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Perspective

Conservation potential of apex predator tourism

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ABSTRACT

In recent decades, public interest in apex predators has led to the creation and expansion of predator-focused wildlife tourism. As wildlife tourism has become an increasing topic of study for both social and biological scientists, researchers have debated whether these activities serve conservation goals by providing non-consumptive values for wildlife. Discussion of predator tourism requires additional recognition of predator-specific biological and ecological characteristics, consideration of human safety concerns, and mitigation of human-wildlife conflict. By reviewing tourism activities centered on both aquatic and terrestrial predators from diverse taxa (sharks, crocodiles, and big cats), we evaluate the potential benefits and conservation challenges associated with predator tourism. Our review suggests that positive conservation outcomes are possible, but not assured given historical, cultural, and ecological complexities. We explore some of the factors which determine whether tourism contributes to conservation outcomes, including (1) effective protection of animals and habitats, (2) avoidance and mitigation of human-wildlife conflict, (3) quality of associated educational interpretation and outreach, (4) collaboration with local stakeholders, and (5) use of generated funds to advance conservation goals. Our findings suggest tourism is most likely to support predator conservation and/or recovery when the industry has both public and political support and under conditions of effective regulation focused on management, monitoring and enforcement by local, national, and international bodies.

1. Introduction

The conservation value of wildlife tourism, both potential and actual, is debated and remains controversial. While wildlife tourism is a complex industry (see definitions Table 1), supporters argue that it can lead to animal and habitat protection, as well as positively shaping the attitudes of locals and tourists (Higginbottom, 2004). Existing literature suggests that wildlife tourism that is well-regulated and performed responsibly, even when not designed to conform to all academic definitions of ecotourism, can generate revenues which lead to increased valuation of wildlife and the environment (Chardonnet et al., 2002; Tisdell, 2003). Although this makes tourism attractive as a potentially "self-funding" conservation strategy, there is concern about negative impacts on wildlife behavior and health from tourism activities (e.g. physiological stress, alteration of animal behavior, reproductive impacts) and questions about the extent to which significant public attitudinal changes occur and manifest as conservation benefits (Tisdell and Wilson, 2005).

Wildlife tourism presently plays an important role in funding the operation of public protected areas, generating some portion of many protected area budgets, driving political support and funding from governments interested in increasing tourism, and spurring the creation of private wildlife reserves (Buckley, 2009, 2010; Bruner et al., 2004). Tourism operations can also serve as *defacto* monitors and deterrents for illegal or environmentally harmful activities, such as poaching or illegal harvest of natural resources (e.g., Mossaz et al., 2015). However, a global meta-analysis of wildlife tourism from 251 case studies concluded that as many as 36% of all wildlife tourism programs were unsustainable due to negative impacts on target species, usually resulting from large numbers of poorly-regulated or managed tourists (Krüger, 2005). Though 63% of operations were classified as sustainable (i.e., not resulting in the long-term destruction or degradation of utilized

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Table 1
Key definitions of tourism-related operations.

Term	Definition	Citations
Ecotourism	Tourism that is ethical, nature-based, educational, and sustainable both environmentally and socio-culturally (with many definitions expecting that it be a net positive for conservation and communities, rather than simply non-damaging).	Fennell, 2001; see also: Goodwin, 1996; Blamey, 1997; Donohoe and Needham, 2006; Diamantis, 1999; Buckley, 2003
Sustainable tourism	Tourism that does not, over time, degrade the natural resources on which it relies or the communities in which it occurs.	Butler, 1999; see also: Hardy et al., 2002; Liu, 2003
Wildlife tourism	Tourism advertised and focused on sightings of and encounters with one or more wildlife species.	Shorthand for "tourism with wildlife"
Nature tourism	Tourism advertised and focused on experiences with the natural world and natural landscapes, which may or may not include wildlife species.	Shorthand for "tourism related to natural systems including landscapes and wildlife"
Predator tourism	Tourism advertised as and focused on sightings of and encounters with one or more predator species.	Shorthand for "tourism with predators"
[Species] tourism	Tourism advertised as and focused on sightings of and encounters with specified species.	Shorthand for "tourism with [species]"
Conservation benefits	For the purpose of this paper, measurable concrete contributions to wildlife conservation, including funding for conservation initiatives and increased protection for species, their habitat, or their prey species.	

wildlife resources), only 18% were found to have made measurable positive contributions to conservation (Krüger, 2005). Moreover, negative impacts on wildlife can be difficult to confirm or predict, as they may not be immediate, obvious, or easily detectable without long-term behavioral or physiological data (Sorice et al., 2003; Williams and Ashe, 2007). While tourism has potential to conserve wildlife, it also has the potential to actively work against conservation by exacerbating human-wildlife conflict or leading to sub-lethal and even lethal consequences for participating animals (Burns and Howard, 2003; Newsome et al., 2015).

Large predators in particular pose special challenges for the design of sustainable wildlife tourism, as many carnivores are intrinsically vulnerable to anthropogenic stressors, and predator population densities tend to be relatively low. In some cases, exposure to human disturbance may impair predator species from performing ecosystem functions or drive them into more marginal habitat (Nevin and Gilbert, 2005; Bejder et al., 2006). Moreover, predators may represent a real or perceived threat to human safety or livestock, resulting in the intentional elimination of predators to reduce human-wildlife conflict (Treves and Karanth, 2003). Though ranchers have reported greater willingness to tolerate predator depredations on livestock without retaliating if they derive financial benefits through payments for stock loss or from tourism (Romanach et al., 2007), in some cases payments have done little to incentivize increased tolerance for carnivores, and do not adequately respond to public concerns about human safety (Patterson et al., 2004; Zimmermann et al., 2005).

Predator tourism may be more likely than other wildlife tourism to positively influence tourist attitudes, given that predators are often viewed negatively. However, this relationship remains largely untested, and the self-selection of the tourist pool could limit potential attitudinal impacts among those predisposed to view predators negatively. Of course, the attention garnered by large predators may also lead to participation in predator tourism by individuals who otherwise have little environmental awareness or interest, potentially engaging them with conservation to a greater degree.

The impacts of predator tourism are further complicated in the case where food rewards or provisioning are used to attract carnivorous species for viewing. The sustainability and safety of these practices is hotly debated, and there is the possibility that provisioning may create risks to human safety, ecological instability, and legal liability for operators or governments (Newsome et al., 2015; McDougal, 1980; Walpole, 2001; Orams, 1995; Burns and Howard, 2003).

Whether predator tourism operations successfully contribute to overall conservation strategies likely depends on the selection of appropriate species and habitats, the ecological and biological resilience of wildlife, the engagement and support of local communities, environmentally responsible behavior (both voluntary and mandated) by tour operators and tourists, minimization of human-wildlife conflict, and effective management.

Here we present three case studies which explore the potential for tourism activities to positively impact predator conservation, and discuss the importance of thoughtful regulation of predator tourism (Fig. 1). We chose to focus on rapidly growing and in-demand examples of predator tourism operations from a range of habitats (marine, riverine/estuarine, terrestrial), taking place with species from diverse taxa (fish, reptile, mammal). Using these examples, we explore some of the factors which determine whether tourism contributes to conservation outcomes and subsequently offer recommendations for policymakers, operators, and researchers intended to improve the social and ecological outcomes of predator tourism.

2. Case studies

2.1. Case study 1: sharks (Fig. 1A)

Sharks are among the world's most iconic predators, with a fearsome reputation built around the 1975 blockbuster movie *Jaws*, which has shaped public perception and policy responses to sharks through the present day (Neff, 2015). In reality, sharks represent a very small threat to human life, but despite low risks, threats to human safety are a primary frame for reporting and public discourse about shark bites, leading to misperceptions about how dangerous sharks are (Neff, 2015; Muter et al., 2013).

While the primary source of shark mortality is commercial fisheries (Dulvy et al., 2014; Oliver et al., 2015), sharks are also targeted in recreational fishing, which represents a threat to shark populations in some parts of the world—in the United States, it has surpassed commercial shark fisheries in scale (Shiffman et al., 2014). Recreational fishermen's motivations for fishing are often related to the size, power, and reputation of sharks (Shiffman and Hammerschlag, 2014). Sharks are also targeted by culling programs in beach tourism destinations aimed at reducing population size to decrease actual or perceived risk of shark bite, though recently there has been public resistance to these practices (Dudley and Cliff, 2010; Crossley et al., 2014; Dulvy et al., 2014). Alongside the substantial impacts of commercial fisheries, these practices have led to significant population declines for many species (Dulvy et al., 2014; Oliver et al., 2015), though sharks have historically received little concern from the public due to their negative reputation (Neff, 2012, 2015; Vianna et al., 2012).

Shark tourism is a global industry generating significant socio-economic values to many countries (Gallagher and Hammerschlag, 2011), and the economic value of sharks in tourism has been used as an argument in favor of shark conservation (Vianna et al., 2011; Gallagher et al., 2015; Haas et al., 2017). However, there are few cases in which

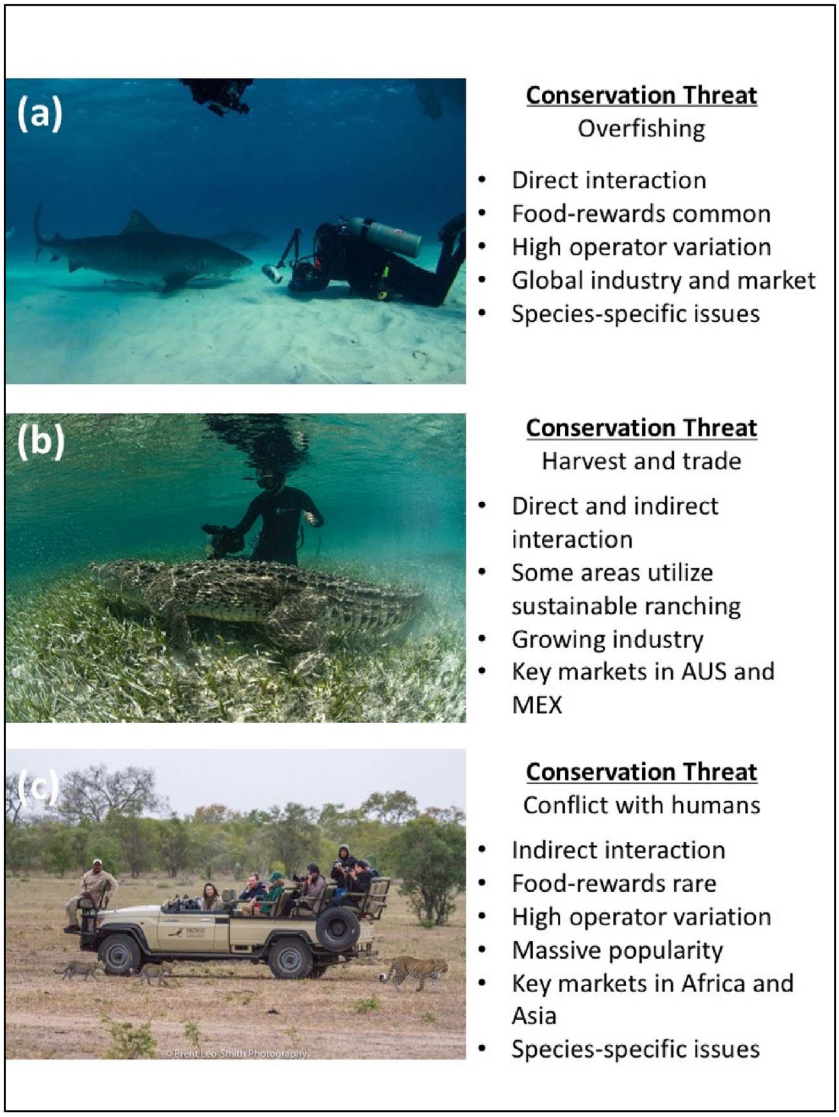

Fig. 1. The potential for ecotourism to contribute to the conservation of top predators is influenced by historical, ecological, economic, and cultural factors specific to the species, industry standards, and region in question: (a) shark diving tourism in the Bahamas featuring scuba-divers and tiger sharks; (b) crocodile viewing tourism in Mexico featuring in-water experiences (although boat and land-based alternatives are the most common methods in other parts of the world); and (c) cheetah tourism as part of a guided safari in South Africa. Direct/indirect interaction refers to whether the tourist interacts with the animals as in (a-b) or whether there is a barrier/safeguard in seen in (c). Photos: (a) Austin Gallagher; (b) Rodrigo Friscone; (c) Brent Leo-Smith.

data exists to allow an in-depth evaluation of the long-term impacts of shark tourism on sharks and local stakeholders (Gallagher et al., 2015), and there have been legal and regulatory challenges to shark tourism operations in some places (e.g., Florida and Hawaii USA). Here, we examine the Shark Reef Marine Reserve (SRMR) in Fiji, a shark tourism project which, due to its small size and extensive cooperation with local communities and researchers, provides valuable insight into what one shark tourism site can—and cannot—accomplish for conservation.

2.1.1. *The Shark Reef Marine Reserve, Fiji*

On the southern coast of Viti Levu, Fiji, the SRMR is a tourism project designed to protect a small reef patch and its fauna while preserving the livelihood of local communities (Brunnschweiler, 2010). The primary attraction at the SRMR is a shark-feeding scuba dive at which up to eight species of shark can be encountered, including bull sharks (*Carcharhinus leucas*) (Brunnschweiler and Earle, 2006). Since 2002, a single dive operator has been granted exclusive access to the no-take zone by villages that traditionally own fishing rights on Shark Reef. In return, villagers receive compensation through a marine park levy paid by every visitor to the reef (Brunnschweiler, 2010).

In November 2014, the government declared the SRMR Fiji's first National Marine Park—a designation specifically intended to protect sharks. SRMR is managed by the tourism operator under the authority of the government in a successful public-private partnership. The SRMR has proven scientifically valuable as a platform to collect data on shark species composition and abundance, as well as residency and movements in and out of the protected area (Brunnschweiler and Baensch, 2011; Brunnschweiler and Barnett, 2013). Longitudinal data of this sort is valuable for quantifying protected area coverage of predator movements, and may be used to argue for expansion of MPA boundaries (Lea et al., 2016).

At the SRMR, the impact of provisioning tourism on sharks seems to be relatively minimal; research suggests bull sharks gather in the SRMR even when feeding is not taking place, and that individual animals exhibit varying degrees of site fidelity to the feeding site (Brunnschweiler and Barnett, 2013). Diver observation and tracking data suggest that bull sharks may leave the SRMR for months at a time, particularly towards the end of each calendar year (Brunnschweiler and Baensch, 2011). These departures are likely related to reproductive activities, which suggests habituation is not severely disrupting key life history events for provisioned sharks (Brunnschweiler and Barnett, 2013).

The SRMR was made possible in large part by engagement with local communities and a careful, responsible approach to tourist safety. These practices are driven by the ethic of the business owner, however, and are not necessarily codified in or required by Fijian law. Local communities are compensated for the loss of fishing access by tourists, who are drawn to the area by the virtual guarantee of seeing sharks—a

guarantee predicated on local willingness to adhere to their commitments not to fish within the SRMR. Another important factor in the SRMR's continuing existence is its "match" to community needs: the program is large enough to generate revenues to offset the costs it imposes on the community. Tourism projects that can do so create long-term, sustainable economic incentives for conservation while facilitating community buy-in (Weladji et al., 2003).

Though the total economic revenue for local villages and the dive operator is constrained by the operator's decision to limit the number of divers it takes to the SRMR to 20 per day (Brunnschweiler, 2010), this also helps ensure that the project will remain sustainable by avoiding the degradation of the reef system. The establishment of the Fiji Shark Corridor in 2006 suggests that the SRMR can potentially serve as a nucleus for increased protection of sharks in greater Fiji. Shark diving has become a major draw for dive tourists, which has led to increased governmental interest in shark conservation, as shown by the formal national protection of the SRMR.

2.1.2. Further considerations

The SRMR project itself protects sharks in a small area, where the no-take policy is enforced by the dive operator (see Fig. 1 in Brunnschweiler, 2010). Additional but largely unmonitored protection for sharks is provided by the Shark Corridor, which nominally protects approximately 30 km of coastline on the southern coast of Viti Levu. This might be adequate to protect small shark species which have relatively small home ranges (Barnett et al., 2012; Vianna et al., 2013a, 2013b), but neither the SRMR nor the shark corridor fully protect larger migratory species, some of which leave these areas regularly (Brunnschweiler and Barnett, 2013). Further, the fact that these practices are largely driven by operators and not backed by significant governmental enforcement resources suggests that related conservation gains are vulnerable to reversal, particularly if additional operations with different philosophies emerge. Norm-setting by an individual operator can be a powerful tool in a limited market, however, the recent addition of further operators will test the extent to which operator-driven conservation in Fiji can survive and thrive in a minimally regulated and increasingly competitive market.

Finally, only a limited number of shark species can realistically benefit from tourism globally, however well regulated (Huveneers and Robbins, 2014). The IUCN Red List's Shark Specialist Group has identified 74 species of sharks as Threatened (Dulvy et al., 2014), but Gallagher and Hammerschlag (2011) found that only nine of these 74 species were commonly associated with dive tourism. A total of 42 of these species whose primary threat is overfishing are unlikely to benefit from tourism due to remote, offshore, or cold habitats, and the remaining 23 Threatened species have not been previously identified as attracting tourist interest (Table 2, Table S1). Furthermore, even in the cases in which a species appeals to tourists and occurs in accessible waters, tourism is likely to mostly have local impacts on shark abundance. However, some regulations that protect shark species that attract tourism attention may indirectly benefit other threatened co-occurring sharks that are not target species of tourism.

In terms of conservation impacts on the 17 shark species most frequently associated with tourism (Gallagher and Hammerschlag, 2011), eight are not threatened by overfishing on a global scale (Table 2). Five of the nine threatened species associated with tourism already have international protections or regulations on trade, which would be unchanged by tourism activities. Marginal further benefits for already protected species are possible, as habitat or prey may be affected by new marine protected areas or other tourism-related changes (e.g., increased supervision of reserves by operators leading to reductions in illegal fishing). However, species of sharks which do not attract tourism interest may benefit substantially from national bans on shark fishing related to shark tourism revenue (as in the Bahamas, which banned commercial shark fishing in 2011), additional regulations would likely be necessary to support population recoveries of threatened species at regional scales.

Table 2
Shark species identified as frequently associated with SCUBA diving ecotourism by Gallagher and Hammerschlag, 2011, along with International Union for the Conservation of Nature (IUCN) Red List threat status (omitting species complexes).

Species	IUCN Red List status
Nurse *Ginglymostoma cirratum*	Data deficient
Bull shark *Carcharhinus leucas*	Near threatened
Blacktip reef shark *Carcharhinus melanopterus*	Near threatened
Caribbean reef shark *Carcharhinus perezi*	Near threatened
Blacktip *Carcharhinus limbatus*	Near threatened
Blue *Prionace glauca*	Near threatened
Tiger *Galeocerdo cuvier*	Near threatened
Lemon *Negaprion brevirostris*	Near threatened
Whale shark *Rhincodon typus*[a]	Vulnerable
Sand tiger/grey nurse/raggedtooth *Carcharias taurus*	Vulnerable
Great white *Carcharodon carcharias*[a]	Vulnerable
Mako (shortfin *Isurus oxyrinchus*, longfin *Isurus paucus*)	Vulnerable (both species)
Lemon *Negaprion acutidens*	Vulnerable
Basking *Cetorhinus maximus*[a]	Vulnerable
Scalloped hammerhead *Sphyrna lewini*[a]	Endangered
Great hammerhead *Sphyrna mokarran*[a]	Endangered

[a] Species is listed on the Convention on International Trade in Endangered Species, regulating or restricting exploitation.

2.2. Case study 2: crocodilians (Fig. 1B)

Crocodilians (alligators, caimans, crocodiles and gharials) are predators in rivers, estuaries, wetland ecosystems, and marine environments. Historically, they have been subjected to unsustainable and largely unregulated exploitation, and illegal international trade in crocodilian products has been extensive (Thorbjarnarson, 1999). By 1971, all 23 species of crocodilians were endangered, depleted, or declining in numbers. Although there is ongoing large-scale trade in crocodilians, today the IUCN Red List assessment classifies 12 species in the Least Concern category, three species as Vulnerable, one as Endangered, six as Critically Endangered, and one species as Data Deficient. The legal international trade in crocodile and caiman skins currently contains the skins of over 1.5 million individuals per year (Caldwell, 2015), but in 2012 roughly two-thirds of these skins were estimated to come from captive-bred or ranched individuals (CITES 2014).

2.2.1. Australian saltwater crocodiles

In northern Australia, saltwater crocodiles (*Crocodylus porosus*) bring in substantial tourism revenue, which has become an important incentive to protect the species in the wild throughout their native range (Ryan and Harvey, 2000). In 1971, after three decades of unregulated hunting, the wild population of saltwater crocodiles in the Northern Territory had been depleted by at least 95%, and estimates suggested only about 3000 individuals remained; adults had become extremely rare (Webb, 2002). Thirty years later, as a result of government-led policy changes, the wild population was back to near pristine levels (> 70,000 individuals) and crocodiles occupied their complete historic range (Webb, 2002).

This conservation success was certainly helped by tourism but depended on several key factors: institutional capacity to pass and enforce new and effective wildlife regulations, deference to those regulations and acceptance of crocodile populations by the general public, and the existence of appropriate habitat for crocodiles to recolonize (Webb et al., 2010). Recovery occurred despite anthropogenic pressures on wild populations including traditional use by indigenous people and incidental catch in commercial fisheries (Webb, 2002).

The process of population recovery, however, was not rapid or uncontested. Between 1971 and 1979, crocodiles were strictly

protected by law and population numbers increased, although initially populations remained strongly biased towards juveniles, and slow growth rates (12–16 years to reach maturity) prevented rapid recruitment of adults (Webb, 2002). By the late 1970s, nine years after protection, crocodiles were far more abundant and the population contained larger individuals, and calls for culling began. The political pressure for culling mounted in 1979–80, following a series of crocodile attacks on people. Managers responded by increasing public education and outreach and removing crocodiles considered to be a problem (approximately 200/year), including individual animals attacking livestock or taking up residence in Darwin Harbour (the capital city of the Northern Territory).

There were two crucial steps to the process of wild population recovery and maintenance: the development of captive populations which reduced hunting pressure on wild individuals, and the creation of economic incentives that encouraged tolerance for growing wild populations (Webb et al., 2010). In the second step, monetization and reimbursement strategies helped garner support from those who bore the costs associated with crocodile conservation. In 1983, a ranching program was implemented which compensated landowners for wild eggs collected on their lands. Approximately 200,000 eggs were collected between 1983 and 2001; collection has steadily increased as populations have grown, to around 50,000 eggs in the 2009–2010 season. These eggs are primarily used to generate captive animals for ranching. This practice encourages landowners to accept large wild populations of crocodiles outside of national parks and protected areas in ways that tourism revenue would be unlikely to achieve alone (Webb, 2002; Fukuda et al., 2011).

Crocodiles are a valuable asset to tourism in Australia, and tourism is giving wild crocodiles their greatest economic value (e.g., Ryan and Harvey, 2000; Tremblay, 2003; Tremblay, 2008). Indeed, most tourists visiting the Northern Territory have the expectation of a crocodile encounter during their trip (Leach et al., 2009). While tourists generally prefer to see crocodiles in the wild, and this is an increasingly sought-after experience, captive crocodile attractions also remain popular (Leach et al., 2009). The growing tourism value of wild crocodiles has led to the creation of areas in which crocodile egg collection and net-fishing (crocodiles are prone to entanglement and drowning) are not permitted—which improves numbers of tourist sightings, but also protects key crocodile habitat.

The enduring combination of conservation-minded regulation, sustainable consumptive and non-consumptive use, and adaptive management has succeeded. Wild populations have recovered and, considering the potential safety risk crocodiles may present to humans, public support for that recovery remains a remarkable achievement (Webb, 2002). This progression—introduction of legal protections, wild population rebound, and growing tourism—has led to increased identification with crocodiles as a regional symbol emblematic of the Northern Territory (Ryan, 1998), creating additional support for conservation in a positive feedback loop. There is no doubt that the economic value of crocodile tourism and the attraction of media attention (saltwater crocodiles are one of the Territory's principal marketing icons), in conjunction with farming and regulated harvest, gave the people and government of the region sound reasons for wanting to conserve wild crocodiles, manage them responsibly, and find ways to minimize and mitigate human-wildlife conflict (Webb, 2002).

2.2.2. Further considerations

For numerous crocodilian populations, creation and enforcement of legal protections and efforts to meet consumptive demand with captive-bred individuals have been crucial to populations recovering to the point that they could be utilized for tourism. However, there are animal welfare concerns about treatment of captive crocodilians, while strategies based exclusively on one economic driver are vulnerable to changes in market value. A downturn in demand and price for crocodile skins in the 1990s saw many sustainable use ranches and farms close (Thorbjarnarson, 1999). Moreover, such projects are necessary but not sufficient from a conservation perspective, as they often do little to promote habitat protection (Thorbjarnarson, 1999; Thorbjarnarson et al., 2006), though habitat loss is one of the most important factors influencing the survival of threatened crocodilians (Ross, 1998; Thorbjarnarson, 1999).

The sequence of events described above relied on several conditions: 1) the relative stability of value for both consumptive and non-consumptive uses of crocodiles, 2) ensuring that crocodiles do not conflict with other strategies for economic development in the region, 3) protecting adequate habitat to minimize human-crocodile conflict, and 4) the protection of human safety. At least the latter three of these conditions may be at risk in the Northern Territory, where the stabilization of saltwater crocodile populations since the mid-1990s, which could reflect carrying capacity in some rivers (Leach et al., 2009; Fukuda et al., 2011), has potential ramifications. For example, anecdotal evidence suggests that the numbers of saltwater crocodiles moving upstream into freshwater reaches of rivers are increasing, posing a potential threat to public safety (Fukuda et al., 2011). There is a mistaken perception that upper reaches of rivers are free from crocodiles and safe for water-based recreation, and increases in crocodile attacks on humans may reduce tolerance for wild crocodiles and negatively impact the tourism industry (Letnic and Connors, 2006). Unsurprisingly, economic benefits associated with tourism or consumptive uses of crocodilians have been shown to be insufficient to offset increased risk of injury or death from crocodile attack (Wallace et al., 2012).

There are also risks that tourism could change crocodile behavior in ways that further threaten humans or harm crocodile populations. Some operators use bait to attract wild crocodiles, creating potential but well-established risks of aggression associated with provisioning and habituation to the presence of humans (e.g., in dingoes, Burns and Howard, 2003; or dolphins, Orams, 2002). For example, jumping crocodile cruises, in which crocodiles leap to seize food suspended several feet above the water, could lead to crocodiles approaching other boats or mistakenly leaping at fishing tourists (Markwell, 2015; Green and Higginbottom, 2001). A fatal attack on a fishermen in the Adelaide River, near a boat-based tourism operation, sparked questions about the potential for crocodile provisioning tourism to impact human safety (http://www.abc.net.au/news/2014-08-19/cruises-not-to-blame-for-adelaide-river-croc-fatal,-operator-say/5680212). As with tourism with other predator species, responsible regulation of operator practices is crucial to human and animal safety.

As previously noted, tourism represented only one component of a successful conservation strategy in Northern Australia, and that success has not always been easily duplicated in other places with other threatened crocodilian species. Though the Critically Endangered Chinese alligator (*Alligator sinensis*) has been the subject of successful captive breeding and tourism, with an existing captive population of $>10{,}000$ individuals, the nearly complete destruction of habitat leaves nowhere to release captive individuals in the wild. Without habitat protection, captive breeding or captive tourism is of limited conservation utility (Kaitlin, 2013). Similarly, despite legal protections under CITES Appendix I and Colombian and Venezuelan law, the release of captive-bred individuals has not substantially assisted in the recovery of the Orinoco crocodile (*Crocodylys intermedius*) because individuals are killed by locals as vermin, and recovery plans have not adequately addressed the need for public outreach and education; until this challenge can be addressed, substantial recovery of wild populations is unlikely, irrespective of tourist interest (Seijas et al., 2010). Successful recovery of threatened crocodilians may be furthered by tourism, but is dependent on economic realities, buy-in by locals, adequate available habitat, and ongoing governmental and social commitment to successful species conservation.

2.3. Case study three: big cats (Fig. 1C)

There are 41 species of cat in family Felidae, but we focus on larger species from the subfamily Pantherinae, including lions (*Panthera leo spp.*) and tigers (*Panthera tigiris spp.*), while also discussing cheetah (*Acinonyx jubatus*) from subfamily Felinae. These species are top predators throughout their ranges, in diverse habitats including savannah, jungle, wetland, and mountainous terrain (Eisert, 2011). Big cats face growing threats, including loss of habitat, poaching for fur or other animal products, hunting for sport, and persecution or control programs due to conflict with humans, particularly depredation on livestock. The native ranges for lions, leopards, and cheetah have declined by between 40% and 75% of their historic size, a reduction which threatens genetic diversity and limits big cat hunting opportunities by decreasing access to prey (Buk and Marnewick, 2010; Ripple et al., 2014). As a result of these anthropogenic stressors, nearly 50% of cats from subfamily Pantherinae are Threatened with extinction according to the IUCN Red List of Threatened Species (IUCN 2016).

There is substantial demand for big cat tourism activities, creating potential economic incentives for conservation. Big cats are the most popular animals in African safari tourism, represented twice in the “big five”, the cornerstone marketing concept for charismatic megafauna tourism in central and southern Africa (Okello, Manka & D'Amour, 2008a; Goodwin and Leader-Williams, 2000). Lions, leopards, and cheetah were ranked as favorite species to observe by international and national tourists in South Africa (Di Minin et al., 2013). Similar patterns have been documented in reserves in Kenya, where tourists reported they would continue to visit until they saw large cats (Okello, D'Amour & Manka, 2008b). Big cats are typically viewed from vehicles, and given the determination many tourists feel to see them, incentives exist for drivers and tour guides—who may rely on tips for a significant portion of their income—to attempt to satisfy the desires of their customers even when to do so might harm or disrupt the wildlife being viewed (Okello, Manka & D'Amour, 2008a). Furthermore, self-driving tourists will go to great lengths to get close to felids, evidenced by large pile-ups around individuals or passing groups of cats (Okello, D'Amour & Manka, 2008b).

Big cat tourism may be a significant economic force in countries where it occurs: in Kenya, wildlife tourism has been valued at US $350 million/year, contributing roughly 12% of the nation's GDP (Okello et al., 2001). Big cat tourism also has the same potential ability as other types of predator tourism to create jobs, engage stakeholders, and contribute portions of the funds earned to communities, scientific research, and conservation initiatives. Hazzah et al. (2017) report that attitudes towards lions are the best predictor of the likelihood of killing a lion, and thus tourism initiatives that improve local attitudes towards big cats may play an important role in fueling future conservation. From a mechanistic standpoint, increased exposure, observation, and photography of easy-to-spot, relatively human-tolerant species may help deter poaching or hunting, as seen in the West African lion (Mossaz et al., 2015).

Because of human persecution, large spatial requirements of the cats, and the ongoing loss of appropriate wild prey, human-wildlife conflict increasingly threatens big cat survival (Schlaepfer et al., 2002). In Namibia, which contains the greatest concentration of remaining wild cheetahs, ranchers will kill any cheetah found near livestock (Barnes and de Jager, 1996). Cheetahs can also represent a substantial money-making opportunity for ranchers—a trophy hunter may pay US $40,000 for the opportunity to kill a cheetah (Barnes and de Jager, 1996). Subsidies to ranchers from small-scale private cheetah tourism operations in the region may hold promise for helping to conserve cheetahs, and a limited number of “predator-friendly” ranches do exist in Namibia, but the current situation underscores the inherent difficulties of conserving large cats based on their propensity to conflict with livestock and their high value on trophy markets (Marker and Dickman, 2004).

The biological and behavioral characteristics of these animals, combined with the significant public interest in seeing them, creates demand for companies to artificially manage small populations, often enclosed in electric fences. Even small private reserves may actually support the preservation of at-risk species, as big cat tourism within Kruger National Park in South Africa is thought to reduce hunting and poaching and may protect key habitat areas (Watermeyer et al., 2011).

2.3.1. Further considerations

Potential conservation benefits of big cat tourism are largely similar to those associated with the shark and crocodile examples above (local protection and population recovery, community-engagement and support for non-consumptive use, flagship advertising), but this potential is constrained by factors specific to the biological and ecological characteristics of big cats, such as their hunting behaviors and high metabolic needs. Especially for cryptic species like snow leopards, jaguars, and cheetah, tourism's ability to contribute to conservation through viewing wild individuals is limited.

While tourism has measurable effects on most species, this added pressure on big cats has been shown to significantly change behavior and physiology on multiple scales. For example, researchers demonstrated higher levels of stress hormones among wildcats (*Felis silvestris*) in reserve areas where tourist hiking is permitted, even though direct encounters between hikers and wildcats were extremely uncommon (Piñeiro et al., 2012). Habitat, prey abundance, and the presence of competitor carnivores were not found to alter hormone levels, suggesting that the impact of encountering humans is more physiologically challenging than other stressors (Piñeiro et al., 2015). Bonner (1993) found that harassment of lions in the Serengeti led to decreases in predation opportunities for lion prides, and found inter-generational and population-level effects, manifested in lower lion cub survival. In fact, both cheetahs and lions exhibit “high response” to tourism vehicles, including fleeing from them on sight (Ceballos-Lascurain, 1996). Cheetahs in particular may struggle to tolerate tourism-related stress, as tourism is more likely disrupt their diurnal hunting activities than those of nocturnal or crepuscular hunters like lions; vehicle concentrations have been shown to sharply diminish both hunting activity and hunt success (Caro, 1994).

Tigers also appear to have species-specific biological characteristics that have limited their recovery in protected areas around tourism hot spots (O'Brien et al., 2003). In spite of large-scale tourist interest, tiger recovery in India has been constrained by low reproductive rates even when appropriate habitat and prey is available. Chapron et al. (2008) found that relative to other large felids like cougars or leopards, which may recover rapidly from depletion due to high reproductive output, tigers require higher survivorship levels or larger initial breeding populations to persist or see populations grow under scenarios of even limited removal. This is further supported by data charting the slow recovery of the Amur tiger (*Panthera tigris altaica*) in Russia following the outlawing of hunting and institution of strict poaching bans (Miquelle et al., 2007). While the level of protection their tourism value has afforded to tigers in India may be adequate for recovery of some cat species, it does not appear to be sufficient to drive a dramatic tiger recovery without stronger enforcement, emphasizing the need for species-specific recovery plans and strategies for tourism exploitation.

Indeed, tiger populations in national parks and reserves in India have yet to recover or stabilize broadly, despite a shooting ban dating to the 1970s and large and growing demand for tiger tourism from both Indian and international tourists. This failure is largely attributed to increased development, as tiger habitat and wildlife corridors have increasingly given way to tourist infrastructure and accommodations, particularly to serve the domestic tourist trade (Karanth and Karanth, 2012). Development also increases ease of access to remote tiger habitat and tiger habituation to humans, making tigers more vulnerable to poaching (Cohen, 2012). Most tiger tourism in India takes place in ten of the 37 total reserves, and in the busy reserves, the tourism value of

an individual adult tiger is estimated to be as high as $130 million over adult lifetimes (Matthews, 2008). The areas in which tiger populations are increasing (and in some cases undergoing crowding) are in many cases those most heavily exploited for tourism, where tourist presence, and resultant greater funding for ranger enforcement, helps prevent poaching; tour operators observe a clear positive correlation between the presence of tourists and the presence of tigers (Curtin, 2011). However, these busy reserves have also seen increasing human-wildlife conflict, including rising human fatalities, as tiger density in small areas increases and tigers seek to find prey and establish territories outside reserves or in buffer zones (Gurung et al., 2008).

Unless and until big cat wildlife product and trophy values decline and mitigation strategies reduce human-cat conflict, the survival of many big cats likely lies within patrolled game reserves and parks, and in many cases fencing of these areas is a key factor in management of cat species and associated tourism industries (Lindsey et al., 2012). Barriers have been hotly contested as a strategy for conservation of large terrestrial mammals (Bode and Wintle, 2010), and create obvious challenges, including risks of injury to animals, truncation of behavior or migratory routes, potential effects on metabolism and fitness, and ecological impacts of landscape and vegetation fragmentation (Lindsey et al., 2012). Although moral, ethical, and philosophical questions about the commodification of nature for tourists are important to debates about the value of such barriers, fencing and other physical protection, like the presence of guards, presently remains important to conserving remaining big cat populations, and tourism dollars can play a role in maintaining these protections.

3. Synthesis and recommendations

Predator tourism is likely to only be effectively able to contribute to conservation outcomes when it is part of an overall strategy to address challenges associated with protecting wildlife. As the case studies presented above illustrate, such approaches are possible (Table 3), but not always assured (Table 4). Below we synthesize some of the most important factors in—and limitations on—tourism's contribution to the successful conservation of predator species (also summarized in Tables 3 and 4).

The economic valuation of nature through tourism does not always represent a practical strategy for protecting predator species. While tourism may contribute to local, national, and international conservation and management, it likely represents only one part of effective species protection strategies. Moreover, protecting species without protecting critical habitat is unlikely to lead to long-term conservation "success"—if the intent of conservation is not simply to keep individual captive-bred animals alive indefinitely, but to protect existing ecosystems and the natural relationships within them.

Tourism is more likely to succeed in contributing to species conservation when programs are tailored to the biological and ecological characteristics of target species. Species that are extremely cryptic or intolerant of anthropogenic disturbance may be very difficult to conserve when being exploited for tourism in a natural setting. Rather than considering a broad mandate for tourist education sufficient, wildlife tourism projects should have measurable conservation goals, and should not base assessments of conservation contributions exclusively on difficult-to-detect and -validate impacts (see Appendix 1 for a list of questions for assessing conservation promoting actions by tourism operators towards local people, wildlife, tourists and scientists).

Given the reality that most tourism operations are first and foremost businesses (Williams and Montanari, 1999), the primary onus likely needs to be placed elsewhere (governments, regulatory bodies, permitting agencies, NGOs, trade associations) to require that tourism activities deliver measurable conservation-related contributions and minimize negative impacts. International management bodies should work to ensure competition does not lead to a regulatory "race to the bottom" as countries compete for wildlife tourism dollars, or displace the riskiest tourism activities to those countries (particularly in the Global South) least able to effectively regulate them. The reality that many predator tourism operations are presently under-regulated emphasizes the importance of not simply local, but national and international cooperation and collaboration to identify and begin to standardize best practices that protect both wildlife and humans. More than that, it seems clear that the most effective conservation initiatives arising from predator tourism operations activate the power of the state (or non-state actors like NGOs) in service of conservation. In Fiji and the Bahamas, the economic value of shark diving tourism has shaped government policy to improve shark conservation. In Australia, the economic value of crocodile tourism and egg harvest has encouraged stakeholders to tolerate a growing population of crocodiles. Thus the tourism operations which best support conservation will not only be

Table 3
Summary of conservation advantages associated with predator tourism operations.

Advantages
Can directly provide funding for conservation of predators and their habitats
Can indirectly benefit conservation by providing tourist or operator oversight of protected species or areas, helping to prevent poaching or illegal clear-cutting
Can gather data to increase scientific knowledge or improve monitoring
Funds from tourism can be used to mitigate human-wildlife conflict, particularly livestock losses, and make locals more tolerant of sharing space with predators
Can provide alternative, non-extractive livelihoods for locals, protecting threatened species without creating negative socioeconomic impacts
Can create add-on benefits for locals, including increased fisheries catches (spillover) or greater resource availability adjacent to protected areas
Can be a resource for educating local people about predator species and engaging them with conservation questions
Can benefit unrelated aspects of a local economy by attracting tourists to the region
Safe encounters with and increased knowledge about predators can positively impact public attitudes, which can create political support for conservation
Wildlife tourism can make some predators more valuable alive than dead, providing an argument against extractive uses of these species
Predators are charismatic and can serve as "flagship" species for the conservation of a region
Predators, which usually require large habitat areas, can also serve as "umbrella" species, with protection of their habitats leading to *defacto* protection for smaller and less charismatic species

Table 4
Summary of conservation limitations associated with predator tourism operations.

Limitations
Many predator wildlife tourism operations do not provide funding for the conservation of predators and their habitats or gather data for research and monitoring
Revenue from many predator wildlife tourism operations does not directly benefit those whose livelihood is affected by the loss of hunting/fishing, and some locals feel that they are being unfairly deprived of access to natural resources
Some predator species are unlikely to benefit because they are biologically or ecologically unsuitable for tourism exploitation, either because of remote or inhospitable habitat, cryptic behavior, or physiological sensitivity to disturbance
Many predator wildlife tourism operations are poorly regulated, resulting in stress, behavioral change, or other harm to the animals
Regulatory compliance of tourism operators is often difficult to monitor, and adherence to guidelines, particularly voluntary codes-of-conduct, may be poor
Baiting/provisioning may result in predators associating humans with food and increased risks to animals and humans
Limited benefits for individuals of threatened species which live in areas outside of where tourism occurs
Tourism may create misperceptions that species are adequately protected and conserved when that is not the case
Tourism infrastructure may increase access to remote, previously undisturbed habitat, and along with habituation, may increase risks from poaching
Local conservation support may decline if predator population increases lead to human injuries or deaths
Revenues from predator tourism are not always high enough to offset negative costs of predator presence (e.g. livestock mortality)
Rarely seen species cannot support local wildlife tourism operations

(and want to be) well-regulated, but will serve to encourage and support governmental protection for the wildlife resources they rely on.

Of course, human dimensions also play a key role in determining the conservation potential of predator tourism. Further rigorous evaluation of the impacts of predator tourism on tourist and local attitudes and behaviors represents an important and necessary future step in evaluating potential and actual conservation benefits. Wherever possible, tourism operators should elicit support from and create benefits for local communities. This includes teaching local people about target species, including outreach to schools, as well as providing professional opportunities and training associated with wildlife tourism to local people. In partnership with local and national governments, tourism operators should help formulate strategies to reduce threats to human safety associated with living near predator species, and engage with plans to minimize stock loss and other human-wildlife conflict. Wildlife tourism operators are key in this discussion. It is undoubtedly challenging to regulate predator and wildlife tourism on a range of scales, but better management is perhaps the most meaningful improvement that could be made to current practices.

Operators should be bound by precautionary science-based regulations or codes-of-conduct which lay out acceptable interaction between tourist groups and wildlife. This should extend to requirements related to staff training; guides, particularly those working closely with predators, must be trained to provide accurate information and protect the safety of both wildlife and tourists. Operators should be incentivized or required to demonstrate a commitment to conservation by participating in monitoring, scientific data collection, habitat protection, or other pro-wildlife activities. Regulatory compliance must be monitored, perhaps in part by tourists themselves, through online reporting and reviewing tools and accrediting bodies (e.g., Sustainable Shark Diving; http://sustainablesharkdiving.com/; as well as more formal programs, The International Ecotourism Society; www.ecotourism.com). There must be meaningful consequences—including loss of permits or concessions—for non-compliant operators. For the potential conservation benefits of tourism to be maximized, fees, taxes and other governmental incomes generated by wildlife tourism should be reinvested in wildlife conservation or paid to locals who bear the costs of living in close proximity to wildlife (or forgo potential consumptive use profits); such profits should not be primarily absorbed into general governmental revenue streams.

In summary, there is a growing argument that tourism can be a conservation solution for threatened wildlife, although tourism involving apex predators requires consideration of predator-specific biological and ecological characteristics, consideration of human-wildlife conflict, and recognition of risks to human safety. These case studies have raised (but, at least using existing evidence, cannot definitively answer) questions about whether or not the conservation benefits of predator tourism as presently practiced outweigh the costs it imposes on wildlife. Answers to these questions are highly dependent on local practices and context, and demand complex moral and ethical judgments about what wildlife is for, and how humans, on a global scale, should interact with the natural world.

Data cannot make those decisions, but it can provide insight into how existing operations and management regimes can maximize contributions to predator conservation. Tourism appears to help foster the conservation of apex predators when at least some of the following conditions occur: (1) effective and enforceable legal protection is given to wildlife and critical habitat (2) protected areas are distant from dense human population centers, (3) high quality interpretation and outreach is part of tourism programming (4) programs are established in consultation with local stakeholders, (5) funds from tourism support protection of animals and habitat; and (6) tourism funds compensate local stakeholders for losses and opportunity costs.

However, conservation benefits from apex predator tourism are not guaranteed, and tourism can have negative consequences for wildlife in the absence of thoughtful management, planning, research and monitoring (e.g., Semeniuk and Rothley, 2008). Tourism is also likely to benefit only charismatic species in areas where they are relatively easily accessible to the public, and is unlikely to support the conservation of entire populations or species on large scales. However, tourism centered on few species in limited areas may lead to greater appreciation for other threatened wildlife at larger scales, supporting conservation outcomes. Further, while tourism can provide some conservation benefits for apex predators, it does not represent a conservation panacea, and by itself cannot generate the funding, awareness and protection of threatened species necessary for effective conservation without other forms of public and political support and responsible species management.

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Appendix A

List of questions for assessing conservation promoting actions by tourism operators towards local people, wildlife, tourists and scientists

Local people

Do operators:

1. Collaborate with local communities?
2. Rely on local businesses when purchasing supplies, for logistical support, etc.?
3. Have the support of local communities and community leaders?
4. Directly support local communities financially (through payments or development projects)?
5. Indirectly support local communities (by encouraging tourists to stay at locally owned hotels, eat at locally owned restaurants, etc.)?
6. Compensate local communities for loss of access to resources, or other losses associated with their use of target species?
7. Work to ensure their practices do not negatively impact human safety?
8. Operate in a manner that is culturally sensitive and not harmful to their community?
9. Provide professional training opportunities to local people?
10. Provide job opportunities to local people?

Wildlife

Do operators:

1. Provide access and data for wildlife monitoring purposes?
2. Provide access and data for scientific research on target species?
3. Contribute directly to funding wildlife protection (e.g., by paying salaries for park rangers, offering space on board for government scientists or observers, etc.)?
4. Contribute indirectly to funding wildlife protection (e.g., by lobbying governments for increased protections for target species or creation of additional protected areas)?
5. Monitor and adapt protocols to minimize potential impacts of tourism activities on participating wildlife?
6. Base these protocols on both their experience and the best available science?
7. Alter operations during critical life history phases to avoid impacts (e.g., on mating, reproduction)
8. Place and enforce limits on tourist behavior (e.g., approach distance/speed, no touching) to protect participating wildlife?
9. Effectively train staff about appropriate interactions with target species and set expectations that limits on tourist behavior will be stringently enforced?
10. Provide briefings and signage to tourists specifying appropriate interactions with target species?

Tourists

Do operators:

1. Provide tourists with accurate and reasonably comprehensive information on ecology and biology of target species?
2. Provide tourists with accurate and reasonably comprehensive information on conservation threats to local species?
3. Discuss conservation challenges in ways that avoid placing blame, particularly on poor communities?
4. Solicit tourist support for conservation initiatives focused on target species or critical habitat?
5. Encourage tourists to take action themselves and spread the word about their experiences to help conserve species?
6. Provide tourists with staff who are knowledgeable and able to answer even reasonably complex questions?
7. Follow up with tourists to provide further information and keep them engaged with local conservation issues?
8. Provide trained staff and equipment which minimizes the risk of tourist injury?
9. Clearly and accurately articulate the reasons for limitations on tourist behavior (e.g., not just “don’t approach nests”, but “approaching nests increases the risk they will be abandoned”)?
10. Make an effort to measure their impacts on tourists in terms of knowledge, attitude, and action?

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