Arctic expedition cruise tourism and citizen science: a vision for the future of polar tourism

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Abstract

Purpose – *The purpose of this paper is to provide a conceptual framework for using citizen science – defined as a data collection method through which non-professionals engage in contributing to authentic scientific inquiry – within the expedition cruise industry to contribute significantly to the collection of environmental data from hard-to-access Arctic areas.*

Design/methodology/approach – *The authors review trends in Arctic expedition cruise tourism and current needs in Arctic research and monitoring, and clarify where the expedition cruise tourism industry could have the most impact by providing data to the scientific community. The authors also compare the regulatory context in the Antarctic to that in the Arctic and discuss how these differences could affect the widespread use of citizen science. At last, the authors describe some general principles for designing citizen science programs to be successful on board, and highlight several existing programs that are being recognized for their contributions to a greater scientific understanding of the Arctic.*

Findings – *The authors find that citizen science data from the expedition cruise industry are underutilized as a tool for monitoring Arctic change. Numerous examples illustrate how citizen science programs on-board expedition ships can successfully collect robust scientific data and contribute to enhancing the knowledge and stewardship capacity of cruise passengers. Inclusion of citizen science data from the expedition cruise industry should be considered a critical part of international Arctic observing networks and systems.*

Social implications – *Active participation in Arctic citizen science by tourists on expedition cruise ships has many potential benefits beyond the collection of high quality data, from increasing passengers' knowledge and understanding of the Arctic while on board, to affecting their attitudes and behaviors after they return home.*

Originality/value – *The potential for tourism to contribute to Arctic observing systems has been discussed previously in the scientific literature; the authors narrow the focus to citizen science programs in the expedition cruise industry, and provide concrete examples, in the hope that this will streamline acceptance and implementation of these ideas by researchers and tourism practitioners.*

Keywords *Education, Citizen science, Arctic tourism, Arctic monitoring, Arctic observing, Expedition cruise industry*

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Sadly, Sarah Auffret passed in the crash of Ethiopian Airlines Flight 302 on March 10, 2019.

Current trends in polar expedition cruise tourism

Reduced sea ice extent and thereby increased accessibility into polar areas has opened up new routes for expedition cruise ships, resulting in changes in cruise travel patterns and in the types of passengers visiting the region (Lück *et al.*, 2010). Additionally, in the last decades global changes in the polar environment have changed the focus for marketing of tourism, and terms like "last chance to visit" have been used to draw in new tourist demographics (Lemelin *et al.*, 2010), some of which are highly adventure oriented and interested in "off the grid" experiences (e.g. Oceanwide, n.d.).

Analysis of recent interviews among stakeholders in the Icelandic cruise service industry show that average cruise passengers are generally well-off and rather senior; industry professionals

mentioned the average age of cruise passengers as being "really high" and described some cruises as "floating resting homes" (Barðadóttir, 2017). Some industry professionals commented on the high education levels and knowledge-seeking interests of these senior passengers, but others described a recent influx of younger, more adventurous visitors, seeking in particular the thrill of "adrenaline tours" and wet landings in remote locations (where passengers access uninhabited areas without dock facilities via tender boats; Barðadóttir, 2017).

In addition to a changing passenger demographic, Arctic cruise traffic has increased immensely in recent years in both the high Arctic and in lower and sub-Arctic locations. Total cruise passenger numbers for the high Arctic destinations of Svalbard, Greenland, Arctic Canada and Franz Josef Land have grown from around 50,000 in 2005 to just below 80,000 in 2016. While smaller in total passenger numbers than conventional cruising, expedition cruising (typically done on smaller ships – 100-200 passengers compared with upwards of 3,000 – with more adventurous itineraries) is a significant segment which is experiencing considerable growth (*Cruise Industry News*, 2019). The Association of Arctic Expedition Cruise Operators (AECO), which represents the majority of operators in the Arctic expedition cruise industry, keeps an overview of the number of passengers carried annually by AECO members. In 2016, expedition cruise passengers constituted a quarter of total cruise passenger numbers, and the number of passengers carried by AECO member ships in AECO's core areas (Svalbard, Jan Mayen, Greenland, Arctic Canada, Russian Arctic National Park, and Iceland) increased from 13,480 passengers in 2008 to 26,296 passengers in 2017 (AECO, unpubl. data). It should be noted that part of this increase is due to more operators becoming AECO members, and therefore being included in the statistics. In the sub-Arctic, the Icelandic Tourism Research Institute is dedicated to increasing understanding of the impact tourism has on the Icelandic economy, society and environment, and therefore is one of the few entities with a direct focus on the increase in tourism in a particular area. In 2014, 60 cruise ships (conventional and expedition classes combined) made in total 284 dockings in Icelandic ports, carrying 212,600 passengers. By 2018, the numbers had increased to 76 cruise ships making 725 dockings, carrying 424,200 passengers combined (Mælaborð, n.d.).

Urry's (1996) tourist gaze concept describes the complex relationship and even power play between tourists and the societies they visit, when what tourists expect to see becomes what they are shown. Thereby the alert but passive views of visitors – their gaze – can result in simplification and homogeneity of environments and cultures as tour operators and local communities try to meet tourists' expectations. Duffy (2019) argues that the tourist gaze may be altered by the now-frequent use of modern smartphones and social media, as the visitors can and do become more active in their on-site searching for relevant information whilst traveling. However, while searching for relevant information on a smartphone while traveling can be informative, it can also be a distraction from fully participating in the tourist experience.

On the other hand, active participation by tourists in authentic research and data collection could alter the tourist gaze by providing a deeper understanding of the environment they are visiting and a fuller sense of place. For example, to many tourists an ice-filled landscape appears "pristine," but cruise passengers who sample Arctic coastlines for marine debris may have their gaze altered by a greater awareness of how interconnected the Arctic is with more temperate regions of the world (from which a large proportion of the global waste stream emanates), and how humans have impacted even the planet's most remote environments (Bergmann *et al.*, 2017). This more critical view, combined with the positive experience of contributing to the "public good" through the process of scientific data collection, can serve to enhance and deepen the visitor experience, such that passengers could return home more aware of the discrepancy between their expectation of the Arctic as a place separate from human interference, and the reality of the Arctic as impacted by human activity. Although no studies have specifically examined the impacts of participation in on-board citizen science on cruise passengers' attitudes and behaviors, passengers who merely engaged with educational programming on board Arctic expedition cruise ships reported having afterwards a greater appreciation for the wilderness and solitude of the Arctic, a greater concern for the environment in terms of resource use and waste and a desire to donate time or money for environment protection or to vote for officials who support the same (Manley *et al.*, 2017).

Current trends and needs in Arctic research and monitoring

As tourism is expanding in the Arctic, the region is also experiencing extremely rapid environmental change due to rates of greenhouse gas-related warming that are twice as high as for temperate regions of the northern hemisphere (Arctic amplification; Serreze *et al.*, 2009). For example, surface air temperatures in the Arctic for the past five years (2014–2018) have exceeded all previous records; the 12 lowest sea ice minimums in the satellite record have occurred in the past 12 years; terrestrial snow cover in June across the Arctic is declining at approximately 15 percent per decade; and coastal landfast ice (important for travel, hunting and protection of Arctic communities) is steadily declining (Osborne *et al.*, 2018). It is now recognized that Arctic amplification has resulted in impacts to the climate and environment of more temperate regions as well (Coumou *et al.*, 2018). Additionally, as the Arctic warms, it is subject to environmental impacts stemming from increased rates of energy development, marine transportation and commercial fishing as new areas become ice free, and from expanding harmful algal blooms related to higher sea surface temperatures (Osborne *et al.*, 2018). Increasing levels of airborne contaminants and marine debris are also a concern. These environmental changes are likely to impact marine and terrestrial food webs, ecosystem functions and services, Arctic communities including Indigenous peoples, and the economies and therefore lifestyles of large sectors of the global human population. Such widespread and significant changes must be monitored carefully as they progress in order to plan for mitigation of and adaptation to climate change impacts.

However, compared to more populated regions of the globe, there is less infrastructure in the Arctic with which to enable systematic tracking of this unprecedented level of change and predict its effects on global society. Arctic observing networks rely heavily on output from individual, short-term research projects funded at the national level (AOS EOC, 2018), but access to the Arctic for research purposes is becoming increasingly expensive (Mallory *et al.*, 2018). In particular, icebreakers and ice capable research vessels are limited in number and time aboard is expensive, so *in situ* observations from ice-rich Arctic marine areas are especially limited (Kodama *et al.*, 2016; Sandven *et al.*, 2018). Community-based monitoring, while a critical component of monitoring Arctic change, relies on the engagement of local communities which are often small and widely dispersed, leaving significant gaps in coverage of observations. The Arctic research community has formally recognized the need for a sustained international network of Arctic observing systems – incorporating both satellite and ground-based measurements – to address ongoing environmental change, and is moving toward this goal through a series of Arctic Observing Summits held in conjunction with the biennial Arctic Science Summit Week (AOS EOC, 2018). However, to date, the potential of tourism and citizen science to contribute to this integrated, sustainable AOS strategy has not been discussed (P. Schlosser, pers. comm.), despite recent encouragement by a number of researchers to do so (see e.g. Murray *et al.*, 2013; de la Barre *et al.*, 2016). For the remainder of this viewpoint paper, we will describe how citizen science in the polar expedition cruise industry could contribute to a better understanding of changing Arctic systems despite differences between the regulatory framework of the Antarctic vs the Arctic, and provide some design principles and examples of successful citizen science programs being used in the expedition cruise industry.

Solving two problems: citizen science aboard expedition cruise ships has the potential to contribute to a sustainable Arctic observing system, and to alter the passive tourist gaze

Based on our experiences as polar and tourism researchers and as members of the expedition cruise industry at several levels, our viewpoint is that citizen science – defined as a data collection method through which non-professionals engage in the process of contributing to authentic scientific inquiry (Dickinson *et al.*, 2012) – on-board polar expedition cruise vessels should be considered as a viable component of an integrated global Arctic observing system. Expedition companies offer the same cruise routes multiple times within seasons and across years, and companies are encouraged by AECO to add value to their offerings by including an educational element such as citizen science on voyages (see below). Expedition passengers, led by

experienced guides following scientifically rigorous study designs, can provide a mechanism for repeated measurements of environmental phenomena (including documenting the effects of increasing tourism itself) in the hard-to-reach marine and nearshore areas of the Arctic Ocean. The research community needs to be made more aware of this opportunity for scientific data collection, and scientists themselves should be encouraged to design study protocols that are appropriate for expedition-based citizen science methodologies. This could be accomplished initially via novel funding programs offered by national or international organizations like the United States' National Science Foundation or the Arctic Council working groups. Once shown to be effective, such expedition-based citizen science programs should be considered as viable for inclusion in international Arctic observing efforts such as the Arctic Council's Sustaining Arctic Observing Networks (SAON) initiative, the European Union's INTAROS project, and the US Arctic Observing Network.

Arctic expedition cruise passengers themselves would benefit from the opportunity to be involved in science and data collection while on tour, because these activities could enable them to obtain a more comprehensive and realistic understanding of the ecosystem in which they travel as well provide the opportunity to develop new conservation-oriented behaviors. Powell *et al.* (2008) studied the place-based knowledge, environmental behaviors and intentions of passengers immediately and then three months after they participated in an expedition cruise tour of Antarctica. While passengers in their study did show an immediate increase in place-based knowledge as well as their intent to participate in several beneficial environmental behaviors (e.g. joining environmental organizations, donating funds to protect Antarctica, etc.), only the place-based knowledge was retained at three months post-tour. However, Powell *et al.* (2008) noted that few tour operators provided "immediate and straightforward" opportunities for passengers to support conservation while still on tour. One operator did couple a slideshow on impacts to albatross populations from long-line fishing with an immediate fundraiser on board and continuous follow-up after the tour to encourage passengers to remain engaged; this operator was quite successful at motivating people to raise funds for seabird research and conservation. While there is currently no literature addressing the effects of participating in citizen science on expedition cruise passengers' long-term behaviors and intentions, it is reasonable to think that passengers who experience immediate positive feedback by contributing to on-board citizen science programs could have a similar reaction as in Powell *et al.*'s (2008) study. If AECO or individual tour operators could provide follow-up information on how the data were used to further scientific understanding of the Arctic, contribute to large-scale Arctic observing systems or assist with making management or policy decisions, engagement with on-board citizen science could translate into a long-term change in passengers' behavior such that they continue to engage in citizen science, provide funding to institutions conducting Arctic research and support conservation of Arctic environments.

A dose of reality: comparison of the situation for encouragement of tourism-based citizen science in the Antarctic vs the Arctic in terms of regulatory structure and expedition cruise industry participation

The polar regions are unique with respect to the experiences sought by tourists and the challenges faced by the expedition cruise industry as it seeks to meet tourist desires. And even while many tour operators have ships that cruise in both polar regions within a given year, and many guides work both the Arctic and Antarctic seasons, the two regions differ widely in terms of ownership, research administration and tourism regulation. To date, on-board citizen science programs have been used more widely as part of the educational toolkit on expedition ships in the Antarctic than in the Arctic, but with expedition cruise tourism in the Arctic poised to reach levels currently seen in Antarctica (circa 40,000 expedition cruise passengers in 2017–2018; IAATO, 2018), it is valuable to consider how differences in the regulatory structure of the two polar regions might affect how scientists, tour operators and guides transfer programs from one region to the other.

Human activity in Antarctica is regulated through the Antarctic Treaty System (ATS), with the Protocol on Environmental Protection to the Antarctic Treaty (the Protocol), in force since 1998,

being the most important legal instrument for tourism. Although the ATS has steered Antarctic stakeholders' actions toward mutually beneficial outcomes, the consensus-based decision-making system presents challenges, which for tourism, are met by the International Association of Antarctica Tour Operators (IAATO). With its mission to practice safe, environmentally responsible travel, IAATO has been self-regulating the tourism sector since its formation in 1991. Today it represents the vast majority of operators in Antarctica and reports its activities annually to the Antarctic Treaty Consultative Meeting.

IAATO subscribes to a set of General Principles agreed by Consultative Parties through Resolution 7 (2009), including requiring that its member operators provide a focus on the enrichment and education of visitors about the Antarctic environment and its protection. Supporting passenger-engaged science fulfills this requirement, creates marketing opportunities and furthers IAATO's vision for creating ambassadors for the region's continued protection. IAATO and the Antarctic science community thus have a long history of working together using vessels of opportunity for transporting researchers or as science platforms. Citizen science particularly appeals because it can deliver high-value, low-cost science while meeting demand from the traveling public who increasingly wish to "give back" to the places they visit.

Citizen science across the IAATO fleet evolved from several marine mammal photo-identification studies. They were led by separate research institutions that supplied the IAATO Secretariat with methodology for inclusion in the IAATO Field Operations Manual. The results had value, but were limited in volume due to quality control, processing burdens and low data submission rates despite the best intentions of expedition naturalists. More coordination was needed to bridge the gap between data collection and dissemination. In 2015, a web-based citizen science photo identification platform called Happywhale was launched that simplified the process. Critically, Happywhale delivers engaging feedback for matches found and marine mammals identified that encourages the submission of quality data through public contributors who are motivated to participate. Happywhale's originator, in collaboration with polar expedition guides, scientists and other industry experts, has since formed the Polar Citizen Science Collective (http://www.polarcollective.org), which works closely with IAATO and more recently AECO to deliver high quality ship-based citizen science projects.

In contrast to the situation in the Antarctic, there is no central power for the Arctic that regulates traffic and activities in the region. Cruise tourism is regulated by individual Arctic nations and international shipping regulations set forth by the International Maritime Organization. The Arctic Council is an intergovernmental organization that addresses issues faced by the Arctic governments and the indigenous people of the Arctic. While the Arctic Council is an important circumpolar forum, it does not have a mandate to regulate tourism. In order to achieve better integration of citizen science across the Arctic expedition cruise industry in the future, it will therefore be important to engage stakeholders directly and encourage voluntary cooperation between industry and research bodies.

A key element in strengthening the link between science and the expedition cruise industry will be to create platforms for information exchange that help operators find projects and vice versa. Many cruise operators are already actively involved and contribute to polar research in a number of ways, including wildlife observations, individual ship-based citizen science initiatives, hosting researchers and providing logistical assistance during field operations. Analysis of informal AECO surveys shows that cruise operators are eager to get involved but may lack the knowledge and contacts necessary to launch initiatives. Operators need information about the educational value that projects can have for their guests whereas researchers would benefit from gaining an understanding of what operators can offer and what makes a project attractive for the tourism sector. Since there is no Arctic equivalent to the ATS, information flow and dialogue becomes especially important. Associations such as AECO, the International Arctic Science Committee and the Polar Citizen Science Collective (see above) can play an important role in collecting and conveying information between stakeholders. Research institutions in Arctic nations and Arctic Council Working Groups such as the Arctic Monitoring and Assessment Programme can also contribute to these efforts.

By connecting all entities at an early stage, citizen science projects for the expedition cruise industry can be developed cooperatively, thus taking the needs of scientists and Arctic observing systems as well as the constraints of the cruise industry into account, leading to more successful projects. There is a great potential for taking advantage of the logistical resource that expedition cruise vessels represent, and operators are increasingly looking to expand their on-board education and participatory offerings with hands-on enriching activities. It is a goal of AECO to help realize this potential for increased collaboration between the Arctic science and tourism sectors through improved dialogue and information exchange in the near future.

What makes a good citizen science program for use on-board expedition cruise ships?

One of the biggest challenges for a successful citizen science program is the selection of appropriate projects; not all research protocols are appropriate for use with passengers on-board expedition cruise ships. This group of authors has noted several requirements that a citizen science project should fulfill to ensure not only a beneficial educational experience for passengers but also robust data collection as well.

Generally, citizen science projects should be able to be easily incorporated into the daily program of activities on board the ship, such that it is not a hardship for passengers to fully participate, and participants will not become bored, distracted or exhausted. Projects should be realizable without extensive prior training, and data protocols should be easy to follow by both the expedition team and the passengers on board. It can be extremely helpful if the scientists designing the project are able to spend time aboard an expedition tour ship so they better understand the nature of the daily schedule and the passengers' abilities. Similarly, the success of citizen science projects is enhanced widely if researchers provide advertising materials like flyers that can be posted on board for passengers to view, detailed project instructions for guides, and an introductory presentation that can be used by expedition staff to engage volunteer participants. Information about the long-term intention of the data resulting from a project, as well as reasons why citizen science was chosen as a method of data collection, fosters a feeling of a higher purpose among passengers which increases involvement and ultimately the success of the project in terms of data collected and educational benefits realized.

From the scientific perspective, projects that work well tend to incorporate predictable visits to the same sampling site across repeat cruises, such that the data collected creates a time series or monitors change in one area over an entire cruising season. Data collection protocols that involve a verifiable observation (e.g. a photograph of an animal or environmental condition like cloud cover or trail width) or a simple measurement (e.g. snow depth or ice thickness at multiple points) are easier to use with untrained passengers than more complex measurements. Particularly engaging for participants is an online project interface where they can see their observations added to a database and view past project information; this makes people feel that they are contributing to something beyond just a single ship's capacity for data collection. It is critical that project scientists provide training for expedition staff (in person, if possible!) such that data being collected match the desired standard; this can also help ascertain that projects are championed in the field by guides and tour operators which results in more and higher-quality data. Throughout the field season, it is essential for project scientists to maintain open lines of communication for expedition staff to ask questions and report problems; lack of access to a means for getting guide or passenger questions answered can result in poor quality data collection or lack of participation in the project. Scientists should consider adding a mechanism for obtaining feedback from project participants (guides or passengers) such as short surveys or online question/answer sessions; these can help gauge participant interest, provide ideas for modifying data collection protocols, and help demonstrate educational effectiveness of projects designed to enhance passengers' understanding of specific topics or raise awareness of environmental concerns. Many funding agencies require demonstration of "broader impacts" from supported projects; direct feedback from participants can be particularly helpful in showing how a project has affected passengers' knowledge or attitudes.

There are some challenges to using expedition cruise ships as a platform for citizen science-based data collection of which scientists should be aware. For example, complex projects may overburden busy expedition staff, resulting in poor quality data collection or infrequent participation. This is a concern from the scientific perspective but also devalues the importance of citizen science as a mechanism for collecting data in the polar regions, and reduces the possibility that the potential for broader educational impacts is realized. Expedition staff may also turn over frequently throughout the full cruising season, which places an additional burden on project scientists in terms of engaging and training new field leaders and champions. If a project will be collecting biological samples, project scientists must obtain all applicable collection and import/export permits for the target organisms, and if the samples must be warehoused until the ship returns to port, storage of those samples needs to be carefully considered as freezer space can be limited and scientific samples need to be separated from food for human consumption. Even once a ship has returned to port and can send samples back to the scientists' home country, the costs and logistics of shipping samples (especially frozen samples) can be a significant challenge; the details of shipping samples need to be worked out well in advance. At last, most but not all tour operators are willing to front the cost of project-specific sampling equipment if the initial buy-in cost is reasonable and expected, but project scientists should consider the useful life of such equipment and how to repair/replace essential components from afar. Just as it is difficult to ship samples from polar cruising regions to scientists' home countries, it is a challenge to send new equipment to the ship if a critical sampling component ceases to function mid-season.

Some examples of citizen science programs currently being used on polar expedition cruise ships

In addition to Happywhale (https://happywhale.com), which is a platform for gathering marine mammal photos from citizen scientists aboard cruise ships worldwide (see above), the Polar Collective maintains a repository of citizen science projects that have been proven to be effective for use in the polar expedition cruise industry. The following examples may be useful for scientists or tour operators considering how to design successful citizen science programs for use on ex pedition cruise ships. For additional examples, see the Polar Collective website (http://www.polarcollective.org/projects/) or contact the Polar Collective team directly.

Ice Watch

Sea ice observations have been conducted each summer since 2015 by expedition staff and passengers during Poseidon Expeditions' cruises to the North Pole on board the Russian nuclear icebreaker 50 Let Pobedy. Data collection occurs on three to four voyages each summer and is timed to coincide with satellite overpasses; resulting observations are entered into the open source Ice Watch ASSIST Data Network. This project delivers the only data for sea ice age, type, topography and melting stage from the vicinity of the North Pole, and forms an important data source to study the effects of climate change on high-latitude Arctic sea ice (Farmer *et al.*, 2016). The project is endorsed by the Year of Polar Prediction (YOPP) and is described in the September 2018 YOPP newsletter.

FjordPhyto

During the polar summer months, passengers led by expedition staff collect samples of phytoplankton from coastal fjords containing tidewater glaciers. Passengers use scientific instruments to measure water quality of the environment in which phytoplankton live and microscopes to view these organisms up close. The project research questions address how freshwater from melting glaciers could potentially alter the existence of phytoplankton that form the basis of the polar marine food web. The project elements were designed by researchers at Scripps Institution of Oceanography with polar guides (including the Polar Collective team) implementing the fieldwork. FjordPhyto has conducted four successful Antarctic field seasons with six tour operators; the first Arctic field season occurred in 2018 but proved slightly more challenging due to more flexible expedition cruising and landing locations in the Arctic compared to the Antarctic, and fewer expedition staff being available to lead citizen science efforts.

FjordPhyto scientists have also been collecting feedback regarding passengers' response to being involved in this research project (A.L. Cusick, unpubl. data); below are several participant responses illustrating the positive outcome of having a "citizen science experience" while cruising:

> Q: Do you feel participating in the FjordPhyto citizen science program enriched your experience in Antarctica? If yes, how?
>
> A: "Yes, for sure. Gives the travel more of a purpose to know you're supporting science."
>
> A: "Participation in citizen science allowed me to be more than just a tourist."
>
> A: "Yes, with more information I can create more connections between global events and tell other people."
>
> A: "Definitely. Helped me understand how it affects the globe with patterns, etc. Felt good to be able to contribute."

Marine debris monitoring

Bergmann *et al.* (2017) document a citizen science-based approach to quantifying marine litter on beaches in the Svalbard archipelago using both sailing and motorized cruise vessels during the summer of 2016. Cruise passengers and expedition staff recorded and then collected litter on set transects and used photography to provide documentation of interactions between marine debris and wildlife or other marine biota. Members of the expedition staff provided additional information about the marine litter situation found on each surveyed beach as well as passenger reactions to the litter and the citizen science project via Skype calls. The project revealed considerable contamination of Svalbard beaches with marine anthropogenic litter, mainly fishing industry related, and a total of 991 kg of litter was collected from the overall sampling area of 11,732 m^2. The resulting publication represents the northern-most report of marine litter to date and is a valuable contribution to our understanding of the distribution of marine debris in the Arctic environment (Bergmann *et al.*, 2017).

Conclusions

Citizen science programs on-board expedition ships undertaking repeated cruise itineraries in the polar regions are underutilized as tools for monitoring Arctic change. We have provided several examples from both poles that illustrate how citizen science programs within the expedition cruise industry can successfully collect robust scientific data and contribute to enhancing the knowledge and stewardship capacity of cruise passengers regarding the Arctic environment. Inclusion of citizen science data from the expedition cruise industry could be used to assist with monitoring of Arctic biodiversity, environmental conditions, pollution, and even impacts from tourism itself, and data gathered in this manner would be valuable to researchers, governments and private industries such as polar logistics, fishing, marine shipping, and tourism. The expedition cruise industry should therefore be considered a critical provider of data to international Arctic observing networks and systems. In addition, citizen science on-board Arctic cruise expeditions should be considered for its potential to result in positive, long-term change in passengers' environmental behaviors and intentions even after they return home from their cruise. Because there is almost no literature on this subject, the tourism research sector could undertake studies to better understand and document the outcomes that result from participation in citizen science during expedition cruises in the Arctic; this would be a valuable contribution to the primary literature on the influence of on-board education and interpretation within the tourism industry.

Dedication and Acknowledgments

The authors dedicate this paper to the co-author Sarah Auffret of AECO, who was a passenger on Ethiopian Airlines Flight 302 when it crashed outside Addis Ababa on March 10th, 2019 with no survivors. Sarah was AECO's Environmental Agent and was on her way to speak about AECO's Clean Seas Initiative at the United Nations Environment Assembly. Sarah worked tirelessly to reduce plastic pollution in the marine environment by campaigning to find alternatives to single-use plastics on Arctic expedition cruise vessels as well as engaging passengers in beach clean-ups while on tour. Through her work for AECO and in previous positions in the Polar tourism industry, Sarah demonstrated that dedicated individuals can inspire

others to learn, get engaged and take meaningful action. Sarah's passion for solving environmental issues was unparalled, and her friendship and enthusiasm are greatly missed.

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