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Declining Trend in Green Turtle (*Chelonia mydas*) Nesting in the southeastern Pacific: Potential Causes and Recommendations for Action

In 2018, the Scientific Committee of the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC) presented the update of the technical document entitled IAC Index Nesting Beach Data Analysis -2009-2018- (CIT-CC15-2018-Tec.14). An extremely alarming trend at the index beach of Quinta Playa in the Galapagos Islands, Ecuador and a similar but less-dramatic declines in green turtle nesting in northwest Costa Rica was detected. As a response, the working group members from the United States, Peru, Chile and Ecuador developed this document suggesting potential causes of the decline and providing recommendations for the consideration of the Consultative Committee of Experts.

We ask the Consultative Committee of Experts to review the information in this document and provide recommendations on this matter to the IAC Conference of the Parties.

Declining Trend in Green Turtle (*Chelonia mydas*) Nesting in the southeastern Pacific: Potential Causes and Recommendations for Action

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TECHNICAL DOCUMENT CIT-CC15-2018-Doc.5

Inter-American Convention for the Protection and Conservation of Sea Turtles

Developed by IAC Delegates from Chile, Ecuador, Peru, and the United States

Executive Summary

In 2018, the Scientific Committee of the InterAmerican Convention for the Protection and Conservation of Sea Turtles (IAC) developed a technical document entitled IAC Index Nesting Beach Data Analysis (2009-2018). This is an update to an earlier nesting beach report that provided data from 2009-2013 (CIT-CC11-2014-Tec.7). We found an extremely alarming trend at the index beach of Quinta Playa in the Galapagos Islands, Ecuador (Fig. 3) and similar but less-dramatic declines in green turtle nesting in northwest Costa Rica (Fig. 4). It is unclear if the declines in the Galapagos and Costa Rica are related; however, the absence of significant threats on the nesting beaches—particularly in the Galapagos—suggests that some other factor besides killing of nesting females is at play. Here we summarize nesting trends at three regions in the eastern Pacific (Mexico, Costa Rica, Galapagos) and we elaborate on potential reasons for the observed declining trends in the southeastern Pacific. These potential reasons may include one or a combination of the following: 1) a change in monitoring effort; 2) spatial shifts in nesting distribution; 3) temporal shifts in nesting distribution; 4) changes in natural predation in foraging areas; 5) an increase in remigration interval, perhaps driven by changes in marine productivity; 6) a decrease in annual nest frequency per female; 7) impacts from red tides; 8) impacts from climate change; 9) fisheries impacts at foraging areas; and 10) plastic ingestion. Based on these considerations, fisheries bycatch and illegal consumption of green turtles in Peru and Ecuador were considered to be the likely primary causes for nesting declines in the Galapagos. However we cannot rule out delayed reproduction due to increase frequency of El Niño events, plastic ingestion, and impacts from red tides as factors in the observed declines. We recommend that the IAC closely monitor the ongoing situation in the Galapagos, mainland Ecuador, Peru and develop a strategy to slow or stop green turtle mortality in waters of the southeastern Pacific. We provide several recommendations to achieve this goal.

INTRODUCTION

The green turtle is globally distributed throughout the tropical, subtropical and temperate regions of the Atlantic, Pacific, and Indian Oceans and Mediterranean Sea (Seminoff *et al.* 2015). Green turtles in the eastern Pacific Region have been defined as a distinct genetic stock that is separate from green turtles in other areas of the Pacific; such stocks have been referred to as regional management units (RMUs; Wallace *et al.* 2010) and distinct population segments (DPSs; Seminoff *et al.* 2015). Green turtles in the eastern Pacific are listed as Threatened on the U.S. Endangered Species List and Endangered on the IUCN Red List.

Within the Eastern Pacific region, green turtles have been documented nesting in Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Mexico, Nicaragua, Panama, and Peru (Seminoff *et al.* 2015; Fig. 1). Green turtles from the East Pacific RMU have been documented in coastal waters of all countries within this geographical region, and have been uncommonly observed in the Central Pacific high seas (Parker *et al.* 2011) and coastal waters of several countries ranging from Japan to New Zealand in the Western Pacific (e.g., Godoy *et al.* 2012, Okamoto and Kamezaki 2014).

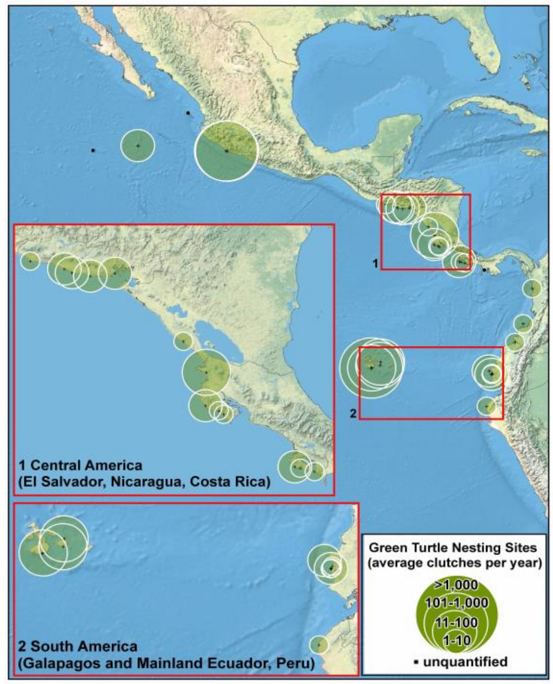

Figure 1. Nesting sites for green turtles in the Eastern Pacific (Seminoff and Wallace 2012).

There are eight countries in which nesting has been documented in the eastern Pacific (39 total sites; Seminoff *et al.* 2015). Long-term (≥10 years) time series nesting beach data are available only for Colola Beach, Michoacán, Mexico that has 38 consecutive years (1981–2018) of data as well as a historic estimate for 1970 (Fig. 2). In addition, there are several independent data sets for Galapagos Islands, Ecuador spanning 39 years; however, these data represent different beaches over different time frames (e.g. 1979–1982, 2001–2005, 2009–2017); Fig. 3). In addition to these two sites for which long-term data are available, nesting beach monitoring efforts along the Pacific coast of Costa Rica suggest that this region is also a stronghold for green turtle nesting in the eastern Pacific, especially in the northwestern state of Guanacaste, where over the last decade several green turtle nesting beaches have been monitored for the first time (Blanco et al. 2012b, Santidrián-Tomillo et al. 2015, Fonseca et al. 2018, P. Santidrián-Tomillo, unpubl. data).

GREEN TURTLE NESTING TRENDS IN THE EASTERN PACIFIC

Current data on nesting trends within the region indicate that there are both increasing and decreasing trends in annual nesting abundance, with increasing trends more apparent in northern portions of the eastern Pacific and decreasing trends in the southeastern Pacific. For example, whereas green turtles at Colola Beach, Mexico have shown a strong recovering trend (Fig. 2), their counterparts in the Galapagos Islands (Figs. 3, 4), and to a lesser extent, in Costa Rica (Fig. 5), have shown a steep decline in recent years). The potential reasons for these trends are discussed below.

Colola Beach, Mexico

In Mexico, the primary information on nesting abundance comes from Colola Beach in the state of Michoacán. Here, researchers and conservationists from NGOs and the University of San Nicholas Hidalgo have been protecting the beach since 1981. Prior to this, poaching of eggs and adults on and adjacent to the Colola was widespread; and even after the onset of nesting beach conservation at Colola, turtles and eggs were taken in large numbers in unprotected areas throughout Mexico. There was also a major legal green turtle fishery throughout northwestern Mexico that landed thousands of green turtles each year (Early-Capistrán et al. 2018). A presidential decree in 1990 (DOF 1990) created a moratorium that outlawed the use of sea turtles for any purpose; and since then there have been encouraging signs of recovery at nesting beaches and foraging areas throughout the country (Delgado-Trejo and Alvarado-Díaz 2012, J. Seminoff unpubl. data).

The steady increase in green turtle nesting in Michoacán is an encouraging sign for a population once considered threatened with extinction. Annual nesting beach data from Colola show that the population went from 229 females/year in the early-to-mid 1980s (1983–1986) to 7,618 females/year from 2014–2017, which amounts to a greater than 3,000% increase in the last three decades. The scale of this increase becomes very apparent considering a report from Dr. Carlos Delgado-Trejo, the leader of the University of Michoacán green turtle nesting beach program at Colola: On 14 September 2014, more than 1,000 green turtles nested in a single night (in litt. to Mr. Earl Possardt of the U.S. Fish & Wildlife Service). The observed increases in the eastern Pacific green turtle population are likely due to increased protection at nesting beaches, minimized threats to sea turtles in foraging areas, and advances in sea turtle fisheries bycatch reduction in the eastern Pacific Ocean (Senko et al. 2011, Seminoff et al 2015).

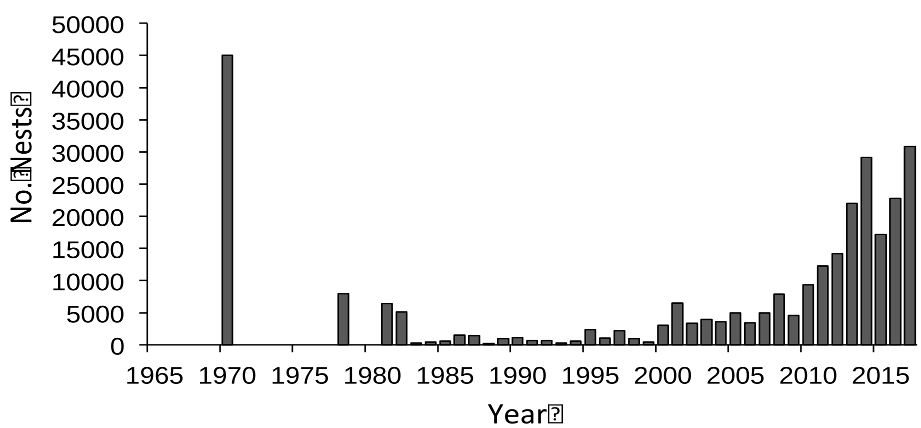

Figure 2. 47-year trend (1970–2018) of number of green turtle nests in Colola, Michoacán, Mexico. 1970 baseline estimated by Cliffton et al. (1982). All other data from Delgado-Trejo and Alvarado-Díaz (2012) and C. Delgado-Trejo (unpubl. data).

Galapagos Islands, Ecuador

In the Galapagos Islands (Ecuador) green turtle nesting at the four primary nesting sites has been monitored by various groups since the mid 1970s (Quinta Playa and Barahona beaches on Isabela Island, Las Bachas beach on Santa Cruz Island, and Las Salinas beach on Baltras Island). From 1979–1982, Hurtado (1984) reported a mean total annual nesting abundance for the four index beaches of ~1,400 females/year. From 2001–2005, a mean of 1,657 females/year nested among these index beaches (Zárate et al. 2006). More recent data are available for Quinta Playa only, and here we provide annual nest counts from 2001–2002 to 2007–08 nesting season (Zárate et al. in Prep) and the 2009–10 to 20017–18 nesting season. These most data were provided by Eduardo Espinoza, Leader of Galapagos's National Park Marine Ecosystem's monitoring team, and are also included in the IAC (2018) Index Beach report. From these data it is apparent that nesting—at least at Quinta Playa—was relatively consistent from the 2001–02 to the 2010–2011 nesting seasons; however, since 2012–13 there has been an apparent decline in the annual number of nesting females at Quinta Playa (Fig. 3). For example, data provided to IAC (2018) show that during the first three years of this dataset (starting in 2009-10) there were a mean of 2,379 tagged females each year (range = 3418–1381 females/year), whereas during the most recent three years of data the mean dropped to 289 females/year (range = 160–570 females/year). The Quinta Playa datasets indicate that Galapagos green turtle nesting is highly variable from year to year (much like other green turtle rookeries), yet the decrease in annual nesting since 2015 is alarming.

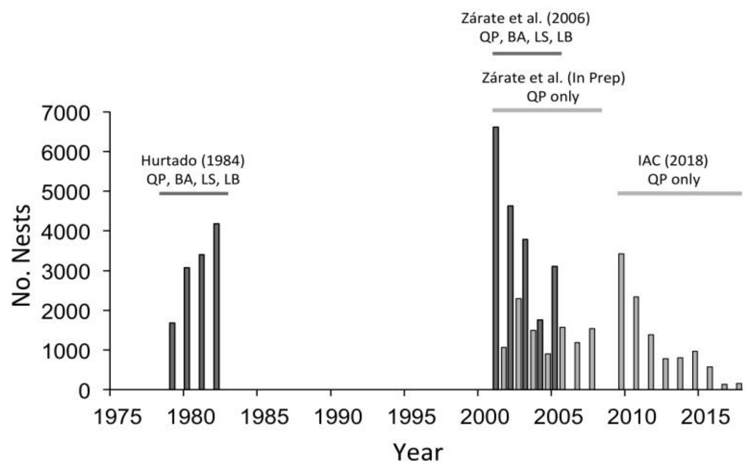

Figure 3. Annual number of green turtle nests at the Galapagos Islands. Data sets are for three different periods, with varying monitoring effort. QP – Quinta Playa, BA – Barahona, LS – Las Salinas, LB – Las Bachas.

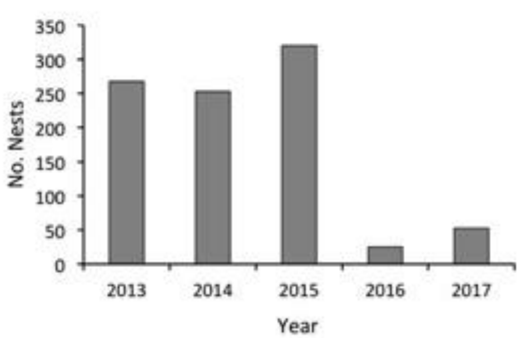

Figure 4. Annual number of green turtle nests during the 2013–14 to 2017–18 nesting seasons at Playa Las Bachas, Galapagos Islands, Ecuador.

When looking at Figure 3, it should be noted that the data represent information collected by three different research groups, and do not constitute one contiguous data set with equal monitoring effort across all years. For example, researchers from the Charles Darwin Research Station conducted monitoring from the 2000–01 nesting season to the 2012–13 nesting season (P. Zárate pers. comm). Since then, monitoring efforts have been under the leadership of the Galapagos National Park. The extent to which this change in leadership impacts the apparent declines is unclear; however, the recent data from Quinta Playa show a ~90% decrease in nesting during the last decade (based on IAC [2018] data). Regardless of the reasons, this decline is alarming and deserving of greater attention. Data are also available for Las Bachas beach (Fig. 4), but only go back to the 2013–14 nesting season (5 yrs. total), which is too short of a time period to draw strong conclusions. However, the fact that the decline at Las Bachas (Santa Cruz Island) mirrors that for Quinta Playa (Isabela Island)—particularly during the 2016–17 and 2017–18 nesting seasons—suggests that the declines were present throughout the Galapagos Archipelago. We explore possible causes for the declines later in this document (see below).

Costa Rica

Costa Rica has numerous green turtle nesting beaches, especially in the northwestern state of Guanacaste. Green turtle nesting activity has been documented since the late 1970s (Cornelius 1982), but in the last decade there has been increased focus on green turtles in the region (e.g. Blanco et al. 2012, Santidrián-Tomillo et al. 2015), and the discovery of at least one major green turtle nesting beach (at Isla San Jose, Fonseca et al. 2018).

Long-term data are not available for any green turtle beaches in Pacific Costa Rica; however, time-series data on number of females are available for three beaches in Guanacaste (Playa Nombre de Jesús since the 2010–11 season, Isla San Jose since the 2012–13 season, and Playa Cabuyal since the 2011–12 season; Fig. 5). The relatively few nests counted during the initial years of these data sets are likely due to lesser monitoring effort while the monitoring projects were getting started. Interestingly, declines in the number of females start during the 2015–16 nesting season at all three sites, and were apparently widespread in Costa Rica during this period (P. Santidrián-Tomillo, pers. comm.), suggesting that declines at any one beach were not likely a result of turtles switching beaches. Of course, this is too short of a time frame to draw conclusions, but in the context of the nesting collapse in the Galapagos Islands, the recent declining trend in Costa Rica draws attention. The potential causes for these declines are discussed below.

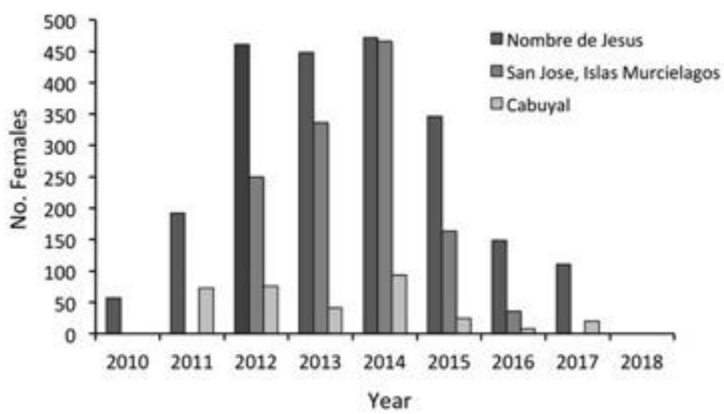

Figure 5. Annual number of green turtle nests at two sites in Pacific Costa Rica. Data from IAC Index Beach Report (2018), Santidrián-Tomillo, unpubl. data, Fonseca et al. (2018).

POTENTIAL CAUSES FOR DECLINE IN GALAPAGOS AND COSTA RICA

1. Change in monitoring effort ***[warrants further study]***

Less monitoring effort on nesting beaches could result in fewer nests being counted during such activities. We know that there were changes in leadership for the nesting beach monitoring in the Galapagos (shifting from the Charles Darwin Research Station to the Galapagos National Park after the 2012-13 nesting season; however, any resulting changes in monitoring effort are unclear. We, therefore, hope for further clarity about the monitoring dates during all monitoring seasons in the Galapagos.

2. Temporal shift in nesting ***[low probability]***

The result of a temporal shift in nesting could cause monitoring efforts to not occur at the correct time of the year. Temporal shifts in nesting attributed to climate change have been observed at other sea turtle nesting beaches (e.g. Azanza-Ricardo et al. 2017). Further, green turtles nesting at Colola Beach, in Michoacán, Mexico had a slightly delayed start to the 2018-19 nesting season (C. Delgado-Trejo, pers. comm.); however, there is no evidence to suggest that changes in timing and duration of nesting activity are widespread or were responsible for the observed declines.

3. Spatial shift in nesting distribution ***[low probability]***

If turtles shift their nesting beach, this could result in a decrease of turtles at one beach and an increase at another, adjacent beach. If this 'new' beach was not monitored by biologists then it is possible that nesting activity could go unreported. Tagging data from the Galapagos and from Costa Rica indicate that green turtles will occasionally switch nesting beaches (Zarate et al. 2006, Fonseca et al. 2018, P. Santidrián-Tomillo, pers. comm.), but this is not likely to be a significant factor in observed declines. Moreover, in the Galapagos, declines were apparent at both Quinta Playa and Playa Las Bachas. Likewise, declines in Costa Rica happened at all three monitored beaches during the same time period. These examples suggest that turtles were not switching beaches in high amounts. Therefore, it is unlikely that a spatial shift in nesting distribution was a significant factor in the observed declines.

4. Changes in natural predation in foraging areas ***[warrants further study]***

Green turtles in the eastern Pacific are depredated by tiger sharks (*Galeocerdo cuvier*) and killer whales (*Orcinus orca*) in coastal foraging areas. In Chile, green turtles are particularly abundant in the area around a thermal discharge from a water-cooled power plant (Mejillones Bay, 23°S) in the Antofagasta Region, and there have been reports of South American sea lions (*Otaria byronia*) killing green turtles assembled in these areas (Sarmiento-Devia et al. 2015). Near the northern limit of Chile, specifically in Arica, during the period 2017–2018, a total of 120 green turtles were stranded with major external injuries. A very high percentage of those were decapitated, the reason is not clear yet, however, the government agency Servicio Nacional de la Pesca attribute this mortalities to local fishermen or to *O. byronia* attacks. Despite these observations, it is unlikely that depredation is having a major impact on nesting abundance in the Galapagos or Costa Rica. Biologist Paula Salinas (pers. comm.) from National University Arturo Prat (UNAP), who works at Chinchorro beach, Arica (18°28'S 70°18'W) a green turtle feeding ground in Chile, informs that turtles arrive highly decomposed making necropsies difficult. Although bycatch could be an important factor for stranded turtles, necropsies carried out on fresh individuals show interactions with sea lions (*Otaria flavescens*) as a torn neck and absence of the stomach. Basically, sea lions are only eating the stomach probably because they are going after the Chilean silverside eggs, suggesting a hunt near the coast. On the other hand, SERNAPESCA is conducting a study on the tissue in the United States, to determine if interactions with sea lions occur before or after the turtle is dead. Some individuals on which necropsies were carried out, showed no signs of drowning but pulmonary embolism a sign of interaction with sea lions. This behavior was also observed in Pisagua (19°35'S, 70°12'W) in the coast of Tarapaca, 130 km south from Arica, where photographic records of sea lions attacking two live sea turtles were obtained. This type of interaction could be due to a lack of food for sea lions. Records of these interactions have been already recorded in Bahia Mejillones (Chile) in 2006 (Guerra et al., 2007).

5. Delayed reproduction due to increase in remigration interval [warrants further study]

Changes to remigration interval may result from changes in marine productivity. This has been shown in leatherback turtles in the Atlantic (Hetherington et al. In Press). However, there are no long-term remigration interval data available for green turtles in the eastern Pacific. Therefore, the decrease in nesting activity due to low marine productivity—perhaps the result of El Niño events or other large-scale changes to the marine environment— cannot be ruled out. This is underscored by the fact that the precipitous drop in annual nesting seen in the Galapagos during the 2016-17 and 2017-18 nesting seasons are also present at some sites in Costa Rica. This suggests that ocean basin-scale (i.e. southeastern Pacific) changes in marine productivity may have caused females to forego nesting due to insufficient energy resources. We encourage a closer look at this possibility.

6. Decrease in annual nest frequency per female [warrants further study]

For the beaches at which abundance trends are based on nest counts (e.g., Galapagos, Mexico), changes in annual nest frequency by adult females could impact the total number of green turtle nests. This would not be a factor if, as is the case in Costa Rica, abundance is determined by tagging females. There are data on nests/female/season for beaches in the Galapagos (Zárate et al. 2002), Mexico (Alvarado-Díaz et al. 2003) and Costa Rica (Blanco et al. 2012, Santidrián-Tomillo et al. 2015, Fonseca et al. 2018); however, there are all single point estimates, and there are no long-term studies to evaluate changes in annual nest frequency. Indeed, increased frequency of El Niño events could lead to low productivity in the foraging areas which may result in changes in annual clutch frequency. We, therefore, recommend further study of this topic.

7. Impacts from red tides [medium probability]

There has been an increasing frequency in the number of reported mass sea turtle mortality events in the eastern Pacific Ocean. In recent years such examples have happened in Mexico, El Salvador, Honduras, Guatemala, and elsewhere. Scientists believe that many of these mortality events were the result of major red tide events. However, despite an effort to improve mass stranding response activities (i.e. tissue sampling, analysis), the linkage between mass mortality events and red tide is still unclear.

Many green turtles nesting in Cabuyal, Costa Rica feed in the Gulf of Fonseca (P. Santidrián-Tomillo, pers. comm.), thus, mass mortality events in Honduras may have included some Costa Rica nesters, and this may contribute in part to the observed declines. The interaction of Galapagos green turtles and red tides is unclear. This impact of red tides on green turtles from both regions (i.e., Galapagos, Costa Rica) needs further investigation.

8. Impacts from climate change [medium probability]

Climate change is very likely having at least some sort of impact on green turtles in the eastern Pacific, via changes in water temperature that are likely impacting foraging habitat quality, or via increases in incubation temperature on the nesting beaches that could feminize the population as incubation temperatures rise. Indeed climate change impacts are closely linked with some potential causes already discussed (e.g., red tides, timing of nesting season, increase in remigration interval). However, the impacts of increased beach temperatures (which will lead to insufficient numbers of male turtles), increased water temperatures (which lead to lower productivity and habitat quality), and sea level rise (which reduces available nesting habitat) are likely to take several more years before there is a major impact to nesting abundance.

An additional potential impact of climate change is the increased frequency of El Niño Southern Oscillation (ENSO) events and red tide events. ENSO has been linked to lower nesting activity in leatherback sea turtles in the eastern Pacific (Saba et al. 2007) and it is possible that ENSO may also impact green turtles, with individuals delaying nesting as a result. If so, this could be a major factor in the observed decreases in nesting in the Galapagos and Costa Rica.

9. Fisheries impacts at foraging areas ***[high probability]***

Impacts from marine fisheries bycatch mortality have been a major challenge for the conservation of sea turtles around the world. To link bycatch mortality with declines in nesting abundance, it is important that the foraging areas and migratory pathways of the decreasing nesting populations are understood. In the eastern Pacific, there have been several satellite-tracking studies of post-nesting migration by green turtles (e.g. Seminoff et al. 2008, Blanco et al. 2012, Hart et al. 2015) as well as flipper tagging studies (Green 1984, Alvarado and Figueroa 1992, Seminoff et al. 2002, and others), that have shown linkages between nesting beaches and foraging areas.

In Costa Rica, Blanco et al. (2012) found that nesters leaving beaches of Guanacaste largely traveled north and established foraging home ranges in coastal waters of Guatemala, El Salvador, Honduras, and Nicaragua. Although quantification of sea turtle bycatch in marine fisheries in these countries is unclear, this is a region that is known to have significant artisanal fishing efforts, and therefore fisheries bycatch cannot be ruled out as a factor in the observed declines.

For Galapagos green turtles, tracking by Seminoff et al. (2008) have shown that some individuals forage in the high seas after nesting, and others move to the coast of Central America. Flipper tag recoveries reported by Green (1984) indicate that a substantial proportion of green turtles nesting in the Galapagos move to the coast of South America to forage, especially along the coasts of Peru and Ecuador. Recent research by Quiñones et al. (2010) have shown elevated recruitment of Galapagos green turtles to Peruvian foraging grounds as a result of El Niño-driven environmental variability.

For turtles within the Peruvian region, many are impacted by illegal capture and consumption (Quiñones et al. 2015, 2017). The numbers of green turtles nesting in Galapagos (apparently driven by ENSO) were opposite to the turtles landed in Paracas, as occurred during the 1970s and 1980s (Quiñones et al. 2010). That is, during years when nesting was high in the Galapagos, landings in Peru were low, and vice versa. However, in the last two years (2017-2018) despite an ENSO event (that would normally result in more green turtles in Peru), the catch per unit effort (CPUE; N° turtles / km net / hour) in Paracas remained extremely low (J. Quiñones, unpubl. data). Moreover, CPUE at Virrila Estuary in Peru declined from 2012 to 2017 (Fig. 6). The causes for this decline are unclear, but ongoing fisheries-related mortality and human consumption are likely at least part of the reason for the declining CPUE.

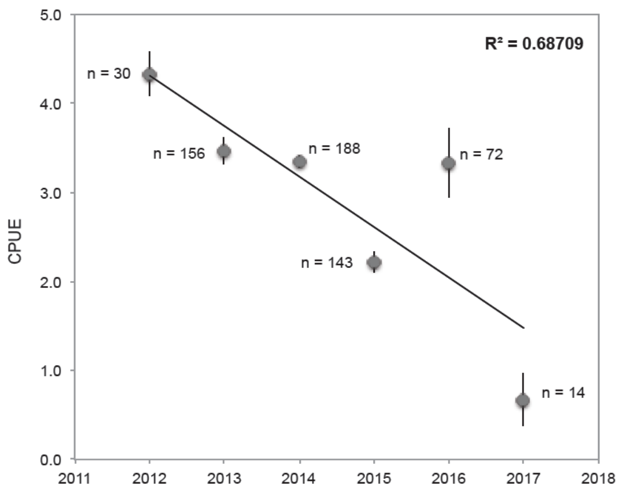

Figure 6. Catch-per-unit-effort for green turtles at Virrila Estuary, Peru (2012 – 2017 (Peru). CPUE is expressed in number of turtles per kilometer of net per hour. Error bars indicate standard error. Notice the negative tendency and low values in 2015 and 2017, which correspond with El Niño events.

In addition to drops in CPUE in Peruvian foraging grounds from 2000 to 2007, Alfaro-Shigueto et al. (2011), used both shore-based and onboard observer programs from three small-scale fisheries ports in Peru to assess the impact artisanal longline, bottom set net, and driftnet fisheries on marine turtles. Based on their interviews, Alfaro-Shigueto et al. (2011) estimated that during this period a mean of ca. 2,400 green turtles each year were bycaught. Although they report that over 90% of these turtles were released alive, this report represents a landmark discovery of the potential extent of bycatch and bycatch-related mortality.

Bycatch of green turtles has also been reported in Chilean industrial longline fisheries (Donoso and Dutton 2010). A more recent paper by Alfaro-Shigueto et al. (2018) shows high bycatch rate of green turtles in coastal artisanal fisheries of Ecuador, Peru, and Chile, with many of these turtles being retained for consumption. Illegal consumption of green turtles in the southeastern Pacific has been ongoing for well over a decade (de Paz et al. 2004), and it is highly likely that these takes are having a large impact on the Galapagos green turtle nesting population. We encourage additional monitoring at foraging areas to determine if declines such as those seen in Peru are also happening in other foraging destinations for Galapagos green turtles.

10. Increase of Plastic debris ingestion in foraging areas ***[warrants further study, but expected to be a factor]***

The damaging effects of marine debris and plastic ingestion by sea turtles have been recognized for many years (Carr 1987, Bjorndal et al. 1994). However due to the increasing magnitude of the plastic debris in the ocean (Kaiser 2010) this issue is receiving more attention worldwide. While plastic ingestion causes a mortality risk to sea turtles by gastrointestinal blockage, plastic polymers are an additional source of contamination as a persistent organic pollutant (Moore, 2008). In two of the most important foraging areas in Peru, “Estuario de Virrilá” (05°50’S) and Paracas (13°50’S), a 23.5 and 45.3% of frequency of occurrence of plastic ingestion were registered respectively in esophageal lavages in Virrila (n=120) and Paracas (n=86). (Javier Quiñones, unpublished data). However, so far there is no direct mortality quantification due to plastic ingestion in the eastern Pacific; this impact needs further investigation in foraging areas.

CONCLUSIONS

Nesting beach monitoring data indicate that green turtles in Mexico have shown a strong recovering trend (Fig. 2), while green turtles in the Galapagos, and perhaps also Costa Rica have shown a significant decline during the last decade. We considered 10 potential causes for these declines. The potential causes that were considered to be unlikely contributors to the observed declines included changes in monitoring effort, spatial and temporal shifts in nesting, and changes in natural predation rates. The causes that may influence nesting abundance, but warrant further study included the possibility of increases in remigration intervals, decreases in annual nest frequency for nesting females, and mortality due to plastic ingestion. Factors that are likely negatively impacting annual nesting female abundance include impacts from red tides, and impacts from climate change. The largest impact to green turtles, particularly those nesting in the Galapagos, are impacts from fisheries bycatch and illegal consumption; these threats seem particularly acute in coastal waters of Peru.

As a result of this report, we urge the IAC to increase focus on the ongoing fisheries bycatch and illegal consumption in Peru. If these threats are not stopped or substantially reduced, there is a very poor long-term outlook for green turtles nesting in the Galapagos.

RECOMMENDATIONS

Based on the best available data, annual green turtle nesting in the Galapagos Islands, and to a lesser extent, Pacific Costa Rica, have declined at an alarming rate. As a result of these declines and our analysis of possible contributing factors, we recommend the following actions be taken:

1. Maintain consistent monitoring effort at the primary index beaches in the Galapagos over the course of the entire green turtle nesting season.
2. Characterize monitoring effort (e.g. start date/finish date) for all nesting seasons and all beaches in the Galapagos
3. Maximize nest success and hatching production in the Galapagos. Strategies to achieve this include predator abatement, and possible shading to achieve optimal incubation temperatures.
4. Implement local efforts (regulations and enforcement) to reduce consumption by humans near the main foraging areas in the southeastern Pacific. Such efforts should be

intensified in areas that overlap with local gillnet fisheries, and should take into account the local social specific particularities.

5. Determine the extent to which decreases in marine productivity (via increased frequency of ENSO and climate change) may be responsible for delayed reproduction in green turtles.
6. Conduct an assessment of plastic ingestion by green turtles in foraging areas throughout the eastern Pacific.
7. Study annual clutch frequency of green turtles in the Galapagos and Costa Rica to monitor changes over time.
8. Study the impact of red tides on green turtles from the Galapagos and Costa Rica. Make use of existing conservation networks to promote rapid collection and analysis of tissues from turtles thought to be killed by red tide intoxication
9. Conduct monitoring at foraging areas for Galapagos green turtles to determine if declines such as those seen in Peru are also happening at these sites.
10. Increase efforts to quantify sea turtle bycatch in fisheries through monitoring programs.
11. Develop programs to implement sea turtle bycatch mitigation measures

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