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PROTECTION OF *IN SITU* SEA TURTLE NESTS FROM DEPREDATION

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INTRODUCTION

Nesting turtles act as biological transporters of nutrients from marine to terrestrial ecosystems, where eggs and hatchlings eaten by terrestrial predators contribute to coastal food chains and nutrient cycles (see Bouchard & Bjorndal, 2000; Madden *et al*., 2008). Depredation of sea turtle nests should, therefore, only be of concern if the affected population is categorised as Threatened, if it is occurring at or has the potential to reach unsustainable levels, if the predator is introduced or reintroduced to the area, or if the increasing population of one predator is the result of control measures against another. Predator management may also be desired if local tourism relies on the presence of sea turtle nests.

A common strategy for protecting eggs and/or hatchlings from excessive predation is to immediately relocate clutches to a hatchery, a protected area enclosed by a fence to reduce animal entry. However, care must be taken to ensure that collecting, handling, and incubating eggs does not itself reduce the number of eggs that hatch (Phillott & Shanker, 2018). A viable alternative to moving eggs to a hatchery is protecting them in their original position. *In situ* protection reduces the potential risks associated with collecting and moving eggs if best practices cannot be implemented due to restricted resources. Nests would still require regular inspection by project personnel or local community members to ensure continued protection. While sea turtle festivals and other environmental education initiatives could continue, participants may need to walk further to reach the nest location.

At nesting beaches throughout the Indian Ocean and Southeast Asia (IO & SEA) region, hatchery programs are commonly and successfully employed to control predation rates. However, *in situ* nest protection and predator management strategies can also be highly effective, as proven by reduced nest depredation rates on the east coast of Florida, USA, from 95% to <10% (Engeman *et al*., 2005). Therefore, this paper reviews methods for *in situ* protection of sea turtle eggs and hatchlings from predators found in IO & SEA countries. While the discussed predators have been limited to those in the region, the strategies for protecting nests have been drawn from studies around the world so conservationists can consider the various potential options and determine what best suits their needs. Before implementing *in situ* nest protection, the animal/s predating on eggs and hatchlings should first be identified by analysing scats (Brown & Macdonald, 1995; Blamires, 2004), stomach contents (Hilmer *et al*., 2010; Engeman *et al*., 2019), tracks in the substrate, digging patterns used to expose nests (e.g., Drake, 1993; Tripathy & Rajasekhar, 2009; Gandu *et al*., 2013), visual observations (Tripathy & Rajasekhar, 2009), and/or camera trapping (reviewed in this issue by Kotera & Phillott, 2020). It is important to distinguish between animals that predate on eggs and hatchlings in undisturbed nests and those that scavenge eggs which have been exposed by other species in order to choose the most appropriate management strategy.

STRATEGIES FOR REDUCING DEPREDATION

Actions to manage depredation can focus on predator control (see below), and/or removal of debris and other obstacles to reduce the time taken by vulnerable hatchlings to cross the beach (Burger & Gochfeld, 2014). It is also not advised that hatchlings emerging from nests protected *in situ* or in hatcheries be held or released in batches of more than one clutch at a time. If this must occur under exceptional circumstances, then personnel should release hatchlings at different times of day and locations to reduce the likelihood of creating 'feeding stations' for predators (Mortimer, 1999).

To manage heavy depredation rates that are reducing population resilience, projects may need to conduct an economic analysis to determine which approaches will result in the greatest benefit in terms of egg and hatchling survival, ongoing ecotourism, ecological and cultural benefits etc., for the budget available (e.g., Engeman *et al*., 2002, 2010). Consulting experts in management of the predator species can dramatically improve the success of intensive management projects (Engeman *et al*., 2011).

Removing predators from nesting beaches and adjacent areas

Baiting, trapping and removal, and/or neutering (desexing) can be used to reduce predator population numbers so predators are effectively removed from the beach and adjacent areas (e.g., Algar *et al*., 2011a,b; Dias *et al*., 2017; Leo *et al*., 2018). However, removal efforts need to be ongoing; when predator removal at Hobe Sound National Wildlife Refuge FL, USA, was stopped part-way through a nesting season, depredation rates increased to 1.5-3.0 times than before management was initiated (Engeman *et al*., 2006). Planning a predator removal project should also consider that removal of a predator species could result in another species taking its place. For example, the use of 1080 (sodium fluoroacetate) poison baits was successful at reducing fox (*Vulpes vulpes*) depredation of nests at Wreck Rock QLD, Australia, but allowed monitor lizards (*Varanus* spp.) to utilise the vacated niche and become the dominant predator (Lei & Booth, 2017). In another case, the removal of racoons (*Procyon lotor*) from beaches in Florida, USA, resulted in increased depredation of eggs and hatchlings by ghost crabs (*Ocypode* spp.), whose individual size and population number were previously kept in check by the racoons (Barton & Roth, 2008).

Excluding predators from nesting beaches

Fencing to exclude predators from the nesting beach has recently been suggested for Gahirmatha, India (e.g., Behera & Kaiser, 2020). However, fences have the potential to entangle nesting sea turtles and reduce the access of terrestrial species and local communities to beach resources, and hence should only be considered after local consultation and with appropriate permits or approval from relevant authorities.

Excluding or deterring predators from nests

Depredation is most likely to occur soon after oviposition, in the period just before hatching, and at hatchling emergence. Clutches laid closer to vegetation and in areas of greater nest density may be at greater risk (see Leighton *et al*., 2011). Therefore, projects with limited resources may choose to focus on protecting the most vulnerable nests or nests during the most vulnerable time.

Chemical deterrents

Various chemicals have been trialled to deter predators from digging into sea turtle nests. Wolf urine (*Canis lupus*) dispensers on nesting beaches deterred coyotes (*Canis latrans*) from depredating nests (Wauson, 2019). Also effective against coyotes was the powder of red savina habanero peppers (*Capsicum chinense*; 400,000–500,000 Scoville units) when applied to the sand surface in a 0.5m radius circle around the nest and covered with a thin layer of sand to minimise disturbance by wind or rain. However, the same powder did not reduce depredation rates when applied to sand ~3cm above the top egg in the nest (Lamarre-DeJesus & Griffin, 2013). Similarly, chilli powder (heat level 10 of 10) applied to a 0.5 x 0.5m square around loggerhead (*Caretta caretta*) nests at a depth of 10cm below the beach surface was not a deterrent to monitor lizards (*Varanus* spp.; Lei & Booth, 2017). Habanero and other pepper or chilli powders may be a more effective deterrent for predators which rely on olfactory cues to detect nests (e.g., coyotes) than species that use a combination of olfactory, visual and/or tactile cues (e.g., racoons) (Lamarre-DeJesus & Griffin, 2015). Projects that want to use pepper/chilli powder as a predator deterrent should remember that effects of the irritant on hatchlings and the predator species have not been studied.

Visual deterrents

Flags have had mixed success in deterring predators from nests. White flags (50 x 80cm), printed with the project name in red and staked so that the flag blew across the top of the nest, successfully decreased predation of loggerhead nests in northeast Brazil (Longo *et al*., 2009; see Figure 2 in the paper). However, red flags (30 x 40cm) on a stake ~70cm above beach surface and ~30cm from nest were not effective against monitor lizards (Lei & Booth, 2017). A study in the use of flags to mark the position of freshwater turtle nests did not find that racoons began to associate flags with a food source (Tuberville & Burke, 1994; Burke *et al*., 2005), but this potential should be investigated with different predators before flags are extensively used to protect nests. The effectiveness of flags in deterring predators from nests would also rely on suitable wind conditions.

Audible deterrents

Only one study has investigated the use of audible deterrents on potential predators of sea turtle eggs. A metal rattle sewn into the base of white flags described by Longo *et al*. (2009; see Figure 2 in the paper) did not improve their deterrence efficiency against foxes.

Nest enclosures

Nest enclosures may be above ground or buried below the beach surface, vertically surrounding and/or horizontally covering the clutch of eggs and surrounding area. Types of enclosures include grids, panels, baskets, and cages, and designs suitable for different types of predators are described below. While the type and design of a nest enclosure may differ depending on type of predator and available materials, several features of the material used to make all enclosures are important:

1. The mesh size should allow hatchlings to escape the enclosure unaided and without risk of entanglement, ~50mm for loggerhead, green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and olive ridley (*Lepidochelys olivacea*) turtle hatchlings, and ~70mm for leatherback (*Dermochelys coriacea*) and flatback (*Natator depressus*) turtle hatchlings. Sometimes, a smaller mesh size is required for the predator (e.g., ghost crabs) or is the only material available. In this case, nest covers buried or at the beach surface level can include a detachable disc that is removed a week before the predicted emergence date so hatchlings do not become trapped (e.g., see Yerli *et al*., 1997). If the nest enclosure is elevated above the beach surface, then it should be removed at dawn and replaced at dusk when most predator activity increases. This will reduce the risk of hatchlings overheating if emergence occurs during the daytime.
2. The material should not disrupt the hatchlings magnetic imprinting. Magnetically inert metals (such as aluminium), plastic, or wood are suitable (Irwin *et al*., 2004).

CONTROL OF SPECIFIC PREDATORS

The same nest enclosure may not be effective against different predators. For example, cages that effectively reduced racoon predation at Keewaydin Island in the USA were not effective against wild/feral pigs (*Sus scrofa*) (Engeman *et al*., 2016). Hence, effective strategies have been summarised by predator species or taxa below.

Ants

Solenopsis spp. (West, 2010) and an unknown species (Kelaskar *et al*., 2016; Arun, 2019) of ants have been reported as invading sea turtle nests, predating on late-stage embryos in pipped eggs, and/or predating on or stinging hatchlings in the IO & SEA. Ants may be attracted to the scent of disturbed sand or secreted mucous during the nesting process or environmental conditions within the egg chamber (Allen *et al*., 2001). Descriptions and images of egg invasion of nests and penetration of eggs are available in Ikaran *et al*. (2020).

The effects of ant depredation on eggs is likely to be low at a population level (Holbrook *et al*., 2019). Ants enter nests via underground foraging trails (Buhlmann & Coffman, 2001), so control of recurring or serious infestations can be challenging because they may not be visible on the beach surface (Kelaskar *et al*., 2016). Infested nests in Malaysia have been excavated and unaffected eggs relocated to a different position (Chan, 2013). Ant control measures reported as successful include powdered neem cake mixed with the top 2-3 inches of sand above a nest (Arun, 2019) or application of a toxic ant bait or pesticide (Hughes, 1971), especially with the active ingredient hydramethylnon (Kelaskar *et al*., 2016; Smith *et al*., 2020), to the surface sand above nests. A negative impact of hydramethylnon on non-target arthropods (Plentovich *et al*., 2010), nest hatching or emergence success (see Miller, 1999 for definitions), or hatchling orientation to the sea have not been detected. However, commercial ant bait involving a carrier (such as the cornmeal and soyabean oil in AMDRO®) might attract other predators to the nest and should cautiously be used lest the bait itself increases the risk of nest depredation (Smith *et al*., 2020).

Birds

Limited records of diurnal (great frigatebird *Fregata minor* (Lagarde *et al*., 2001), crow *Corvus splendens*, brown-headed gull *Larus ridibundus*, brahminy kite *Haliastur indus*, (Tripathy & Rajasekhar, 2009), white-bellied sea eagle *Haliaeetus leucogaster* (Clohessy, 2014), undescribed hawk and kite species (Thi *et al*., 2011)) and nocturnal (black-necked stork *Ephippiorhynchus asiaticus* (Whiting & Guinea, 1999)) bird predation on eggs and/or hatchlings are available for the IO & SEA region. Studies worldwide have described different avian predation methods on sea turtle nesting beaches, including the probing of nests for eggs or hatchlings, feeding on eggs exposed by other predators, or preying on emerged hatchlings (Whiting & Guinea, 1999; Burger & Gochfeld, 2014; Korein *et al*., 2019). Hatchlings are most vulnerable to birds in the short period from when they emerge from the nest and crawl to the sea. 'Nest-to-surf' mortality (Erb & Wyneken, 2019) is often low in comparison with mortality due to other predators and does not have a great impact at the population level. However, high rates of predation- such as great frigatebirds feeding on every hatchling (n=1,828) during all observed nest emergences (n=38) at Europa Island (Lagarde *et al*., 2001)- may occur at some locations; protection against this level of predation may be neither possible or desirable.

If needed, nest covers made of bamboo or other materials can reduce the access of birds, including different types of vultures, to sea turtle eggs in the nest (Korein *et al*., 2019), but will have to be checked frequently to ensure hatchling release. The presence of human observers during hatchling releases should further reduce bird attempts at feeding (Burger & Gochfeld, 2014).

Cats

Records of cat (*Felis catus*) predation on hatchlings are uncommon worldwide, but are included in reports from Qatar (Ficetola, 2008), the Seychelles (Seabrook, 1989), Myanmar (Thi *et al*., 2011) and Western Australia (Hilmer *et al*., 2010) in the IO & SEA. Most cats that prey on turtle hatchlings are not domestic pets (categorised as feral, stray, or free-roaming cats in different countries). Turtle nest protection devices against cats have only been used in Qatar where a 1m square plastic mesh square positioned above the nest and buried under 5cm sand significantly reduced predation by both cats and foxes (Ficetola, 2008). The design included a central detachable disc that was removed 1 week before the predicted emergence date to allow hatchlings to escape the nest (see Yerli *et al*., 1997). Other effective nest enclosures against foxes could also likely reduce cat depredation.

Control measures recommended for free-roaming cat populations include removal by trapping (Algar *et al*., 2011b; Dias *et al*., 2017), poisoned baiting (Algar *et al*., 2011b), or hunting (Leo *et al*., 2018). Several studies suggest combinations of strategies, such as baiting and trapping (Algar *et al*., 2011b) and removal and neutering (Dias *et al*., 2017). It is also recommended that pet or house cats be neutered (Algar *et al*., 2011a) and prevented from roaming free outdoors (Dias *et al*., 2017) to prevent their contribution to the free-roaming populations of cats.

Crabs

Ghost crabs are common on sea turtle nesting beaches worldwide, and predation on eggs and hatchlings in the IO & SEA has been reported from India (Tripathy & Rajasekhar, 2009), Sri Lanka (Ekanayake *et al*., 2010; Ellepola *et al*., 2014), the Seychelles (Hitchins *et al*., 2004), Myanmar (Thi *et al*., 2011), Malaysia (Ali & Ibrahim, 2002; Chan, 2013), West Papua, and Papua New Guinea (Kinan, 2005). Prey are detected through sight, sensing vibrations, or hearing (Lucrezi & Schlacher, 2014). Only a few eggs per nest are usually predated by crabs, although they may enter many nests (Korein *et al*., 2019). Thus, the population-level influence is likely to be low except in specific locations (see Marco *et al*., 2015) or if crab depredation attracts other predators to the nest (this may increase the likelihood of nest depredation by racoons; Barton & Roth, 2008). An enclosure of small-diameter (0.5cm) mesh around the nest may successfully exclude crabs (Ali & Ibrahim, 2002) but would not allow hatchlings to escape without assistance.

Crocodiles

Saltwater crocodiles (*Crocodylus porosus*) preying on nesting sea turtles, eggs, and hatchlings is only reported from northern and north-western Australia (Whiting & Whiting, 2011). Nest depredation alone occurs in West Papua and Papua New Guinea (Kinan, 2005). Crocodile distribution in the IO & SEA also includes nesting beaches in the Andaman and Nicobar Islands and Southeast Asia, but there have been no similar descriptions from these locations (A. Swaminathan, pers.comm.). There are easier prey species for crocodiles to target so high levels of predation on eggs is unlikely.

Dogs and Jackals

Dogs (*Canis familiaris*) and side-striped (*Canis adustus*) or unidentified jackals prey on sea turtle eggs and/or hatchlings in South Africa (G. Hughes, pers.comm.), Yemen (Nasher & Al Jumaily, 2015), India (Tripathy & Rajasekhar, 2009), Sri Lanka (Ekanayake *et al*., 2010; Ellepola *et al*., 2014), Myanmar (Thi *et al*., 2011), West Papua, and Papua New Guinea (Kinan, 2005, Hitipieuw *et al*. 2007). The impact of these canids at a population level has not been reported. Distinguishing between native and introduced species, dogs have previously been shot when posing a serious risk to eggs and/or hatchlings in South Africa but the indigenous side-striped jackals which posed an equivalent threat were not controlled (G. Hughes, pers.comm.).

Habanero pepper powder (Lamarre-DeJesus & Griffin, 2013) or trapping and removal (Eskew, 2012) have reduced turtle nest depredation by coyotes, another canid, and could also be used for dogs and jackals. Similarly, protection devices against foxes would also likely be effective. Semi-domestic dogs (often referred to as 'village' dogs in South Asia) should be adequately fed to reduce their likelihood of eating eggs and hatchlings, and access to nesting beaches should be limited by restricting their roaming at night (Ruiz-Izaguirre *et al*., 2015).

Foxes

Descriptions of fox depredation of sea turtle nests in the IO & SEA region are less common than those of other animals. The Rüppell's fox (*Vulpes rueppelli*) completely destroyed >80% of unprotected nests on a beach in Qatar

(Ficetola, 2008), and nests are protected against the European red fox (*Vulpes vulpes*) in Western Australia (Waayers et al., 2012) and an unidentified species in Pakistan (Waqas et al., 2011). Foxes use olfactory and visual cues to locate turtle nests and learned behaviour about finding nests can be passed from adult to offspring (O'Connor *et al*., 2017). Adults may raid nests then cache eggs away in a different location to feed young on subsequent nights (Macdonald *et al*., 1994). In some locations, foxes have been regarded as the single greatest terrestrial predator of eggs and hatchlings (e.g., eastern Australia; Limpus, 2008).

Successful control measures to reduce fox depredation of nests have included combinations of nest enclosures and flags in northeast Brazil (Longo *et al*., 2009), and trapping with subsequent euthanasia, den fumigation with carbon monoxide, and nest enclosures in eastern Australia (O'Connor *et al*., 2017). Nest enclosures effective against foxes are usually mesh screens. A 1m square piece of plastic mesh, with 100mm openings, held in place above the nest with eight 30cm stakes and covered in 2cm of sand protected loggerhead nests in eastern Australia (O'Connor *et al*., 2017). Wire mesh, also 1m square, positioned above the nest, buried under 5cm sand, and with a central detachable disc, has been used with loggerhead nests in Turkey (see Yerli *et al*., 1997). Plastic-covered metal or plastic mesh (1m square; mesh size 70mm) buried 5-10cm below the beach surface protected green, hawksbill, loggerhead and olive ridley turtle nests in Brazil (Marcovaldi & Laurent, 1996; Longo *et al*., 2009).

Goannas, Lizards and Monitors (Varanids)

Varanids, including the Asian or common water monitor (*Varanus salvator*) in Sri Lanka (Ekanayake *et al*., 2010), the Andaman and Nicobar Islands (Chandi *et al*., 2006) and Malaysia (Salleh *et al*., 2012), the Bengal monitor/common Indian monitor (*Varanus bengalensis*) in Sri Lanka (Ekanayake *et al*., 2010), the coastal/yellow-spotted goanna (*Varanus panoptes*) in northern Australia (Blamires *et al*., 2003) and an unnamed species in Bangladesh (Islam, 2002), Malaysia (Chan, 2013), West Papua, and Papua New Guinea (Kinan, 2005), depredate sea turtle nests. Depredation rates exceeded 90% of nests on some islands in the Andamans and Nicobars (Chandi *et al*., 2006). Analysis of goanna scats at Fog Bay in northern Australia indicated that flatback turtle eggs were a major prey item in the dry season (Blamires, 2004) but the impact on the turtle population was unknown.

Varanids likely use visual (e.g., nest mound) and/or chemical (e.g., scent of eggs, fluids or hatchlings) cues to locate eggs (Blamires *et al*., 2003; Lei & Booth, 2018) and clutches laid on the dune crest may be more vulnerable to depredation than those at dune base (Blamires *et al*., 2003).

Panels of aluminium mesh, described above as effective against foxes (O'Connor *et al*., 2017), have also reduced high rates of goanna depredation of turtle nests. A top 1m square panel with four side panels of 10-25cm width should be buried to 20cm below the beach surface and the sand replaced to original beach height (Lei & Booth, 2017; Madden Hoff *et al*., 2019, see also Supplementary Plate 1 for image of nest cover being placed). A single plastic mesh panel- 1.2 x 1.5m, 50mm mesh size, buried to 10cm below the beach surface and secured in place with 40cm wooden stakes at the corners- was effective against yellow-spotted goannas predating on loggerhead turtle nests at Wreck Rock QLD, Australia (Lei & Booth, 2017). However, plastic mesh (90cm x 100cm; mesh size 50mm), buried 10cm below the sand surface and staked with up to nine sand pegs around the perimeter did not reduce goanna depredation of olive ridley turtle nests on the Cape York Peninsula QLD, Australia (Nordberg *et al*., 2019). "Netlon" mesh (1.5 x 1.5m; mesh size not described but see images) has been used to protect nests against varanids in Malaysia (Chan, 2013).

Honey Badgers

Honey badgers (*Mellivora capensis*) are only found in Africa, West Asia, and the Indian subcontinent. Predation on turtle eggs and hatchlings by this species has only been described in South Africa (Bourjea *et al*., 2008; de Wet, 2012), Tanzania (West, 2010), and Mozambique; predation is considered low in the first two countries but perceived as an emerging threat and in need of assessment in Mozambique (Williams *et al*., 2019). Only one study trialled exclusion methods and found cages of wire mesh (90 x 90 x 75cm cage of 5 x 10cm mesh, with the bottom 15cm bent outwards and buried; Boulon Jr., 1999) successfully prevented access of honey badgers to the nest (West, 2010).

Hyenas

Hyenas (species not named) or their tracks have been associated with depredated turtle nests in Kenya (Olendo *et al*., 2016) and India (Tripathy & Rajasekhar, 2009; Karnad, 2017). Enclosures to protect nests from hyenas have not been described, but protection devices used against foxes would probably be effective for the taxon.

Mongooses

Water/marsh mongoose (*Atilax paludinosusis*) depredate a low proportion of nests in South Africa (Bourjea *et al*., 2008; de Wet, 2012) and Sri Lanka (Ekanayake *et al*., 2010). If excluder devices were needed to protect turtle nests from this species, mesh covers or cages effective against goannas or foxes, as described in the current paper, could be appropriate.

Pigs

Reports of feral or wild pigs depredating turtle nests in the IO & SEA come from Sri Lanka (Ellepola *et al*., 2014), the Andaman and Nicobar Islands (Chandi *et al*., 2006), West Papua (previously Irian Jaya; Salm, 1982; Suganuma, 2005; Thebu & Hitipeuw, 2005; Hitipieuw *et al*., 2007), and Papua New Guinea (Kinan, 2005). Egg loss due to pig depredation can be severe; for example, ~90% of nests were depredated during some nesting seasons in Sri Lanka (Ellepola *et al*., 2014). Pigs can quickly become conditioned to recognise sea turtle nests as a food source, and so predator management strategies should be implemented as soon as possible once nest depredation behaviour becomes established in a population (Engeman *et al*., 2016). Depredation by pigs occurs soon after oviposition, suggesting that visual and olfactory cues are used to find the nest (Whytlaw *et al*., 2013).

The biological and economic costs of pig destruction of turtle nests was considered to be so high at North Island SC, USA, that a combination of trapping and removal, nighttime sharpshooting, aerial sharpshooting, public hunts, and private hunters with dogs have been used over time to control the animals (Engeman *et al*., 2019). These methods and their associated cost may not be feasible everywhere. However, enclosures have not been successful at protecting nests from pigs. For example, pieces of plastic mesh (90 x 100cm; mesh size 50mm), buried 10cm below the sand surface and staked with up to nine sand pegs around the perimeter did not reduce pig depredation of olive ridley turtle nests on the Cape York Peninsula QLD, Australia (Nordberg *et al*., 2019).

Porcupines

The only published record describing porcupines as a predator of sea turtle nest contents comes from Kenya (Olendo *et al*., 2016). The rate of depredation was unquantified so is likely to be low. If it were to become a problem, nest enclosures described in the current paper as being effective against foxes or goannas would likely be effective.

MONITORING EFFICACY

The number of predator tracks in surface plots at the base of the dune vegetation line and strip transects from dune to shore over fixed time periods can be used to calculate a passive tracking index for predators (see Engeman *et al*. (2003) for detailed methods and formula) and camera traps can be used to estimate predator abundance (e.g., Gilbert *et al*., 2020). These methods will also detect population increases among other potential nest predators as the target species is controlled. Nests should be monitored regularly to calculate changes in depredation rates before and after nest protection and/or predator management. The results can guide the choice of strategy, timing, and area for predator control strategies, and also assess the effectiveness of the strategy after it has been implemented. (Engeman *et al*., 2003, 2005).

SUMMARY AND RECOMMENDATIONS

Depredation of turtle nests play an important role in supporting coastal food chains and nutrient transfer from marine to terrestrial environments, and only requires management if egg and/or hatchling loss is likely to threaten population recruitment. While relocation of eggs to hatcheries for protection is a common strategy to reduce the likelihood of predation, other potential strategies include predator removal or exclusion from the nesting beach, deterrents, and nest enclosures. There are clear limitations to physically protecting every nest, especially along beaches on which turtles may nest over tens or hundreds of kilometres. If a known predator is introduced or invasive, then the most efficient method for its population management and/or sea turtle nest protection should be applied. If the predator is a native species, especially one long associated with the nesting site, then caution should be exercised and predation control should focus on nest protection rather than predator control, unless the conservation needs of the turtles far outweigh those of the predators.

Finally, researchers are encouraged to consider the potential use of suitable tissues from depredated clutches or hatchlings for studies of sex ratios (e.g., Rebelo *et al*., 2012) and stable isotopes (Carpentier *et al*., 2015; Chabot *et al*., 2019).

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