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# InfoNorth

## Vocal Behaviour of Killer Whales in the Eastern Canadian Arctic and the Role of Calls in Predator-prey Interactions

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### INTRODUCTION

The life history of most Arctic and sub-Arctic species is closely tied to the sea ice. Thus, changes in sea ice features (e.g., extent, timing) have a myriad of impacts on the ecology of species. For marine mammals, sea ice changes have strong impacts on availability and timing of food (Hop et al., 2011), interactions with other species (Matthews et al., 2020), movement patterns (Higdon et al., 2014), and other aspects of their lives. Further, in many Arctic and sub-Arctic regions, various marine mammal species are of cultural, ecological, and economic significance, and thus the continual changes are also impacting human communities. In turn, marine mammals are impacted by anthropogenic activities combined with climate related changes. Therefore, to conserve marine mammal species and the human communities for which they are important, there is a need to better understand and be able to monitor their behaviour and interactions.

Most marine mammals rely on vocalizations as their primary modality for communication, navigation, foraging, and predator avoidance (Tyack, 1981; Janik and Slater, 1998; Madsen et al., 2002; Stimpert et al., 2007). This primary role of acoustic communication is thought to be due to the longer distance over which sound, compared to light (visual signals), can travel underwater (Urick, 1983). Thus over the last several decades, bioacoustics, particularly passive acoustic monitoring (PAM), has become a powerful and popular tool to study various aspects of marine mammal ecology. Understanding vocal behaviour—the number and types of calls produced and the context in which they are used—is important as it may allow PAM to be used to observe both the presence/absence of a species along with activity patterns within a given area. Further, the increased utility of PAM would allow a better understanding of aspects of ecology such as the time spent in different activities (Papale et al., 2017), habitat use (Frankel et al., 1995), communication space (Wang et al., 2016), and how flexible vocal behaviour is under different conditions (Holt et al., 2009). Investigations of vocal behaviour have begun for some marine mammal species, but many others remain understudied.

Killer whales (*Orcinus orca*) are a highly vocal species of cetacean that are exhibiting changes in movement and residency patterns throughout their range. Killer whales are top predators in every ocean basin (Forney and Wade, 2006) and thus can have a large impact on shaping ecosystems. Linked to decreasing sea-ice extent and timing, killer whales are increasing in prevalence in the circumpolar Arctic (Higdon and Ferguson, 2009). In the Eastern Canadian Arctic (ECA), this increasing prevalence (Higdon et al., 2014; Lefort et al., 2020) is leading to an increase in the temporal and spatial overlap of killer whales with narwhals (*Monodon monoceros*), belugas (*Delphinapterus leucas*), bowhead whales (*Balaena mysticetus*), and seals (Pinniped spp.), all of which are preyed upon by killer whales (Ferguson et al., 2012; Higdon et al., 2012; Matthews and Ferguson, 2014). This has led to growing concern over the lethal and non-lethal impacts that killer whales may have on these prey species, most of which are of cultural and economic importance to local communities.

Much of the work related to killer whales in the ECA has been in response to this growing concern from local Inuit communities about the impact of killer whales on subsistence species, such as narwhal. Traditional ecological knowledge (TEK) has been critically important in understanding the baseline and changing presence of killer whales in the ECA, and ongoing and new work aims to add to and compliment this existing knowledge. There have been extensive efforts in recent years to understand various aspects of killer whale ecology (Higdon et al., 2014; Lefort et al., 2020). Studies have examined prey preferences (Ferguson et al., 2012; Higdon et al., 2012; Matthews and Ferguson, 2014), the non-lethal impacts of killer whales on prey species (Breed et al., 2017; Matthews et al., 2020), and population size and relatedness to other killer whales in the North Atlantic and ECA (Lefort, 2020). These studies have employed a variety of methods such as interviews to synthesize TEK, satellite tagging, stable isotope analysis, and photo-identification. Despite the increasing effort, little is known about the vocal behaviour or group structure, in terms of relatedness or stability, of killer whales in the ECA or the extent of their impact on other marine mammal species.

Killer whales produce three main categories of vocalizations: whistles, clicks, and pulsed calls (Diercks

et al., 1973; Steiner et al., 1979; Awbrey et al., 1982; Ford, 1987). Whistles are continuous, mainly tonal sounds that are generally variable and are produced commonly during periods of socialization (Ford, 1989). Clicks are rapid and brief bursts of sound used for echolocation (Ford, 1987). Lastly, pulsed calls are the predominant sound produced by killer whales during most activities, consisting of rapidly repeated pulses that result in the calls appearing tonal (Ford, 1987). Pulsed calls are proposed to function in general contact, maintaining group cohesion, or to aid in individual recognition among relatives (Ford, 1984, 1989; Miller, 2002). Pulsed calls are often highly stereotyped, allowing them to be classified into distinct categories and compared across groups (Ford, 1989; Selbmann et al., 2021). In the North Pacific, where killer whales have been most extensively studied, Ford (1984) described the presence of group/pod-specific dialects of pulsed calls. It was later determined that group-specific dialects and the broader vocal traditions of clans provide measures of maternal relatedness and, therefore, information about the amount of movement of individuals among sympatric or geographically close groups (Ford, 1991; Strager, 1995; Yurk, 2005; Deecke et al., 2010; Selbmann et al., 2021). Thus, studying killer whale vocalizations can provide information on their behaviour, interactions with both con- and heterospecifics, and group structure.

The overall goal of my work is to contribute to an understanding of how killer whales influence Arctic ecosystems. Specifically, I propose to examine links between killer whale calls and behavioural/social context and investigate the interactions of killer whales with their marine mammal prey species, such as narwhal, using vocal behaviour. First, I hypothesize that the vocal behaviour of killer whales in the ECA will be influenced by social and behaviour context. I predict that killer whales will vary the amount of calling and call types according to behavioural context, with more complex behaviours (e.g., during an active attack) expected to be associated with more calling and more diverse call types than simpler behaviours (e.g., resting); and within a given behavioural context, that the amount of calling will vary with group size, (e.g., larger groups expected to produce more calls to coordinate more individuals than smaller groups) and composition (e.g., more calling by mother-calf pairs than between unrelated individuals). Second, I hypothesize that killer whales will influence the vocal behaviour of their prey species, such as narwhals, when in close proximity and vice versa. As narwhals will likely be the focal prey species, predictions will focus on their interactions with killer whales, but could be applied to other prey species that may be observed. I expect that narwhals will reduce calling, go silent, or produce alarm calls once they detect killer whales, either directly by detecting killer whale calls or indirectly through acoustic cues from con- or heterospecifics (i.e., reduced calling, alarm calls), and that killer whales that are hunting narwhals will reduce calling or go silent as they move closer to narwhals to similarly avoid detection. Lastly, the data collected to address these hypotheses, in combination with ongoing photo-identification work, will be used to examine whether killer whales in this region form stable groups and have group-specific dialects, as is found in other regions (Ford, 1984, 1987).

## RESEARCH APPROACH

The start of data collection for this project was delayed because of the global pandemic, resulting in data collection during the summers of 2022 and 2023. This work is being conducted out of two communities on Baffin Island, Pond Inlet (Mittimatalik) in the Eclipse Sound region and Pangnirtung in the Cumberland Sound region (Fig. 1). In the Eclipse Sound region, data for this project will be collected primarily in Milne Inlet where killer whales have been sighted in past years (Lefort et al., 2020) and are being seen more regularly and for longer periods (Ferguson et al., 2010; Higdon et al., 2014). Narwhals are common in Milne Inlet (Marcoux et al., 2009) and Tremblay Sound (Heide-Jørgensen et al., 2002). In Cumberland Sound, whales are also being seen more often and for longer periods, and it is an important habitat for belugas and bowhead whales (Richard and Stewart, 2009; Young et al., 2020; Watt et al., 2021). This makes these areas ideal locations to study both the interactions of killer whales with some of their marine mammal prey types and the potential impacts of increasing killer whale presence. Approval for drone observations and dip hydrophone recordings was obtained from both communities for 2022.

To address my first hypothesis, I will integrate acoustic recordings from a portable, dip hydrophone with drone-based observations. I will be collecting acoustic recordings using a Cetacean Research Technologies C57 hydrophone with a DR-110mkIII Handheld digital stereo recorder or a Tascam Portacapture X8 high resolution adaptive multi-recorder. I will collect concurrent behavioural observations using a DJI Phantom 4 drone during August – September 2022 – 23 in Milne Inlet, Nunavut (Fig. 1). Our collaborator, Ricky Kilabuk, will repeat the same protocol using the same equipment in Cumberland Sound, Nunavut, during July – August 2022 (Fig. 1). The boat will be positioned approximately 300 – 500 m from a focal group of killer whales and in the direction of travel when possible. Recording sessions will be in intervals of up to 30 minutes, ending either when the drone battery is exhausted or when killer whales move out of the range of the drone. From drone videos, I will record the number of individuals present along with group composition information using size and height of dorsal fins (Steiner et al., 1979; Clark and Odell, 1999), combining this data with the existing photo-identification catalogue for the Eclipse Sound region. I will use focal group sampling to record the predominant behaviour of the group in 30 second intervals and ad libitum sampling to note any other contextual information (e.g., presence of other con- or heterospecifics, presence of other vessels, other behaviours from focal group members). I will

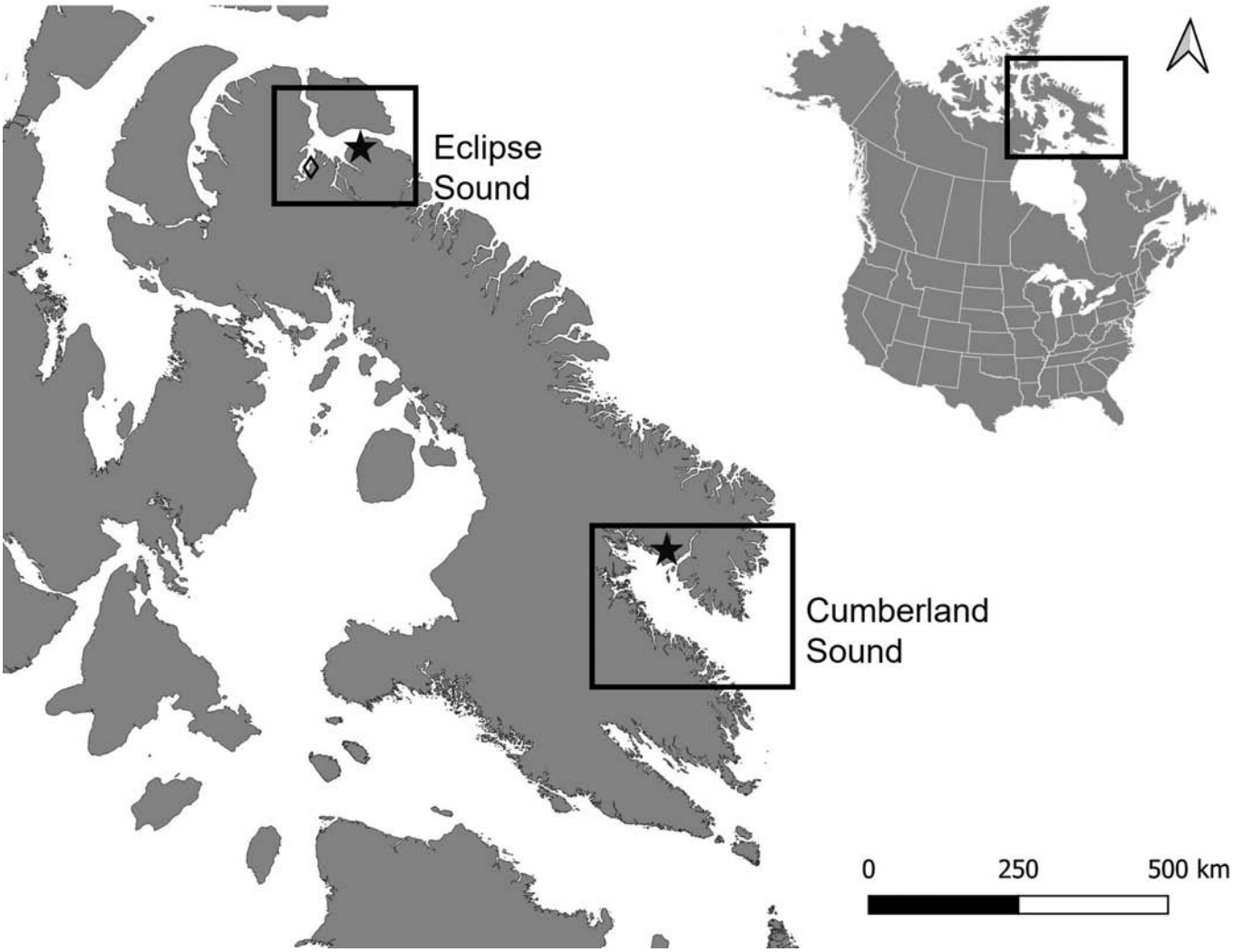


*Fig. 1. Map of Baffin Island, Nunavut, Canada, indicating the Eclipse Sound region where the community of Pond Inlet (star) and Milne Inlet (diamond) are located, and Cumberland Sound, where the community of Pangnirtung (star) is located.*

manually examine dip hydrophone recordings for killer whale calls and classify them into call types based on their aural/visual features in comparison to existing repertoires in other regions (Steiner et al., 1979; Ford, 1987; Deecke et al., 2005; Selbmann et al., 2021). The 30 s intervals from the drone videos will be matched to the same 30 s intervals from the dip hydrophone recordings. To examine whether call behaviour varies with social and behavioural context, I will use generalized linear models to quantify how the number of each call type (response variable) varies with behaviour (e.g., foraging, travelling; predictor variable) and social context (e.g., group size, prey type; other predictor variables).

To address my second hypothesis, I will use both the data collected for the first hypothesis and recordings from a past array of bottom-mounted hydrophones and field observations from 2017–19 collected in Tremblay Sound and Milne Inlet. Our collaborator, Ricky Kilabuk, will opportunistically collect dip hydrophone recordings, with or without drone videos, of beluga and bowhead whales in Cumberland Sound when killer whales are absent and present. This data will be used to examine temporal and spatial overlap of killer whales with narwhals in the Eclipse Sound region and with belugas and bowhead whales in Cumberland Sound. From acoustic recordings, I will quantify the number of calls from killer whales, narwhals, belugas, bowhead whales, and any other potential prey (e.g., pinniped spp.). I will integrate these recordings with drone-based observations and past field observations of the presence/absence of killer whales and their prey within ~1-2 km of hydrophones. These observations will be supplemented when available with presence/absence of these species from sightings reports from local people (2022–23) and aerial surveys conducted by the Baffinland Mine. Species presence/absence will be used to determine whether reduction in call activity or absence of calls reflects absence of animals or silence. I will use generalized linear models to determine whether the vocal behaviour of killer whales and their prey species, specifically, amount of calling and call types (response variables), varies with the

presence/absence of other marine mammal species in the area (predictor variables).

Lastly, to explore group-specific dialects in the Eclipse Sound region, I will use a combination of the ongoing photo-identification catalogue and dip hydrophone recordings. During hydrophone recordings, another member of the research team (Caila Kucheravy, MSc student) will collect photographs of the focal killer whales as well as any non-focal killer whales in the immediate area. These photos will be compared to the existing photo-identification catalogue for the region. Information on the number of different individuals and any associations from the catalogue, along with previous genetics work in the region (Lefort, 2020), will be used to inform whether an examination of group-specific dialects might be warranted for Eclipse Sound killer whales. If stable associations are identified, I will examine calls recorded from different groups during observations. I will focus on pulsed calls, as that is the call type in other regions that shows group-specificity (Ford, 1987, 1991; Deecke et al., 2010). I will take a set of measurements of the acoustic features of the calls following previously established methods and measurements (Sportelli, 2019; Madrigal et al., 2021; Selbmann et al., 2021) and use a random forest analysis and a principal component analysis to determine whether call types differ among groups, indicating group-specific dialects.

## COLLABORATIONS

Local Inuit have been involved in related killer whale and narwhal research programs in Nunavut since 2009. In Eclipse Sound, local Inuit researchers took the lead on equipment deployment and data collection during the 2020 and 2021 field seasons, and these partners will continue to be involved in my research. I am involving the Mittimatalik Hunters and Trappers Organization (HTO) and Pangnirtung HTO as well as other interested community members in both study areas in research design and implementation, thereby integrating both traditional ecological knowledge and cultural perspectives in my research. I am committed to disseminating research findings in a culturally sensitive manner (e.g., in-person meetings, translations into Inuktitut), thereby helping ensure my research can inform management decisions that benefit both the wildlife and the communities.

## SIGNIFICANCE

Knowledge of the call use (e.g., social/behavioural context, dialects), predator-prey interactions, and habitat use of killer whales will inform management and conservation of killer whales and their prey (e.g., narwhal, beluga), many of which are of cultural and economic importance for Inuit and may be negatively affected by increasing killer whale presence in the Arctic (Ferguson et al., 2012; Breed et al., 2017; Lefort et al., 2020; Matthews et al., 2020). Further understanding of the impact of killer whales could help inform prey stock assessments to help ensure a sustainable harvest of the prey species. Using recordings and observations to examine whether different groups exist and use acoustic dialects, as found in other regions (Ford, 1991; Strager, 1995; Yurk, 2005; Deecke et al., 2010; Selbmann et al., 2021), could help in understanding population and group structure of killer whales in the ECA. Further, although PAM has become a powerful tool for monitoring many marine mammals, without an understanding of call context, it is generally limited to monitoring presence/absence. Knowing the contexts in which calls are used could allow PAM to be used to monitor the activities of killer whales in the ECA throughout their residency with relatively little effort and disturbance as compared to surveys and observations. In turn, this increased utility of PAM could aid in assessing the impacts of and responses to climate-driven changes for this species.

The data collected in this project will contribute to the ongoing monitoring of marine mammals in both the Eclipse Sound and Cumberland Sound regions. Although efforts to understand killer whale impacts have increased over recent years, the addition of further understanding of how calling behaviour relates to other behaviour will improve monitoring capacity in these regions. This will be critical as sea ice conditions and killer whale temporal and spatial presence continues to change. For the Pond Inlet region, the presence and potential expansion of the Baffinland Mine presents numerous challenges for monitoring and management. Therefore, it is even more critical to understand what impact killer whales are having and how that impact might be compounded by the impact of anthropogenic activities and changing climatic conditions on other marine mammals in the region.

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