Set-back Distances to Protect Nesting and Roosting Seabirds off Vancouver Island from Boat Disturbance

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Abstract.—Recreational boat traffic is increasing worldwide and there is a need for scientifically based regulations that sustain both seabirds and wildlife viewing. The effects of boat disturbance to seabirds off Vancouver Island, Canada were quantified by testing distances that roosting or nesting birds showed an agitation response to an approaching motorboat or a kayak. The effects of species sensitivity, vessel type, habituation and season on agitation distance were examined. At 40 m from approaching boats, nesting Double-crested (*Phalacrocorax auritus*) and Pelagic (*P. pelagicus*) cormorants, Black Oystercatchers (*Haematopus bachmani*), Glaucous-winged Gulls (*Larus glaucescens*), and Pigeon Guillemots (*Cepphus columba*) had less than 6% probability of being agitated with either a kayak or motorboat, while at 50 m there was less than 2% probability of agitation. Roosting birds had larger response distances than nesting birds. Roosting Harlequin Ducks (*Histrionicus histrionicus*) were particularly sensitive with 24% probability of agitation at distances less than 50 m. Agitation distances were reduced by habituation to boat traffic and a single kayak could approach closer than a motorboat without disturbing seabirds. A general set-back guideline of 50 m would protect most nest and roost sites while allowing viewers to appreciate seabirds. Set-backs could be adjusted to protect locally sensitive sites or species. *Received 7 May 2012, accepted 20 September 2012.*

Key words.—Boat disturbance, Black Oystercatcher, Brandt's, Double-crested and Pelagic cormorants, Glaucous-winged Gull, habituation, Harlequin Duck, Pigeon Guillemot, seabirds, set-back distances, viewing guidelines

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Sustainable ecotourism has many positive benefits to natural ecosystems and wildlife, including educational opportunities, increased support for natural areas and wildlife (Newsome *et al.* 2002; Gill 2007), economic benefits (Gray *et al.* 2003; Leonard 2008), and informed input to management. Well-managed ecotourism, which involves setting scientifically-based guidelines, consultation with stakeholders, and interpretation, can be used to reduce negative impacts on the environment, minimize effects on wildlife, decrease enforcement problems and encourage visitors to adhere to selected locations and set-back distances. Nature tourism is particularly dependent on the resources (seabirds in this case), so it is important to sustain the seabirds that viewers are observing. Disturbances through approaches that are too close are often cited as a major threat to birds (Manuwal 1978; Anderson and Keith 1980; Vennesland and Butler 2004) and are known to disrupt nesting, care of young, feeding, and resting (Burger *et al.* 1995; Frid and Dill 2002). Recreational boaters, fishermen and sea kayakers visit offshore islets, reefs and coastal areas that support roosting and nesting seabirds. Disturbance of wildlife by people, vehicles and boats is a serious issue that park and wildlife managers routinely face (Galicia and Baldassarre 1997; Roe *et al.* 1997; Newsome *et al.* 2002; Langston *et al.* 2007), yet scientific information to assess the level of threat and the effectiveness of mitigation measures is often not available. Scientifically based guidelines and rules will have a greater degree of acceptance and compliance than guidelines that are based on opinion alone.

The effects of boat disturbance on nesting and roosting seabirds off Vancouver Island were studied. Some of the species nesting on Vancouver Island, including Brandt's Cormorant (*Phalacrocorax penicillatus*), Double-crested Cormorant (*P. auritus*), and Common Murre (*Uria aalge*), are listed provincially as species-at-risk (British Columbia Conservation Data Centre 2012) and Pelagic Cormorants (*P. pelagicus)* are declining (Chatwin *et al.* 2002). The objectives of the study were to measure, with a standardized approach, the distances at which roosting and surface-nesting seabirds display a disturbance response to boats, and to test whether disturbance responses were affected by nesting vs. roosting, species, boat type, boat traffic (as a measure of habituation), and seasonal timing. Based on the results, recommendations are made for set-back distance guidelines that will protect seabirds from boating disturbance while allowing viewers to appreciate the birds.

METHODS

We experimentally sampled the distance that a motorboat or kayak could approach seabirds at roost or nest sites in the vicinity of Victoria, Southern Gulf Islands, Nanaimo, Pacific Rim Park, Clayoquot Sound and Mitlenatch Island off the coast of Vancouver Island, British Columbia (Fig. 1). Each roost or nest location within the study areas was categorized as to the degree of boat traffic during summer as a measure of habituation. Based on personal experience before and during the study and after consultation with local experts (Chatwin 2010), boat traffic was rated as High (at least six boats of any type pass in the vicinity each day), Medium (one to six boats per day) or Low (less than one boat per day). In total we sampled 15 nesting sites with various nesting combinations of Brandt's, Double-crested and Pelagic cormorants, Black Oystercatchers (*Haematopus bachmani*), Glaucous-winged Gulls (*Larus glaucescens*), and Pigeon Guillemots (*Cepphus columba*). We sampled approximately 50 different roost sites with these species, plus non-breeding Harlequin Ducks (*Histrionicus histrionicus*). Shorebirds were few in number and were included in pooled data only (see below); these included Whimbrels (*Numenius phaeopus*), Black Turnstones (*Arenaria melanocephala*), and Surfbirds (*Aphriza virgata*). An attempt was made to sample each study area three times during the breeding season to determine if time of year had an effect on disturbance distances. Survey dates were classified as Early (15 May-15 June), Mid-season (16 June-15 July) or Late (16 July-10 August). There was some annual variation in breeding chronology of the birds but these categories seemed to capture the major trends. The majority of tests were conducted in 2006 ($n = 143$, 78 and 355 for Early, Mid and Late season, respectively) with additional tests done in 2005 ($n = 0$, 2 and 10), 2007 ($n = 0$, 33 and 30) and 2009 ($n = 49$, 29 and 6 for Early, Mid and Late season, respectively).

The field trial involved driving the motorboat slowly (ca. 4-6 km/hr, at a similar speed to a wildlife-watching tour vessel) or paddling the kayak directly towards the islet with the roost and/or nest site. Species and numbers of birds were recorded and distances were mea-

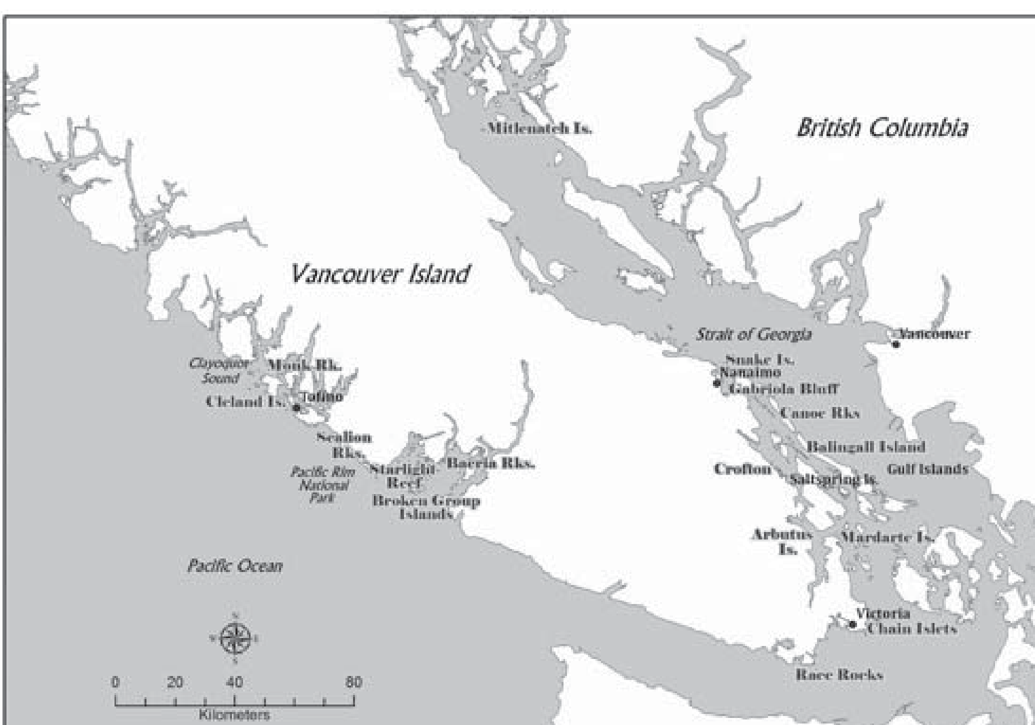

Figure 1. Study areas off Vancouver Island showing major seabird nest and roost sites sampled in this study.

sured with a Bushnell Yardage-Pro Rangefinder (resolution 1 m). The rangefinder measured the horizontal distance from the boat to the nearest bird. We started all trials at distances greater than 200 m to be outside of the range of agitation. We recorded the distance that the first bird in the group showed a visible agitation reaction to the approach (hereafter referred to as agitation distance). Usually several birds began reacting at the same time. Agitation was characterized by activities that differed from normal resting behaviour, such as alertness, neck raising, looking back and forth, or standing up more erect. At any one of these visible signs of agitation, this agitation distance was recorded and the boat backed away. We tried to avoid causing the birds to flush and therefore do not report flight distance, unlike some other similar studies (e.g., Rodgers and Smith 1995).

Groupings of birds (separated from other groups far enough to not be affected by agitation or flights made by birds in adjacent trials) constituted one trial and each species encounter was recorded separately. Trials were done if seabirds were not reacting to external stimuli such as an overflight by a Bald Eagle (*Haliaeetus leucocephalus*). In cases where disturbance had occurred (even flight), we left that particular area, returning after more than 30 min to resume the trials. For some trials it was not possible to approach the birds close enough to elicit an agitation response. In such cases, the closest distance from the birds that we could approach was recorded despite birds not showing agitation. The kayak tests were conducted if sea conditions permitted. The kayaker had a radio to communicate the distances, species and bird numbers to a recorder aboard the motorboat. The sequence of testing with the motorboat and kayak was randomized to reduce the chance of acclimatization. Data recorded included date, locality, motorboat or kayak, boat traffic, bird species, roost or nest, number of birds in the group, distances from boat to birds when the tests were started and when agitation was observed.

Data Analysis

Various authors (Erwin 1989; Carney and Sydeman 1999; Blumstein *et al.* 2003) indicated that the distance at which birds might be disturbed is dependent on species sensitivity, timing of disturbance (seasonal and time of day), approach type and habituation or previous exposure to human activity. Using agitation distance as the response variable, the species sensitivity was analyzed for nesting and roosting birds first. As kayakers were able to paddle very close to seabird roosts and nest sites and because a kayaker could make a quiet and sudden approach to birds, it was important to test experimentally if kayaks or motorboats had the same response distances so this variable was analyzed. Boat traffic (as a categorical variable of habituation) and survey date were compared to determine if they affected the agitation distance. Data on sea conditions were not analyzed as most tests occurred in weather when boats could go out (swell height less than 1 m and wind less than 15 km per hour). Sample sizes were not adequate to rigorously test the effects of group size on disturbance responses in addition to species effects and other variables examined.

Kaplan-Meier survival analysis is a method used to model the time or distance to a discrete event (Lawless 2002) especially when there are cases of no response. In our analyses, the agitation of a focal bird or group of birds was taken as the discrete event of interest, and the probability of the bird becoming agitated was modeled as a function of distance from the bird to the source of agitation (motorboat or kayak). In the context of this disturbance study, the usual plot of a survival function was turned around so that the survival function is the distance to agitation from an origin where no birds were disturbed (200 m from the focal group). During data collection, there were times when the boat could not get close enough to elicit a behavioral response from the birds due to waves or rocks, or because birds showed no agitation response (122 out of 514 trials); in these cases the closest distance was included in the survival analysis. A major advantage of using survival analysis is that these tests contribute to the estimate of the survival function rather than being omitted as missing data (Lawless 2002). Survival-type curves for distance to agitation (hereafter referred to as response curves) were plotted by species for roosting and nesting birds. To achieve sufficient sample size, species were pooled for statistical testing of boat type, boat traffic and seasonal timing. The non-parametric logrank test (Harrington 2005) was used to compare the shape of the response curve across all distances. We tested for significant differences between motorboat and kayak and among boat traffic categories and the three seasonal periods. Where significance of a test involving more than two categories was found (i.e., testing if disturbance responses differed between seven roosting bird species), multiple pairwise comparisons were conducted to distinguish which categories were similar or dissimilar. We used a Cox proportional hazard model to examine the effect of habituation to boat traffic by roosting species. All data analyses were conducted using R software (R Development Core Team 2012).

RESULTS

Agitation Distances by Species

There were 514 trials, of which 496 involved seven focal species used for analysing species effects (Table 1). Sample sizes for Harlequin Ducks, Brandt's, Double-crested and Pelagic cormorants, Black Oystercatchers, Glaucous-winged Gulls, and Pigeon Guillemots were sufficient to analyze agitation distances by species with other interaction factors. The remaining 18 trials involved less common species including Bald

Table 1. Number of trials conducted by species, boat traffic category (Low, Medium and High), and by kayak or motorboat.

	Motorboat (n = 319)				Kayak (n = 177)			
Species	Low	Medium	High	Total by species	Low	Medium	High	Total by species
Harlequin Duck	10	9	0	19	4	3	1	8
Brandt's Cormorant	15	4	3	22	6	4	2	12
Double-crested Cormorant	0	32	11	43	0	20	8	28
Pelagic Cormorant	20	79	30	129	1	41	22	64
Black Oystercatcher	16	9	4	29	0	10	3	13
Glaucous-winged Gull	16	25	13	54	5	16	11	32
Pigeon Guillemot	2	10	11	23	0	7	13	20
Total by boat type	79	168	72	319	16	101	60	177

Eagles, Heermann's (*Larus heermanni*) and California (*Larus californicus*) gulls, Common Murres and shorebirds, which were only included in analyses involving pooled data from all species.

The response curves for the proportion of agitated birds across distance (Fig. 2; pooled data from motor boat and kayak trials on all species) showed a significant difference between nesting (n = 200 trials) and roosting (n = 314 trials) seabirds (logrank test, χ^2 = 8.1, P = 0.005). Therefore, trials with nesting birds were analyzed separately from those with roosting birds (Fig. 2 and Table 2). Nesting birds had significantly different sensitivities among species (logrank test, χ^2 = 62.0, P < 0.001). At distances greater than or equal to 40 m no species of nesting bird had more than 6% chance of being agitated: Double-crested Cormorants (3.6%), Pelagic Cormorants (3.3%), Black Oystercatchers (0%), Glaucous-winged Gulls (2.8%) and Pigeon Guillemots (5.3%). At 50 m, the chance of agitation decreased to 0% for all nesting species, except for Pelagic Cormorants with a 1.1% chance of agitation. Multiple pairwise comparisons showed Glaucous-winged Gulls to be significantly less sensitive to disturbance compared to Double-crested and Pelagic cormorants, and Black Oystercatchers; other pairwise comparisons were not significant for nesting birds.

Roosting seabirds were generally more sensitive than nesting birds to boat disturbance (Fig. 2 and Table 2). Roosting Harlequin Ducks, Brandt's and Pelagic cormorants were significantly more sensitive to disturbance than the other species,

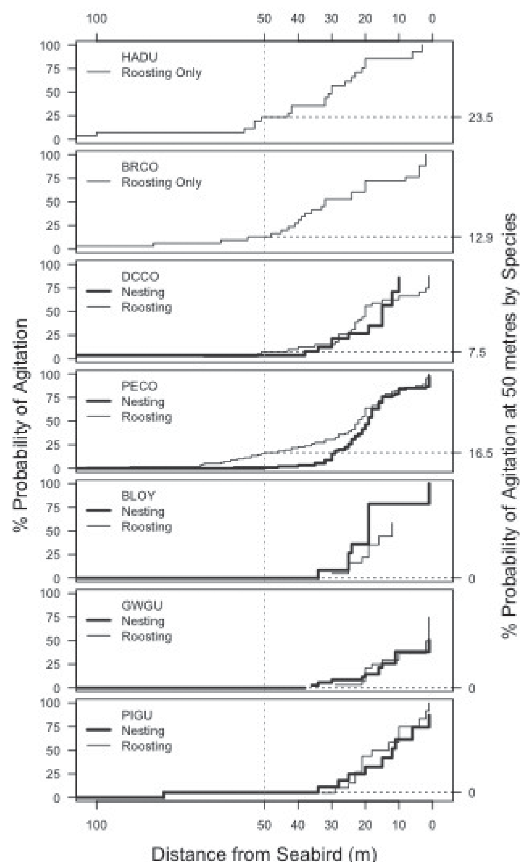

Figure 2. Plots of the proportions of nesting and roosting seabirds agitated at varying distances, based on Kaplan-Meier survival analyses. The dashed horizontal lines show the probability of agitation at 50 m (vertical dashed line) for the higher percentage agitation; roosting or nesting. Species codes for Brandt's Cormorant, (BRCO), Double-crested Cormorant (DCCO), Pelagic Cormorant (PECO), Glaucous-winged Gull (GWGU), Pigeon Guillemot (PIGU), Black Oystercatcher (BLOY) and Harlequin Duck (HADU).

Table 2. Estimate of probability (%; SE in parentheses) of nesting and roosting birds being agitated at various approach distances using the Kaplan-Meier survival function for the seven focal species.

	% Probability of agitation at these approach distances							
	70 m		50 m		40 m		30 m	
Species	Nest	Roost	Nest	Roost	Nest	Roost	Nest	Roost
Harlequin Duck	—	7.4 (5.0)	—	23.5 (8.4)	—	35.6 (9.6)	—	57.1 (10.1)
Brandt's Cormorant	—	6.4 (4.3)	—	12.9 (6.0)	—	30.8 (8.6)	—	52.7 (9.4)
Double-crested Cormorant	0	2.5 (2.5)	0	7.5 (4.2)	3.6 (3.5)	12.5 (5.3)	21.6 (8.6)	15.1 (5.7)
Pelagic Cormorant	0	2.0 (1.4)	1.1 (1.1)	16.5 (3.8)	3.3 (1.9)	22.8 (4.3)	15.5 (3.8)	30.4 (4.7)
Black Oystercatcher	0	0	0	0	0	0	8.3 (8.0)	5 (4.9)
Glaucous-winged Gull	0	0	0	0	2.8 (2.7)	0	8.3 (4.6)	3.1 (3.1)
Pigeon Guillemot	0	0	0	0	5.3 (5.1)	0	11.2 (7.5)	4.8 (4.6)

Note: Brandt's Cormorants and Harlequin Ducks did not nest in the study area. Zeros mean that there were no seabirds agitated at this distance in our trials.

with 23.5%, 12.9% and 16.5%, respectively, agitated at a distance of 50 m. At a distance of 70 m roosting Harlequin Ducks and Brandt's Cormorants had greater than 6% chance of agitation. Roosting Black Oystercatchers, Glaucous-winged Gulls and Pigeon Guillemots were significantly less sensitive to disturbance than roosting birds of other species, showing no agitation at 50 m.

Motorboat vs. Kayak Agitation Distances

Using pooled data for all species, the proportions of seabirds agitated with the approach of a motorboat or kayak were plotted (Fig. 3) and the averages at 70, 50, 40 and 30 m were calculated (Table 3). The kayak could approach significantly closer to the birds without agitation than the motorboat (logrank test; $\chi^2 = 19.7$, $P < 0.0001$).

Effects of Boat Traffic on Agitation Distance

There were 132 tests for the seven focal species at sites classified as High boat traffic, 269 tests at Medium boat traffic sites, and 95 tests at Low boat traffic sites (Table 1). All of the Low boat traffic sites were located on the west coast of Vancouver Island and were generally inaccessible to kayaks. The effects of boat traffic were analyzed based on pooling the seven species of seabirds, as well pooling motorboat, kayak, nesting and roosting.

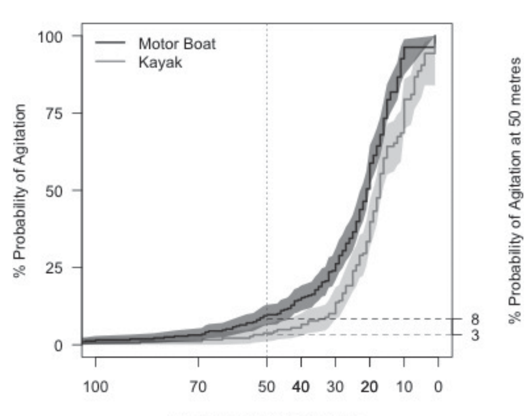

Figure 3. Plot of Kaplan-Meier estimate of proportions of birds agitated when approached by a motorboat or a kayak, using pooled data from all bird species. The shaded polygons show 95% confidence intervals, and horizontal dashed lines show the proportions agitated at 50 m.

Table 3. Kaplan-Meier estimate of probability (%; SE in parentheses) of seabirds (all species pooled) agitated at 70, 50, 40 and 30 m when approached by a kayak (n = 186) or motorboat (n = 328).

	% Probability of agitation at these approach distances			
Boat type	70 m	50 m	40 m	30 m
Kayak	1.0 (0.8)	3.3 (1.3)	5.6 (1.7)	12.7 (2.6)
Motorboat	2.5 (0.9)	8.4 (1.6)	13.5 (1.7)	24.0 (2.5)

There was a significant difference ($\chi^2 = 50.7$, $P < 0.001$) between the agitation distributions at the three boat traffic levels (Table 4). At all the approach distances summarized (70, 50, 40 and 30 m) the proportion of birds agitated was always highest at Low boat traffic sites, intermediate at Medium boat traffic sites, and lowest at High boat traffic sites (Table 4). Clearly, seabirds were seldom agitated beyond 70 m at any boat traffic category; while at distances less than 30 m, higher percentages of seabirds were agitated regardless of local boat traffic. There was no agitation for High boat traffic sites when boats were beyond 50 m, while agitation rates were considerably higher at this distance for Low and Medium boat traffic sites (Fig. 4). There is some overlap of confidence intervals between High and Medium boat traffic tests showing less difference in agitation distance between these categories. Habituation to boat traffic therefore reduced the probability of disturbance from approaching boats. Because roosting species were agitated at greater distances than nesting seabirds, a separate analysis was conducted to determine if boat traffic effects were specific to particular species. Roosting Harlequin Ducks, Brandt's and Pelagic cormorants were particularly sensitive at Low boat traffic sites where 20.1%, 16.8% and 28.7% were agitated at 50 m, respectively. At distances less than 50 m, the chance of agitation was even higher. In the multiple comparisons tests, Pelagic Cormorants were significantly more frequently agitated at Low boat traffic sites compared to Medium and High traffic sites.

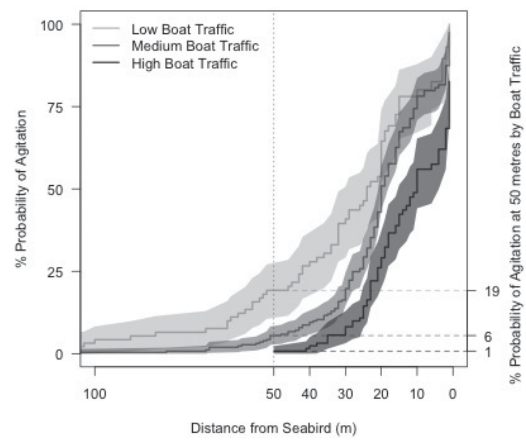

Figure 4. Kaplan-Meier estimates of the proportion of roosting and nesting seabirds agitated at High, Medium and Low boat traffic sites plotted against distance of boat or kayak from birds. The shaded polygons are the 95% confidence intervals, and horizontal dashed lines show the proportions agitated at 50 m.

Table 4. Kaplan-Meier estimate of probability (%; SE in parentheses) of seabirds (all species pooled) being agitated at various approach distances at High, Medium and Low Boat traffic sites.

	% Probability of agitation at these approach distances			
Boat traffic	70 m	50 m	40 m	30 m
High	0	0.8 (0.8)	1.6 (1.1)	5.6 (2.1)
Medium	0.8 (0.5)	5.5 (1.4)	8.7 (1.8)	16.3 (2.4)
Low	6.5 (2.6)	19.2 (4.2)	26.6 (4.8)	39.5 (5.4)

Seasonal Timing and Agitation Distance

Nesting Double-crested and Pelagic cormorants, Glaucous-winged Gull, Black Oystercatcher and Pigeon Guillemot were included in the Early, Mid and Late breeding season analysis (Table 5). There was no significant difference between the three breeding periods in the proportions of birds agitated (logrank test; $\chi^2 = 4.8$, $P = 0.09$).

DISCUSSION

The study revealed the trends and variations in approach distances that birds off Vancouver Island will tolerate, and contrib-

Table 5. Kaplan-Meier estimate of probability (%; SE in parentheses) of nesting seabirds being agitated at 50, 40 and 30 m approach distances during early, mid and late breeding season.

	% Probability agitated at these approach distances		
Season	50 m	40 m	30 m
Early	0	1.2	17.1
15 May-15 June (N = 94)		(1.2)	(4.2)
Mid	0	2.8	8.5
16 June-15 July (*n* = 41)		(2.7)	(4.7)
Late	4.7	6.4	15
16 July-10 August (*n* = 65)	(2.6)	(3.1)	(4.6)

utes to establishing set-back distances for management in this area. Many of these or similar species occur elsewhere and these results are therefore valuable for managing boat disturbance in other locations. Nesting seabirds on Vancouver Island allowed a closer approach by a boat before showing agitation than did roosting birds. In terms of fitness, a nesting bird must evaluate the cost and benefits of staying on the nest to defend its eggs or young or fleeing to protect itself (Montgomerie and Weatherhead 1988). Since seabirds are generally long-lived and have high adult survival, their populations are sensitive to adult mortality (Gaston 2004). Therefore, as a strategy, seabirds (particularly cormorants) will flee when under predation risk as they can re-nest later in the season or in another year (Moul and Gebauer 2002). However, nesting seabirds have little to gain by responding to boat approach before it is necessary. Flight could expose eggs or chicks to thermal stress or predation. It follows then, that nesting birds should stay at the nest until the perceived threat is close. In contrast, roosting birds responding to a perceived risk by a boat face only an energetic loss or a temporary displacement and would therefore be more inclined to be agitated and flee at farther approach distances.

Despite the trend for less sensitivity among nesting birds, there were a couple of exceptions. Black Oystercatchers had a higher chance of being agitated at distances less than 30 m when nesting than roosting. Black Oystercatchers nest on the surface of a barren rocky islet or beach and crouch down low to avoid being noticed. Their nests are vulnerable to predation if the adult leaves the nest and breeding adults are highly distressed by humans landing or walking near their nest. Therefore, nest sites especially require protection from landing boats and foot traffic. Pigeon Guillemots appeared to be reasonably tolerant of boat approach when roosting but nesting birds had the highest agitation response at distances less than 40 m. At 50 m, however, there were few agitated birds and, with this set-back distance, Pigeon Guillemots on the rocks or swimming near nest sites would be protected from disturbance.

In common with other studies (Rodgers and Schwikert 2002; Blumstein *et al.* 2003; Beale 2007), agitation responses differed among the species tested off Vancouver Island. Roosting Harlequin Ducks, Brant's and Pelagic cormorants responded to boat traffic at farther distances than did Double-crested Cormorants, Pigeon Guillemots, Glaucous-winged Gulls and Black Oystercatchers. For the three cormorant species, we found a strong increase in the proportions agitated between the 40 m to 30 m thresholds. Other authors report similar sensitivity of Brandt's, Double-crested and Pelagic cormorants to disturbance especially in the early stages of nesting (Vermeer and Rankin 1994; Cairns *et al.* 1998; Moul and Gebauer 2002; Denlinger 2006). Glaucous-winged Gulls were more tolerant than all of the other species and Double-crested Cormorants were more tolerant than the other two cormorant species, which corresponds to these species' distributions near urban centres.

Site-specific set-backs are needed where two highly sensitive species, Harlequin Ducks and Brandt's Cormorants, occur. Although Harlequin Ducks are not at-risk in British Columbia (British Columbia Conservation Data Centre 2012), they are sensitive to disturbance (Goudie and Ankney 1986) and likely declining in British Columbia (Rodway *et al.* 2003). During the summer when the study was conducted, male Harlequin Ducks congregate in moulting aggregations around small islets. They are often flightless at this time and therefore particularly sensitive to disturbance. Site-specific set-back buffers of 70 m would protect roosting aggregations of Harlequin Ducks and Brandt's Cormorants from disturbance while allowing closer access to other seabird viewing sites. In the study area, most of the aggregations of Harlequin Ducks and Brandt's Cormorants occurred at Low boat traffic sites.

Although we found no significant seasonal variations in agitation responses, other authors working with Great Blue Herons (*Ardea herodius),* Common Terns (*Sterna hirundo*) and Black Skimmers (*Rhynchops niger)* found that pre-incubation was the most sensitive time for flight (Erwin 1989; Burger *et al.* 2010; Vennesland 2010). In the pre-incubation stage of nesting, birds have the lowest amount of energy invested in reproduction and may readily decide to flee and save themselves for another nesting attempt. In our study the lack of statistical significance could be explained by the variety in the various species' breeding chronology. By 15 June, Black Oystercatchers had chicks, some Glaucous-winged Gulls had eggs, while the three cormorant species were in the pre-incubation stage (Campbell *et al.* 1990). Therefore, it would only be feasible to determine the effect of breeding chronology on disturbance response by focusing the study on single species. In our study we kept the seasonal divisions non-specific in order to provide more general management guidelines. Since the effect of seasonality was not great enough to be discerned at the overall level, this factor would be considered secondarily.

In our study a single kayak could approach closer than a motorboat to seabird roost and nest sites without an agitation response. However, kayakers generally travel in groups and seabirds likely perceive a group of kayakers as a larger threat than a single kayak and might become agitated at greater distances than shown in our single-kayak tests. Amato (1995) stressed that kayakers were disturbing to seabirds because they were able to approach and land on islands that motorboats could not access. Burger *et al.* (2010) discuss the value of setting a single set-back distance that is easier to understand, remember and enforce. Therefore, we recommend a general single set-back distance for kayakers based upon the motorboat agitation response threshold of 50 m. If the Harlequin Duck and Brandt's Cormorant roost sites are provided the extra 20 m buffer and a strict no-landing policy is maintained, then disturbance to seabirds from kayaks could virtually be eliminated. Kayakers should also be educated to approach seabirds tangentially, which causes least disturbance (Burger and Gochfeld 1981) and to avoid approaching directly or stealthily behind rocks.

Surface-nesting and roosting seabirds on Vancouver Island appeared to habituate to Medium and High levels of boat traffic, which corroborates other studies of seabirds' responses to humans (Burger and Gochfeld 1981; Fowler 1999). Nisbet (2000) recommends promotion of habituation in waterbird colonies as it can be beneficial to conservation under controlled conditions and could permit and promote beneficial educational and recreational uses. Observations during this study and by Giesbrecht (2001) showed that roosting and nesting seabirds off Vancouver Island responded at much greater distances to a real predator (e.g., > 40 m at the approach of a Bald Eagle) even though they were habituated to boat traffic (generally did not respond until approached to 20 m). While the boat traffic analysis showed that there were effects of habituation, clearly there were also differential species effects.

Burger *et al.* (2010) suggested a series of steps to determine appropriate set-back distances, which included selecting the behavioural measure of most concern, the most sensitive reproductive stage, the level of response (mean, maximum or in-between) and then deciding whether to establish an additional buffer to reduce risk. Since our study involved multiple species that often co-occur, selecting a suitable buffer for Vancouver Island seabirds should also involve selecting whether to set the distance based on roosting or nesting, which species is the most sensitive to disturbance and whether that species is of management concern. A set-back guideline of 50 m would protect most seabird sites on Vancouver Island from the majority of boat disturbance, and from more extreme responses (i.e., flight). However, roost sites for aggregating Harlequin Ducks and remote sites with Low boat traffic (e.g., on the west coast of Vancouver Island) would be better protected by a 70 m set-back distance. These set-back distances will allow viewers to appreciate seabirds and encourage compliance (Rollins *et al.* 2009). Education, permitting requirements, marker buoys and having warden enforcement are methods recommended to promote adherence to the guidelines.

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