Conservation Research Needs of Easter Island (*Rapa Nui*) Marine Turtles

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rather steady throughout the year (Santa Clara Valley Water District, *pers. comm.,* April 2011).

Our observations indicate that basking periods interrupted by human disturbance are significantly shorter than undisturbed basking periods. Disturbances of this nature reduce time for thermoregulation and loss of heat energy, which could have profound effects on a turtle's ability to survive and reproduce (Crawford et al. 1983; Edwards and Blouin-Demers 2007). There are some benefits that could be gleaned from habitat alteration, as Lambert et al. (2013) concluded that basking sites shielded from human activity may lead to higher-quality basking potential, especially for native freshwater turtles. Thus, we recommend 1) limiting vehicular traffic near important *A. marmorata* basking habitat whenever possible, 2) encouraging drivers of required service vehicles to avoid driving near basking habitat during peak basking times, and 3) investigating installation of high vegetation and other ways to conceal turtles from trail use, especially by vehicles.

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Conservation Research Needs of Easter Island (*Rapa Nui*) Marine Turtles

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ABSTRACT. – Easter Island has experienced a marked increase in tourism during the past few decades; this has intensified the use of natural resources, which has in turn posed new threats to marine wildlife. To gather

information on marine turtle species inhabiting Easter Island and research needs for their conservation, we conducted interviews with local communities and combined them with coastal and underwater surveys. Interviews indicated the presence of five marine turtle species and highlighted an important historical connection with the *Rapa Nui* culture; we identified several potential threats associated with growing tourism that should be taken as a research priority and integrated with environmental education programs in order to ensure the long-term conservation of marine turtles on this remote island in the Southeast Pacific.

Easter Island, or *Rapa Nui,* is a Polynesian island and Chilean territory, recognized as a center of biodiversity and endemism in the Eastern Indo-Pacific (Roberts et al. 2002) and declared a World Heritage Site by the United Nations Educational, Scientific and Cultural Organization in 1995. Its culture, isolated location, and natural and archaeological heritage attract $>$ 40,000 visitors/yr and tourism is now the most important economic activity in terms of income and employment (Quijada 2007; INE 2013). The island contains a permanent population of approximately 5800 people, of which 2800 are *Rapa Nui* indigenous people (Moreno and Zurob 2013). Unfortunately, over the past few decades this growth in tourism has also intensified demand for natural marine resources and led to an increase in recreational aquatic activities on the island (Figueroa and Rotarou 2013; Zylich et al. 2014). This has resulted in a parallel increase in threats to marine wildlife such as pollution and overfishing (Bonert et al. 2005; Figueroa and Rotarou 2013; Castilla et al. 2014; Zylich et al. 2014).

To date, there have only been a handful of studies conducted on the marine wildlife of Easter Island, and these have focused mainly on algae, fishes, and invertebrates (Fernández et al. 2014; Flores et al. 2014; Hucke-Gaete et al. 2014). Marine vertebrate studies are scarce (Flores et al. 2014; Hucke-Gaete et al. 2014), and marine turtles, despite their endangered status, are poorly represented in the literature, with most available data being anecdotal. In 1971, Harrisson noted the occurrence of at least 3 marine turtle species on the island; however, he did not specify which species were present. Later, the presence of *Chelonia mydas* was reported by Cárdenas and Stutzin (1985), then by Zárate (2012), and also appeared in the Inter-American Convention for the Protection and Conservation of Sea Turtles report of 2013 (Ponce et al. 2013). In 2012 Zárate also noted the presence of *Dermochelys coriacea* around the island. Furthermore, anecdotal reports (personal communications, photographs, videos) have recently confirmed the year-round residence of marine turtles on the waters around *Rapa Nui*; however, it should be noted that no reproductive activity has been reported.

Across the Pacific Ocean, marine turtles have had a long history of use by human population and are flagship species of great cultural and spiritual significance for many coastal communities (Maison et al. 2010; Woodrom 2010). Archaeological and ethnographic studies show the sociocultural context in which these animals were used (i.e., ornamental purposes, to make objects like jewelry, tourist trinkets, instruments, and wall hangings, etc.) and consumed in different Pacific islands, including those comprising Polynesia (Allen 2007; Woodrom 2010). At present, however, data on the historical relationship between marine turtles and *Rapa Nui* people are almost nonexistent.

The present study aims 1) to identify the extant marine turtle species and their main feeding grounds around Easter Island, 2) to identify the main threats to the former in order to define future research needs, and 3) to explore the historical and current connection between marine turtles and *Rapa Nui* culture. This study will be the first to systematically contribute to our knowledge of the Easter Island marine turtles and defining potential threats to their populations, which will form a basis for further research and management decisions on these threatened species in this island.

Methods. — Data were gathered in July 2011 through local community interviews and coastal and underwater surveys. The interviews, all of which took place in Hanga Roa and Hanga Piko bays (27°9′S 109°26′W), were conducted among *Rapa Nui*'s indigenous inhabitants and people who had lived on the island for $>$ 10 yrs. These bays are located in the southwest portion of the island and are the most populated areas on Easter Island (Fig. 1). We explored the local people's knowledge, perceptions, and attitudes about marine turtles through a questionnaire with open-ended and closed-ended questions. The questionnaire was conducted in both bays with a previous oral consent, guaranteeing voluntary participation and confidentiality about personal information. Respondents were directly approached, and all of them agreed to be part of the study. The questionnaires lasted approximately 20–30 min. Reference photographs and maps were provided to respondents to help them with species recognition and in identification of common turtle-sighting spots. The analysis developed from the questionnaire was descriptive, and the data gathered corresponded to categorical variables. The results obtained were presented in frequencies of answers according different categories. To directly assess species and feeding grounds, we performed coastal observations from fixed points in 7 locations: Tahai, Hanga Roa, Hanga Piko, Vaihu, La Perouse, Ovahe, and Anakena (Fig. 1). These locations were selected from the places reported by respondents that were accessible by land. During coastal observations, surfacing frequency of turtles was recorded, and species identification was done when possible. The number of different individuals was estimated according to differences in head size, colora-

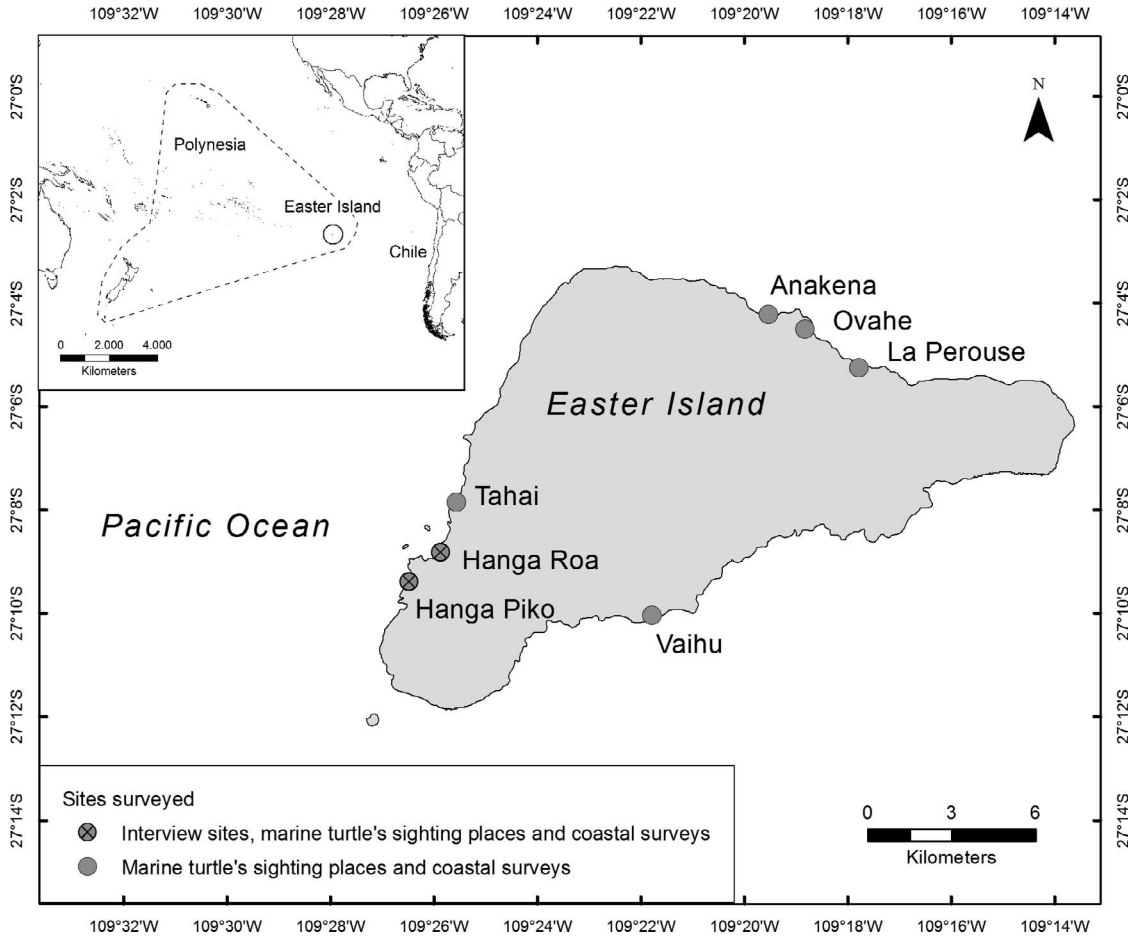

Figure 1. Map of Easter Island (*Rapa Nui*) showing its location on the Pacific Ocean. The figure shows interview sites, turtle-sighting spots reported by respondents, and locations where coastal surveys were performed.

tion, and co-occurrence (i.e., individuals without physical differences that were surfacing at the same time). This number represents the minimum number of individuals that we were sure to be present. We completed 9 hrs of observations in each location, divided into 3 blocks of 3 hrs each (0800–1100, 1100–1400, and 1400–1700 hrs). For each block the surfacing frequency and the number of different individuals were recorded. Complementary underwater surveys, performed using scuba equipment, were conducted for 2 hrs/location in Hanga Roa, Hanga Piko, Anakena, and La Perouse (Fig. 1). During these prospections, all encounters with marine turtle species were recorded on an underwater slate. Potential threats were assessed through interviews, and from observations made during coastal walks and underwater prospections in the locations mentioned above.

Results. — Twenty-seven people between 18 and 60 yrs old—19 men and 8 women—participated in this study. Of these, 14 were fishermen, 5 were divers, 2 were surfers, and 6 were merchants. Twenty-five respondents reported interaction with marine turtles around the island (while turtles were swimming, feeding, trapped in fishing nets, basking, etc.). Respondents identified 5 distinct marine turtle species. Four of these species have been previously reported for continental Chile (*Caretta caretta, C. mydas, D. coriacea,* and *Lepidochelys olivacea*; Ponce et al. 2013). Three (*C. mydas, D. coriacea,* and *Eretmochelys imbricata*) have been reported for Easter Island (Cárdenas and Stutzin 1985; Zárate 2012; Ponce et al. 2013). The presence of *E. imbricata* was confirmed for Easter Island in 2014 by Álvarez-Varas et al. (in press).

The species most frequently recognized by respondents was *C. mydas* (green turtle; $n = 23$), which was generally spotted in Hanga Roa and Hanga Piko bays (8 respondents had seen turtles only in Hanga Roa, 5 only in Hanga Piko, and 10 in both bays). Some respondents ($n = 6$) recognized 2 distinctive types of green turtle through photographs. *Dermochelys coriacea* (leatherback turtle) was the second-most-recognized species ($n = 8$), though it was only by fishermen and offshore sailors. The other 3 species (*C. caretta, E. imbricata,* and *L. olivacea*) had only been sighted occasionally near the coast ($n = 5$, $n = 3$, and $n = 4$ respectively; Fig. 2). When asked about feeding, respondents mentioned that turtles had been observed feeding on algae ($n = 20$), fishing left-

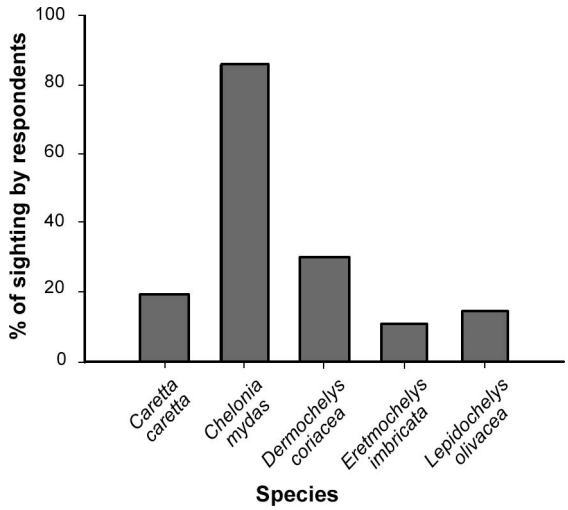

Figure 2. Number of respondents that reported marine turtle species on Easter Island (*Rapa Nui*).

overs ($n = 9$), and bread ($n = 2$) that fishermen and tourists had thrown to them. According to respondents, marine turtles of different sizes are present throughout the year, with the highest perceived abundance being during the summer (December to March). Observers did not report reproductive activity of these species on the island. Locations that were identified by respondents as turtle-sighting locations are shown in Fig. 1.

Fishermen ($n = 14$) stated that they seldom interacted with turtles ($n = 6$) and that they generally released "bycaught" individuals when they became trapped in fishing nets. Occasionally, when dead turtles were found, they reported collecting the shell for ornamental purposes or to sell to tourists. In addition, some fishermen ($n = 3$) noted that restaurants on the island sometimes asked for turtle meat, for which they offered large sums of money. Regarding direct take, two respondents stated that they had hunted turtles (i.e., *C. mydas* and *D. coriacea*) with harpoons approximately 20 yrs ago. Some local people ($n = 7$) reported having consumed turtle meat in the past, and noted that it used to be common practice 3–4 decades ago. Nevertheless, most respondents ($n = 22$) assured us that direct take and consumption are widely rejected currently. Boat collisions were identified as a key threat to marine turtles by respondents ($n = 12$). In general (i.e., regarding of age, gender, and occupation), people ($n = 22$) mentioned the ancestral presence of marine turtles, referring to myths, legends, and petroglyphs across the island. Also respondents mentioned that turtles bring good luck when they are seen in the ocean, and that they are considered fertility symbols (through myths), as well as guides for sailors because of the fact that "they always come ashore". Furthermore, turtles were also described as harmless, charismatic, and beneficial for tourism. The following comments from respondents depict this positive view on turtles: "On the island turtles are one of the things that are mostly protected," "Fishermen don't allow anybody to disturb the turtles; they feed them and touch them when they approach," "Here, we take great care of the turtles because they attract tourists," and "Fishermen consider turtles as a touristic attraction of the island."

Underwater and coastal surveys allowed us to confirm the presence of *C. mydas* in Hanga Roa and Hanga Piko (Fig. 1). No turtles were recorded in other locations. In the coastal surveys, Hanga Roa presented a higher number of individuals and surfacing frequency than Hanga Piko in all 3-hr observation blocks. The highest surfacing frequency for Hanga Roa was recorded between 1100 and 1400 hrs, reaching 44 surfacing events. Also 8 different turtles were recorded in this bay. In Hanga Piko, the highest surfacing frequency was 31, recorded between 1100 and 1400 hrs as well. In this location, 4 different individuals were recorded. During underwater surveys in both Hanga Roa and Hanga Piko, we observed individuals feeding

Figure 3. Carapace color variation in individuals of *Chelonia mydas* present on Easter Island. Photos by Rocío Álvarez Varas. (Color version is available online.)

Figure 4. Turtle shell with propeller marks in Hanga Piko bay, Easter Island. Photo by Servicio Nacional de Pesca de Chile-SERNAPESCA.

on seaweeds (green and red algae) and on fishing leftovers from fishermen. Additionally, juveniles and adults of *C. mydas* were identified, and carapace color variation (yellowish brown and dark black) was observed among individuals (Fig. 3). The potential threats identified by the underwater and coastal surveys included the abundant presence of industrial fishing residuals (mainly plastics), intensive aquatic recreational activities (diving and snorkeling), overfishing, and turtles feeding alongside fishermen, divers, and tourists. Furthermore, during this study, a turtle wounded by a boat collision was observed in Hanga Piko bay. Multiple fractures were present on its shell, including exposure of lung tissue (Fig. 4). Previously this turtle came ashore daily to bask and suddenly it appeared with propeller marks on its shell, suggesting that the collision took place near the island coast. Weeks later we were informed that the turtle died.

Discussion. — Developmental and foraging habitats offer year-round support to juvenile and interreproductive adult individuals, which have different breeding origins (Luke et al. 2004; Dutton et al. 2008). Thus, these habitats represent critical areas for marine turtle conservation, and their identification is fundamental to the success of any conservation or management program (Diez and Ottenwalder 1999). During the interviews respondents indicated the presence of 5 turtle species in Easter Island, which differed from our on-site surveys, where only *C. mydas* was observed. People also indicated several turtle-sighting locations around the island where turtles of different sizes are observed throughout the year. Through coastal and underwater surveys, we identified green turtles of varied size (juvenile and adults) and coloration in Hanga Roa and Hanga Piko. Furthermore, turtles were observed feeding on algae in both bays. Hanga Roa presented a higher surfacing frequency and number of individuals than Hanga Piko during coastal observations, suggesting that the former is more suitable habitat for the species. However studies on habitat quality and food availability are needed to elucidate these differences. All these preliminary observations suggest that Easter Island may play an important role as a foraging habitat or stopover for marine turtles because of its isolated location in the middle of the Pacific Ocean. Nevertheless, studies on the genetic origin, migration patterns, and residence times of marine turtles are critical to clarify these hypotheses. Similarly, further research involving greater observation efforts and a larger number of observation sites is needed to confirm the presence of other turtle species on Easter Island.

Studies suggest that individuals of *C. mydas* encountered in Southeast Pacific foraging areas come from distant reproductive stocks (Amorocho et al. 2012; Heidemeyer et al. 2014). Amorocho et al. (2012) analyzed the genetic and morphological variation among *C. mydas* from the Colombian Pacific. Their results showed that turtles with a greenish black carapace were associated with the common East Pacific haplotypes. In contrast, turtles with carapace colorations varying from green to

dark yellow were associated with haplotypes falling within phylogenetic clades from Central and Western Pacific rookeries. Similarly, Zárate (2012), among other researchers (Slevin 1931; Carr 1967; Pritchard 1971; Green 1993), reported an interesting dichotomy among *C. mydas* individuals in Galápagos feeding grounds, with the presence of both a dark morph and a lighter morph known as the "yellow turtle". Although no genetic studies have yet been published, Zárate (2012) indicated that the yellow morph appears to have originated from rookeries in the Indo-Pacific Region. Several authors have noted the morphological differences between yellow and black turtles, indicating that in adult black turtles the carapace and plastron are much darker, and the carapace is domed with indented edges above the hind limbs (Carr 1961; Balazs 1979; Chassin-Noria et al. 2004; Zárate 2012). Even, some authors have described the black morph as a subspecies of *C. mydas* (*C. m. agassizii*; Kamezaki and Matsui 1995). Sympatry of both morphs in feeding grounds has also been reported in New Zealand, Hawaii, Papua New Guinea, and Costa Rica (Balazs 1979; Pritchard 1999; Heidemeyer et al. 2014; D.A. Godoy, unpubl. data, 2015). In this study, although we could not differentiate between yellow and black morphs through direct observation (i.e., plastron coloration and indented edges in the darker turtles were not observable; Fig. 3), our findings suggest that the variation in carapace color is consistent with the variation described in other studies, and further research is therefore needed to characterize the extant morphotypes and genetic origin of the Easter Island turtles.

The range of *E. imbricata* (the hawksbill turtle—Critically Endangered according to the International Union for Conservation of Nature) in the Pacific Ocean stretches from the coast of North America to Peru (Quiñones et al. 2011) and includes several islands of the Indo-Pacific and Polynesia (Woodrom 2010). Until recently there had been no official reports of this species for Easter Island. However, in October 2014, Álvarez-Varas et al. (in press) confirmed the presence of *E. imbricata* around the island for the first time with photographs. These data changed our knowledge about its distribution range in Polynesia and also increased the number of marine turtle species encountered in Chile. This finding is concordant with our field interviews, in which local people mentioned the occasional sightings of hawksbill turtles ($n = 3$). It also highlights the need to conduct further research on this threatened species and its habitat in *Rapa Nui*.

Marine turtle consumption has traditionally been a common practice among the coastal communities of Polynesia, being an important part of their cultural identity (Leach et al. 1984; Allen 2007). Traditionally, these species have played a fundamental role in religious ceremonies and in mediating the relationships between communities through the exchange of meat and other turtle subproducts (Allen 2007). According to *Rapa Nui* literature and legends, turtle consumption was common in the past, although the practice was restricted to kings and priests (Woodrom 2010). As described by some respondents in this study, apparently these species represented a regular item in the *Rapa Nui* diet until 3 or 4 decades ago. However, as indicated by our results, currently Easter Island's marine turtles are perceived locally as charismatic species and beneficial for tourism, and their capture and consumption seem to be widely rejected by the local community. This apparent decrease in turtle consumption over the past few decades may be due in part to the national legal protection granted to marine turtles by the Chilean government for all species through a 30-yr moratorium established in 1995 (Iriarte 1999). This reduction in turtle consumption may also stem from the acculturation process of the *Rapa Nui* people, which has intensified in recent years through tourism (e.g., diversification of available foodstuffs). Nevertheless, this trend and the local community perception about turtle consumption have only been discerned from preliminary data, and further quantitative studies will be needed to shed light on them.

The marked growth in tourism on the island (i.e., 19.9% between 2011 and 2012; INE 2013) has increased potential threats toward marine wildlife. During our study we detected various incidents that posed a direct threat to marine turtle populations on Easter Island. Boat collisions, incidental capture, direct take for consumption in restaurants, and recreational aquatic activities were identified as potential threats during interviews and direct observation. In addition, we observed marked marine pollution, dominated by plastics and fishing residuals, which could lead to habitat degradation of the turtles' feeding grounds. Several studies have identified these factors as major threats for marine turtle populations around the world (Mast et al. 2005; Lewison and Crowder 2007; Hamman et al. 2010). Derkinger et al. (2013) studied the impact of boat strikes on a green turtle population in Galápagos Marine Reserve, where an exponential growth in tourism, maritime traffic, and urban development had taken place in the past decade. Although data on survival rates from boat strikes were not given, the authors stated that many turtles die from the trauma caused by the impact. This study shows that the overall threat from boat strikes has an important effect on the Galápagos green turtle population, suggesting that boating speed limits should be instituted in key turtle habitats for conservation purposes. Consumption and poaching of marine turtles in the Pacific Ocean have also been reported by several authors (Aguirre et al. 2006; Koch et al. 2006; Mancini and Koch 2009). An example is the study by Koch et al. (2006), who examined 1945 turtle carcasses found along beaches and in seaside towns in Baja California Sur, Mexico. They observed that slaughter for human consumption was the primary cause of death for the turtles found in the towns, while bycatch was the main

cause on beaches. Likewise, Aguirre et al. (2006) mentioned several cases of marine turtle meat and subproduct consumption around the world. Similar to the threats mentioned above, incidental capture of marine turtles has been widely reported in the literature during the past decades, particularly in the Eastern Pacific Ocean (Alfaro-Shigueto et al. 2007, 2011; Lewison and Crowder 2007). Alfaro-Shigueto et al. (2007) studied the interactions between leatherback turtles (*D. coriacea*) and Peruvian artisanal fisheries from 2000 to 2003. During this period, 133 leatherbacks were caught; 76% of them were captured in artisanal gill nets and the rest in longlines. Other species from bycatch included green (*C. mydas*) and loggerhead (*C. caretta*) turtles. Of the total leatherbacks captured, 41.4% were released alive and 58.6% were retained for human consumption. Later, the same author (Alfaro-Shigueto et al. 2011) studied small-scale fisheries in Peru from 2000 to 2007 and reported the capture of 807 turtles of 4 species: *C. caretta* (51.2% of total captures), *C. mydas* (41.4%), *L. olivacea* (3.2%), and *D. coriacea* (2.1%). This study reported that Peruvian small-scale fisheries have the potential to severely impact sea turtles in the Pacific, especially loggerheads, green, and leatherback turtles. Likewise in international waters off the Chilean exclusive economic zone, Donoso and Dutton (2010) studied sea turtle bycatch associated with the pelagic longline fishery targeting swordfish (*Xiphias gladius*). Leatherbacks ($n = 284$) and loggerheads ($n = 59$) were the most common species captured; however, leatherbacks were caught in $< 4\%$ of the longline sets and loggerheads in $< 1\%$ of sets. According to the authors, despite the low catch rate of leatherbacks, the potential impact of this fishery on the severely depleted nesting populations in the Eastern Pacific could be significant when combined with other fisheries and threats in the region. In Easter Island's particular case, our results indicate there is low interaction between artisanal fishermen and turtles currently. However, the recent increase in numbers of the artisan fleet (from 21 boats in 1995 to 123 in 2011; Castilla et al. 2014) and the growth in tourism constitute alarming threats for turtle populations around Easter Island, and this highlights the importance to conduct further quantitative studies.

Little is known about how recreational aquatic activities could affect marine turtle behavior in touristic localities. Meadows (2004) suggested that marine turtles may be negatively affected by snorkelers and highlighted the need for further research about the tourism direct impact on turtle behavior, especially in places with growing tourist activity. Activities such as diving, snorkeling, and recreational fishing also could affect Easter Island turtle populations indirectly through habitat degradation (Figueroa and Rotarou 2013). A similar situation (i.e., an indirect impact) may be occurring with marine pollution. Several studies have described a high frequency of occurrence of synthetic flotsam, mainly plastics, in the digestive tract of marine turtles in the Pacific Ocean. Boyle and Limpus (2008), for example, found plastic in 74% of stranded green turtles and in 57% of loggerhead turtles from the southwest Pacific. Similarly, Russell et al. (2011) examined the gastrointestinal tracts of 2471 green turtles from the Hawaiian Islands, finding miscellaneous nonfood debris items (e.g., plastic, paper, and string) in 76 individuals. To date no quantitative data have been published on the environmental impact of pollution on Easter Island; however, a recent study reported the existence of a garbage island in the Southern Pacific close to *Rapa Nui* (Eriksen et al. 2013). This finding emphasizes the urgent need for further investigation into the impact of pollution on marine wildlife in this isolated place, and particularly on threatened species such as marine turtles.

Although tourism is an important source of income for *Rapa Nui* people, its uncontrolled growth may be an important driver of negative impacts on marine turtle population on Easter Island. Thus, in order to make appropriate management and conservation decisions, further research must be conducted on marine turtles and their habitats. Studies on ecology (e.g., genetics, migration, residence times), habitat quality, and food availability will be need to elucidate the role of Easter Island as foraging site or stopover for marine turtles. Moreover, research involving longer observation periods and a greater number of observation sites will be required to confirm the presence of the other turtle species and morphotypes of *C. mydas*. Likewise, quantitative studies will be needed to shed light on perceptions and trends of turtle capture and consumption, bycatch rates, and direct impact of recreational activities and marine pollution on turtle populations. All these topics should be taken as research priority and integrated with environmental education programs in order to ensure the long-term conservation of marine turtles on this remote Pacific island.

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The Olive Ridley Turtle, *Lepidochelys olivacea*, in the Persian Gulf: A Review of the Observations, Including the First Nesting of the Species in the Area

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ABSTRACT. – In total, there are 11 confirmed records of the olive ridley turtle, *Lepidochelys olivacea*, from the Persian Gulf through June 2015, including 9 and 2 records from northern and southern coasts of the Gulf, respectively. Furthermore, on 16 May 2013, nesting was recorded from Nayband Marine-Coastal National Park, which is the first record of olive ridley nesting in the Gulf and is also the most northerly nesting account for the species in the Western Indian Ocean. Although few, these records suggest that the species lives and reproduces in the Persian Gulf.

Marine reptiles in Iranian coastal waters of the Persian Gulf and Gulf of Oman fall into 2 groups: sea snakes (Elapidae: Hydrophiinae), with 9 species (8 species in the genus *Hydrophis* and 1 other in the genus *Microcephalophis*; Leviton et al. 1992), and sea turtles, with 5 species. Hawksbill turtles, *Eretmochelys imbricata*, and green turtles, *Chelonia mydas*, are the most abundant species in the area (Gasperetti et al. 1993; Price et al. 1993). Leatherback turtles, *Dermochelys coriacea*, and loggerhead turtles, *Caretta caretta*, are very scarce, but have been reported from the Iranian coastal waters in both areas (Firouz 2005; Dakhteh 2014).

Olive ridley turtles, *Lepidochelys olivacea*, have been recorded from the Iranian coast of the Gulf of Oman (Kami 1997), but no records exist for the Iranian coast of the Persian Gulf. The species is known as the most abundant sea turtle in the world; nonetheless, it is