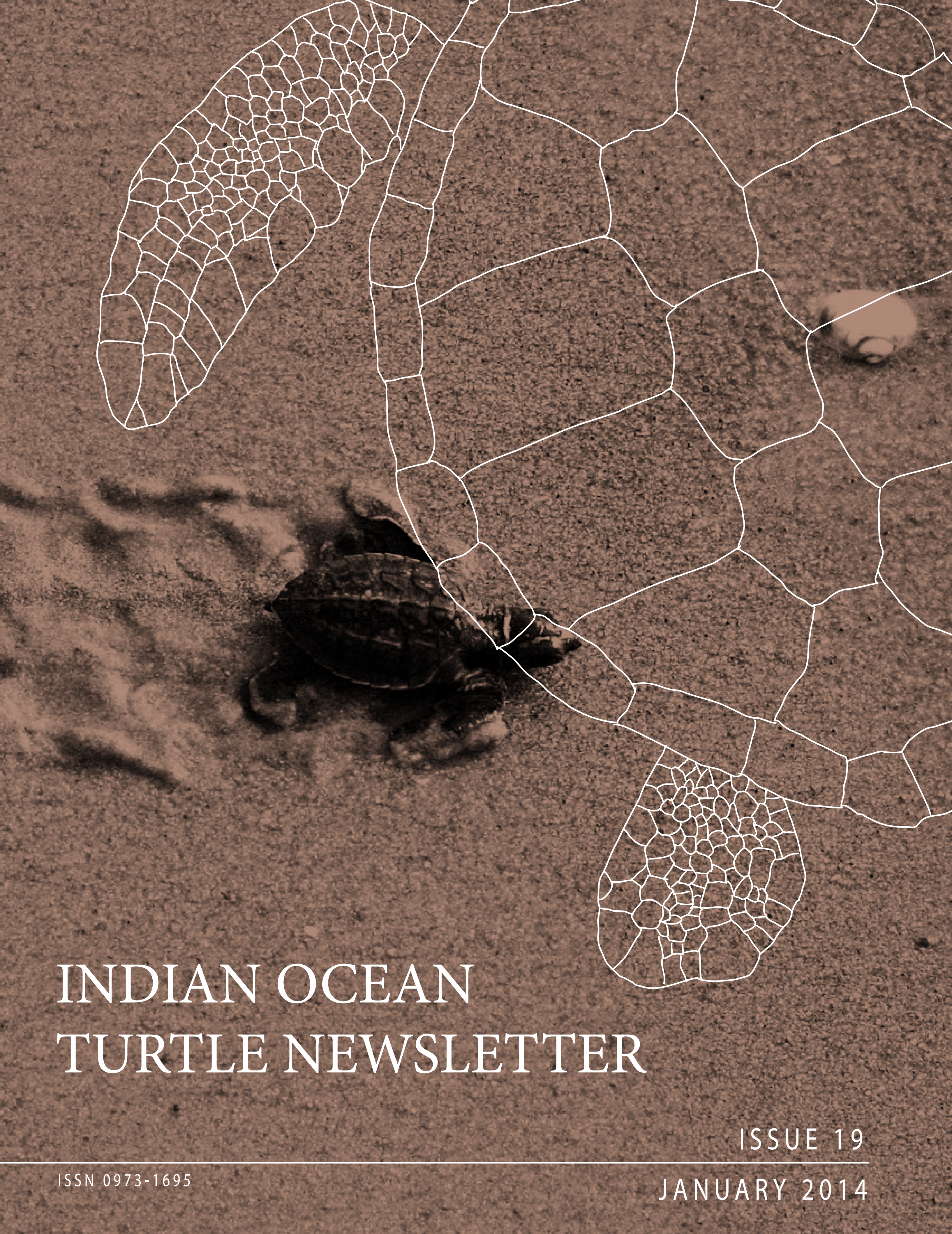

INDIAN OCEAN TURTLE NEWSLETTER

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The Indian Ocean Turtle Newsletter was initiated to provide a forum for exchange of information on sea turtle biology and conservation, management and education and awareness activities in the Indian subcontinent, Indian Ocean region, and south/southeast Asia. The newsletter also intends to cover related aspects such as coastal zone management, fisheries and marine biology.

The newsletter is distributed free of cost to a network of government and non-government organisations and individuals in the region. All articles are also freely available in PDF and HTML formats on the website. Readers can submit names and addresses of individuals, NGOs, research institutions, schools and colleges, etc. for inclusion in the mailing list.

This issue was produced with support from:

MCBT dakshin INTERNATIONAL SEA TURTLE SOCIETY WILDLIFE WITHOUT BORDERS

Cover photograph: Olive ridley hatchling at Orissa in 2008.
Photo Courtesy: Coralie D'Lima.

IOTN is available online at www.iotn.org

EDITORIAL

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Issue 19 (January 2014) of IOTN explores some of the threats to sea turtles and their habitats, including ocean acidification, loss of seagrass beds, alteration of nesting beaches, offshore fisheries, and ghost nets. We highlight conservation efforts and community outreach programs in the Seychelles, Madagascar, India and Kenya, and review the status of loggerhead turtles in the Indian Ocean and south-east Asia and Red List assessment of global leatherback populations and Indian Ocean subpopulations. Readers are encouraged to respond if they can identify the unknown carapace tag in the image on page 30, and participate in the survey of hatchery management practices in our region. Lalith and I look forward to meeting IOTN readers attending the 34th Annual Symposium on Sea Turtle Biology and Conservation in April, and will report back on events and discussions for those readers who are unable to travel to New Orleans. ■

CALL FOR SUBMISSIONS

The Indian Ocean Turtle Newsletter was initiated to provide a forum for exchange of information on sea turtle biology and conservation, management and education and awareness activities in the Indian subcontinent, Indian Ocean region, and south/southeast Asia. Issue 20 of IOTN will focus on genetic studies; if you would like to submit a research article, project profile, note or announcement, please email material to iotn.editors@gmail.com before 1st May 2014. Guidelines for submission can be found on the last page of this newsletter or at http://www.iotn.org/submission.php. ■

ARTICLES

THE FIRST SEYCHELLES SEA TURTLE FESTIVAL

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On August 9^{th} and 10^{th} 2013, the first Seychelles Sea Turtle Festival was held on the island of Mahe. Global Vision International and the Marine Conservation Society Seychelles organised the festival, with support from the Seychelles Ministry of Environment, to celebrate the Seychelles marine turtle population and raise awareness of issues surrounding their conservation.

Global Vision International (GVI) is a volunteer based community development and conservation organisation working in the Seychelles under the invitation of the Seychelles National Parks Authority (SNPA). Since 2004, international volunteers have been visiting the Seychelles on GVI programmes to undertake scientific monitoring of the islands coral reefs and terrestrial habitats. The Marine Conservation Society Seychelles (MCSS) is a non-governmental organization that promotes the conservation of the marine environment through education and research. Both GVI and MCSS have long standing sea turtle monitoring programmes within the Seychelles.

There are five species of marine turtle found in Seychelles waters, however it is only the hawksbill turtle (*Eretmochelys imbricata*) and the green turtle (*Chelonia mydas*) that nest on Seychelles' shores. They are listed as 'critically endangered' and 'endangered' on the IUCN Red List respectively. The Seychelles hawksbill population is the largest remaining within the Indian Ocean, and is one of only five populations worldwide that still have more than one thousand females nesting annually.

Within the Seychelles there is a long tradition of harvesting marine turtles, and green turtles remained an important food source up until the mid 1990s. In addition to their meat, the glutinous layer known as 'Calipee', found beneath the lower shell of the animal, was considered a delicacy. Though the prevalence of biotoxins within the flesh meant hawksbills were never a preferred food choice, the animals were not spared as their shells were highly prized within the local and illegal international markets where they were made into jewelry and ornaments.

Although the economic value placed on turtles created a lucrative market for their products, the Seychelles has a commitment to conservation. Since 1994, sea turtles have been afforded full protection under Seychelles law, and it is illegal to kill, possess or eat turtle meat. Though small scale poaching does still occur, the main threats to local turtle populations today include coastal development, pollution, and entanglement in longlines and fishing nets.

The Seychelles Sea Turtle Festival was an opportunity to unite different organisations that have turtle monitoring programs and to raise awareness of the issues surrounding turtle conservation. In total eight national organizations and one international organization (GVI) participated in the event. On August 9^{th} 2013 the opening ceremony of the festival took place at the Ministry of Education. The ceremony was opened by the Director General for Schools and was followed by a song entitled 'The Turtles in the Sea' performed by La Rosiere primary school.

During the course of the afternoon, prizes were awarded to the winners of the turtle themed artwork competition, which had been run throughout all schools in the Seychelles during the previous two months. Approximately 50% of schools in the Seychelles entered the competition, with over 150 primary and secondary school students providing turtle themed artwork. The festival provided an opportunity to discuss and share information on turtle conservation within the Seychelles and to reach the next generation of budding conservationists. Mr Chris Boyes from the Save Our Seas Foundation (Figure 1), Miss Gilberte Gendron from the Seychelles National Parks Authority and world-renowned turtle expert Dr Jeanne Mortimer delivered presentations on turtle biology and conservation. The afternoon culminated in an animated puppet show created by the students

Figure 1. Chris Boyes from the Save Our Seas Foundation presents on sea turtle biology.

Photo credit: Christophe Mason-Parker

of the Academy by the Sea and a closing speech by the Minister for Tourism and Culture, Mr Alain St Ange. On Saturday August 10th 2013, a viewing of the documentary film ‘Turtle: the Incredible Journey' was held at the local cinema, with entry free to children under the age of sixteen. The film was followed by a ‘Family Fun Day' adjacent to the beach area in Beau Vallon. Several NGOs and government departments provided information on turtle monitoring programmes being conducted throughout the Seychelles, including the Seychelles Islands Foundation (SIF) who are tagging green turtles on the UNESCO world heritage site of Aldabra, GVI, SNPA whose hawksbill nesting monitoring programme runs within the Curieuse Island National Park, and MCSS who monitor the beaches of south Mahe. Many of the organizations hosted interactive displays and ran turtle based activities aimed at educating people of all ages in turtle conservation. In addition to GVI, MCSS and SIF, the other participating conservation organisations (in no particular order) were the, Save Our Seas Foundation, Island Conservation Society, Seychelles National Parks Authority, Ministry of Environment, WiseOceans, and TAGS.

Aside from the message of education, the day was all about having fun and there were plenty of activities to keep everyone entertained (Figures 2-3). Local DJs provided music while dozens of street vendors offered refreshments throughout the day. For the kids there was face painting and arts and crafts, as well as a sandcastle competition. There was also the opportunity to try snorkeling and experience the marine environment first hand.

The first Seychelles Sea Turtle Festival was a great success in bringing together people from all backgrounds and ages. The festival received a significant amount of media

Figure 2. The MCSS stall at the Family Fun Day at Beau Vallon beach.

Photo credit: Christophe Mason-Parker

Figure 3. Adults and children join in the activities at the 'Family Fun Day'.
Photo credit: Christophe Mason-Parker

coverage from both newspapers and local television and was well received by all those who attended. In total over the two days it is estimated that around one thousand people attended the event, while many more followed the activities though different social media outlets. As the festival was held in Beau Vallon, the main tourist area of Mahe Island, it attracted a good mix of local residents and international tourists.

The event would not have been possible without the assistance of the Ministry of Environment, the Ministry of Education, the support of the Seychelles Tourism Board, and the generosity of all the sponsors.

As we enter the start of the Hawksbill nesting season it is hoped that there will be a new awareness regarding the obstacles that face marine turtles and a heightened sense of pride in the Seychelles close association with these amazing creatures. ■

Seychelles Sea Turtle Festival
9th -10th August 2013

THE EFFECTS OF OCEAN ACIDIFICATION ON HAWKSBILL SEA TURTLES (*ERETMOCHELYS IMBRICATA*): AN ECOSYSTEM APPROACH

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Hawksbill sea turtles (*Eretmochelys imbricata*) are listed as critically endangered by the International Union for Conservation of Nature (IUCN), with global populations demonstrating a decline of more than 80% over the past century (Troëng *et al.*, 2005; Boden, 2008). Hawksbill sea turtles are one of the only vertebrate species that feed exclusively on sponges, relying on tropical coral reefs and their associated biodiversity for foraging grounds and shelter (Meylan, 1988; Eckert & Grobois, 2001). Coral reef ecosystems are directly threatened by ocean acidification, and may reach a point in the near future beyond which corals will no longer be the dominant benthic organisms (Hoegh-Guldberg *et al.*, 2007; Veron, 2008). Species which supplement the hawksbill sea turtle's diet may also be adversely affected due to their reliance on a high saturation state of aragonite and a stable pH, both of which will decline as emissions continue to rise (Kurihara, 2008). More research is needed on ecological and biological impacts of ocean acidification in order to understand how hawksbill sea turtles will respond or adapt to their changing environment.

Since the beginning of the Industrial Revolution, atmospheric carbon dioxide (CO_2) concentrations have risen by approximately 100ppm to around 395ppm, levels higher than those observed for the past 800,000 years (Feely *et al.*, 2008; Doney *et al.*, 2009; Tans & Keeling, 2013). This increase has led to the reduction of the average surface water pH from 8.21 (preindustrial) to the current 8.10 (Doney *et al.*, 2009). As CO_2 emissions continue, projections by the Intergovernmental Panel on Climate Change (business-as-usual emission scenario) show that atmospheric concentrations could exceed 800ppm near the end of the century, further decreasing the pH of surface water by approximately 0.3-0.4 units (Doney *et al.*, 2009; Feely *et al.*, 2008). Produced primarily by processes such as fossil fuel combustion, deforestation, agriculture, and cement production, these emissions are causing the ocean to become more acidic, leading to a fundamental alteration of marine ecosystems through a series of chemical reactions (Doney *et al.*, 2009; *Olivier et al.*, 2012).

$$CO_{2(atmos)} \leftrightarrow CO_{2(aq)} + H_2O \leftrightarrow H_2CO_3 \leftrightarrow HCO_3^- + H^+ \leftrightarrow CO_3^{2-} + 2H^+$$

As the ocean absorbs CO_2, the molecules react with seawater to form carbonic acid (H_2CO_3), which then dissociates into bicarbonate (HCO_3^-) and hydrogen ions (H^+). This dissociation causes a reduction in pH. Acidification is buffered through the bonding of carbonate and hydrogen ions, lowering the calcium carbonate ($CaCO_3$) saturation state (Hoegh-Guldberg *et al.*, 2007; Doney *et al.*, 2009). The saturation state is calculated by the following formula, and represents the thermodynamic potential of dissolution or formation of calcium carbonate.

$$\Omega=[Ca^{2+}][CO_3^{2-}]/(K_{sp}')$$

The apparent stoichiometric solubility product for mineral phases of calcium carbonate is represented by K_{sp}'. Aragonite (Ω_{arg}) and calcite (Ω_{cal}) are the two phases, with aragonite being the most common in modern times (Kleypas *et al.*, 1999). Currently, the saturation state is determined by carbonate, as calcium ions are abundant. If the saturation state is less than one, it is considered undersaturated and results in the dissolution of calcium carbonate. If greater than one, the water is saturated, and mineral formation can take place (Kleypas *et al.*, 1999).

In waters with high saturation states, corals form their calcium carbonate skeletons through a process within the cell layers. The coral polyp precipitates calcium carbonate from solution, creating crystals within membrane-bound vesicles. The crystals act as nuclei for crystal growth and are extruded through the epidermis as the polyp lifts itself from the basal plate, creating a space in which a new plate is formed, allowing the polyp to grow upward (Goreau *et al.*, 1979).

According to Kleypas *et al.* (1999), estimates based on the last 8,000 to 10,000 years have shown that hermatypic, or stony corals, have developed in conditions with a Ωarg value of at least 4.0. Currently, the average saturation state in the tropics is 4.0 ± 0.2 (1 SD), but will decrease to 2.8 ± 0.2 by the end of the century. Coral calcification rates in some species stop, or become negative, at Ωarg > 3.3, which may occur if atmospheric CO_2 concentrations equal or exceed 480ppm (Kleypas *et al.*, 1999; Hoegh-Guldberg *et al.*, 2007). During periods of high acidification, some species of coral may survive as soft-bodied polyps, reforming their skeletons when CO_2 levels drop and ocean conditions return to levels more conducive to accretion (Hoegh-Guldberg *et al.*, 2007; Stanley, 2007). Though this is a beneficial adaptation for corals, many marine animals, such as the hawksbill sea turtle, are vulnerable to the loss of habitat and biodiversity that would result from the dissolution of coral reefs (Hofmann *et al.*, 2012).

If atmospheric CO_2 concentrations continue to rise, a tipping point may be reached beyond which tropical coral reefs may be dominated by other species, such as algae, grasses, or sedentary filter feeders such as sponges and gorgonians, resulting in a new equilibrium. A deviation of more than 2°C, combined with an atmospheric CO_2 content higher than 480ppm, and corresponding carbonate ion concentration of greater than 100μmol kg^{-1} may result in reefs that are no longer dominated by corals (Hoegh-Guldberg *et al.*, 2007). If this were to occur, reefs could take thousands to millions or years to reform into a system similar to those seen today, due to the slow process of evolution and neutralization process required to buffer ocean acidity (Veron, 2008). With increased pressures, including bleaching, human disruption, and disease, coral communities are declining worldwide, especially in the Caribbean where a decline of 80% has occurred since the mid-1970's (Hoegh-Guldberg *et al.*, 2007; Perry *et al.*, 2013). If declines continue, they may result in a drastic loss of biodiversity, which are considered necessary for reef systems and healthy hawksbill sea turtle populations (Meylan, 1988; Fabricius *et al.*, 2011). Hawksbill sea turtles will be directly affected by ocean acidification in a variety of ways. Though they migrate and use a variety of habitats throughout their lives, tropical coral reefs provide caves and ledges for rest and refuge, protection for nesting beaches, as well as the primary feeding grounds for adults and older juveniles (Eckert & Grobois, 2001). According to Meylan (1988), sponges contributed up to 95.3% of the dry mass of all food items recovered from the stomach contents of 61 hawksbills in the Caribbean. From the sponges identified, *Chondrilla nucula* was the most common, with *Ancorina sp.* being second. In a similar study by León & Bjorndal (2002), ingested prey species of hawksbill sea turtles in the SW Dominican Republic were compared with their local availability in order to evaluate the effects of hawksbill foraging on reef ecosystems, as well as to identify prey species. The study found that hawksbills fed on six demosponges (*Chondrilla nucula, Geodia neptuni, Myriastra kalitetilla, Spirastrella coccinea,* and *Tethya crypta*). When compared to availability, results indicated that both *Spirastrella coccinea* and *Myriastra kalitetilla* were rare, yet highly sought by hawksbills, indicating that these sea turtles were beneficial to maintaining a balance between corals and the more competitive sponges (León & Bjorndal, 2002). Spongivory, particularly of the aggressive *Chondrilla nucula*, helps to maintain diversity within the reef, though currently to a lesser extent due to the low hawksbill population levels (Hill, 1998; León & Bjorndal, 2002). Thus, the declining number of hawksbill turtles has increased the stress on tropical coral reefs, exacerbating the effects of ocean acidification, and in turn resulting in the degradation of critical habitat (Hill, 1998).

In a study by Goodwin *et al.* (2013), sponge species and cover along pH gradients at CO_2 vents off Ischia in the Tyrrhenian Sea were recorded and analyzed in accordance to pH ranges (8.1-8.2 (normal), mean 7.8 (lowered pH), 6.6 (extremely low)). *Chondrilla nucula* was found to be restricted to sites with normal pH, along with *Phorbas tenacior, Petrosia ficiformis,* and *Hemimycale columella*. The limited range of *Chondrilla nucula* is significant due to the diet specialization of this species by hawksbills. Seven species were recorded in the areas with lower pH, while only one species (*Crambe crambe*) was found at the lowest average gradient in significant numbers. Sponges of the class Demospongia will be affected by increasing CO_2 emissions, altering sponge community structure, thus affecting hawksbill sea turtles (Goodwin *et al.*, 2013).

The majority of sponges included within the studies by Meylan (1988) and Goodwin *et al.* (2013) belong to the class Demospongia, and use spicules made of silica for support and defense (Meylan, 1988). Spicules form the sponge skeleton, and are either calcareous or siliceous. Siliceous spicules are amorphous hydrated silica, making up much of the class Demospongia, while calcareous spicules are comprised of either crystalline calcite or aragonite (Simpson, 1984). Future research must be conducted on the effects of ocean acidification on sponges (and their differing spicules) to understand the potential impacts on hawksbill sea turtles and tropical reef ecosystems, as little information is currently available on the subject.

While many studies have found that hawksbill sea turtles are mainly spongivores, Bell *et al.* (2013) surveyed the ingested prey species to determine feeding strategies in regards to climate change. Gastric lavage (467 samples) and buccal cavity ingesta (71 samples) items were obtained from 120 hawksbills in the reefs in the Far North Section of the Great Barrier Reef (GBR) Marine Park. Of the total samples examined (n = 538), 72.7% came from three algal taxonomic divisions. Only 10.4% of the samples were sponge material, while 12.6% were invertebrates, and 5.4% were inorganic material. Citing that hawksbills are spongivores in most reef locations, this varied diet may benefit GBR hawksbills through increased algal growth if corals decline as predicted due to ocean acidification and climate change (Bell *et al.*, 2013).

The invertebrates that hawksbill sea turtles consume to supplement their diet will also be directly affected by ocean acidification (Bodin, 2008; Byrne, 2011). As atmospheric CO_2 increases, increased acidification and temperature will negatively impact various life stages of these marine invertebrates. It is expected that metabolism, skeletogenesis, molting, reproduction, larval development dispersal and settlement of invertebrates will be negatively impacted, while some will be further affected due to their limited abilities to compensate for acid-base disturbances (Kurihara, 2008; Byrne, 2011; Whiteley, 2011; Hofmann *et al.*, 2012). Acidification is especially detrimental to organisms which begin calcification in their larval and/or juvenile stages (Ross *et al.*, 2011). These impacts may lead to species extinctions as effects accumulate and acidification increases. Because tolerance differs between life stages, some organisms may survive to a particular stage, only to succumb to acidification at a later phase. Many invertebrate species are not important only to hawksbill sea turtles; they are also keystone species and will thus cause further changes in tropical reef ecosystems as they are affected by acidification (Bodin, 2008; Kurihara, 2008).

The effects of ocean acidification on marine ecosystems are varied and require additional studies. Though there is no indication yet of the direct physiological effects of acidification on hawksbill sea turtles, it is clear that these turtles will be greatly affected through drastic changes in their environment and prey species. The current rate of change is occurring at a rapid pace, with projected atmospheric CO_2 levels and temperature much higher than those of the past 42,000 years, during which most extant marine organisms evolved (Hoegh-Guldberg *et al.*, 2007). There is a critical need for information on the ability of corals and other marine invertebrates to adapt and evolve. Long-term studies will help to forecast how hawksbill sea turtles, and the tropical reef ecosystems and organisms they rely on, will be affected as the world's oceans warm and become increasingly acidic.

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BIOLOGY AND STATUS OF SEAGRASSES IN GULF OF KACHCHH MARINE NATIONAL PARK AND SANCTUARY, INDIA

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The lesser known but vibrant coastal ecosystem of seagrass meadows are very important for coastal communities as they are a critical component of the interdependent and interconnected series of coastal ecosystems; coastal mangroves, coral reefs, seagrasses and sand dunes that are often in close proximity and form a mosaic of micro-organism, algal, fungal, floral and faunal communities (Kallesoe *et al*., 2008).

Seagrass components and habitat

Seagrasses are seed-bearing, flowering, rooted plants, which grow submerged, exclusively in marine coastal waters and coastal wetlands. Like grasses in terrestrial habitats, they form meadows on the bed of coastal seas. They are dependent on light for photosynthesis, and therefore, seagrass generally grows only in clear and shallow waters in estuaries and coastal seas. Seagrass cannot survive exposure out of water, so often survives behind shelter from a sand bar or coral reef. Seagrasses are different from the seaweeds, which lack the vascular system for transport of food and water possessed by seagrasses. Similarly, seaweed also lack specialized reproductive structures, such as flowers and fruits, and roots. Seagrasses are the only flowering plants that have adapted to a completely submerged life in the tidal and sub-tidal marine environment, where they must withstand the wave energy of the sea and sub-marine pollination. Air-filled tissues in the leaves facilitate gas exchange with the environment. The underground rhizomes and roots anchor the plants; sugars and oxygen are produced during photosynthesis. Seagrasses need more sunlight (10% of the light at the water surface) than algae (1% of the light at the water surface), which do not have underground components (Bjork *et al.*, 2008). This necessity limits the depth to which seagrasses can grow (Orth *et al.*, 2006).

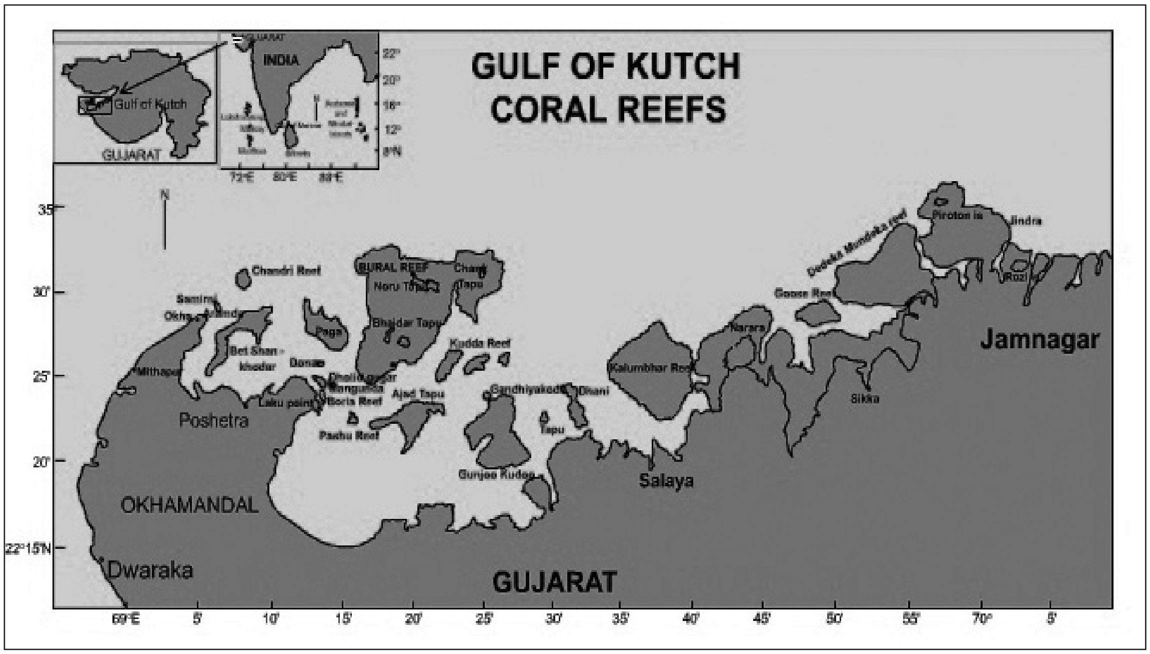

Figure 1. Gulf of Kachchh Marine National Park and Sanctuary, Gujarat, India.

Importance of seagrass

Seagrass meadows constitute ecologically and economically important habitats. Many edible fish inhabit seagrass beds, which also act as nurseries for many commercial fish and shellfish species. Seagrass meadows prevent coastal erosion and pollution and sedimentation of coastal waters, stabilize the floor of coastal seas, are primary producers in coastal ecosystems, support coastal biodiversity, enrich nutrients in coastal waters, and may be monitored as an indicator of coastal ecosystem health. They also act as filters for coastal waters, slowing water currents and trapping inorganic particles, organic nutrients and pollutants washed from inland waters to coastal areas.

Distribution of seagrass in Gulf of Kachchh Marine National Park and Sanctuary

The Gulf of Kachchh Marine National Park and Sanctuary (MNP&S) is situated in Jamnagar and Rajkot districts along the southern coast of India, between 20°15´N to 23°40´N latitude and 68°20´ to 70°40´E longitude (Figure 1). An area of 620 km^2, was declared a MNP&S by Government of Gujarat in 1980 and 1982, includes 42 islands ranging from a few hectares to ~7,000 hectares in size. The MNP&S comprises a variety of habitats; including coral reefs, mangrove forests, sandy beaches, mudflats, rocky coast, seagrass beds, and wide intertidal areas the greatest depth of water is 10-15m around most islands (Satyanarayana & Ramakrishna, 2009; Dixit *et al.*, 2010).

Six species of seagrass are reported from the region, constituting 10% of the total number described worldwide (Phillips & Menez, 1988). There are few published studies on seagrasses in the Gulf of Kachchh MNP&S, but the distribution of seagrass has been recorded by various agencies/organizations working among the mangroves, coral reefs and other habitats. Jagtap (1991) reported the occurrence of four species of seagrass from Gulf of Kachchh: *Halophila beccarii* was reported to be common while *Halodule uninervis*, *Halophila ovalis* and *Halophila ovata* were very rare. The status of seagrass was reported to be degraded. Nair (2002) reported three species, *Halodule univervis*, *Halophila ovate* and *Halophila beccari* on sandy regions of Narara and Kalubhar reefs. A comprehensive study on biodiversity and management issues of the MNP&S by Singh *et al.* (2004) indicates the status of seagrass in different locations. Maximum abundance was observed at Paga Reef, Chandri Reef, Noru Reef, Bhural Chank Reef, Kalubhar Reef, Narara Reef, Boria Reef, Mangunda Reef, Goose Reef and Pirotan Island. Low density seagrass meadows were reported at Meetha Chusna Island, Bhaidar Island, Chank Island, Ajad Island, Jindra Island, Chhad Island and Poshitra reef (see Table 1). Areas without seagrass included Bet Dwarka Island, Khara Chusna Island, Dedeka Island, Mundeka Island, Okha Village and Arambhda Village. Singh *et al.* (2004) reported only three species of seagrass from the intertidal reef areas of Gulf of Kachchh MNP&S compared with the six species reported by SAC (2010).

Thalassia hermprichii and algae were mapped on the coastal side of the reef flats of Bural Chank and Paga Reefs, Kalubhar Island, Narara Reef and Pirotan Island. Common seagrasses found growing on the muddy substrate of the seaward side of reef flats are *Halophilaovalis*, *Halophila beccarii* and *Zostrea marina* (SAC, 2010).

Table 1. Size of seagrass meadows in Gulf of Kachchh Marine National Park and Sanctuary.

Seagrass Location	Area Covered (ha.)
Bhural Reef	1321.72
Ajad Island	8.94
Gandhio kado Island	3.01
Goose Reef	15.65
Sikka Reef	198.81
Dedika-Mundika Reef	354.62
Pirotan Island	504.18
Chhad and Jindra Islands	25.38
Total	2432.31

Marine megafauna associated with seagrass in the Gulf of Kachchh MNP&S

Dugong feeding trails among beds of *Halophila* spp. adjoining Pirotan Island (22°34´40.4´´N; 69°59´07.3´´) in Gulf of Kachchh (Pandey *et al.*, 2010) and Yogesh Kumar *et al.*, (2013) observed dead dugong in Gulf of Kachchh. Green sea turtle carcasses found on the Bhaider island and Narara reef itself during the study period (pers. obs.) suggest seagrass meadows in the Gulf of Kachchh MNP&S support herbivorous marine megafauna and may be important feeding sites.

Potential threats to seagrass meadows in Gulf of Kachchh Marine National Park and Sanctuary

Like all coastal ecosystems, seagrass meadows are subjected to multiple impacts at local, national and global levels. Many anthropogenic activities impact seagrass ecosystems, and it is estimated that 65% of the seagrass meadows have been lost as a result of coastal development and alteration (Bjork *et al.*, 2008). Both natural and anthropogenic threats to seagrass occur in Gulf of Kachchh MNP&S.

One of the major threats to the seagrass meadows in Gulf of Kachchh MNP&S is pollution, due to various industries, and sedimentation affecting the water quality. Because sea grass meadows are dependent on sunlight for photosynthesis, water clarity and quality are important for the productivity of this ecosystem. Excessive sedimentation and turbidity often occur after dredging and coastal development.

- Industrial and domestic pollution and runoff from inland areas carrying nitrogen and phosphorus from fertilizers, animal and domestic waste leads to eutrophication and increased algal growth which reduces light and oxygen penetrating to depths at which seagrasses grow. Other sources of pollution, such as oil spillage from tankers, ships and sub-sea pipelines, and hot water discharge from industries also affect the condition of seagrasses.

- Coastal port, harbor and jetty developments lead to the increase of sedimentation, solid waste and marine pollution. Fishing activities, in particular trawling, shore seine and gill net operations and boat anchorage adversely affect seagrasses. Boat propellers can slash seagrass leaves and rhizomes, leading to fragmentation.

- Seagrass meadows are at risk from climate change-induced changes in marine conditions, including higher water temperature, acidification, sea level rise, increased intensity and frequency of storms and extreme weather events, season and amount of rainfall, wave height and frequency, and fresh water intrusion (IUCN, 2007).

Conclusion

The seagrass are the one of the important producer in the marine environment; serves as feeding and nursery habitat for endangered species like dugong, sea turtles and many recreationally important fish species. Seagrass diversity in the marine environment of Gulf of Kachchh Marine National Park and Sanctuary in India is being affected due to increase in Coastal port, harbor and jetty developments and fishing activities. The attempt revealed that seagrass distribution was significantly decreased in lead to the increase of sedimentation, solid waste, trawling, shore gill net operations and boat anchorage. Sea grass areas should be regulated as boat restriction zone especially for mechanised boats. Hence, it is essential to monitor the status of the seagrass in the marine environment of Gulf of Kachchh.

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ONE DAY WORKSHOP ON EFFICIENT HATCHERY MANAGEMENT TRAINING PROGRAM AT MANGROL, GUJARAT, INDIA

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A one-day workshop on efficient hatchery management was held at Mangrol, Gujarat on 8th January 2014, organised by the Gujarat Forest Department, Junagdh Division, in collaboration with the local Turtle Action Group (TAG) member, Prakruti Nature Club (PNC). The workshop primarily focused on training forest staff in efficient turtle hatchery management practices. Dinesh Goswami and Jignesh Gohil from PNC were the key resource persons for this training program (Figure 1). There were nearly 65 participants, mostly forest department officials from Mangrol, Kutiyana and Veraval regions (Figure 2). In addition to Aradhana Sahu, the Deputy Conservator of Forests and Wildlife of Junagadh, there were Range Forest Officers from nearby regions, forest guards, personnel from Marine National Parks, Jamnagar and Madhupur hatchery centres, and volunteers from PNC and Van Mitra. The workshop included general talks and oral presentations with slide shows and video clips, along with a field visit to the nearby beach.

During the inaugural session, Dinesh Goswami spoke about the importance and conservation of sea turtles, and about TAG and its role in bringing together NGOs working towards turtle conservation across different Indian states. Vijay V. Sholanki spoke about the Madhupur hatchery where he works at, and Aradhana Sahu spoke about role of the forest department and local people in conservation. Jignesh Gohil described the sea turtle

Figure 1. Dinesh Goswami of PVC addressing the workshop participants

Photo credit: PNC Volunteer

Figure 2. Forest officials making notes during the talks
Photo credit: PNC Volunteer

Figure 3. Demonstration of hatchery management techniques to forest officials
Photo credit: PNC Volunteer

species found in Indian sub-continent, their life cycle and ecology, mass nesting, conservation threats and mortality rates of hatchlings. He also spoke about outreach and conservation awareness and the role that local communities can play in marine turtle conservation.

During a field visit to Mangrol beach, participants were divided into three teams and asked to find turtle nests. Pravin M. Sholanki of Marine National Park, Jamnagar, demonstrated the techniques of tracking flipper marks, locating nests, measuring nest depth and width, measuring substrate temperature, and collecting eggs for incubation at a hatchery. The participants were given demonstrations on operating a GPS and noting the location and time of the nesting event, how to transfer the eggs to the hatchery (Figure 3), and how to relocate the hatchlings back to sea. Jignesh Gohil described the appropriate care of turtle eggs when in the hatcheries, and the role of temperature in determining hatchling sex. During the two hour field demonstration, three nests and two hatchlings were located. One of hatchlings was relocated to the nearby hatchery while the other one, being healthy, was released back into the sea.

With a vote of thanks by Mr. R.D. Vansh, Range Forest Officer Mangrol, this one day workshop on hatchery management practices came to an end.

*The report is based on details provided by Mr. Jignesh Gohil of Prakruti Nature Club, Kodinar, Gujarat. ■

PHOTO OF INTEREST

By-Catch Net Release of a green juvenile in Watamu Marine Park marking our 10,000th sea turtle release!

The Local Ocean Trust's 'By-Catch Net Release Programme' have now released over 10,000 sea turtles back into the wild, many of which would have been slaughtered for their meat, oil and carapace. This magnificent achievement would not have been possible without the continued support from the local fishing communities, who we in turn support through our Conservation Education and Community Outreach & Awareness programmes that all work hand in hand together. We would like to thank our core funders African Fund for Endangered Wildlife (AFEW) & Disney Worldwide Conservation Fund (DWCF) for their long term support that has helped us to achieve such a monumental goal.

Photo credit: Local Ocean Trust: Watamu Turtle Watch

A REVIEW OF THE ADVERSE EFFECTS OF *CASUARINA* SPP. ON COASTAL ECOSYSTEMS AND SEA TURTLE NESTING BEACHES

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Introduction

Casuarina spp. are extensively cultivated worldwide for beach establishment, erosion control, wind breaking, coastal sand dune stabilization, and as ornamental trees (NRC, 1984). Throughout Asia, bioshields of *Casuarina* spp. are also recommended for construction (Danielsen *et al*., 2005; Kesavan & Swaminathan, 2006; De Zoysa, 2008; Mattsson *et al*., 2009) or reinforcement (Tanaka, 2009; Samarakoon *et al*., 2013) to mitigate the impacts of future tsunamis and other natural disasters.

However, *Casuarina* spp. reduce biological diversity and beach integrity, and *C. equisetifolia* has been reported as a serious invasive species in many coastal regions of the world, including Florida and Hawaii in the USA, countries throughout the Caribbean Sea (Wheeler *et al*., 2011), and the Republic of Palau in the Pacific Ocean (Space *et al*., 2003). Eight of 33 countries at the 2012 IOSEA Marine Turtle Memorandum of Understanding meeting described the planting of *Casuarina* spp. as a current conservation activity, yet six countries identified it as a problem on their nesting beaches (see http://iosea-reporting.org/test/reporting/Test.asp).

Natural growth of *Casuarina* spp. and effect on beach ecosystems

The Genus *Casuarina*, of the Family Casuarinaceae, contains 17 species. *Casuarina equisetifolia*, commonly known as the beach she-oak, beef wood, or Australian pine, has the widest distribution of all *Casuarina* species and is native from Australia eastward to Melanesia and westward to coastal Southeast Asia (Whistler & Elevitch, 2006). *Casuarina* spp. are capable of very fast growth, require little attention, and thrive in sandy and saline conditions. The natural habitat is semi-arid to sub-humid, with a mean annual temperature of 10-35°C and mean annual rainfall of 200-3,500mm. *Casuarina* spp. grow best in well-drained and coarse-textured soils, such as sands and sandy loams, occur naturally on sand dunes, in sands alongside estuaries and behind fore-dunes, and on gentle slopes near the sea, and persist at the leading edge of dune vegetation where plants are subject to salt spray and inundation with seawater at extremely high tides (Hanum & van der Maesen, 1997).

Although very little is known about the effects of salinity on its physiology and biochemistry, basic metabolic adaptations such as the accumulation of osmolytes (e.g. proline), as occurs in other saline-tolerant plants, may ensure adaptability to the saline stress (Desingh, 2002; Tani & Sasakawa, 2006). The accumulation of antioxidant enzymes may also contribute to the tolerance of *Casuarina* spp. to salinity (Desingh, 2002). Tolerance to adverse environmental conditions allows *Casuarina* spp. to easily colonise new environments, after which it can often outcompete other species due to its mode of reproduction. *Casuarina* spp. are both monoecious and dioecious; the genera reproduces sexually, via seed, and vegetatively through the sprouting of new clonal trunks from existing rootstock (Hanum & van der Maesen, 1997) or by rooting along branches that touch the ground (Whistler & Elevitch, 2006). Some *Casuarina* spp. are capable of flowering year long, so individual trees can produce thousands of seeds in a year, with each seed remaining viable for up to a year and germinating within 4-8 days under suitable conditions (Hanum & van der Maesen, 1997). Wind pollination aids in rapid seed dispersal over a large area (Whistler & Elevitch, 2006). These characteristics contribute to the production of a large number of seedlings in a short period of time.

Stands of *Casuarina* spp. compete easily with native vegetation, as actinorhizal root nodules that form with a bacterial symbiont of the genus Frankia allow the trees to fix nitrogen (Potgieter *et al*., 2014). Once established, they displace native vegetation by producing heavy shade and a thick layer of leaf litter; the genera can accumulate up to 120 t/ha of litter (Bernhard-Reversat & Loumeto, 2002). Such thick accumulation of leaf litter, and the production of phytotoxic allelopathic compounds, inhibits the germination and seedling growth of understorey vegetation (Batish & Singh, 1998; Batish *et al.*, 2001). Thus, these species can form monocultures and alter soil chemistry to further inhibit competitors (Batish *et al.*, 2001).

The high primary production of *Casuarina* spp. may be aided by strategies that reduce the decomposition rate of leaf litter and improving the synchrony between mineralization and uptake. Although leaf decomposition rate is affected by both litter type and the forest type of invaded sites (Hata *et al.*, 2012), the tannin concentration of *Casuarina* spp. leaves inhibit decomposition of litter and soil organic matter, form tannin-protein complexes relatively resistant to decomposition, induce toxicity to microbial populations, and inhibit microbial enzyme activities (Zhang *et al.*, 2013). The ecological consequences of elevated tannin levels may include allelopathic responses, changes in soil quality and reduced ecosystem productivity. These effects may also alter or control succession pathways of natural vegetation (Kraus *et al.*, 2003) and, therefore, beach structure.

Impacts of *Casuarina* spp. on beach structure

Beaches are not rigid or permanent structures; they are maintained by seasonal weather and wave action. Coastal dunes are formed by the aeolian (wind) transport of sand from the near-shore to the back-beach. The first plant colonisers of the bare sand, usually grasses or small shrubs (Martinez *et al.*, 2001), reduce wind velocity and the capacity for aeolian transport and trap sand (reviewed by Sloss *et al.*, 2012). Growth of the pioneer species is stimulated by sand entrapment and accumulation, and the roots begin to bind the surface sand layers together. As the substrate becomes more stable and suitable for successive plant species to colonise, humus formed from the decomposition of fallen vegetation increases substrate nutrition, cohesion, and water retention (reviewed by Pye, 1982; Martinez *et al.*, 2001) and promotes further growth.

Abundant native vegetation on the dunes traps sand and aids in progressive widening of the beach; an annual addition of up to 10,000 cubic meters of sand per kilometer of beach is possible on a well vegetated dune (see Sealey, 2006). Introduced *Casuarina* spp. out-competes or inhibits native vegetation and destabilizes the beach as sand is deposited between the *Casuarina* trees instead of accumulating vertically in front of dune-stabilising grasses. The beach subsequently becomes flattened and can be more easily stripped of sand by waves during severe storms to create a steep beach, which further erodes to become a narrow beach (see Gordon, 1998; Burroughs & Tebbens, 2008; Schmid *et al.*, 2008). With each successive storm, the beach shrinks to the *Casuarina* tree line (Schmid *et al.*, 2008). Beach destruction may eventually occur if the erosion continues and there is insufficient sand in the longshore currents to rebuild the beach by normal processes (Samsuddin & Suchindan, 1987). *Casuarina* trees are also prone to falling because of their height and shallow root system (Sealey, 2006; Schmid *et al.*, 2008) so erosion continues as the front trees are uprooted and washed away (Sealey, 2006).

Impacts of *Casuarina* spp. on sea turtles and their nests

Casuarina spp. are often planted on sea turtle nesting beaches (Figure 1) as a physical shield between urban areas and the ocean so as to reduce light levels and create suitable photic conditions for nesting (Salmon *et al.*, 1995) or as shade during adaptive practices to manage the effect of rising ambient temperatures resulting from global climate change on sea turtle nests (Wood *et al.*, 2014). However, if *Casuarina* spp. are allowed to alter beach structure, nesting and hatching success may be reduced and natural hatchling sex ratios altered.

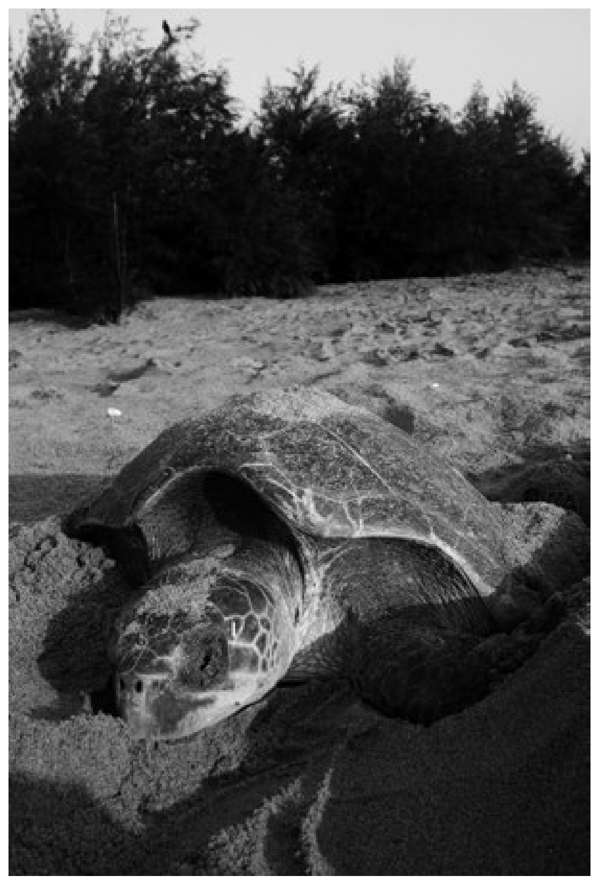

Figure 1. Olive ridley nesting in front of *Casuarina* trees at Rushikulya, Odisha, India.

Photo credit: Kartik Shanker

Stands of *Casuarina* spp. are only likely to be a moderate impediment to nesting sea turtles that can maneuver around them to nest (Witherington *et al.*, 2011), but fallen trees can create physical obstacles for nesting females to navigate (NRC, 1984) and result in abandoned nesting attempts or nesting in sub-optimal areas. The dense, shallow roots of *Casuarina* spp. may interfere with nest construction so females abandon their nesting attempts (NRC, 1984; Wood *et al.*, 2014) or penetrate the nest and destroy eggs during incubation (Hays and Speakman, 1993; Leslie *et al.*, 1996). Hatchlings emerging from nests laid within dense forests are at risk of entanglement in roots during emergence or disorientation into supralittoral vegetation (Godfrey and Baretto, 1995).

The formation of significantly steeper and narrower beaches in the presence of dense stands of *Casuarina* spp. may impact hatchling survival as nests laid close to the sea are at risk of egg loss due to erosion and mortality due to salt water inundation (Foley *et al.*, 2006; Caut *et al.*, 2010). Nest temperatures during incubation may be lowered by *Casuarina* spp. shading nests (Morreale *et al.*, 1982; Spotila *et al.*,1987; Kamel, 2013), lowering the water table and exhausting soil moisture (NRC, 1984), or blanketing the beach surface with a thick layer of leaf litter (NBII & ISSG, 2010). Lower nest temperatures can skew hatchling sex ratios to result in more males and reduce hatchling swimming performance (e.g. Burgess *et al.*, 2006). The relationship between the primary sex ratios of hatchlings, hatchling fitness, and the operating sex ratios of adult populations is currently unknown, but the resulting population demographics may influence the capacity of a species to persist during global climate change (Stewart & Dutton, 2014).

Recommendations

Beach vegetation initiatives should be carefully planned to ensure dune preservation and stability (see comments by Mascarenhas, 2006) and utilise indigenous plant species instead of exotics or invasives such as *Casuarina* spp. Natural forests in relatively undisturbed areas can be examined to determine the species most likely to grow in different localities, and can possibly be sourced from local NGOs or communities. If little natural forest remains, then local botanists may be able to suggest the most suitable species. The removal of existing stands of *Casuarina* trees can be expensive and time consuming, but a priority in areas where nesting and hatching success is low. Careful, physical removal is likely to have less effect on the environment, and sea turtle nests, than methods of chemical or biological control (see Conrad *et al.*, 2011; Wheeler *et al.*, 2011).

The problems experienced on beaches planted with *Casuarina* spp. should be remembered when plans to introduce exotic species or interfere with natural beach processes are considered. Other methods of stabilization, including groin construction, beach dewatering, beach nourishment (Grain *et al.*, 1995), piling installation (Bouchard *et al.*, 1998), and artificial reef construction also change beach dynamics and have an adverse impact on sea turtles; it should be remembered that beaches are dynamic structures and local development should be prepared to cope with a changing environment.

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PROJECT PROFILE

REEFDOCTOR.ORG

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Introduction

Extending along the Southwest coast of Madagascar, the Toliara Barrier Reef Complex is a highly-productive marine turtle foraging ground associated with the migratory routes of many of the turtle species found within the region (Rakotonirina & Cooke, 1994). However, little is known about the spatiotemporal variations in occurrence, nor the demographics of the turtle population frequenting this important foraging ground of the southern Mozambique Channel.

Since its foundation in 2001, ReefDoctor, a UK marine conservation NGO, has been stationed in the Bay of Ranobe (BRB). Located 25km north of the regional capital of Toliara, the BRB is a semi-enclosed lagoon and a sub-section of the Toliara Barrier Reef Complex, supporting diverse marine habitats including coral reefs, seagrass meadows, and mangrove forests (Figure 1).

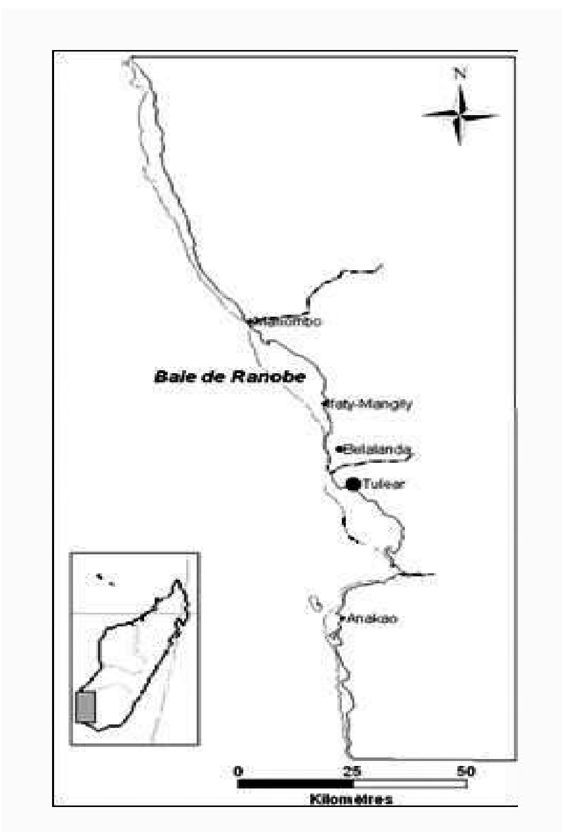

Figure 1. Bay of Ranobe, sub-section of the Toliara Barrier Reef Complex, Southwest Madagascar

Indigenous communities are divided into three ethnic groups and/or tribes; Vezo – marine foragers, Masikoro - cattle herders and farmers, and Mikea - hunter gatherers. The extreme poverty of this semi-arid region (Tucker, 2012; Cavendish, 2000; Reardon & Vosti, 1995) has resulted in resource over-exploitation (Gore *et al.*, 2013) and severe habitat degradation.

As specialist marine foragers, the Vezo obtain approximately 84% of their income from the near shore marine environment (Tucker *et al.*, 2010). Nonetheless, primitive fishing technology, such as dugout canoes equipped with one outrigger and a sail, restricts the distance from shore fishermen are willing to travel. Similarly, sea-state and weather restrict fishing days, resulting in periodic food shortages (Tucker *et al.*, 2010).

For centuries Vezo communities have exploited marine turtles (Lilette, 2006; Frazier, 1975; Louvel *et al.*, 1927), which are considered to hold intrinsic spiritual, economic, and subsistence values (Eckert, 1999; Frazier, 1976, 1980; Muir, 2005). In terms of spiritual value, local communities believe it to be beneficial for their families to perform the ritualistic sacrifice of these animals, acting as a form of ancestor worship (Lilette, 2006) that results in the obligatory consumption of the turtle meat (Cinner, 2007). In addition, turtle eggs are targeted for trade by the Vezo as a food item, and turtle oil is used in traditional medicine (Rakotonirina & Cooke, 1994). In 1923, legislation was put into place for the protection of marine turtles in Madagascar in prohibiting the capture of nesting females and individuals with a carapace diameter of less than 50cm (Decree 23; Louvel *et al.*, 1927). In 1975, Madagascar ratified the Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora (Decree 75-014), and in 1988, Decree 88-243 prohibited the exploitation and sale of marine turtles throughout Madagascar. However, whilst the decrees provide protection to marine turtles at a national level, nationwide enforcement is weak, or even non-existent, due to the lack of financial resources available to enforcement officials.

Despite the lack of government-led enforcement of national laws, in rural areas around 75% of governance takes the form of distinct social codes and pre-established rules, which are conveyed principally in the form of oral traditions passed down from one generation to the next (Ratsimbazafy *et al.*, 2013; Pollini & Lassoie, 2011). Whilst the ritualistic consumption of turtle meat by the Vezo may have been sustainable in the past, it is now evident that the capture, trade, and sale of turtle meat is becoming much more commonplace. With the erosion of the cultural value of turtles and emphasis being placed on their economic value, undoubtedly greater-and-greater exploitation pressure will be placed on these already fragile marine turtle populations.

Project objectives

In 2008 ReefDoctor, with sponsorship from the Rufford Small Grants Foundation, pioneered an innovative conservation approach to protect marine turtles of the BRB region. Integrating fisheries management strategies and grassroots, community-based conservation initiatives provided a foundation for the Vezo community to develop their own approach towards the sustainable exploitation of marine turtles. The project hopes to promote this through (a) collating ethnographic information to assess patterns of turtle-human interactions (b) an evaluation of the marine turtle fishery through the collection of biological data on the capture and consumption of marine turtles in the BRB and, (c) the development of the first marine turtle protection association whose core members are Vezo turtle hunters.

Our scientific objectives are:

Research and Monitoring as a tool for securing conservation

- Developing tools for structured decision-making to support adaptive environmental management of the Bay of Ranobe (BRB)

Evaluation of marine turtle fishery - direct hunting and incidental capture of the globally important, yet understudied marine turtle population of the BRB.

- Collection of biological data on the capture and consumption of marine turtles in the BRB

Implementation of community-based conservation fisheries management strategies, policies and local indigenous laws (dina) related to conservation and sustainable use of marine turtles and their habitats

Capacity building of rural communities

- Exit strategies for fishers; adult education and training in alternative livelihoods to promote self-fulfilment of rural young people, to develop entrepreneurship spirit and to encourage personal risk and initiative taking.
- Institutional integration; building a network connecting rural communities with local, national and international institutions.

Public awareness

- Delivering an innovative working model and platform for marine turtle conservation throughout the Western Indian Ocean.

Project result

Since the launch of this project over 1500 marine turtles have been captured and slaughtered in the Ranobe region. The green turtle (*Chelonia mydas*), constitutes 97% of the fishery although all five species of marine turtle, present in Madagascan waters, are targeted. Hawksbill turtles (*Eretmochelys imbricata*), loggerhead turtles (*Caretta caretta*), olive Ridley turtles (*Lepidochelys olivacea*) and leatherback turtles (*Dermochelys coriacea*) are only occasionally caught.

Estimates of annual income derived from marine turtle products indicate an increase from £3,000 in 2009 (£2.60 per kg) to £6,900 in 2012 (£3.60 per kg). Over the same time period, average straight carapace length has decreased, in green turtles, from 78 cm in 2009 to 69 cm in 2012. The capture of large individuals has become rare.

A community conservation effort has evolved through a grassroots movement by turtle hunters to protect their identity, and livelihood, through the protection of marine turtles. The group Fikambanana MPaniriky Miaro ny Fano (FI.MPA.MI.FA)- the first grassroots marine turtle management association in Madagascar was recognised as a legal association by the Malagasy government in 2012. Focusing on reducing the illegal exploitation of marine turtles in the Bay of Ranobe, the Association seeks to use indigenous knowledge to develop a practical fisheries management framework. Earlier this year the first 'dina', or traditional law, preventing the hunting of turtles under 70 cm, was implemented throughout thirteen communities, with an estimated population of over 20,000 people. Each of the thirteen communities of the BRB have formed turtle protection teams composed of elders and fishermen, who are responsible for the administration of the dina. These teams are largely reducing conflict and providing a platform for marine turtle protection in the region.

In September 2013, ReefDoctor Fano (marine turtle) project and FI.MPA.MI.FA teamed up with Kelonia marine observatory in Reunion. The objectives of this partnership are to implement the first community-based tagging program of juvenile turtles in South-west Madagascar. Juvenile marine turtles under 70 cm CCL, protected by the newly established dina created by FI.MPA.MI.FA, are tagged and released by the association. The first juvenile turtle to be protected by the dina was delivered to the association on 5 October 2013. The 47 cm CCL female was tagged by ReefDoctor's community turtle officer and released by the president of FI.MPA.MI.FA.

Future research

The challenge, over the next few years, for the ReefDoctor marine turtle project is to describe the structure of the marine turtle population inhabiting the reef complex of Toliara. This will require an estimation of stage and population-specific partitioning of habitat use, age at maturity, and seasonal and ontogenetic shifts in habitat occupation. This will be attained through:

- Stomach content analysis; to determine habitat use and diets of juvenile and adult marine turtles.
- Urogenital analysis; evaluating the reproductive stage, age, and size at reproductive maturity of marine turtles exploited in the fishery.

For further information on the ReefDoctor FANO (marine turtle) project please contact emma@reefdoctor.org.

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OLIVE RIDLEY PROJECT: ACTIVELY FIGHTING GHOST NETS IN THE INDIAN OCEAN

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Introduction

The Olive Ridley Project was initiated in response to large numbers of olive ridleys turtles (*Lepidochelys olivacea*) found entangled in fishing nets in the Maldives. This species of sea turtle is rarely observed in the Maldives; however, since 2011 marine biologists, dive masters and boat captains have recorded 47 olive ridleys entangled in fishing nets. The recorded entanglements have occurred through chance encounters suggesting the data only reflects a small proportion of the actual number of ghost net entrapments of olive ridleys in this region. Since the inception of the Olive Ridley Project in July 2013 a further 20 olive ridleys have been found. Often turtles spend extended periods of time entangled in nets and their condition quickly deteriorates. Dehydration, amputations and deep lacerations are some of the injuries sustained. The risk of predation by opportunistic predators increases when entangled and defenceless and this brings with it further trauma to the turtles. Once found, their condition can be so severe that often they do not survive. Dedicated teams in the Maldives, Sri Lanka and India are working towards rehabilitating injured turtles, but the problem continues.

Net fishing techniques

Unfortunately artisanal and commercial fisheries surrounding the Indian Ocean rely heavily on fishing nets. Net fishing bycatch is difficult to accurately estimate as records are absent or poorly kept (Amandè *et al.*, 2010) but is thought to be responsible for ecological effects on key species such as turtles, sharks, rays, mammals and other marine organisms that are relevant to ecosystem structure and function (Garcia *et al.*, 2003).

Population growth leads to increased competition for natural resources throughout the world. Artisanal fisheries have to compete with large commercial fisheries and each other for healthy catches, which often leads to travelling greater distances and illegal fishing activity. Trawling, seine and gill netting methods make up the different techniques practiced in the Indian Ocean.

Fishing nets made of nylon are easily broken. Some communities in Sri Lanka use nets for only 6 days before they become too damaged and need to be replaced (M. Stelfox 2013, pers.comm., 10 November). In addition nets often become entangled on the sea floor during use and removal becomes almost impossible. Net fishing is not only unsustainable but when discarded at sea the nets remain very effective long after use. They are also very expensive for the fishermen and communities waste a significant amount of money replacing lost or damaged nets (M. Stelfox 2013. pers.obs.).

Figure 1. Olive ridley trapped in ghost net.
Photo credit: Chiara Fumagalli

What are ghost nets?

Ghost nets are any fishing nets that have been lost abandoned or discarded in the Ocean. Unfortunately these nets continue to trap marine species long after they become ghost nets. The true extent of the problem in the Indian Ocean is unknown; however, fish stocks are under ever increasing pressures and ghost nets contribute significantly to the balance of this delicate ecosystem.

Where the nets come from?

Line and pole is the primary fishing technique used in the Maldives, which ensures catches are extremely selective and bycatch rate is around 4% (Ardill *et al.*, 2013). However, bait fish are caught by fishing nets and a small proportion could become ghost nets.

The two main monsoon seasons in the Indian Ocean bring with them changing current patterns and these play a significant role in ghost net distribution. Fishing methods in Sri Lanka and India rely heavily on nets and practices still remain largely unsustainable. It is likely that ghost nets that remain in the ocean are subject to strong currents surrounding the coastal regions meaning they can travel great distances in a relatively short space of time. Encounters between nets and olive ridleys and other marine life are extremely likely and currents eventually bring entangled wildlife to the Maldives. The West Indian Coastal Current may be responsible for bringing nets and turtles to the Maldives in the South-West Monsoon, while the East Indian Coastal Current and the North Monsoon Current may be carrying nets eastwards towards the Maldives during the North-East Monsoon.

Analysis of current maps reveal other areas in the Indian Ocean where ghost nets may originate and we are looking at reaching out to Oman, Mauritius, Seychelles and Madagascar to target other ghost net hot spots.

What are we doing?

Currently, 94 net samples have been analysed and removed from the Indian Ocean, collected from India, Sri Lanka and the Maldives. We continue to collect net data and add to our database. We hope to eventually identify what types of fisheries significantly contribute to ghost net numbers. We are also in the process of analysing current models to identify potential origins and final destinations of ghost nets.

We actively work with artisanal fisheries to understand the

Figure 2. Undhoodhoo Island, in Baa atoll, Maldives, an uninhabited island with a ghost net on its beach.
Photo credit: Olive Ridley Project

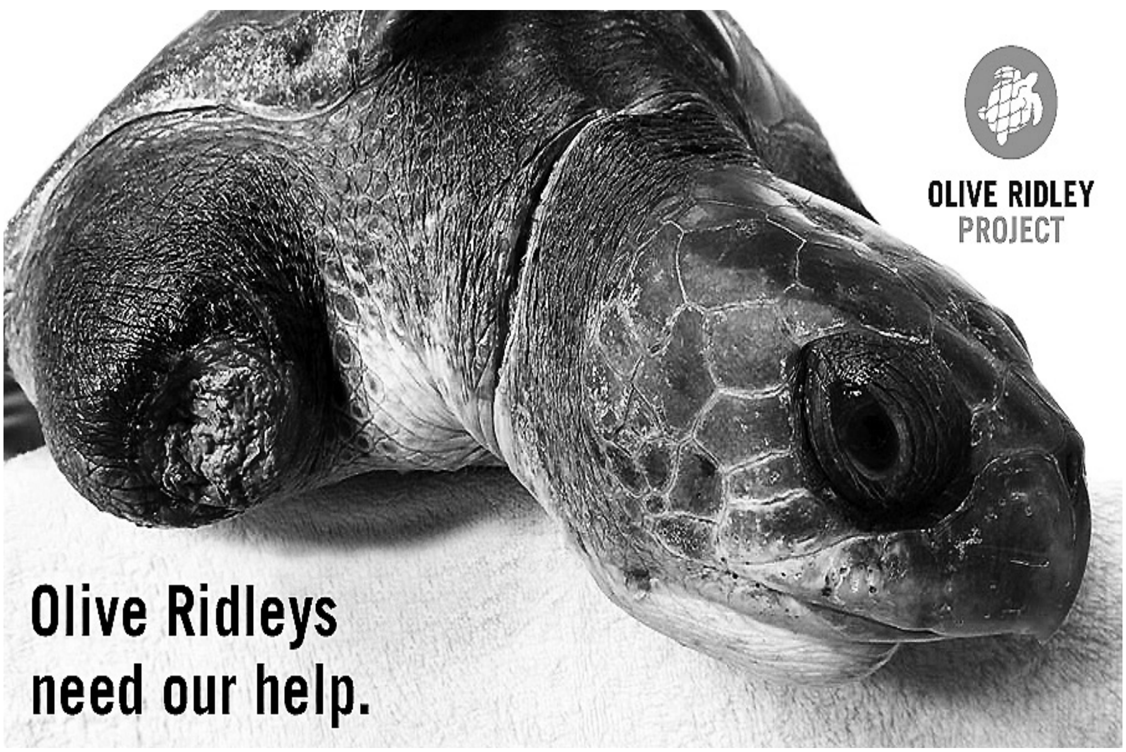

Figure 3. Injuries sustained by an olive turtle after rescue from a ghost net. Double amputation of front flippers and deep lacerations around neck occurred during entanglement.
Photo credit: Olive Ridley Project

problems fishermen face on a daily basis. We consolidate information from individuals working with fishing communities in the Indian Ocean. We are working towards effective alternatives that communities could adopt to improve their catch rates, reduce bycatch, and prevent their fishing nets from ending up in the ocean. We are also expanding our network in the Indian Ocean to create a platform for others to share ideas and target this problem.

How can we become involved?

Awareness is a large part of what we do and by reaching out to a large audience we are able to raise our profile, and connect with similar people/organisations working out in the field. Awareness can be increased through blogs, social media posts or website features specifically focusing on how people can get involved and contribute to the Olive Ridley Project. We also try to attend symposiums and workshops to spread our message; please email us if you are interested in contributing. We welcome anybody with an interest.

Scientific data can help us understand the true threat ghost nets pose in the Indian Ocean; currently data on ghost nets in this region is insufficient and, in response, we have created a database collecting information on any ghost net found either on beaches or at sea. We take basic parameters such as webbing size, twine dimensions, twist direction, material and knot construction. A detailed explanation of this method of data collection can be found on our website or Facebook group. We are happy to collect information from anybody that may come across ghost nets whilst walking beaches or out diving in the Indian Ocean. This information adds to our database to understand how many nets are out there, and where they may be coming from.

We also welcome contributions from NGOs, organisations or individuals working closely with artisanal and commercial fisheries. Information on incidental catches, target species and number of lost nets play an important part in understanding ghost nets in the Indian Ocean. The amount of money that is wasted by communities to replace broken nets can also contribute towards effective alternatives and sustainable fishing practices.

If you would like to get involved or have any further questions please email oliveridleyproject@yahoo.com.

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HOW MANY HATCHERIES?

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Thanks to the IOTN readers in India who have contributed information to help us determine the contribution of hatcheries in the Indian Ocean and south-east Asia to sea turtle conservation. A larger dataset would be more valuable, and those involved with hatchery management can obtain a copy of the survey from Dr. Andrea Phillott at andrea.phillott@auw.edu.bd. A summary of results will be published in a later issue of IOTN. ■

A SUMMARY OF THE LOGGERHEAD TURTLE IN THE IOSEA REGION

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A summary based on: Hamann M., Kamrowski, R.L., and Bodine, T. (2013) Assessment of the conservation status of the loggerhead turtle in the Indian Ocean and South-east Asia. IOSEA Marine Turtle MoU Secretariat, Bangkok http://www.ioseaturtles.org/UserFiles/File/Loggerhead_Assessment_LQ-FINAL-Sept2013.pdf

Following assessment of the leatherback turtle in the IOSEA region in 2006 and its update in 2012, we conducted a review of the loggerhead turtle in the Indian Ocean and South-east Asia region. Similar to other species of marine turtles, loggerhead turtles have regional, genetically distinct populations. There are six distinct populations/management units (MU) of loggerhead turtles within the IOSEA region: South-west Indian Ocean, North-west Indian Ocean, North-east Indian Ocean, South-east Indian Ocean, North Pacific Ocean and South Pacific Ocean.

The status of each population was previously assessed by the United States National Marine Fisheries Service (US NMFS) and as part of the Burning Issues initiative of the Marine Turtle Specialist Group (Wallace *et al*., 2011). While there were some small differences in the results of both assessments, the key differences were (1) Wallace *et al*. (2010; 2011) considered Sri Lankan loggerheads to be a distinct MU and classed it as one of the 11 most endangered MUs in the world; and, (2) the North-west Indian Ocean population was classed as 'Endangered' by US NMFS and low risk-low threats by Wallace *et al.* (2011). The different opinions expressed in the two assessments raise important questions about the population's status and condition. A key finding of the assessment is that there is a well-recognised need for both data analysis and continued research and monitoring on this population to improve assessment accuracy.

Our assessment found that loggerhead turtles nest in 10 nations within the Indian and Pacific Ocean basins. Seven of these nations are Signatory States of the Indian Ocean and South-East Asia Marine Turtle Memorandum of Understanding (IOSEA); one nation, Japan, is within the range of the IOSEA but is not a signatory; and, two nations, New Caledonia and Vanuatu, are outside of the IOSEA region. The assessment also noted that there are anecdotal records of loggerhead turtles nesting in Vanuatu but these require verification. Although there are also anecdotal records of loggerhead nesting from Myanmar and Bangladesh, these are now believed to have been mis-identified olive ridley sightings.

It is clear from the assessment that loggerhead turtles reside in or migrate through the waters of many IOSEA nations. Following a review of various data sources and publications we found data from tag recoveries, satellite telemetry (end points), and fisheries bycatch which combined indicate that loggerhead turtles forage within the Exclusive Economic Zones of 23 of the IOSEA Signatory States (and their Territories). In addition, loggerhead turtles have been recorded in six non-signatory range states and four non-range states. Importantly, we found that specific threats to loggerhead turtles were identified in publications and reports for 10 IOSEA Signatory States.

Overall, the assessment identified seven key knowledge gaps for the species in the IOSEA region and presented general snapshots of projects, expected outcomes and target States or agencies that could be involved in research and monitoring projects to address the gaps.

The key gaps were:

1. Species specific by-catch from coastal and oceanic fisheries.
2. An understanding of hatchling and post-hatchling dispersal.
3. Vulnerability to climate change.
4. Lack of quantifiable data on the abundance and demography of loggerhead turtles in coastal and oceanic habitats.
5. Lack of data on population identification for

loggerhead turtles in Sri Lanka.
6. Vulnerability to marine debris.
7. Unclear status and trend of the loggerhead turtle population in the north-west Indian Ocean.

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A SUMMARY OF THE LEATHERBACK TURTLE RED LIST ASSESSMENTS IN THE INDIAN OCEAN

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A summary based on:
Tiwari, M., Wallace, B.P. & Girondot, M. 2013. *Dermochelys coriacea* (Northeast Indian Ocean subpopulation). In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org.

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Wallace, B.P., Tiwari, M. & Girondot, M. 2013. *Dermochelys coriacea* (Southwest Indian Ocean subpopulation). In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org.

The appropriateness of global listings on the IUCN Red List of Threatened Species has long been debated by sea turtle biologists and conservationists (Groombridge & Luxmoore, 1989; Mrosovsky, 2003; Godfrey and Godley, 2008), with concerns that variations in population size and dynamics, geographic range, and subpopulation conservation status (including risk of extinction) were not adequately assessed. To address these concerns, the most recent Red List assessment for the leatherback turtle now includes both global and sub-population listings.

The global Red List status of leatherback turtles is 'Vulnerable', with fisheries by-catch posing the greatest threat. Other threats include human consumption of eggs and meat, and coastal development; there are insufficient data to gauge the threats posed by pollution and pathogens, and climate change to all subpopulations. The Southwest Indian Ocean, Southwest Atlantic, East Pacific and West Pacific subpopulations are listed as 'Critically Endangered', Northwest Atlantic populations as 'Least Concern', and Northeast Indian Ocean and Southeast Atlantic subpopulations as 'Data Deficient' (Wallace *et al.*, 2013a).

Nearly 99% of the global leatherback population is expected to comprise turtles from the large, and increasing, Northwest Atlantic subpopulation by 2040. It is, therefore, essential that population growth of this subpopulation be sustained. However, conservation efforts to protect leatherback turtles and habitats in the Indian Ocean and other regions are equally as important in light of the significant threats to all subpopulations and the historical collapse of large Pacific subpopulations (Wallace *et al.*, 2013a).

The Southwest Indian Ocean subpopulation of leatherback turtles in KwaZulu Natal, South Africa and Mozambique is small and geographically constrained. The size estimate is 148 adult turtles, with indications of a small but continuing decline (Wallace *et al.*, 2013b). Major threats to the population include fisheries by-catch

(Wallace *et al.*, 2011; Nel, 2012), although this must be quantified, and harvest of eggs and meat in Mozambique (Nel, 2012). For further information on this leatherback subpopulation, see also Lombard and Kyle (2010), Nel (2010; 2012) and Nel *et al.* (2013).

The Northeast Indian Ocean subpopulation of the Andaman and Nicobar Islands, India, and Sri Lanka is listed as Data Deficient (Tiwari *et al.*, 2013). A long term monitoring programme on Great Nicobar Island was terminated after the December 2004 tsunami (Andrews *et al.*, 2006), and has been resumed on Little Andaman Island only since 2007 (Swaminathan *et al.*, 2013). Consistent survey effort over more nesting seasons is required to determine population size and dynamics, and further surveys to measure geographic range. Similarly, insufficient information is available to identify and quantify major threats, although depredation of eggs is believed to be high. Published studies on these turtles include Andrews *et al.* (2006), Hamann *et al.* (2006), Namboothri *et al.* (2012), Swaminathan *et al.* (2011), Swaminathan *et al.* (2013) and Nel (2012).

In summary, the key knowledge gaps for leatherback turtles in the Indian Ocean include:
1. Quantified mortality rates of fisheries by-catch.
2. Continuous, long-term datasets with consistent monitoring for the Northeast Indian Ocean subpopulation.
3. Knowledge of geographic boundaries of the Northeast Indian Ocean subpopulation.
4. Estimates of leatherback egg and meat harvest and depredation.

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PHOTO OF INTEREST

Unknown Turtle Tag

A hawksbill turtle with an unreadable carapace tag was photographed at Valla Lhohi, Dhaalu Atoll in the Maldives. Observers would like to know who is using this type of tag and, if possible the origin of the turtle. Please email Agnese Mancini of IUCN Maldives Marine Projects (agnese.mancini01@gmail.com) if you have any information.

Photo credit: Judith Hannak

RESOURCES OF INTEREST: USB GPS RECEIVER AND DATA LOGGER DONGLE

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There was a recent question on the CTURTLE listerserv about recording movements of offshore fishers during bycatch studies. I have previously used the GR-312 USB GPS Receiver and Data Logger Dongle with the BB-100 Battery Bank from NaviSys at http://www.navisys.com.tw (Figure 1). Weighing <50g, the dongle and battery bank are not waterproof but can be protected within a capped PVC tube or other plastic sealed container and attached to the deck of fishing vessels. Provided they are in direct line of sight to the sky, the system will receive and log GPS signals at pre-programmed time intervals. Vessel speeds can be determined by the distance travelled between intervals' signals and used to determine fishing activity levels. The NaviSys GR-312 (with BB-100 as standard) costs ~US$30, operates within normal temperatures experienced on a fishing vessel, and provides up to 24 hours of continuous working time to record latitude, longitude, velocity, date, and time. Longer recoding times can be achieved with an external battery pack like those used to recharge mobile phones and other electronic devices. Data upload can be wired (USB) or wireless (Bluetooth). Two free PC/Windows management tools are provided: NaviLogManager allows the user to set a unique logging ID, logging interval, download data, and clear the memory, while NaviFilter retrieves data and generates reports for the preferred trip interval. Data can be integrated with Google Earth to generate tracking images.■

Figure 1. GR-312 GPS Tracker (left) and BB-100 Battery Bank (right) from NaviSys

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References in text: References should appear first in chronological then alphabetical order.

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More than 2 authors: first author *et al.* (*et al.* in italics) e.g., *Roy et al.*, 2004

Two publications of the same year for the same author(s), the reference in the text should be Sharma 1960a, b not 1960a, 1960b and the two publications should be dated accordingly in the references.

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List personal communication references in text only. e.g. (Hariya pers. comm., 2011)

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Use complete page ranges. e.g., 371–379 (not 371–9); 227–235 (not 227–35).

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