

A comparison of two methods for surveying mortality of beached birds in British Columbia

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Abstract

Systematic surveys of beached birds are often limited in their ability to classify the causes of death of the carcasses recovered. Two methods of determining the cause of death of seabirds encountered during surveys of beaches of southwestern Vancouver Island, British Columbia, are compared. Birds were either subjected to external visual examinations by volunteer beach surveyors or submitted for gross postmortem examination by a veterinarian. The reliance on external examination of birds on beaches often prevented the accurate classification of the reproductive status and cause of death of the birds collected, but was valuable for describing the species, locations, and numbers of birds affected. The use of gross postmortem examinations of carcasses allowed for a more refined classification of the cause of death, as well as providing reliable descriptions of the bodily condition and sex of the birds examined. However, almost one half of the carcasses encountered were unsuitable for necropsy because of scavenging and decomposition. It is concluded that a combination of field and necropsy observations provides a useful method with which to monitor the pattern of mortality of beached seabirds.

Résumé

Comparaison entre deux (2) méthodes d'évaluation des causes de mortalité chez les oiseaux riverains en Colombie-Britannique

Les méthodes d'évaluation systématique fournissent souvent des renseignements limités pour classer les causes de mortalité des oiseaux riverains à partir de carcasses retrouvées. Cette étude compare deux (2) méthodes déductives afin de déterminer les causes de mortalité des oiseaux marins trouvés sur les plages du sud-ouest de Vancouver en Colombie-Britannique, lors des rondes de surveillance. Les oiseaux étaient soumis soit à un examen sommaire effectué par les surveillants de plage ou soit à une autopsie macroscopique effectuée par un vétérinaire. L'examen sommaire des oiseaux riverains était une méthode valable pour déterminer l'espèce, la localisation et le nombre d'oiseaux affectés. Fréquemment, il ne permettait pas d'établir le statut du système reproducteur de l'oiseau ni la cause de la mort. L'autopsie

macroscopique des carcasses a fourni des renseignements sur le sexe et la condition générale des oiseaux, et a permis d'établir une classification plus précise des causes de mortalité. Toutefois, près de la moitié des oiseaux ne pouvaient pas être soumis à une autopsie à cause d'une carcasse décharnée ou en voie de décomposition. Les auteurs concluent que les observations effectuées sur le terrain, associées à celles obtenues lors d'une autopsie, fournissent une méthode pratique pour surveiller les causes de mortalité chez les oiseaux marins riverains.

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Introduction

In the eastern North Pacific, the coastal waters of British Columbia support some of the highest densities of seabirds, shorebirds, and waterfowl, including breeding, visiting, and migrating birds (1). In many parts of the world, including British Columbia, systematic surveys of beaches have been used to monitor the effects of oil pollution on populations of marine birds (2,3). Although these surveys have improved our ability to measure the impact of oil pollution, there continues to be relatively little known about the general pattern of mortality in seabirds in British Columbia.

A systematic survey of beached birds was begun in southwestern British Columbia in 1989, in response to the perceived risk of oil spillage and the lack of information regarding the pattern of mortality in local seabirds. Since 1990, this program has regularly surveyed 35 beaches covering approximately 850 km of shoreline in southern British Columbia. The primary aims of the program were to provide data on the seasonal and regional patterns of mortality in beached birds in southern British Columbia, and to monitor large and small scale episodes of oiling. One of the limiting factors of this program has been the inability of surveyors to determine the cause of death for most carcasses (2). In this paper, we examine two methods used for determining causes of mortality of seabirds collected during beach surveys, and explore the strengths and weaknesses of each technique as tools for investigating mortality in seabirds.

Materials and methods

The study was restricted to birds collected during regular beach surveys of the west and south coasts of Vancouver Island, between 1989 and 1992. Surveys on the west coast of the island included 11 beaches between Tofino and Port Renfrew. Virtually all of these beaches were predominantly sandy, with occasional rocky shelves or boulders, and were exposed to significant wave action. There were 10 beaches involved in the surveys on the south coast of the island, stretching between China Beach and Sidney. Rocky and sandy beaches were included in

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Surveys of beached birds in British Columbia have been sponsored by the Royal British Columbia Museum and the Emergency Services Branch, British Columbia Ministry of Environment, Lands and Parks.

Table 1. Criteria used for necropsy classification of the cause of death of beached seabirds in southwestern British Columbia

Mortality category	Diagnostic criteria
Emaciation	Body score of 1 plus no other abnormality noted
Oiling	Oil scores of 3 or 4, or oil score of 2 coupled with oil in the digestive tract
Possible oiling	Oil scores of 1 or 2 with the absence of oiling of the digestive tract and no other abnormality noted
Shot	Entry and exit wounds and/or a projectile associated with significant trauma
GIT ^a	Trauma, infection or abnormality primarily related to the digestive tract
Trauma	Debilitating skeletal or soft tissue injury unassociated with gunshot
Fisheries	Entanglement in fishing nets or lines or severe injury due to fishing hooks
Infection	Gross pathological evidence of infectious processes other than those of the digestive tract
Open	No significant gross abnormality
Other	Necropsy findings other than those described here

^aLesions of the gastrointestinal tract

this region. Tidal currents were strong at these sites, but most beaches were subjected to low wave action, except during storms.

The surveys were made on foot by local volunteers at each beach once a month throughout the year at approximately the same date, according to the methods described by Ainley *et al* (4) and Burger (5). Beaches were selected on the basis of accessibility and proximity to the volunteers. Most of the volunteers were experienced naturalists. Details on all dead or incapacitated birds that were found were recorded on standardized field sheets. Birds that were not in a state of advanced decomposition or heavily scavenged were retained for later museum or necropsy examination. Carcasses not retained were thrown well above the tideline to avoid being counted twice. Carcass identification was aided by the use of a field guide to beached birds (4) and through comparison with museum specimens.

Two methods were used to classify birds with respect to probable cause of death: external examination of the carcass by volunteers in the field (field method) and necropsy examination by a veterinarian (C.S.) of previously frozen birds collected by beach surveyors (necropsy method). The instructions to volunteers asked beach surveyors to examine for evidence of scavenging, carefully look for signs of oil on the plumage, and record a suspected cause of death. Surveyors were asked not to guess at the cause of death, but to look for definite signs such as net entanglement, broken bones, or oiled plumage. Space was provided on the data sheets

for surveyors to comment on the evidence they used to reach their diagnosis. Species, age class, and sex were recorded when possible.

Necropsied birds were placed into one of 10 disease categories, based primarily on their gross postmortem lesions (Table 1). Histological and microbiological evaluation of the birds were rarely useful because of the frequency of autolysis, freezing artifacts, or post-mortem contamination. Although the mortality categories were not mutually exclusive, birds were placed into the category that best described the primary abnormality found at necropsy. All birds examined at necropsy were assigned an ordinal, categorical score of bodily condition, based on the subjective evaluation of the subcutaneous and abdominal fat depots, and the degree of atrophy of the pectoral muscles. Body scores ranged from 1 to 4. A score of 1 was assigned to a bird with marked pectoral atrophy and total depletion of internal and subcutaneous fat stores, whereas a score of 4 was given to birds with large fat stores and no pectoral muscular atrophy. An oil score was assigned to oiled carcasses that were necropsied. External surfaces were classified for degree of oiling as: 1 (<10% covered), 2 (10%–50% covered), 3 (51%–75% covered), or 4 (>75% covered). Descriptive statistics and confidence intervals were calculated by using Statistix 4.0 software (Analytical Software, 1992, St. Paul, Minnesota, USA).

Results

The sample of birds (n = 213) examined in this study was composed of alcids (murres, auklets, and relatives) (59%), gulls (15%), ducks and geese (14%), grebes (4%), procelleriforms (fulmars and relatives) (4%), loons (2%), and cormorants (1%). Of the 42 species collected during the course of this study, the common murre (*Uria aalge*) and glaucous-winged gulls (*Larus glaucescens*) were the two most commonly encountered (49% and 11%, respectively). No other single species exceeded 4% of the total number of birds examined. The field survey (n = 140) assessed 17% more alcids but 11% fewer grebes than did the necropsy series (n = 73); otherwise, species were similarly represented in the two groups. A majority of the carcasses examined were of adult birds for both the field and necropsy samples (90% and 75%, respectively). In the necropsy series, the sex of 31% of the birds could not be determined due to immaturity, autolysis, or scavenging. For the remainder, 48% were male and 52% were female. The sex of over 80% of the birds examined in the field was not recorded.

Field assessment provided mortality classifications for only 56% of the beached carcasses. Mortality classification was not possible in the remaining 44% because of extreme decomposition or excessive scavenging. In comparison, 84% of the birds examined by necropsy could be classified. This discrepancy was due mainly to the lower number of severely scavenged or decomposed carcasses encountered in the necropsy series, as field surveyors generally did not submit such samples for further examination. External examination of carcasses alone rarely provided conclusive evidence for the cause of death in the birds examined in the field. However, most surveyors provided comments that allowed us to understand the basis for their diagnosis.

Table 2. Proportional mortality classification of beached seabirds in southwestern British Columbia

Diagnosis	Necropsy series ^a (n = 73)	Field series ^a (n = 140)
Emaciation	18%	54%
Oiling	19%	24%
Possible oiling	7%	4%
Shot	1%	11%
Open	16%	0
Gastrointestinal tract lesions	15%	0
Trauma	10%	1%
Other	10%	1%
Infection	7%	1%
Predation	0	3%
Fisheries	0	2%

^aTotals may exceed 100% because of rounding errors

Deaths attributed to oil pollution were frequently recorded in both the field and necropsy series (Table 2). Oiled birds were encountered year round. Approximately 81% of the oiled birds were covered with potentially lethal amounts of a petroleum product. These birds were affected by thick bunker or crude oil, light fuel oil or creosote from pilings. Eighteen species were included in the *oiled* and *possibly oiled* groups; 63% were alcids, 16% gulls, 8% grebes, 5% procellariiforms, 3% loons, 3% cormorants, and 3% ducks and geese. Generally, heavily oiled birds were in better bodily condition than were lightly oiled birds. All birds assigned an oil score of 4 (n = 8) had bodily condition scores of 4, whereas birds with oil scores of 1 (n = 5) had a mean body score of 1.4. Birds with intermediate oil scores of 2 and 3 (n = 6) had an average bodily condition score of 2.5.

Anthropogenic causes of mortality other than oil pollution were also recorded by both methods, but in different proportions. Hunting mortality comprised a large portion (11%) of the field diagnosed groups, but were comparatively rare in the necropsied sample. Frequently, field surveyors circumstantially diagnosed hunting as the cause of death upon finding a hole in the carcass or when there was considerable hunting activity on the surveyed beach. The stricter case definition used in the necropsy series placed many of the possible hunting mortalities into the *trauma* or *open* category. The final group of anthropogenic deaths comprised those associated with fisheries' activities. Two birds were found entangled in fish nets, whereas a third was traumatized by a large fishing hook embedded in its pectoral muscles.

The diagnosis of predation was similar to that of the *shot* category in that beach surveyors often reached this diagnosis on the basis of field observations and not on the postmortem features of the carcass. Field surveyors often listed predation as a suspected cause of death when an eagle or other animal was observed eating the carcass or when a partial carcass was found. Such criteria did not allow the investigator to distinguish predation from scavenging, unless fresh blood was observed on the plumage. At necropsy, all birds with signs of predation or scavenging were placed in the *open* category, unless there were other significant findings.

Table 3. Mean body score (95% confidence interval) for specific mortality categories as determined by necropsy examination of beached seabirds in southwestern British Columbia

Category	Mean value (95% CI) ^a	N
Shot	4.0	1
Oiling	3.7 (3.1-4.0)	14
Open	3.0 (2.5-3.5)	11
Trauma	2.6 (1.4-3.7)	7
Other	2.6 (1.2-4.0)	7
GIT ^b	2.0 (1.0-3.1)	10
Infection	1.8 (1.4-2.3)	5
Possible oiling	1.4 (1.0-2.1)	5
Emaciation ^c	1.0	13

^a95% confidence intervals (CI) are restricted to the range of 1-4

^bGastrointestinal tract lesions

^cBy definition, emaciation must have a body score of 1

The field surveyors most frequently classified birds as emaciated. This diagnosis was made primarily by observing wasting of the pectoral musculature. Table 3 illustrates the relationship between bodily condition and diagnosis seen at necropsy. The mean scores of bodily condition of carcasses were consistent with the suspected clinical course of the disorders diagnosed. For diagnoses in which an acute death seemed probable, a high mean body score was observed, whereas more chronic problems were associated with lower scores. Necropsy examination of many of the birds judged externally to be emaciated, frequently revealed underlying disorders such as trauma, infection, and abnormalities of the digestive system, which were considered to be the principal cause of death.

The remaining categories of mortality were virtually exclusive to the necropsy series, as they generally required internal examination of the carcass. Among the disorders classified in the *infection* category, fungal airsacculitis, fungal pneumonia, fungal nephritis, internal infections secondary to external wounds and grossly diagnosed septicemias were observed. Only one juvenile common murre from the field sample was placed in the *infection* category. This bird had pox-like lesions on its eyelid and proximal bill. Approximately 36% of the birds diagnosed with abnormalities of the gastrointestinal tract (GIT) had marked esophageal and periesophageal inflammation associated with the nematode *Pococicum* sp. Two birds had peritonitis secondary to puncture of the ventriculus by plastic foreign bodies. The remaining birds in the GIT category had either impaction of the gizzard with rocks or feathers, ventricular ulceration, a dissecting hematoma of the esophageal wall, or a distended esophagus filled with semisolid food. Included in the *other* category were single cases of pulmonary congestion, apparent drowning, and cardiomegaly. The majority of the case in the *trauma* category were birds with fractures of the long bones, cervical vertebrae, or

coracoid. Many of the trauma cases, such as the fractured coracoid, required necropsy for diagnosis.

Discussion

The limitations of surveys of beached birds have been discussed in depth elsewhere (3). Because beached birds represent only a portion of the affected populations of seabirds, local densities of birds, oceanographic and weather conditions affecting inshore drift, differential rates of carcass disappearance at sea, and persistence of carcasses on beaches are some of the parameters that must be considered before the results of beach surveys can be extrapolated to the general population (2,6,7). Despite their limitations, systematic monthly surveys of beaches have been used internationally to monitor the mortality and frequency of oiling of seabirds (2). Regular surveys allow investigators to determine "expected" numbers of beached birds and to describe seasonal and species patterns of mortality. Access to this information assists in the interpretation of surveys conducted during major oil spills, as well as helping to monitor chronic, small scale episodes of oiling (8). The seasonal, geographic, and species patterns of carcass retrieval observed during beach surveys in southern British Columbia are the subjects of another publication (5).

Although field assessment of mortality was adequate for determining the species involved and for the identification of carcass exposure to oil, it was limited in its ability to determine the cause of death of the majority of the birds encountered. A significant limiting factor was the poor condition of a large proportion of the birds found. Advanced decomposition and scavenging often prevented field surveyors from speculating on a possible cause of death. Because of the convenience method of sampling employed in this survey, a direct comparison of the necropsy and field groups is not strictly valid. However, the results of this study suggest that field evaluation of carcasses tends to overestimate causes of death such as hunting and starvation, while underestimating infectious and traumatic processes. The reliance on circumstantial evidence, in the form of field observations, and the lack of internal examination of the birds are largely responsible for the potential misclassification of the causes of death made by field assessments.

Necropsy examinations of birds recovered during these surveys provided an additional degree of validity to the classification of the cause of mortality. Although the lack of ancillary tests such as histopathology, bacteriology, and toxicology limited the interpretation of the gross postmortem findings for a number of the birds, valuable information was nevertheless obtained by necropsy. Because many of the coastal species of birds on the coast of British Columbia lack prominent secondary sexual characteristics, determining their sex by external examination alone can be difficult or impossible. Inspection of the gonads at necropsy allowed for a direct assessment of the reproductive status of a bird. Gross postmortem examination also provided a better description and interpretation of bodily condition. The category *emaciation* was likely unduly large in the field sample because of the inability of surveyors to establish underlying reasons for the poor bodily condition of the birds. The combination of a system of body scoring with gross postmortem examinations often revealed an

underlying cause for poor bodily condition. By providing a means to describe changing proportion of deaths associated with acute and chronic mortality, body scoring of carcasses may be useful in characterizing changes in the clinical course of deaths after environmental disasters such as oil spills.

The necropsy series was not without limitations as a tool for monitoring mortality of seabirds. The method was biased to examining only the subsample of birds judged not to be markedly decomposed or scavenged. Differential rates of scavenging and decomposition may be an important consideration, especially in the investigation of mortality associated with environmental disasters, such as oil spills, when persistence of carcasses may be affected by oil coverage, species, beach type, and time since beaching (9,10). In addition, necropsy series may underestimate losses due to natural conditions, such as predation, because of the inability of the technique to reliably classify such causes of death.

Although the methods employed in this study prevent the extrapolation of the results to the general population of seabirds, they do highlight areas of concern. In southern British Columbia, man-made factors were an important cause of death of beached birds, accounting for almost 40% of the total mortality. Deaths attributed to oil pollution were responsible for over one quarter of all diagnoses made in this study. However, caution must be exercised when interpreting the presence of oil on beached carcasses. External oiling can be an antemortem event that results in the death of the bird, or it can be the result of postmortem oil exposure when the carcass is on the beach or floating at sea (6). Attributing death due to oil exposure based solely on the presence of external oiling creates the risk of over-diagnosing oil-induced mortality in individual birds. However, the proportion of birds found oiled in this survey likely represents a minimum estimate of the extent of oiling in the population of seabirds in British Columbia. It has been suggested that 20% of birds dying from the effects of oil pollution lack external signs (11). Ingested oil has direct toxic effects than can result in the death of seabirds, yet leave few characteristic gross postmortem lesions (12). In addition, oil pollution has been demonstrated to have long-term population impacts beyond acute mortalities. The list of their effects includes decreased bodily condition indices, depressed growth of young birds, and reduced reproductive efficiency (12). The likelihood that all oiled birds are recovered on beached bird surveys is low. Surveyors likely miss lightly oiled birds. Many factors, including wind, the coastal habitat, the species affected, and ocean currents, are all known to affect the proportion of dead oiled birds that can be recovered on shore after dying at sea (7,10). It has been shown in drift experiments that relatively few oiled birds ever reach shore (7). Taking these factors into consideration, we believe that the high proportion of oiled birds found on beaches year round indicate that there is a continual problem of oil pollution on the southern coast of British Columbia that requires attention.

Neither the field assessments nor necropsy examinations provided a complete and precise estimation of the proportional mortality of seabirds in this study. However, a more comprehensive description of the patterns of mortality of beached seabirds can be made

by combining the demographic and environmental information collected by beach surveys with the necropsy examination of individual birds, than by employing either technique alone.

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