RESEARCH/REVIEW ARTICLE

Killer whale (*Orcinus orca*) photo-identification in the eastern Canadian Arctic

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Abstract

We identified individual killer whales (*Orcinus orca*) using recent (2004–09) photographs to obtain a minimum count of whales that use eastern Canadian Arctic waters. Fifty-three individuals were identified from nine different sightings; 11 individuals from western Hudson Bay sightings and 42 from the areas around northern and eastern Baffin Island. One whale was re-sighted: an adult female or large juvenile photographed 17 days and 375 km apart at Churchill, Manitoba, and off-shore of Rankin Inlet, Nunavut, in August 2007. With only one individual re-sighted, the number of individuals that use this area is likely much larger. No re-sightings occurred between Arctic killer whales and individuals photographed off the coast of Newfoundland. Our results represent the minimum number of killer whales sighted in eastern Canadian Arctic waters and provide the foundation for further killer whale research. Little is known about Arctic killer whales and, as a top predator, it is unclear what effect they have on Arctic marine ecosystems.

The killer whale (*Orcinus orca*) is a highly recognized cetacean species known to occur in all oceans (Leatherwood & Dahlheim 1978; Heyning & Dahlheim 1988). While widely distributed, other than in a few well-studied areas such as the North Pacific (Bigg et al. 1990; Ford et al. 2000), Antarctica (Pitman & Ensor 2003) and the north-east Atlantic (Foote et al. 2009, 2010), relatively little is known about the majority of killer whale populations. This is especially true for the Canadian Arctic where, historically, killer whales have not often been observed, have not been traditionally hunted and have not been the subject of any in-depth scientific studies (Baird 2001).

There has been a recent increase in the number of reported killer whale sightings in some areas of the Canadian Arctic, which could be related to a change in killer whale distribution, an increase in population size and/or an increase in sighting effort (Higdon 2007). Historically, killer whales occurred in Davis Straight and Baffin Bay (Reeves & Mitchell 1988) but have only recently arrived in the Hudson Bay region (Higdon & Ferguson 2009). It has been suggested that some areas of the eastern Canadian Arctic are becoming more accessible to killer whales as the concentration of sea ice in choke points decreases with climate change (Higdon & Ferguson 2009). This is consistent with the findings of Reeves & Mitchell (1988) who believed the presence of killer whales in Arctic waters has been historically limited by the presence of pack ice in winter, in contrast to Antarctic waters where killer whales occupy sea-ice areas (Gill & Thiele 1997).

Long-term photo-identification studies can be a highly effective, non-invasive method of study used to increase understanding of a given species or population in a variety of ways. For killer whales, photo-identification studies have been used to study social structure and to estimate population size or to obtain minimum counts (Bigg et al. 1990; Leatherwood et al. 1990; Dahlheim 1997), to study range size and patterns of movement (Matkin et al. 1997; Dahlheim et al. 2008) and to understand the overall biology and natural history of

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populations (Olesiuk et al. 1990; Ford et al. 2000; Saulitis et al. 2000).

Killer whales are an ideal species for photo-identification studies because they have a number of unique features that are easily identifiable in good quality photographs and can be used to distinguish individual whales (see Bigg et al. 1990; Dahlheim 1997; Ford et al. 2000; Visser & Makelainen 2000). Determining the sex of individuals identified in the photographs is important in understanding social structure and population dynamics. Adult male killer whales are larger than females and they have a much taller, straighter dorsal fin, while females and juvenile males have a shorter, curved dorsal fin (Baird 2001).

Photo-identification has also been used in some areas to differentiate between killer whale populations. Physical characteristics such as dorsal fin shape and saddle patch pigmentation are known to vary considerably between some populations (Baird & Stacey 1988; Ford et al. 2000). These populations may also vary in one or more of natural history patterns, social structure, vocal behaviour and diet (Baird & Stacey 1988; Barrett-Lennard et al. 1996; Ford et al. 1998; Ford et al. 2000; Baird 2001; Foote & Nystuen 2008). One of the best examples of this occurs off the Pacific coast of North America, where two well-studied sympatric populations, termed "residents" and "transients", differ in a number of characteristics including saddle patch pigmentation patterns, dorsal fin shape and diet (Ford et al. 2000; Baird 2001). A third, less studied sub-group, termed "off-shore" killer whales, also occurs here and can be differentiated from "residents" and "transients" by physical characteristics and diet (Baird 2001; Dahlheim et al. 2008). Similarly, Antarctica is home to three distinct killer whale forms: Types A, B and C that also differ in physical and behavioural characteristics, such as the presence or absence of a dorsal cape, the size and orientation of the eye patch and diet (Pitman & Ensor 2003). Differentiation between two sympatric types of killer whale in the north-east Atlantic has also been observed. Foote et al. (2009) confirmed the presence of a smaller generalist type (Type 1) that feeds on both fish and marine mammals and a larger specialist type (Type 2) that feeds on marine mammals.

The objectives of this study were to identify individual killer whales photographed in the eastern Canadian Arctic and to obtain a minimum count of the number of individuals using these waters. Digital photographs of killer whales were opportunistically collected during 14 sightings in western Hudson Bay and around Baffin Island from 2004 to 2009 (Fig. 1). Photographs were obtained from a number of sources including Inuit hunters, eco-tourists, students, researchers and professional photographers with a variety of different camera models. To assess photograph quality, we followed the methods of McSweeney et al. (2007). Based on a number of criteria, photographs were placed into one of four categories: poor, fair, good or excellent. Based on the presence of unique features, individuals in the fair, good and excellent quality photographs were also given a distinctiveness score of (1) not distinctive, (2) slightly distinctive, (3) distinctive or (4) very distinctive (McSweeney et al. 2007). To ensure a higher level of confidence in our results and to avoid counting the same individuals twice, photographs rated as poor quality and individuals rated as not distinctive were not included in the analyses.

Photographs were cropped and, when needed, brightness/contrast adjustments were made using Adobe Photoshop 7 to reveal more detail in the dorsal fin and saddle patch. For each sighting, slightly distinctive, distinctive and very distinctive whales with a photo-quality rating of fair, good or excellent were assigned a number and counted as an individual. Individuals from each sighting were compared to determine if there were any re-sightings. Photographs from this study were also compared to an online collection of photographs containing 43 individual killer whales sighted off the coast of Newfoundland (www.atlanticwhales.com).

Both the left and right sides of the whales were used for comparisons because of limited availability of photographs. To compare dorsal fin shapes/nicks from photographs of left and right sides, Photoshop was used to flip one of the photographs to allow for a more direct comparison when images were overlaid. Unfortunately, this method is only effective for comparing whales that have very unique fin shapes or nicks that are visible from the left and right sides. Therefore, it is possible that a small number of whales were counted as two separate individuals. As the size of our photographic catalogue increases this limitation will be eliminated. The type of saddle patch pigmentation patterns of photographed whales was assessed to allow for comparisons to other populations. The different saddle patch pigmentation patterns are described in Baird & Stacey (1988) and consist of three complex patterns (vertical notch, horizontal notch and hook) and two less complex patterns (smooth and bump patterns).

Fifty-three individuals were identified from photographs of nine killer whale sightings over the years of 2004–09. Additional sightings north of Cape Churchill, Manitoba (near point 3 on Fig. 1), in 2004; at Rankin Inlet, Nunavut, in 2006; two sightings north of Baffin Island near Pond Inlet, Nunavut, in 2004 and Pangnir-

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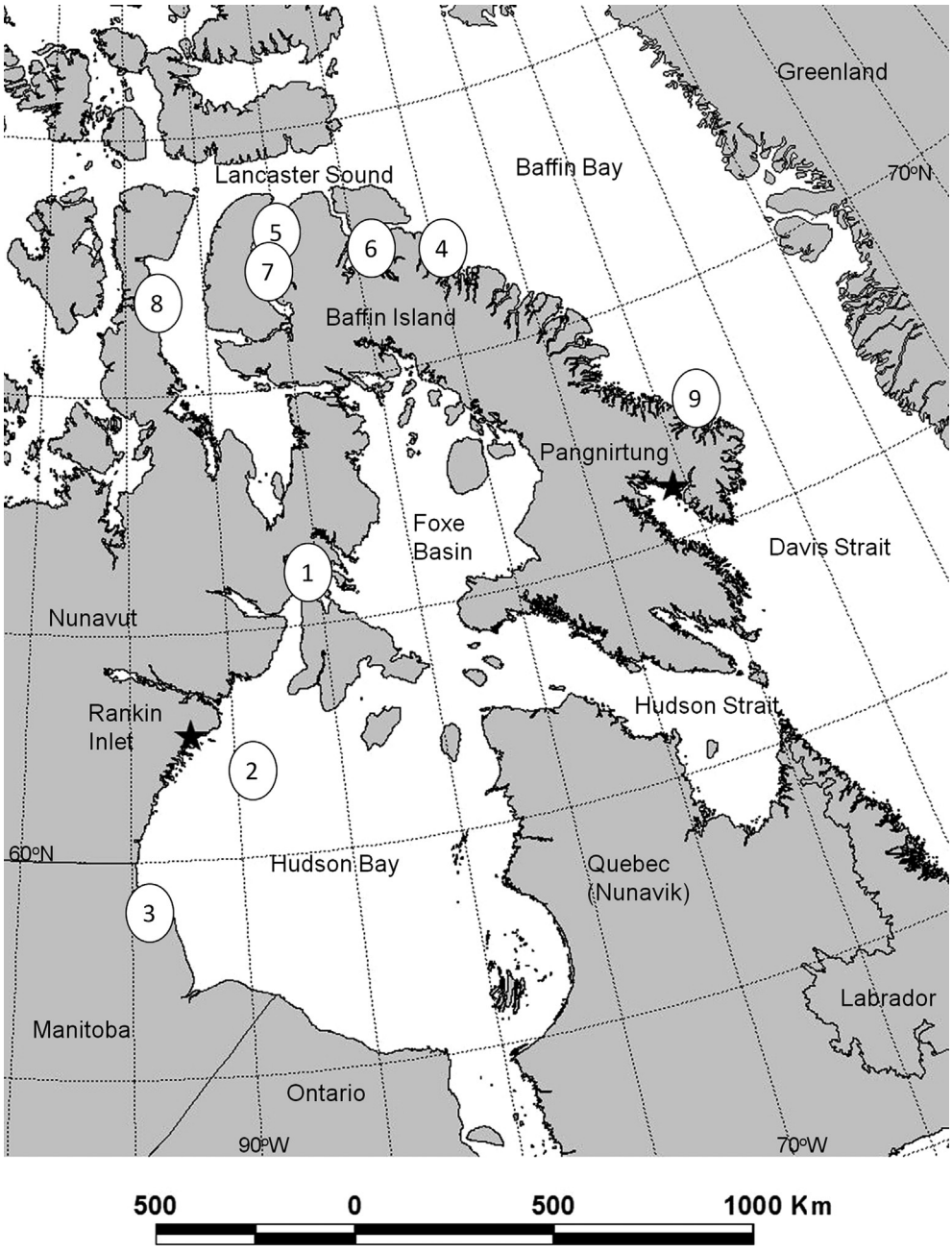

Fig. 1 Locations of photographed killer whale (*Orcinus orca*) sightings in the eastern Canadian Arctic between 2004 and 2009. The numbers on the map correspond to the sightings presented in Table 1.

tung, Nunavut, in 2008 (Fig. 1) were not included in the analyses because they contained only poor quality photographs or non-distinctive individuals. Out of the 53 identified whales, 11 were from western Hudson Bay and 42 were from northern and eastern Baffin Island (Table 1). A discovery curve (Fig. 2) shows a strong linear increase in the number of identified individuals, suggesting that the actual number of killer whales that make use of eastern Canadian Arctic waters is higher and more whales are expected to be identified in coming years. Based on dorsal fin size, 12 of the 53 whales were adult males, 34 were either adult females or sub-adult males and 7 were juveniles. Calves were also photographed during two sightings (Table 1) but were not included as individuals because they lacked distinctive markings and/or photographs were of poor

Table 1 Photographed killer whale (*Orcinus orca*) sightings in western Hudson Bay and Baffin Island between 2004 and 2009. The number of adult males and total number of whales reported by observers are compared with the numbers of individuals identified in the photographs. When calves were photographed, they were not counted as individuals because they lacked distinctive markings or the photographs were of poor quality. The sighting numbers correspond to map locations represented in Fig. 1. Latitude and longitude are expressed as decimal degrees.

					Number reported		Number identified				
Sighting number	Date	Location	Latitude	Longitude	Adult males	Total	Adult males	Adult females/sub-adult males	Juveniles	Calves seen	Total
Western Hudson Bay											
1	20/08/05	Repulse Bay, NU	66.37	–86.06	N/A	5–10	2	0	0	No	2
2	05/08/07	south-west Hudson Bay (off-shore of Rankin Inlet)	61.78	–91.06	N/A	7–9	0	5	2	Yes	7
3	22/08/07	Churchill, MB	58.86	–94.21	2	7	0	3	0	No	3
Baffin Island											
4	26/08/04	Buchan Gulf, NU	71.76	–74.34	N/A	N/A	1	1	0	No	2
5	20/08/05	Kakiak Point, NU	72.72	–86.32	1	12–15	1	2	0	No	3
6	11/08/08–13/08/08	Pond Inlet, NU	72.07	–80.5	N/A	12–30	5	7	2	Yes	14
7	15/08/09, 19/08/09	Kakiak Point, NU	72.63	–86.34	3	15–20	2	14	2	No	18
8	2/09/09	Bellot Strait, NU	72.28	–93.63	2	20	1	2	1	No	4
9	19/09/09	Qikiqtarjuaq, NU	67.78	–64.07	N/A	N/A	0	1	0	No	1

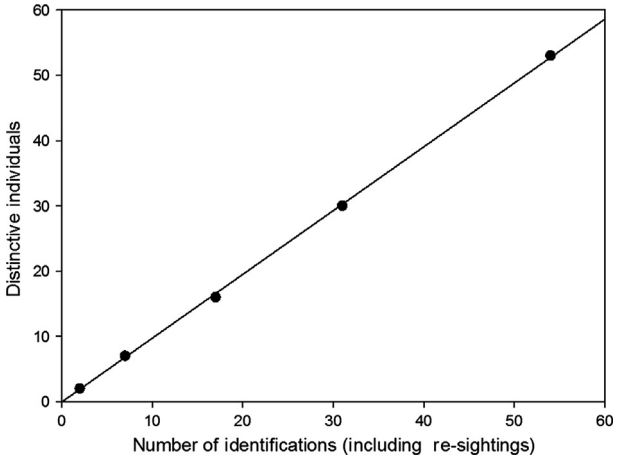

Fig. 2 The discovery curve of the total number of distinctive individual killer whales (*Orcinus orca*) versus the total number of identifications (including re-sightings) made in the eastern Canadian Arctic between 2004 and 2009.

quality. It is possible that the ratio of adult males to females/juveniles is biased towards males because they may be more likely to have distinctive markings and to be photographed by observers. For western Hudson Bay based on observer reports, group size ranges between five and 10 individuals (Table 1). In the areas around Baffin Island when observer reports were given, group size ranges between 12 and 30 individuals (Table 1). All 45 individuals with visible saddle patches had the smooth type of pigmentation pattern that is seen in residents, transients and off-shore killer whales in the North Pacific.

A group of seven to nine whales were reported off-shore of Rankin Inlet, Nunavut, on 5 August 2007 and 17 days later on 22 August 2007, a group of seven whales were reported to the south at Churchill, Manitoba (Table 1). We identified one adult female or large juvenile that was photographed at each of these two sightings. This re-sighting was based on a prominent nick in the dorsal fin (Fig. 3) as well as the timing and locations of the two sightings.

The behaviours of the photographed killer whales were not always available in the observer reports but at least one of these groups was observed attacking and feeding on narwhal (*Monodon monoceros*) at Kakiak Point in Admiralty Inlet on 20 August 2005 (Laidre et al. 2006). During the Kakiak Point sighting in 2009, large pieces of narwhal skin and blubber presumed to be remnants of a killer whale attack were observed and photographed. According to analysis of killer whale sighting records in the Canadian Arctic and West Greenland over the years 1756–2006, narwhal appears to be a common prey item (Higdon 2007). In general, marine mammals have been commonly reported as prey, while reports of Arctic killer

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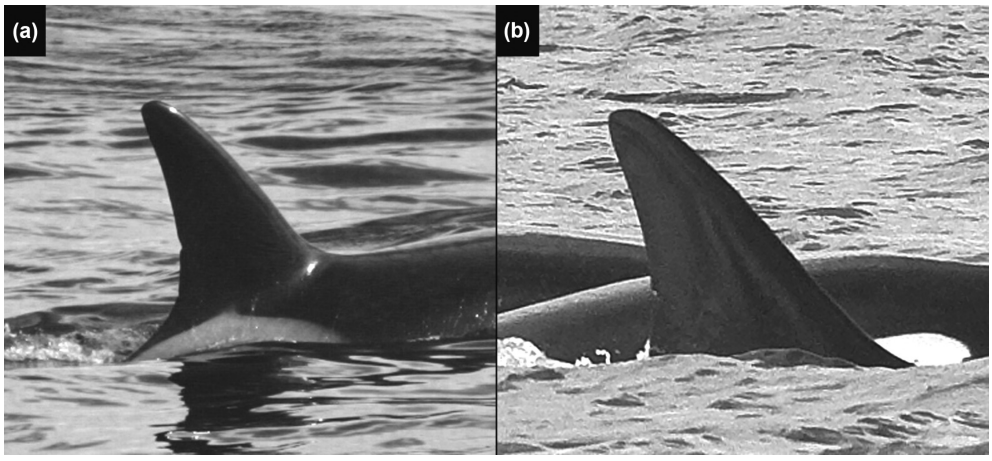

Fig. 3 An adult female or large juvenile killer whale was photographed (a) off-shore of Rankin Inlet, Nunavut, on 5 August 2007 (photographer: Trevor Lush/Students on Ice) and (b) at Churchill, Manitoba, on 22 August 2007 (photographer: Mike Macri). Note the nick in the trailing edge of the dorsal fin.

whales feeding on fish were rare (Higdon 2007). While it is known that Arctic killer whales prey on marine mammals, it is possible that they also prey on fish and are more of a generalist population, similar to Type 1 killer whales in the north-east Atlantic (Foote et al. 2009). In order to understand their diet preferences, close observation of individuals for extended periods would be required as well as diet studies that make use of stable isotope and fatty acid analysis of killer whale tissue and/or analysis of faecal samples.

The eastern coast of North America was suggested by Reeves & Mitchell (1988) as a possible over-wintering area for eastern Canadian Arctic killer whales. The comparison of our photographs with those from Newfoundland and Labrador did not reveal any re-sightings between the two areas. As both sets of photographs were taken over the summer months, any matches between the two catalogues would not have confirmed an over-wintering area but would have suggested that Arctic ranging killer whales also make use of areas off the coast of Newfoundland and Labrador.

Other over-wintering areas that have been suggested include areas of the open Atlantic Ocean east of Labrador, south of Greenland and east of Newfoundland (Reeves & Mitchell 1988). It is also possible that these Arctic whales range as far south as the Caribbean Sea (Mitchell & Reeves 1988). In August 2009, one killer whale was tagged in Admiralty Inlet (northern Baffin Island) and by mid-November it had travelled into the open Atlantic Ocean, nearly as far as the Azores (Matthews et al. 2011). Further comparison of photographs between the Arctic and other photographic catalogues may confirm a wintering area for eastern Canadian Arctic killer whales. In addition to photo-identification studies, satellite telemetry of killer whales tagged in the Arctic will improve our knowledge of movements, migration and over-wintering areas (Matthews et al. 2011).

The results of this study, the first killer whale photo-identification study in the Arctic, indicate their widespread use of eastern Canadian Arctic waters (also see Higdon 2007; Higdon et al. in press). As the length of the ice-free season increases (Gagnon & Gough 2005), some areas of the eastern Canadian Arctic will become more accessible to killer whales (Higdon & Ferguson 2009). A number of marine mammal species are expected to experience changes in distribution and abundance as they adapt to changing conditions and compete for resources (Tynan & DeMaster 1997). Killer whales are known to prey on marine mammals (Higdon 2007; Ferguson et al. 2010; Higdon et al. in press) and it is unclear exactly how an increased presence of this top predator will impact food web dynamics of Arctic marine ecosystems. Continued photo-identification work on Arctic killer whales will allow us to better understand the biology, natural history, abundance, distribution and movements of this population and to understand what role they may play in the changing Arctic ecosystems.

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