Can singing be used to predict critical habitats?

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ABSTRACT

Climate-induced changes may be more substantial within the marine environment, where following ecological change is logistically difficult, and typically expensive. As marine animals tend to produce stereotyped, long-range signals, they are ideal for repeatable surveying. In this study we illustrate the potential for calling rates to be used as a tool for determining habitat quality. With a good understanding of the vocal behaviour of the species, their seasonal and diurnal patterns, sex and age-related differences, an underwater passive-acoustic survey conducted alongside a visual survey in an arc of 4,225 km across the Davis Sea, Eastern Antarctica, showed that while acoustic and visual surveys identified similar regions as having high densities, the acoustic surveys surprisingly identified the opposite regions as being 'critical' habitats. We propose that density surveys of species that cannot be differentiated into population classes can be misleading because overall density can be a negative indicator of habitat 'quality' for some species where dominant individuals secure space in prime habitats.

Recent climatic change has affected a broad range of organisms with diverse geographical distributions. These include changes in phenology, the timing of seasonal activities of animals and plants, range shifts and changes in the distribution patterns of species, changes in the composition of and interactions within communities, and the structure and dynamics of ecosystems (Walther *et al*., 2002).

Acoustic surveying is often used to monitor terrestrial species such as birds (Laiolo *et al.*, 2008), frogs (de Solla *et al*., 2005), and bats (Mayer and von Helversen, 2001), which are secretive, elusive or uncommon, but exhibit species-specific, easily detectable vocalizations. With the recent increase in the sophistication and capability of marine acoustic devices (Mellinger *et al.,* 2007; Van Parijs *et al*., 2009) attention is now focusing on the use of acoustic techniques for improving site-occupancy challenges for marine animals.

Under special conditions where distance sampling methods are compromised and the target species have highly stereotyped calling behavior, as is the case for many marine animals, conventional 'timed-count' methods, typically used for surveying songbirds (Buckland *et al*., 2001), may be appropriate.

Here we explore a case study of how passive-acoustic monitoring greatly enhanced ecological understanding of marine species. We discuss different ecological situations where passive-acoustic monitoring could lead new light on ecological questions.

We used the leopard seal, *Hydrurga leptonyx,* as a case study to examine how passive-acoustics performed, as estimating its distribution patterns and abundance using traditional visual survey effort has faced challenges, with research hampered by the inaccessibility of the seals, as well as the logistical difficulties of conducting surveys within the Antarctic pack ice.

Leopard seals are important top predators in the Antarctic ecosystem, and are a potential source of information on ecosystem interactions and environmental variability over a wide range of spatial and temporal scales.

They are an ideal species to conduct an acoustic survey on as they occur at low densities (Southwell *et al*., 2008), their behavior is secretive and they spend long periods of time in the water making them unavailable to visual surveys.

During a traditional visual survey conducted as part of an internationally coordinated program under the Scientific Committee of Antarctic Research (SCAR), the APIS (Antarctic Pack Ice Seal) program, there was so few leopard seals sighted that it was a major obstacle in developing population estimates from the data (Southwell *et al*., 2008; Forcada *et al*., 2012]. The resulting range of plausible estimates were correspondingly very wide (Southwell *et al*., 2008) and the authors cautioned the use of these estimates. Coupled with this high uncertainty are the peculiar logistical difficulties of working within the Antarctic pack ice, which made the visual survey effort expensive. Alongside one of the APIS programs' visual surveys (Southwell *et al*., 2008) we conducted a passive-acoustic survey and here we propose to use this opportunity to examine how the passive-acoustic survey performed in comparison to the visual survey.

Underwater passive-acoustic recordings were made from 4 December 1999 to 10 January 2000 at 101 sites within the pack ice between 64°31'S, 149°31'E and 67°17'S, 62°42'E within the Davis Sea, Eastern Antarctica. This timing coincides with the peak underwater vocalizing period for the leopard seal and the height of their breeding season. At the time of the survey this comprised an area of 1,500,000 km^2 and included all areas with $>^{1}/_{10}$ ice-cover between 64°E and 150°E (Southwell *et al*., 2008). This area would represent the majority, if not all, of the breeding population between these longitudinal boundaries (Southwell *et al*., 2008).

At the time of the acoustic surveys a visual survey for pack ice seals was being conducted off the same survey platform, the *RSV Aurora Australis* (Southwell *et al*., 2008). Each underwater recording was made remotely using a sonobuoy (Sparton Electronics AN/SSQ-57A) which sampled over a frequency range from 10 to 22,000 Hz. The signal was recorded using a Sony Digital Audio Tape recorder (DAT TCD-D8) with a frequency bandwidth range between 10 and 22, 000 Hz ± 3 dB. Recordings of thirty-minute duration were made at each acoustic survey point between 1600 and 0300 hours (local time), coinciding with what was believed to be the diurnal calling behavior for the leopard seal (Thomas and DeMaster, 1982).

Here the survey was conducted as a timed cue count as incorporating distance measures into sampling was not possible. In order to estimate the abundance of a species using underwater acoustic recordings we need to take into account not only the acoustic behaviour of the animal, that is the stereotypy of their calls and temporal pattern of calling behaviour, but also the detection probability of the animal's calls themselves, which accounts for the physical acoustics of the call as well as the features of the underwater environment.

Here we capitalized on the leopard seals calling behaviour in both the stereotypy in the rate at which they produce the most frequently heard Low double trill call, as well as the potential to use this same call to identify different age cohorts. Passive acoustics provided the ability to distinguish between the calls of adults and sub-adults using their acoustic features namely the fundamental frequency (F_0) of the Low double trill calls, the rate of vibration of the vocal folds (Titze, 1994), as an age-related classification tool as older seals produce calls with higher fundamental frequencies (Rogers, 2007).

Leopard seal calls were detected acoustically in most of the study sites, in this instance using passive acoustics to identify the simple presence or absence of animals as a survey tool offered less value. If we had intended to use acoustics as a spatial 'presence or absence' detection method we would have identified nearly all areas as being important habitat, with no ability to distinguish between locations.

As solitary leopard seals call during the breeding season as part of a long-range display, their calls are designed to travel great distances underwater. This means that the acoustic range is broad and therefore not surprising that the likelihood of detecting animals at any of the sites was very high, nor that at any site there were several overlapping calls in both the near and far fields, indicating that two or more seals were detected at any one location.

The acoustic data identified similar regions to the visual surveys (Southwell *et al*., 2008) as having higher densities of leopard seals. However, the acoustic surveys identified the higher-density areas as having more sub-adult seals where as the lower-density areas had adult seals.

This supports a concern that density can be a negative indicator of habitat quality for some species (Van Horne, 1983). High density as an indicator of 'high' quality habitat can be misleading in species where dominant individuals secure space in prime habitats, forcing subordinate individuals to aggregate in large numbers in marginal areas (Van Horne, 1983; Bock and Jones, 2004).

Unlike the acoustic surveys, in this circumstance visual surveys did not have the capacity to provide age-related information. Density surveys that cannot differentiate between population classes could be misleading for species where overall density can be a negative indicator of habitat quality because dominant individuals are territorial and secure the prime habitats.

Under special circumstances acoustics can offer enormous advantage over traditional techniques and open up monitoring to regions that are remote, difficult and expensive to work within, no longer restricting long-term community assessment to resource-wealthy communities.

Acoustics has the ability to open up monitoring to regions that are remote, difficult and expensive to survey as well as to species that are secretive, rare, at low-densities or just difficult to work on.

Passive-acoustics can be extremely cost effective compared to traditional surveys (Mellinger et al. 2007), and opens up long-term monitoring to communities that are more resource restricted, no longer restricting long-term community assessment to resource-wealthy communities.

As climatic change affects a broad range of organisms across geographic boundaries (Walther *et al*., 2002) we propose that capitalising on the significant advances in passive acoustic technology, alongside physical acoustics and population modelling, will help address ecological questions more broadly. Such tools are useful to faunal managers and scientists alike and can be used across faunal taxa that use stylized repetitive calling, which occurs commonly in marine animals.

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