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ARTICLE

The utility of drones for studying polar bear behaviour in the Canadian Arctic: opportunities and recommendations[1]

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Abstract: Climate-induced sea-ice loss represents the greatest threat to polar bears (*Ursus maritimus* Phipps, 1774), and utilizing drones to characterize behavioural responses to sea-ice loss is valuable for forecasting polar bear persistence. In this manuscript, we review previously published literature and draw on our own experience of using multirotor aerial drones to study polar bear behaviour in the Canadian Arctic. Specifically, we suggest that drones can minimize human–bear conflicts by allowing users to observe bears from a safe vantage point; produce high-quality behavioural data that can be reviewed as many times as needed and shared with multiple stakeholders; and foster knowledge generation through co-production with northern communities. We posit that in some instances drones may be considered as an alternative tool for studying polar bear foraging behaviour, interspecific interactions, human–bear interactions, human safety and conflict mitigation, and den-site location at individual-level small spatial scales. Finally, we discuss flying techniques to ensure ethical operation around polar bears, regulatory requirements to consider, and recommend that future research focus on understanding polar bears' behavioural and physiological responses to drones and the efficacy of drones as a deterrent tool for safety purposes.

Key words: animal behaviour, behavioural ecology, unmanned aircraft systems, *Ursus maritimus*.

Résumé : La perte de glace de mer causée par le climat représente la plus grande menace pour les ours polaires (*Ursus maritimus* Phipps, 1774), et l'utilisation de drones pour caractériser leurs réactions comportementales face à la perte de glace de mer est important pour prévoir la persistance de l'ours polaire. Dans ce manuscrit, les auteurs passent en revue des documents publiés antérieurement et ils se fondent sur leur propre expérience de l'utilisation de drones aériens multirotor pour étudier le comportement des ours polaires dans l'Arctique canadien. Plus précisément, les auteurs suggèrent que les drones peuvent réduire au minimum les conflits entre les humains et les ours en permettant aux utilisateurs d'observer les ours d'un point de vue sécuritaire; produire des données comportementales de grande qualité qui peuvent être examinées autant de fois que nécessaire et

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être partagées avec de multiples intervenants; et favoriser la production de connaissances par la coproduction avec les collectivités du Nord. Les auteurs postulent que, dans certains cas, les drones peuvent être considérés comme un outil de rechange pour étudier le comportement d'alimentation des ours polaires, les interactions interspécifiques, les interactions entre les humains et les ours, la sécurité humaine et l'atténuation des conflits, ainsi que l'emplacement des tanières à de petites échelles spatiales individuelles. Enfin, ils discutent des techniques de vol pour assurer une exploitation éthique autour des ours polaires, des exigences réglementaires à prendre en compte, et recommandent que les recherches futures se concentrent sur la compréhension des réactions comportementales et physiologiques des ours blancs aux drones et sur l'efficacité des drones comme outil de dissuasion à des fins de sécurité. [Traduit par la Rédaction]

Mots-clés : comportement animal, écologie comportementale, systèmes d'aéronefs sans pilote, *Ursus maritimus*.

1. Introduction

The Arctic has received much attention from conservation biologists in recent years as this region is experiencing increasing temperatures at up to three times the global average rate (Koenigk et al. 2013; Voosen 2020; AMAP 2021). Warming in the Arctic has resulted in rapid deterioration of seasonal sea-ice cover (Stroeve and Notz 2018), which has been particularly detrimental to polar bears (*Ursus maritimus* Phipps, 1774) throughout their circumpolar range (Derocher et al. 2011; Bromaghin et al. 2015; Lunn et al. 2016). Polar bears primarily hunt marine mammals using the sea-ice (Stirling and Archibald 1977; Galicia et al. 2015), but the amount of time they can access prey is decreasing due to a spatiotemporal decline in sea-ice extent (Stern and Laidre 2016). Concordantly, restricted prey accessibility for polar bears has led to reduced adult body condition (Stirling et al. 1999; Obbard et al. 2016), decreased cub recruitment (Laidre et al. 2020), and population decline (Bromaghin et al. 2015; Lunn et al. 2016) in parts of their range. While the effects of climate-induced reductions in sea-ice on polar bear populations are generally well studied (Vongraven et al. 2018), investigations of individual behaviours in response to climate change are rare. Such responses may include, for example, long-distanced swimming bouts (Durner et al. 2011; Pilfold et al. 2017), increased visits to research camps (Laforge et al. 2017), and increased foraging on land-based resources (e.g., Gormezano and Rockwell 2013; Iverson et al. 2014; Stempniewicz et al. 2021). As a secondary consequence of climate-induced sea-ice loss, humans are expected to expand their footprint into the Arctic ecosystem (Atwood et al. 2017), which may bring additional bear behavioural implications, such as increased human–bear conflicts (Dyck, 2006; Wilder et al. 2017) and disturbance to denning females with cubs (Amstrup 1993; Larson et al. 2020). In any case, more investigations into polar bear behaviours will inform the contribution of individual responses to population-level trends (Bro-Jørgensen et al. 2019; Wilson et al. 2020).

In recent years, aerial drones (hereinafter, "drones"; Chapman 2014) have become a popular tool for wildlife conservation research (Koh and Wich 2012; Chabot and Bird 2015) and are increasingly recognized as potential alternatives to conventional data collection methods (Schiffman 2014). Drones are affordable, relatively non-invasive (if researchers employ "best practices" for minimizing wildlife disturbance, Hodgson and Koh 2016), and safe to operate compared to some other data collection methods (Sasse 2003; Linchant et al. 2015; Christie et al. 2016; Jiménez López and Mulero-Pázmány 2019). However, to date, drones have primarily been used to conduct counts of focal species or perform habitat assessments using high-resolution imagery (Chabot 2018). One potential of drones that has not been widely explored is the ability to investigate animal behaviours, although a few examples have highlighted their potential. For instance, drones have been used to gain novel insights about the foraging behaviour of many marine species (i.e., gray whales, *Eschrichtius robustus* (Lilljeborg, 1861), Torres et al. 2018; tiger sharks, *Galeocerdo cuvier* (Péron and Lesueur in Lesueur, 1822); saltwater crocodiles, *Crocodylus porosus* Schneider, 1801, Gallagher, Papastamatiou, and Barnett 2018; and white sharks, *Carcharodon carcharias* (Linnaeus, 1758), Tucker et al. 2021); the courting and mating behaviour of green sea turtles (*Chelonia mydas* (Linnaeus, 1758), Bevan et al. 2016) and loggerhead sea turtles (*Caretta caretta* (Linnaeus, 1758), Schofield et al. 2017); the parasitic micro-predation behaviour of kelp gulls (*Larus dominicanus* Lichtenstein, 1823) on southern right whales (*Eubalaena australis* (Desmoulins, 1822), Azizeh et al. 2021); and the nursing behaviour of southern right whales with associated bioenergetic costs (Nielsen et al. 2019). In a similar fashion, our research team used DJI Phantom 3 and 4 Pro (multirotor) drones to film polar bears foraging on seabird eggs — an increasing phenomenon at our study site (Iverson et al. 2014) — and subsequently estimate the energetic consequence of this behaviour (Jagielski et al. 2021*a*) and examine the foraging performance of bears (Jagielski et al. 2021*b*). Given our success with using drones to glean important insights into polar bear foraging behaviour, we believe that there is great potential for drones to be used to study other aspects of polar bear behaviour as well.

In the following sections, we highlight the benefits of using drones to study polar bear behaviour by reviewing previously published studies and drawing on our own experience of using drones for studying polar bear foraging behaviour on East Bay Island, Nunavut, Canada (64°01’47.00” N, 81°47’16.7”W) over three field seasons (2016–2018). Given that many of the challenges associated with using drones to study polar bear behaviour in the Arctic (e.g., environmental, mechanical, technical, logistical) overlap with the challenges already comprehensively discussed elsewhere in the literature, we do not reiterate them here and instead refer readers to the works of Christie et al. (2016), Duffy et al. (2018), Hughey et al. (2018), Kramar and Määttä (2018), and Gao et al. (2021) for guidance. However, we present the limitations of other data collection methods used to study polar bears and then suggest areas of research where drone technology can be applied to study certain aspects of polar bear behaviour. Finally, we discuss flying techniques that elicit only minor behavioural responses in bears to ensure ethical drone operations, flight regulatory issues to address, and we conclude with future research needs. For additional details on study design and technical specifications of the drones used in these studies, see Jagielski and colleagues (2021*a*, 2021*b*).

2. Benefits of drone technology for studying polar bear behaviour

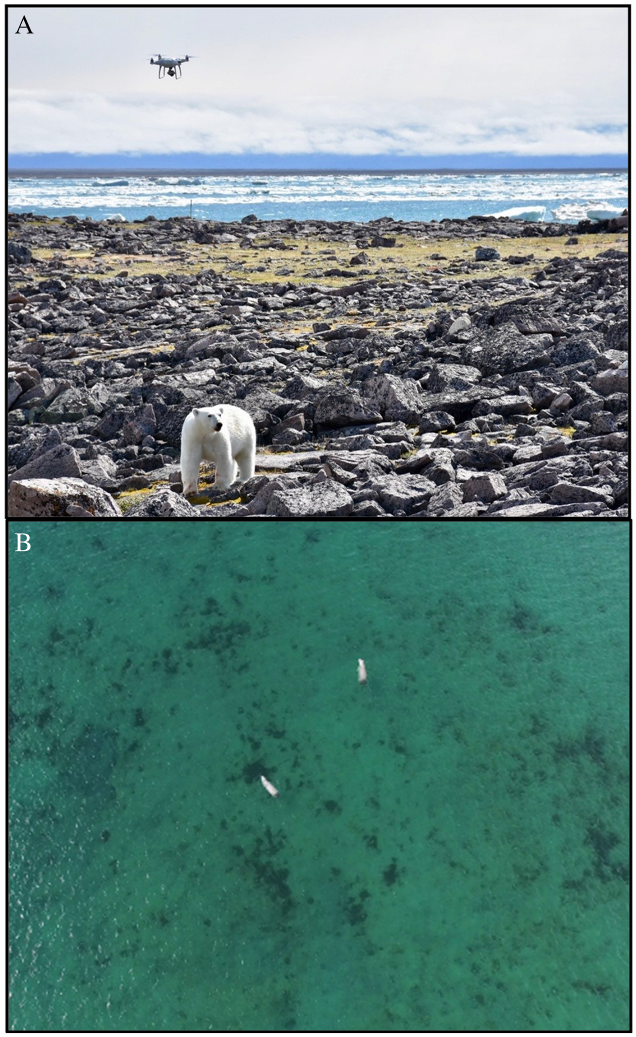
2.1. Human and bear safety

Researching polar bears in close proximity is inherently dangerous (Dyck 2006; Wilder et al. 2017), so applying technologies that reduce human–bear interactions should be pursued. Given that drone pilots are able to remotely fly drones several kilometres (e.g., up to 7 km with our models) away from the launch point, they can observe and monitor individual bears from a safe distance. In our case, because the field site is small (i.e., 24 ha), researchers routinely operated the drones from behind an electrified bear fence, but were nonetheless able to observe bears from this vantage point and at a safe distance from across the island. (See Section 4 for more details on human–bear safety).

2.2. Data collection and quality

Multirotor drones have the capacity to hover over bears (Fig. 1A), record their behaviours from above in high-quality format (up to 4K) and reach areas that are inaccessible to researchers, such as in the water (Fig. 1B). In our own experience, this “top-down” vantage point paired with the high-quality video footage capability of modern drones allowed us

Fig. 1. (A) Drone hovering over a polar bear on East Bay Island (Nunavut, Canada). This picture demonstrates polar bears' apparent disinterest (no behavioural response) in drones when operated appropriately. Photo credit: Evan S. Richardson. (B) Screenshot from drone videography of two polar bears swimming in the water off the shore of East Bay Island.



to discern when bears consumed seabird eggs from a nest, ignored a full clutch, and (or) visited an empty nest (Jagielski et al. 2021a, 2021*b*). We could also assess bears' use of visual cues to locate nests when they responded to a hen flushing from her nest (Jagielski et al. 2021*b*). Drones also allowed the pilot to follow a focal bear nearly continuously (other than when replacing batteries and re-locating the focal animal, which can take between 5 and 20 minutes on average) and adjust viewing angles when necessary. This almost continuous "eye" on individual bears also allowed researchers to quantify temporal aspects of their foraging ecology, including rates of caloric intake from eating eggs, the proportion of time spent resting, and the frequency with which bears interacted with other individuals. Further, while not used in our own research, the positional data collected by the drone can be used to infer rate of movement and body mass to better estimate foraging energetics (see Nielsen et al. 2019).

2.3. Data storage and review

Drones record data in-flight and store it onboard, thus allowing researchers to download data after flights are completed. Consequently, researchers are not forced to make possibly incorrect or inaccurate inferences of bear behaviour immediately in the field based on direct observations. Instead, the complete video footage of bear behaviours can be reviewed after the field season is complete, as many times as needed, and by multiple independent assessors, which has the potential to produce more consistent standardized datasets. For instance, analyzing drone footage after the field season enabled us to accurately document behaviours by slowing down and (or) replaying the videos to observe fine-scale behavioural decisions, and enlarging the nest images if we were uncertain whether they were full or empty when evaluating foraging performance. We note that for the purpose of our research objectives (i.e., quantifying fine-scale foraging behaviour), our videos were recorded using 2700 pixels $\times$ 1520 pixels at 30 frames per second, which inherently produced several hundred gigabytes of data (>740 gigabytes for $\sim$ 18 h of filming). Researchers exploring macro-scale questions (e.g., polar bear movement) can adjust their drone settings to record at a lower resolution (e.g., 720p) to save space on their SD cards and speed up processing times during video analysis. Advancements in computational technology are also making it possible for researchers to "train" programs to analyse animal behaviours from drone video footage (Graving et al. 2019). Importantly, given that flights are well documented (i.e., stored on SD cards), the collection of drone-based video produces a digital record of bear behaviour, which can be shared among researchers to limit biases during analysis and facilitate transparency (Parker et al. 2016; Clark et al. 2017).

2.4. Collaboration opportunities with local communities

There is growing interest from both northern communities (Peacock et al. 2011; Wong et al. 2017) and among Arctic researchers (Sjöberg et al. 2018; Wheeler et al. 2020) to foster knowledge generation through co-production (Latulippe and Klenk 2020). The emergence of "community drones" (Vargas-Ramírez and Paneque-Gálvez 2019) presents an exciting opportunity in the data collection process to support co-management of natural resources (e.g., Paneque-Gálvez et al. 2014, 2017; but see Sandbrook 2015 to ensure an ethical approach). It is important for local people to acquire skills necessary for drone operation as well as managing large datasets that drone videography generates. If they do, communities can lead diverse environmental monitoring projects, such as wildlife surveys, climate impacts on polar bears, and documenting changes to sea-ice conditions, according to community needs. For example, community-based monitoring of polar bear behaviour will be critical for understanding the bears' transforming ecology (due to climate change) and for substantiating scientific results (Rode et al. 2021). Collectively, co-involvement from planning to execution promotes local knowledge sovereignty and environmental governance of resources; both of which are desired social and economic outcomes (Gilchrist et al. 2005; Gilchrist and Mallory, 2007; Loseto et al. 2020).

3. Limitations of other data collection methods used in polar bear behaviour research

Spotting scopes are a timeless observation tool that have yielded important insights into polar bear behaviour, such as hunting (e.g., Stirling 1974; Stirling and Latour 1978; Dyck and Romberg 2007), playing (e.g., Latour 1981), post-denning activity (e.g., Hansson and Thomassen 1983), and breeding (e.g., Stirling et al. 2016). However, with spotting scopes, observers are limited in their "viewpoint" as bears may move out of their direct line-of-sight, ultimately impeding observations of bears' entire suite of behaviours. Observers may also overlook key behaviours as fatigue sets in from many hours of continual observations which, in turn, may lead to incomplete and (or) biased notes (Lardner et al. 2019).

Further, observations by researchers in close proximity to bears may alter the bears' natural behaviours (Boydston et al. 2003) and also present safety concerns for both bears and humans (Dyck 2006; Wilder et al. 2017). Technological innovations, such as camera traps, ameliorate some of these limitation and biases by allowing researchers to observe polar bears safely and without influencing the animals' behaviours (LaForge et al. 2017; Barnas et al. 2020; but see Meek et al. 2016, 2014). However, camera traps are limited by their stationary viewpoint, and the large home range of polar bears may produce infrequent observations of behaviours. Other technologies, such as tri-axial accelerometer collars (Pagano et al. 2017) and video camera collars (Pagano et al. 2018), have further advanced our knowledge of polar bear behaviours. For instance, Pagano et al. (2018) used both methods to determine polar bear activity and behaviour to quantify observed variation in field metabolic rates, which lead to a better understanding of polar bear activity/energy budgets. Again, these methods are not without limitations as capturing, sedating and collaring bears is costly, logistically challenging, may induce short term behavioural changes, and may not be culturally acceptable in all areas of the Arctic (Peacock et al. 2011; Rode et al. 2015; Wong et al. 2017). While we are certainly not suggesting that drones replace these methods/ technologies, as they are invaluable in their own right, we suggest that in some instances, drones may be considered as an alternative tool for examining certain polar bear behaviours (i.e., individual-level at small spatial-scales), which we suggest below.

4. Potential drone applications for polar bear behaviour research

4.1. Foraging behaviour

In response to changing sea-ice conditions, some polar bears (particularly those inhabiting seasonal-ice zones) are increasingly foraging on terrestrial resources (e.g., Gormezano and Rockwell 2013; Iverson et al. 2014; Stempniewicz et al. 2021), although the energetic contribution of most food items, while suspected to be minimal (Rode et al. 2015), is still unknown (but see Gormezano and Rockwell 2015). Drones can be used to film polar bears eating, searching for food, and resting to produce daily activity budgets, which can subsequently be used to estimate the energetic consequences of consuming a particular resource to help inform the energetic contribution to polar bears' terrestrial diet (e.g., Jagielski et al. 2021*a*; also see Subsection 4.2).

4.2. Interspecific interactions

The co-occurrence of polar bears with other species is increasingly being documented and is attributed to warming temperatures. For instance, there are now reports of black bears (*Ursus americanus* Pallas, 1780) and brown bears (*Ursus arctos* Linnaeus, 1758) overlapping their range with polar bears in the west coast of Hudson Bay, Canada, with the behavioural–ecological consequence of this phenomenon still unknown (Clark et al. 2018). Drones can be used to document competition for resources, such as brown bears excluding female polar bears with cubs from important foraging sites (e.g., at whale carcass sites, such as that documented in Alaska; Miller et al. 2015; Rode et al. 2015), and breeding occurrences between polar bears and brown bears. Indeed, during our research at East Bay Island, we recorded avoidance behaviours by smaller bears that came onto the island and left almost immediately after determining another bear(s) was already foraging in the area (thus inadvertently excluding the smaller bears from foraging). Additionally, we recorded several bouts of male and female bears interacting with each other (presumably playing or courting). While these examples are of intraspecific interactions, it is reasonable to assume that the same idea applies to recording polar bears and brown bears interacting as well. Characterizing the social hierarchy of competitive exclusion at foraging sites and the prevalence of interspecies breeding will be pivotal to informing management decisions.

Interspecific interactions between other predators can also be captured with drones. For instance, in our study system, it is common to see herring gulls (*Larus argentatus* Pontoppidan, 1763) capitalizing on newly exposed clutches of eggs as bears walk through and disturb the nesting seabird colony; whether these avian predators act as facilitators, competitors, or scavengers, and how polar bear resource acquisition rates are impacted remain to be studied. Being capable of covering a wide landscape view, drones can facilitate studying the impacts of multiple predator interactions on the foraging success of bears, and also the effects foraging bears have on nesting birds (e.g., flush initiation distance, colony-wide responses, Barnas, personal communication, 2021). Collectively, this information can further detail the influence competing species have on polar bears' foraging energetics, as well as allow greater determination of polar bear consumptive impacts on their prey, including the future availability of this resource (Hanssen and Erikstad 2013).

4.3. Human–bear interaction

Polar bear ecotourism (Lemelin et al. 2008) presents a unique opportunity to study the impacts of human presence on polar bears' behaviours. In places like Churchill, Manitoba, Canada, people from around the world are able to view polar bears from the safety of tundra buggies (specialized polar bear viewing vehicles) and learn about their ecology (Dyck and Baydack 2004). While there is evidence to suggest that some bears respond behaviourally to tundra buggies (Dyck and Baydack 2004; Eckhardt 2005), the overall impacts these tourism activities have on polar bears is debated (Dyck et al. 2008; Stirling et al. 2008) and is therefore an avenue for continued research. Assessing the long-term impacts of tourism on polar bear ecology (e.g., effects of increased energetic use, as a result of disturbance, on body condition) would require a study design well above the capabilities of drones (indeed more suitable for radio collars); however, behavioural observations of individual bears at these viewing areas are plausible. If flown at an appropriate altitude so as not to influence bears' vigilance behaviour further (Barnas et al. 2018), drones can be used to assess the vigilance behaviour of bears in response to tundra buggy commotion and distance (Dyck and Baydack 2004) as unnecessary movement caused by disturbance can influence polar bears' energetic expenditures (Dyck and Baydack 2004; Eckhardt 2005). Understanding the magnitude of the effect tourism has on polar bear behaviour will be informative for management decisions associated with polar bear viewing activities. In addition, understanding the movement patterns of disturbed polar bears around human-occupied areas would be advantageous for safety purposes as well (see Subsection 4.4).

4.4. Human safety and conflict mitigation

The combined impact of increased human activity in the Arctic and longer ice-free periods may result in more bears searching for supplemental food on land, increase use of terrestrial habitats, and subsequently increase the potential for human–bear interactions and conflicts (Dyck 2006; Atwood et al. 2017; Wilder et al. 2017). Therefore, there is an increasing need to develop bear monitoring and deterrent tools to help humans and bears to avoid each other (Clark et al. 2012). Drones can be used to monitor potentially dangerous bears that frequent dumps or congregate at whale carcass sites near human settlements (Miller et al. 2006; Towns et al. 2009), and to perform safety checks in remote field locations to ensure that bears are not present and undetected in an area while researchers are working (e.g., Butcher et al. 2020). On East Bay Island, researchers routinely use drones to maintain visual contact with bears when they are around camp but not visible with the naked eye or a spotting scope (e.g., when they are behind a ridge). Moreover, there is developing interest in using drones as a deterrent tool for large mammals (Hahn et al. 2017; Penny et al. 2019), including their use to deter bears away from summer camps, field stations, and human settlements, although the efficacy of this method has yet to be tested on bears.

4.5. Den site location

Increased human activity in the Arctic, facilitated by climate change, is expected to disturb denning polar bears (Amstrup 1993; Atwood et al. 2017), which can have negative fitness consequences, especially if a mother with dependent cubs abandons her den (Linnell et al. 2000; Lunn et al. 2004). In a recent study, Larson et al. (2020) discovered that overall, denning polar bears are quite tolerant of human disturbance; however, the degree of tolerance is dependent on the disturbance stimuli (e.g., machinery vs. humans on foot) and its distance from the den. Locating polar bear denning sites will be informative in guiding management decisions in an increasingly human-occupied Arctic (Florko et al. 2020). Once dens are discovered, monitoring den sites will aid in understanding how bears respond to den abandonment near human occupied areas. For instance, how far bears move away from "disturbance zones" and whether they then re-den. Currently, occupied aircraft equipped with forward-looking infrared technology is one technique being used to locate polar bear maternal dens in the snow (Smith et al. 2020). However, occupied aircraft have been demonstrated to initiate den abandonment (Larson et al. 2020). Drones are substantially smaller and quieter than occupied aircraft so it is plausible to assume that they would not elicit the same disturbance response to denning bears. Therefore, while not a direct "behavioural" application, per se, drones equipped with forward-looking infrared technology can be used to locate den sites at a reduced financial and safety (Sasse 2003) cost, technology that is already being tested in Alaska (Pederson et al. 2020). However, implementation of drone surveys at the landscape-level scales similar to those achieved by occupied aircraft is currently limited by the drone technology available to many researchers (or by local bylaws, e.g., beyond-visual-line-of-sight surveys are typically prohibited in many regions), although, recent pilot studies with more advanced drone models show promise for the progress of these tools at greater geographic scales (Angliss et al. 2018; Pfeifer et al. 2019).

5. Ethical consideration

One important stipulation of using drone technology for wildlife research is that it does not impact the animal being studied. Black bears appear to exhibit weak outward behavioural responses to drones but do exhibit increased heart rate when drones are nearby (Ditmer et al. 2015). While heart rate was not studied here, Palomino-González et al. (2021) and Barnas et al. (2018) found that polar bears also exhibit low behavioural responses to drones when flown between 20 and 120 m above them, respectively. We found that our technique of flying drones at 30 m in altitude or greater and following the bear from behind (Fig. 2) was sufficient for minimizing disturbance to the bears when collecting our data. However, when flown below 30 m and (or) in the bears' line-of-sight (which occurred very infrequently), the drones elicited two types of responses, although not always: (*i*) common, look up at the drone; and (*ii*) uncommon, move away from approaching drone. We add that the apparent lack of behavioural responses may have been due not only to an appropriate flying altitude, but also to noise created by strong winds and from the seabird and gull colonies, and to bears being harassed and distracted by flying gulls. Therefore, the appropriate flying altitude and approach may vary depending on the study location and (or) current weather conditions (i.e., it may be necessary to fly even higher when not in a noisy avian colony). Clearly, much work still remains to ensure that the use of drones to study wild animals such as polar bears is done ethically and with little impact. However, the best available data to date suggest that bears are able to habituate to the novel visual and acoustic presence of

Fig. 2. Screenshot from drone videography showing an overhead view of a separate drone recording a polar bear (from behind) foraging in the seabird colony on East Bay Island (Nunavut, Canada).

drones (Ditmer et al. 2019), or are seemingly either unaware of or undisturbed by them. For now, we suggest that researchers employ best practices for minimizing wildlife disturbance (Hodgson and Koh 2016) and follow our approach at a minimum until further studies on polar bears' responses (both behavioural and physiological) are conducted and operational techniques are improved.

6. Regulations

As drone use gains traction in conservation research, regional laws and legislation are changing to keep pace, so it is advised that research is planned around current regional bylaws, which will include permitting and training. For example, during our research in 2016–2018, bylaws at the time only required *Wildlife Research* and *Animal Use Protocol* permits to conduct polar bear research in Nunavut. However, at the time of writing (October 2021), researchers are now required to hold *Drone Pilot Certification* as well. In Canada, we direct researchers to consult Transport Canada's *Drone Safety* page when planning research projects for up-to-date regulations (https://tc.canada.ca/en). For those researchers outside of Canada, it is recommended to consult country-specific regulations as they may differ.

7. Conclusion and future research needs

Studying individual-level responses of polar bears to the effects of climate change will be informative for characterizing population-level trends. Drones emerged onto the wildlife conservation scene about a decade ago (Watts et al. 2010) and are now increasingly being used to study animal behavior. Based on our experience of using drones to study polar bear foraging behaviour (Jagielski et al. 2021*a*, 2021*b*), we believe that drone technology in its current state is advanced enough to contribute to individual-level polar bear behaviour research at small spatial scales. However, prior to widespread use, we earnestly recommend that future research focus on examining polar bears' behavioural and physiological responses to drones to ensure that wildlife of cultural, subsistence, and economic importance to indigenous northern populations are not unintentionally harassed when being studied. Future research should also evaluate the efficacy of using drones as a deterrent tool (strictly for safety purposes), as this could potentially reduce injurious human–bear interaction. Although still in its infancy, drone technology is advancing quickly, and improvements to battery capacity and associated range may eventually allow researchers to reduce the need for costly and dangerous helicopter surveys to address distribution and abundance questions.

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Competing interests

The authors declare there are no competing interests.

Contributors statement

Conceptualization, P.M.J. and A.F.B.; funding acquisition, H.G.G., E.S.R., O.P.L., and C.A.D.S.; writing, original draft, P.M.J. and A.F.B.; writing, review and editing, P.M.J., A.F.B., H.G.G., E.S.R., O.P.L., and C.A.D.S.

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