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**ORIGINAL ARTICLE**

# Argentinian coastal waters: A temperate habitat for three species of threatened sea turtles

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**Abstract**

Three out of the five threatened species of sea turtle occurring in the SW Atlantic Ocean are regularly found in the coastal waters of Argentina: green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles. From 1995 to 2008, fishery and beach surveys were carried out along 2800 km coastline and reports from the public were gathered. Incidental capture in artisanal fisheries and strandings suggest that an important concentration of these species occurs in the estuarine, highly productive areas of Samborombón Bay (35°30′S–36°30′S) and El Rincón (39°S–41°S), although green and loggerhead turtles were also recorded as far south as northern Patagonian waters (42°35′S–64°17′W). Depending on the species, different age classes use these temperate areas probably as foraging grounds: small juvenile green turtles, juvenile to adult loggerheads and adult leatherbacks. All three species are mainly captured in small-scale, gillnet fisheries. This information provides an essential background to conduct further studies and propose mitigation plans to reduce sea turtle mortality in Argentina. Global conservation strategies will also benefit from including temperate environments of the SW Atlantic Ocean as regular habitats in the life history of threatened turtles.

**Key words:** *Bycatch,* Caretta caretta, Chelonia mydas, Dermochelys coriacea, *SW Atlantic Ocean*

## Introduction

The life history of sea turtles spans a range of ecosystems, from terrestrial habitats where oviposition and embryonic development occur to developmental and foraging habitats in coastal waters as well as in the open ocean (Bolten 2003). Sea turtles usually perform extensive migrations between these ecosystems, travelling from tropical to temperate latitudes (Musick & Limpus 1997; Plotkin 2003).

Historically, sea turtle research and conservation efforts had mostly focused on nesting areas (Bjorndal 2000). It was not until recently that foraging grounds received attention (e.g. With-

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erington 2002; Hatase et al. 2006; James et al. 2006a, 2007; Makowski et al. 2006). Within the foraging grounds, however, tropical habitats are frequently studied, while only few reports refer to cold-temperate habitats (e.g. Epperly et al. 1995; James et al. 2004, 2005, 2006a,b, 2007). This gap in the understanding of the ecology of threatened sea turtles is an obstacle to comprehensive and sound conservation actions.

This study focuses on sea turtles in a temperate environment: the coastal waters off Argentina (Figure 1). Data on sea turtles for the area are scarce and information is restricted to the listing of the species with no ecological or behavioural data (Koslowsky 1898; Gallardo 1977; Richard & De la Fuente 1988; Freiberg 1945). In the mid 1980s, the occurrence of three species – green (*Chelonia mydas* Linnaeus, 1758), loggerhead (*Caretta caretta* Linnaeus, 1758) and leatherback (*Dermochelys coriacea* Vandelli, 1761) turtles – was recorded according to a compilation of specimens from museums (Frazier 1984); however, field evidence and monitoring efforts were still lacking. Furthermore, given the relatively cold waters of the region (Piola & Rivas 1997) and the fact that sea turtles stay within preferred temperature ranges (Coles & Musick 2000; Bentivegna 2002), their occurrence in these southern latitudes was thought to be infrequent.

Unlike previous local works, this study is based on data gathered during fishery and beach surveys and also from public reports in the southernmost boundary of sea turtle distribution in the Southwest Atlantic Ocean. The objectives of this article are: (1) to show that sea turtle occurrence in coastal waters of Argentina is more frequent than previously thought, (2) to update their species composition, (3) to assess their spatio-temporal distribution, (4) to determine their size and infer stages, and (5) to identify fishing gear that interacts with sea turtles. This knowledge provides an essential background as a basis for further studies in the region.

## Methods

### *Study area*

The study areas ranges from Gualeguaychú (33°01′S, 58°31′W), well inside the Uruguay River, to Península Valdés in northern Patagonia (42°35′S, 64°17′W) (Figure 1), along 2800 km of coastline. The study area was divided in 1°-latitudinal sectors that, from north to south, start at the Uruguay River (sector I) and follow with the Uruguay River mouth (sector II), and Río de la Plata estuary, including Samborombón Bay (sectors III and IV). The following sectors comprise the main geographic and coastal landmarks of the northern coast of Argentina: San Antonio Cape and the Mar Chiquita coastal lagoon (sectors IV and V). Sector VI represents the area where the continental shelf break is closest to the

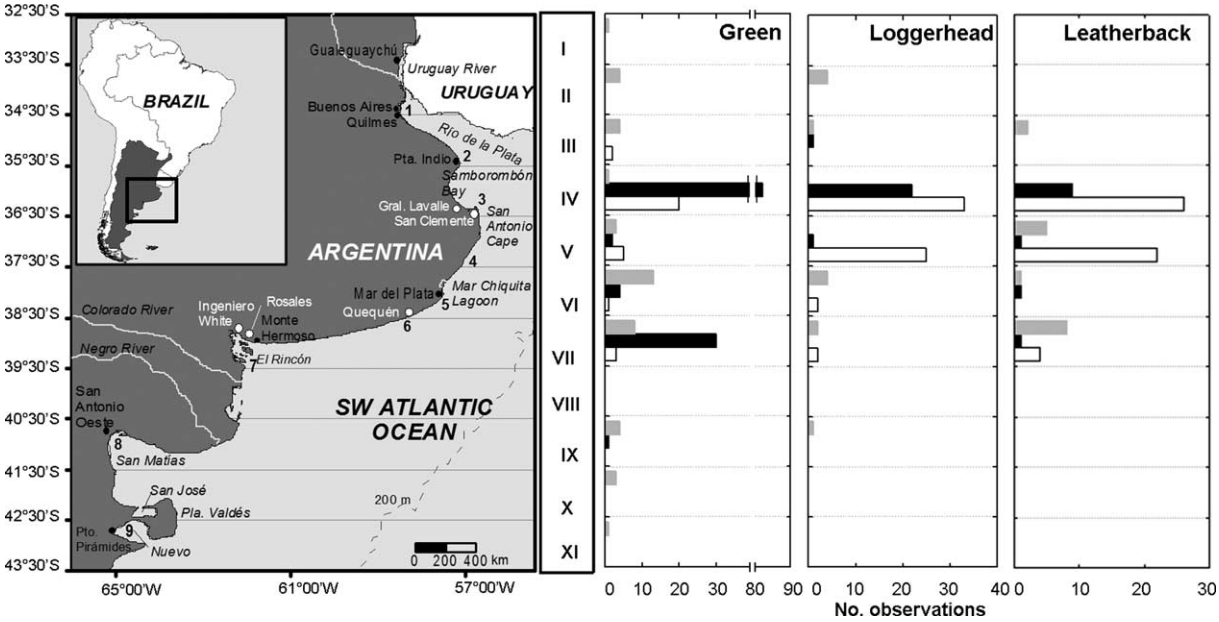


Figure 1. Spatial distribution of green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles. Records were obtained from fishery surveys (black bars), beach surveys (white bars) and the public (grey bars). Ports are lettered in white. Numbers indicate the geographic location of organizations under the Regional Program for Sea Turtle Research and Conservation of Argentina: (1) Buenos Aires Aquarium, (2) Proyecto Peyú, (3) Fundación Mundo Marino, (4) Aquamarina, (5) Fundación Mar del Plata Aquarium, (6) Proyecto ECOFAM, (7) Reserva Natural de Usos Múltiples Bahía Blanca, Bahía Falsa y Bahía Verde, (8) Instituto de Biología Marina y Pesquera Alte. Storni and (9) Fundación Patagonia Natural. Insert shows main currents in the SW Atlantic.

coastline. Sectors VII and VIII include El Rincón estuarine area and the Colorado River mouth. Sectors IX–XI include the Negro River mouth and three Patagonian gulfs: San Matías, San José and Nuevo.

### *Sea turtle sampling*

Data were gathered from 1995 to 2008 by nine organizations: Buenos Aires Aquarium, Proyecto Peyú, Fundación Mundo Marino, Aquamarina, Fundación Mar del Plata Aquarium, Proyecto ECOFAM, Reserva Natural de Usos Múltiples Bahía Blanca, Bahía Falsa y Bahía Verde, Instituto de Biología Marina y Pesquera Alte. Storni and Fundación Patagonia Natural (Figure 1); working under the Regional Program for Sea Turtle Research and Conservation of Argentina (PRICTMA) since 2004.

We had three sources of data: fishery surveys, beach surveys and public reports. Fishery surveys included monitoring of artisanal ports and coastal villages mainly from November to May. Daily visits to ports and villages generated a trusted relationship between fishermen and PRICTMA personnel, allowing us to gather information on sea turtle captures through different methodologies depending on the port and even the fisherman. In some cases, fishermen were interviewed and asked about captured turtles, in other cases they voluntarily reported turtles and even brought them to land, and with the more trusted ones, we were able to place onboard observers during their fishing activities. Ports monitored were General Lavalle, San Clemente, Quequén, Rosales and Ingeniero White (Figure 1). Regarding coastal villages (over 40 along the study area), surveys were conducted from Punta Indio to Ingeniero White and from San Antonio Oeste to Puerto Pirámides (Figure 1).

Fishery surveys provided information on date, type of fishing gear, location and/or GPS position of the capture, species captured and its curved carapace length (CCL). CCL was measured according to Bolten (2000), from the nucal notch to the posterior notch at midline between supracaudal scutes. Fishing gear monitored included gillnet, bottom trawling and shrimp net as main types. When possible, captured turtles were brought to land or were examined by observers aboard fishing boats. For a description of the fishing fleets and gears involved throughout the study range see Bordino et al. (2002) and Crespo et al. (1994).

Most beach surveys were conducted throughout the year, by foot or vehicle, from San Clemente to Puerto Pirámides (Figure 1). Data obtained on strandings were date, location and/or GPS position and species. When the carapaces of carcasses were not damaged, the CCL was also recorded.

The monitoring efforts of ports and beaches were not constant. No correction based on survey effort could be made and derived conclusions should be treated with caution.

The public (tourists, park rangers, lifeguards and people in general) reported sea turtles to the Coast Guard or directly to PRICTMA. Data obtained for this source were date, type of record (incidental capture or stranding), location, species and CCL. Species identification and measurements were carried out by experienced and trained personnel of PRICTMA.

From all sources of information, only records corroborated by direct observation of the authors were included. When fishermen reported a live captured turtle released by them, only records which provided proof with a skin or picture sample were included in our database. Captured or stranded turtles found alive were moved to the nearest rehabilitation center to evaluate health status and tagging prior to release.

### *Data analysis*

The three sources of information (fisheries, beach surveys and public reports) were analysed separately. Public reports were analysed with no discrimination between captures and strandings. As public reports were opportunistically recorded and fishery surveys were done mostly during warm months, these records were not used to infer seasonality.

The mean size of captured and stranded turtles was compared with Mann–Whitney $U$ tests (Sokal and Rohlf 1979) with a significance level of 0.05. A non-parametric test was used because the assumptions of normality and homoscedasticity were not fulfilled.

The classifications of Musick & Limpus (1997) and Bolten (2003) were adopted to define the turtle's ontogenetic stage. The term 'juvenile' includes turtles that have started feeding on neritic habitats and are smaller than the minimum breeding size. 'Adult' describes all turtles equal or larger than the minimum size for breeding, independent of their sexual maturity status. Because turtles from multiple populations are found on foraging grounds (Lahanas et al. 1998; Naro-Maciel et al. 2007), we chose the smallest minimum size for breeding reported for nesting grounds in the South Atlantic as the threshold value to differentiate between juveniles and adults. A CCL of 101, 83 and 124 cm was used as minimum size for breeding for green, loggerhead and leatherback turtles, respectively (Hirth 1997; Kotas et al. 2004; Thomé et al. 2007).

Table I. Number of strandings, incidental captures and public reports documented from 1995 to 2008 along 2800 km of Argentinian coastline.

| | Green | Loggerhead | Leatherback | Total |
|---|---|---|---|---|
| Strandings | 31 | 62 | 52 | 145 |
| Incidental captures | 119 | 24 | 11 | 154 |
| Public reports | 42 | 12 | 16 | 70 |
| Total | 192 | 98 | 79 | 369 |

## Results

A total of 369 records were gathered along 2800 km of coastline from 1995 to 2008. Most records were incidental captures and strandings (42 and 39%, respectively) (Table I), with 95% of them occurred during the period 2004–2008 (Figure 2). Records involved three species: green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles, the green turtle being the species most frequently recorded (Table I).

### *Spatial distribution*

Eighty-five percent of the captures and strandings were recorded between sectors IV and VII, comprising about 700 km of coastline, whereas public reports covered a larger area (Figure 1). Most incidental captures occurred in coastal waters of Samborombón Bay (outer Río de la Plata, sector IV); where artisanal gillnet fleets operate. Captures of green turtles were also frequent in El Rincón estuarine area (sector VII), where an artisanal shrimp fisheries operates.

Strandings were more frequent on sandy beaches of San Antonio Cape (sectors IV and V). Most animals were found dead (71, 97 and 98% for green, loggerhead and leatherback turtles, respectively).

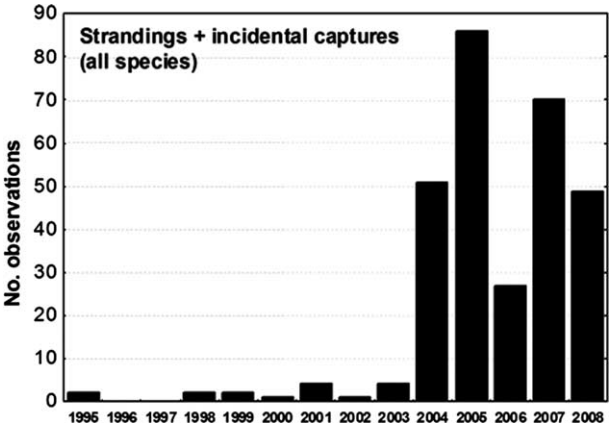


Figure 2. Total number of sea turtle strandings and incidental captures before and after the beginning of Regional Program for Sea Turtle Research and Conservation of Argentina in 2004.

Public reports expanded the records of the three species to the freshwaters of the Uruguay River and the Rio de la Plata (sectors I and II, Figure 1). Southernmost records of green and loggerhead turtles also reached coastal Patagonia (40°43′S, sector XI). Southernmost records for leatherbacks occurred at 38°55′S (sector VII, Figure 1).

Most of the captures in fisheries recorded were in gillnets at Samborombón Bay, San Antonio Cape and coastal villages of sector VI (Figure 3). Turtles captured in this fishing gear were mostly dead (72, 68, and 100% for green, loggerhead and leatherback turtles, respectively). Green turtles were also captured in shrimp nets (Figure 3) in El Rincón estuarine area,

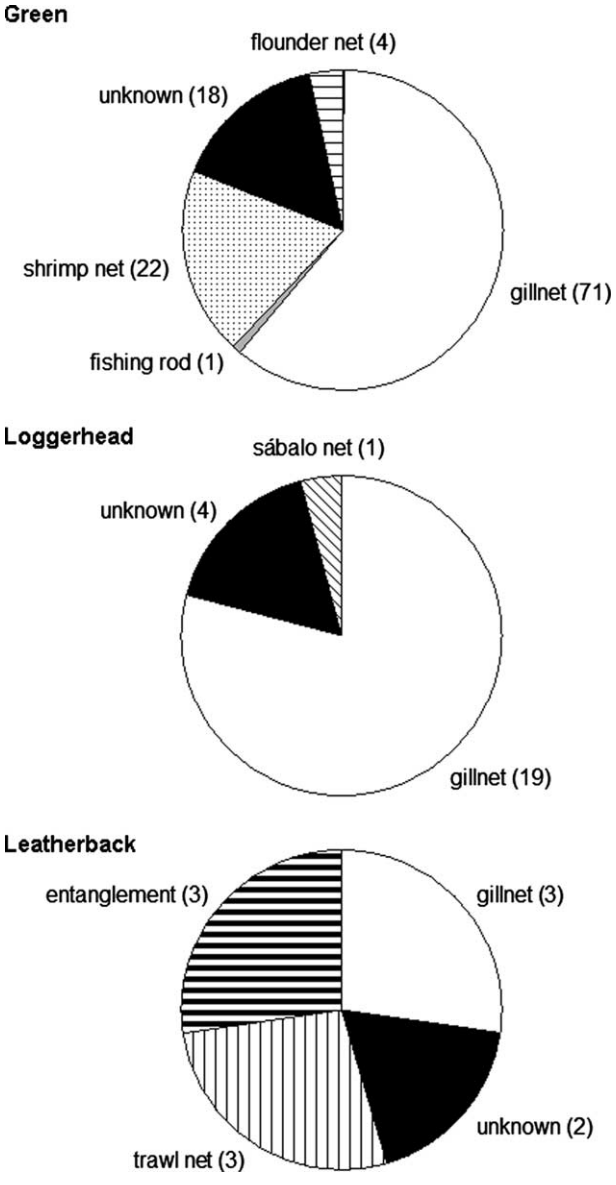


Figure 3. Fishing gears recorded which affect green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles in Argentina. Numbers in parentheses indicate sample size.

but all 22 turtles reported were alive. Other fishing gears capturing green turtles were flounder nets and sport fishing (Figure 3) in El Rincón estuarine area. Loggerheads were also captured in nets for freshwater fish (Figure 3) in the Río de la Plata and leatherbacks were captured in trawl nets and found entangled in anchor ropes and main lines of artisanal longline (Figure 3).

*Seasonal patterns*

Although fishery data could not be used to infer seasonality, fishermen that work throughout the year stated that turtles were seen and/or captured only during summer months. Beaches, however, were surveyed throughout the year and strandings were mostly recorded during late summer and early autumn for the three species, allowing us to suggest a seasonal occurrence of sea turtle in these temperate waters (Figure 4).

*Size distribution*

Only juvenile green turtles occurred in coastal waters of Argentina (Table II, Figure 5) and no significant differences in CCL were found between green turtles captured or stranded ($U=1106.5$, $P=0.569$). Among loggerheads, both juveniles and adults were found, and stranded loggerheads were significantly larger than captured ones ($U=70.5$, $P<0.001$) (Table II, Figure 5). Leatherback turtles were either large juveniles or adults (Table II, Figure 5) and no significant differences in CCL were found between stranded and captured turtles ($U=40.5$, $P=0.188$).

Reports of green turtles obtained from the public have similar CCL to those gathered through fishery and beach surveys (Table II). In the case of loggerheads and leatherbacks, a small sample size of the public reports precludes us from observing any pattern.

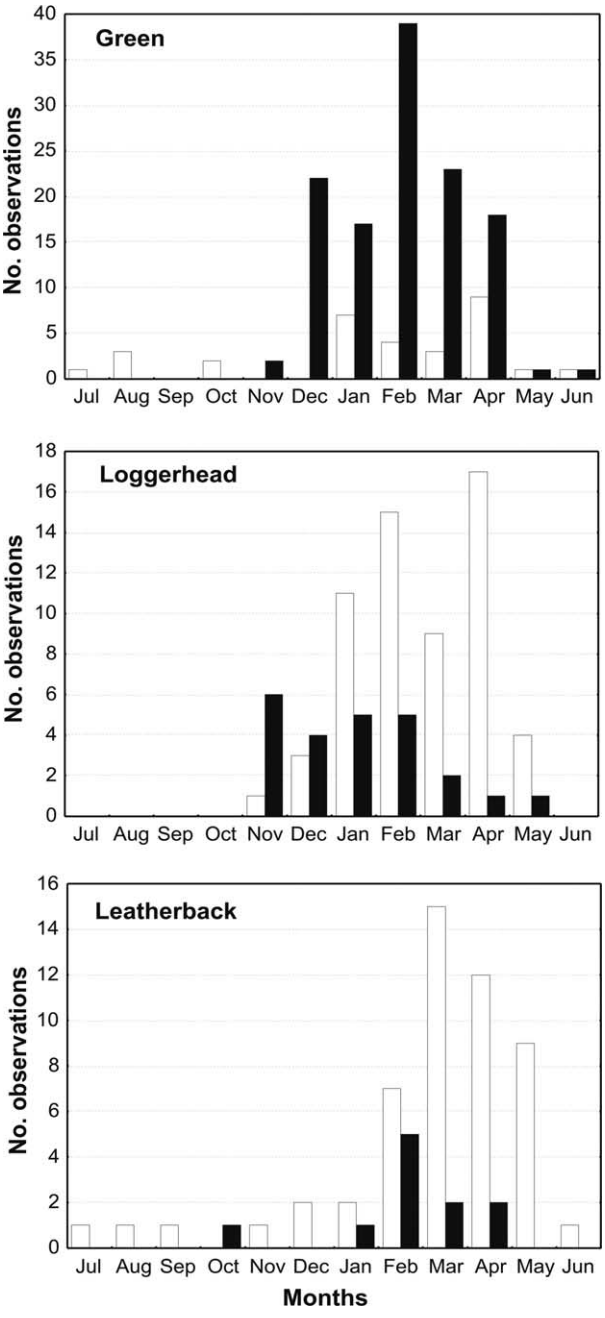


Figure 4. Temporal distribution of incidental captures (black bars) and strandings (white bars) for green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles in Argentine coastal waters.

## Discussion

Green, loggerhead and leatherback turtles occur regularly along the coast of Argentina, in the temperate waters of the SW Atlantic Ocean. Data on stranding suggest that sea turtles arrive seasonally and remain from late spring to early fall in estuarine areas of Samborombón Bay and El Rincón, at about 35–39°S. Green and loggerhead turtles were also recorded further south, along the coast of Patagonia, at latitudes above 40°S (Figure 1). Our findings reveal a broad distribution of sea turtles in coastal waters of Argentina and show that an important part of the life history of three sea turtle species takes place in temperate areas of the SW Atlantic Ocean.

Depending on the species, sea turtles were found to be represented by different ontogenetic stages and therefore different phases of the life history patterns proposed by Bolten (2003). The size of green turtles, for example, coincides with the recruitment sizes of juveniles reported in other regions such as the east coast of the United States (Mendonça & Ehrhart 1982) and the Bahamas (Bjorndal & Bolten

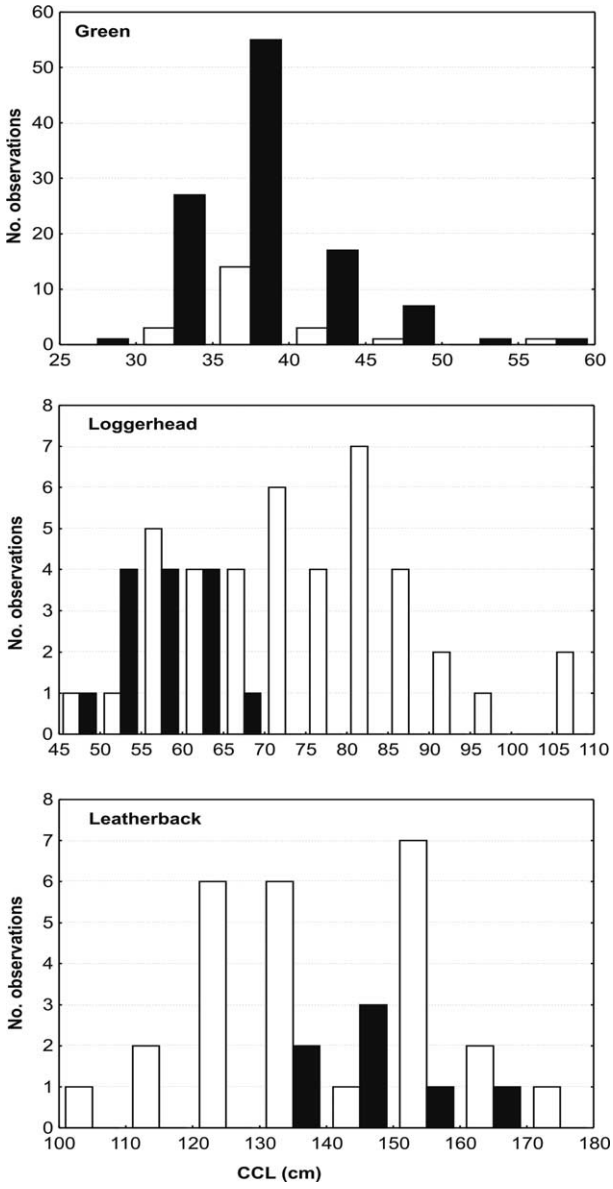


Figure 5. Size distribution of green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles. Black and white bars represent incidental captures and strandings, respectively.

1988), suggesting that the coastal waters of Argentina could be a foraging and developmental ground where young green turtles recruit after being in the oceanic realm. Ubatuba (Brazil) has been identified as another developmental habitat for small juvenile green turtles in the SW Atlantic Ocean (Gallo et al. 2006).

Similarly, the size of loggerheads coincides with the recruitment sizes found along the east coast of the United States (Lutcavage & Musick 1985; Carr 1987; Bjorndal et al. 2001) and the East coast of Australia (Limpus et al. 1994); also suggesting that recruitment from the oceanic habitat occurs at these high latitudes. However, along with young loggerheads, larger turtles, some of them of adult size, were also found, indicating that the coastal waters of Argentina could also be a foraging ground for larger juveniles.

However, only sub-adult and adult leatherbacks were found. Even though leatherbacks were considered to be pelagic throughout most of their life (Bolten 2003), today it is known that adults can approach coastal waters to feed between reproductive seasons in the NW Atlantic Ocean as shown by James et al. (2005, 2006a, 2007). In the SW Atlantic Ocean, López-Mendilaharsu et al. (2009) showed that sub-adult and adult leatherbacks migrate south seasonally to feed on jellyfish in the Río de la Plata estuary (including the Samborombón Bay) and this is considered to be a key foraging area for this species.

Regardless of the ontogenetic stage, sea turtles seem to arrive in the coastal waters of Argentina in late spring and depart mostly around the beginning of autumn, although some turtles were recorded during the winter. A seasonal pattern such as that observed in this study is expected when considering that sea temperature at these latitudes ranges from 18–23°C in summer to 8°C in winter (Lucas et al. 2005). The role of sea temperature as a factor driving sea turtle occurrence in temperate foraging habitats was also observed in the black turtle

Table II. Descriptive statistics for curved carapace length (CCL) for green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles. Types of records are: incidental captures (I), strandings (S) and public reports (P).

| | Green | | | Loggerhead | | | Leatherback | | |
|---|---|---|---|---|---|---|---|---|---|
| CCL (cm) | I | S | P | I | S | P | I | S | P |
| Mean | 38.2 | 39.1 | 42.6 | 57.6 | 75.5 | 70.1 | 148.5 | 141.1 | 146.3 |
| SD | 4.4 | 5.4 | 8.5 | 5.4 | 14.3 | 22.4 | 9.7 | 17.7 | 13.9 |
| *N* | 109 | 22 | 29 | 14 | 41 | 9 | 7 | 26 | 4 |
| Min | 30.0 | 32.0 | 31.5 | 49.7 | 48.8 | 67.0 | 137.0 | 110.0 | 134.0 |
| Max | 56.0 | 58.6 | 71.0 | 68.5 | 107.0 | 119.0 | 164.0 | 180.0 | 166.0 |

*N*, number; SD, standard deviation.

(*Chelonia agassizii* (Bocourt, 1868)) that reaches southern, coastal foraging grounds off the Peruvian coast helped by intrusions of warmer waters during ENSO episodes (Quiñones et al. 2010).

Sea turtles on foraging grounds belong to multiple genetic stocks from different nesting beaches (Lahanas et al. 1998), and currents could be one of the factors driving the genetic structure of the foraging populations (Bass et al. 2006). Green turtles off the coast of Argentina came mainly from Ascension Island (7°56′S, 14°22′W), with fewer numbers from Aves Island (15°40′N, 63°36′W) and some beaches in Suriname (L. Prosdocimi, pers. comm.). Loggerheads may come from Brazilian nesting beaches and probably from Africa, the Mediterranean and even the Indian Ocean; although genetic studies are not yet conclusive (Soares 2004; Caraccio et al. 2008). Leatherbacks arrive in Argentina after having performed an extensive post-breeding migration from nesting beaches in Gabón (Billes et al. 2006), and also after feeding in Brazilian foraging grounds (Barata et al. 2004; López-Mendilaharsu et al. 2009). As nesting beaches for the three species are located in northern latitudes, it is possible that the Brazil Current with its southward flow of warmer water plays a major role in enabling sea turtles to reach temperate waters of the coast of Argentina (Figure 1). However, further studies using satellite telemetry are needed.

The cost of arriving in Argentina from distant locations (some 6000–8000 km away) necessarily have to be compensated with a large biomass of food, especially for post-breeding females and juvenile stages newly recruited. Depending on resource availability, metabolic requirements influence reproductive outputs, as well as growth and morphometrics (Brown et al. 2004; Wallace & Jones 2008). The Argentinian continental shelf is characterized by coastal frontal zones of high biological productivity such as the Río de la Plata and El Rincón estuaries (Acha et al. 2004). These areas, where most of the sea turtles were recorded, sustain a large biomass of potential food resources, such as gelatinous zooplankton (Mianzan & Guerrero 2000; Mianzan et al. 2001a; Alvarez Colombo et al. 2003) and extensive benthic beds (Giberto et al. 2004), suggesting that they could be the main foraging grounds in Argentina.

Productivity that may attract turtles also supports intense fishing effort in these areas (Mianzan et al. 2001b; Carozza et al. 2004). The three species are incidentally captured by small-scale fisheries, especially those operating with bottom gillnets in Samborombón Bay and San Antonio Cape. Mortality is also seen in stranded animals which can provide only a minimum estimate of mortality since not all turtles that die at sea wash ashore (Epperly et al. 1996). Furthermore, strandings may have been caused by other hazards such as marine debris ingestion, or by other fisheries not monitored in this study. Marine debris ingestion has been recorded in green, loggerhead and leatherback turtles along the coast of southern Brazil (Bugoni et al. 2001; Tourinho et al. 2010) and bycatch in the industrial bottom-trawling fishery is known to occur in the Río de la Plata estuary (Domingo et al. 2006).

Most captures occurred in two estuarine areas which are important to sea turtles but also coincide with fishing grounds of main artisanal ports. This may suggest that the relative frequency of records could be affected by opportunity. Likewise, fewer records in southern sectors could also be due to a lower density of organizations devoted to turtle research compared to northern sectors. Beyond potential biases in the records, a relatively large number of turtles are caught by small-scale fisheries and late ontogenetic stages (sub-adult and adult loggerheads and leatherbacks) that offer the greatest potential for population recovery (Crouse et al. 1987; Heppel 1998) are being affected. Small changes in the location of fishing effort during late summer conducted in accordance with local fishermen community may be one of the most efficient conservation tools at the local level to decrease the impacts of the threat to sea turtle populations in Argentina, although mitigation plans are not in place yet. In addition, the inclusion of temperate foraging habitats such as the Argentinian coastal waters in conservation strategies of the SW Atlantic Ocean is needed.

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