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BRIEF COMMUNICATION

"Turtle watching" conservation guidelines: green turtle (*Chelonia mydas*) tourism in nearshore coastal environments

Melissa S. Landry · Christopher T. Taggart

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Abstract We propose a conservational opportunity for humans to 'use' the green turtle (*Chelonia mydas*) in a non-consumptive manner. Although the concept of a social safe-minimum standard analysis, as applied to the sustainability of tourism-dependent turtle watching, has focused on beach-nesting habitats, other tourist activities like diving and snorkelling also occur in shallow coastal habitats frequented by juvenile and adult turtles. When integrated over time, at a specific location, such tourism activities may compromise turtle physiology in a manner that limits conservation goals for the species and hence the tourism. We identify research insights that can be used to achieve a creatively managed tourism—one that allows tourists to observe turtles in their natural coastal habitat in a manner that is commensurate with functional turtle conservation. We propose management options loosely based on whale-watching: i.e. voluntary and/or mandatory regulations based on home-range studies that identify localized temporal and spatial patterns of habitat use exhibited by turtles. We recommend temporally- and spatially-dynamic stratified-random-design tours that exclude critical local (small-scale) habitat and include less-critical habitat on a randomized rotational basis. Practical guidelines for tour operators that are founded on turtle habitat-occupancy patterns may ensure expanded life-history conservation measures and sustainable turtle-watching tourism.

Keywords Green turtle · *Chelonia mydas* · Turtle watching · Tourism · Sea turtle conservation · Adaptive management

M. S. Landry (✉) · C. T. Taggart
Marine Affairs Program, Dalhousie University, 6100 University Avenue, Suite 2127, Halifax, NS B3H 3J5, Canada
e-mail: mslandry@dal.ca

C. T. Taggart
Oceanography Department, Dalhousie University, 3700 Oxford Street, Halifax, NS B3H 4J1, Canada

Introduction

Historically, the green turtle (*Chelonia mydas*) and its eggs have been harvested for subsistence and commercial economies—so much so that human exploitation is identified as the root cause of global decline in the species (Carr 1955; Lutz et al. 2003; Seminoff 2004). Recent reports of increases in nesting populations at some of the principal rookeries around the world demonstrate that management and protection are having a positive impact (Chaloupka et al. 2007). Tourism provides the opportunity for humans to 'use' sea turtles in a non-consumptive (sustainable) manner through the economic and social values associated with the turtles. Such values enable tourism to contribute to the conservation of the turtles (Tisdell and Wilson 2002). If scientific research and the insights it provides can be employed to achieve a tourism management that provides the opportunity for water-borne tourists to observe turtles in their natural coastal-ocean habitat in a manner that is commensurate with the conservation of turtles and their habitat, then functional turtle conservation might be achievable. To date, this kind of management typified by the social safe-minimum standard analysis explored by Tisdell and Wilson (2002) and applied to the sustainability of tourism that is dependent on turtle-watching, has focused on beach-nesting habitats (Hooker and Gerber 2004; Wilson and Tisdell 2001). A review of the contemporary literature found in Web of Science®, over the period 1980–2006 inclusive, using key words searches for "sea turtle + conservation + tourism*", "turtle tourism" and "sea turtle + conservation + coast*" resulted in 66 articles. None of the 66 articles identified address sea turtle tourism management and policy planning examine the creation of an equally safe minimum for divers and snorkelers participating in turtle-watching in nearshore sea turtle habitats. Such habitats are critical for the feeding, growth and resting behaviours and the physiological aspects of green turtle life-history.

Turtle watching by tourists occurs in shallow, coastal habitats frequented by juvenile and adult green sea turtles. Our focus is on the virtually unrestricted access to sea turtles that divers and snorkelers have in some coastal regions. Websites for turtle watching tourism explicitly advertise (e.g.) "Come swim with the turtles in Barbados!" (www.barbados.org/species/turtles-romance.htm) or announce, "Hale O Honu ("turtle town") is a snorkel area easily accessible for all ages and abilities." (www.sailhawaii.com/turtles.html). When integrated over time at a given location, such tourism activities may compromise turtle behaviour and physiology in a manner that limits conservation goals for the species and hence the tourism. The uncertainty surrounding the magnitude of physiological impacts resulting from tourists in nearshore turtle environments demands tourism scenarios that minimize disturbance. We draw upon the available scientific information to propose a creatively managed tourism—one that allows tourists to observe turtles in their natural coastal habitat in a manner that corresponds with functional turtle conservation. We propose management options loosely based on whale-watching tourism (i.e. voluntary guidelines and/or mandatory regulations), and on home-range studies that identify localized temporal and spatial patterns of habitat use exhibited by turtles. Practical guidelines for tour operators that are founded in turtle habitat-occupancy patterns may ensure expanded life-history conservation measures and thus a more conservation oriented turtle-watching tourism—an opportunity for humans to 'use' the endangered green turtle sustainably.

Wildlife-based tourism: opportunity for conservation or self destruction?

During the period from 1991 to 1998, the number of marine mammal 'watchers' increased from four million to nine million (Sorice et al. 2006). From the conservation standpoint, the general premise of wildlife-based tourism is that it promotes non-consumptive resource use and conservation, increases awareness about the target species, generates economic opportunities for communities and contributes to scientific research (Tapper 2006; Tepelus 2005; Tisdell and Wilson 2002). It is contended that when tour operators become motivated to conserve species their example fosters support from the rest of the community; a crucial aspect of conservation. Sceptics of this form of alternative tourism caution that its use can emerge as a convenient cover for 'business as usual' (Stronza 2001). Stronza (2001) maintains that if improperly managed, wildlife-based tourism result in negative impacts on habitat, species and local communities that depend on the resource.

Behavioural studies of wildlife-based tourism target species such as whales, dolphins, manatees and stingrays have challenged the merits of wildlife-based tourism (Butler 1991; Constantine 2001; Kenchington 1989; Norris 1994; Sorice et al. 2006; Tapper 2006; Valentine et al. 2004; Van Parijs and Corkeron 2001; Williams et al. 2002). Research has shown that tour boats influence the behaviour of target species, including sea turtles, and can cause injury and/or habitat destruction (Corkeron 1995; Davenport and Davenport 2006; Heckel et al. 2003; Lusseau 2003; Oros et al. 2005; Seminoff et al. 2003; Tisdell and Wilson 2002; Valentine et al. 2004). Swimmers and boaters seeking a close-approach for a whale or dolphin "experience" often disturb the normal behaviour of the target animal that induces unnecessary stress in the same (Constantine 2001; Heckel et al. 2003; Sorice et al. 2006; Valentine et al. 2004; Van Parijs and Corkeron 2001). Williams and colleagues (2002) note that killer whales increase swimming speed and deviate from tour boats when stressed, thereby expending energy reserves. High densities of tourists and site-overcrowding are identified as major contributors to disturbance resulting in behavioural changes for manatees and suboptimal experiences for tourists (Sorice et al. 2006). Similarly, recent research has revealed physiological changes in blood chemistry and stress hormone levels in species such as stingrays that are subject to repeat disturbance by tourists (Tapper 2006). Investigations on the long-term impacts of these physiological changes are in their initial stages and therefore little is known about the effects on the fitness and survival rates of a given species. Sorice and colleagues (2006, p. 70) warn that human disturbance to wildlife has the potential to have a "…significant effect on an individual's fitness, with potential implications at the population and community level".

These examples demonstrate that disturbance negatively impacts both the target species and the tourism industry. We argue that they also emphasize the need for guidelines and/or regulations for all forms of wildlife-based tourism. If management plans are not outlined, wildlife tourism has the potential to follow the "self-destruct theory of tourism" Holder (1988).

Green turtle behaviour in a tourism context

The warm, coastal feeding habitats of green turtles make them one of the most targeted species of sea turtle for snorkelers and divers. Research provides evidence that untrained divers and snorkelers cause extensive physical damage to coral reefs and seagrass beds—critical sea turtle habitat (Barker and Roberts 2004; Hawkins et al. 1994; Walters and Samways 2001). Information that addresses the effects of repeat disturbance on these

turtles in their aquatic coastal environment is sparse (Balazs et al. 1987; Seminoff et al. 2003; Taquet et al. 2006). Specifically, the period of time needed for turtle 'recovery' from direct human disturbances is unknown. Meadows (2004) and later Taquet et al. (2006) speculate that high levels of human disturbance from snorkelers or divers may alter turtle feeding-success and therefore can negatively impact turtle behaviour and physiology. As the demand for tourist-sea turtle encounters grows, there is an increased potential for increasingly negative impacts on the already vulnerable green turtle populations. As stated by Tapper, "…as the scale and frequency of tourism to watch a particular population of animals increases, the recovery periods become shorter and the impacts of disturbance on wildlife can rapidly increase" (Tapper 2006, 52 pp). Cumulatively, the uncontrolled effects of disturbance could lead to the "self destruction" of this sector of the tourism industry. Thus, it is the disturbance integral that may lead to the chronic nature of the problem for the turtles and the tourism. The question becomes how to decrease the integral?

To relate scientific behavioural information to the management of turtle watching, we address sea turtle habitat use with regard to space and time. We do so because both tourists and turtles engage in certain activities (behaviours), at certain places, during certain times of the day. To meet the goals of sustainable turtle-watching tourism it is logical that tourists and turtles occupy places at times in a manner designed to balance minimal turtle disturbance with maximal tourist experience (enjoyment).

The green turtle has a well documented and high affinity for specific areas (small-scale, local) within its coastal habitat (Bjorndal 1980; Mendonca 1983; Ogden et al. 1983; Brill et al. 1995; Whiting and Miller 1998; Seminoff et al. 2003; Makowski et al. 2006; Taquet et al. 2006). Both Seminoff and Makowski and colleagues (above) suggest that green turtles use a home range sufficient to enhance access to food sources required for growth and physiological health. Consequently, within the home range, green turtles use certain "core areas" more frequently than others (Makowski et al. 2006). These core areas represent principle feeding (typically groups) and resting (typically individuals) grounds. The core feeding-areas are generally those containing new shoots of seagrass (Makowski et al. 2006) that have higher nutrient value (Bjorndal 1980) as green turtles must consume large amounts of seagrass to obtain nutrients and energy sufficient for maintenance, growth and reproduction.

Behavioural research identifies 'normal' activities for green turtles that include feeding during the day and resting at night (Bjorndal 1980; Brill et al. 1995; Mendonca 1983; Ogden et al. 1983; Taquet et al. 2006). On average, daytime feeding occurs between 06:00 to 19:00 local time (Ogden et al. 1983; Seminoff et al. 2003; Makowski et al. 2006; Taquet et al. 2006). Green turtles occasionally leave feeding grounds for short periods at midday; a behavioural pattern attributed to the physiology of thermal regulation (Bjorndal 1980; Mendonca 1983; Ogden et al. 1983; Brill et al. 1995; Taquet et al. 2006). Our examination of the literature reveals there are at least four site-specific deviations from 'normal' green turtle activity (Balazs et al. 1987; Whiting and Miller 1998; Seminoff et al. 2003; Makowski et al. 2006) and two are attributable to human activity. For example, Seminoff et al. (2002) report that green turtles in Bahia de Los Angeles, Mexico are primarily found in nearshore feeding grounds at night, presumably a response to increased boat-traffic during the day, while Balazs et al. (1987) note that some Hawaiian green turtles appear to avoid human activity by feeding at night.

Scientific information, such as that summarized above, can be used to develop guidelines for tourist-turtle encounters. We also suggest the use of two management tools frequently used in the whale-watching industry: mandatory regulation and voluntary guidelines. Mandatory regulation is employed where tour-operator permits are required

and where enforcement measures are in place (i.e. protected areas). In such areas it is possible to enforce area zoning, maximum number of tourists and/or boats per area, and proximity and duration of tourist-wildlife encounter etc. (Garrod and Fennell 2004; NRC 2001). When third-party enforcement is not possible, minimising environmental impact becomes the sole responsibility of tour operators and is often instrumented through voluntary 'best practices' or 'codes of conduct' developed by the operators (Garrod and Fennell 2004; Heckel et al. 2003; Sorice et al. 2006; Tepelus 2005). Such voluntary 'regulations' give operators decision-making privileges that are considered preferable to enforced regulation (Sorice et al. 2006).

Effective guidelines for tourist-wildlife encounters, whether mandatory or voluntary, require tour operator and tourist compliance (Heckel et al. 2003; Garrod and Fennell 2004; Tepelus 2005; Sorice et al. 2006). When operators are included in developing conservation guidelines a self-determined responsibility for the target species and their habitat evolves. From such responsibility grows advocacy and a societal enforcement of guidelines, thus making management efficient. For example, Vieitas et al. (1999) report that through management partnerships, a community in Brazil that once harvested sea turtles for commercial purposes now relies on the turtles as a renewable resource 'harvested' through tourism. Consequently, the community assumed the responsibility for beach and nest protection. In such a situation, collaboration between tour operators and scientists can also provide opportunities for the collection of data concerning the species and the habitat, with benefits accruing to the operators and to the advancement of the science.

When tour operators and tourists subscribe to voluntary compliance (buy-in) a positive feedback-loop begins to evolve. Operators with management guidelines who offer educational opportunities can attract 'eco-friendly' tourists who value conservation and thus the operators begin to differentiate themselves from the competition (Tepelus 2005), and we add that the informed tourists likely begin to discriminate amongst the operators. This self reinforcing system appears to be effective in dolphin tourism (Hughes 2001) especially when there is a societal shift away from traditional mass tourism to eco-tourism (Miller 1993; Stronza 2001).

Adaptive management of tourist-turtle encounters

Our review and interpretation of the limited primary literature related to green turtles and turtle-tourism in nearshore sea turtle habitats (exclusive of nesting) leads us to consider several possibilities for an adaptive management of tourist-turtle encounters. Our explicit premise is that the spatial and temporal patterns of behaviour for the tourists (tour operators) and the turtles provide the key to minimizing turtle disturbance in nearshore coastal environments while maintaining a viable turtle-based tourism.

Spatial interpretation of habitat use shows that turtles have local specific-use areas within their home range. Thus, habitat zoning, based on site-specific home range and use appears to be essential. How then can habitat zoning minimize the negative impacts of tourist encounters with turtles and ensure tourists have a positive experience? We suggest first that some 'core' feeding areas be closed to tourists and tour operators permanently and if only for extended periods, then with replacement. Tour operators can take tourists to other, less critical, feeding areas. Most importantly, by having some areas void of tourists the turtle is able to, at some level, 'control' the encounter level with tourists (i.e. stay or leave). Valentine et al. (2004) suggest that tourist-whale encounters involve some degree of freedom on the part of the whale to dictate the nature of the encounter. In addition, we

suggest that divers and snorkelers only approach from one side and avoid 'enclosing' the turtle from above as it inhibits the turtle's ability to surface and breath. This presumes of course that the tourist and operator comply with some sort of code of conduct. Second, to increase the likelihood of seeing a turtle, tours should be conducted during the times of day that maximize the possibility of turtle presence and minimise overly and overtly negative impact on the turtles; i.e. avoid midday when turtles frequently vacate feeding grounds for thermal regulation purposes (Bjorndal 1980; Brill et al. 1995; Mendonca 1983; Ogden et al. 1983; Taquet et al. 2006).

Some research demonstrates that sea turtles, like other animals, appear to adapt to disturbances or perceived dangers in their environment (Balazs et al. 1987; Makowski et al. 2006; Seminoff et al. 2003). We speculate that if tourists frequent specific habitats at regular intervals the turtles will adapt to such disturbances via avoidance behaviour—to the detriment of the tourists (Fig. 1a). To prevent this situation, we suggest that the location and time of tour operations be randomized in a stratified manner. We recommend a temporally- and spatially-dynamic stratified-random-design for tours that exclude critical regions of the local habitat and include the less-critical on a randomized rotational basis (Fig. 1b).

Uncertainty surrounds the outcome of tourist-turtle encounters in nearshore coastal environments. Our recommendations represent only a part of what is required for developing effective management guidelines for green turtle tourism. To achieve effective and practical management, other questions must be answered. How many operator boats and tourists should be present in a turtle-watching area at one time? What are the proximity limits for visual encounters? What are the direct and indirect biological and physiological effects on turtles that result from of tourist encounters with turtles, even within prescribe limits, and if negative, how long does it take for a turtle to 'recover'? Until answered, it would appear the uncertainties demand tourist-turtle encounter scenarios that give turtles some measurable degree of 'control' over the duration, location, and proximity of the encounter. Practical guidelines for tour operators that are founded in turtle habitat-

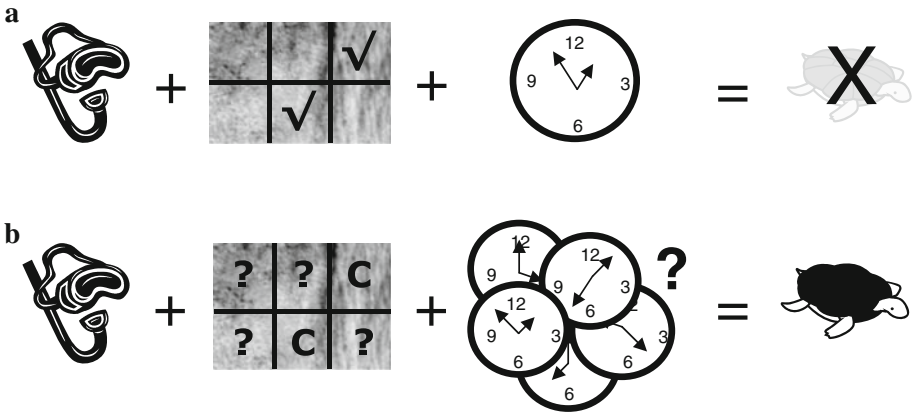

Fig. 1 Depiction of turtle avoidance behaviour where (**a**) illustrates daily tourist (*mask/snorkel*) occupation of zoned sea turtle habitat (*grid*) at the same location ($\surd$) and time (*clock*) that is expected to result in turtle avoidance behaviour (*x on turtle*) and (**b**) illustrates a temporally and spatially randomized turtle-watching schedule where the predicted result (*turtle* = turtle viewing) accrues via the creation of 'closed' habitat areas (*c* = habitat area closed to tours) and when other habitat locations and times are chosen randomly for turtle-watching tours (*?* = randomization of habitat location and time)

occupancy patterns, as we have suggested, provide that degree of encounter-control by the turtles such that it may ensure expanded life-history conservation measures and sustainable turtle-watching tourism.

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