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Probable effects of resident and transient killer whales (*Orcinus orca*) on the activity levels of Steller sea lions (*Eumetopias jubatus*) at Carmanah Point, British Columbia

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Prey species that are able to efficiently and appropriately react to predators are likely to have an advantage over species that cannot, since accurate predator recognition will minimize the cost (time and energy expenditure) of unnecessary antipredator responses. This is particularly true if predators are present but only sometimes a threat, or if only a subset of the predator species is an actual threat. The latter is true with killer whales (*Orcinus orca*), which are predators of several pinniped species including fur seals (*Callorhinus ursinus*), harbor seals (*Phoca vitulina*), and Steller sea lions (*Eumetopias jubatus*). However, not all killer whales pose a threat to pinnipeds; some are mammal specialists, while others are fish specialists (Bigg *et al.* 1990). If these predator specializations are consistent, we expect that it would be advantageous for the pinniped species that encounters both forms of killer whale to be able to distinguish between them. Deecke *et al.* (2002) tested this question with harbor seals, and found that the seals could differentiate between the vocalizations of transients (mammal predators) and local residents (fish predators). Importantly, the seals only mounted antipredator behaviors in response to transients. Here, we have quantified the behavior of Steller sea lions in response to a natural encounter with unthreatening (resident) and threatening (transient) assemblages of killer whales at a haul-out site in the eastern North Pacific Ocean. In our natural experiment,

comparing activity levels during baseline and “treatment” encounters indicates that Steller sea lions are capable of distinguishing between the two forms of killer whales and respond only to those that pose a significant threat of predation.

Killer whales were determined to be a primary predator of sea lions with the identification of 14 sea lion flipper tags in the stomach of an adult killer whale carcass (Saulitis *et al.* 2000, Heise *et al.* 2003). Numerous anecdotal accounts and observations, coupled with stomach content analysis of many other killer whales since 1992 have supported this conclusion (Baird and Dill 1995, Heise *et al.* 2003). While the actual predation pressure imposed on Steller sea lions by killer whales remains unknown for the West Coast subpopulation, Maniscalco *et al.* (2007) showed that the Gulf of Alaska transient killer whales demonstrated heavy preference for Steller sea lions, and were responsible for 3%–7% of the annual 20% Steller sea lion mortality in the Kenai Fjord.

Killer whale populations in the north Pacific can be divided into three distinct, non-interbreeding assemblages that vary in their foraging behavior (often called ecotypes; Bigg *et al.* 1990, Krahn *et al.* 2007). Resident killer whales hunt and travel in relatively large matrilineal groups and eat fish exclusively (Ford *et al.* 1998, Saulitis *et al.* 2000, Herman *et al.* 2000). Transient killer whales, on the other hand, travel in small groups (often 3–5 individuals), and eat marine mammals (Baird and Dill 1995, Saulitis *et al.* 2000, Herman *et al.* 2000). Residents are known to echolocate continuously throughout foraging (Hawkins and Johnstone 1978, Ford 1991) whereas transients tend to use echolocation infrequently while hunting (Barrett-Lennard *et al.* 1996, Deecke *et al.* 2005), a difference that presumably relates to the hearing ability of their prey species. The last group, offshore killer whales, are known to consume foods distinct from those eaten by transients and residents (Krahn *et al.* 2007), but their diet and basic biology remains relatively unknown.

Our study was conducted during July 2008 at Carmanah Point lighthouse (48°36′–48°41′N, 124°45′–124°4′W) on the west coast of Vancouver Island, British Columbia, Canada. Observations were collected on the Steller sea lions of Sea Lion Rock, a moderately sized (70–160 animals) sea lion haul-out that is clearly visible from the lighthouse. This site was not considered a rookery, due to the fact that few pups are born here and adult males do not hold territories with females. Data were gathered from a vantage point (helicopter landing pad) that was 90 m from the lighthouse, at an elevation of 215 m, and 720 m away from Sea Lion Rock. A Celestron Ultima spotting scope with an 18–55× eyepiece was used for all observations. Scan sample counts of the Steller sea lions (Martin and Bateson 2002) were taken every 30 min beginning at 0700 and finishing when it became too dark to clearly see individuals (*ca.* 2200). Upon killer whale sightings, count times were shortened to every 15 min. The total number of sea lions on land and the number in the water surrounding the haul-out were recorded. The total number of sea lions on land was then further divided into the proportion of animals prone (*i.e.*, sleeping or laying), posturing (*i.e.*, upright but immobile and pointing its head upwards), moving (*i.e.*, moving while not changing location, such as active orientation, grooming, and head bobbing), or traveling (*i.e.*, terrestrial locomotion). Tidal heights and the general subjective level of noise due to sea lion vocalizations were also recorded with counts.

On 12 July 2008, at 0725, 27 killer whales were observed moving from west to east across the horizon. At 0730, they were estimated to be 100 m away from and directly parallel to Sea Lion Rock. They did not appear to change their trajectory or speed in response to the sea lions, and continued eastward until 0745, when they disappeared from sight. Radio communication with a local research vessel (Brian Gisbourne, captain of the *Michelle Diana* and crew) tracking the whales, revealed they were members of the J, K, and L pods (southern Vancouver Island resident killer whales).

At 2130 on the same day, five killer whales were observed approaching and circling Sea Lion Rock. Using the spotting scope, we were able to clearly identify them as transient killer whales (*i.e.*, they had pointed/triangular dorsal fins and open saddle patches) (Baird and Stacey 1988, Ford *et al.* 2000), but were not able to identify individuals. After approximately 2 min of circling at a distance of ~ 100 m from the haul-out, four of the whales were observed moving eastward away from Sea Lion Rock. While these four whales disappeared from sight shortly thereafter, the fifth whale was observed at 2147 still circling at a radius of ~ 75 m away from the haul-out. At 2152, this whale also disappeared from view.

To determine whether encounters with resident and transient killer whales affected the Steller sea lions at Sea Lion Rock differently, sea lion activities during the encounter were compared with those recorded on the same day before the arrival of killer whales (Pre), and at the same time on two prior days (10 and 11 July 2008) when there were no killer whale sightings (Control, Fig. 1). This control was necessary

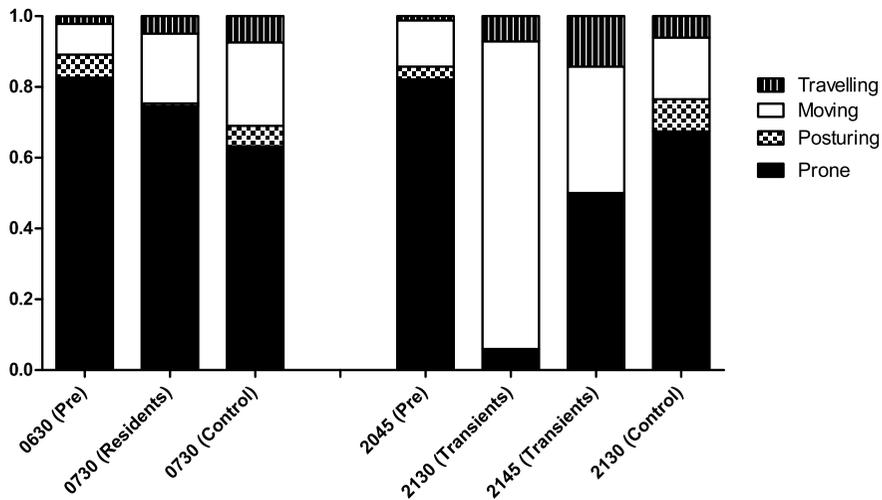


Figure 1. Activity levels of Steller sea lions (*E. jubatus*) at Sea Lion Rock, Carmanah Point, British Columbia. Total numbers of sea lions on the haul-out were counted, and the proportions of those prone, posturing, moving, and traveling were determined before (Pre), and during encounters with two ecotypes (Resident and Transient) of killer whales (*O. orca*). Activity levels were significantly different only during the transient encounter ($\chi^2 = 293.3$, $P < 0.001$). The “2145 (Transients)” bar shows the activities of sea lions 15 min after the apparent departure of the transient killer whales. “Control” bars show the activity of individuals at the same time of day as the killer whale encounters, but on days when no killer whale sightings were documented at Sea Lion Rock.

to ensure that regular peaks in Steller sea lion activity levels were not responsible for any observed changes that may otherwise be attributed to approaching killer whales. Also, it should be noted that no counts or behavioral recordings of sea lions in the water were recorded, due to the limited accuracy of counts and individual differentiation when in the water.

The results indicate that the presence of resident killer whales had little effect on the activities of Steller sea lions. Prior to the arrival of residents, 85% ($n = 114$) of the sea lions on the haul-out were prone. During the encounter, 75% ($n = 106$) of individuals remained in a prone posture. In comparison, 63% ($n = 77$) of the sea lions at the haul-out were observed prone during the previous 2 d at the same time of day (10 and 11 July 2008, 0730). The number of sea lions prone during the encounter with resident killer whales was within natural variation (Fig. 1).

In contrast, the appearance of transient killer whales later the same day significantly increased sea lion activity levels ($\chi^2 = 293.3$, $P < 0.001$; Fig. 1). Prior to the arrival of the transients, 82% ($n = 69$) of the colony was prone and 13% ($n = 11$) were moving. During the encounter, only 5% ($n = 5$) remained prone, while 87% ($n = 73$) of the colony began moving (Fig. 1). Observations indicate that 94% ($n = 79$) of the moving involved active orientation (presumably vigilance), with only 6% ($n = 5$) devoted to grooming or other movements such as head bobbing. In comparison, 76.5% ($n = 89$) of sea lions were prone at the same time of day when no encounters were observed on the previous 2 d (10 and 11 July 2008, 2130). In addition, posturing disappeared during the transient encounter, and 19 individuals (23% of the hauled out colony) jumped off the rock and into the water. Further, the transient encounter prompted substantially louder vocalizations from the sea lion colony, including a "barking" call not heard at other times. The subjective amplitude of vocalizations was also not matched at any other time during the study. Lastly, even after four of the transients had moved away to the east, an elevated proportion of the sea lion colony remained active (*i.e.*, at 2145; Fig. 1), perhaps as a result of their awareness that one transient remained behind. The sea lions did not return to the observed "normal" activity levels until 2205, 35 min after our initial sighting of transient whales. The most parsimonious explanation for the sudden and substantial increase in sea lion movement and general activity level observed is the presence of the transient killer whales.

On two occasions, large boats passing within 200 m of the haul-out caused a 24% and 32% increase in movement, respectively. However, these increases subsided within 5 min of the boats' departure, and were not correlated with mass evacuations of the haul-out, or a perceivable increase in vocalizations. No perturbations occurred during the times of killer whale sightings, and events, such as eagles overhead, aircrafts, or large waves at other times did not cause changes in Steller sea lion activity.

Our observations indicate that Steller sea lions appear to be capable of predator identification and reaction, since their responses reflected the level of threat posed by resident and transient killer whales. This behavioral tactic decreases the costs associated with antipredator defense.

An approach by resident killer whales did not result in changes to activity levels or induce alarm responses. In contrast, an approach by transient killer whales resulted

in increased movement on the haul-out, accounted for mostly by increased vigilance behaviors. The approach of transients also seemed to cause sea lions to increase the amplitude of their vocalizations, and evacuate the haul-out in favor of the water. It remains unclear why the sea lions evacuated the haul-out when a known predator was nearby and it was clearly safer to remain out of the water. However, we speculate that the chaos caused by the transient approach simply caused individuals sitting on the perimeter of the haul-out to be pushed off.

Our preliminary results differ from those of Permyakov and Burkanov (2009) but appear to support the findings of Deecke *et al.* (2002). Permyakov and Burkanov (2009) found that Steller sea lions in the Kuril Islands only reacted to a small proportion (9%) of killer whale encounters. However, they were not able to confirm the ecotype (fish or mammal eater) of the whales. In the majority of these encounters, the killer whales were >100 m away from the sea lions and did not appear to be hunting, so it may be that most encounters were not with mammal eating killer whales. Of the 18 encounters observed at distances <100 m, 9 (50%) elicited responses. Although it is difficult to compare these observations directly with our own given our limited sample size, it does suggest that distance may be an important cue in distinguishing predators, since while no predation events were witnessed in our study, transient killer whales clearly appeared to be harassing the hauled out sea lions. Deecke *et al.* (2002) found that harbor seals reacted strongly to transient but not to local resident killer whale vocalizations, indicating a clear ability to discriminate between ecotypes and mount responses appropriately. Importantly, while it is known that transient and resident vocalizations are distinct (Ford 1991, Foote and Nystuen 2008), transients are generally silent while hunting (Barrett-Lennard *et al.* 1996, Deecke *et al.* 2005) indicating that the antipredator response mechanism of seals is selective habituation to local resident vocalizations while responding to unfamiliar vocalizations or silent predator approaches (Deecke *et al.* 2002). While it seems logical to presume that Steller sea lions also use vocal cues (or the absence thereof) to distinguish residents from transients, our study could not provide any evidence to suggest this to be the case. It is possible that the sea lions reacted to the predatory behavior of the transients, since they circled the haul-out repeatedly, while the residents did not show interest in the sea lions. However, given that both groups came within 100 m of the haul-out, it would appear that distance was not what elicited the strong reaction to transients. It may also be possible that sea lions cue in on visual signals, such as the body shape or swimming pattern differences between ecotypes. If this is the case, our observations may be especially interesting, since the transient approach occurred during sunset, a period of limited visibility. More research is certainly warranted to determine whether visual, auditory, or an unexplored mechanism elicits antipredator responses in Steller sea lions.

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