NOTE / NOTE

Regulation compliance by vessels and disturbance of harbour seals (*Phoca vitulina*)

Amber Johnson and Alejandro Acevedo-Gutiérrez

Abstract: The US National Oceanic and Atmospheric Administration established a buffer zone around marine mammals to prevent harassment. The buffer zone varies by species listing status and by geographic area. However, it is unknown the extent to which vessels comply with these buffer zones. We selected harbor seals (*Phoca vitulina* L., 1758) as a case study to describe compliance with the buffer zone. We conducted land-based observations from Yellow Island, Washington State, in a geographic area where the buffer zone is 91 m (100 yards), to estimate vessel distance from hauled-out seals and to evaluate seal response. We recorded 85.7% of kayaks, 57.1% of stopped powerboats, and 4.6% of passing powerboats violating the buffer zone. Seals were disturbed by kayaks and stopped powerboats at distances >91 m from the haul-out sites but not by moving powerboats ≤91 m from the sites. Hence, compliance of the buffer zone varied with vessel type and vessel activity. We suggest that a larger buffer zone for vessels lingering around the haul-out sites and enforcement of the buffer zone will minimize seal disturbance.

Résumé : L'Administration nationale de l'océan et de l'atmosphère des États-Unis a établi des zones tampons autour des mammifères marins afin de prévenir le harcèlement. La zone tampon varie en fonction du statut de l'espèce sur la liste des espèces menacées et de la région géographique. On ne sait cependant pas dans quelle mesure les navires respectent ces zones tampons. Nous avons choisi le phoque gris (*Phoca vitulina* L., 1758) pour faire une étude de cas du respect de la zone tampon. Nous avons fait des observations depuis la côte sur Yellow Island, état de Washington, dans une région géographique où la zone tampon est de 91 m (100 verges) afin d'estimer la distance entre les navires et les phoques en échouerie et pour évaluer les réactions des phoques. Nous avons noté que 85,7 % des kayaks, 57,1 % des bateaux à moteur qui s'arrêtent et 4,6 % des bateaux à moteur qui passent tout droit ne respectent pas la zone tampon. Les phoques sont perturbés par les kayaks et les bateaux à moteur qui s'arrêtent à des distances >91 m des sites d'échouerie, mais pas par les bateaux à moteur qui passent tout droit à ≤91 m des sites. Le respect des zones tampons varie donc en fonction du type de bateau et du type d'activité du bateau. Nous proposons d'élargir la zone tampon pour les bateaux qui s'attardent près des sites d'échouerie et de faire respecter les zones tampons pour minimiser la perturbation des phoques.

[Traduit par la Rédaction]

Introduction

Marine tourism has rapidly developed into a global industry (Miller 1993) and has been accompanied by both positive and negative impacts. On the plus side, tourism can lead to increased profits to local economies and benefit conservation goals through increased education and awareness (Giannecchini 1993; Kals et al. 1999; Schänzel and McIntosh 2000). However, tourism also poses dangers to sensitive environments and wildlife communities (Giannecchini 1993; Sorice et al. 2006). In 1972, the US government established the Marine Mammal Protection Act, which prohibits the harassment of marine mammals. As a result, interest in the harassing effects of vessel-based tourism on marine mammals has increased since the inception of the act and the development of marine tourism (Orams 1999). Numerous studies have shown that vessels have a negative effect on marine mammals (Acevedo 1991; Suryan and Harvey 1999; Constantine et al. 2004), leading to management recommendations for reducing these impacts (Lück 2003; Wilson et al. 2004; Ward-Geiger et al. 2005).

Guidelines established by the US National Oceanic and Atmospheric Administration (NOAA) for managing marine mammals and preventing their harassment prohibit the intentional approach by humans and vessels within a certain distance of any marine mammal, which in the case of pinnipeds (seals and sea lions) includes individuals hauled-out on land (http://www.nmfs.noaa.gov/pr/pdfs/education/viewing_northwest.pdf [accessed 20 December 2006]). In most cases, the extent of the buffer zone is 100 yards (approximately 91 m). The buffer zone is a well-known guide-

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A. Johnson[1] and A. Acevedo-Gutiérrez.[2] Department of Biology, Western Washington University, Bellingham, WA 98225-9160, USA.

[1]Present address: Department of Fisheries and Wildlife, Nash Hall, Room 104, Oregon State University, Corvallis, OR 97331-3803, USA.
[2]Corresponding author (e-mail: acevedo@biol.wwu.edu).

line; however, to our knowledge, little is known about compliance by humans. In Uruguay, fences were erected to keep humans on land at a distance from hauled-out South American fur seals (*Arctocephalus australis* (Zimmermann, 1783)). This approach resulted in a reduction of human–seal interactions and stressful seal responses (Cassini et al. 2004). In the water, fences are usually not an option, and as an alternative, NOAA has relied upon education and voluntary compliance with the 91 m buffer, since it lacks adequate resources for enforcement. However, evidence from terrestrial systems in other countries suggests that voluntary compliance is largely an ineffective means of management (Rowcliffe et al. 2004).

Pinnipeds breed and haul-out in coastal colonies with certain spatial and temporal predictability that makes them easily accessible by vessels and humans, often resulting in disturbance (Tershy et al. 1997; Engelhard et al. 2001). Because pinnipeds haul-out on land, it is relatively easy to observe them from afar without causing disturbances and evaluate vessel compliance with the 91 m buffer zone. Harbor seals (*Phoca vitulina* L., 1758) are the most abundant and common pinniped species in Puget Sound, Washington State (Jeffries et al. 2003), where shipping, fishing, and recreational boating activities are high. Consequently, the potential for vessel disturbance of harbor seals in this region is high. For these reasons, we selected the harbor seal and Puget Sound as a case study to determine the compliance by humans to the buffer zone and the usefulness of the marine buffer policy to protect marine mammals from disturbance.

The aim of our study was to estimate compliance with NOAA's 91 m buffer zone. To accomplish this goal, we (*i*) estimated the minimum distance between vessels and the haul-out sites, (*ii*) identified vessel types, and (*iii*) described vessel behavior associated with seal disturbance.

Materials and methods

Study site

We collected data from 26 June through 12 September 2004 at the west spit (48°35′N, 123°02.00′W) of Yellow Island, Washington State, USA, in the San Juan Islands Archipelago. The spit overlooks the heavily traversed San Juan Channel and is characterized by a bluff, with an altitude of 14.05 m above mean sea level, from which we conducted all observations. The spit faces two rocky outcrops facing to the southwest and southeast, with a distance of 250 and 190 m from the observation post, respectively. The two outcrops are almost completely covered by water at high tide (approximately 170 cm above mean sea level) and harbor seals employ them as haul-out sites at lower tide levels. We conducted our observations when the seal haul-outs were exposed 2–4 h before low tide and 2–10 h after low tide and only during weekends, which are the days with the highest boat traffic in the area. The observation schedule ensured that we collected data when seals were most likely to encounter vessels; however, it had the potential bias that seals were already habituated to heavy boat traffic and hence more easily disturbed by rare vessel encounters on nonobservation days.

Compliance with regulations

We tracked every vessel within 600 m of the haul-out site with a Leica TC605L theodolite (±5 in. (127 mm) accuracy) and followed a standard methodology to determine position and speed of marine mammals and vessels (Würsig et al. 1991). We measured the vertical and horizontal angles of each vessel relative to the theodolite from when the vessel first came into sight until it was no longer visible, allowing us to collect three or more readings per vessel, including the closest perceived vessel approach to each haul-out site. The angle readings allowed us to estimate the distance of each vessel to the haul-out sites in the following manner: the tangent of the vertical angle and the height of the theodolite above sea level (after correcting for tide height) were used to calculate the horizontal distance from the observation post to each vessel. We followed the Law of Cosines to calculate the horizontal distance between each vessel and the haul-out sites. The height of the theodolite was determined with a stadia rod and a level at a given sea level; we adjusted this height according to tide levels, which were obtained from the software Tides and Currents, version 2.5b (Nautical Software, Inc., Jeppesen Marine, Portland, Oregon).

Seal disturbance and recovery

We observed seals continuously during the observation periods through 7 × 50 binoculars. We counted the number of seals hauled-out and in the water at 15 min intervals, distinguishing adults and pups by the much larger relative size of the adults, and recorded the largest adult seal count for the day. By counting pups, we were able to describe pupping season in the area and the potential impact of vessel disturbance on them. In addition, we employed digital video to record the behavior and numbers of seals when vessels moved nearby the haul-out sites. The counts allowed us to determine how many seals were apparently disturbed as a result of the presence of a vessel. A disturbance was defined as any activity that resulted in the flushing of seals from the haul-out site into the water (Suryan and Harvey 1999). After a disturbance, we monitored the number of seals at 5 min intervals for 180 min to estimate the amount of time at which seal numbers reached 50% and 100% of predisturbance levels on land. Individual identification was not assessed; therefore, we assumed that postdisturbance counts indicated resumption of haul-out behavior.

Statistical analysis

Compliance with regulations

We tested whether different vessel types (kayaks, stopped powerboats, and moving powerboats) differed in the distance to the haul-out sites with a single-factor ANOVA. We selected the closest distance from each vessel to either haul-out site. Owing to the large disparity in the number of passing powerboats relative to either stopped powerboats or kayaks, we randomly selected a subset of passing powerboats for analysis. Because variances were unequal, we log-transformed each distance to achieve homoscedasticity (Zar 1999). We also tested if the number of boats ≤600 m from the haul-out sites varied with weekend with a single-factor ANOVA.

Fig. 1. Mean (SD) number of adult and pup harbor seals (*Phoca vitulina*) at Yellow Island during the summer of 2004. Each datum represents 3 d of observations.

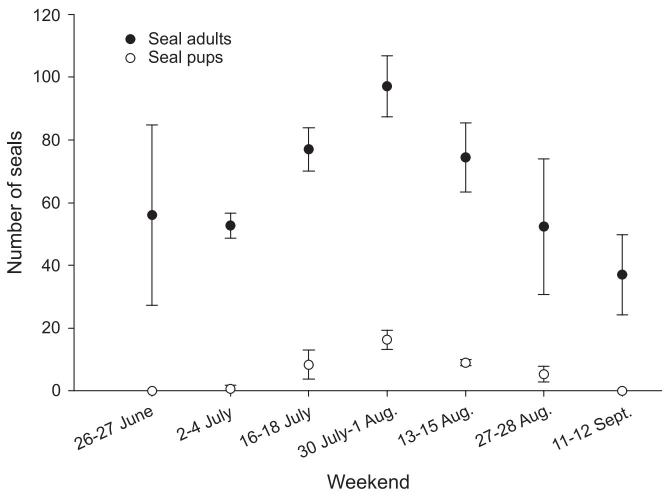
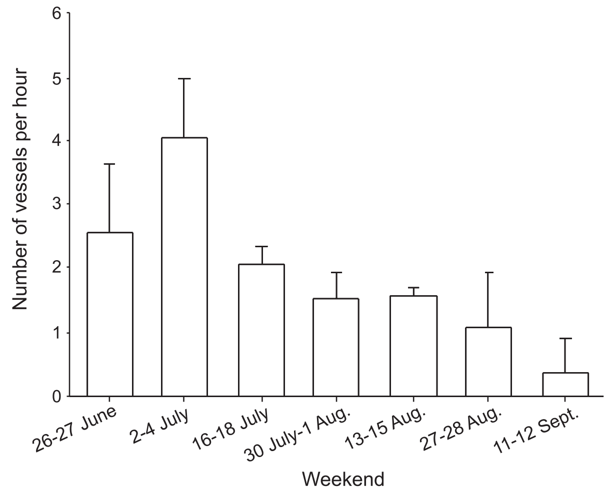


Fig. 2. Mean (SD) number of boats per hour within 600 m of harbor seal haul-out sites at Yellow Island during the summer of 2004. Each column represents 3 d of observations.



Seal disturbance and recovery

We tested whether the distance at which seals were disturbed and whether the time at which seals reached 50% and 100% of predisturbance numbers varied with vessel type. Because no moving powerboats disturbed the seals, the three analyses were conducted with *t* tests between kayaks and stopped powerboats as grouping variables. We also examined if seal disturbances were correlated with boat traffic or number of seals hauled-out with Pearson correlation tests.

Results

We observed no more than 108 seals at any one time in the study area. However, the number of adult seals hauled-out varied among weekends, peaking on the 30 July – 1 August weekend (one-way ANOVA: $F_{[6,19]} = 4.29$, $p = 0.01$) (Fig. 1). We were unable to distinguish adult males, adult females, or juveniles. Pups were first observed on the 2–4 July weekend; their numbers peaked to 19 pups on the 30 July – 1 August weekend, when they represented up to 17% of the total number of seals.

Compliance with regulations

We observed 7 kayak groups, 7 stopped powerboats, and 173 moving powerboats ≤600 m from either haul-out site in the 115.25 h of observation. The kayak groups averaged 2.4 ± 1.1 kayaks (mean ± SD), with a minimum and maximum of 1 and 4 kayaks, respectively. The distance (mean ± SD) of each vessel type from the closest haul-out site averaged 58.6 ± 21.7 m for kayaks, 112.3 ± 58.9 m for stopped powerboats, and 225.7 ± 92.2 m for passing powerboats. These average distances were significantly different from each other (one-way ANOVA: $F_{[2,20]} = 18.44$, $p < 0.001$; Tukey–Kramer MCT = 3.38, $p < 0.05$ for all pairwise comparisons). The 91 m buffer zone was violated by 6 of 7 kayak groups (85.7%, range of distances = 27.9–94.1 m), 4 of 7 stopped powerboats (57.1%, range of distances = 54.6–214.4 m), and 8 of 173 moving powerboats (4.6%, range of distances = 39.3–448.4 m).

The number of boats ≤600 m from the haul-out sites varied with the weekend (one-way ANOVA: $F_{[6,19]} = 7.88$, $p < 0.001$). The weekend with the highest number of observed boats was the 4 July weekend, peaking on 2 July when 5.1 boats per h were observed (Fig. 2). Boat traffic near the haul-out sites was related to tourism; only 11.2% of all the vessel types were commercial ships. Tourist vessels represented 96.3% and 90.0% of boat traffic during the two busiest weekends: 26–27 June and 2–4 July, respectively; this percentage diminished during the remaining weekends, reaching a low of 75% during the 27–29 August weekend.

Seal disturbance and recovery

We recorded 14 human-related disturbances during the study period in the seven weekends of the study: 26–27 June (4), 2–4 July (7), 16–18 July (1), 30 July – 1 August (0), 13–15August (2), 27–28 August (0), and 11–12 September (0). The largest numbers of disturbances were recorded during the two weekends with the highest boat traffic. This positive correlation between boat traffic and number of disturbances was significant (Pearson's correlation: $r = 0.93$, $p = 0.002$, $n = 7$). No correlation was observed between number of seals and number of disturbances (Pearson's correlation: $r = -0.23$, $p = 0.62$, $n = 7$).

At least one disturbance occurred on 50% of the observation days and more than one disturbance was recorded on 33% of the days. Disturbances were only observed in association with stopped powerboats and kayaks. Powerboats stopped either to observe seals or to fish in the area, while kayaks were circumnavigating the coastline of the island. The distance (mean ± SD) at which seals were disturbed averaged 91.0 ± 36.3 m for kayaks and 190.5 ± 124.8 m for stopped powerboats; however, the difference was nonsignificant (Student's *t* test: $t_{[12]} = -1.40$, $p = 0.19$). Seals went into the water when stopped powerboats were as far as 371 m and as close as 27 m from where they were hauling-out; kayaks elicited the same response when they were as far as 138 m and as close as 37 m. All seals, including pups, went into the water during a disturbance.

After a disturbance, the time (mean ± SD) that it took harbor seals to reach 50% of predisturbance levels averaged 5.7 ± 1.9 min for kayaks (n = 7) and 35.0 ± 44.6 min for stopped powerboats (n = 6). Perhaps because of sample size, there was no significant difference between the two vessel types (Student's t test: $t_{[11]} = -1.79$, $p = 0.10$). The time to reach 100% of predisturbance levels averaged 21.8 ± 20.7 min for kayaks (n = 4) and 55.4 ± 51.5 min for stopped powerboats (n = 5). Perhaps because of to sample size, there was no significant difference between the two vessel types (Student's t test: $t_{[7]} = -0.84$, $p = 0.43$). In 11 of the 14 disturbances, seal numbers recovered to 50% of the predisturbance levels in ≤10 min, and only on one occasion, the numbers did not reach this percentage within 180 min. In 7 of the 14 disturbances, seal numbers fully recovered to predisturbance levels in ≤60 min, and on five occasions, the numbers did not reach this percentage within 180 min.

Discussion

The vast majority of kayaks, 42.8% of stopped powerboats, and 7.5% of passing powerboats violated the buffer zone. Kayaks tended to follow along the shores of Yellow Island, explaining why they most closely approached the haul-out sites. Stopped powerboats drifted in the water as they approached the haul-out sites either to fish or to observe the seals (and at times yell at them). There is a channel marker located approximately 150 m southwest from the haul-out sites and passing powerboats traveled on the far side of the channel (presumably to avoid the shallow reefs), moving for the most part no closer than 91 m from the haul-out sites. It is then apparent that the marker inadvertently became a cost-effective manner to increase the distance between moving vessels and resting seals and hence minimize disturbances. It is unclear if vessels in other regions of the United States respect the 91 m zone. Given that laws protecting wildlife and the environment in other countries have been ineffective unless adequately enforced, even if the public is aware of them (Pagh 1999; Rowcliffe et al. 2004), it is likely that compliance levels are universally low.

Hauled-out seals did not engage in noticeable physical activity. Although we did not record specific behaviors, resting is the predominant behavior when seals are on land (Krieber and Barrette 1984; Henry and Hammill 2001). However, when kayaks and stopped powerboats were present at Yellow Island, seals became noticeably active and moved into the water. These disturbances occurred when stopped powerboats and kayaks were at distances as far as 371 and 138 m, respectively. Seals were unaffected by passing powerboats, even those approaching as close as 39 m, indicating that they have become tolerant of the brief presence of the vessels that do not pay attention to them. Hence, harbor seal disturbances were caused by vessels that lingered or slowly moved along the haul-out sites, such as kayaks or stopped powerboats, a reaction that has been reported in other areas (Allen et al. 1984; Suryan and Harvey 1999; Henry and Hammill 2001). Seals were not attracted to stopped powerboats that might have been fishing; they remained in the water away from the boats and did not move in a manner suggestive of taking baitfish. Hence, we believe that all seal reactions to vessels reflected disturbance rather than attraction.

Disturbances were positively correlated with higher boat traffic and did not correlate with seal numbers, suggesting that disturbances may be reduced by limiting the number of boats stopping or coming in close contact with the seals. The correlation also indicates that conducting observations during weekends did not bias the results; if seals had been habituated to days with heavy boat traffic (weekends) and more susceptible to days with few boats (weekdays), we would have expected a negative correlation between disturbances and weekend boat traffic.

In general, seals quickly recovered from disturbance. On average, all seals returned back to the haul-out sites in ≤60 min and only on 21% of disturbances did seal numbers not return to predisturbance levels within 180 min of the disturbance, even if a haul-out site was available. In sites where alternative haul-out locations are limited, such as the haul-out sites at Yellow Island, disturbances may result in site abandonment (Suryan and Harvey 1999). However, the return of seal numbers to predisturbance levels and the relatively regular seasonal cycle in abundance throughout the study argue against that idea.

Our study period included prepupping, pupping, and the very beginning of moulting (Huber et al. 2001). Although we did not notice moulting seals during the study, seasonal factors could have potentially affected seal reactions to boat traffic. Harbor seal hauled-out behavior varies by sex and season (Thompson et al. 1989) and this variability affects their response to boats. For instance, harbor seals do not enter the water as frequently in the presence of a boat during moulting season as during other seasons (Henry and Hammill 2001). A thorough understanding of the impact of vessels on seals at Yellow Island requires identification of the age structure to account for seasonal effect on disturbance responses.

Our results indicate that tourism-related vessels comprised the majority of boat traffic ≤600 m from either haul-out site at Yellow Island and were associated with all of the disturbances. It is unknown if vessel operators were mostly local residents or tourists without much information about the area. Although such data are important to inform specific management strategies and further research is recommended, it seems clear that without a combination of education and enforcement, violations of the buffer zone and harassment of seals will continue to occur. Ensuring that boat operators and kayakers receive information stating which areas are inhabited by wildlife and how they should approach them seems critical (e.g., http://www.nmfs.noaa.gov/pr/pdfs/education/viewing_northwest.pdf [accessed 20 December 2006]).

Our study indicates that a buffer zone should take into account the type of vessel and the approach that it is employing, suggesting that a fixed buffer zone, although practical, might not be always suitable. About 36% of disturbances resulted from stopped powerboats at a distance of >91 m from the haul-out sites. Yet, none of the few passing powerboats that violated the buffer zone apparently disturbed the seals. Our results allow us to predict that passing powerboats could come as close as 28 m from the Yellow Island haul-out sites without disturbing seals if the path of the boat diverged from the seals. In contrast, stopped powerboats and kayaks as far as 371 and 138 m from the haul-out sites, respectively, could potentially disturb seals. A flexible buffer zone that varies according to vessel type and activity seems difficult to implement; however, there are already a few flexible buffer zones in the United States. NOAA fisheries are divided into six geographic regions, some of which have different buffer zones for marine mammals, depending on the species (http://www.nmfs.noaa.gov/pr/education/regional.htm#ne [accessed 20 December 2006]).

This study addressed the case of vessels near a land site where harbor seals are hauled-out. Many seal and sea lion species in the United States and in the world haul-out in areas that are relatively accessible by vessel. Thus, we believe that the results and conservation implications of our study are applicable to other regions. Our four broad conservation recommendations are (*i*) a flexible buffer zone relative to vessel type and activity, (*ii*) a navigational marker around a haul-out site that forces vessels to remain distant, (*iii*) more intensive outreach and educational efforts, and (*iv*) enforcement of the buffer zone.

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