frontiers in Ecology and Evolution

ORIGINAL RESEARCH
published: 15 November 2016
doi: 10.3389/fevo.2016.00128

Stakeholder Perspectives on Triage in Wildlife Monitoring in a Rapidly Changing Arctic

Helen C. Wheeler[1,2,3]*, Dominique Berteaux[3], Chris Furgal[4], Brenda Parlee[5], Nigel G. Yoccoz[1] and David Grémillet[2,6]

[1] Department of Arctic and Marine Biology, UiT the Arctic University of Norway, Tromsø, Norway, [2] Centre d'Ecologie Fonctionnelle et Evolutive, UMR 5175, Centre National de la Recherche Scientifique - Université de Montpellier - Université Paul-Valéry Montpellier - EPHE, Montpellier, France, [3] Centre for Northern Studies, Université du Québec à Rimouski, Rimouski, QC, Canada, [4] Indigenous Environmental Studies and Sciences, Trent University, Peterborough, ON, Canada, [5] Department of Resource Economics and Environmental Sociology, University of Alberta, Edmonton, AB, Canada, [6] Department of Science and Technology - National Research Foundation Centre of Excellence, Percy FitzPatrick Institute, University of Cape Town, Rondebosch, South Africa

OPEN ACCESS

Edited by:
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***Correspondence:**
Helen C. Wheeler
hcwheele@ualberta.ca

Specialty section:
This article was submitted to Conservation, a section of the journal Frontiers in Ecology and Evolution

Received: 22 April 2016
Accepted: 28 October 2016
Published: 15 November 2016

Citation:
Wheeler HC, Berteaux D, Furgal C, Parlee B, Yoccoz NG and Grémillet D (2016) Stakeholder Perspectives on Triage in Wildlife Monitoring in a Rapidly Changing Arctic. Front. Ecol. Evol. 4:128. doi: 10.3389/fevo.2016.00128

Monitoring activities provide a core contribution to wildlife conservation in the Arctic. Effective monitoring which allows changes in population status to be detected early provides opportunities to mitigate pressures driving declines. Monitoring triage involves decisions about how and where to prioritize activities in species and ecosystem based monitoring. In particular, monitoring triage examines whether to divert resources away from species where there is high likelihood of extinction in the near-future in favor of species where monitoring activities may produce greater conservation benefits. As a place facing both rapid change with a high likelihood of population extinctions, and serious logistic and financial challenges for field data acquisition, the Arctic provides a good context in which to examine attitudes toward triage in monitoring. For effective decision-making to emerge from monitoring, multiple stakeholders must be involved in defining aims and priorities. We conducted semi-structured interviews with stakeholders in arctic wildlife monitoring (either contributing to observation and recording of wildlife, using information from wildlife observation and recording, or using wildlife as a resource) to elicit their perspectives on triage in wildlife monitoring in the Arctic. The majority (56%) of our 23 participants were predominantly in opposition to triage, 26% were in support of triage and 17% were undecided. Representatives of Indigenous organizations were more likely to be opposed to triage than scientists, and those involved in decision-making showed greatest support for triage amongst the scientist participants. Responses to the concept of triage included that: (1) The species-focussed approach associated with triage did not match their more systems-based view (5 participants), (2) Important information is generated through monitoring threatened species, which advances understanding of the drivers of change, responses and ecosystem consequences (5 participants), (3) There is an obligation to try to monitor and conserve threatened species (4 participants), and (4) Monitoring needs to address local people's needs, which may be overlooked under triage (3 participants).

The complexity of decision-making to create monitoring programmes that maximize benefits to biodiversity and people makes prioritization with simple models difficult. Using scenarios to identify desirable trajectories of Arctic stewardship may be an effective means of identifying monitoring needs.

Keywords: arctic monitoring, decision-making, polar observation, prioritization, recording, wildlife conservation

INTRODUCTION

The Arctic faces multiple pressures, which have substantial potential to affect arctic wildlife and the ecosystems that support these species (Post et al., 2009, 2013; Gilg et al., 2012; CAFF, 2013). A rapid rate of change is observed and projected in the Arctic, given warming is considerably higher than the global average (Hartmann et al., 2013). In addition to climate change, the dramatic rate of increases in mining and petroleum exploration and development, commercial wildlife uses, subsistence harvesting and long-range pollution are all potential drivers of change in the population, distribution, and health of many species in the Arctic (Johnson et al., 2005; Huntington et al., 2007; CAFF, 2013). Consequently, the monitoring of wildlife plays an important role in identifying change in populations and habitat such that actions can be taken to mitigate or minimize pressures. Accordingly, it is essential to identify the motivations for monitoring in the Arctic, what should be monitored and how monitoring should be undertaken (Yoccoz et al., 2001).

The Arctic represents a system in which it is necessary and timely to examine triage in wildlife monitoring. Understanding the speed of changes in the Arctic, governments are increasingly recognizing the need to address what science needs to be done and how it should be implemented (Tesar et al., 2016). Due to remoteness and difficulties with access, the costs of monitoring in the Arctic can be very high, creating a strong need for prioritization of activities.

Triage involves the prioritization of how to distribute limited resources. Multiple definitions of conservation triage exist, varying in breadth. The traditional definition of conservation triage concerns selecting between species (McIntyre et al., 1992), populations or subpopulations (McDonald-Madden et al., 2008) based on their probability of survival, given a level of investment. This has been broadened to other situations related to prioritization of actions to maximize conservation benefit (Bottrill et al., 2008). The latter, broadened definition can encompass a wide range of decision-making processes and algorithms. Under this broad definition, triage effectively encompasses any strategic decision making concerning conservation. As argued by Bottrill et al. (2008), triage under this broadened definition, may simply be smart decision-making and is already implicit in the planning of many conservation activities. Under the broad definition, any failure can be attributed to mis-specification of the problem rather than a fundamental issue with the approach. Here, we focus on the traditional (narrower) definition of triage in reference to monitoring of arctic wildlife. In particular, we focus on whether the likelihood of survival of a population or species should influence the amount of effort devoted to monitoring.

To evaluate the appropriateness of triage in monitoring, we need to define the desirable outcomes from monitoring, the extent to which triage can achieve desired outcomes and whether triage provides an acceptable route to achieving these objectives. Lindenmayer and Likens (2010) define three types of monitoring: identifying change in populations, often in response to political directives and government mandates; testing predictions to understand processes and mechanisms underlying changes; and curiosity-driven monitoring, which has less direct goals and rationale. Perhaps the most direct outcome of monitoring is management decisions. Monitoring has an important role in adaptive management and adaptive co-management in complex socio-ecological systems, such as found in the Arctic (Armitage et al., 2009). In these systems, monitoring contributes to decision-making based on ecosystem state by informing evaluation of effectiveness of management actions and facilitating learning about the system (Lyons et al., 2008). More indirect outcomes from monitoring are increased awareness of the public and politicians, increased support, leverage, and effort toward reaching desired outcomes through local, public, and political engagement (via publicity from monitoring or active engagement in monitoring), and discovery of new and useful information (Possingham et al., 2012). These more indirect outcomes of monitoring can have substantial benefits to society (Possingham et al., 2012) but are more often overlooked when evaluating the benefits of monitoring. Many of the indirect benefits of monitoring relate to facilitating different stakeholders in learning about socio-ecological systems, with the goal of driving action, however often the link between monitoring, management at learning is poorly defined (Armitage et al., 2008, 2009), as is the link between learning and action. This high degree of complexity creates challenges in determining the applicability of strategies such as triage to meeting often diverse and diffuse outcomes from monitoring.

Spatial scale is a key consideration regarding the needs and motives for monitoring and conservation (Pearson, 2016). Stressors acting on the Arctic range from global drivers such as climate change, which are primarily generated outside the Arctic, to regional pressures associated with increased opportunities for development under warming, to local pressures such as harvesting (CAFF, 2013; Andrew, 2014). The spatial scale at which action is required to address these pressures varies widely as does the ability and mechanisms to exert control over stressors. While climate change and contaminants in wildlife may require concerted global action, resource use may be manageable more locally.

A range of methods for observing and recording changes in wildlife populations exist in the Arctic, in particular scientific monitoring, community based monitoring, and traditional knowledge (Moller et al., 2004). These methods include a range of stakeholders including scientists, local resource users, government agencies, and industry (Kouril et al., 2015). It is important to consider the needs of multiple stakeholders when examining the concept of triage in wildlife monitoring in the Arctic. A range of stakeholders are either involved in monitoring, use information from monitoring or are affected by decisions arising from monitoring. In particular, the potential for monitoring and conservation plans to be co-produced with local communities is being recognized (Johnson et al., 2005), however the extent to which Indigenous peoples have land rights and the degree of self-determination varies very substantially across the Arctic, particularly between countries. In North America, local participation of Indigenous peoples is greatest, primarily occurring in local and regional decision-making through wildlife management boards and this is also observed in greater levels of community based monitoring (Kouril et al., 2015). Further, little is currently known about the perspectives of different actors in arctic wildlife monitoring and conservation regarding the application of triage.

Using interviews with multiple stakeholders, we explore views on triage in monitoring with a focus on arctic terrestrial vertebrate and seabird systems. We explore perspectives among those involved in, directing the collection of, or who are recipients of the data generated by monitoring programs. We examine attitudes toward triage, opinions on the validity of the assumptions underlying triage (e.g., transferability of resources between species and sites) and how characteristics of the Arctic might influence the applicability of triage. In particular, we address the following questions:

1. Are stakeholders broadly in support or opposition to triage in wildlife monitoring in the Arctic?
2. What are the core justifications given by stakeholders in support of triage?
3. What are the core justifications given by stakeholders in opposition to triage?
4. What factors modify whether triage in wildlife monitoring in the Arctic might be appropriate?
5. What other issues might affect prioritization of monitoring in the Arctic?

MATERIALS AND METHODS

We conducted one-on-one semi-directed interviews (Gubrium et al., 2012) with 23 individuals who were involved in the production or use of observations and recordings, were associated with arctic wildlife use, or were designated representatives of those groups. Interviewees were selected from attendees at Arctic Council working group and expert group meetings, international conferences and via snowball or referral sampling among interviewed participants (**Table 1**). Across stakeholder groups, we aimed to achieve representation of circumpolar countries and arctic Indigenous groups. Within the group of scientists interviewed, we attempted to achieve representation of those who work solely on scientific monitoring and those who incorporate community-based monitoring and traditional knowledge. We also tried to incorporate both scientists heavily focussed on decision-making and applied science, and those primarily engaged in fundamental science. Some participants filled more than one of these roles.

TABLE 1 | Summary of all participants interviewed on triage, with their affiliations (unless otherwise requested), and countries.

Name	Affiliation	Country
Jason Akearok	Nunavut Wildlife Management Board	Canada
Tycho Anker-Nilssen	Norwegian Institute for Nature Research	Norway
Robert Barrett	University of Tromsø	Norway
Christine Cuyler	Greenland Institute of Natural Resources	Norway
Knud Falk	Independent	Denmark/ Greenland
Maria Gavrilo	Russian Arctic Nature Reserve	Russia
Grant Gilchrist	Environment Canada	Canada
Olivier Gilg	University of Bourgogne	France
Ann Harding	Pribilof Island Seabird Youth Network	U.S.A.
Henry Huntington	Huntington Consulting/NGO	U.S.A.
Gabriela Ibarguchi	Arctic Institute of North America	Canada
David Irons	US Fish and Wildlife Service	U.S.A.
Sarah Kalhok Bourque	Indigenous and Northern Affairs	Canada
Gary Kofinas	University of Alaska, Fairbanks	U.S.A.
Eva Krümmel	Inuit Circumpolar Council	Canada
Flemming Merkel	Aarhus University	Denmark
Don Reid	Wildlife Conservation Society	Canada
Manon Simard	Makivik Corporation	Canada
Martin Sommerkorn	WWF	Norway
Michael Stickman	Arctic Athabascan Council	U.S.A.
Hallvard Strøm	Norwegian Polar Institute	Norway
Ole-Anders Turi	Saami Council	Norway
Bob van Dijken		Canada

At the time of interviews, individuals followed an informed consent process after which each participant was asked questions to elicit their perspectives on using triage in the allocation of monitoring effort. A process of thematic content analysis (Saldaña, 2015) was applied to transcribed qualitative data from interviews. All questions were posed in a semi-structured form to allow participants to discuss the premise of the questions, generate new ideas and explore nuances in their answers. To maintain consistency across interviews, interviewees were given a definition of the traditional view of triage prior to being asked questions. Interviews were conducted either in person at arctic conferences and working group meetings or remotely via skype and telephone. In each case, interviews were audio recorded and then transcribed and reviewed to identify key themes in responses (Gubrium et al., 2012). Applicable portions of transcripts of responses were then associated or coded to commonly identified themes. All participants were given the options of having their names associated with quotes or quotes being used anonymously.

In analysis, responses were categorized as being largely supportive, largely opposed, or discussing both advantages and disadvantages such that they neither showed strong support nor strong opposition, or they were undecided. Interviews were conducted as part of a larger project on monitoring needs for the Arctic, which included additional participants. The study was carried out under the approval of Trent University Research Ethics Board. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

In order to compare views on the traditional triage with views on other forms of prioritization aimed at maximizing conservation benefit (the broadest definition of triage), a subset of 11 participants were asked their perspectives on prioritizing resources toward monitoring that would generate the greatest conservation benefit. Five of these individuals were representatives of Indigenous organizations and five were scientists, of which one was involved in decision making, and two participants were from NGOs (one was a scientist, one was not). To examine perspectives on some of the key assumptions of triage, we then asked participants the extent to which they thought resources for monitoring were transferable between species and locations. This subset of individuals represented the last individuals interviewed, reflecting the development of the interview structure as we identified the need to examine the triage theme in greater detail.

Although, our primary goal was to explore stakeholder perspectives across all groups, we also assessed differences in responses between groups to indicate where key differences in perspectives may occur. We compared proportions of participants in each of the categories described below giving each response type (e.g., support or opposition for traditional triage and for monitoring for maximization of conservation benefits, context dependence in attitude toward traditional triage); we did not use inferential statistics, as our sample should be considered non-random. Given the distribution of participants among designated groups (representatives of Indigenous organizations, scientists, people involved in decision-making, and NGOs), all but one individual was either attributed to an Indigenous organization or was a scientist and there was no overlap between categories, we therefore focused our quantitative analysis on comparing responses by representatives of Indigenous organizations with those by scientists. This excluded the single individual who was a representative of an NGO and neither a scientist of representative of an Indigenous organization. We then focused on variation in response between those strongly involved in decision-making and those who were not. We did not compare representatives of NGOs with other categories due to low sample size within this group.

RESULTS

General Attitudes to Triage

Of the 23 participants interviewed concerning triage, six participant's primary role was to communicate Indigenous needs, nine were strongly linked to decision-making or policy-related organizations, and 16 were actively working in arctic science. Three participants worked for NGOs. Of our 23 participants, 13 (57%) gave responses predominantly opposing triage, six (26%) gave responses predominantly in favor, and four (17%) were either unsure or had views showing equal support and opposition to triage.

Participant type appeared to influence the degree of support for triage, in particular representatives of Indigenous organizations showed a strong opposition to triage (**Figure 1A**, left panel). In contrast, within scientists the response was more divided between support and opposition (**Figure 1A**, right panel). Within the scientists, a greater proportion of decision-makers were supportive of triage than non-decision-makers, although this difference was weaker than that observed between representatives of Indigenous organizations and scientists (**Figure 1A**). Fifty percent of those participants predominantly in favor of triage proposed some level of context specificity in the relevance of its application as opposed to 38% of participants in opposition to triage (**Figure 1B**), suggesting most respondents were only supportive of triage in limited contexts if at all.

Participants showed greater support for prioritizing monitoring according to maximization of conservation benefits than for the traditional definition of triage (where conservation was defined as benefits for wildlife and people, **Figure 1C**). Of a subset of 11 participants asked, 64% were in favor of monitoring being prioritized toward activities with clear conservation benefits, while only 18% of that subset were in favor of triage as a means of prioritization. This suggests that while most participants were not opposed to all monitoring prioritization efforts, many of those participants were not in favor of triage.

Responses to Triage As a Means of Prioritization of Monitoring

Interviews generated seven main types of response (**Tables 2–4**). Those addressing the conceptual framework of triage included criticism of the species-focussed worldview that underlies triage ($n = 5$) and the wildlife focussed view that may not take into account human needs ($n = 3$). Some participants also addressed the ecological validity of triage. These opinions on ecological validity were proposed both in support and in opposition to triage. Views included highlighting (in opposition to triage) the low functional redundancy in high latitude systems and perhaps greater need to preserve all species, or conversely (in support of triage) the prevalence of abundant species in the Arctic and the need to focus on common species.

The relevance of monitoring triage to information needs was also discussed. The need to learn about how species respond to rapidly changing arctic processes was highlighted. The lack of current ability to predict species responses to change was also cited as a reason not to apply triage approaches, as it may not be possible to accurately predict which species are least likely to persist and thereby accurately select species for triage. Practical issues were identified, such as whether threatened species generate their own funding in opposition to triage or whether it is more cost-efficient to monitor abundant species in support of triage. Political and ethical issues were also identified. More specifically, participants raised the need to monitor threatened species in order to highlight species declines

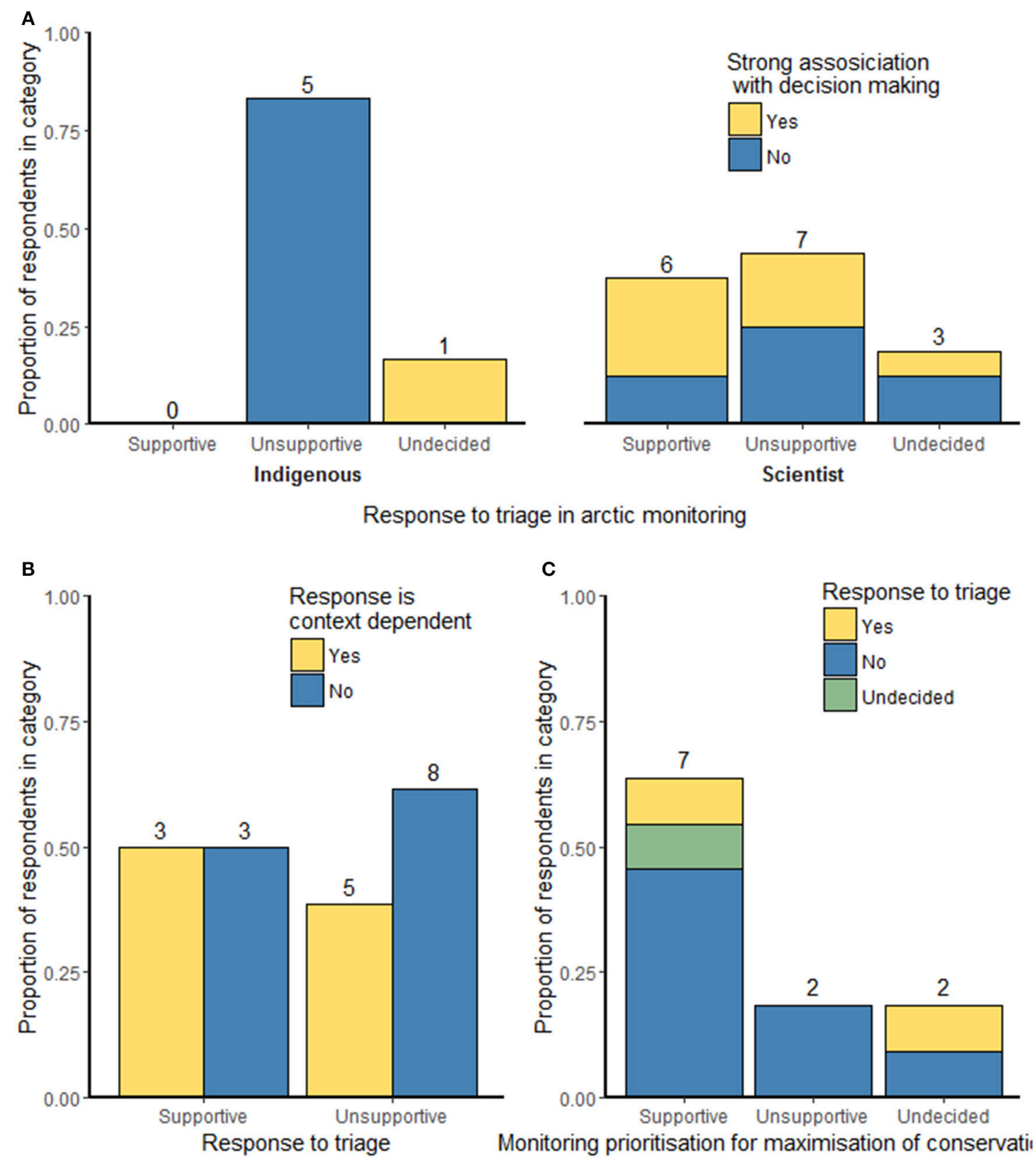


FIGURE 1 | Summary of stakeholder responses to triage and related issues (A) shows differences between representatives of Indigenous groups, scientists and individuals strongly related to decision-making in responses to triage, **(B)** shows the whether respondents supportive and unsupportive to triage showed a degree of context dependence in whether application of triage might be justified, **(C)** shows the responses of a subset of individuals asked whether monitoring should be prioritized for maximization of benefit for conservation and whether individuals were supportive of triage. Numbers of participants responding in a given way are indicated above bars.

and generate attention toward issues of arctic change, as well as the ethical stance that species should not be abandoned.

In addition, a number of modifying factors were acknowledged which might affect the applicability of triage. It was suggested that the applicability of triage might depend on spatial scale, and that species that are threatened locally (e.g., the Arctic fox in Norway, **Table 2**, quote 4.7.1) but not at a pan-arctic scale might be less important foci than those threatened across the entire Arctic. Whether there were means of addressing declines was also an important consideration in whether triage might be appropriate. Finally a consideration of who decides was an important modifying factor, with particular reference given to the need to involve Indigenous people and local communities in setting monitoring agendas. Several participants gave responses

TABLE 2 | Summary of stakeholder conceptual and ecological issues in monitoring triage for arctic wildlife.

Ref.	±	Theme	Participant quotes
4.1 CONCEPTUAL ISSUES			
4.1.1	–	Species focussed approach is antithetic to world views	"In monitoring of the environment, I'm thinking of broader issues..... I'm driven by environmental marine issues" Grant Gilchrist (Environment Canada, Canada)
			"I think it is better to have a wider approach, so you focus on a set of species and you do not focus on the very rare species who are likely to go extinct whatever you do" Hallvard Strøm (Norwegian Polar Institute, Norway)
			"Because the First Nations are very ecosystem [focussed] and holistic, I think it would probably be a tough argument to say now we'll just cut one loose, concentrate on the others [species]" Bob van Dijken (Canada)
			"That's a tough one because we pretty much depend on everything out there, so everything is important" Michael Stickman (Arctic Athabascan Council, U.S.A.)
			"Things that prioritise one population above the other could have an effect on the whole ecosystem in those areas but also people; because the whole population are dependent on other populations of species and [triage should be an] absolute last resort" Ole-Anders Turi (Saami Council, Norway)
4.1.2	–	Monitoring for the needs of local people	"If you want to look at it in terms of a human perspective, in terms of diversity to secure options (such as options for future human choices or ecological response options) and food security for example, I don't think it is a very good idea" Martin Sommerkorn (WWF, Norway)
			"Caribou seems to be important here, focussing conservation efforts for instance on caribou, again it is very important culturally to people, it's very important for people's diet and I think it is also important spiritually, I guess you are on the land and connecting with the land again for caribou, so I think that would be a fair approach" Jason Akearok (Nunavut Wildlife Management Board, Canada)
			"When you prioritise funds for one species above the other...their extinction has such an effect on the species you are trying to maintain, the communities of those species and the community of people, especially in the Arctic areas....Some [people] are so dependent on animals..." Ole-Anders Turi (Saami Council, Norway)
4.2 ECOLOGICAL ISSUES			
4.2.1	+	The conservation of abundance	"We are trying to keep the common species common, and if we put all out resources into trying to just help threatened species, the resources are all skewed towards...emergencies, many of which we can't help" Grant Gilchrist (Environment Canada, Canada)
			"One of the great things we have going in Alaska in the conservation world is we are in the position to conserve abundance..... We talk about the decline of the western caribou herd, that is has gone from 500 000 to something over 200 000, this is not an extinction problem, we are facing right now, we are trying to conserve that abundance" Henry Huntington (NGO and Huntington Consulting, U.S.A.)
4.2.2	–	Lack of functional redundancy	"The little functional redundancy we have in the Arctic, we just don't know which ones we can let go and still have a functioning ecosystem. In the Arctic...species are often irreplaceable" Martin Sommerkorn (WWF, Norway)

Where a perspective is compatible with triage is denoted + and incompatible –.

both in support and opposition to triage, therefore quotes in support or opposition to triage do not necessarily represent that a given participant gave an overall response of the same nature.

Finally, our interviews also identified how existing structures within arctic monitoring might impact the ability to prioritize monitoring across the Arctic and perspectives on current foci in arctic monitoring. In particular, the large number of agencies involved and the variety of their mandates may limit flexibility in monitoring across the Arctic. Participants identified the current focus on harvested species and economically relevant species as a potential concern within the current monitoring agenda.

DISCUSSION

General Attitudes to Triage

Our study demonstrates an overall lack of support for triage in monitoring within our participant group. Opposition was particularly pronounced for representatives of Indigenous organizations. This opposition may reflect a more holistic view of socio-ecological systems (and thus a lesser tendency to reduce them to their individual components) or a stronger cultural and spiritual value placed on arctic species (Cochran et al., 2013). Scientists were more split in their support; those strongly associated with decision-making had greatest support for triage. This may reflect a willingness of and necessity for those closer to the decision making process to make compromises concerning certain values to deal with trade-offs within decision-making.

Reconciling perspectives between different actors is an important part of decision-making regarding monitoring, to promote effective arctic stewardship under continuing rapid socio-ecological change. In the Arctic, meaningful involvement of Indigenous peoples in decision-making processes regarding monitoring priorities may be one way of managing the variation in perspectives toward monitoring, to obtain mutually acceptable monitoring agendas. This includes decisions regarding scientific monitoring and use of Indigenous knowledge, local ecological knowledge, and community based monitoring. Although, there are increasing efforts for Indigenous and local community involvement in setting monitoring agendas (Russell et al.,

TABLE 3 | Summary of stakeholder perspectives relating to information needs and cost efficiency in relation to triage in wildlife monitoring in the arctic.

Ref.	±	Theme	Participant quotes
4.3 INFORMATION NEEDS			
4.3.1	–	Important knowledge generated through monitoring	"I think [threatened species] are important because they can still tell us things about the marine environment, so we are studying Ivory Gulls not just because they are a rare or endangered species but because they are a really arctic species.....if that population is declining or its range is shrinking and we can relate that to sea ice conditions..that's a very big issue" Grant Gilchrist (Environment Canada, Canada)
			"The Ivory Gull......could be one of the first to disappear from climate change because it is so strictly linked to sea ice......we know that in in 20, 30, 50 years the sea ice will disappear in summer...it will likely die or adapt...it is extremely interesting knowledge for us because we can eventually infer how other species will react in the longer future..potentially all these species are facing a decline or extinctions in the longer term, so the sooner we understand part of how it works, the sooner we will be able to have alternative conservation policy and strategy" Olivier Gilg (University Bourgogne, France)
			"We must still learn about some management opportunities, just closing your eyes doesn't help" Knud Falk (Independent, Denmark/Greenland)
			"If there is a species which we think is doomed, what does that represent to the ecosystem?" Robert Barrett (University of Tromsø, Norway)
			"We want to keep an eye out for the local disappearance, extirpation or sudden die off of key species, and then pin point the cause(s) why.... we have got to find out why because the cause(s) could negatively impact populations elsewhere, possibly involving the entire arctic." Christine Cuyler (Greenland Institute of Natural Resources, Greenland)
4.3.2	–	Uncertainty in species responses	"Our projections can be wrong" Participant B
			"We don't know the impact of the environmental change to come and so there actually is only one strategy that makes sense in such a situation and that is conserve diversity" Martin Sommerkorn (WWF, Norway)
4.4 COST EFFICIENCY			
4.4.1	+	Greater efficiency in conserving and monitoring more abundant species	"The common species are easier to monitor, you get more bang for your buck" David Irons (US Fish and Wildlife Service, U.S.A.)
			"One of the problems I see with things like the endangered species focus is that is just sucks up so much time and attention to a handful of species or cases and this is to the detriment of the ones that are abundant or are doing well.....What do we lose by devoting all our resources to one animal to say it is still there, when we are neglecting what could be major shifts in populations of other animals" Henry Huntington (NGO and Huntington Consulting, U.S.A.)
4.4.2	–	Threatened species generate research funds	"when you know it is collapsing the money is often there" Robert Barrett (University of Tromsø, Norway)

Where a perspective is compatible with triage is denoted + and incompatible –.

2015), and the need has been long-highlighted, in many cases involvement remains limited. Notable exceptions are the strong participation of Indigenous and local communities in monitoring of contaminants to better understand impacts on traditional foods (Berkes et al., 2001) and co-production of knowledge in co-management of narwhal and beluga entrapments and Dolly Varden char (Armitage et al., 2011).

Greater understanding of how to involve Indigenous people in monitoring decisions may be gained from applying the successful approaches adopted in management. There is substantial geographic variation in the degree of Indigenous rights across the Arctic (Nuttall, 2000). Across arctic states, co-management is most advanced in North America, where land claims agreements define ownership of land, rights to resource use and processes of co-management involving Indigenous and government organizations (Kocho-Schellenberg and Berkes, 2014; Boudreau and Fanning, 2016). Effectiveness of decision-making within arctic co-management structures has been linked to key individuals acting as focal nodes for communication networks, involvement of bridging organizations in facilitating communication and bringing together different sources of knowledge (Kocho-Schellenberg and Berkes, 2014) and frequent and high quality interactions between stakeholders over extended time periods (Brooks and Bartley, 2016). Limitations to co-management include overreliance on individuals and small advisory councils to speak for multiple tribes and communities (Brooks and Bartley, 2016) and excessive burden on a limited number of individuals (Gallagher, 1988).

Our data suggest that evaluating triage in isolation from other strategies for prioritizing monitoring activities gives an incomplete picture of attitudes toward prioritization of monitoring activities. The lower acceptance of triage relative to monitoring for maximization of conservation benefit, suggests that triage is not perceived to be the most effective or acceptable way of maximizing conservation benefits from monitoring. Most of those who were supportive of triage expressed context dependence in this belief. This also suggests that few individuals believed that triage could be a single strategy for prioritization of monitoring efforts. A wider set of trade-offs need to be evaluated to understand how to maximize the multiple desirable benefits that may be attained from monitoring. Examining attitudes to triage may elucidate some of alternate underlying trade-offs of importance to stakeholders, which should determine broader monitoring agendas.

TABLE 4 | Summary of perspectives on political and ethical issues and factors that modify the applicability of triage in arctic wildlife monitoring.

Ref.	±	Theme	Participant quotes
4.5 POLITICAL AND ETHICAL ISSUES			
4.5.1	–	Political risks in the absence of monitoring of a species	"I mean you can have a policy where you say that if you don't know enough about something ... then we perhaps lower the quota, or we reduce the hunting season because we don't know enough to know whether this utilisation is sustainable or not. If that is the practise, well then it is easier not to know a lot. But if the other way round is that when we don't know a lot and as far as we know there is not a problem, so we just go ahead and shoot the birds or fish the fish stocks then it is more dangerous in terms of conserving the resources for the next generation." Flemming Merkel (Aarhus University, Denmark) "Without a monitoring program, gathering information, you have nothing to talk about. You have nothing to present and then the assumption is that everything's stable, so that's where monitoring is so key." Grant Gilchrist (Environment Canada, Canada)
4.5.2	–	Obligation to try	"If they are so threatened and we have a chance to save them, then we need to invest" Participant A "As long as there are two mating animals out there; there is an opportunity." Michael Stickman (Arctic Athabascan Council, U.S.A.) "If you stop monitoring a species that is being threatened..., you are giving up on it; and I don't agree with that approach at all" Participant B "I just try to be hopeful that...we don't have to sacrifice one because of limited resources, but that would be my view, that we try to get resources to be able to prevent extinction of any type of species and hopefully will not be faced with that choice." Jason Akearok (Nunavut Wildlife Management Board, Canada)
4.6 MODIFIERS			
4.6.1		Spatial scale	"When we introduced national Red Lists, those were really biased toward the small population component within our borders ....for borderline species that might do very well elsewhere, you should expect that they do worse when they are at the limit of their range, so you should be more reluctant to address those populations...........Management at the national level should be addressed with an international perspective and that is not always the case" Tycho Anker-Nilssen (Norwegian Institute for Nature Research, Norway)
4.6.2		Are drivers of change addressable?	"If we cause [the decline] then there is a way to reverse it, that's different, but if they are at the end of their range and they are disappearing... This is an example, the Kittlitz's [Murrelets] are dependent on glaciers......the glaciers are gone, the Kittlitz's Murrelets and going to go away. So if you want more Kittlitz's Murrelets, it might be best to spend money on enhancing their habitat rather than on the birds themselves" David Irons (US Fish and Wildlife Service, U.S.A)
4.6.3		Who decides?	"I would hope that would be hopefully partly a community decision rather than a regional or national conversation or a wildlife management conservation in isolation" Bob van Dijken (Canada) "I am very uncomfortable with getting ourselves to a point of allowing ourselves to have anything go extinct but I understand that you might have to make some very difficult decisions, but they should be very well supported decisions from various points of view." Gabriella Ibaguchi (University of Calgary, Canada)

Where a perspective is compatible with triage is denoted + and incompatible –.

Conceptual Issues in Triage

The species-centered focus of triage and the lack of integration of needs of local people were two core conceptual issues where triage did not conform to the world view on how monitoring effort should be allocated (**Table 2**). Both scientific and Indigenous perspectives highlight the need to move beyond species approaches to more complex monitoring and management (Mace, 2014). The scientific viewpoint often points toward the need for incorporation of more components of the ecological system, for example a more dynamic ecosystem and landscape-focussed approach to arctic conservation has been proposed (Elmqvist et al., 2004). Indigenous systems of thought also highlight the need for more systems-based and holistic approaches, but have greater emphasis on the inclusion of culture and spiritual aspects (Cochran et al., 2013).

In the Arctic, some agencies are transitioning from more species-focussed to more location-focussed monitoring and management, for example:

> "the Yukon government used to use that model of a wolf biologist, a bear biologist, a sheep biologist and a caribou biologist and a moose biologist, so everyone was siloed, had their specialties, would compete for budgets every year.... About 10 years ago, the Yukon government moved to another model with regional biologists who.. had specific areas of the Yukon, and they worked with the First Nations and Renewable Resources Canada and populations and looked at the region rather than the species." B. van Dijken (Canada).

However, a mixture of species-focussed and more ecosystem-based monitoring approaches exist within arctic ecosystem monitoring (Ims R. et al., 2013), with only a few addressing both human-ecosystem interactions and ecosystems in an integrated programme. When networks of monitoring sites are used to monitor ecological change at pan-arctic scale, the need for an ecosystem-based approach has been highlighted (Christensen et al., 2013); however the complexities of synthesizing information at large scales often result in single species assessments. Therefore, while the concept of triage at a species level may be compatible with some existing mechanisms of monitoring and conservation in the Arctic, it may be less compatible with aspirations for more systems-based monitoring and Indigenous perspectives.

The second conceptual misalignment that triage does not explicitly incorporate the needs of local people (**Table 2**) also emerges from an increased focus on more socio-ecological systems in conservation and management. As many arctic Indigenous people use wildlife through harvest, the persistence of certain species directly affects food security (Power, 2008). Prioritizing monitoring decisions based on likelihood of persistence of species or population does not take into account the cultural, social and physical value of species to local people. For example, the Ivory Gull is both near threatened and a species that has generated local concern over declines; it has traditionally been hunted and although not a principle food source, it is highly valued by local people (Gilchrist and Mallory, 2005). A triage approach based on probability of species survival alone might consider Ivory Gulls a candidate for monitoring triage. Long term persistence of the Ivory Gull may be limited by rapid increases in heavy methyl mercury burden from anthropogenic mercury, increases in other contaminants (Braune et al., 2007; Bond et al., 2015), and also by the species' strong association with sea ice and changes in wintering conditions (Gilchrist and Mallory, 2005; Spencer et al., 2015). However, the value of Ivory Gulls to local people may render such a triage approach inappropriate.

Arctic Ecological Characteristics and Triage

Two apparently contrasting views in response to triage were that a key goal in the Arctic was to conserve abundance to maintain species functions in ecosystems, and that the low species richness in the Arctic leads to low functional redundancy, meaning it was critical to not allow extinction of rare species. The need to conserve abundance could support the concept of triage, where focus should be given to dominant rather than rare species. The potential for conservation of abundance also partly reflects the current situation in the Arctic, where more large-scale ecological and social processes remain from ancestral times and therefore there is still the opportunity to conserve abundance (Chapin et al., 2006, **Table 2**). Changes in abundance of widely distributed dominant species in the Arctic might have substantial or even disproportionate ecological and social consequences relative to lower abundance species (Chapin et al., 2006; Díaz et al., 2006). A lack of functional redundancy in the Arctic was proposed in opposition to triage by one participant (**Table 2**). The Arctic is characterized by low species diversity and relatively simple food webs, which might lead to lower resilience to loss of species. This lack of functional redundancy has been used to suggest that allowing certain species to go extinct may have greater ecological consequences than in lower latitudes (Post et al., 2009) and highlights a potential need not to limit monitoring to abundant and widespread species. Relevant to both arguments is the existence of ecological (Power et al., 1996) or cultural keystone species (Garibaldi and Turner, 2004), which could be problematic to an abundance-driven monitoring agenda. Identifying keystones and ecosystem engineers (where species have a large role but this can be driven by abundance) with respect to arctic ecosystems and cultures should be core to developing monitoring agendas.

Information Needs and Triage

The need to learn from the trajectories of threatened species was stated by four participants in opposition to triage (**Table 3**). Participants highlighted the need for a greater mechanistic understanding of species responses to changing climate and habitat in order to plan more effective preparations and responses. The ability for species to adapt to rapidly changing conditions is indeed uncertain and a complex area of research (Sih, 2013; Merilä and Hendry, 2014). Excluding species from monitoring based on projections of high risk of extinction may thus be misguided if there is insufficient certainty in the predictions that these species will go extinct or that populations will be extirpated (Morrison et al., 2016). Rapidly changing ice and snow conditions are expected to pose a substantial challenge for arctic vertebrates and rates of cryospheric change may exceed the limits of phenotypic plasticity and rates of adaptation (Gilg et al., 2012). Monitoring responses of species at high risk of extinction may provide information that is unreplicable in higher abundance populations.

Cost Efficiency Issues in Triage

The ability to achieve greater efficiency in monitoring of abundant species was highlighted by two participants and in particular the cost of excessive focus on endangered species was discussed (**Table 3**) in support of triage. This may be particularly true when monitoring is focussed on single species. However, integrated ecosystem-based monitoring programs (Meltofte and Berg, 2004; Gauthier and Berteaux, 2011; Ims R. A. et al., 2013) and community based monitoring and greater use of traditional knowledge may reduce the inefficiencies of monitoring low density or difficult to observe species:

> "So we're trying to ....develop an integrated ecosystem-based monitoring design,... the idea is to capture,.. as many things as possible.. you are still using the same number of people in the field and the same number of days in the field. For just a little bit of extra effort you can capture a whole new level of information" G. Ibarguchi (Arctic Institute of North America, Canada).

Ecosystem-based monitoring may capture rare species without the explicit monitoring for rare species, although this is dependent on the co-occurrence of species with monitoring sites. However, many funding mechanisms are not currently structured in ways that facilitate these approaches.

In contrast, another participant highlighted that the decline or collapse of a species tended to generate money for monitoring (**Table 3**). These resources may not be transferable to other species. It may not be appropriate therefore to incorporate monitoring of certain species (particularly charismatic or rapidly changing species likely to gain attention) in to a cost benefit analysis of species rarity or abundance and economic efficiency of investment unless these contributions are fully quantified.

Political and Ethical Issues in Triage

One of the most common responses to the idea of triage was primarily ethical. The idea that people should not give up on a species even if it is severely threatened was common amongst scientists and Indigenous representatives (**Table 4**). The application of triage might also increase acceptability of species extinctions (Buckley, 2016). Two participants highlighted that there may be political implications to reducing the amount of attention to threatened species (**Table 4**), as they may highlight undesirable drivers of change. Two participants highlighted that in the absence of information, it may be assumed that an ecosystem is in good condition or a species is being exploited at a sustainable level. Without a precautionary approach to development and management across the Arctic, highly threatened species may be an important component of highlighting threats to ecosystem, the application of triage could be detrimental to these initiatives.

One consideration in the Arctic, mentioned in our interviews is whether it is possible to address drivers of decline, and whether this should determine monitoring focus. In the Arctic, drivers of ecological change range from locally generated pressures such as local harvesting to broader spatial extent pressures such as resource extraction, commercial fishing, and land conversion to impacts generated at the global scale such as climate change, and long distance pollutants. Often it is easier to translate monitoring activities into desirable outcomes at the local scale than address global drivers of change. Focussing monitoring on maximizing benefits may create inequalities in the expectations of behavioral change from different stakeholders and institutions, while not holding to account other actors contributing to change.

Existing Structures and Monitoring

The realities of both organizational structures and monitoring needs may limit the ability to prioritize monitoring at large scales across the Arctic. The responsibility for monitoring of species and decision making regarding management and conservation rests with a large number of agencies across the Arctic with different mandates, operating at different spatial scales.

> "...caribou is very important to people here and the principle enforcement organization is the Nunavut government... the migratory birds, that's managed by the federal government so there's two legislative authorities managing different species so it is not always easy to be able to ... take one pocket of money over to another organization when there's different mandates for different organizations." J. Akearok (Nunavut Wildlife Management Board, Canada).

One participant mentioned that academic scientific research may provide greater opportunities for switching between species than governmental organizations with specific mandates, when asked the extent to which resources for monitoring were transferable between species, they replied:

> "... you need to apply for funds, so it depends on the argument you have, you cannot suddenly switch all the monitoring from one species that is sexy and makes the front line news to a more boring species, because you cannot argue with the same arguments for the need for monitoring. So, I'd say, for a science grant certainly you could, but when it comes to management kind of funding pool, I think you would have quite a challenge in just switching." K. Falk (Independent, Denmark/Greenland).

Although, explicit coordination of prioritization across all organizations may be unlikely, organizations may inform their internal prioritizations according to where effort is already allocated, for example one participant in a wider analysis of monitoring needs commented:

> "WWF is not really very much working on birds as species because of different reasons. One reason is that there are many other organizations working on birds, so that's why we decided to prioritize our limited resources...somewhere where probably there are less efforts." A. Shestakov (WWF, Canada).

While there has been extensive effort to coordinate monitoring and research efforts across the Arctic via a number of organizations (e.g., the Circumpolar Biodiversity Monitoring Program and Arctic Monitoring and Assessment Program), it is unlikely that any system of prioritization can provide sufficient flexibility to incorporate the needs of stakeholders and biodiversity objectives across the vast range of relevant scales and these will most likely need to be tailored to different agency needs.

Does Triage Currently Occur in Arctic Monitoring?

Prioritization is implicit in the current status of monitoring across the Arctic. This does not necessarily reflect a species triage approach, but does reflect priorities advanced by a set of stakeholders and decision-makers who have varying levels of influence on these processes. A number of species were perceived as current foci, such as commercially important species and harvested species. For example:

> ".. we don't have enough resources to deal with everything. It doesn't matter what we do, we necessarily leave certain species or certain locations out of the equation and they become second cousins by default. So high political and governmental interest in harvested species necessarily means that a whole bunch of other species will not get attention." D. Reid (Wildlife Conservation Society, Canada).

These were not always perceived to reflect the needs of all stakeholders. For example when asked about the biggest weaknesses in current arctic monitoring in interviews for a larger project on arctic monitoring C. Behe (Inuit Circumpolar Council, U.S.A.) responded:

> "Economic driven questions. I think for me personally, that's the largest weakness, because it's often laden with intentions. I mean we always have intentions but it's laden with the intention of extracting from the environment that you're monitoring and that's really concerning. I'm not saying there shouldn't be development of extraction from the environment, obviously, I drive a car. But, for that to be the only intention and reason that we're gathering information makes it impossible for us to make management decisions, whether its long term or short term."

In order to rectify these problems, greater attention should be put toward identifying a full set of arctic stakeholders, discussing and defining the legitimacy of different stakeholder groups and defining monitoring needs of a broad set of arctic stakeholders and compare the support for proposed strategies relative to that for existing monitoring priorities.

Emerging Opportunities and Triage

The need for triage in monitoring might be altered by greater inclusion of different types of information concerning wildlife. Community-based monitoring has been gaining increasing attention in the Arctic as a means of co-production of knowledge between Indigenous people and scientists. This may allow more extensive and integrated monitoring without some of the substantial costs associated with externally driven monitoring (Pulsifer et al., 2014):

> "Over the long-term I think strategic investment in community based monitoring may get you the same results and a smaller price tag and more chance of keeping continuity in programs" B. van Dijken.

Involvement of local people in monitoring may also have other benefits, such as accelerating decision-making processes at local scales (Danielsen et al., 2010) and a high potential for local participation in data gathering and analysis has been identified for arctic monitoring at an international scale (Danielsen et al., 2014). Within such locally driven programs there will be greater need to engage local people in prioritization of monitoring needs.

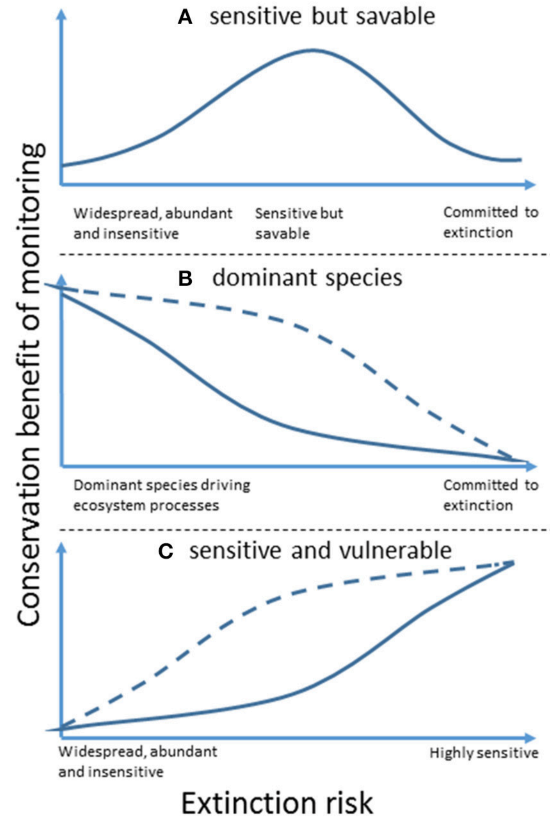
Conclusions

Ecological monitoring fulfills a number of roles which can benefit conservation, from identifying drivers to ecosystem change, to generating understanding of how ecosystems respond to change, to simply documenting observed changes (Lindenmayer and Likens, 2010; Possingham et al., 2012). Each of these can help generate outcomes that contribute to conservation benefits. Outcomes include identifying actions that can mitigate undesirable changes, predicting how ecosystems will respond to change to facilitate adaptation and evaluate potential outcomes of different decisions. Monitoring can also produce information that generates public and political will to take effective action to alter trajectories of change where it will lead to desirable outcomes. In most circumstances, the routes between monitoring and these outcomes are indirect and the extent to which individual monitoring decisions contribute to these outcomes are impossible to fully quantify. Within monitoring of these complex systems, benefits and outcomes are derived at multiple scales and can differ between stakeholders (Cash and Moser, 2000).

Increasingly the need for a stewardship is being proposed and a need to address future arctic scenarios in a more systems-based approach (Chapin et al., 2015), which highlights the need to identify desirable outcomes as a prerequisite to identifying monitoring strategies to achieve them (such as monitoring triage). Better understanding of desirable outcomes is required to inform improved arctic monitoring agendas. The use of scenarios may be one way of addressing the substantial complexity in decision-making. Defining desirable arctic futures may provide one route to fostering stakeholder involvement and understanding what the most effective priorities for arctic monitoring will be (Chapin et al., 2010). Structured decision-making, whereby a set of objectives, alternative actions, and projected consequences are defined and information is fed back to improve monitoring may also be an effective mechanism of making decisions about what to monitor with respect to more direct use of information such as in monitoring for management (Lyons et al., 2008), particularly where these three characteristics are more easily defined. The related field of biocultural conservation places greater emphasis on governance structures and multiple knowledge systems (Gavin et al., 2015) and is equally relevant to arctic monitoring. Here, the role of multiple objectives and stakeholders are incorporated to making (in this case monitoring) decisions based on the socio-ecological context.

Traditional triage might be considered decision-making based on an assumed relationship between likelihood of persistence and conservation benefit to be derived from monitoring. This could take a number of forms (**Figure 2**) and models could be applied at a number of levels of organization, including ecosystems, species, and populations or other ecosystem components. Our participants were primarily unsupportive of triage approaches but showed a greater level of support for monitoring that would maximize benefits for biodiversity and people, suggesting greater support for a broadened view of triage (described in Bottrill et al., 2008).

Perhaps a prerequisite to deciding on any given set of appropriate monitoring strategies (including triage) is identifying the essential characteristics of strategies for monitoring prioritization for stakeholders. In evaluating their reasons for support or opposition to triage, our participants identified a number of factors that might affect the validity of triage approaches and could give a broader indication to necessary characteristics of monitoring strategies. These include whether approaches monitor the trajectories of functionally and culturally important components of the system, whether they take a systems-based approach considering linkages within and between ecosystems and society and are compatible with stakeholders perspectives, whether they are a cost-efficient means of achieving monitoring objectives, whether they are appropriate to the scale at which monitoring is conducted and take in to account relevant information at other scales and whether they are ethically acceptable to all stakeholders. We also identified that the outcomes of strategies should not increase injustices in the burden of responsibility for ecological change or create undesirable outcomes such as caused by the assumption that no reported change equates to healthy ecosystems. Linking between these requirements and desirable outcomes is a key challenge for those creating monitoring programs for conservation purposes. Our analysis suggests that stakeholders differ in their perspectives on the validity of approaches according to their worldview and we suggest that greater meaningful integration of multiple stakeholder in decision-making regarding monitoring might help develop strategies, which reconcile these differences.



Arguments	Ecological questions	Socio-political questions
Species with intermediate extinction risk have specific habitat needs and are sensitive to change. Unlike highly at risk species, for which there may be few options for remediation of declines, there are opportunities to effectively protect these species.	To what extent are certain species committed to extinction, is there enough information to identify such species? To what extent are dominant species insensitive to arctic drivers of change?	What is the cultural significance of rare species in the arctic? What would be the effects of loss of these species?
Dominant species can have a key role in ecosystem processes. Changes in their abundance may have the most substantial ecosystem effects	To what extent do dominant species drive ecosystem processes compared to less common species? Are rare species somewhat functionally redundant in arctic ecosystems, if so to what extent?	Are dominant species more frequently important resources or of cultural importance of species? Are the public and political bodies as likely to respond to changes in abundance as risk of extinction?
Species at high extinction risk are likely to be highly sensitive to drivers of change and in most urgent need of action for conservation.	To what extent are highly endangered species able to recover or adapt to novel environments?	To what extent does evidence of declines in rare species drive public understanding of ecosystem change and conservation action? To what extent do rare species generate independent funding for monitoring?

FIGURE 2 | Three possible scenarios for the relationship between extinction risk and conservation benefit of monitoring: (A) where monitoring both high and low extinction risk species provides fewer conservation benefits, **(B)** where greatest benefits derive from monitoring dominant species, and **(C)** where greatest benefits are generated from high extinction risk species. Both **(A,B)** involve the concept of triage. Explanations for each approach are given under arguments in the associated table and ecological and socioecological questions pertinent to each model are given. Solid and dashed lines represent alternative function forms within the same broad concept. Note that questions can also have overlapping applicability between multiple models.

AUTHOR CONTRIBUTIONS

All authors were involved in the conception or design of the project. HW conducted, analyzed and interpreted the interviews and wrote the manuscript. DG, CF, DB, NY, and BP revised the manuscript and provided important intellectual content.

ACKNOWLEDGMENTS

We are grateful to J; Akearok, T. Anker-Nilssen, R. Barrett, C. Behe; C. Cuyler, K. Falk, M. Gavrillo, G. Gilchrist, O. Gilg, A. Harding, H. Huntington, G. Ibarguchi, D. Irons, S. Kalhok-Bourque, G. Kofinas, E. Krümmel, F. Merkel, D. Reid, A. Shestakov, M. Simard, M. Sommerkorn, M. Stickman, H; Strøm, O.-A. Turi, and B. van Dijken for their participation in interviews. We also thank other members of the CAFF CBird expert group for interesting discussions. Funding was provided by a Belmont Forum Small Cooperation Grant (TAMANI project), supported by the National Sciences and Engineering Research Council of Canada, Agence Nationale de la Recherche, France and The Research Council of Norway. We are also grateful to the National Science Foundation (USA) and the French Polar Institute Paul-Emile Victor (ADACLIM programme No. 388) for support.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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