Reducing vessel noise increases foraging in endangered killer whales

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Science translation by Cindy Elliser, PhD 2022

Abstract

Disturbance from underwater noise is one of the primary threats to the critically endangered southern resident killer whales (SRKWs). Previous studies have demonstrated that SRKWs spend less time feeding when vessels are present. Size and speed of boats affects the amount of noise they make. In 2018, we measured the effects of a voluntary vessel slowdown action in SRKW critical habitat to assess whether ship speed affects foraging behaviour. We observed SRKWs and ships from land-based sites on San Juan Island, WA, USA, overlooking the Haro Strait slow-down area. Results showed that as noise levels increased, the SRKW were more likely to stop foraging, or not start at all – so overall they were foraging less. Reducing ship speed, and therefore ship noise amplitude will help decrease the probability of ship noise disrupting SRKW foraging activity and may help to increase their ability to locate and catch salmon.

Introduction

Underwater noise is one of three primary threats to the survival and recovery of southern resident killer whales, along with not enough prey and chemical pollution. Southern resident killer whales (SRKWs) depend on salmon, and in particular, Chinook salmon. Previous studies have shown that SRKWs spend less time feeding in the presence of all vessel types than in their absence (Lusseau et al. 2009; Holt et al. 2021). Years of not enough food is associated with high SRKW death rates and low birth rates, shrinking their population size. As efforts are underway to increase the number of Chinook salmon available to the whales, actions to reduce noise and disturbance may help to increase the proportion of salmon that are accessible to the whales.

The amount of noise that comes from a vessel is called the source level, and the louder this is, the harder it is for whales to communicate (Figure 1).

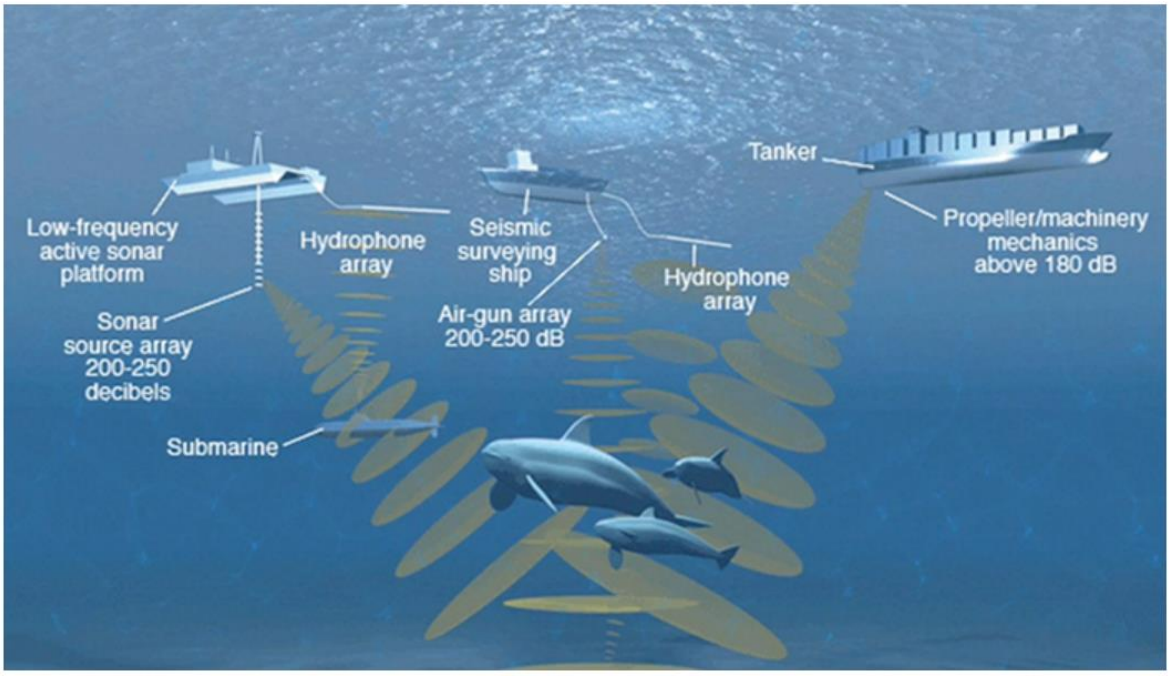

Figure 1| Source levels from a variety of vessels impact killer whales ability to hear their own echolocation clicks and pod members' calls. Diagram by NOAA

Imagine trying to talk with your friends at a loud concert – how easy would it be to make a plan to go find some food for lunch? SRKWs use different calls to communicate with each other during foraging and use echolocation clicks to find food. By making the waters quieter, we can make it easier for the whales to hear their clicks and each others' calls over greater distances.

In summer 2018, the ECHO program asked ships to slow down to 11 knots while in Haro Strait. Haro strait, west of San Juan Island, is a key SRKW foraging area in the summer months, making it a great place to study the relationship between vessel noise levels and foraging behavior of SRKW. Previous studies showed that for each 1 knot reduction in speed, ship noise is reduced by about 1 dB (Veirs et al. 2016). The ECHO program recorded a 2.5 dB reduction in noise in Haro Strait on average with the decreased ship speeds during their study. And that was with just over half of the ships slowing down, as requested.

Of course, slowing down means the ship will take longer to get through the area and the noise will be present longer. However, reducing the amplitude of ship noise will increase the range that the orcas' burst-pulse calls (likely used for group coordination in cooperative foraging), and echolocation clicks (used during prey detection and capture) can be detected over the background noise, which we expected would result in more salmon capture success!

A theodolite is a surveying instrument with a rotating telescope for measuring angles (Figure 2). We used theodolites from shore to track whales' positions in relationship to ships movements and noted the whale's behavior.

Our **research question** was, what are the effects of reducing noise level from ships and small boats on SRKW foraging behavior? Our **hypothesis** was that reducing noise levels would increase the chances that SRKW would be foraging.

Figure 2 | A theodolite measures angles, distances, elevation, and more to calculate distances of objects from one another. Image by Billie Grace Ward, Flickr CC 2.0

Methods

From July 12th to Oct 1st, 2018, rotating teams of observers tracked whale and boat activity from locations along the west side of San Juan Island (Figure 3).

Using theodolites and math called trigonometry, we can determine the position and location of the whales in relation to the vessels. A team of 3 observers (the theodolite tracker, a computer operator and observer with spotting scope and binoculars) observed an individual or small group of whales for 20 minutes at a time.

Whales were identified using saddle patch and fin shapes and compared with the photo-identification catalogue made by the Center for Whale Research.

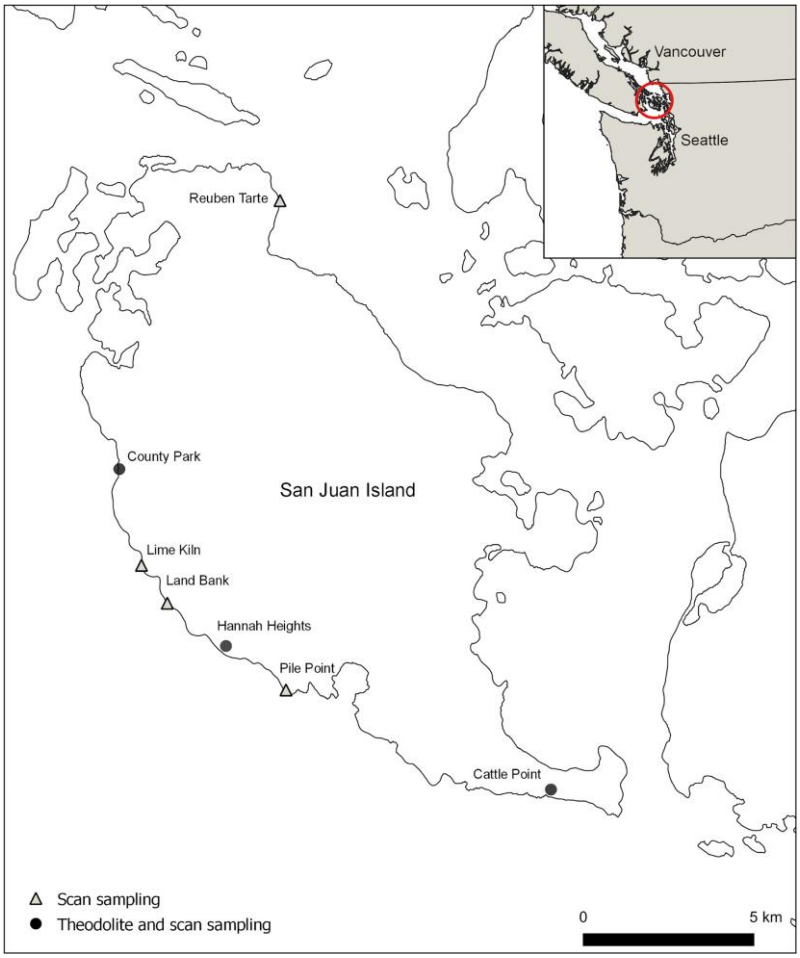

Figure 3| Map of field sites used for tracking whales and ships during the 2018 field season.

A special computer program called Pythagoras was used to collect, manage, and analyze the theodolite data. In addition, we recorded whale behavior: swimming speed, how close together they were, and how synchronous their movements were (did they all surface together at the same time?). Then we assigned the whale's behavior to one of four activity states: travelling, foraging, resting, and socializing (Table 1).

Table 1

Whale behavior categories recorded every 5 minutes along with number of whales in the subgroup, and types, numbers, and distances of boats and ships from the whales.

Activity Code	*Definition*
Resting	Long surface periods, moving slowly
1	Deep rest – whales hanging, logging, not making progress forward
2	Slow travel
Traveling	Progress through the water with a group of more than 4 whales
3	Moderate travel – travel without "porpoising"
4	Fast travel – travel with "porpoising"
Foraging	Progress through the water by lone whales or while a member of a subgroup of 4 or fewer whales
5	Dispersed travel - foraging in a directional manner
6	Milling, feeding, pursuit of prey: foraging involving changes in direction
Socializing	Interacting with another whale or species in a non-predator-prey way.
7	Tactile - touching another whale, such as petting or nudging
8	Display - socializing that does not involve touching, but may include behaviours such as spy hops, tail slaps and breaches

We also documented the number and location of ships and boats in relation to where the whales were. Of course, all this was only done when we were actually lucky enough to find whales, which occurred on just 29 out of 82 days in the field (such is wildlife science!).

We used mathematical equations to calculate noise level each time the whale surfaced during each activity type. Our equations were based on vessel type and speed and how close they were to the whales. We used a model, or math equation, that reveals how some parts of the environment affect others, to look at how likely it was that the noise level from boats and ships factor affected the whales' decision to forage or not forage.

Results

We were able to observe whales 740 time during scans and record 34 theodolite tracks of whales and ships (Table 2). Note that *n* stands for sample size (number of observations in this case).

Table 2

SRKW behavioural data were derived from a combination of scan samples ($n = 740$) and theodolite tracks ($n = 34$) collected between July and September 2018. The below sample sizes are based on the total number of scan samples.

SRKW behavioural data	Sample size
Pod	
J pod	166
Mixed group (J, K, and/or L pods)	47
K pod	3
L pod	11
Unidentified	513
Sex	
Males	450
Females and/or unidentified juveniles	501
Age class	
Adults	425
Juveniles	155
Calves	98
Unidentified	497

Our observations showed that whales foraged more without ships present (Figure 4).

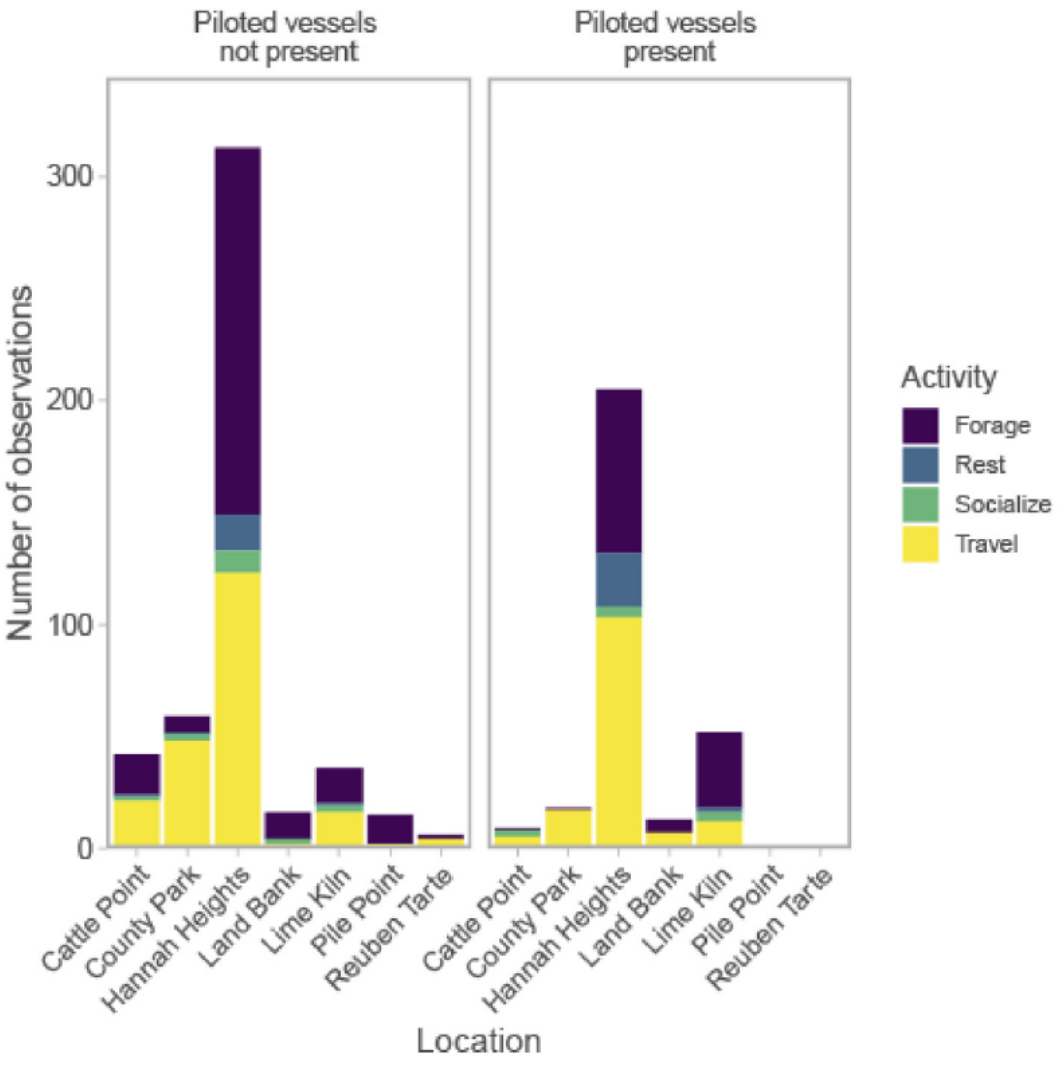

Figure 4| Sample size (5-minute scan sample observations) by location, activity, and presence or absence of piloted ships within 10 km at the time of the observations.

Our mathematical models showed that as boat and ship noise levels increased, it had a strong effect on SRKW stopping foraging (Figure 5). Noise levels had a lesser effect on if they would start foraging, but still showed they were less likely to start as noise levels increased. This means that the whales were more likely to switch from foraging to another behavior (or not start foraging at all) when the noise levels began to get too loud.

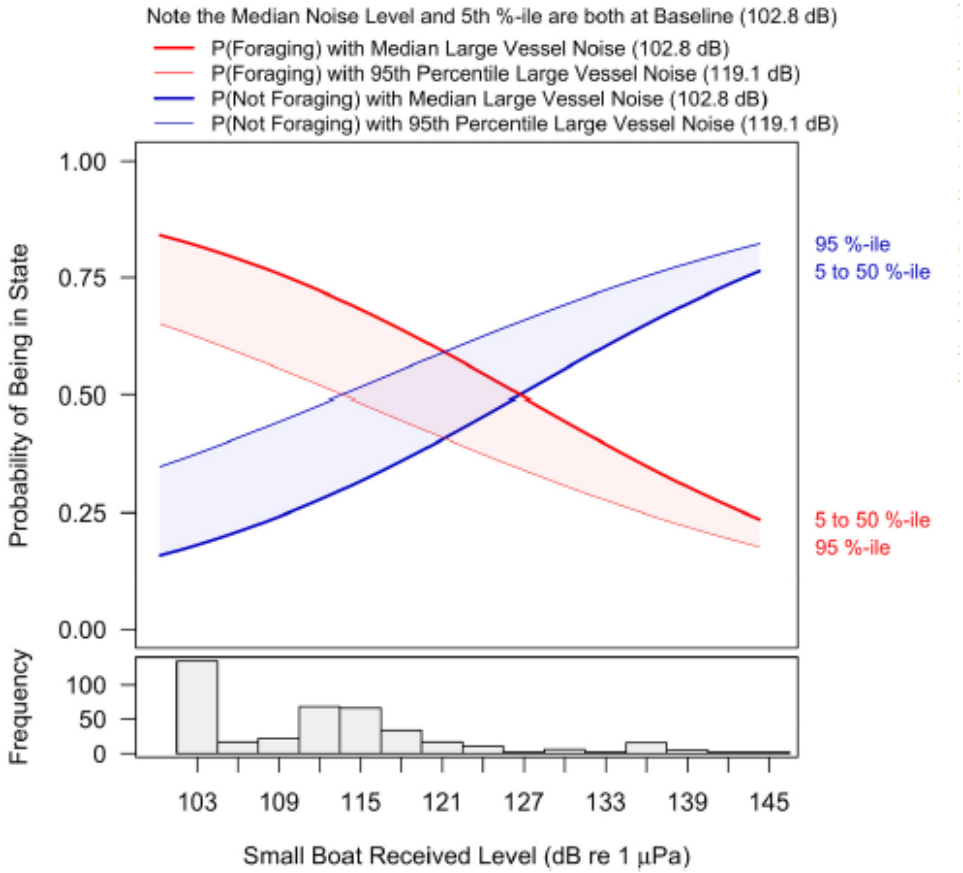

Figure 5|This graph shows the probability (P) of whales foraging (red line) and not foraging (blue line) in relation to noise levels from small boats (thin red or blue lines) and large vessels (thick red or blue lines). The main thing to note here is as you go to the right on the x-axis, vessel noise increases, the probability of not foraging increases (blue lines) and the probability of foraging decreases (red lines).

Discussion

The behavior of SRKW was shown to be affected by the level of boat and ship noise in their surroundings. They were less likely to start foraging in the first place, and more likely to stop foraging, as the noise levels increased. This means that their time spent foraging overall is decreased, and this can have a strong effect on their overall health. Imagine you had to go and

collect/capture food - how much could you collect in only 2 hours versus 5 hours, would it be enough?

It is important to remember that all models have uncertainty in them (we can't account for everything in a model!), but the evidence strongly indicates that reducing noise levels received by SRKW increases the chances that they will continue to forage in Haro Strait. This is supported by other research that has shown that slowdowns can reduce noise levels and that this benefits the whales (Ross 1976; Veirs et al. 2016).

There are a few different ways to reduce noise for whales:

- Reduce vessel speed
- Move shipping lanes away from prime foraging habitat
- Replace the noisiest vessels in the fleet and/or making them quieter.

These results suggest reducing noise should be a primary goal to help SRKW survive.

Potential improvements to research design

We acknowledge that the choice of model has limitations, and that a different model may be needed to explore other relationships in the data. Additionally, regulations for boats being around killer whales have increased in recent years, so that vessels must stay farther away from the animals (vessels are now required to stay 200m away instead of 100m). This means that there were not as many boats that were close to the whales. While that is good for the whales, it also reduces the researcher's sample size, or how much data they have to analyze. Since the sample size is relatively small, we acknowledge that having a larger sample size might increase our confidence in the results.

In the future, to improve the study, we suggest that noise levels could be directly measured by hydrophones (underwater microphones) and more detail on the types of small boats and their noise level could be collected. It is also important to know how much time the SRKW need to spend feeding to meet their nutritional needs. We suggest future studies that include bioenergetic models that help determine how much food an animal needs and foraging efficiency - how much energy has to be spent to capture a prey item. This will help determine how much of an effect the decreased foraging time due to increasing noise has on the health of the SRKW.

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