes	Adult			1	1		2			1			1	25	28
	Unknown	1			1		2	1	1		1		3	17	22
	Total grebes	*1*	*0*	*1*	*2*	*0*	*4*	*1*	*1*	*1*	*1*	*0*	*4*	*42*	*50*
Procellariiforms	Adult	2			1		3						0	5	8
	Immature						0						0	1	1
	Unknown		1		1		2			1			1	21	24
	Total procellariiforms	*2*	*1*	*0*	*2*	*0*	*5*	*0*	*0*	*1*	*0*	*0*	*1*	*27*	*33*
Cormorants	Adult				1	1	2						0	11	13
	Immature						0						0	2	2
	Unknown						0			1			1	15	16
	Total cormorants	*0*	*0*	*0*	*1*	*1*	*2*	*0*	*0*	*1*	*0*	*0*	*1*	*28*	*31*
Herons	Adult						0						0	1	1
	Immature						0						0	1	1
	Unknown		1				1		1	1			2	6	9
	Total herons	*0*	*1*	*0*	*0*	*0*	*1*	*0*	*1*	*1*	*0*	*0*	*2*	*8*	*11*
Waterfowl	Adult	8	2	25			35			1	15	3	19	84	138
	Immature		1				1				1	2	3	7	11
	Unknown			18	3		21	1	1		7	1	10	60	91
	Total waterfowl	*8*	*3*	*43*	*3*	*0*	*57*	*1*	*1*	*1*	*23*	*6*	*32*	*151*	*240*
Shorebirds	Adult						0				3		3	3	6
	Immature						0						0	1	1
	Unknown	4					4						0	5	9
	Total shorebirds	*4*	*0*	*0*	*0*	*0*	*4*	*0*	*0*	*0*	*3*	*0*	*3*	*9*	*16*
Larids	Adult	3	1	1			5		1	4	7	1	13	186	204
	First year	6	1	1			8		1	2	1		4	69	81
	Immature		1	1			2		2		2		4	47	53
	Second year		1				1				1		1	15	17
	Third year						0			3			3	5	8
	Unknown		2		2		4			2	1		3	38	45
	Total larids	*9*	*6*	*3*	*2*	*0*	*20*	*0*	*4*	*11*	*12*	*1*	*28*	*360*	*408*
Alcids	Adult			9	1		10	88		12			100	69	179
	Immature			3		1	4	1		4	4		9	113	126
	Unknown						0		1	5	7		13	86	99
	Total alcids	*0*	*0*	*12*	*1*	*1*	*14*	*89*	*1*	*21*	*11*	*0*	*122*	*268*	*404*

Table 8. Monthly variations in the reported causes of mortality for beached carcasses in BC. Data from all regions were pooled in this analysis.

Cause of death	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Apparently natural causes													
Predation	3	5	2	0	2	1	0	1	7	0	2	5	28
Injury	1	0	0	0	1	0	2	3	0	1	2	2	12
Starved	44	0	0	0	0	0	0	4	8	1	1	1	59
Storm	1	1	0	0	0	0	0	0	1	0	3	5	11
Other natural causes	0	0	1	0	0	0	0	1	0	0	0	0	2
Total natural causes	49	6	3	0	3	1	2	9	16	2	8	13	112
% natural causes	43.8	5.4	2.7	0.0	2.7	0.9	1.8	8.0	14.3	1.8	7.1	11.6	100
Related to human activities													
Gillnets	0	0	0	1	0	0	0	71	15	4	0	0	91
Other fishing gear	0	0	0	0	0	0	1	1	3	0	3	1	9
Oiled	2	1	9	4	0	2	1	7	1	3	2	7	39
Shot	8	3	0	3	0	0	1	12	0	17	6	2	52
Other human	1	0	1	0	0	0	3	1	0	1	0	0	7
Total human causes	11	4	10	8	0	2	6	92	19	25	11	10	198
% human causes	5.6	2.0	5.1	4.0	0.0	1.0	3.0	46.5	9.6	12.6	5.6	5.1	100
Unknown causes	81	53	41	41	33	10	37	155	136	161	122	80	950
Total	141	63	54	49	36	13	45	256	171	188	141	103	1260

Table 9. Number of birds of each species reported with oiled plumage in each region.

Species	West Coast Vancouver Island	Southern Vancouver Island	Strait of Georgia	Haida Gwaii QCI	Total	% of total
Pacific Loon	2	0	0	0	2	5.1
Western Grebe	1	0	0	0	1	2.6
Sooty Shearwater	1	0	0	0	1	2.6
Unspecifiied cormorant	1	0	0	0	1	2.6
Great-blue Heron	0	1	0	0	1	2.6
Red-breasted Merganser	0	1	0	0	1	2.6
California Gull	1	0	0	0	1	2.6
Glaucous-winged Gull	4	1	4	0	9	23.1
Unspecifiied gull	1	0	0	0	1	2.6
Total gulls	6	1	4	0	11	28.2
Ancient Murrelet	1	0	0	1	2	5.1
Cassin's Auklet	2	0	0	0	2	5.1
Common Murre	11	0	0	0	11	28.2
Pigeon Guillemot	0	1	0	0	1	2.6
Rhinoceros Auklet	2	0	0	0	2	5.1
Tufted Puffin	2	0	0	0	2	5.1
Unspecified alcid	1	0	0	0	1	2.6
Total alcids	19	1	0	1	21	53.8
Total all birds	30	4	4	1	39	100.0

Table 10. Number of surveys in each region reporting evidence of oil on the beach.

Category	Oil code	Description	Region* WCVI	SVI	SGI	STG	WRBB	CNC	QCI	All regions	% of BC total
No oil reported	1		350	381	154	151	156	122	6	1319	92.2
Oil reported	2	Oily sheen	7	2	1	1	5	1	0	17	1.2
	3	Few small blobs	45	2	0	0	0	0	8	55	3.8
	4	Many small blobs	2	0	0	0	0	0	2	4	0.3
	5	Thick pancakes	0	0	0	0	0	0	2	2	0.1
	6	Oiled birds, no other oil	14	4	0	7	1	0	1	27	1.9
	2&6	Oiled birds plus oily sheen	0	0	0	1	0	0	0	1	0.1
	3&6	Oiled birds plus few blobs	4	0	0	0	0	0	1	5	0.3
		All with oil	72	8	1	9	6	1	14	112	7.8
		% within region	17.1	2.1	0.6	5.6	3.7	0.8	70.0	7.8	
Total all surveys			422	389	155	160	162	123	20	1431	100

* Region codes: WCVI - West Coast Vancouver Island; SVI - Southern Vancouver Island; SGI - Southern Gulf Islands; STG - Strait of Georgia; WRBB - White Rock and Boundary Bay; CNC - Central and Northern Coast: QCI - Haida Gwaii/Queen Charlotte Islands.

Table 11. Comparison of the incidence of beached carcasses and oiling in seabirds within the regions in BC (data from this study) and Newfoundland (Wiese 2002). The Newfoundland data covered the winter which was the period of highest deposition.The BC data are shown year-round and for the period of highest deposition (August to January).

Study area	Total carcasses per km	Oiled carcasses per km*	% carcasses oiled*	No. of carcasses assessed for oiling
British Columbia (Year-round)				
West Coast Vancouver Island	0.42 ± 0.51	0.041	55.6	54
Southern Vancouver Island	0.27 ± 0.28	0.007	12.5	32
Southern Gulf Islands	0.003 ± 0.008	0.000	0	0
Strait of Georgia	0.13 ± 0.12	0.010	12.1	33
White Rock & Boundary Bay	0.82 ± 0.46	0.000	0	182
Central and Northern Coast	1.25 ± 1.55	0.000	0	8
Haida Gwaii QCI	0.02 ± 0.03	0.015	100	1
All of BC	0.37 ± 0.56	0.014	12.3	310
British Columbia (August-January)				
West Coast Vancouver Island	1.14 ± 2.19	0.045	44.4	36
Southern Vancouver Island	0.37 ± 0.74	0.013	16.0	25
Southern Gulf Islands	0.01 ± 0.06	0.000	0	0
Strait of Georgia	0.21 ± 0.33	0.010	8.7	23
White Rock & Boundary Bay	1.52 ± 3.32	0.000	0	174
Central and Northern Coast	0.18 ± 0.81	0.000	0	7
Haida Gwaii QCI	0	0.000	0	0
All of BC	0.66 ± 1.79	0.017	8.3	265
Southeastern Newfoundland	2.25	0.77	62.0	708

*The % of oiled carcasses and rates of oiled carcasses per km are based on carcasses with known causes of mortality. This explains why the % applied to the total carcass density does not give the rate of oiled carcasses shown here.