Universidade de Aveiro
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Distribuição das Tartarugas Verdes (Chelonia mydas) nos Açores: Conhecimento Ecológico Local (CEL) como abordagem

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Biologia Marinha Aplicada, realizada sob a orientação científica do Doutor Frederic Vandeperre, Investigador Auxiliar do Instituto de Investigação em Ciências do Mar (IICM) da Universidade dos Açores e da Doutora Clara Lúcia Ferreira Rodrigues, Investigadora auxiliar do Departamento de Biologia e do Centro de Estudos do Ambiente e do Mar da Universidade de Aveiro.

O júri

Presidente

Professora Doutora Maria Marina Pais Ribeiro da Cunha
Professora Associada, Departamento de Biologia, Universidade de Aveiro

Arguente

Professor Doutor Frank Thomas Ussner Dellinger
Professor Associado, Estação de Biologia Marinha do Funchal, Faculdade de Ciências da Vida, Universidade da Madeira

Orientador

Doutor Frederic Walter Leonardo Annie Vandeperre
Investigador Auxiliar, Instituto de Investigação em Ciências do Mar – Okeanos, Universidade dos Açores

agradecimentos

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palavras-chave

Açores, Chelonia mydas, Ciência do Cidadão, Conhecimento Ecológico Local (CEL), Locais de Refúgio, Tartarugas Marinhas, Tartarugas Verdes

resumo

Estratégias eficazes de conservação para tartarugas marinhas requerem conhecimento dos movimentos e distribuição dos animais, proteção dos habitats biologicamente importantes e das suas fases de vida. Para as tartarugas marinhas juvenis, conhecer seus locais de refúgio e a sua ecologia é fundamental para a proteção bem-sucedida das espécies e a identificação precisa de suas vulnerabilidades. Este estudo utiliza o conhecimento ecológico local (CEL) através da realização de um questionário sobre a presença de tartarugas verdes (Chelonia mydas) no Arquipélago dos Açores entre os meses de agosto de 2020 e abril de 2021. Os Açores são um grupo de nove ilhas vulcânicas com numerosos locais de águas pouco profundas e características emergentes, assim como vales de águas profundas e desfiladeiros submarinos. É influenciado climatologicamente pelo Giro Subtropical do Atlântico Norte e pela corrente do Golfo, criando as condições perfeitas para um hotspot de biodiversidade, hospedando um grande número de megafauna marinha.

As tartarugas marinhas são uma presença comum no arquipélago dos Açores e, embora a presença de C. mydas seja de conhecimento geral, não existem estudos científicos sobre a presença desta espécie nos Açores.

A importância do Conhecimento Ecológico Local em cenários com poucos dados é cada vez mais reconhecida na conservação. Esta integração dos dados CEL com a ecologia é de valor crítico para a conservação e gestão de habitats, pois contribui para uma visão holística do estado de conservação contemporâneo de uma espécie.

A tartaruga verde é um réptil marinho de longa vida, disperso pelo globo e ameaçado de extinção. A ignorância da localização das suas diferentes fases de vida pode constituir um obstáculo para o estudo e a gestão das populações. Espécies migratórias como esta são conhecidas por representar um desafio para a conservação, pois é essencial compreender a sua complexa história de vida para implementar ações de conservação eficientes.

O questionário foi dividido em duas seções: 1) descrição do avistamento da tartaruga-verde e 2) perfil dos entrevistados. A primeira seção é composta por 11 questões para descrever a tartaruga marinha e o que a rodeia. A segunda seção contêm 9 questões para descrever o perfil do entrevistado a fim de avaliar a influência pessoal no avistamento. Foram realizadas 68 entrevistas, 27 presenciais e 41 online, que resultaram em 87 avistamentos de tartarugas verdes. Os resultados confirmaram a presença de tartarugas verdes no arquipélago dos Açores. A descrição do tamanho reto da carapaça (entre 10 cm e 79 cm) confirmou que todas as tartarugas verdes nesta área são juvenis. A maioria dos avistamentos ocorreu durante o verão e outono, perto do fundo do mar rochoso a cerca de 8 metros de profundidade. Sendo a maioria dos entrevistados oriundos das ilhas do Faial e do Pico, é aqui que se verifica a maior parte dos avistamentos.

Este é um estudo inicial das tartarugas verdes nos Açores. Abre as portas para a realização de estudos mais sistemáticos e baseados em hipóteses, alimentando futuras estratégias de gestão, nas quais as populações locais sejam participantes ativos, especialmente considerando que estão na linha de frente da conservação nessas áreas isoladas do arquipélago.

keywords

Azores, Chelonia mydas, Citizen science, Foraging grounds, Green Turtles, Local Ecological Knowledge (LEK), Sea turtles

abstract

Effective conservation strategies for sea turtles require knowledge of animal movements and protection of biologically important habitats and life history stages. For juvenile sea turtles, knowing their foraging grounds and foraging ecology is imperative to the successful protection of the species and the accurate identification of their vulnerabilities. This study uses Local Ecological Knowledge (LEK) by conducting a questionnaire about the presence of green turtles (Chelonia mydas) in the Azorean Archipelago between August 2020 and April 2021. The Azores is a group of nine volcanic islands with numerous shallow-water and emergent features, as well as deep-water ridges, submarine canyons. It is influenced climatologically by the North Atlantic Subtropical Gyre and the Gulf Stream current creating the perfect condition for a biodiversity hotspot, hosting a large number of marine megafauna.

Sea turtles are a common presence in the Azorean archipelago, and, even though the presence of C. mydas is of common knowledge, there are no scientific studies about the presence of this species in the Azores.

The importance of LEK in data-poor scenarios is increasingly recognized in conservation. This integration of LEK data with ecological science is of critical value for conservation and management of habitats, as it contributes to a holistic view of a species' contemporary conservation status.

The green turtle is a long-lived, wide-ranging and endangered marine reptile. The ignorance of the location of its different life stages can hinder the study and management of populations. Migratory species like this one are known to pose a challenge for conservation since it is essential to understand their complex life history in order to implement efficient conservation actions.

The questionnaire was divided in two sections: 1) description of the green turtle sighting and 2) interviewees' profile. The first section was composed of 11 questions to describe the sea turtle and its surroundings. The second section had 9 questions to describe the profile of the interviewee in order to evaluate its influence on the sighting. In total, 68 interviews were performed, 27 in person and 41 online, which resulted in 87 green turtle sightings. The results confirmed the regular presence of green turtles in the Azorean archipelago. The description of the straight carapace length (between 10 cm and 79 cm) confirmed that all green turtles in this area are juveniles. Most sightings occurred during the summer and autumn, close to the rocky sea floor at around 8 meters deep. Since the majority of the interviewees were from Faial and Pico islands, that is where most sightings occurred.

This study is the initial study of green turtles in the Azores. It opens the doors to conduct more systematic and hypothesis-driven studies to feed future management strategies in which local people are active participants, especially considering they are at the frontline of conservation in these isolated areas of the archipelago.

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1. Introduction

1.1 Sea turtles

There are around 10500 extant species of reptiles, but only 80 can be considered primarily marine animals (Rasmussen et al., 2011; Uetz et al., 2021). The majority of these are sea snakes, most of which have a short lifespan and have severed their terrestrial link. Sea turtles and crocodiles, on the other hand, have a long lifespan and return to land to lay their eggs, making them secondary marine animals (Gaffney and Meylan, 1988; Hirayama, 1997; Pritchard 1997).

Sea turtles evolved from terrestrial turtles over 100 million years ago. They are part of the suborder Cryptodirae and belong to two families, Dermochelydae and Cheloniidae. From their past, they kept, among other features, lungs to breathe air and the need to incubate eggs in nests dug on sandy beaches. These animals are perfectly adapted to the marine environment, with hydrodynamic bodies and physiology adapted to prolonged apnea (Lutz and Bentley, 1985; Wyneken, 1997). Most species of sea turtles share similar life history characteristics, with some variation among species and populations. Generally speaking, however, sea turtles are long-lived animals that grow and mature slowly, occupying multiple habitats throughout their life cycle, including neritic, pelagic, estuarine and beach habitats (Seminoff, 2004). Sea turtles have a circumglobal distribution and can be found in tropical, sub-tropical and temperate waters (Seminoff, 2004). One key characteristic of sea turtle species is their ability to migrate great distances, with some species even crossing ocean basins from foraging grounds to reach their rookeries of origin through a behaviour known as natal philopatry (Bowen et al., 1995).

The basic sea turtle life strategy is similar in all Cheloniidae. After sea turtles mate in near-shore waters, females store sperm for several weeks after a single mating. They lay eggs in nests dug on tropical, subtropical or warm-temperate beaches. All marine turtles lay white, spherical cleidoic eggs with flexible calcareous shells (Miller, 1985). The shape and size of eggs laid in each clutch varies slightly between clutches laid by one female as well as considerably within and between species (Hirth, 1980; Van Buskirk and Crowder, 1994). Parental care beyond the energetic contribution to each egg is limited to the choice of nesting site, stereotyped burial, smoothing and camouflaging of the nest area. Female sea turtles lay several clutches per nesting season (up to 7 nests) at intervals of 9 to 30 days, but usually do not breed every year. Eggs, which are larger and more numerous than most freshwater species, incubate for about 2 months, hatching usually at night. Incubation temperature determines the sex of hatchling sea turtles during the third stage of embryonic development, with low temperatures producing males and high temperatures producing females (Yntema and Mrosovsky, 1982). The hatchlings crawl down the beach and swim rapidly and continuously for 24 hours out to sea, the “swimming frenzy”, (Salmon and Wyneken, 1987; Wyneken and Salmon, 1992; Davenport, 1997) so as to be carried away from the coast into the neritic zone (Bolten, 2003).

As hatchlings, sea turtles swim from their natal beaches into the open sea (Georges et al., 1993) often taking refuge in circular current systems (gyres) that serve as moving, open-ocean nursery grounds (Hendrickson, 1982). Most species have relatively long (up to more than 10 years) oceanic stages tending to have high-density nesting localities, located adjacent to major oceanic currents. These major oceanic currents can maintain small juveniles passive and safe long enough for them to grow large enough. This strategy lowers predation risk and give them the mobility to actively swim to developmental habitats. Current hypothesis suggests that early juveniles use oceanic zones, whereas larger juveniles and adults primarily limit their movements to neritic habitats, with the exception of Dermochelys coriacea. The oceanic-neritic pattern is the most common life history pattern used in sea turtles, adopted by four of the seven sea turtle species (Bolten, 2003; Carr, 1987; Reich et al., 2007). It was long assumed that passive drifting in surface currents was the leading dispersal mechanism for hatchlings during this phase. However, there is growing evidence suggesting directed swimming may affect the trajectories of hatchlings and in turn the locations of neritic foraging habitats to which they recruit as juveniles (Carr and Meylan 1980; Bass et al., 2006; Shamblin et al., 2018). The juveniles and subadults of many populations reside in coastal feeding areas that are located hundreds or thousands of kilometres from the beaches on which the turtles hatched (Van Buskirk and Crowder, 1994; Bjorndal et al., 1985; Limpus et al., 1992). Adult females, however, periodically leave their feeding sites and migrate to their natal beaches to nest; after nesting, many return to their own specific feeding areas (Bjorndal, 1981).

Cheloniidae juveniles, actively recruit to demersal neritic developmental habitats in the tropical and temperate zones. Demersal juveniles in some temperate zone populations make seasonal migrations to foraging areas at higher latitudes in summer and lower latitudes in winter while those in tropical areas are more localized in their movements. When approaching maturity: pubescent turtles move into adult foraging habitats. In some populations adult habitats are geographically distinct from juvenile developmental habitats (Schroeder and Witherington, 1994); in others, they may overlap or coincide (Van Buskirk and Crowder, 1994; Bjorndal et al., 1985). Upon maturity, as the nesting season approaches, adults migrate toward the nesting beaches.

Cheloniidae is a family of turtles characterized by an extensively roofed skull with well-developed rhamphotheca and secondary palate present. Head incompletely retractile or nonretractile, extremities are in the nonretractile form, flippers covered with numerous small scales and the forelimbs have highly elongate digits firmly bound together by connective tissue. The claws are reduced to one or two on each limb, and the radius and ulna immobilized against independent movement by juxtaposed rugose surfaces. The shell is covered with horny scouts, variable in number, together with an unbroken series of three or four pairs of inframarginal, multiple axillary scouts. The plastron often has persistent fontanelles, one in the middle and others in the entoplastral and xiphiplastral regions. It is not cruciform, and the posterior plastral lobe is relatively long and wide (Baur, 1890).

Cheloniidae species exhibit two strategies within their developmental habitat; (1) the area is shared with adults and will constitute the adult residential foraging grounds where juveniles will later spend their inter-reproductive period (Limpus and Limpus, 2001; Bolten and Witherington, 2003) or (2) the area will be frequented only by juveniles that will subsequently shift to a different feeding area when they reach maturity (Musick and Limpus, 1997; Luschi et al., 2003). To date, the spatial and temporal variability of ontogenetic or developmental migrations in late-stage juvenile sea turtles is the least known stage in the life cycle of sea turtles (Luschi et al., 2003; Godley et al., 2008; Hamann et al., 2010; Varo-Cruz et al., 2016).

Due to their highly migratory and oceanic life history, research on sea turtles has been largely restricted to nesting females and hatchlings. This has led to conservation efforts primarily focused on nesting beaches and on hatchlings, rather than in-water habitats utilized by breeding adults or post-nesting juveniles. Protecting in-water habitats is critical for effective species conservation as breeding individuals and juvenile feeding grounds contribute disproportionately to sustaining populations (Maxwell et al., 2011).

Sea turtles are an ancient and hardy group of species, having survived massive extinction events as well as glaciations. However, within an average human lifespan, many sea turtle populations have come close to the brink of extinction. With a few notable exceptions (Bjorndal et al., 1999; Balazs and Chaloupka, 2004; Chaloupka et al., 2008), many populations are considered depleted or declining (e.g., Meylan, 1999; Witherington et al., 2009). Besides direct take, sources of mortality include high volumes of incidental capture in fishing gear, debris ingestion, disease, and the widespread loss or degradation of coastal habitats (Eckert, 1995). These factors, in combination with a late age at maturity, make for slow and difficult population recovery (Crouse et al., 1987).

1.2 Green turtles

The Green Turtle (Chelonia mydas) has a worldwide distribution across tropical and warm temperate oceans and was previously listed as globally Endangered on the IUCN Red List (Seminoff, 2004). Green turtles in the Gulf of Mexico, Caribbean, and North Atlantic Ocean are part of the North Atlantic Distinct Population Segment and are classified as Threatened under the United States Endangered Species Act (Seminoff et al., 2015; NMFS and USFWS, 2016). In the Azorean archipelago, C. mydas was identified as a priority species for conservation (e.g., PAF Natura 2000).

The green turtle is the largest turtle in both size and weight of the family Cheloniidae, averaging about 120cm straight carapace length and approximately 68-190 kg in size at adulthood. Next to the leatherback, the green turtle is the second largest extant sea turtle (Eckert et al., 1999). The green turtle gets its common name from the colour of its fat, which is green due to its predominantly herbivorous diet of seagrass and algae.

Green turtles can be identified by the following external physical characteristics: smooth oval shell, 5 vertebral scutes, 4 pairs of costal scutes, 4 inframarginal scutes, a pair of prefrontal scales and 4 pairs of postorbital scales on the head, as well as a serrated lower jaw, though occasionally physical mutations can occur (Ergene et al., 2011) (Figure 1).

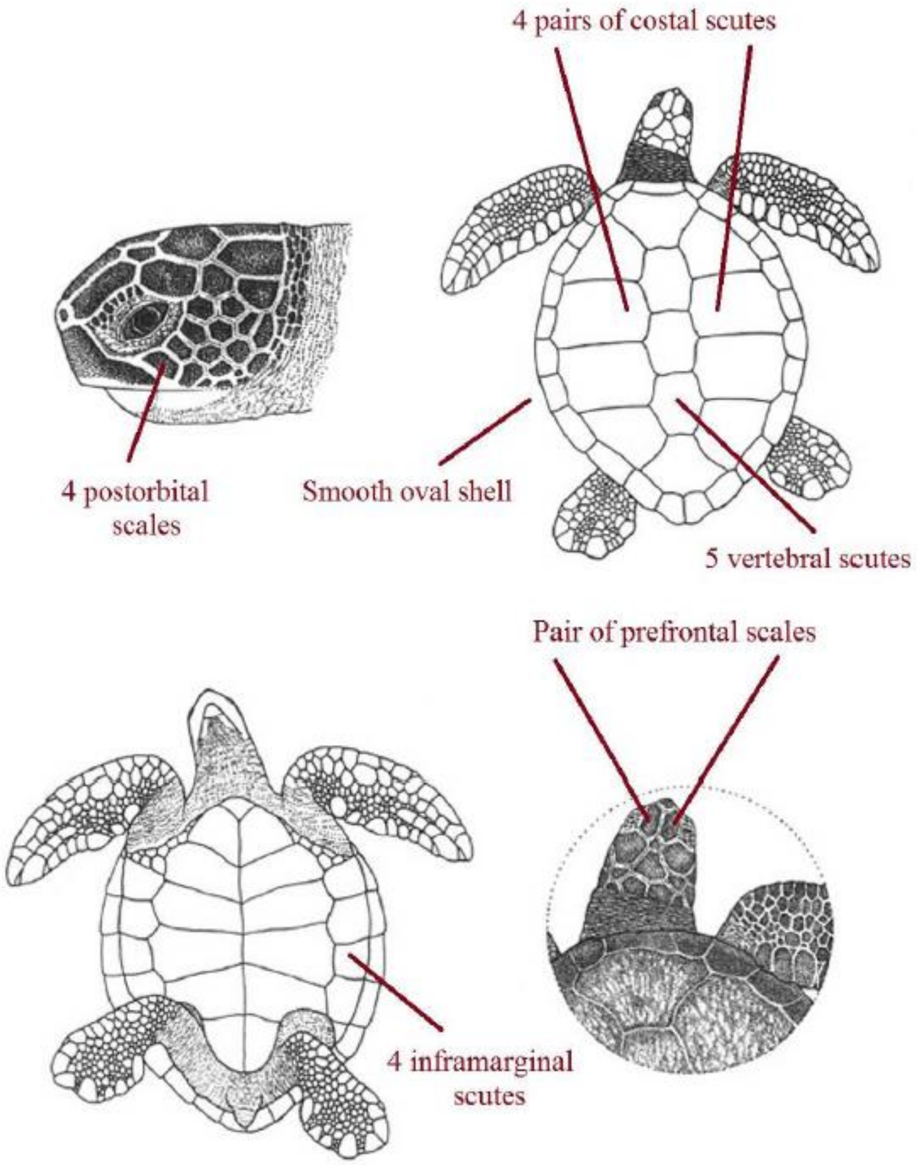


Figure 1 Green turtle external morphology (modified from Eckert et al., 1999)

After green turtle eggs are laid by adult females under the beach sand, they incubate for approximately 50-60 days. When the juveniles emerge, they will typically move immediately to the ocean. Then, they immediately begin swimming rapidly through open water. They enter an oceanic phase, lasting between 3 and 10 years (Zug and Glor, 1998; Zug et al., 2002; Reich et al., 2007) feeding primarily on sea jellies and salps (Bolten et al., 1998; Bjorndal et al., 2003), recruiting to their neritic habitats at sizes of about 25–35 cm straight carapace length (Carr, 1987; Reich et al., 2007;

Meylan et al., 2011). Once they have reached foraging grounds, green turtles often maintain localized, nearshore ranges (Hart and Fujisaki, 2010; Christiansen et al., 2017; Levy et. al., 2017).

Estimates of mean age at maturity tend to vary between populations and the method used to make the estimate, though recent findings from a Pacific population of green turtles (in Hawaii) has recently estimated age at first maturity being 23 years of age and carapace length of 89.7 cm (Van Houtan et al., 2014).

Upon reaching sexual maturity, female green turtles will migrate from foraging grounds to breeding every few years. The migrations between foraging and nesting grounds can vary from hundreds to thousands of kilometres, depending on the population and individual (Limpus, 2008). However, the movements of adult male green turtles are not well-studied overall.

A growing number of studies have suggested that males may mediate gene flow between populations by mating opportunistically between genetically distinct nesting populations (Roden et al., 2013, Nishizawa et al., 2011). This type of mating can occur in the three major habitats utilized by adult sea turtles: nesting areas, mixed foraging aggregations and migratory routes. During the nesting season, females and males aggregate offshore from nesting areas. There, females can mate with either males of the same natal origin or potentially with males of a geographically distant origin that have traveled in search of mating opportunities. This “mate-seeking behaviour” has been reported in males that have migrated between several beaches throughout a nesting season, purportedly to mate with females residing offshore (Wright et al., 2012).

Studies about green turtles diet associate this with seagrass meadows as seen in these early observations in the Indian Ocean (Frazier, 1971; Hirth et al., 1973) and long-term studies in the Caribbean (Bjorndal, 1980; Mortimer, 1981; Vander Zanden et al., 2013) that reported an herbivorous diet dominated by seagrasses. However, back in 1965 Van Bruggen made an observation in the Port Elizabeth Aquarium that green turtles fed on molluscs and fish regularly and sometimes grazed algae on the walls of the tank concluding “In my opinion it is rather doubtful whether these reptiles are true vegetarians; very probably they are omnivorous with a preference for plants if available” Some examples of foraging sites where seagrass is absent or sparse are Japan (Shimada et al., 2014), Queensland, Australia (Garnett et al., 1985; Prior et al., 2016), Turkey (Özdilek et al., 2015), and Uruguay (Darré Castell et al., 2005). At these foraging sites, the green turtle diet is supplemented or dominated by macroalgae. Terrestrial plant material, especially mangrove leaves and propagules, can also feature prominently in green turtle diets at some sites (Arthur et al., 2009; Nagaoka et al., 2012). Although green turtles are primarily herbivorous, reports of a wide-ranging diet of seagrass, marine algae and invertebrates (Jones and Seminoff, 2013) include purposely ingested animal matter, such as gelatinous macrozooplankton (e.g., scyphozoan jellyfish and salps), sponges, molluscs and fish (Mortimer, 1981; Bjorndal, 1997; Burkholder et al., 2011; Fukuoka et al., 2019; Piovano et al., 2020).

Worldwide, green turtle populations are conservatively estimated to have declined by 37–61% over the last 141 years (Seminoff, 2002). Egg harvesting and consumption of turtles are now regulated in most places. However, direct and indirect threats continue to threaten populations: bycatch in fishing gear kills thousands of turtles per year (Wallace et al., 2010), pollution with artificial lights on nesting beaches disrupts nest-site choice and orientation (Witherington and Martin, 2003), and oil spills affect marine turtles through direct contact or by fouling of their habitats. Current conservation practices include the protection of eggs and females on nesting beaches; reduced or no lighting on nesting beaches, chiefly to avoid the disorientation of hatchlings going to sea (Bjorndal et al., 1999); and the implementation of a number of measures to reduce bycatch of sea turtles in a variety of fisheries, such as spatial or temporal no-fishing closures (Lewison et al,. 2003), turtle excluder devices (TEDs) in trawl fisheries (Crouse et al., 1987), and changes in hook design and bait type in pelagic longlines (Watson et al., 2005; Cox et al., 2007). Animals or populations do not occur in isolation, but depend on the environment in which they live, and successful long-term recovery of endangered species can only be achieved if conservation efforts consider the wider goal of protecting an ecosystem's structural (e.g., diversity) and functional (e.g., resilience) attributes.

1.3 Local Ecological Knowledge

The Azores region lacks information about the green turtle population. This challenging situation has led to the use of Local Ecological Knowledge (LEK) as a research tool that includes traditional knowledge of indigenous peoples, to better understand long-term environmental change and human-environment interactions (De Castro et al., 2014; Bao and Drew, 2016; Lee et al., 2019; Barrios-Garrido et al., 2018) since most records come from free-divers that observe the animals in coastal bays and from stranded animals. LEK is used in data-poor scenarios and it is increasingly recognized in conservation, both in terms of uncovering historical trends and for engaging community stewardship of historic information (Early-Capistrán et al., 2020). LEK can be defined as place-based empirical knowledge, held by a specific group of people about their surrounding environments and biota (Bélisle et al., 2018). LEK can provide insights about local natural resources and their value in the lives of local inhabitants and can yield important insights about local beliefs and practices relating to wildlife (Berkes et al. 2000). Understanding LEK and attitudes of local residents have become increasingly important when addressing issues related to natural resource use and conservation (Pierotti and Wildcat, 2000; Charnley et al., 2007; Azzurro et al., 2011), especially considering the intimate links between humans and nature in remote and undeveloped areas (Campbell, 2003). There are a variety of approaches to engage local residents about topics related to natural resource management, such as inviting them to workshops, joining their daily activities, asking them to collect data, and/or conducting interviews to learn LEK.

Indeed, these types of efforts have previously discovered important and novel insights about the biology of local wildlife species and ecosystem functioning (e.g., Wedemeyer-Strombel et al., 2019). For example, local consultation via formal interviews has been effective in obtaining reliable data for assessing the conservation status of a variety of sea turtle populations (Liles et al., 2015; Lucchetti et al., 2017; Palaniappan et al., 2018; Wedemeyer-Strombel et al., 2019). These interviews may help identify critical habitats and strongholds for threatened and endangered species, which is a first step in species conservation. Sea turtles are a taxon for which LEK may be particularly useful for revealing nesting and foraging sites not previously identified (e.g., Liles et al., 2015), and for guiding the implementation of field surveys in previously unstudied and/or remote areas (Carr and Carr, 1991; Tapilatu et al., 2017). LEK does not require that knowledge-holders be indigenous, nor embedded in a broader shared culture, and thus can be applied to people and communities with relatively short histories of interactions with a specific environment (cf. Narchi et al., 2014). LEK data have been used in combination with official records and historical documentation to reconstruct long-term abundance trends of exploited marine species in multiple contexts (Jackson et al., 2001; Beaudreau and Levin, 2014; Lee et al., 2019). LEK also provides baseline data that fill knowledge gaps that cannot be addressed through natural sciences alone (Mukherjee et al., 2018; Mason et al., 2019). Examples include knowledge of ecological change over broad time-scales (Lee et al., 2019), traditional and local resource use (Barrios-Garrido et al., 2018), and conceptual frameworks for ecological modelling (Ainsworth, 2011; Bélisle et al., 2018).

1.4 Azores

The Azores (Portugal) is the most remote oceanic archipelago in the North Atlantic, located between 37º to 41º N and 25º to 31º W, distancing about 1,400 and 2,000 km from continental Europe and North America, respectively. This group of nine volcanic islands and the numerous surrounding seamounts, sits right on the mid-Atlantic ridge at a triple (tectonic plate) junction (Eurasian, Nubian, and North American plates), and was formed by the high eruptive activity in this region. The nine volcanic islands are all inhabited and are divided into three groups: eastern group (composed of the islands of São Miguel and Santa Maria), central group (composed of the islands of Graciosa, Terceira, São Jorge, Pico and Faial) and western group (composed of the islands of Flores and Corvo) (Figure 2). The archipelago extends more than 600 km along with a northwest–southeast trend crossing the Mid–Atlantic Ridge (Morton et al., 1998).

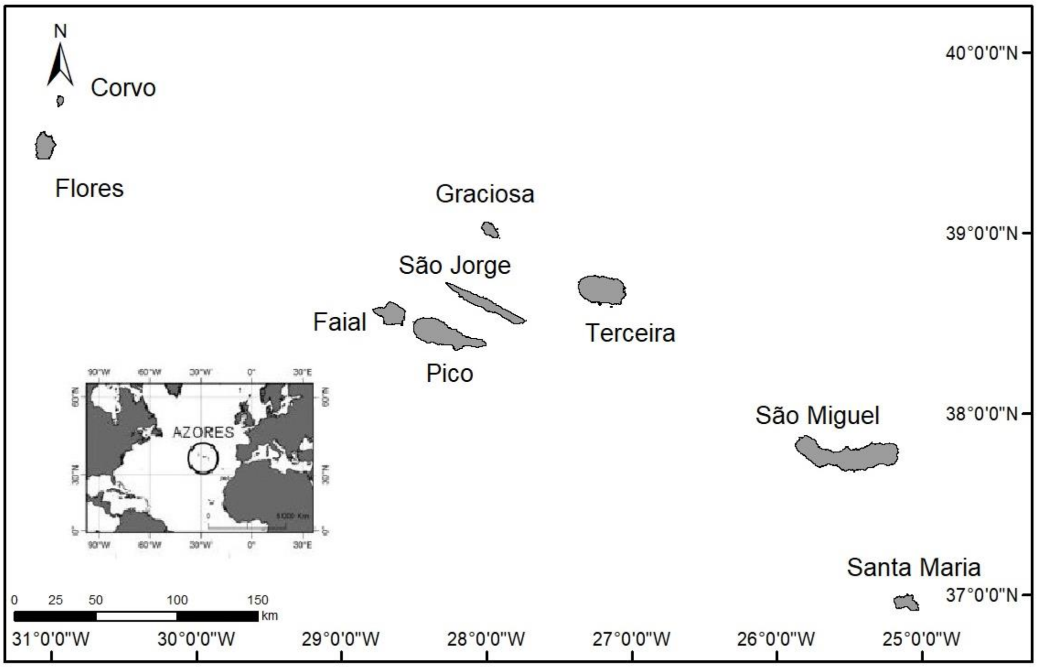


Figure 2 Map of the distribution of the Azores Islands.

The bottom topography of the region is characterized by numerous shallow-water and emergent features (shoals, seamounts, islets and the islands) rising steeply from abyssal depths (>4000 m), as well as deep-water ridges and submarine canyons. This complex topography influences local and regional patterns of ocean circulation, which in turn affects the distribution of marine organisms (Santos et al., 1995).

Present-day volcanic activity in the Azores is marked by highly active fumarolic fields, hot springs and soils diffuse degassing phenomena (Ferreira et al., 2005), where degassing areas are related to hydrothermal systems (Ferreira, 1994) and anomalous

CO_2 fluxes are mainly controlled by tectonic structures and by the geomorphology of the volcanic complex (Viveiros et al., 2010).

The marine environment of the Azores Archipelago and the Exclusive Economic Zone, with 930 687 square kilometres (DGRM, 2021), are of marine biological and conservation interest, in large part due to their isolated location, and the recent age of the Archipelago. The oldest part of the Archipelago is the island of Santa Maria, about 10 to 8 million years old (M.Y.) (Abdel-Monem et al., 1975). The most recent area is the Capelinhos volcano, which is approximately 63 years old, in Faial Island. Most of the islands are aged between 3 M.Y. and less than 1 M.Y.) (Azevedo et al., 1991; Santos et al., 1995).

In climatological-oceanographic terms, the Azores represent an ecotone: its otherwise temperate geographic location is tuned for a subtropical hint by the North Atlantic subtropical gyre via the southeastern branch of the Gulf stream (the Azores current) and its eddies flowing through the southern part of the region (Santos et al., 1995; Caldeira and Reis, 2017). This unique blend of a dynamic oceanography interacting with high seafloor complexity in the middle of the North Atlantic basin is thought to provide the particular conditions which attract oceanic vertebrate megafauna (Afonso et al., 2020).

The Azores Archipelago is situated at the northern edge of the North Atlantic Subtropical Gyre, the rotor of the North Atlantic Circulation (Maillard, 1989). The Gulf Stream current feeds the area, and its southeastern branch generates the eastward-flowing Azores Current (Klein and Siedler, 1989). The Gulf Stream and North Atlantic and Azores currents, and the dynamic Azores Front, are responsible for the seasonal and interannual dependent complex pattern of ocean circulation that characterizes the Azores, and results in the high salinity, high temperature and low-nutrient regime waters (Johnson and Stevens, 2000; Santos et al., 1995).

The Azorean archipelago is characterized by a high oceanographic instability, resulting in numerous cyclonic and anticyclonic eddies regularly detaching from the Azores current (Alves et al., 2002; Alves and Colin de Verdière, 1999; Gould, 1985). Features like mesoscale eddies enhance the primary productivity affecting the entire marine food chain through bottom-up processes in both cyclonic and anticyclonic eddies (Lévy et al., 2001). These mesoscale features are key foraging habitats for many pelagic predators (Scales et al., 2014) such as sea turtles (Chambault et al., 2016; Mansfield et al., 2014; Polovina et al., 2006). These features favour a variety of oceanic and pelagic organisms that bloom along the year (Frick et al., 2009; Dodge et al., 2011), for example, a wide range of gelatinous organisms (Lucas et al., 2014).

The Azores are also known to be a biodiversity hotspot (Santos et al., 1995), hosting a large number of marine megafauna species such as cetaceans (e.g., Clua and Grosvalet, 2001; Hartman et al., 2008; Magalhães et al., 2002; Silva et al., 2014; Steiner et al., 2008), seabirds (e.g., Monteiro et al., 1999, 1996), fishes (e.g., Thorrold et al., 2014; Vandeperre et al., 2014a, 2014b) and sea turtles (Bolten et al., 1998; Santos et al., 2007).

Tourism has largely increased in the archipelago, mostly due to marine-related activities such as sailing, surfing, whale watching and scuba diving (Calado et al., 2011), the geological underwater formations such as caves, tunnels and seamounts and its large iconic species (including sea turtles, groupers, tunas, sharks, manta rays) are at easy access throw all the islands.

Sea turtles are a common presence in the Azorean archipelago. The first records are from 1595 when the Dutch sea captain Van Linschoten wrote in his sailing directions: "…when you pass from 36º to 39º 1/3 degrees you will come to see the island of Flores with many turtles floating in the water". Biologists started asking about the origin of sea turtles in the eastern Atlantic and interest the studying of this animals increased in the 18th and 19th centuries. Prince Alberto of Monaco was a pioneer in this studies, concluding in his several published observations that sea turtles in the Azores must have been transported by the Gulf Stream originating from "Antilles or Floride" (Martins et al., 2018). The hatchlings of loggerhead sea turtles (Caretta caretta) leave the beaches of south-eastern United States with the size of 5 cm carapace length, disappear into the sea and when they are observed again in benthic foraging areas in the Western Atlantic, they have grown into juveniles of about 50 cm. It is this "missing" life stage that was called the "lost year" (Carr, 1982).

Six out of seven species of sea turtles occur in Azorean waters (C. caretta is the most abundant, C. mydas is the second most sighted, less frequently than the previous, D. coriacea not very frequently sighted and, Eretmochelys imbricata, Lepidochelys kempi and Lepidochelys olivacea have very few sighting records) (Santos et al., 1995; Varo-Cruz et al., 2017; Bolten and Martins, 1990; Barcelos et al., 2021) but there are no records of nesting sea turtles in the Azores, mainland Portugal or in other Atlantic European countries (Cabral et al., 2005; Brongersma, 1982; Carr, 1957; Deraniyagala, 1952). Conservation of marine turtles in the Azores is ruled by international conventions (e.g., Bern Convention) which establish total protection of the species. Some local exploitation for food and curios was common until a few years ago. This has stopped as public opinion has changed (Santos et al. 1995).

The Azores region is along the migratory corridor during oceanic leatherback turtle migrations between feeding and nesting areas (Fossette et al., 2010) and it is used as a feeding foraging site for loggerhead turtle juveniles' population nesting in the southeastern United States (Bolten et al., 1993, 1998).

The green turtle is thought to be common in the archipelago however hardly any information exists for this species in the area. Green turtles are highly migratory and have a long and complex life cycle. In the Azores, they consist exclusively of juveniles that have a cryptic lifestyle and are therefore seldom observed. A study by Witham (1980) provided a model for the transport of neonate green turtles from the east coast of Florida in the Gulf Stream, around the North Atlantic Basin in the North Atlantic gyre, with return to the Caribbean and Florida in the North Equatorial Current. He also provided tagging records of yearling green turtles released in Florida and recovered in the Azores (Witham, 1980).

1.5 Objectives of the study

Effective conservation strategies for sea turtles require knowledge of animal movements and protection of biologically important habitats and life history stages. Understanding both their inshore and pelagic spatial patterns is imperative to the successful protection of the species and the accurate identification of their vulnerabilities. This study aims to characterize the occurrence and distribution of green turtles in the Azores. Our approach consists in gathering and exploring different sources of information by (i) gathering local knowledge through questionnaires; (ii) analysing the data to create maps of the C. mydas geographical distribution in the Azores, (iii) and exploring citizen science approaches. This will help us identify green turtle geographical distribution in the Azores as well as an initial description of the ecology of the species in the area.

2. Methods

2.1 Study site

The data were collected in the Azores. The archipelago is predominantly deep waters and steep island slopes with small shelves delimitate coastal habitats (Pitcher et al., 2008; Isidro, 1996). The region is characterised by a high salinity, high temperature and low nutrient regime (Santos et al., 1995). The study area comprises the coastal zones of Faial and Pico, having similar marine environment with common hard- and soft-bottom features like bedrocks, boulder fields, sandy bays, caves, shallow banks, cliffs and canyons. Most of the coast is exposed to the full forces of wind and swell but smaller areas with shelter exist, mainly in bays along the coastline. The littoral areas present a great variety of coastal habitats including boulder fields, bedrock reefs, volcanic cones, cliffs and enclosed bays that are subject to a great variety of hydrodynamic conditions (Schmiing et al., 2013).

The Azores archipelago is an emerging tourism destination for marine-related activities such as sailing, surfing, whale watching and scuba diving (Calado et al., 2011) mainly due to its large iconic species (including sea turtles, groupers, tunas, sharks, manta rays) and its geological underwater formations such as caves, tunnels and seamounts. Divers have abundant access to the water in the study islands consequently they become a great source of information in marine life they observe.

2.2 Interviewing method

Data collection took place from August 2020 to April 2021. The research followed a quantitative, descriptive and non-experimental method of data collection, deploying a structured questionnaire survey for marine users, that was mainly directed at divers, and free divers in particular (e.g., spear fishers). They were invited to answer a series of questions regarding the presence of green turtles (C. mydas) in the archipelago. The sampling method chosen was the snowball method (Bailey, 1982). A sampling procedure may be defined as snowball sampling when the researcher accesses informants through contact information that is provided by other informants. This process is, by necessity, repetitive: informants refer the researcher to other informants, who are contacted by the researcher and then refer the researcher to yet other informants, and so on. Hence the evolving ‘snowball’ effect, captured in a metaphor that touches on the central quality of this sampling procedure: its accumulative (diachronic and dynamic) dimension (Noy, 2008). It is sometimes used as the main vehicle through which informants are accessed, or as an auxiliary mean, which assists researchers in enriching sampling clusters, and accessing new participants and social groups when other contact avenues have dried up (Hendriks, 1992).

No personal data of the participants was collected. Therefore, all data were treated anonymously. Further, no sensitive data were requested throughout the research, respecting the privacy of the participants.

Initially, interviews were conducted in the island of Faial. These interviewees were sampled using the snowball method in which marine users in Faial indicated other marine users and how to contact them. Field data were collected first through semi-structured interviews and later through well-designed questionnaires which are suitable for research where it is desired to quantify the results subsequently. The marine users were approached individually, initially at Horta's marina where marine tourism companies operate.

2.3 Online questionnaire

As the research advanced, some complications were encountered due to the current pandemic situation where free circulation was limited and in-person questionnaires were no longer feasible as a result of social distancing. The extension of the fieldwork to Pico was therefore made impossible. As a result, an online questionnaire was designed with Google Forms (www.google.com/forms/) following the same structure as the in-person questionnaire. This allowed an expansion of the study site from Faial to all the islands in the Azorean archipelago. The snowball sampling was applied in this case as well. Regarding the contact with the freedivers, the questionnaire was sent to ARPLA (Associação Regional de Pesca Lúdica dos Açores) and from there the association sent it to all its members where they could access it. The members would be contacted via email with the link (https://bit.ly/2HXFPCx) to the questionnaire and the indication to share it with other free divers they knew (Figure 3).

Avistamento de tartarugas verdes (Chelonia mydas)

O objetivo deste questionário é caracterizar a ocorrência e distribuição das tartarugas verdes (Chelonia mydas) nos Açores.

A tartaruga verde é comum no arquipélago e foi identificada como uma espécie prioritária para conservação devido ao seu estado de conservação precário (lista vermelha da IUCN "em perigo"). No entanto, não existe quase nenhuma informação para esta espécie na área.

As tartarugas verdes são altamente migratórias e têm um ciclo de vida longo e complexo. Nos Açores, são exclusivamente constituídos por juvenis com um estilo de vida enigmático e, por isso, raramente observados.

A maioria dos registros vem de mergulhadores livres que observam os animais em baías costeiras e de animais encalhados.

Assim, temos como objetivo chegar ao máximo de pessoas (mergulhadores, caçadores submarinos, entre outros) para que estas nos possam ajudar no registo da presença desta espécie no arquipélago dos Açores.

Pode ser encontrada mais informação em:
https://costaproject.org/
https://www.facebook.com/seaturtlesintheazores

*Obrigatório

Figure 3 Online questionnaire introduction (https://bit.ly/2HXFPCx).

2.4 Description of the questionnaire

The survey was composed of 20 questions divided into two sections: 1) description of the green turtle sighting and 2) interviewees' profile (Figure 27).

The first section contained 11 questions of three types, closed, multiple-choice and interactive choice-based questions. Closed questions were about the date the sighting occurred, the depth of the sighting and if the same individual was sighted on multiple occasions.

In the multiple-choice questions the interviewee could choose between predetermined answers. These questions were related to the knowledge about the different sea turtle species in the Azores, the seafloor type, the sea turtle size, the sea turtle activity during the sighting and in which island the sighting occurred.

The interactive choice-based question was about the location of the sighting. On the in-person questionnaire, the interviewee was asked to pinpoint the exact place on the map where the sighting took place and provide a short description of the location (e.g., 50 meters from the coast in the direction of the lighthouse). For the online survey some adjustments were made. The interviewee was directed to the map of the island where the sighting occurred. The map was layered with a grid table and labelled with letters and numbers. The interviewee was asked to indicate the grid cell of the location together with a short description of the location (e.g., D7, 50 meters from the coast in the direction of the lighthouse).

The second section of the questionnaire was a description of the interviewees' profiles and activity. All of the information provided was anonymous in order to respect the interviewees' privacy. The objective was to assess possible bias in the survey and obtain information about the observation effort.

This section was composed of 9 questions, closed, multiple-choice and interactive choice-based questions. Closed questions included the age of the interviewee, years of practice of the activity and the average duration of each event (e.g., spearfishing trip) and, in the case of diving related activities, the maximum depth the interviewee dives. Multiple choice questions comprehended the residence of the interviewee, the activity practiced by the interviewee, level of experience and frequency.

The last question was an interactive choice-based about the where and with which intensity the activity was practiced in order to obtain a semi-quantitative estimate of the observation effort. The interviewee was asked to indicate on a map where he practices his activity with, high (>50% of the occasions), medium (<50% and >10%) and low (<10%) intensity. On the in-person survey, they would indicate these areas on a map and identify the intensity with the letters A (high), M (medium) and B (low). On the online survey, they were directed to the maps, layered with a table grid and labelled with numbers and letters, where they had three different closed questions. On the first question, they would indicate the squares where they practice their activity with high intensity, the second question where they practice their activity with medium intensity and the third and last question where they practice their activity with low intensity.

2.5 Data analysis

Closed and multiple questions were analysed with RStudio (R Core Team, 2021). The packages "ggplot2" (Wickham, 2016) and "tidyverse" (Wickham, 2019) were used to determine the mean, median, maximum and minimum of the closed questions. With the data collected by both close and multiple questions histograms were plotted to visualize peaks and/or identify anomalies.

All geospatial analysis and visualisations were performed using ArcGIS 10.8.1 software (ESRI, 2021). The location of sightings was placed by hand and connected to the additional information provided by the previous questions. The sighting density was calculated using the Kernel Density tool (Silverman, 1986). The surface value is highest at the location of the point and diminishes with increasing distance from the point. Only a circular neighbourhood is possible. The density at each output raster cell is calculated by adding the values of all the kernel surfaces where they overlay the raster cell centre.

The sighting effort was calculated based on the areas with high, medium and low frequency. To calculate the sighting effort a value was assigned to each frequency (high intensity = 6, medium intensity =3 and low intensity = 1) and it was multiplied by the average hours of each dive and the average number of dives per year. The value obtained was calculated with the grid calculations and created a map that illustrates the areas with more or less sighting effort.

2.6 Citizen science

At the end of each questionnaire, the interviewees were encouraged to share any type of image (video or pictures) of the encounter with the green turtle, past and future, to help confirm the species determination and eventually other relevant information from the footage. They were also handed a laminated flyer (Figure 4) that would help the interviewee with the identification of the sea turtle species. In the online survey the interviewees were given an email (recapturas@gmail.com) to share the images and ask any questions in case of doubts about the questionnaire or the species. For further information about sea turtles, they were directed to the Facebook page “Sea Turtles in the Azores” (which was also a form of contact for the questionnaire) and to the COSTA Project website (https://costaproject.org) (Figure 5).

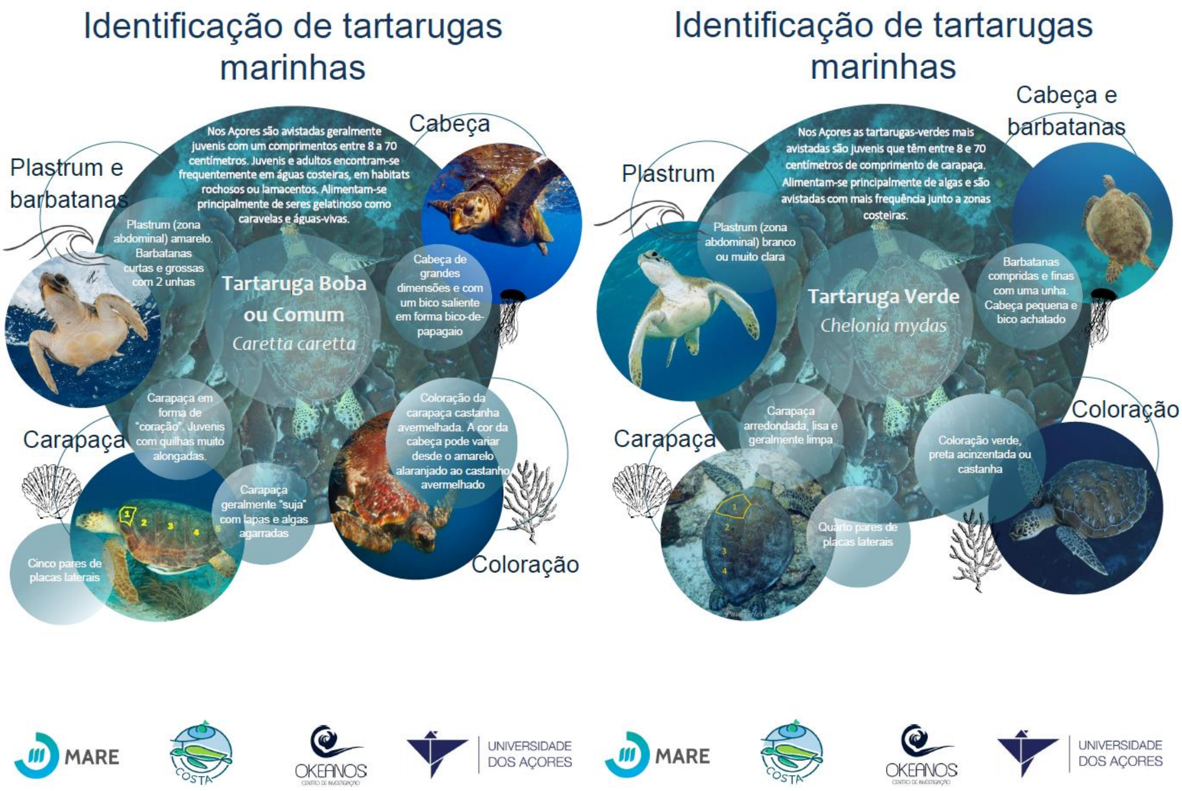


Figure 4 Informative flyer to help distinguish Caretta caretta from Chelonia mydas

Avistamento de tartarugas verdes (Chelonia mydas)

A sua resposta foi registada.
Obrigada pela participação!

Se tiver alguma dúvida entre em contacto em:
recapturas@gmail.com
ou
https://www.facebook.com/seaturtlesintheazores

Pode ser encontrada mais informação em:
https://costaproject.org/

Enviar outra resposta

Figure 5 Contact information on the online questionnaire.

3. Results

3.1 Profile of marine users

Sixty-eight marine users were interviewed for this study. Questionnaires were performed in two different ways, twenty-seven in-person and forty-one online. Sixty-six were from residents of the Azores coming from six out of the nine islands (São Miguel n=3, Santa Maria n=2, Terceira n=4, São Jorge n=1, Pico n=7, Faial n=49). Two questionnaires came from non-residents (Figure 6).

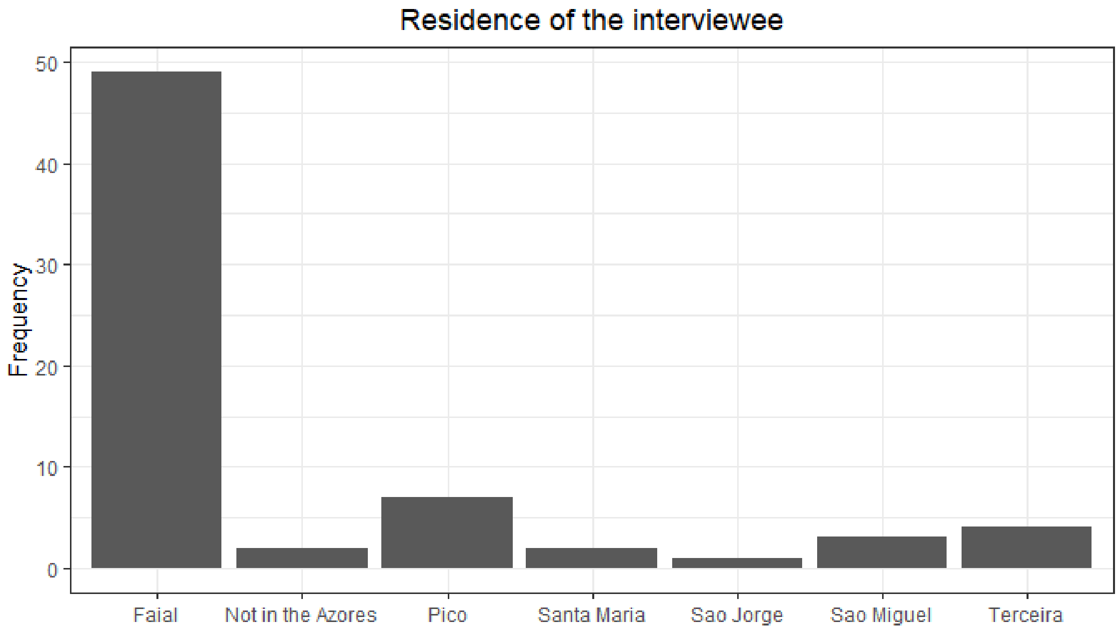


Figure 6 Graphical representation of where the interviewees are from, distinguished by Azoreans (specifying from which island) and non-Azoreans.

These results show the geographic distribution of the interviewees, displaying a clear peak of answers coming from Faial Island with 72.1% answered surveys, followed by Pico Island with 10.3% of survey answers. These two islands have easy access between them, allowing interviewees to perform their activity on both islands. This allowed for a more detailed analysis of the distribution of the sightings and sighting effort in Faial and Pico islands.

Analysis of the age distribution showed a range between 15 and 63 years of age. Most interviewees, 45.6%, were between 30 and 40 years old (Figure 7).

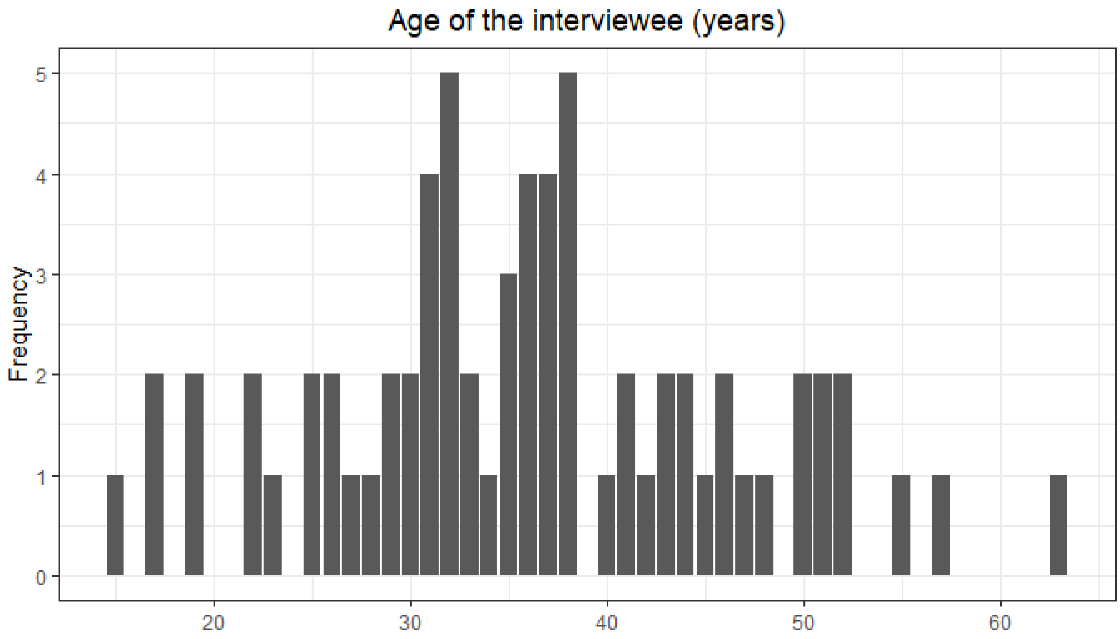


Figure 7 Graphical representation of how old the interviewee is (years).

When asked about the nautical activity they practiced, the majority (91.2%) answered scuba diving and freediving (inshore fishing n=2, free diving n=2, biologist (during fieldwork) n=1, maritime-tourism n=2, sail n=1, scuba diving n=15, snorkelling n=5, spearfishing n=39, swimming n=1) (Figure 8). Two peaks can be observed as 57.4% of the interviewees practiced spearfishing and 22.1% practiced scuba diving. For this study, only sightings performed during diving related activities were analysed in order to avoid biases related to the activity.

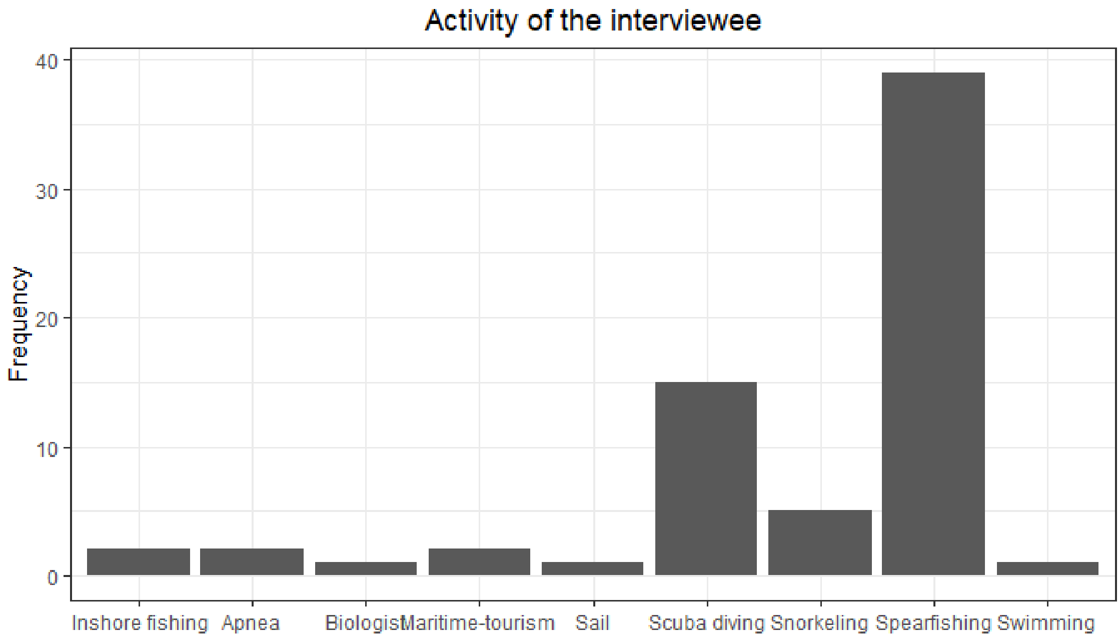


Figure 8 Graphical representation of what is the activity performed by the interviewee.

Nevertheless, the interviewees who practiced diving related activities showed relevant differences when asked about their maximum dive depth. Scuba divers displayed a wider range of depth (maximum=70 m, minimum=18 m) (Figure 9a) than free divers (maximum=45 m, minimum=2 m) (Figure 9b).

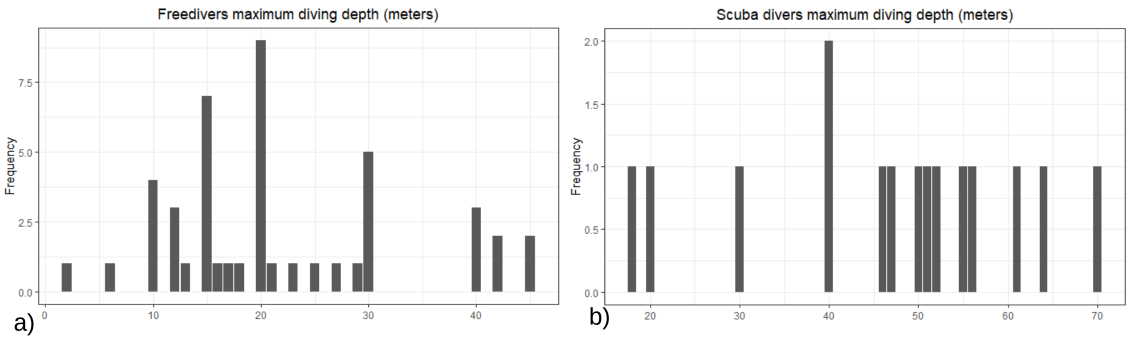


Figure 9 Graphical representation of: a) what is the maximum depth free divers dive (meters) and b) what is the maximum depth scuba divers dive (meters).

The next set of questions had the objective of understanding the experience of the interviewees at their activity. When asked for how long they practiced the activity in years the answers were mostly 10 or 20 years of experience (maximum=50, minimum=1, mean=15, median=14) (Figure 11).

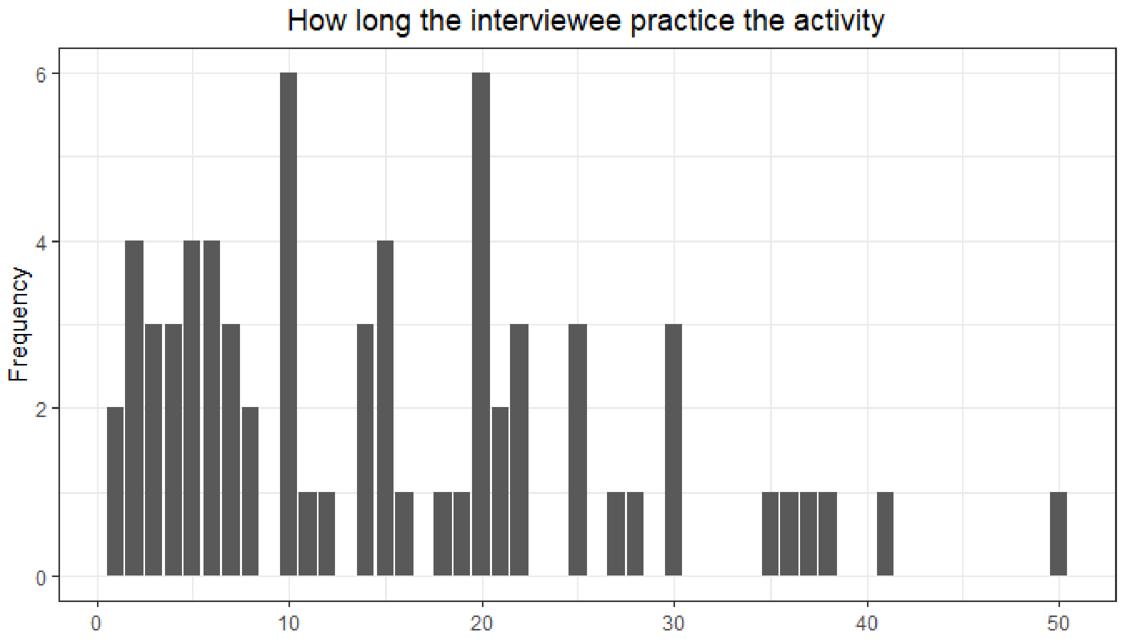


Figure 10 Graphical representation of how long the interviewees have been performing their activity (years).

Ten people self-classified themselves with low experience, 32 people self-classified themselves with medium experience and 26 people self-classified themselves with high experience (Figure 11a). Therefore, 85.3% of the interviewees self-classified themselves as medium and high experienced.

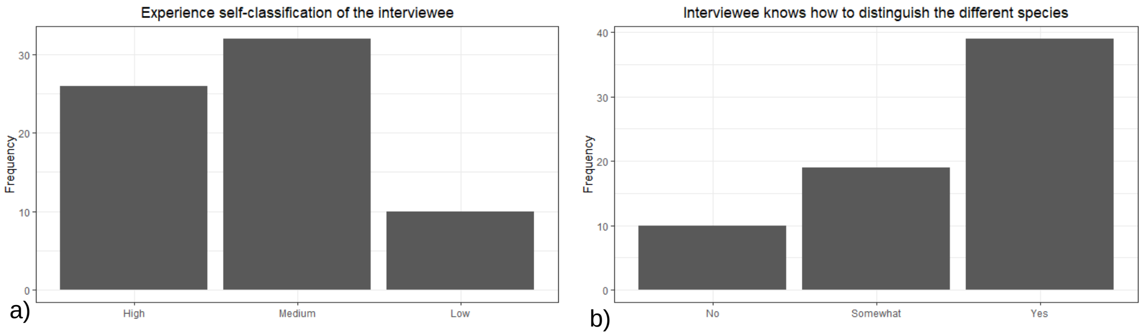


Figure 11 Graphical representation of: a) how the interviewees self-classify themselves on how much experience they have performing their activity and b) how many interviewees know to distinguish the different species of sea turtles that occur in the Azores.

When questioned about their capacity to distinguish the different sea turtle species that occurred in the Azores, 57.4% responded that they were able to distinguish the different species, 27. 9% responded that they were somewhat able to distinguish the different species and 14.7% responded that they were not able to distinguish the different species (Figure 12b).

When comparing the interviewees who sighted at least one green turtle with their knowledge of the species of the interviewee (Table 1) it is possible to see that twenty-seven sightings (56.3%) were from people who could distinguish the different species, seventeen (35.4%) from people that could somewhat distinguish the different species and four sightings (8.3%) were from people who said they could not distinguish the different species.

On the other hand, there were twelve people (60.0%) who could distinguish the different species, but did not sight a single green turtle, two people (10.0%) who could somewhat distinguish the different species but did not sight a green turtle and six people (30.0%) who could not distinguish the different species of sea turtles and did not sight a green turtle.

Table 1 Results about the comparison of the interviewees knowledge of how to distinguish the different species of sea turtles in the Azorean waters and if a sighting occurred or not.

	Knows how to distinguish the different species		
Sighting	Yes	Somewhat	No
Yes	27	17	4
No	12	2	6

The results also show that there is a clear relationship between experience and the knowledge to distinguish the species. Of the people who self-classify as highly experienced, 29.4% claim to be able to distinguish the species, whereas this percentage decreases to 22.1% and 5.9% for people with medium and low experience respectively. However, 1.5% of the interviewees self-classify as highly experienced and are not able to distinguish the species, whereas this percentage increases to 7.3% and 5.9% for people with medium and low experience respectively.

Table 2 Results about the comparison of the interviewees' knowledge of how to distinguish the different species of sea turtles in the Azorean waters and how they self-classify their experience practicing their activity.

	Knows how to distinguish the different species		
Experience	Yes	Somewhat	No
High	20	5	1
Medium	15	12	5
Low	4	2	4

When looking deeper at the activities, 46.2% of the spear fishers indicated that they know how to distinguish the different species of sea turtles and 38.5% know somewhat how to distinguish the different species, while 28.2% of spear fishers self-classify with high experience and 59.0% with medium experience.

In the scuba divers case there are two evident peaks that 86.7% know how to distinguish the different species of sea turtles and 73.3% self-classify with high experience.

Table 3 Results about the comparison of the interviewees' activity and their knowledge on how to distinguish the different species of sea turtles in the Azorean waters and how they self-classify their experience practicing their activity.

	Knows how to distinguish the different species			Experience self-classification		
Activity	Yes	Somewhat	No	High	Medium	Low
Spearfishing	18	15	6	11	23	5
Scuba diving	13	1	1	11	2	2
Snorkelling	3	1	1	1	2	2

The forty-seven free divers that answered the questionnaire sighted 70 green turtles and the eleven scuba divers sighted 15 green turtles. At the same time, scuba divers only spent an average of 0.81 hours and free divers spent an average of 2.42 hours each dive.

Even though these are two different activities with likely a different probability to sight green turtles, the data were aggregated, in this study as the main objective was to characterise the distribution of green turtles and the locations used for both activities largely overlapped, with the exception of marine reserves.

When looking at age, the data show that in the group 10 to 30 years old a similar percentage of interviewee indicated that they know (44.4%) or know somewhat (50.0%) to distinguish the species. However, in the older groups, 31 to 50 years old and 51 to 70 years old, the majority of respondents indicate that they were able to distinguish the species (60.5% and 71.4% respectively).

Table 4 Results about the comparison of the interviewees' age and their knowledge on how to distinguish the different species of sea turtles in the Azorean waters.

	Knows how to distinguish the different species		
Age class (years)	Yes	Somewhat	No
10 to 30	8	9	1
31 to 50	26	10	7
51 to 70	5	0	2

3.2 Green turtles sightings

Eighty-seven sightings of green turtles were described by the interviewees, of which 36.8% were single sightings, where one interviewee sighted one green turtle, and 63.2% were multiple sighting, where an interviewee sighted more than one green turtle in different occasions.

For the years 2020 and 2021 sixty-one sightings were recorded (70.1%) (Figure 12). Before 2020, interviewees reported twenty-six sightings (29.9%), the oldest sighting being 2001.

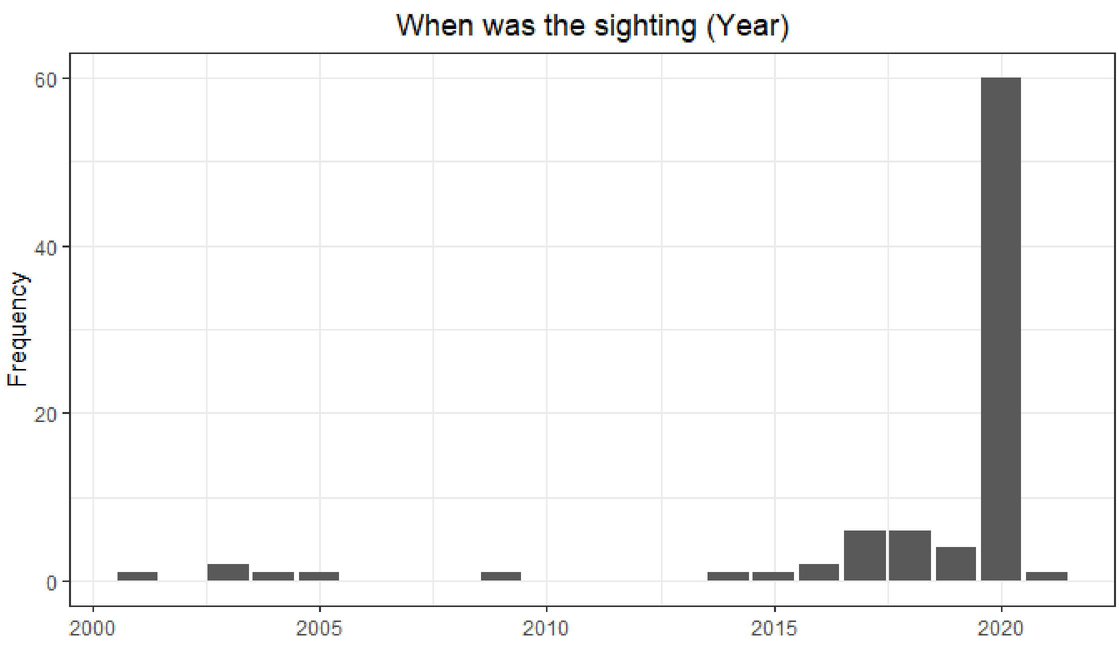


Figure 12 Graphical representation of the year when the sighting of the green turtle occurred.

In terms of seasonality, most sightings occurred in summer and autumn (Figure 13) which corresponds to the seasons when the interviewees practiced diving more frequently. They hereby often referred to weather and sea conditions as reason.

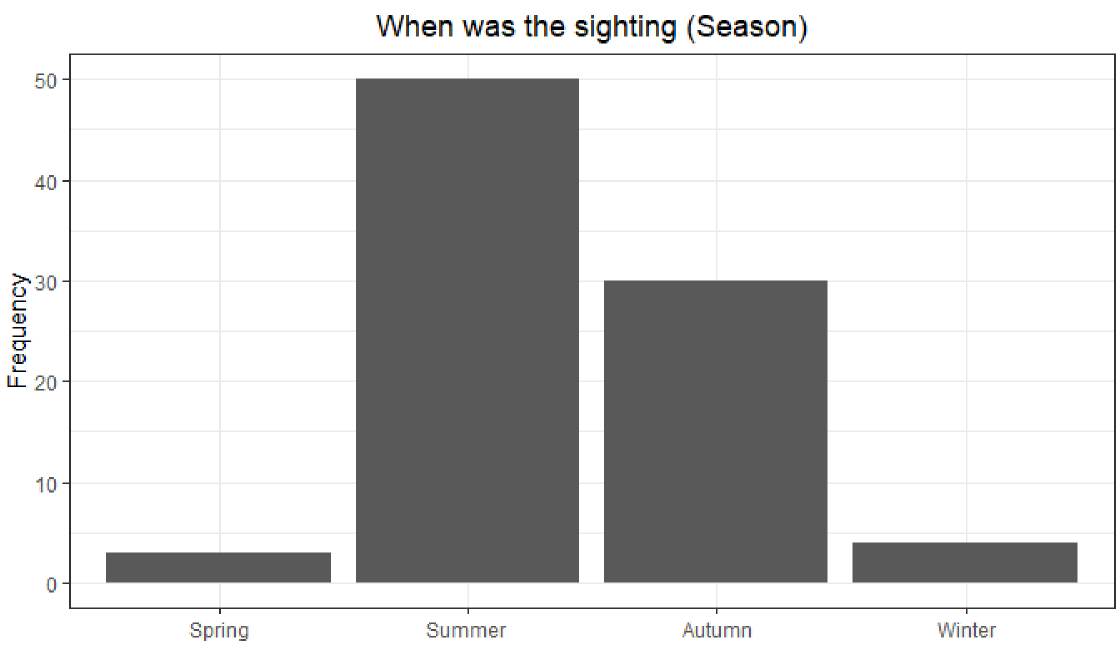


Figure 13 Graphical representation of when the sighting of the green turtle occurred. Spring = March, April and May; Summer = June, July and August; Autumn = September, October and November; Winter = December, January and February.

Interviewees were asked to describe the turtle carapace length and the majority estimated size between 30 and 49 cm (Figure 14). Since a known size at maturity is 89.7 cm, it is possible to affirm that all sighted green turtles were juveniles.

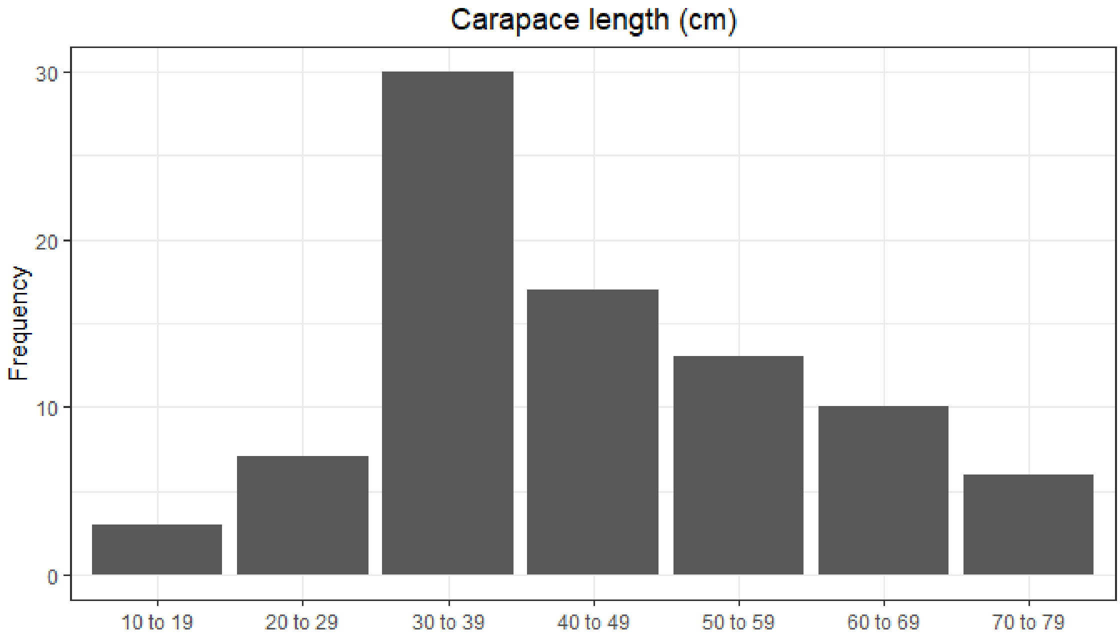


Figure 14 Graphical representation of the size of the sighted green turtle in centimetres

Activity of the turtle was mainly swimming at the bottom (33.3%) and lying still at the bottom (27.6%) (Figure 15). Other activities described were swimming at half-water (14.9%), swimming at the surface of the water (14.9%) and only 8.0% were feeding and one blank, indicating the interviewee was not able to remember the activity.

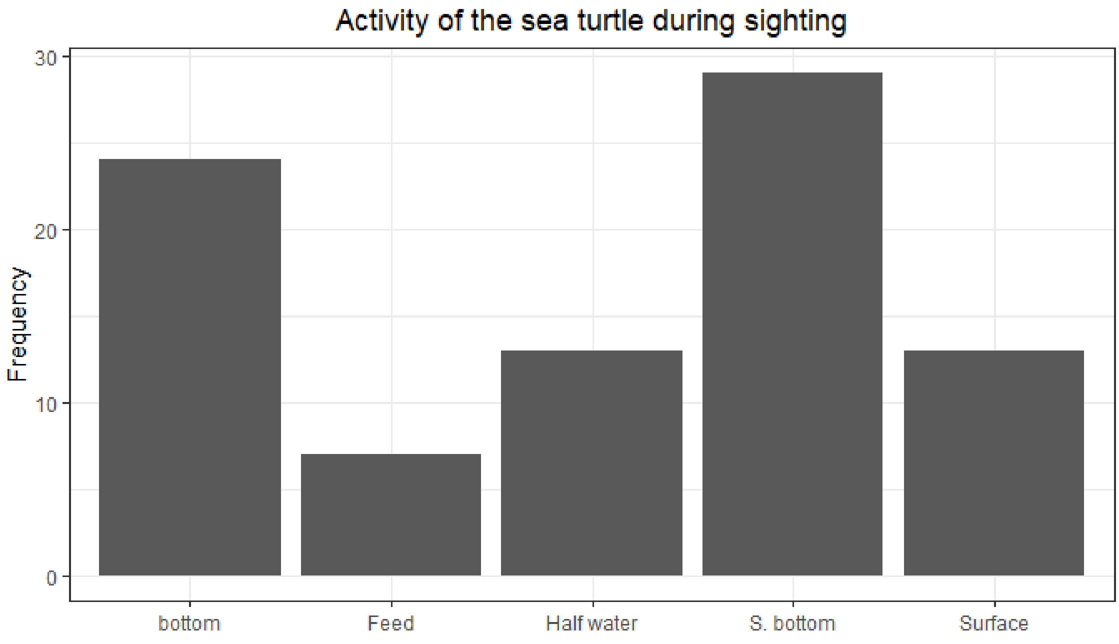


Figure 15 Graphical representation of the activity of the sighted green turtle. Bottom = lying still at the bottom, feed = feeding, half water = swimming at half water, s. bottom = swimming at the bottom and surface = at the surface.

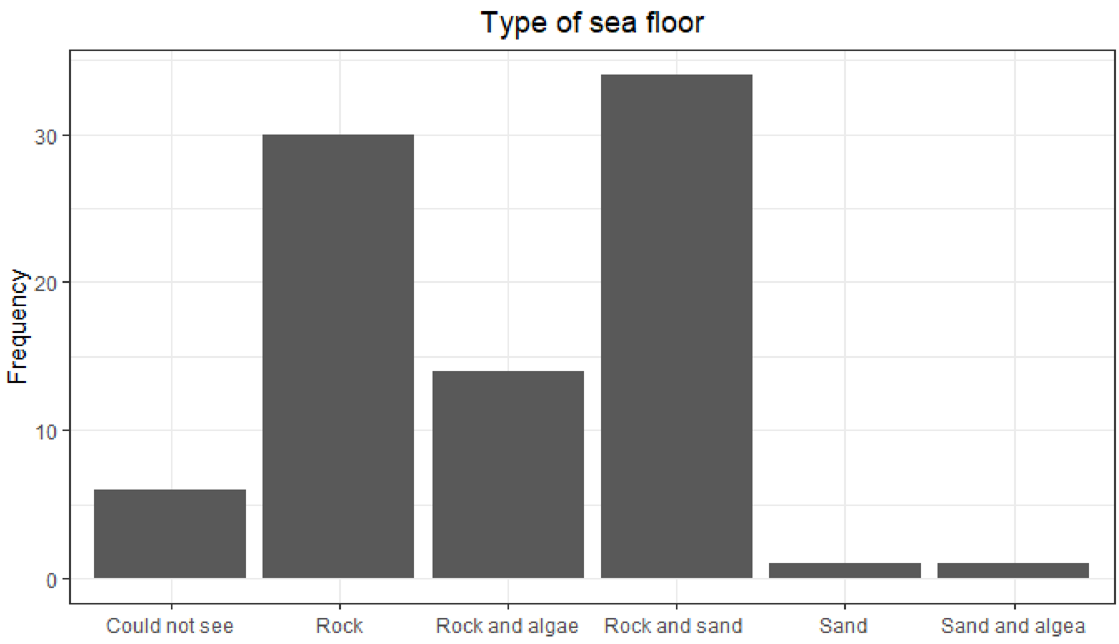


Figure 16 Graphical representation of the type of seafloor where the sighting occurred.

The interviewees described the seafloor type where the sighting occurred mainly as rocky (90%; rock n=30, rock and algae n=14, rock and sand n=34) (Figure 16).

Depth at which the sea turtle was sighted ranged from the surface to 25 meters depth with a mean and median of 8 meters (Figure 17).

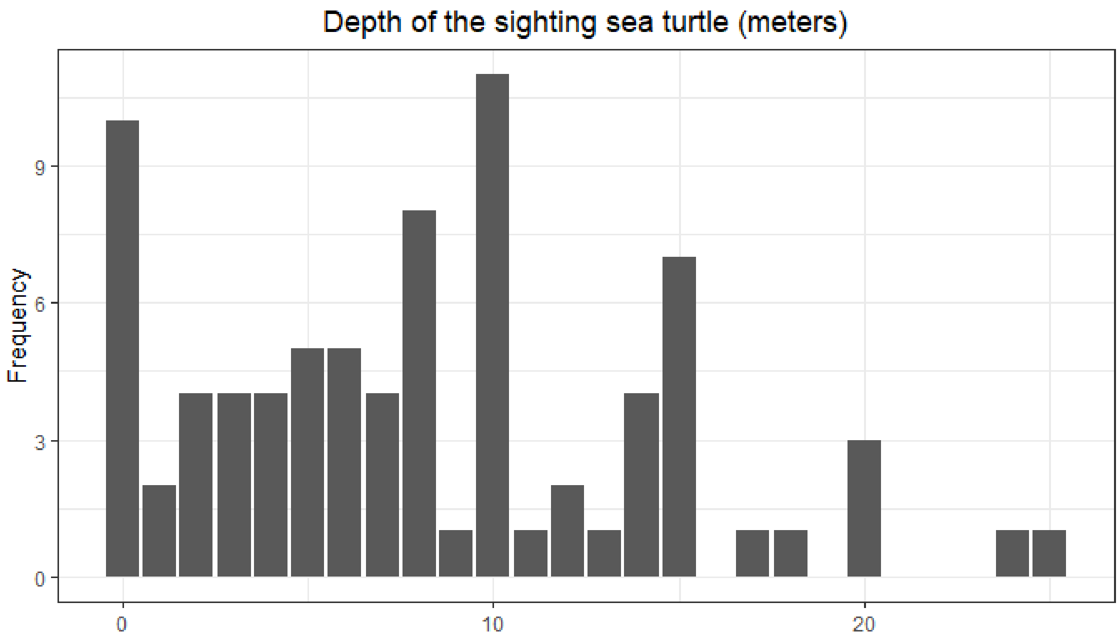


Figure 17 Graphical representation of the depth which green turtles were found.

The location of the sightings was first classified by the island after which a more detailed description of the location was asked. Figure 18 shows that the majority of sightings occurred in the islands of Faial (n=39) and Pico (n=30), which were also the islands for which most questionnaires were answered (Table 5).

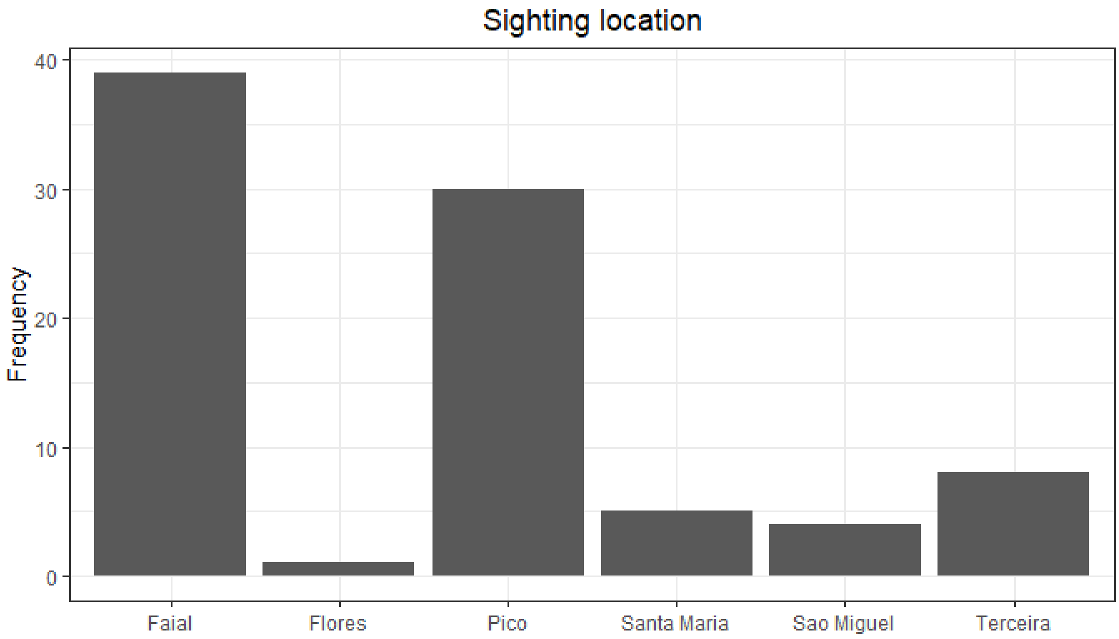


Figure 18 Graphical representation of in which Azorean island the green turtle sightings occurred.

Table 5 Percentages of questionnaires from each island and percentage of sighting in each island.

	Azores Islands								
Values	Corvo	Faial	Flores	Graciosa	Pico	Santa Maria	São Jorge	São Miguel	Terceira
Questionnaires	0	72.1%	0	0	10.3%	2.9%	1.5%	4.4%	5.9%
Sightings	0	44.8%	1.1%	0	34.5%	5.7%	0	4.6%	9.2%

Overall, respondents affirmed to have seen the same turtle on different occasions in only 5.7% of the questionnaires (Figure 19).

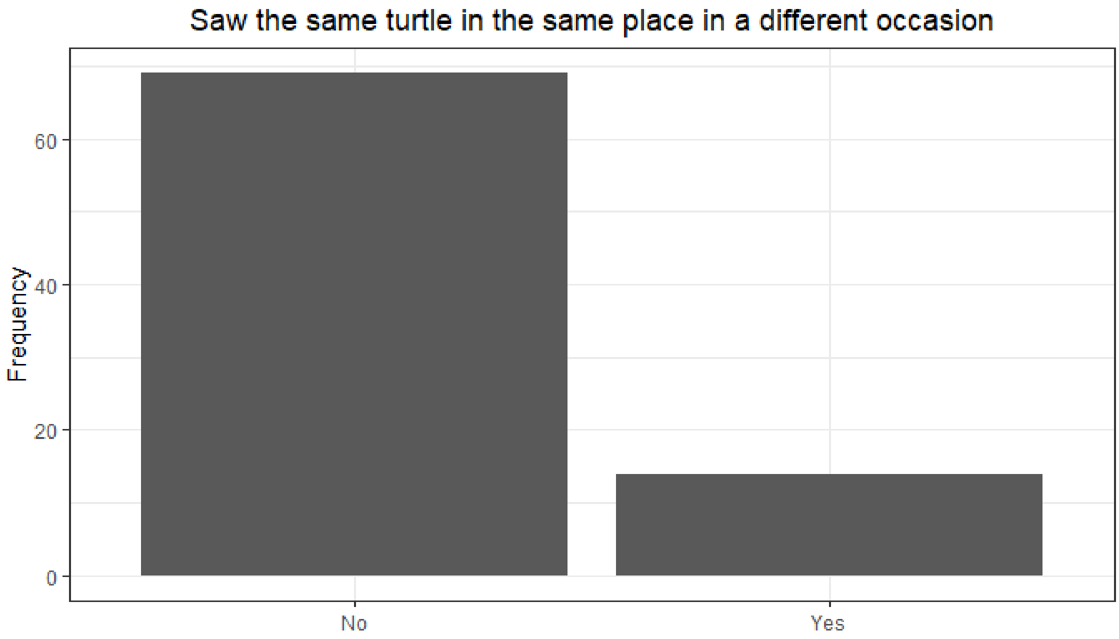


Figure 19 Graphical representation of how often the same person see the same green turtle in the same location but at a different occasion.

3.3 Maps with the distribution of the sightings (Faial and Pico)

Most sightings occurred around Faial and Pico as described previously, and as a consequence, only those islands have enough information to build informative maps. By introducing the information given in the questionnaires, maps were built in ArcGIS software that show the location (dark blue circles) and density of the sightings (red represents high density and green low density) (Figure 20).

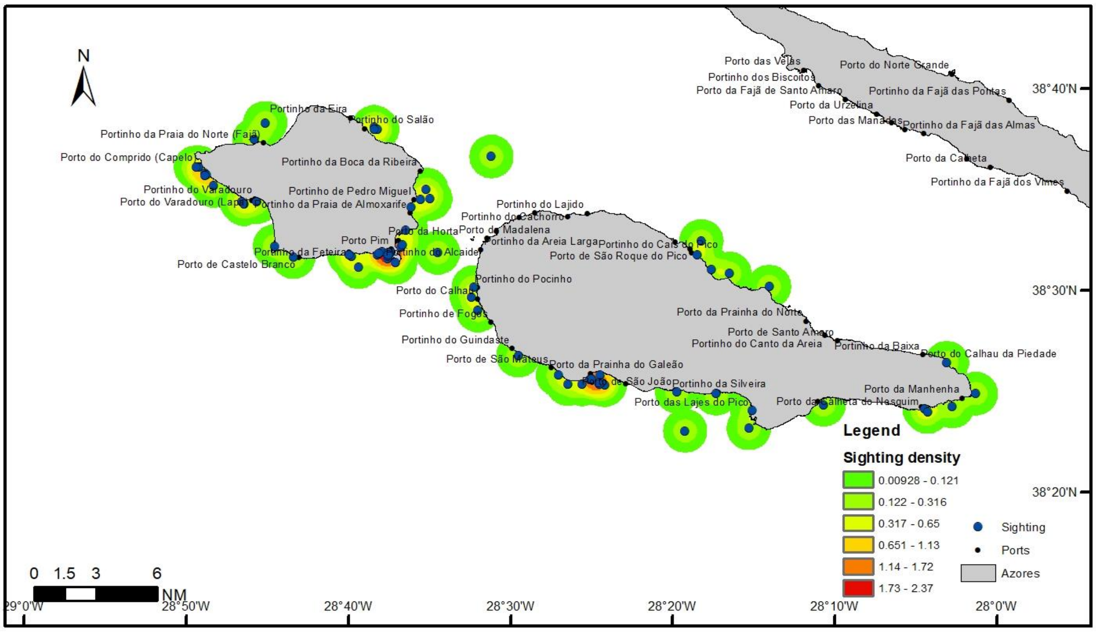


Figure 20 Graphical illustration of locations of green turtle sightings occurred and sighting density in the islands of Faial and Pico, Azores.

Most green turtles in Faial Island were sighted in Porto Pim and Portinho do Alcaide and the area around Monte da Guia, followed by Porto do Comprido (Capelo) and Portinho do Salão.

In Pico Island the most sightings of green turtles occurred in Porto da Prainha do Galeão, the second most sightings occurred in Porto do Calhau and Portinho de Fogos followed by Porto da Calheta do Nesquim.

To compare with information given in the questionnaires, different layers were overlaid on the sighting location and sighting density layers contouring lines of the seafloor depth around the islands (Figure 21) and type of sediment (Figure 22).

Figure 23 illustrates a higher density of sightings in the shallower areas. Most sightings occurred within the 500 meter depth contour, close to the shore and in areas with a rocky seafloor. This information is seconded with the information provided by the questionnaires where the seafloor was mainly described as rock, rock and sand, and rock and algae (90%).

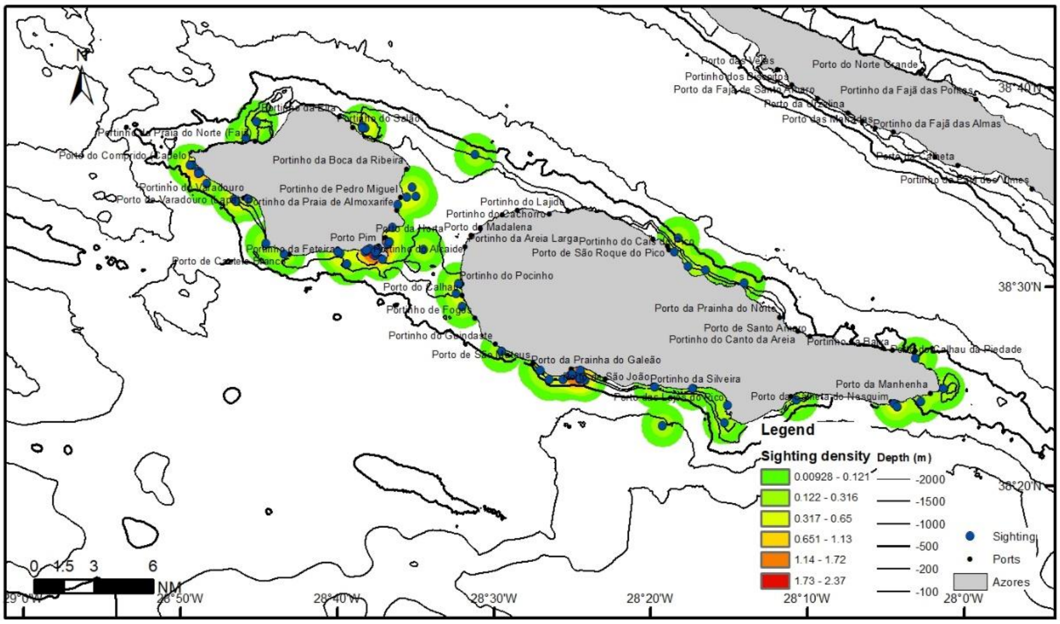


Figure 21 Graphical illustration of the islands Pico and Faial and the places where the sightings occurred (dark blue circles) and the sightings density complemented with the contouring of the depths (meters).

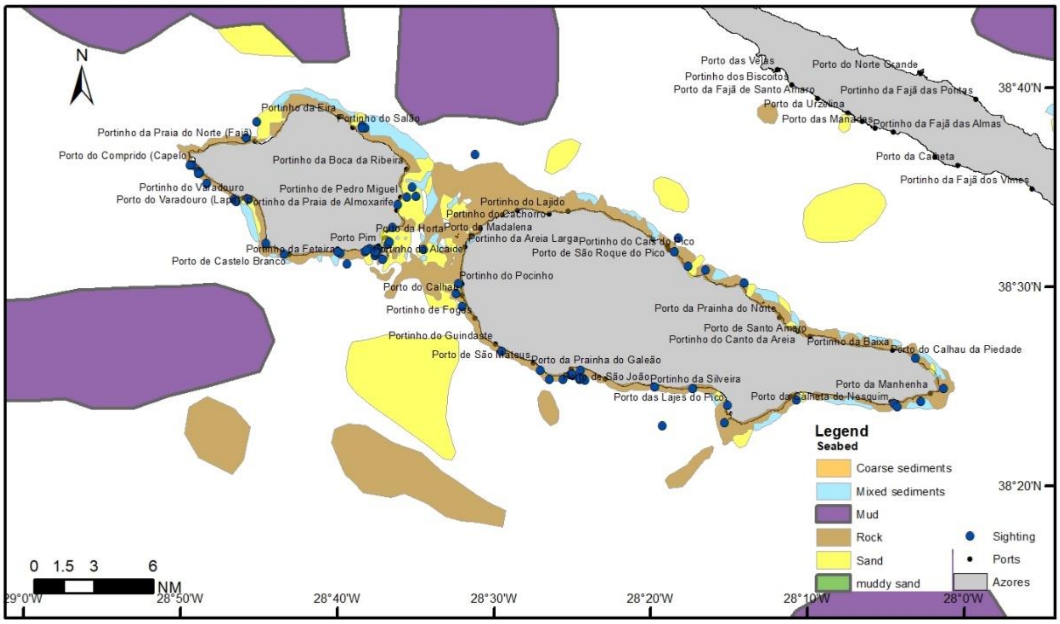


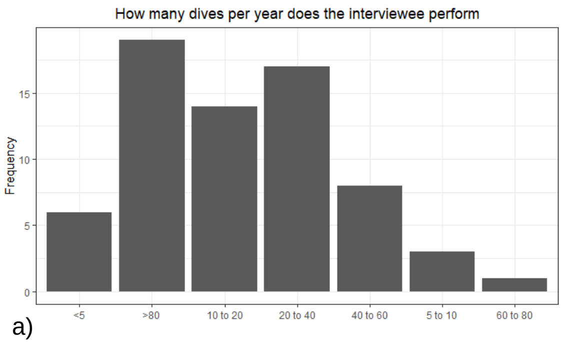
Figure 22 Graphical illustration of the islands Pico and Faial and the places where the sightings occurred (dark blue circles) complemented with the type of seafloor.

3.4 Divers sighting effort

Sighting effort was only calculated for diving related activities and for the islands of Faial and Pico. The semi-quantitative estimate of sighting effort was calculated from the following information (Figure 23):

1) Frequency with which the activity was practised: 27.9% of the interviewees answered more than 80 times a year, 25.0% practiced their activity 20 to 40 times a year and 20.6% practiced their activity 10 to 20 times a year.

2) Average duration of the activity: the duration ranged from 0.5 to 10 hours, with a mean of 1.98 hours and median of 2 hours.



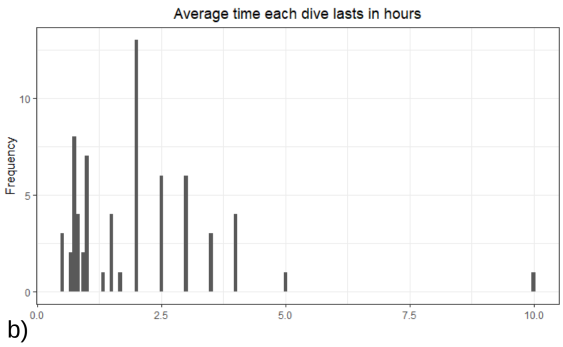


Figure 23 Graphical representation of: a) how many times a year does the interviewee practices his activity and b) how many hours, in average does which dive takes (hours).

Together with the areas where respondents claimed to practise their activity with high, medium and low intensity, a semi-quantitative map of sighting effort was build (Figure 26). The sighting effort was not uniform along nearshore areas, but it was higher near ports that facilitate the access to the water. On Faial, the highest sighting effort was observed near Porto Pim and around Monte da Guia, which is a steeply sloping Caldeira in the southeast corner of the island. Other locations in Faial with a high sighting effort were Portinho do Salão, Porto do Varadouro and Portinho da Praia de Almoxarife. In Pico, the areas with high sighting effort were from Portinho de Fogos to Porto do Calhau, Portinho do Alcaide, Portinho do Cais do Pico and from Porto de São Mateus to Porto da Prainha do Galeão.

The map shows that areas with high sighting effort often coincided with areas with many sightings, namely in Porto Pim in Faial island and Porto da Prainha do Galeão in Pico. However, there are also some areas with a high sighting effort but with no or low number of sightings, such as the area between Porto de Castelo Branco and Portinho da Feteira in Faial, and between Portinho da Areia Larga and Portinho da Formosinha in Pico. Between Portinho do Cais do Pico and Porto da Prainha do Norte the opposite is observed, there are a number of sightings but a low sighting effort.

Looking at the seabed floor type (Figure 25), it is possible to notice that the majority of the locations where the interviewees dived were rocky, while some were also made up of mixed sediment and sand, having a wider distribution area than the sighted sea turtles.

The red circles in figures 24 and 25 represent the central area where the interviewees dive. Each circle as a value attributed according to the intensity of the sighting effort, originating a sighting effort density shown in figure 26.

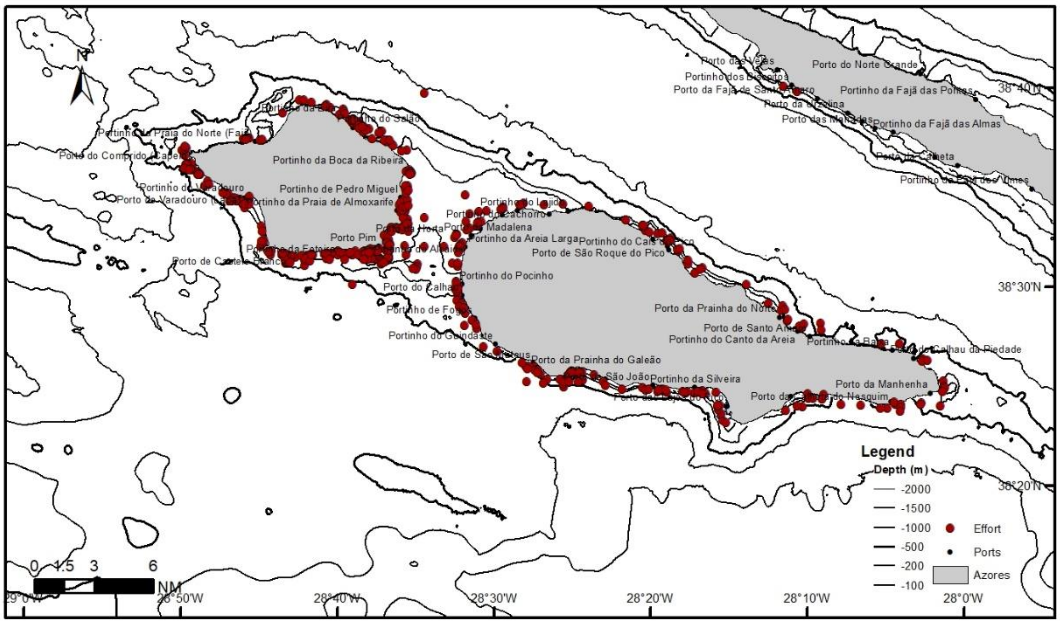


Figure 24 Graphical illustration of the places where divers dive (red circles) complemented with the contouring of the depths (meters).

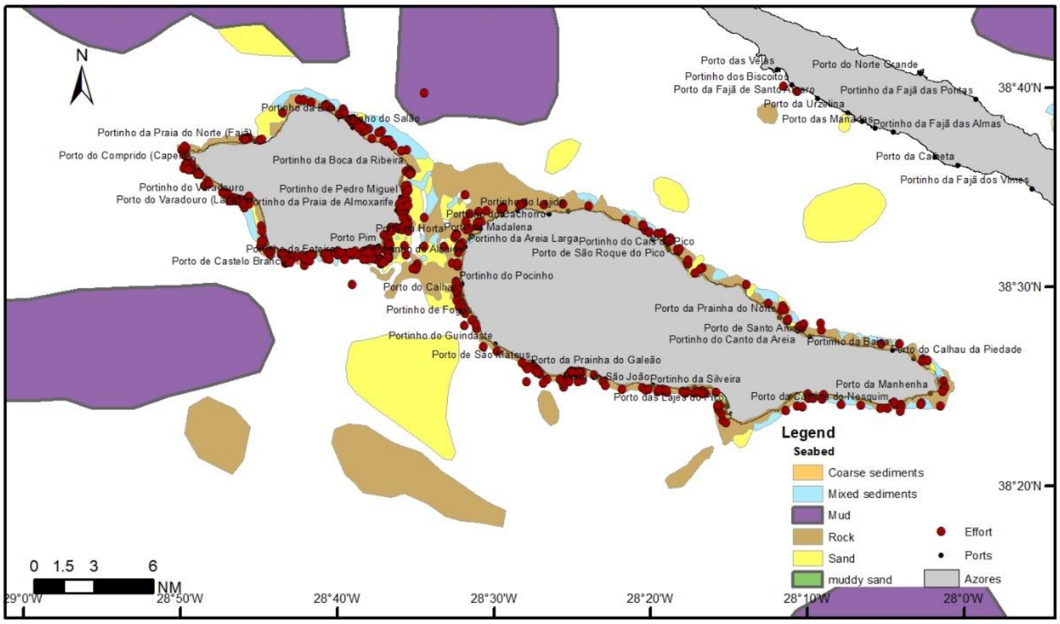


Figure 25 Graphical illustration of the places where divers dive (red circles) complemented with the type of seafloors.

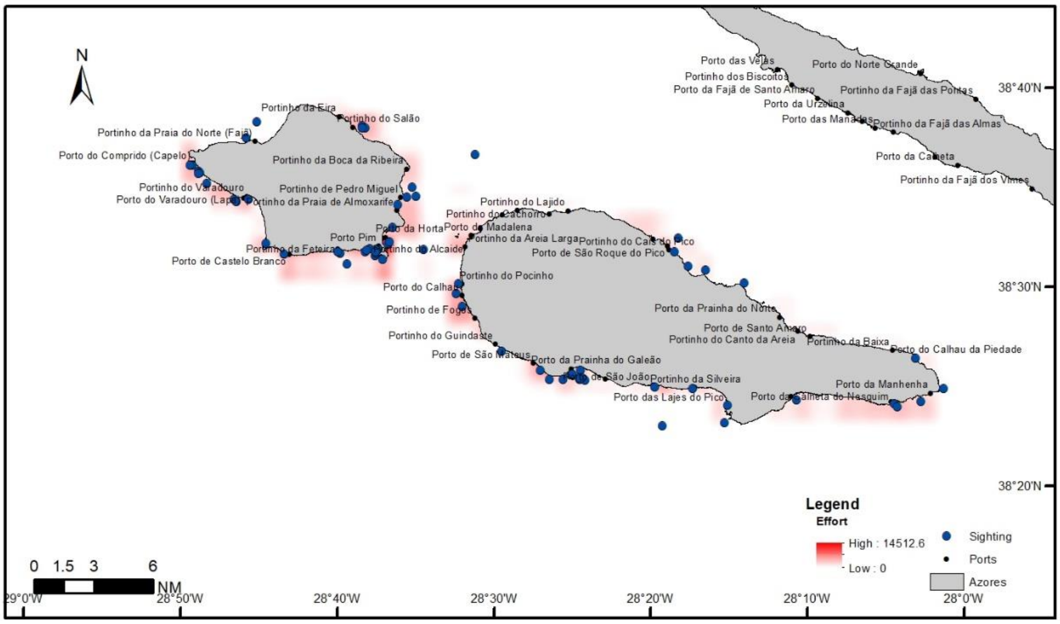


Figure 26 Graphical illustration of the effort made by the divers and the green turtle sightings (dark blue circles).

4. Discussion

In this study, the presence of green turtles was investigated in foraging habitats around the Azorean archipelago (30-38°N) using LEK to characterise the distribution and seasonality of green turtles (C. mydas). This is the first study to collect such information on this emblematic species in the Azores.

Species with cryptic life stages, such as sea turtles, in unknown or inaccessible locations, pose a special challenge to scientists and conservationists. The ignorance of the location or inaccessible locations of life stages can impede the study and management of species. In the Azores, sea turtles do not come out of the water to lay eggs or rest on the beach (Bolten et al. 1993; Martins et al. 2018) posing a difficult situation to study sea turtles in the area. A solution found, to help scientists study its ecology and distribution, is LEK, in which locals who access the ocean regularly share information from personal experience.

LEK allowed us to perform a first characterisation of green turtles in the Azores, in terms of distribution, seasonality and size composition. Information derived from the community members' knowledge of the environment can assist in management and co-management efforts, contribute to the existing knowledge of the biology of various organisms and their interactions with the environment (Begossi et al., 2002) and provide important data to help shape the decisions of policy-makers and researchers (Stave et al., 2007; Brook and McLachlan, 2008).

The application of LEK has many obvious advantages in understanding and responding to ecological problems (Bart, 2006), however, it also allowed us to better characterise the marine users to target for further studies on green turtles. Most of the interactions between humans and their environment are known to be mediated by feelings, behaviours, knowledge and beliefs (Marques, 2001). Understanding and comprehension of the bio-cultural memory associated with the local knowledge of particular communities (Toledo et al., 2010) is increasingly being utilized and incorporated in the responses to environmental and social changes (Davis and Wagner, 2003).

The necessity to interact with users, preferentially in person, proved a difficulty during the sanitary crisis. Particularly older people, that showed to have more accumulated knowledge, were more difficult to reach. The online questionnaire broke some barriers, however not everyone have access to a computer/smartphone or internet (Klimova and Poulova, 2018).

4.2 Greens turtle sightings

4.2.1 Geographical distribution and sighting description

The size of the green turtles sighted was the first important descriptor. With the size of the carapace it is possible to infer their age class. Since the loggerhead studies performed in the area indicate that the individuals present in the Azores are juveniles hatched in Florida (USA) (Carr, 1957; Bolten et al., 1993; Martins et al., 2018) and that loggerheads and green turtles share foraging grounds (Hays et al., 2002a; Lamont and Iverson, 2018) it was expected that green turtles that inhabit the Azorean waters were juveniles as well.

With the data collected from the questionnaires, where the size of the green turtles sighted was between 10 and 79 centimetres, we can infer that all of the sighted green turtles were juveniles. Determining the age and growth rates of wild green turtles is difficult. The usual capture-recapture methods used to study the growth of marine organisms are inefficient due to the long life span of C. mydas. Additionally, the change of the habitat, and the resultant change in feeding behaviours experienced by juvenile turtles, expose the green turtles to several different growth conditions throughout their life (Ehrhardt and Witham, 1992).

Green turtles take a long time to reach sexual maturity (between 31 and 36 years) having a slow growth rate (Heppell et al., 2003). Estimates from other studies suggest that green turtles would require 6 (Zug and Glor, 1998) to 17 years (Bjorndal and Bolten, 1988, 1995; Bjorndal et al., 2000) to grow from approximately 30 to 75 cm in carapace length (SCL), and reach mean nesting size between 18 and 36 years of age (Mendonca, 1981; Frazer and Ehrhart, 1985; Frazer and Ladner, 1986). Similarly, Bjorndal et al., (2000) noted that it takes approximately 30 years for green turtles at Union Creek, Bahamas, to grow from 30 to 82 cm SCL.

In this study, maps were built showing the distribution of green turtles and it is the first effort made towards understanding the ecology of the population of green turtles in the Azores. These maps show that most sightings occurred in Faial, in Porto Pim and Portinho do Alcaide and the area around Monte da Guia, which is a steeply sloping Caldeira in the southeast corner of Faial. Sites around the Caldeira varied in wave exposure, from sheltered (Porto Pim) to extremely exposed (the outside of Porto da Horta). Porto Pim is located on the southwest corner of the island of Faial. The beach is small (approximately 280 m in length) facing southwest. The north and south coasts of the beach area are rocky. The southern border is the edge of the Monte da Guia protected area. The maximum tidal range is 1 m with a maximum horizontal area of the beach at low water of approximately 30 m (Santos and Nash, 1995).

Other areas with a high number of sightings were Porto do Comprido (Capelo) and Portinho do Salão. These areas are rocky ports with easy access from land to the sea for divers and fishers (Peran et al., 2016).

In Pico Island, the most sightings of green turtles occurred in Porto da Prainha do Galeão, in Porto do Calhau and Portinho de Fogos followed by Porto da Calheta do Nesquim.

The locations where the most sightings occurred, generally overlapped with areas with higher sighting effort. This may suggest a largely homogenous distribution, but exceptions such as the area between Porto de Castelo Branco and Portinho da Feteira in Faial with few sightings despite the high effort, warrant further investigation. Another example can be found in Pico, where, even though Porto do Calhau and Porto da Prainha do Galeão have similar sighting effort, in Porto da Prainha do Galeão more sightings were registered. The distribution maps therefore represent an important starting point for future studies.

Most of the sightings were near the shore and the seafloor type around the islands is mostly rock (Peran et al., 2016). This is ideal for protection against predators and physical factors of the environment (Makowski et al., 2006). Nearshore hard-bottom reef habitats offer shelter for many animals and provide a substrate on which invertebrates and many types of marine algae can attach and grow (Moyer et al., 2003; Zale and Merrifield, 1989). As a result, these protected areas provide a diverse food web, sustaining a diverse community of marine fauna and flora (Lindeman and Snyder, 1999; Lindeman et al., 2009).

The activity of the sea turtle at the moment of the encounter was also a point of interest. It is hypothesised that green turtles use the Azorean waters as a foraging ground, where juveniles feed until they reach sexual maturity, using loggerhead sea turtles as a proxy (Bolten et al., 1993; Martins et al., 2018). From the results collected, most of the sighted sea turtles were either swimming, feeding or resting on the seafloor.

As a feeding ground, the Azores sea floors are scarce in seagrass, and previous studies demonstrate that seagrasses dominate the diet of green turtles at a range of sites across the Mediterranean (Margaritoulis and Teneketzis, 2003; Cardona et al., 2010; Karaa et al., 2012), Indian Ocean (Hasbún et al., 2000; Whiting et al., 2007;

Stokes et al., 2019) and Pacific Ocean (Limpus and Reed, 1985; Arthur et al., 2009; Prior et al., 2016).

Most recent studies show that where seagrass is scarce, juvenile turtles exploit macroalgae and other foods (Cardona et al., 2009; Carman et al., 2012; Russell and Balazs, 2015; Santos et al., 2015; Howell et al., 2016). Even in locations with seagrass, gastric lavage samples of juvenile turtles (Brand-Gardner et al., 1999) show that some individuals specialize in macroalgae while others consume seagrass. This feeding adaptation may justify why the Azores is a chosen feeding ground for juvenile C. mydas.

When reaching foraging habitats, green turtles switch to a neritic life stage inhabiting the inshore marine environment after a period of pelagic development following hatching (Carr, 1982). It is believed that recruitment to neritic habitats coincides with a direct shift from omnivory to herbivory (Carr and Ogren, 1960; Bjorndal, 1997; Bolten, 2003). Stomach contents of post-hatchling individuals from the southwest Pacific Ocean reveal a pelagic existence (Boyle and Limpus, 2008) with further support from stable isotope analyses indicating a shift from a pelagic, omnivorous life stage to a neritic herbivorous existence after recruitment to a foraging ground (Reich et al., 2007; Arthur et al., 2008). Various studies, however, indicate populations may vary in the ontogenetic shifts of green turtles when they arrive at neritic foraging grounds. In the Mediterranean (Godley et al., 1998) and Japan (Hatase et al., 2006) green turtle populations exhibit facultative diet shifts with older individuals incorporating animal products into their diet. Evidence from Mauritania (Cardona et al., 2009) and Mediterranean green turtles (Cardona et al., 2010) suggests an asynchronous shift in diet and habitat contradicting previous hypotheses of direct ontogenetic shifts. The variable methods of habitat and dietary shifts may denote differences in foraging mechanisms between and/or among green turtle populations suggesting that direct dietary shifts may not occur in all populations. When attending to the size class, it may be expected to play a role in determining rates of omnivory. Studies across taxa demonstrate that individuals maximise growth rates from juvenile to maturity by selecting a high protein diet (Esteban et al., 2020). With this, it is likely that the green turtles in the Azores go through dietary shift upon reaching the archipelago and don’t require a seagrass based feeding ground.

Regarding when the sightings occurred, most of them were in 2020 but this has no ecological importance. It does not mean that there were more sightings or the presence of green turtles in the Azores increased in that year, it is believed that it is related to what free divers remember, most likely they remember better what happened recently than what happened a long time ago (Bernard, 1988).

Regarding seasonality, most sightings occurred during summer and autumn, which is likely to be the period when the interviewees practiced there activity more frequently. This information is coherent with other studies (Broderick et al., 2007; Lamont and Iverson, 2018; Fukuoka et al., 2019) where juvenile green turtles in similar latitudes are mostly present during warmer months and then either move to deeper waters for longer periods of time or do short migration to warmer latitudes during the colder seasons, returning when the water is warmer again.

When analysing the depth of the sightings, the majority were between the surface and 10 meters, with the deepest sighting at 25 meters. Since the sightings occurred relatively in the nearshore, the seafloor depth was less than 500 meters. This information is seconded with other studies in Florida (Salmon et al., 2004, Makowski et al., 2006), Australia (Southwood et al., 2003), Cyprus and Ascension Island (Hays et al., 2002b) where the green turtles performed shallow dives during the summer and slightly deeper dives during the winter. With this, we could also formulate an alternative hypothesis that most sightings occurred during the summer and autumn because the maximum diving depth of the divers is, on average, 28 meters deep, while green turtles perform deeper dives during the winter that exceed the sighting range of divers.

To try and have an idea of site fidelity of green turtles to foraging grounds, it was asked in the questionnaire if they sighted the same sea turtle in the same place in different occasions and only 5.7% of the sightings were the same turtle in the same place but in a different occasion. According to Hart and Fujisaki (2010) fidelity to the same place is related to areas of sufficiently abundant prey or sufficient resources for forage. During this developmental phase, juveniles occupy home ranges and exploit closely spaced resource patches (e.g., South Texas, Renaud et al., 1995; Florida, Makowski et al., 2006).

4.1.2 Interviewees data

After analysing the knowledge of the interviewees of the different sea turtle species, it is possible to affirm that 56.3% of the interviewees who sighted green turtle could distinguish the different sea turtle species and 35.4% of the interviewees who sighted green turtle could somewhat distinguish the different sea turtle species that occur in the Azores (Table 1). This was question an important to incorporate in the questionnaire so it could be seen how confident the interviewees were when sighting a green turtle or another species, for example, a loggerhead sea turtle (C. caretta) which is the most common sea turtle present in the Azores (Bolten et al., 1993). The results show that we could be confident about the majority of the sighting reports since over 50% of the interviewees were certain of the species they saw and over 90% were at least somewhat confident it was a green turtle they encounter.

Additionally, the location of the turtle sighting provided us with additional certainty, because previous articles showed that Chelonia mydas foraging grounds are generally located in shallow near-shore waters, whereas foraging grounds of Caretta caretta are mostly further offshore (Mendonça and Ehrhart, 1982; Smith and Salmon, 2009).

In table 2 it was possible to see a direct relation between the experience of the interviewee performing his activity and the ability to distinguish the different species of sea turtles in the Azores, where the higher the experience the more confident they are about what the sighted sea turtle species was.

Within the different activities the interviewees performed, there was also a slight difference between spear fishers and scuba divers and their ability to distinguish the different species. It is possible to observe that 86.7% of the scuba divers interviewed could distinguish the different species of sea turtles but only 46.2% of the spear fishers could distinguish the different species of sea turtles. This is seconded with the experience self-classifications of the interviewees of both activities where 73.3% of the scuba divers self-classify with high experience but only 28.2% of the spear fishers self-classify with high experience. This information helps to conclude that it is important to educate spear fishers to better distinguish the sea turtle species.

Finally, the results have shown that the experience have a greater influence on the knowledge of the sea turtle species than the age of the interviewees.

4.2 The use of Local Ecological Knowledge (LEK)

This study was the first LEK survey about sea turtles in the Azores and it revealed to be a positive experience. Locals were eager to share their knowledge by participating in the survey and at the same time asking questions about sea turtles (their behaviour, ecology, threats, the best way to behave when in contact with the animal, etc.). LEK can contribute to conservation and management practices by establishing local baselines and recovery targets, evaluating population status, integrating the cultural dimensions of human-environment interactions and supporting equitable and inclusive practices (Early-Capistrán et al., 2020; Lee et al., 2019; Poe et al., 2014).

LEK-based approaches will become increasingly relevant as sea turtle populations grow and cease to be mere conservation targets (cf. Christianen et al., 2021), particularly considering that conservation conflicts have arisen when management frameworks failed to account for the sea turtles' cultural importance (cf. Barrios-Garrido et al., 2018). In the Azores local exploitation for food and curios was common until a few years ago (Santos et al. 1995). This led to some mistrust from the locals at the beginning of the questionnaire since they thought the survey was to know if they still hunt sea turtles and to report to the local authorities. After clarifying the intent of the survey the interviewees gained trust and since the public opinion has changed in Portugal in the last few years about sea turtle exploitation, they have shown more interest in protecting the sea turtles than hunting them.

Throughout the years, LEK has been derived from many types of experienced informers, including farmers (Leedy, 1949; Vaughan et al., 2003), fishermen (Carter and Nielsen, 2011; Lozano-Montes et al., 2008; Rehage et al., 2019; Turvey et al., 2013), even urbannature enthusiasts (Yli-pelkonen and Kohl, 2005), and it has been used to assess a wide range of land and marine species. By collecting and cross-comparing interview data and empirical scientific data from the same time periods to evaluate sighting frequencies for several charismatic marine species.

Studies such as this, which solicit LEK via structured interviews can result in the collection of highly conservation-relevant information about resource use and management. During the interviews, local people were eager to communicate their knowledge, showing a lot of interest in participating in scientific activities. This information may help facilitate the involvement of local people in future conservation and monitoring initiatives (Senko et al., 2011).

4.3 Limitation of the surveys

A few limitations to this study must be considered. The first one encountered was the current pandemic situation that caused some difficulties to interview people in-person, leading to the switch of the interviewing method to an online questionnaire, limiting the personal connection that sometimes led to some extra information about the sighting or description of the interaction with the sea turtle as well as the exclusion of scuba divers and free divers that are who are not comfortable/familiarized with computer technologies.

Limitations of interview data include biased responses and memory decay (Bernard, 1988), for example, misinformation about the description of the sighting either from mistaken the species of the sea turtle or some interviewees did not answer a few questions about the description of the sighting. An important limitation of the local ecological knowledge approach to map the presence of green turtles is that is only possible to obtain information about the distribution of the sea turtles where the interviewees dive, leaving out the inaccessible areas or the areas of least interest from the perspective of the interview. In addition, the number of LEK questions may be insufficient, limiting verification of the effects of LEK. The findings of the present study nevertheless add to the body of knowledge concerning the presence of the green turtles in the Azorean archipelago.

Whether survey methods are cross-sectional (sampling a group at a single point in time), longitudinal (interviewing the same panel over time) or retrospective (calling on respondent memory), certain biases and errors must be considered (Rafferty et al., 2015; Rindfleisch et al., 2008). Retrospective bias, for example, manifests as inadequate recall and/or inaccurate perception of historic declines and can hinder the accuracy of resulting assessments (O'Donnell et al., 2010). Human characteristics including familiarity with the study area, age, gender, personality and even interactions with the interviewer can further influence respondents' answers (Brook and McLachlan, 2005; Gerhardinger et al., 2009; Moser, 1951). When the potential bias is properly mitigated and reported, social surveys can have substantial collaborative power (Thornton and Maciejewski Scheer, 2012), and LEK can provide insight into species abundance in regions of ecological interest where periodic biomonitoring is limited (Anadón et al., 2009; Turvey et al., 2013).

4.4 Conservation implications

An understanding of what sea turtles' ecological roles are should take into account both their ecosystem requirements and their ecosystem impacts through their foraging activity. Although critical to establishing realistic recovery targets, to date, only limited efforts have been expanded to identify what these roles may be (see Bjorndal, 2003; Bjorndal and Jackson, 2003).

Since juvenile sea turtles inhabit coastal sites and demonstrate strong residency patterns (Hart and Fujisaki, 2010; Makowski et al., 2006), it is highly probable that by managing certain habitats that are heavily utilized, conservation measures can ensure protection for green turtles during these particular stages of their lives. There are numerous approaches by which we can understand the relationship between turtles and their habitat. Broad-scale or opportunistic visual observations are useful in scoping potential high-use areas, and more rigorous observations are able to characterize turtle aggregations and the features which drive them (Jean et al., 2010). Interestingly, animal-borne observations may be increasingly useful in attempts to understand unique habitats which have been previously overlooked. Once these high-use areas are identified, capture-mark-recapture techniques (CMR) can quantify the importance of the areas relative to other areas which lack high turtle concentrations (Bjorndal et al., 2005 and Casale et al., 2009). CMR techniques can also quantify patterns of residency and site fidelity over long courses of time. And the wide array of tracking technology allows us to describe turtle movements in many different temporal and spatial aspects. Given the utility of all these approaches and the depth of knowledge that can be gained when applying several of them, we should be able to compile a comprehensive understanding of green turtle habitat use, whether it is in the interest of protecting areas for critical conservation or proactively mitigating impacts at areas to facilitate the recovery of regional populations.

5. Conclusion

This study confirms the presence of green turtles in the Azores archipelago and it appears to be an important foraging ground for this species where juveniles seek protection and food resources. This thesis raises a number of questions that imply the need for further study of the green turtle population in the area, such as 1) where do this juvenile sea turtles originate from; 2) what is the size and residency of this population; 3) is this population affected by bycatch or other anthropogenic activities.

Given the ecological role and the ecosystem services provided by green turtles, it is increasingly apparent that green turtle aggregations within discrete areas may yield ecosystem-level benefits with wide ecological implications. Dietary studies, for example, are vital to understanding the ecological role of organisms and their trophic interactions (Duffy et al., 2007), which for large marine vertebrates are often not well understood (Matich et al., 2011). Moreover, a better understanding of dietary requirements may help resource managers respond to shifts in trophic interactions between taxa (Brodeur et al., 2017) and, for sea turtles, more effectively prioritize conservation zones and policies for foraging grounds (Hamann et al., 2010; Rees et al., 2016).

Sea turtles do not exist in isolation but form an integral part of the natural environment. Thus, once the basic features of growth, mortality and food consumption have been understood at the scale of the individual and current populations, this understanding needs to be placed into an ecosystem context. In attempting to understand dynamics at the ecosystem level, community models are one of the most valuable tools available to permit controlled exploration of a complex reality and to help elucidate patterns and processes that are not apparent from empirical data alone.

Successful conservation of coastal, particularly foraging, habitats (Eckert and Abreu-Grobois 2001) is therefore critical to the conservation of sea turtles. The close connection between achieving sustainable long-term sea turtle recovery and management, and the conservation of critical coastal habitats. Protecting critical habitats (e.g., nesting beaches, and foraging areas) is essential, since population trends may not reflect small-scale impacts until after a time lag of several years. In particular, threats such as recreational fishing activities, algae harvest, vessel traffic, and personal watercraft use may impact certain age classes in spatially explicit areas (e.g., foraging and resting habitats), and although they may not currently have an effect on regional population trends, if not managed properly, the cumulative effects of these small-scale threats may have consequences in the future.

Ultimately the successful recovery of sea turtles is highly dependent on the conservation of the habitats on which they depend. Overharvesting and habitat destruction together represent the greatest threats to biodiversity and therefore the loss of ecosystem function and a reduction in the provision of ecosystem services (Sala and Knowlton 2006). Clearly, without healthy habitats, management schemes directed at particular species are doomed to failure (Reaka-Kudla, 1996).

This study marks the first effort in the region to use LEK to orient local survey efforts related to sea turtles. This course of action may lead to the implementation of a citizen science project, where local communities gain and share knowledge about sea turtles and conservation activities. This study opens the doors to conducting more systematic and hypothesis-driven studies to feed future management strategies in which local people are active participants, especially considering they are at the frontline of conservation in these isolated areas of the archipelago.

This study revealed a need for further awareness and education of the community about the different sea turtle species, in order for them to be more active participants in sea turtle conservation.

Conservation actions or programs should integrate scientific and educational activities with the local communities to enable ecological, cultural, social, economic and political development (Robinson, 2011). Many programs around the world have shown positive results regarding behavioural changes of the fishers and their engagement in conservation initiatives (Okemwa et al., 2004; Gelcich et al., 2004; Risien and Tilt, 2008; Bretos et al., 2017). In contrast, there are situations with less engagement between communities' members and researchers/government institutions, with a lack of confidence that harms the conservation programs and their effectiveness (Pita et al., 2010; Engel et al., 2014; Matera, 2016).

6. References

Abdel-Monem, A. A., Fernandez, L. A. and Boone, G. M. (1975). K-Ar ages from the eastern Azores group (Santa Maria, São Miguel and the Formigas islands). Lithos, 8(4), 247-254. https://doi.org/10.1016/0024-4937(75)90008-0.

Afonso, P., Fontes, J., Giacomello, E., Magalhães, M. C., Martins, H. R., Morato, T., Neves, V., Prieto, R., Santos, R. S., Silva, M. A. and Vandeperre, F. (2020). The Azores: a mid-Atlantic hotspot for marine megafauna research and conservation. Frontiers in Marine Science, 6, 826. https://doi.org/10.3389/fmars.2019.00826.

Ainsworth, C. H. (2011). Quantifying species abundance trends in the Northern Gulf of California using local ecological knowledge. Marine and Coastal Fisheries, 3(1), 190-218. https://doi.org/10.1080/19425120.2010.549047.

Alves, M. L. and Colin de Verdière, A. (1999). Instability dynamics of a subtropical jet and applications to the Azores Front Current System: eddy-driven mean flow. Journal of Physical Oceanography, 29(5), 837-864. https://doi.org/10.1175/1520-0485(1999)029<0837:IDOASJ>2.0.CO;2

Alves, M., Gaillard, F., Sparrow, M., Knoll, M. and Giraud, S. (2002). Circulation patterns and transport of the Azores Front-Current system. Deep Sea Research Part II: Topical Studies in Oceanography, 49(19), 3983-4002. https://doi.org/10.1016/S0967-0645(02)00138-8.

Anadón, J. D., Giménez, A. and Ballestar, R. (2010). Linking local ecological knowledge and habitat modelling to predict absolute species abundance on large scales. Biodiversity and Conservation, 19(5), 1443-1454. https://doi.org/10.1007/s10531-009-9774-4

Arthur, K. E., Boyle, M. C. and Limpus, C. J. (2008). Ontogenetic changes in diet and habitat use in green sea turtle (Chelonia mydas) life history. Marine Ecology Progress Series, 362, 303-311. https://doi.org/10.3354/meps07440

Arthur, K. E., McMahon, K. M., Limpus, C. J. and Dennison, W. C. (2009). Feeding ecology of green turtles (Chelonia mydas) from Shoalwater Bay, Australia. Marine Turtle Newsletter, 123(6).

Azevedo, J. M. M., Ferreira, M. R. and Martins, J. Á. (1991). The emergent volcanism of Flores Islands, Azores (Portugal). Arquipélago-Life and Earth Sciences, 9, 37-46.

Azzurro, E., Moschella, P. and Maynou, F. (2011). Tracking signals of change in Mediterranean fish diversity based on local ecological knowledge. PloS one, 6(9), e24885. https://doi.org/10.1371/journal.pone.0024885

Bailey, K. D. (1982) Methods of social research. New York: The Free Press, Macmillan Publishers

Balazs, G. H. and Chaloupka, M. (2004). Thirty-year recovery trend in the once depleted Hawaiian green sea turtle stock. Biological Conservation, 117(5), 491-498. https://doi.org/10.1016/j.biocon.2003.08.008

Bao, K. and Drew, J. (2016). Traditional ecological knowledge, shifting baselines, and conservation of Fijian molluscs. Pacific Conservation Biology, 23(1), 81-87. https://doi.org/10.1071/PC16016

Barcelos, L. M., Michielsen, G., Sérgio, B., Oliveira, S. and Barreiros, J. P. (2021). First record of the Olive Ridley Sea Turtle, Lepidochelys olivacea (Eschscholtz, 1829), in the Azores Islands, northeastern Atlantic Ocean (Testudines, Cheloniidae). Herpetology Notes, 14, 371-373.

Barrios-Garrido, H., Palmar, J., Wildermann, N., Rojas-Cañizales, D., Diedrich, A. and Hamann, M. (2018). Marine turtle presence in the traditional pharmacopoeia, cosmovision, and beliefs of Wayuú indigenous people. Chelonian Conservation and Biology, 17(2), 177-186. https://doi.org/10.2744/CCB-1276.1

Bart, D. (2006). Integrating local ecological knowledge and manipulative experiments to find the causes of environmental change. Frontiers in Ecology and the Environment, 4(10), 541-546. https://doi.org/10.1890/1540-9295(2006)4[541:ILEKAM]2.0.CO;2

Bass, A. L., Epperly, S. P. and Braun-McNeill, J. (2006). Green turtle (Chelonia mydas) foraging and nesting aggregations in the Caribbean and Atlantic: impact of currents and behavior on dispersal. Journal of Heredity, 97(4), 346-354. https://doi.org/10.1093/jhered/esl004

Baur, G. (1890). The genera of the Cheloniidae. American Naturalist, 1890, 486-487.

Beaudreau, A. H. and Levin, P. S. (2014). Advancing the use of local ecological knowledge for assessing data-poor species in coastal ecosystems. Ecological Applications, 24(2), 244-256. https://doi.org/10.1890/13-0817.1

Begossi, A., Hanazaki, N. and Silvano, R. A. M. (2002). Ecologia Humana, Etnoecologia e conservação. In: Amorozo, M. C. M., Ming, L. C. and Silva, S. P. Métodos de Coleta e Análise de dados em Etnobotânica, Etnoecologia e Disciplinas correlatadas. Rio Claro.

Bélisle, A. C., Asselin, H., LeBlanc, P. and Gauthier, S. (2018). Local knowledge in ecological modeling. Ecology and Society, 23(2). https://doi.org/10.5751/ES-09949-230214

Berkes, F., Folke, C. and Colding, J. (editors). (2000). Linking social and ecological systems: management practices and social mechanisms for building resilience. Cambridge University Press.

Bernard, H. 1988. Research methods in cultural anthropology. Newbury Park, Sage Publications.

Bjorndal, K. A. (1980). Nutrition and grazing behavior of the green turtle Chelonia mydas. Marine Biology, 56(2), 147-154. https://doi.org/10.1007/BF00397131

Bjorndal, K. A. (1981). Biology and conservation of sea turtles. In Proceedings of the World Conference on Sea Turtle Conservation, Smithsonian Institution Press, Washington, D.C..

Bjorndal, K. A. (1997). Foraging ecology and nutrition of sea turtles. In: Lutz, P. L., Musick, J. A. (editors) The biology of sea turtles. CRC Press, Boca Raton, 237–283.

Bjorndal, K. A. (1999) Priorities for research in foraging habitats. In: Eckert, K., Bjorndal, K., Abreu-Grobois, F. A. and Donnelly, M., Research and management techniques for the conservation of sea turtles, 12-18. IUCN/SSC Marine Turtle Specialist Group Publication No. 4, Washington, D.C., USA.

Bjorndal, K. A. (2003). Roles of loggerhead sea turtles in marine ecosystems. In: Bolten, A. B. and Witherington, B. E. (editors), Loggerhead Sea Turtles. Washington, DC: Smithsonian Books, 235-254.

Bjorndal, K. A. and Bolten, A. B. (1988). Growth rates of immature green turtles, Chelonia mydas, on feeding grounds in the southern Bahamas. Copeia, 555-564. https://doi.org/10.2307/1445373.

Bjorndal, K. A. and Bolten, A. B. (1995). Comparison of length-frequency analyses for estimation of growth parameters for a population of green turtles. Herpetologica, 160-167.

Bjorndal, K. A. and Jackson, J. B. (2002). Roles of sea turtles in marine ecosystems: reconstructing the past. In: Lutz, P. L., Musick, J. A. (editors) The biology of sea turtles. CRC Press, Boca Raton, 2, 259.

Bjorndal, K. A., Bolten, A. B. and Chaloupka, M. Y. (2000). Green turtle somatic growth model: evidence for density dependence. Ecological Applications, 10(1), 269-282.

https://doi.org/10.1890/1051-0761(2000)010[0269:GTSGME]2.0.CO;2.

Bjorndal, K. A., Bolten, A. B. and Chaloupka, M. Y. (2005). Evaluating trends in abundance of immature green turtles, Chelonia mydas, in the Greater Caribbean. Ecological Applications, 15(1), 304-314. https://doi.org/10.1890/04-0059.

Bjorndal, K. A., Bolten, A. B., Dellinger, T., Delgado, C. and Martins, H. R. (2003). Compensatory growth in oceanic loggerhead sea turtles: response to a stochastic environment. Ecology, 84(5), 1237-1249. https://doi.org/10.1890/0012-9658(2003)084[1237:CGIOLS]2.0.CO;2.

Bjorndal, K. A., Carr, A., Meylan, A. B. and Mortimer, J. A. (1985). Reproductive biology of the hawksbill Eretmochelys imbricata at Tortuguero, Costa Rica, with notes on the ecology of the species in the Caribbean. Biological Conservation, 34(4), 353-368. https://doi.org/10.1016/0006-3207(85)90040-0.

Bjorndal, K. A., Wetherall, J. A., Bolten, A. B. and Mortimer, J. A. (1999). Twenty-six years of green turtle nesting at Tortuguero, Costa Rica: an encouraging trend. Conservation Biology, 13(1), 126-134. https://doi.org/10.1046/j.1523-1739.1999.97329.x.

Bolten, A. B. (2003). Variation in sea turtle life history patterns: neritic vs. oceanic developmental stages. In: Lutz, P. L., Musick, J. A. (editors) The biology of sea turtles. CRC Press, Boca Raton, 2, 243-257.

Bolten, A. B. and Martins, H. R. (1990). Kemp’s ridley captured in the Azores. Marine Turtle Newsletter, 48(23).

Bolten, A. B. and Witherington, B. E. (editors). (2003). Loggerhead Sea Turtles. Washington, DC: Smithsonian Books.

Bolten, A. B., Bjorndal, K. A., Martins, H. R., Dellinger, T., Biscoito, M. J., Encalada, S. E. and Bowen, B. W. (1998). Transatlantic developmental migrations of loggerhead sea turtles demonstrated by mtDNA sequence analysis. Ecological Applications, 8(1), 1-7. https://doi.org/10.1890/1051-0761(1998)008[0001:TDMOLS]2.0.CO;2.

Bolten, A. B., Martins, H. R., Bjorndal, K. A. and Gordon, J. (1993). Size distribution of pelagic-stage loggerhead sea turtles (Caretta caretta) in the waters around the Azores and Madeira. ARQUIPÉLAGO. Ciências Biológicas e Marinhas= Life and Marine Sciences, 11, 49-54.

Bowen, B. W., Abreu-Grobois, F. A., Balazs, G. H., Kamezaki, N., Limpus, C. and Ferl, R. J. (1995). Trans-Pacific migrations of the loggerhead turtle (Caretta caretta) demonstrated with mitochondrial DNA markers. Proceedings of the National Academy of Sciences, 92(9), 3731-3734. https://doi.org/10.1073/pnas.92.9.3731.

Boyle, M. C. and Limpus, C. J. (2008). The stomach contents of post-hatchling green and loggerhead sea turtles in the southwest Pacific: an insight into habitat association. Marine Biology, 155(2), 233-241. https://doi.org/10.1007/s00227-008-1022-z.

Brand-Gardner, S. J., Limpus, C. J. and Lanyon, J. M. (1999). Diet selection by immature green turtles, Chelonia mydas, in subtropical Moreton Bay, south-east Queensland. Australian Journal of Zoology, 47(2), 181-191. https://doi.org/10.1071/ZO98065.

Bresette, M., Gorham, J. and Peery, B. (1998). Site fidelity and size frequencies of juvenile green turtles (Chelonia mydas) utilizing near shore reefs in St. Lucie County, Florida. Marine Turtle Newsletter, 82(5).

Bretos, F., Ricardo, J. A., Moncada, F., Peckham, S. H., Valdés, J. A. A., Diego, A. and Thompson, K. R. (2017). Fisheries learning exchanges and sea turtle conservation: An effort between Mexico, Cuba and the US to engage Cuban coastal communities in non-consumptive alternative behaviors. Marine Policy, 77, 227-230. https://doi.org/10.1016/j.marpol.2016.05.022

Broderick, A. C., Coyne, M. S., Fuller, W. J., Glen, F. and Godley, B. J. (2007). Fidelity and over-wintering of sea turtles. Proceedings of the Royal Society B: Biological Sciences, 274(1617), 1533-1539. https://doi.org/10.1098/rspb.2007.0211

Brodeur, R. D., Smith, B. E., McBride, R. S., Heintz, R. and Farley, E. (2017). New perspectives on the feeding ecology and trophic dynamics of fishes. Environmental Biology of Fishes, 100(4), 293-297. https://doi.org/10.1007/s10641-017-0594-1.

Brongersma, L. D. (1982). Marine turtles of the eastern Atlantic Ocean. Smithsonian Institution Press, Washington DC, 407-416.

Brook, R. K. and McLachlan, S. M. (2005). On using expert-based science to “test” local ecological knowledge. Ecology and Society, 10(2).

Brook, R. K. and McLachlan, S. M. (2008). Trends and prospects for local knowledge in ecological and conservation research and monitoring. Biodiversity and conservation, 17(14), 3501-3512. https://doi.org/10.1007/s10531-008-9445-x

Burkholder, D. A., Heithaus, M. R., Thomson, J. A. and Fourqurean, J. W. (2011). Diversity in trophic interactions of green sea turtles Chelonia mydas on a relatively pristine coastal foraging ground. Marine Ecology Progress Series, 439, 277-293. https://doi.org/10.3354/meps09313

Cabral, M.J. (coord.); J. Almeida, P.R. Almeida, T. Delliger, N. Ferrand de Almeida, M.E. Oliveira, J.M. Palmeirim, A.I. Queirós, L. Rogado, M. Santos-Reis (editors) (2005). Livro Vermelho dos Vertebrados de Portugal. Instituto da Conservação da Natureza. Lisboa. 659p.

Calado, H., Borges, P., Phillips, M., Ng, K. and Alves, F. (2011). The Azores archipelago, Portugal: improved understanding of small island coastal hazards and mitigation measures. Natural Hazards, 58(1), 427-444. https://doi.org/10.1007/s11069-010-9676-5

Caldeira, R. and Reis, J. C. (2017). The Azores confluence zone. Frontiers in Marine Science, 4, 37. https://doi.org/10.3389/fmars.2017.00037

Campbell, L. M. (2003). Challenges for interdisciplinary sea turtle research: perspectives of a social scientist. Marine Turtle Newsletter, 100, 28-32.

Cardona, L., Aguilar, A. and Pazos, L. (2009). Delayed ontogenic dietary shift and high levels of omnivory in green turtles (Chelonia mydas) from the NW coast of Africa. Marine Biology, 156(7), 1487-1495. https://doi.org/10.1007/s00227-009-1188-z

Cardona, L., Campos, P., Levy, Y., Demetropoulos, A. and Margaritoulis, D. (2010). Asynchrony between dietary and nutritional shifts during the ontogeny of green turtles (Chelonia mydas) in the Mediterranean. Journal of Experimental Marine Biology and Ecology, 393(1-2), 83-89. https://doi.org/10.1016/j.jembe.2010.07.004

Carman, V. G., Falabella, V., Maxwell, S., Albareda, D., Campagna, C. and Mianzan, H. (2012). Revisiting the ontogenetic shift paradigm: the case of juvenile green turtles in the SW Atlantic. Journal of Experimental Marine Biology and Ecology, 429, 64-72. https://doi.org/10.1016/j.jembe.2012.06.007

Carr, A. (1957). Notes on the zoogeography of the Atlantic sea turtles of the genus Lepidochelys. Revista de Biologia Tropical, 5(1), 45-61.

Carr, A. (1982). Notes on the behavioral ecology of sea turtles. Pp. 19-26 in: Bjorndal, K.A. (editor) Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington D.C., USA. 583 pp.

Carr, A. (1987). New perspectives on the pelagic stage of sea turtle development. Conservation Biology, 1(2), 103-121. https://doi.org/10.1111/j.1523-1739.1987.tb00020.x

Carr, A. and Meylan, A. B. (1980). Evidence of passive migration of green turtle hatchlings in Sargassum. Copeia, 1980(2), 366-368.

Carr, A. and Ogren, L. H. (1960). The ecology and migrations of sea turtles. 4, The green turtle in the Caribbean Sea. Bulletin of the American Museum of Natural History, 121, 1-48.

Carr, T. and Carr, N. (1991). Surveys of the sea turtles of Angola. Biological Conservation, 58(1), 19-29. https://doi.org/10.1016/0006-3207(91)90042-8

Carter, B. T. and Nielsen, E. A. (2011). Exploring ecological changes in Cook Inlet beluga whale habitat though traditional and local ecological knowledge of contributing factors for population decline. Marine Policy, 35(3), 299-308. https://doi.org/10.1016/j.marpol.2010.10.009

Casale, P., Mazaris, A. D., Freggi, D., Vallini, C. and Argano, R. (2009). Growth rates and age at adult size of loggerhead sea turtles (Caretta caretta) in the Mediterranean Sea, estimated through capture-mark-recapture records. Scientia Marina, 73(3), 589-595. https://doi.org/10.3989/scimar.2009.73n3589

Castell, E. D., López-Mendilaharsu, M. and Izquierdo, G. (2005). Hábitos Alimentarios de Juveniles de Tortuga Verde (Chelonia mydas) en Cerro Verde, Rocha-Uruguay. Anais II Jornada de Conservação e Pesquisa de Tartarugas Marinhas no Atlântico Sul Ocidental, Praia do Cassino, Brasil, 15-18.

Chaloupka, M., Bjorndal, K. A., Balazs, G. H., Bolten, A. B., Ehrhart, L. M., Limpus, C. J., Suganuma, H., Troeng, S. and Yamaguchi, M. (2008). Encouraging outlook for recovery of a once severely exploited marine megaherbivore. Global Ecology and Biogeography, 17(2), 297-304. https://doi.org/10.1111/j.1466-8238.2007.00367.x

Chambault, P., de Thoisy, B., Heerah, K., Conchon, A., Barrioz, S., Dos Reis, V., Berzins, R., Kelle, L., Picard, B., Roquet, F., Le Maho, Y. and Chevallier, D. (2016). The influence of oceanographic features on the foraging behavior of the olive ridley sea turtle Lepidochelys olivacea along the Guiana coast. Progress in Oceanography, 142, 58-71. https://doi.org/10.1016/j.pocean.2016.01.006.

Charnley, S., Fischer, A. P. and Jones, E. T. (2007). Integrating traditional and local ecological knowledge into forest biodiversity conservation in the Pacific Northwest. Forest ecology and management, 246(1), 14-28. https://doi.org/10.1016/j.foreco.2007.03.047.

Christianen, M. J., van Katwijk, M. M., van Tussenbroek, B. I., Pagès, J. F., Ballorain, K., Kelkar, N., Arthur, R. and Alcoverro, T. (2021). A dynamic view of seagrass meadows in the wake of successful green turtle conservation. Nature Ecology & Evolution, 5(5), 553-555. https://doi.org/10.1038/s41559-021-01433-z.

Christiansen, F., Esteban, N., Mortimer, J. A., Dujon, A. M. and Hays, G. C. (2017). Diel and seasonal patterns in activity and home range size of green turtles on their foraging grounds revealed by extended Fastloc-GPS tracking. Marine biology, 164(1), 1-11. https://doi.org/10.1007/s00227-016-3048-y.

Clua, É. and Grosvalet, F. (2001). Mixed-species feeding aggregation of dolphins, large tunas and seabirds in the Azores. Aquatic Living Resources, 14(1), 11-18. https://doi.org/10.1016/S0990-7440(00)01097-4.

Cox, T. M., Lewison, R. L., Žydelis, R., Crowder, L. B., Safina, C. and Read, A. J. (2007). Comparing effectiveness of experimental and implemented bycatch reduction measures: the ideal and the real. Conservation Biology, 21(5), 1155-1164. https://doi.org/10.1111/j.1523-1739.2007.00772.x.

Crouse, D. T., Crowder, L. B. and Caswell, H. (1987). A stage-based population model for loggerhead sea turtles and implications for conservation. Ecology, 68(5), 1412-1423. https://doi.org/10.2307/1939225

Davenport, J. (1997). Temperature and the life-history strategies of sea turtles. Journal of thermal biology, 22(6), 479-488. https://doi.org/10.1016/S0306-4565(97)00066-1

Davis, A. and Wagner, J. R. (2003). Who knows? On the importance of identifying “experts” when researching local ecological knowledge. Human ecology, 31(3), 463-489. https://doi.org/10.1023/A:1025075923297

de Castro, F. R., Stutz-Reis, S., Reis, S. S., Nakano-Oliveira, E. and Andriolo, A. (2014). Fishermen's perception of Neotropical otters (Lontra longicaudis) and their attacks on artisanal fixed fence traps: The case of caiçara communities. Ocean & Coastal Management, 92, 19-27. https://doi.org/10.1016/j.ocecoaman.2014.01.008

Deraniyagala, P. E. P. (1952). A coloured atlas of some vertebrates from Ceylon. Volume 1: fishes. National Museums of Ceylon, Colombo, 149 pp., 34 pls.

DGRM 2021. Direção-Geral de Recursos Naturais, Segurança e Serviços Marítimos - Zonas Marítimas sob Soberania e ou Jurisdição Portuguesa https://www.dgrm.mm.gov.pt/am-ec-zonas-maritimas-sob-jurisdicao-ou-soberania-nacional Accessed on: 10 October 2021

Dodge, K. L., Logan, J. M. and Lutcavage, M. E. (2011). Foraging ecology of leatherback sea turtles in the Western North Atlantic determined through multi-tissue stable isotope analyses. Marine Biology, 158(12), 2813-2824. https://doi.org/10.1007/s00227-011-1780-x.

Duffy, J. E., Cardinale, B. J., France, K. E., McIntyre, P. B., Thébault, E. and Loreau, M. (2007). The functional role of biodiversity in ecosystems: incorporating trophic complexity. Ecology letters, 10(6), 522-538. https://doi.org/10.1111/j.1461-0248.2007.01037.x.

Early-Capistrán, M. M., Solana-Arellano, E., Abreu-Grobois, F. A., Narchi, N. E., Garibay-Melo, G., Seminoff, J. A., Koch, V. and Saenz-Arroyo, A. (2020). Quantifying local ecological knowledge to model historical abundance of long-lived, heavily-exploited fauna. PeerJ, 8, e9494. https://doi.org/10.7717/peerj.9494

Eckert, K. L. (1995). Anthropogenic threats to sea turtles. in: Bjorndal, K.A. (editor) Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington D.C., USA, 611-612.

Eckert, K. L., Bjorndal, K. A., Abreu-Grobois, F. A. and Donnelly, M. (1999). Taxonomy, external morphology, and species identification. Research and management techniques for the conservation of sea turtles, 21, 11-13.

Eckert, K.L. and F. A. Abreu Grobois (eds.) 2001. Proceedings of the Regional Meeting: “Marine Turtle Conservation in the Wider Caribbean Region: A Dialogue for Effective Regional Management,” Santo Domingo, 16-18 November 1999. WIDECAST, IUCN-MTSG, WWF, and UNEP-CEP. xx + 154 pp

Ehrhardt, N. M. and Witham, R. (1992). Analysis of growth of the green sea turtle (Chelonia mydas) in the western central Atlantic. Bulletin of Marine Science, 50(2), 275-281.

Engel, M. T., Marchini, S., Pont, A. C., Machado, R. and de Oliveira, L. R. (2014). Perceptions and attitudes of stakeholders towards the wildlife refuge of Ilha dos Lobos, a marine protected area in Brazil. Marine Policy, 45, 45-51. https://doi.org/10.1016/j.marpol.2013.11.012

Ergene, S., Aymak, C. and UÇAR, A. H. (2011). Carapacial scute variation in green turtle (Chelonia mydas) and loggerhead turtle (Caretta caretta) hatchlings in Alata, Mersin, Turkey. Turkish Journal of Zoology, 35(3), 343-356. https://doi:10.3906/zoo-0808-8

ESRI. 2021. ArcGIS Esri Maps and Data, Resource Center. Available at http://www.esri.com (Accessed 15 October 2021).

Esteban, N., Mortimer, J. A., Stokes, H. J., Laloë, J. O., Unsworth, R. K. and Hays, G. C. (2020). A global review of green turtle diet: sea surface temperature as a potential driver of omnivory levels. Marine Biology, 167(12), 1-17. https://doi.org/10.1007/s00227-020-03786-8

Ferreira, T. (1994). Contribuição para o estudo das emanações gasosas associadas a processos de vulcanismo no arquipélago dos Açores. Provas de Aptidão Pedagógica e Capacidade Científica. Universidade dos Açores, Ponta Delgada, 183.

Ferreira, T., Gaspar, J. L., Viveiros, F., Marcos, M., Faria, C. and Sousa, F. (2005). Monitoring of fumarole discharge and CO2 soil degassing in the Azores: contribution to volcanic surveillance and public health risk assessment. Annals of Geophysics, 48(4-5).

Fossette, S., Hobson, V. J., Girard, C., Calmettes, B., Gaspar, P., Georges, J. Y. and Hays, G. C. (2010). Spatio-temporal foraging patterns of a giant zooplanktivore, the leatherback turtle. Journal of Marine systems, 81(3), 225-234. https://doi.org/10.1016/j.jmarsys.2009.12.002

Frazer, N. B. and Ehrhart, L. M. (1985). Preliminary growth models for green, Chelonia mydas, and loggerhead, Caretta caretta, turtles in the wild. Copeia, 73-79. https://doi.org/10.2307/1444792

Frazer, N. B. and Ladner, R. C. (1986). A growth curve for green sea turtles, Chelonia mydas, in the US Virgin Islands, 1913-14. Copeia, 1986(3), 798-802. https://doi.org/10.2307/1444963

Frazier, J. (1971). Observations on sea turtles at Aldabra Atoll. Philosophical Transactions of the Royal Society of London. B, Biological Sciences, 260(836), 373-410. https://doi.org/10.1098/rstb.1971.0019

Frick, M. G., Williams, K. L., Bolten, A. B., Bjorndal, K. A. and Martins, H. R. (2009). Foraging ecology of oceanic-stage loggerhead turtles Caretta caretta. Endangered Species Research, 9(2), 91-97. https://doi.org/10.3354/esr00227

Fukuoka, T., Narazaki, T., Kinoshita, C. and Sato, K. (2019). Diverse foraging habits of juvenile green turtles (Chelonia mydas) in a summer-restricted foraging habitat in the northwest Pacific Ocean. Marine Biology, 166(3), 25. https://doi.org/10.1007/s00227-019-3481-9

Gaffney, E. S. and Meylan, P. A. (1988). A phylogeny of turtles, in: Benton, M. J. Phylogeny and Classification of the Tetrapods. Published for the Systematics Association by the Clarendon Press.

Garnett, S. T., Price, I. R. and Scott, F. J. (1985). The diet of the green turtle, Chelonia Mydas (L.), in Torres Strait. Wildlife Research, 12(1), 103-112. https://doi.org/10.1071/WR9850103

Gelcich, S., Kaiser, M. J., Castilla, J. C. and Edwards-Jones, G. (2008). Engagement in co-management of marine benthic resources influences environmental perceptions of artisanal fishers. Environmental Conservation, 35(1), 36-45. https://doi.org/10.1017/S0376892908004475

Georges, A., Limpus, C. J., and Parmenter, C. J. (1993). Natural history of the Chelonia. in: Glasby, C. J., Ross, G. J. B., and Beesley, P. L. Fauna of Australia. Vol. 2A: Amphibia and Reptilia. Fauna of Australia, 2, 120-128.

Gerhardinger, L. C., Godoy, E. A. and Jones, P. J. (2009). Local ecological knowledge and the management of marine protected areas in Brazil. Ocean & Coastal Management, 52(3-4), 154-165. https://doi.org/10.1016/j.ocecoaman.2008.12.007

Godley, B. J., Blumenthal, J. M., Broderick, A. C., Coyne, M. S., Godfrey, M. H., Hawkes, L. A. and Witt, M. J. (2008). Satellite tracking of sea turtles: where have we been and where do we go next?. Endangered species research, 4(1-2), 3-22. https://doi.org/10.3354/esr00060

Godley, B. J., Thompson, D. R., Waldron, S. and Furness, R. W. (1998). The trophic status of marine turtles as determined by stable isotope analysis. Marine Ecology Progress Series, 166, 277-284. https://doi.org/10.3354/meps166277

Gould, W. J. (1985). Physical oceanography of the Azores Front. Progress in Oceanography, 14, 167-190. https://doi.org/10.1016/0079-6611(85)90010-2

Hamann, M., Godfrey, M. H., Seminoff, J. A., Arthur, K., Barata, P. C. R., Bjorndal, K. A., Bolten A. B., Broderick A. C., Campbell L. M., Carreras C., Casale P., Chaloupka M., Chan S. K. F., Coyne M. S., Crowder L. B., Diez C. E., Dutton P. H., Epperly S. P., FitzSimmons N. N., Formia A., Girondot M., Hays G. C., Cheng I. J., Kaska Y., Lewison R., Mortimer J. A., Nichols W. J., Reina R. D., Shanker K., Spotila J. R., Tomás J., Wallace B. P., Work T. M., Zbinden J. and Godley, B. J. (2010). Global research priorities for sea turtles: informing management and conservation in the 21st century. Endangered species research, 11(3), 245-269. https://doi.org/10.3354/esr00279

Hamann, M., Grech, A., Wolanski, E. and Lambrechts, J. (2011). Modelling the fate of marine turtle hatchlings. Ecological Modelling, 222(8), 1515-1521. https://doi.org/10.1016/j.ecolmodel.2011.02.003

Hart, K. M. and Fujisaki, I. (2010). Satellite tracking reveals habitat use by juvenile green sea turtles Chelonia mydas in the Everglades, Florida, USA. Endangered Species Research, 11(3), 221-232. https://doi.org/10.3354/esr00284

Hartman, K. L., Visser, F. and Hendriks, A. J. (2008). Social structure of Risso's dolphins (Grampus griseus) at the Azores: a stratified community based on highly associated social units. Canadian Journal of Zoology, 86(4), 294-306. https://doi.org/10.1139/Z07-138

Hasbún, C. R., Lawrence, A. J., Samour, J. H. and Al-Ghais, S. M. (2000). Preliminary observations on the biology of green turtles, Chelonia mydas, from the United Arab Emirates. Aquatic Conservation: Marine and Freshwater Ecosystems, 10(5), 311-322. https://doi.org/10.1002/1099-0755(200009/10)10:5<311::AID-AQC414>3.0.CO;2-Z.

Hatase, H., Sato, K., Yamaguchi, M., Takahashi, K. and Tsukamoto, K. (2006). Individual variation in feeding habitat use by adult female green sea turtles (Chelonia mydas): are they obligately neritic herbivores?. Oecologia, 149(1), 52-64. https://doi.org/10.1007/s00442-006-0431-2.

Hays, G. C., Broderick, A. C., Glen, F., Godley, B. J., Houghton, J. D. R. and Metcalfe, J. D. (2002a). Water temperature and internesting intervals for loggerhead (Caretta caretta) and green (Chelonia mydas) sea turtles. Journal of Thermal Biology, 27(5), 429-432. https://doi.org/10.1016/S0306-4565(02)00012-8

Hays, G. C., Glen, F., Broderick, A. C., Godley, B. J. and Metcalfe, J. D. (2002b). Behavioural plasticity in a large marine herbivore: contrasting patterns of depth utilisation between two green turtle (Chelonia mydas) populations. Marine biology, 141(5), 985-990. https://doi.org/10.1007/s00227-002-0885-7

Hendrickson, J. R. (1982). Nesting behavior of sea turtles with emphasis on physical and behavioral determinants of nesting success or failure in: Bjorndal, K. A. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, DC, 53-58.

Hendriks, V. M., Blanken, P., Adriaans, N. F. P., & Hartnoll, R. (1992). Snowball sampling: A pilot study on cocaine use. IVO, Instituut voor Verslavingsonderzoek, Erasmus Universiteit Rotterdam.

Heppell, S. S., Snover, M. L. and Crowder, L. B. (2003) Sea Turtle Population Ecology. In: Lutz, P. L., Musick, J. A. (editors) The biology of sea turtles. CRC Press, Boca Raton, 2, 275-306.

Hirayama, R. (1997). Distribution and diversity of Cretaceous chelonioids. In Ancient marine reptiles (pp. 225-241). Academic Press.

Hirth, H. F. (1980). Some aspects of the nesting behavior and reproductive biology of sea turtles. American Zoologist, 20(3), 507-523. https://doi.org/10.1093/icb/20.3.507

Hirth, H. F., Klikoff, I. G. and KT, H. (1973). Seagrasses at Khor Umaira. Peoples Democratic Republic of Yemen with reference to their role in diet of green turtle, Chelonia mydas. Fishery Bulletin, 71(4), 1093-1097.

Howell, L. N., Reich, K. J., Shaver, D. J., Landry Jr, A. M. and Gorga, C. C. (2016). Ontogenetic shifts in diet and habitat of juvenile green sea turtles in the northwestern Gulf of Mexico. Marine Ecology Progress Series, 559, 217-229. https://doi.org/10.3354/meps11897

Isidro, E. J. L. F. (1996). Biology and population dynamics of selected demersal fish species of the Azores Archipelago (Doctoral dissertation, University of Liverpool).

Jackson, J. B., Kirby, M. X., Berger, W. H., Bjorndal, K. A., Botsford, L. W., Bourque, B. J., Bradbury, R. H., Cooke, R., Erlandson, J., Estes, J. A., Hiughes, T. P., Kidwell, S., Lange, C. L., Lenihan, H. S., Pandolfi, J. M., Peterson, C. H., Steneck, R. S., Tegner, M. J. and Warner, R. R. (2001). Historical overfishing and the recent collapse of coastal ecosystems. science, 293(5530), 629-637. https://doi.org/10.1126/science.1059199

Jean, C., Ciccione, S., Talma, E., Ballorain, K., & Bourjea, J. (2010). Photo-identification method for green and hawksbill turtles-First results from Reunion. Indian ocean turtle NewsLeTTER, 11, 8-13.

Johnson, J. and Stevens, I. (2000). A fine resolution model of the eastern North Atlantic between the Azores, the Canary Islands and the Gibraltar Strait. Deep Sea Research Part I: Oceanographic Research Papers, 47(5), 875-899. https://doi.org/10.1016/S0967-0637(99)00073-4.

Jones, T. T. and Seminoff, J. A. (2013). Feeding biology: advances from field-based observations, physiological studies, and molecular techniques, in: Lutz, P. L., Musick, J. A. (editors) The biology of sea turtles. CRC Press, Boca Raton, 3, pp 211-247.

Karaa, S., Bradai, M. N., Jribi, I. and Bouain, A. (2012). The occurrence of the green sea turtle Chelonia mydas, in the Gulf of Gabes (Tunisia). Vie et Milieu-Life and environment, 62(4), 1-6.

Klein, B. and Siedler, G. (1989). On the origin of the Azores Current. Journal of Geophysical Research: Oceans, 94(C5), 6159-6168. https://doi.org/10.1029/JC094iC05p06159.

Klimova, B. and Poulova, P. (2018). Older people and technology acceptance. In: Zhou, J. and Salvendy, G. (editors) Human Aspects of IT for the Aged Population. Acceptance, Communication and Participation. ITAP 2018. Lecture Notes in Computer Science, vol 10926. Springer, Cham. https://doi.org/10.1007/978-3-319-92034-4_7

Lamont, M. M. and Iverson, A. R. (2018). Shared habitat use by juveniles of three sea turtle species. Marine Ecology Progress Series, 606, 187-200. https://doi.org/10.3354/meps12748

Lee, L. C., Thorley, J., Watson, J., Reid, M. and Salomon, A. K. (2019). Diverse knowledge systems reveal social–ecological dynamics that inform species conservation status. Conservation Letters, 12(2), e12613. https://doi.org/10.1111/conl.12613

Leedy, D. L. (1949). Ohio pheasant nesting surveys based on farmer interviews. The Journal of Wildlife Management, 13(3), 274-286. https://doi.org/10.2307/3795869

Lévy, M., Klein, P. and Treguier, A. M. (2001). Impact of sub-mesoscale physics on production and subduction of phytoplankton in an oligotrophic regime. Journal of marine research, 59(4), 535-565. https://doi.org/10.1357/002224001762842181

Levy, Y., Keren, T., Leader, N., Weil, G., Tchernov, D. and Rilov, G. (2017). Spatiotemporal hotspots of habitat use by loggerhead (Caretta caretta) and green (Chelonia mydas) sea turtles in the Levant basin as tools for conservation. Marine Ecology Progress Series, 575, 165-179. https://doi.org/10.3354/meps12146

Lewison, R. L., Crowder, L. B. and Shaver, D. J. (2003). The impact of turtle excluder devices and fisheries closures on loggerhead and Kemp's ridley strandings in the western Gulf of Mexico. Conservation Biology, 17(4), 1089-1097. https://doi.org/10.1046/j.1523-1739.2003.02057.x.

Liles, M. J., Peterson, M. J., Lincoln, Y. S., Seminoff, J. A., Gaos, A. R. and Peterson, T. R. (2015). Connecting international priorities with human wellbeing in low-income regions: lessons from hawksbill turtle conservation in El Salvador. Local Environment, 20(11), 1383-1404. https://doi.org/10.1080/13549839.2014.905516.

Limpus, C. J. (1992). Estimation of tag loss in marine turtle research. Wildlife Research, 19(4), 457-469. https://doi.org/10.1071/WR9920457

Limpus, C. J. (2008). A biological review of Australian marine turtles. 2. Environmental Protection Agency, Brisbane.

Limpus, C. J. and Limpus, D. J. (2001). The loggerhead turtle, Caretta caretta, in Queensland: breeding migrations and fidelity to a warm temperate feeding area. Chelonian Conservation and Biology, 4(1), 142-153.

Limpus, C. J. and Reed, P. C. (1985). Green Sea Turtles Stranded by Cyclone Kathy on the South-Westeern Coast of the Culf of Carpentaria. Wildlife Research, 12(3), 523-533. https://doi.org/10.1071/WR9850523

Limpus, C. J., Miller, J. D., Paramenter, C. J., Reimer, D., McLachlan, N. and Webb, R. (1992). Migration of green (Chelonia mydas) and loggerhead (Caretta caretta) turtles to and from eastern Australian rookeries. Wildlife Research, 19(3), 347-357. https://doi.org/10.1071/WR9920347

Lindeman, K. C. and Snyder, D. B. (1999). Nearshore hardbottom fishes of southeast Florida and effects of habitat burial caused by dredging. Fishery Bulletin, 97(3), 508-525.

Lindeman, K. C., McCarthy, D. A., Holloway-Adkins, K. G. and Snyder, D. B. (2009). Ecological functions of nearshore hardbottom habitats in East Florida: a literature synthesis. Prepared for the Florida Department of Environmental Protection Bureau of Beaches and Coastal Systems. Tallahassee, Florida.

Lozano-Montes, H. M., Pitcher, T. J. and Haggan, N. (2008). Shifting environmental and cognitive baselines in the upper Gulf of California. Frontiers in Ecology and the Environment, 6(2), 75-80. https://doi.org/10.1890/070056

Lucas, C. H., Jones, D. O., Hollyhead, C. J., Condon, R. H., Duarte, C. M., Graham, W. M., Robinson, K. L., Pitt K. A., Schildhauer M. and Regetz, J. (2014). Gelatinous zooplankton biomass in the global oceans: geographic variation and environmental drivers. Global Ecology and Biogeography, 23(7), 701-714. https://doi.org/10.1111/geb.12169

Lucchetti, A., Vasapollo, C. and Virgili, M. (2017). An interview-based approach to assess sea turtle bycatch in Italian waters. PeerJ, 5, e3151. https://doi.org/10.7717/peerj.3151

Luschi, P., Hays, G. C. and Papi, F. (2003). A review of long-distance movements by marine turtles, and the possible role of ocean currents. Oikos, 103(2), 293-302. https://doi.org/10.1034/j.1600-0706.2003.12123.x

Lutz, P. L. and Bentley, T. B. (1985). Respiratory physiology of diving in the sea turtle. Copeia, 671-679. https://doi.org/10.2307/1444761

Magalhães, S., Prieto, R., Silva, M. A., Gonçalves, J., Afonso-Dias, M. and Santos, R. S. (2002). Short-term reactions of sperm whales (Physeter macrocephalus) to whale-watching vessels in the Azores. Aquatic Mammals, 28(3), 267-274.

Maillard, C. and Käse, R. (1989). The near-surface flow in the subtropical gyre south of the Azores. Journal of Geophysical Research: Oceans, 94(C11), 16133-16140. https://doi.org/10.1029/JC094iC11p16133.

Makowski, C., Seminoff, J. A. and Salmon, M. (2006). Home range and habitat use of juvenile Atlantic green turtles (Chelonia mydas L.) on shallow reef habitats in Palm Beach, Florida, USA. Marine Biology, 148(5), 1167-1179. https://doi.org/10.1007/s00227-005-0150-y

Mansfield, K. L., Wyneken, J., Porter, W. P. and Luo, J. (2014). First satellite tracks of neonate sea turtles redefine the 'lost years' oceanic niche. Proceedings of the Royal Society B: Biological Sciences, 281(1781), 20133039. https://doi.org/10.1098/rspb.2013.3039

Margaritoulis, D. and Teneketzis, K. (2003). Identification of a developmental habitat of the green turtle in Lakonikos Bay, Greece. In: Margaritoulis, A. and Demetropoulos, A. (editors) Proceedings of the First Mediterranean Conference on Marine Turtles. Barcelona Convention — Bern Convention —Bonn Convention (CMS), Nicosia, Cyprus, p 170-175

Marques, J. G. W. (2001). Pescando pescadores: ciência e etnociência em uma perspectiva ecológica. NUPAUB/USP.

Martins, H. R., Bjorndal, K. A., Ferreira, R. L., Parra, H. A. E., Pham, C. K., Rodríguez, Y., Santos, M.R., Vandeperre, F. and Bolten, A. B. (2018). Sea turtles: University of Florida–University of the Azores connection 1984–present. A review. Arquipélago-Life and Marine Sciences, 35, 85-94.

Mason, J. G., Alfaro-Shigueto, J., Mangel, J. C., Brodie, S., Bograd, S. J., Crowder, L. B. and Hazen, E. L. (2019). Convergence of fishers' knowledge with a species distribution model in a Peruvian shark fishery. Conservation Science and Practice, 1(4), e13. https://doi.org/10.1111/csp2.13

Matera, J. (2016). Livelihood diversification and institutional (dis-) trust: Artisanal fishing communities under resource management programs in Providencia and Santa Catalina, Colombia. Marine Policy, 67, 22-29. https://doi.org/10.1016/j.marpol.2016.01.021

Matich, P., Heithaus, M. R., & Layman, C. A. (2011). Contrasting patterns of individual specialization and trophic coupling in two marine apex predators. Journal of Animal Ecology, 80(1), 294-305. https://doi.org/10.1111/j.1365-2656.2010.01753.x

Maxwell, S. M., Breed, G. A., Nickel, B. A., Makanga-Bahouna, J., Pemo-Makaya, E., Parnell, R. J., Formia, A., Ngouessono, S., Godley, B.J., Costa, D.P., Witt, M.J and Coyne, M. S. (2011). Using satellite tracking to optimize protection of long-lived marine species: olive ridley sea turtle conservation in Central Africa. PloS one, 6(5), e19905. https://doi.org/10.1371/journal.pone.0019905

Mendonça, M. T. (1981). Comparative growth rates of wild immature Chelonia mydas and Caretta caretta in Florida. Journal of Herpetology, 15(4), 447-451. https://doi.org/10.2307/1563536

Mendonça, M. T. and Ehrhart, L. M. (1982). Activity, Population Size and Structure of Immature Chelonia mydas and Caretta caretta in Mosquito Lagoon, Florida. Copeia, 1982(1), 161–167. doi:10.2307/1444280

Meylan, A. B. (1999). Status of the hawksbill turtle (Eretmochelys imbricata) in the Caribbean region. Chelonian Conservation and Biology, 3(2), 177-184.

Meylan, P. A., Meylan, A. B. and Gray, J. A. (2011). The ecology and migrations of sea turtles 8. Tests of the developmental habitat hypothesis. Bulletin of the American Museum of Natural History, 2011(357), 1-70. https://doi.org/10.1206/357.1

Miller, J. D. (1985). Embryology of marine turtles, in Biology of the Reptilia, Vol. 14A, Gans, C., Billett, F. and Maderson, P. F. A., Eds., Wiley-Interscience, New York, 269-328.

Monteiro, L. D. R., Ramos, J. A., Pereira, J. C., Monteiro, P. R., Feio, R. S., Thompson, D. R., Bearhop, S., Furness, R.W., Laranjo, M., Hilton, G., Neves, V.C., Groz, M.P. and Thompson, K. R. (1999). Status and distribution of Fea's petrel, Bulwer's petrel, Manx shearwater, Little shearwater and Band-rumped storm-petrel in the Azores Archipelago. Waterbirds, 358-366. https://doi.org/10.2307/1522111.

Monteiro, L. R., Ramos, J. A. and Furness, R. W. (1996). Past and present status and conservation of the seabirds breeding in the Azores archipelago. Biological conservation, 78(3), 319-328. https://doi.org/10.1016/S0006-3207(96)00037-7.

Mortimer, J. A. (1981). The feeding ecology of the West Caribbean green turtle (Chelonia mydas) in Nicaragua. Biotropica, 49-58. https://doi.org/10.2307/2387870

Morton, B., Britton, J. C. and Martins, A. D. F. (1998). Coastal ecology of the Açores: i-viii, 1-247. Sociedade Afonso Chaves, Associação de Estudos Açoreanos, Ponta Delgada.

Moser, C. A. (1951). Interview bias. Revue de L'institut International de Statistique, 28-40. https://doi.org/10.2307/1401500

Moyer, R. P., Riegl, B., Banks, K. and Dodge, R. E. (2003). Spatial patterns and ecology of benthic communities on a high-latitude South Florida (Broward County, USA) reef system. Coral Reefs, 22(4), 447-464. https://doi.org/10.1007/s00338-003-0334-1

Mukherjee, N., Zabala, A., Huge, J., Nyumba, T. O., Adem Esmail, B. and Sutherland, W. J. (2018). Comparison of techniques for eliciting views and judgements in decision-making. Methods in Ecology and Evolution, 9(1), 54-63. https://doi.org/10.1111/2041-210X.12940

Musick, J. A. and Limpus, C. J. (1997). Habitat Utilization and Migration in Juvenile Sea Turtles. in: Lutz, P. L., Musick, J. A. (editors) The biology of sea turtles. CRC Press, Boca Raton, 6.

Nagaoka, S. M., Martins, A. S., Dos Santos, R. G., Tognella, M. M. P., de Oliveira Filho, E. C. and Seminoff, J. A. (2012). Diet of juvenile green turtles (Chelonia mydas) associating with artisanal fishing traps in a subtropical estuary in Brazil. Marine Biology, 159(3), 573-581. https://doi.org/10.1007/s00227-011-1836-y

Narchi, N. E., Cornier, S., Canu, D. M., Aguilar-Rosas, L. E., Bender, M. G., Jacquelin, C., Thiba M., Moura, G. G. M. and De Wit, R. (2014). Marine ethnobiology a rather neglected area, which can provide an important contribution to ocean and coastal management. Ocean & Coastal Management, 89, 117-126. https://doi.org/10.1016/j.ocecoaman.2013.09.014

National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) (2016). Endangered and Threatened Wildlife and Plants; Final Rule to List Eleven Distinct Population Segments of the Green Sea Turtle (Chelonia mydas) as

Endangered or Threatened and Revision of Current Listings Under the Endangered Species Act. Silver Spring, MD: Office of Protected Resources.

Nishizawa, H., Abe, O., Okuyama, J., Kobayashi, M. and Arai, N. (2011). Population genetic structure and implications for natal philopatry of nesting green turtles Chelonia mydas in the Yaeyama Islands, Japan. Endangered Species Research, 14(2), 141-148. https://doi.org/10.3354/esr00355

Noy, C. (2008). Sampling knowledge: The hermeneutics of snowball sampling in qualitative research. International Journal of social research methodology, 11(4), 327-344. https://doi.org/10.1080/13645570701401305

O'Donnell, K. P., Pajaro, M. G. and Vincent, A. C. J. (2010). How does the accuracy of fisher knowledge affect seahorse conservation status?. Animal Conservation, 13(6), 526-533. https://doi.org/10.1111/j.1469-1795.2010.00377.x

Okemwa, G. M., Nzuki, S. and Mueni, E. M. (2004). The status and conservation of sea turtles in Kenya. Marine Turtle Newsletter,105, 1-6.

Okuyama, J., Kitagawa, T., Zenimoto, K., Kimura, S., Arai, N., Sasai, Y. and Sasaki, H. (2011). Trans-Pacific dispersal of loggerhead turtle hatchlings inferred from numerical simulation modeling. Marine Biology, 158(9), 2055-2063. https://doi.org/10.1007/s00227-011-1712-9

Özdilek, Ş. Y., Akdeniz, B., Firat, A. R., Balkan, E. Ý., Gürsoy, S., Sönmez, B. and Erduðan, H. (2015). Green turtles (Chelonia mydas) feeding on invasive algae Caulerpa taxifolia in Turkey. Russian Journal of Herpetology, 22(2), 139-142.

Palaniappan, P., Nazuhar, N. N. N., Ali, M. and Hussein, S. (2018). Quantifying the nesting density and assessing the potential threats to sea turtles in Kuala Penyu, Sabah, Malaysia. International Journal of Fisheries and Aquatic Studies 6:193–198.

Peran, A. D., Pham, C. K., Amorim, P., Cardigos, F., Tempera, F. and Morato, T. (2016). Seafloor characteristics in the Azores region (North Atlantic). Frontiers in Marine Science, 3, 204. https://doi.org/10.3389/fmars.2016.00204

Pierotti, R. and Wildcat, D. (2000). Traditional ecological knowledge: the third alternative (commentary). Ecological applications, 10(5), 1333-1340. https://doi.org/10.1890/1051-0761(2000)010[1333:TEKTTA]2.0.CO;2.

Piovano, S., Lemons, G. E., Ciriyawa, A., Batibasaga, A. and Seminoff, J. A. (2020). Diet and recruitment of green turtles in Fiji, South Pacific, inferred from in-water capture and stable isotope analysis. Marine Ecology Progress Series, 640, 201-213. https://doi.org/10.3354/meps13287.

Pita, C., Pierce, G. J. and Theodossiou, I. (2010). Stakeholders' participation in the fisheries management decision-making process: fishers' perceptions of participation. Marine policy, 34(5), 1093-1102. https://doi.org/10.1016/j.marpol.2010.03.009

Pitcher, T. J., Telmo, T., Hart, P. J. B., Clark, M. R., Haggan, N., and Santos, R. S. (editors) (2008). Seamounts: ecology, fisheries and conservation. John Wiley & Sons, 2008.

Poe, M. R., Norman, K. C. and Levin, P. S. (2014). Cultural dimensions of socioecological systems: key connections and guiding principles for conservation in coastal environments. Conservation Letters, 7(3), 166-175. https://doi.org/10.1111/conl.12068

Polovina, J., Uchida, I., Balazs, G., Howell, E. A., Parker, D. and Dutton, P. (2006). The Kuroshio Extension Bifurcation Region: a pelagic hotspot for juvenile loggerhead sea turtles. Deep Sea Research Part II: Topical Studies in Oceanography, 53(3-4), 326-339. https://doi.org/10.1016/j.dsr2.2006.01.006.

Prior, B., Booth, D. T. and Limpus, C. J. (2016). Investigating diet and diet switching in green turtles (Chelonia mydas). Australian Journal of Zoology, 63(6), 365-375. https://doi.org/10.1071/ZO15063.

Pritchard, P. C. (2017). Evolution, phylogeny, and current status. In: Lutz, P. L., Musick, J. A. (editors) The biology of sea turtles. CRC Press, Boca Raton, pp 1–28.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Rafferty, A., Walthery, P. and King-Hele, S. (2015). Analysing change over time: Repeated cross sectional and longitudinal survey data. UK Data Service, University of Essex and University of Manchester.

Rasmussen, A. R., Murphy, J. C., Ompi, M., Gibbons, J. W. and Uetz, P. (2011). Marine reptiles. PLOS one, 6(11), e27373. https://doi.org/10.1371/journal.pone.0027373.

Reaka-Kudla, M. L., Wilson, D. E. and Wilson, E. O. (Eds.). (1996). Biodiversity II: understanding and protecting our biological resources. Joseph Henry Press.

Rees, A. F., Alfaro-Shigueto, J., Barata, P. C. R., Bjorndal, K. A., Bolten, A. B., Bourjea, J., Broderick, A. C., Campbell, L. M., Cardona, L., Carreras, C., Casale, P., Ceriani, S. A., Dutton, P. H., Eguchi, T., Formia, A., Fuentes, M. M. P. B., W. J. Fuller, M. Girondot,

M. H. Godfrey, M. Hamann, K. M. Hart, G. C. Hays, S. Hochscheid, Kaska, Y., Jensen, M. P., Mangel, J. C., Mortimer, J. A., Naro-Maciel, E., Ng, C. K. Y., Nichols, W. J., Phillott, A. D., Reina, R. D., Revuelta, O., Schofield, G., Seminoff, J. A., Shanker, K., Tomás, J., van de Merwe, J. P., Van Houtan, K. S., Vander Zanden, H. B., Wallace, B. P., Wedemeyer-Strombel, K. R., Work, T. M. and Godley, B. J. (2016). Are we working towards global research priorities for management and conservation of sea turtles?. Endangered Species Research, 31, 337-382. https://doi.org/10.3354/esr00801

Rehage, J. S., Santos, R. O., Kroloff, E. K. N., Heinen, J. T., Lai, Q., Black, B. D., Boucek, R. E. and Adams, A. J. (2019). How has the quality of bonefishing changed over the past 40 years? Using local ecological knowledge to quantitatively inform population declines in the South Florida flats fishery. Environmental Biology of Fishes, 102(2), 285-298. https://doi.org/10.1007/s10641-018-0831-2

Reich, K. J., Bjorndal, K. A. and Bolten, A. B. (2007). The ‘lost years’ of green turtles: using stable isotopes to study cryptic lifestages. Biology letters, 3(6), 712-714. https://doi.org/10.1098/rsbl.2007.0394.

Renaud, M. L., Carpenter, J. A. and Williams, J. A. (1995). Activities of juvenile green turtles, Chelonia mydas, at a jettied pass in South Texas. Fish. Bull, 93(3), 586-593.

Rindfleisch, A., Malter, A. J., Ganesan, S. and Moorman, C. (2008). Cross-sectional versus longitudinal survey research: Concepts, findings, and guidelines. Journal of marketing research, 45(3), 261-279. https://doi.org/10.1509/jmkr.45.3.261

Risien, J. M. and Tilt, B. (2008). A comparative study of community-based sea turtle management in Palau: Key factors for successful implementation. Conservation and Society, 6(3), 225-237.

Robinson, J. G. (2011). Ethical pluralism, pragmatism, and sustainability in conservation practice. Biological Conservation, 144(3), 958-965. https://doi.org/10.1016/j.biocon.2010.04.017

Roden, S. E., Morin, P. A., Frey, A., Balazs, G. H., Zarate, P., Cheng, I. J. and Dutton, P. H. (2013). Green turtle population structure in the Pacific: new insights from single nucleotide polymorphisms and microsatellites. Endangered Species Research, 20(3), 227-234. https://doi.org/10.3354/esr00500

Russell, D. J. and Balazs, G. H. (2015). Increased use of non-native algae species in the diet of the Green Turtle (Chelonia mydas) in a primary pasture ecosystem in

Hawaii. Aquatic Ecosystem Health & Management, 18(3), 342-346. https://doi.org/10.1080/14634988.2015.1027140

Sala, E., & Knowlton, N. (2006). Global marine biodiversity trends. Annu. Rev. Environ. Resour., 31, 93-122. https://doi.org/10.1146/annurev.energy.31.020105.100235

Salmon, M. and Wyneken, J. (1987). Orientation and swimming behavior of hatchling loggerhead turtles Caretta caretta L. during their offshore migration. Journal of Experimental Marine Biology and Ecology, 109(2), 137-153. https://doi.org/10.1016/0022-0981(87)90012-8.

Salmon, M., Jones, T. T., & Horch, K. W. (2004). Ontogeny of diving and feeding behavior in juvenile seaturtles: leatherback seaturtles (Dermochelys coriacea L) and green seaturtles (Chelonia mydas L) in the Florida Current. Journal of Herpetology, 38(1), 36-43. https://doi.org/10.1670/228-01A

Santos, M. A., Bolten, A. B., Martins, H. R., Riewald, B. and Bjorndal, K. A. (2007). Air-breathing visitors to seamounts: sea turtles. Seamounts: Ecology, Fisheries and Conservation. Fisheries and Aquatic Resource Series, Blackwell Scientific, 239-244.

Santos, R. G., Martins, A. S., Batista, M. B. and Horta, P. A. (2015). Regional and local factors determining green turtle Chelonia mydas foraging relationships with the environment. Marine Ecology Progress Series, 529, 265-277. https://doi.org/10.3354/meps11276

Santos, R. S. and Nash, R. D. (1995). Seasonal changes in a sandy beach fish assemblage at Porto Pim, Faial, Azores. Estuarine, Coastal and Shelf Science, 41(5), 579-591. https://doi.org/10.1016/0272-7714(95)90028-4

Santos, R. S., Hawkins, S., Monteiro, L. R., Alves, M. and Isidro, E. J. (1995). Marine research, resources and conservation in the Azores. Aquatic Conservation: Marine and Freshwater Ecosystems, 5(4), 311-354. https://doi.org/10.1002/aqc.3270050406.

Scales, K. L., Miller, P. I., Hawkes, L. A., Ingram, S. N., Sims, D. W. and Votier, S. C. (2014). On the Front Line: frontal zones as priority at-sea conservation areas for mobile marine vertebrates. Journal of Applied Ecology, 51(6), 1575-1583. https://doi.org/10.1111/1365-2664.12330.

Schmiing, M., Afonso, P., Tempera, F. and Santos, R. S. (2013). Predictive habitat modelling of reef fishes with contrasting trophic ecologies. Marine Ecology Progress Series, 474, 201-216. https://doi.org/10.3354/meps10099

Schroeder, B. A. and Witherington, B. E. (1994). Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation, 23-27 February 1993, Jekyll Island, Georgia.

Seminoff, J. (2002). Global status of the Green Turtle (Chelonia mydas): a summary of the 2001 status assessment for the IUCN Red List Programme. In Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop (pp. 197-211).

Seminoff, J. A., Allen, C. D., Balazs, G. H., Dutton, P. H., Eguchi, T., Haas, H., Hargrove, S. A., Jensen, M., Klemm, D. L., Lauritsen, A. M., MacPherson, S. L., Opay, P., Possardt, E. E., Pultz, S., Seney, E. E., Van Houtan, K. S. and Waples, R. S. (2015). Status review of the green turtle (Chelonia mydas) under the Engangered Species Act.

Seminoff, J.A. (Southwest Fisheries Science Center, U.S.) (2004). Chelonia mydas. The IUCN Red List of Threatened Species 2004: e.T4615A11037468. https://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T4615A11037468.en. Downloaded on 22 July 2021.

Senko, J., Schneller, A. J., Solis, J., Ollervides, F. and Nichols, W. J. (2011). People helping turtles, turtles helping people: understanding resident attitudes towards sea turtle conservation and opportunities for enhanced community participation in Bahia Magdalena, Mexico. Ocean & coastal management, 54(2), 148-157. https://doi.org/10.1016/j.ocecoaman.2010.10.030

Shamblin, B. M., Witherington, B. E., Hirama, S., Hardy, R. F. and Nairn, C. J. (2018). Mixed stock analyses indicate population-scale connectivity effects of active dispersal by surface-pelagic green turtles. Marine Ecology Progress Series, 601, 215-226. https://doi.org/10.3354/meps12693.

Shimada, T., Aoki, S., Kameda, K., Hazel, J., Reich, K. and Kamezaki, N. (2014). Site fidelity, ontogenetic shift and diet composition of green turtles Chelonia mydas in Japan inferred from stable isotope analysis. Endangered Species Research, 25(2), 151-164. https://doi.org/10.3354/esr00616.

Silva, M. A., Prieto, R., Cascão, I., Seabra, M. I., Machete, M., Baumgartner, M. F. and Santos, R. S. (2014). Spatial and temporal distribution of cetaceans in the mid-Atlantic waters around the Azores. Marine Biology Research, 10(2), 123-137. https://doi.org/10.1080/17451000.2013.793814.

Silverman, B. W. (1986) Density Estimation for Statistics and Data Analysis. New York: Chapman and Hall.

Smith, M. M., and Salmon, M. (2009). A comparison between the habitat choices made by hatchling and juvenile green turtles (Chelonia mydas) and loggerheads (Caretta caretta). Marine Turtle Newsletter, 126, 9-13.

Southwood, A. L., Reina, R. D., Jones, V. S. and Jones, D. R. (2003). Seasonal diving patterns and body temperatures of juvenile green turtles at Heron Island, Australia. Canadian Journal of Zoology, 81(6), 1014-1024. https://doi.org/10.1139/z03-081

Spotila, J. R., O'Connor, M. P. and Paladino, F. V. (1997). Thermal biology In: Lutz, P. L., Musick, J. A. (editors) The biology of sea turtles. CRC Press, Boca Raton, 297–314.

Stadler, M., Salmon, M. and Roberts, C. (2015). Ecological correlates of green turtle (Chelonia mydas) abundance on the nearshore worm reefs of southeastern Florida. Journal of Coastal Research, 31(2), 244-254. https://doi.org/10.2112/JCOASTRES-D-14-00070.1

Stave, J., Oba, G., Nordal, I. and Stenseth, N. C. (2007). Traditional ecological knowledge of a riverine forest in Turkana, Kenya: implications for research and management. Biodiversity and Conservation, 16(5), 1471-1489. https://doi.org/10.1007/s10531-006-9016-y

Steiner, L., Silva, M. A., Zereba, J. and Leal, M. J. (2008). Bryde's whales, Balaenoptera edeni, observed in the Azores: a new species record for the region. Marine Biodiversity Records, 1. https://doi.org/10.1017/S1755267207007282.

Stokes, H. J., Mortimer, J. A., Hays, G. C., Unsworth, R. K., Laloë, J. O. and Esteban, N. (2019). Green turtle diet is dominated by seagrass in the Western Indian Ocean except amongst gravid females. Marine Biology, 166(10), 1-12. https://doi.org/10.1007/s00227-019-3584-3

Tapilatu, R. F., Wona, H. and Batubara, P. P. (2017). Status of sea turtle populations and its conservation at Bird's Head Seascape, Western Papua, Indonesia. Biodiversitas Journal of Biological Diversity, 18(1). https://doi.org/10.13057/biodiv/d180118

Thornton, T. F. and Scheer, A. M. (2012). Collaborative engagement of local and traditional knowledge and science in marine environments: a review. Ecology and Society, 17(3). https://doi.org/10.5751/ES-04714-170308

Thorrold, S. R., Afonso, P., Fontes, J., Braun, C. D., Santos, R. S., Skomal, G. B. and Berumen, M. L. (2014). Extreme diving behaviour in devil rays links surface waters and the deep ocean. Nature communications, 5(1), 4274. https://doi.org/10.1038/ncomms5274.

Toledo, V. M., Barrera-Bassols, N., Silva, V. A., Almeida, A. L. S. and Albuquerque, U. P. (2010). Etnobiologia e etnoecologia-pessoas & natureza na américa latina. A etnoecologia: uma ciência pós-normal que estuda as sabedorias tradicionais, 13-36.

Turvey, S. T., Risley, C. L., Moore, J. E., Barrett, L. A., Yujiang, H., Xiujiang, Z., Kaiya, Z. and Ding, W. (2013). Can local ecological knowledge be used to assess status and extinction drivers in a threatened freshwater cetacean?. Biological Conservation, 157, 352-360. https://doi.org/10.1016/j.biocon.2012.07.016

Uetz, P., Freed, P. and Hošek, J. (editors). (2021). The reptile Database.www.reptile-database.org (accessed 8 March 2021).

Van Bruggen, A. C. (1965). Records and observations in the Port Elizabeth Oceanarium in 1960. Zool. Gart. Leipzig, 31(3-4), 184-202.

Van Buskirk, J. and Crowder, L. B. (1994). Life-history variation in marine turtles. Copeia, 66-81. https://doi.org/10.2307/1446672.

Van Houtan, K. S., Hargrove, S. K. and Balazs, G. H. (2014). Modeling sea turtle maturity age from partial life history records. Pacific Science, 68(4), 465-477. https://doi.org/10.2984/68.4.2

Vandeperre, F., Aires-da-Silva, A., Fontes, J., Santos, M., Serrão Santos, R. and Afonso, P. (2014a). Movements of blue sharks (Prionace glauca) across their life history. PLoS One, 9(8), e103538. https://doi.org/10.1371/journal.pone.0103538.

Vandeperre, F., Aires-da-Silva, A., Santos, M., Ferreira, R., Bolten, A. B., Santos, R. S. and Afonso, P. (2014b). Demography and ecology of blue shark (Prionace glauca) in the central North Atlantic. Fisheries Research, 153, 89-102. https://doi.org/10.1016/j.fishres.2014.01.006.

Vander Zanden, H. B., Arthur, K. E., Bolten, A. B., Popp, B. N., Lagueux, C. J., Harrison, E., Campbell, C. L. and Bjorndal, K. A. (2013). Trophic ecology of a green turtle breeding population. Marine Ecology Progress Series, 476, 237-249. https://doi.org/10.3354/meps10185.

Varo-Cruz, N., Bermejo, J. A., Calabuig, P., Cejudo, D., Godley, B. J., López-Jurado, L. F., Pikesley, S. K., Witt, M. J. and Hawkes, L. A. (2016). New findings about the spatial and temporal use of the Eastern Atlantic Ocean by large juvenile loggerhead turtles. Diversity and Distributions, 22(4), 481-492. https://doi.org/10.1111/ddi.12413.

Varo-Cruz, N., Cejudo, D., Calabuig, P., Herrera, R., Urioste, J. and Monzón-Argüello, C. (2017). Records of the Hawksbill Sea Turtle (Eretmochelys imbricata) in the Canary Islands. Marine Turtle Newsletter, 154, 1-6.

Vaughan, N., Lucas, E. A., Harris, S. and White, P. C. (2003). Habitat associations of European hares Lepus europaeus in England and Wales: implications for farmland management. Journal of Applied Ecology, 40(1), 163-175. https://doi.org/10.1046/j.1365-2664.2003.00784.x

Viveiros, F., Cardellini, C., Ferreira, T., Caliro, S., Chiodini, G. and Silva, C. (2010). Soil CO2 emissions at Furnas volcano, São Miguel Island, Azores archipelago: Volcano monitoring perspectives, geomorphologic studies, and land use planning application. Journal of Geophysical Research: Solid Earth, 115(B12). https://doi.org/10.1029/2010JB007555

Wallace, B. P., Lewison, R. L., McDonald, S. L., McDonald, R. K., Kot, C. Y., Kelez, S., Bjorkland, R. K., Finkbeiner, E. M., Helmbrecht, S. and Crowder, L. B. (2010). Global patterns of marine turtle bycatch. Conservation letters, 3(3), 131-142. https://doi.org/10.1111/j.1755-263X.2010.00105.x.

Watson, J. W., Epperly, S. P., Shah, A. K. and Foster, D. G. (2005). Fishing methods to reduce sea turtle mortality associated with pelagic longlines. Canadian Journal of Fisheries and Aquatic Sciences, 62(5), 965-981. https://doi.org/10.1139/f05-004.

Wedemeyer-Strombel, K. R., Peterson, M. J., Sanchez, R. N., Chavarría, S., Valle, M., Altamirano, E., Gadea, V., Sowards, S.K., Tweedie, C.E. and Liles, M. J. (2019). Engaging fishers' ecological knowledge for endangered species conservation: four advantages to emphasizing voice in participatory action research. Frontiers in Communication, 4, 30. https://doi.org/10.3389/fcomm.2019.00030.

Whiting, S. D., Guinea, M. L., Limpus, C. J. and Fomiatti, K. (2007). Blood chemistry reference values for two ecologically distinct populations of foraging green turtles, eastern Indian Ocean. Comparative Clinical Pathology, 16(2), 109-118. https://doi.org/10.1007/s00580-006-0646-y

Wickham, H. (2016). ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York. ISBN 978-3-319-24277-4, https://ggplot2.tidyverse.org.

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T. L., Miller, E., Bache, S. M., Müller, K., Ooms, J., Robinson, D., Seidel, D. P., Spinu, V., Takahashi, K., Vaughan, D., Wilke, C., Woo, K., and Yutani, H. (2019). Welcome to the tidyverse. Journal of Open Source Software, 4(43), 1686. https://doi.org/10.21105/joss.01686.

Williard, A. S., Wyneken, J., Lohmann, K. J. and Musick, J. A. (2013). Physiology as integrated systems. In: Lutz, P. L., Musick, J. A. (editors) The biology of sea turtles. CRC Press, Boca Raton, 3, 1-30.

Witham, R. (1980). The "lost year" question in young sea turtles. American Zoologist, 20(3), 525-530. https://doi.org/10.1093/icb/20.3.525.

Witherington, B. E. and Martin, R. E. (2003). Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches. St. Petersburg, FL, Florida Marine Research Institute. Technical Report, TR-2, 3, 9-10.

Witherington, B., Kubilis, P., Brost, B. and Meylan, A. (2009). Decreasing annual nest counts in a globally important loggerhead sea turtle population. Ecological Applications, 19(1), 30-54. https://doi.org/10.1890/08-0434.1

Wright, L. I., Fuller, W. J., Godley, B. J., McGOWAN, A. N. D. R. E. W., Tregenza, T. O. M. and Broderick, A. C. (2012). Reconstruction of paternal genotypes over multiple breeding seasons reveals male green turtles do not breed annually. Molecular ecology, 21(14), 3625-3635. https://doi.org/10.1111/j.1365-294X.2012.05616.x

Wyneken, J. (2017). Sea turtle locomotion: mechanisms, behavior, and energetics. In: Lutz, P. L., Musick, J. A. (editors) The biology of sea turtles. CRC Press, Boca Raton, pp 150–184.

Wyneken, J. and Salmon, M. (1992). Frenzy and postfrenzy swimming activity in loggerhead, green, and leatherback hatchling sea turtles. Copeia, 478-484. https://doi.org/10.2307/1446208

Yli-Pelkonen, V. and Kohl, J. (2005). The role of local ecological knowledge in sustainable urban planning: perspectives from Finland. Sustainability: science, practice and policy, 1(1), 3-14. https://doi.org/10.1080/15487733.2005.11907960

Yntema, C. L., & Mrosovsky, N. (1982). Critical periods and pivotal temperatures for sexual differentiation in loggerhead sea turtles. Canadian Journal of Zoology, 60(5), 1012-1016. https://doi.org/10.1139/z82-141.

Zale, A. V. and Merrifield, S. G. (1989). Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (South Florida): Reef-building tube worm (No. 4). US Army Corps of Engineers, Waterways Experiment Station, Coastal Ecology Group.

Zug, G. R. and Glor, R. E. (1998). Estimates of age and growth in a population of green sea turtles (Chelonia mydas) from the Indian River lagoon system, Florida: a skeletochronological analysis. Canadian Journal of Zoology, 76(8), 1497-1506. https://doi.org/10.1139/z98-090.

Zug, G. R., Balazs, G. H., Wetherall, J. A., Parker, D. M. and Murakawa, S. K. (2002). Age and growth of Hawaiian seaturtles (Chelonia mydas): an analysis based on skeletochronology. Fishery Bulletin, 100(1), 117-127.

7. Appendices

Ilha: Id:

Tipo de abordagem:

Contacto:

Autor:

Avistamento de tartarugas verdes (*Chelonia mydas*)

Avistamentos de tartaruga verde no ano 2019 e 2020	
Conhece e sabe distinguir as espécies de tartarugas marinhas que ocorrem nos Açores?	
Espécie	
Quando foi o avistamento? (mês e ano)	
Quantos indivíduos foram avistados?	
Onde foi o avistamento? (descrição e localização no mapa)	
Descrição aproximada do tamanho em centímetros do(s) individuo(s)	
Descrição da atividade do(s) individuo(s). (Alimentar-se, descansar, apenas a nadar – a superficie, meia agua, no fundo, etc.)	
Descrição do local do avistamento. (Rocha, areia, mistura rocha-areia; baixa costeira ou não, etc.)	
Profundidade	
Já avistou o mesmo individuo em outras alturas? (o mesmo individuo em diferentes ocasiões)	
Tem imagens do encontro com a tartaruga?	
Em comparação com anos anteriores, acha que há mais ou menos tartarugas nos locais que frequenta?	
Outras observações	
Perfil do pescador	
É residente nos Açores? (Indicar a ilha de residência)	
Idade?	
Atividade do entrevistado (caça submarina, snorkeling, mergulho com escafandro, natação, pesca costeira, pesca de embarcação - profissional/recreio)?	
Há quantos anos pratica a atividade?	
Quão experiente na atividade se autoclassifica? (Muito experiente, Experiente ou Pouco Experiente)	
Qual profundidade máxima a que mergulha?	
Quantas vezes pratica a atividade ao ano? (<5, 5-10, 10-20, 20-40, 40-60, 60-80, >80)	
Média de tempo de cada mergulho?	
Quais são as áreas onde pratica a sua atividade com alta/media/baixa intensidade? (indicar no mapa)	
Outras observações	
Avistamento de tartarugas em anos anteriores	
Quando foi o avistamento? (ano e mês ou estação do ano)	
Quantos indivíduos foram avistados?	
Onde foi o avistamento? (descrição e localização no mapa)	
Descrição aproximada do tamanho em centímetros do(s) individuo(s)	
Descrição do local do avistamento. (Rocha, areia, mistura rocha-areia; baixa costeira ou não, etc.)	
Descrição da atividade do(s) individuo(s). (Alimentar-se, descansar, apenas a nadar – a superficie, meia agua, no fundo, ect.)	
Outras observações	

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Figure 27 In-person questionnaire template.

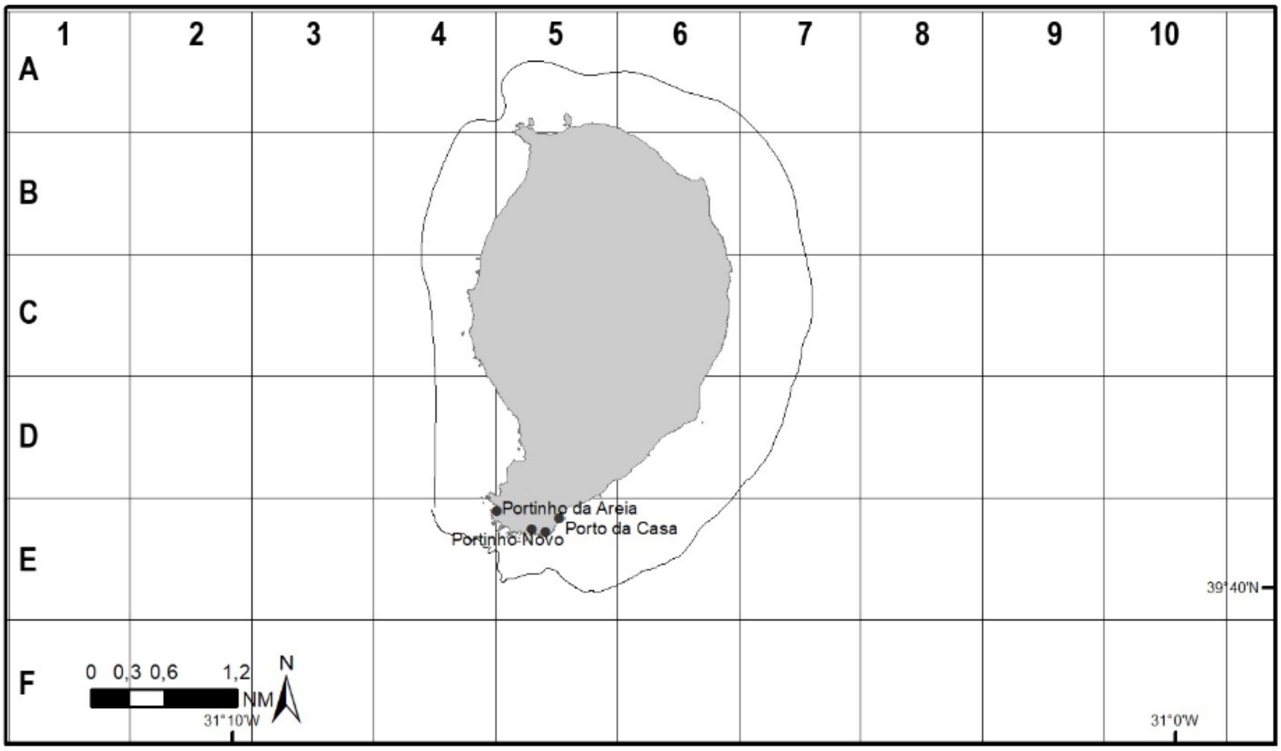

Figure 28 Map of Corvo Island with grid table.

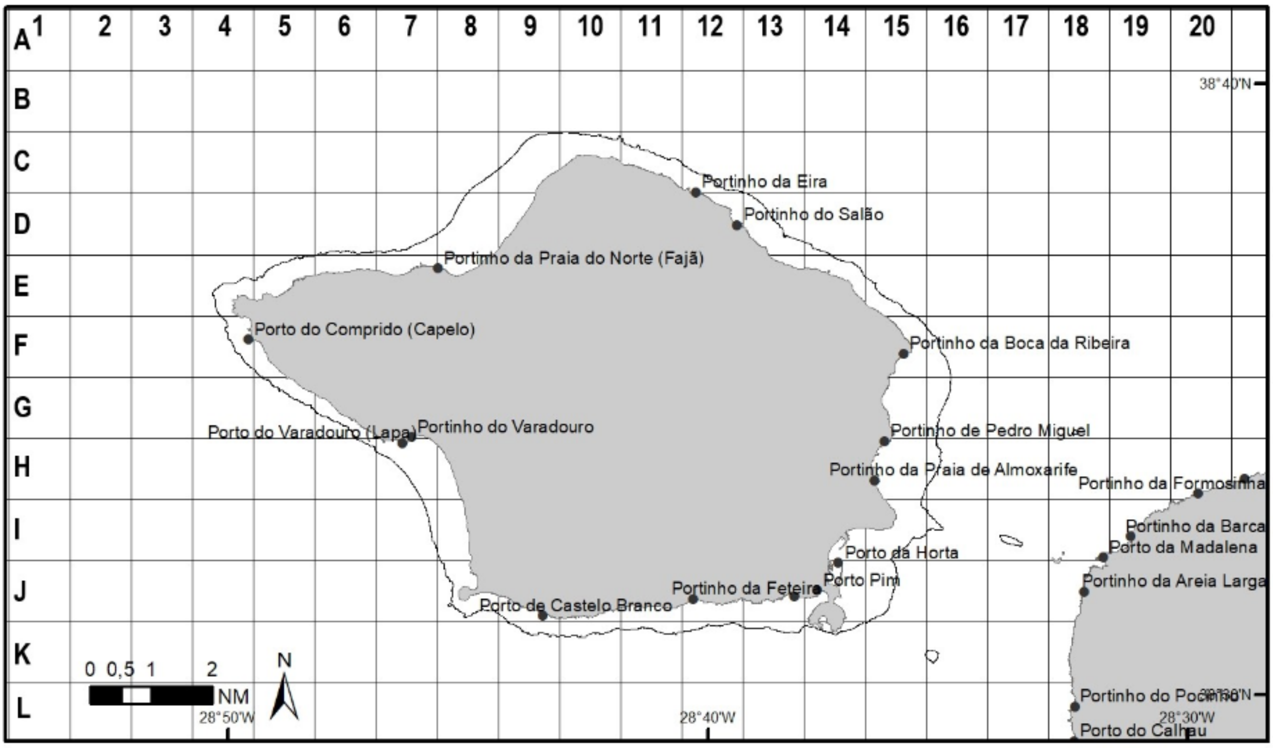

Figure 29 Map of Faial Island with grid table.

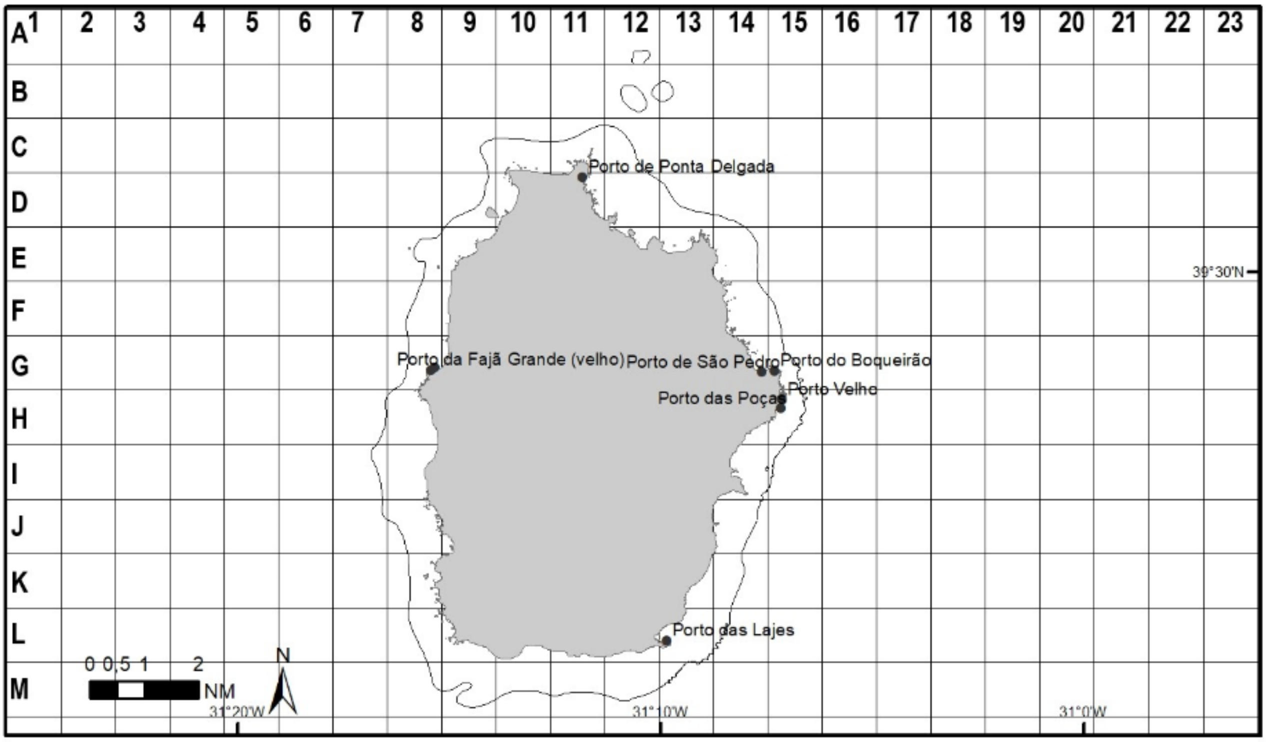

Figure 30 Map of Flores Island with grid table.

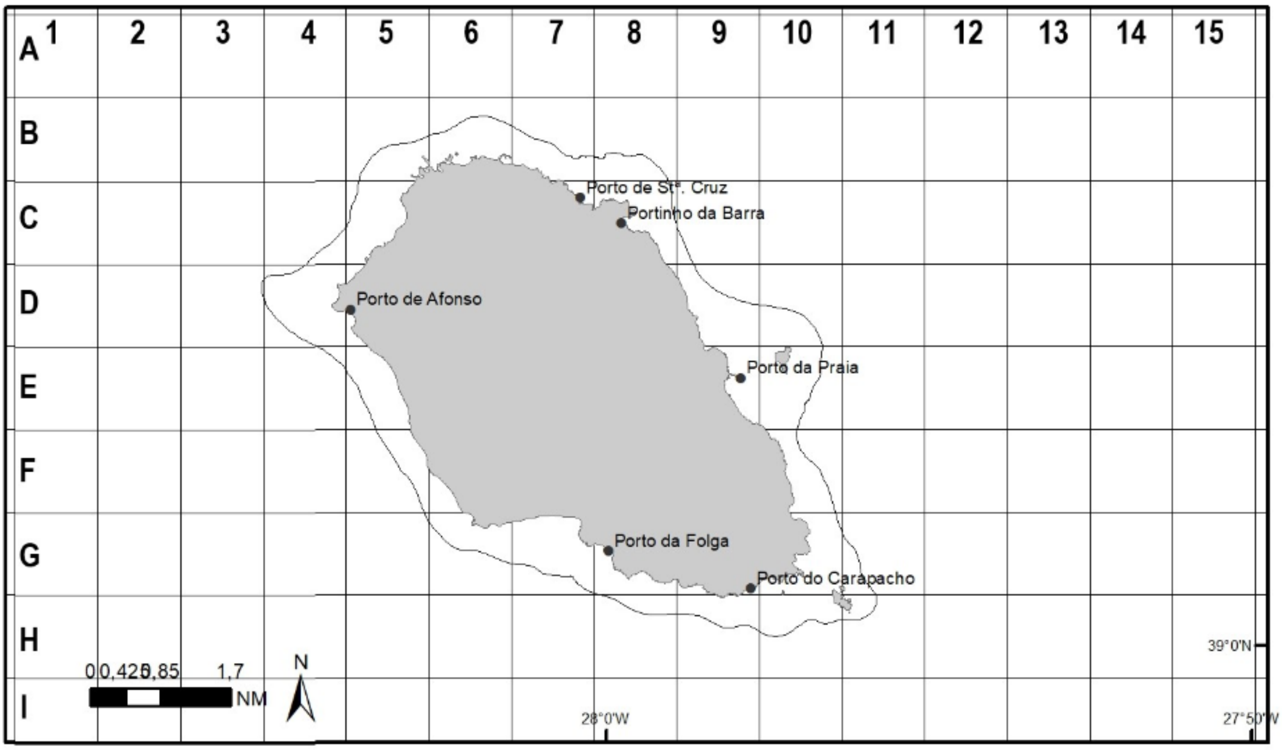

Figure 31 Map of Graciosa Island with grid table.

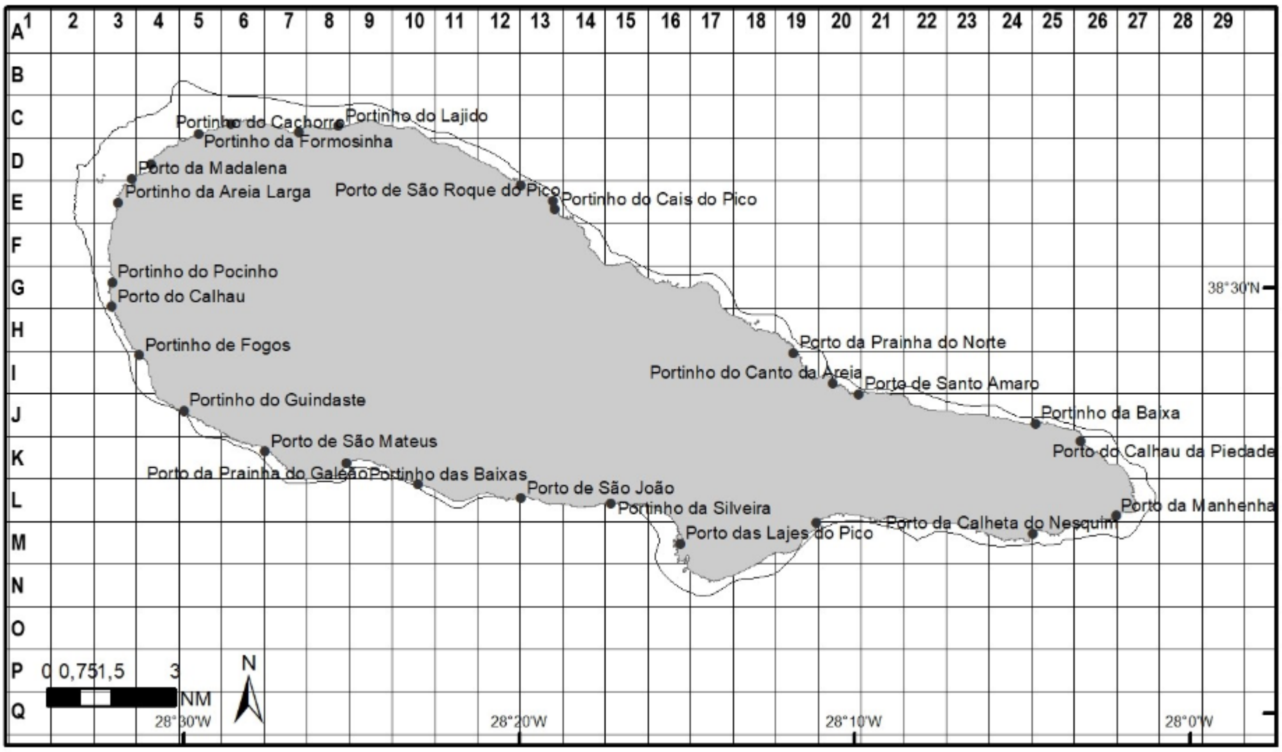

Figure 32 Map of Pico Island with grid table.

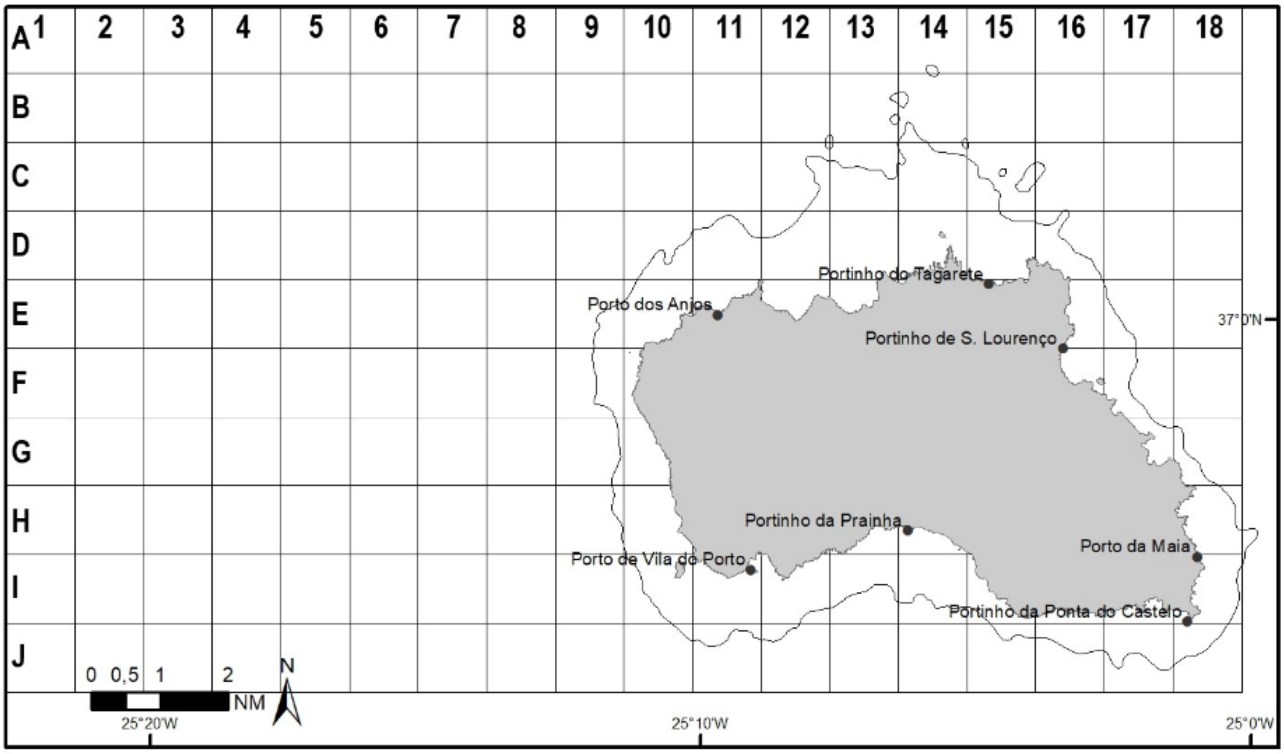

Figure 33 Map of Santa Maria Island with grid table.

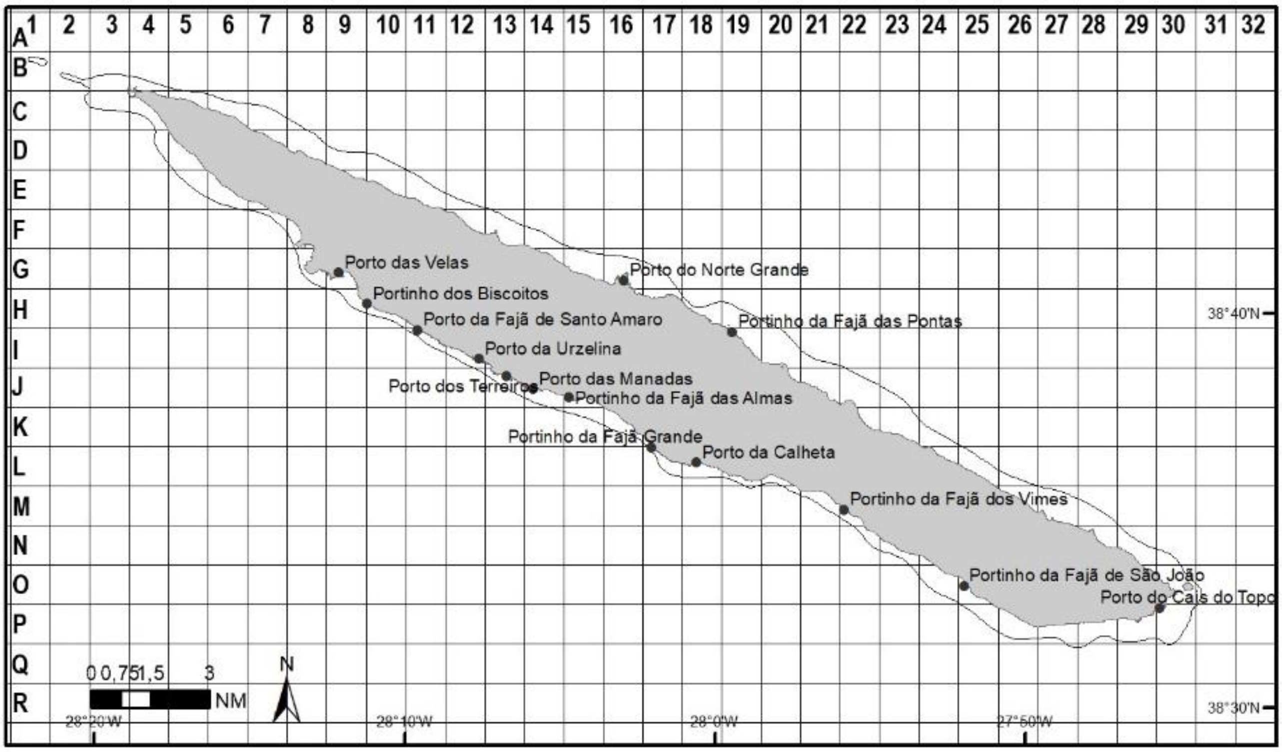

Figure 34 Map of São Jorge Island with grid table.

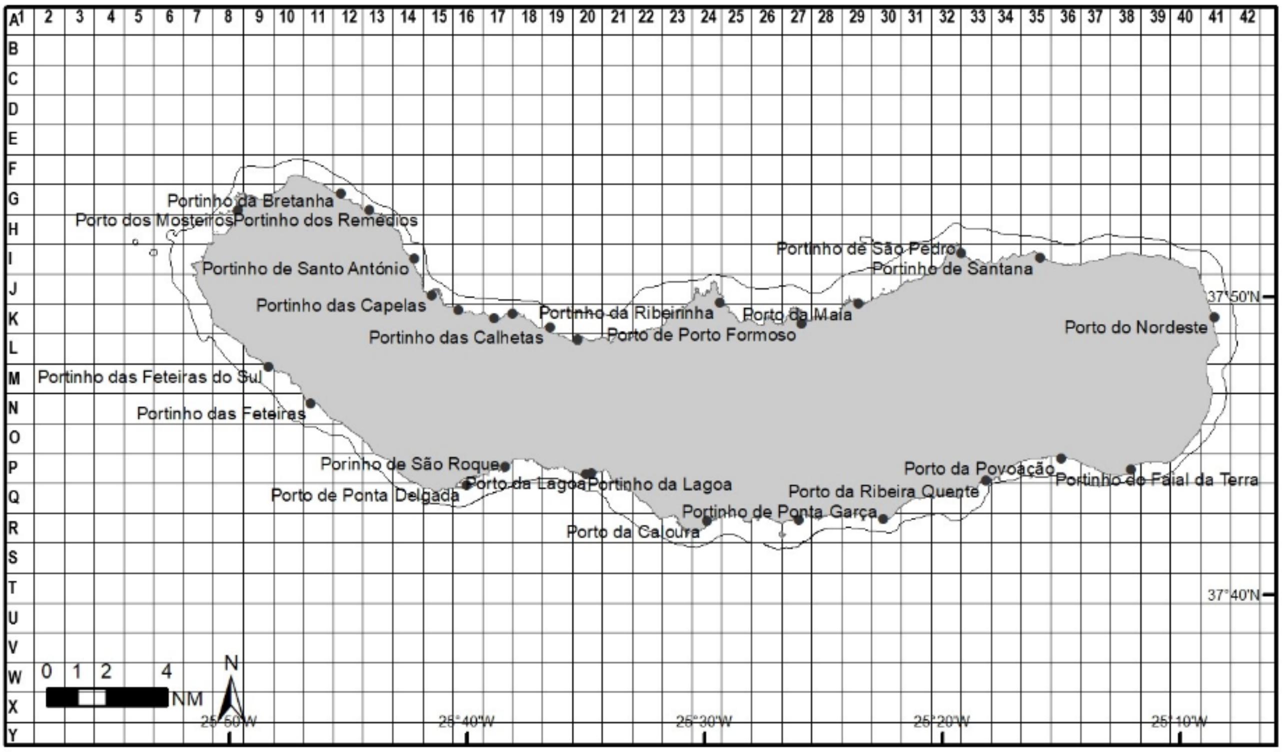

Figure 35 Map of São Miguel Island with grid table.

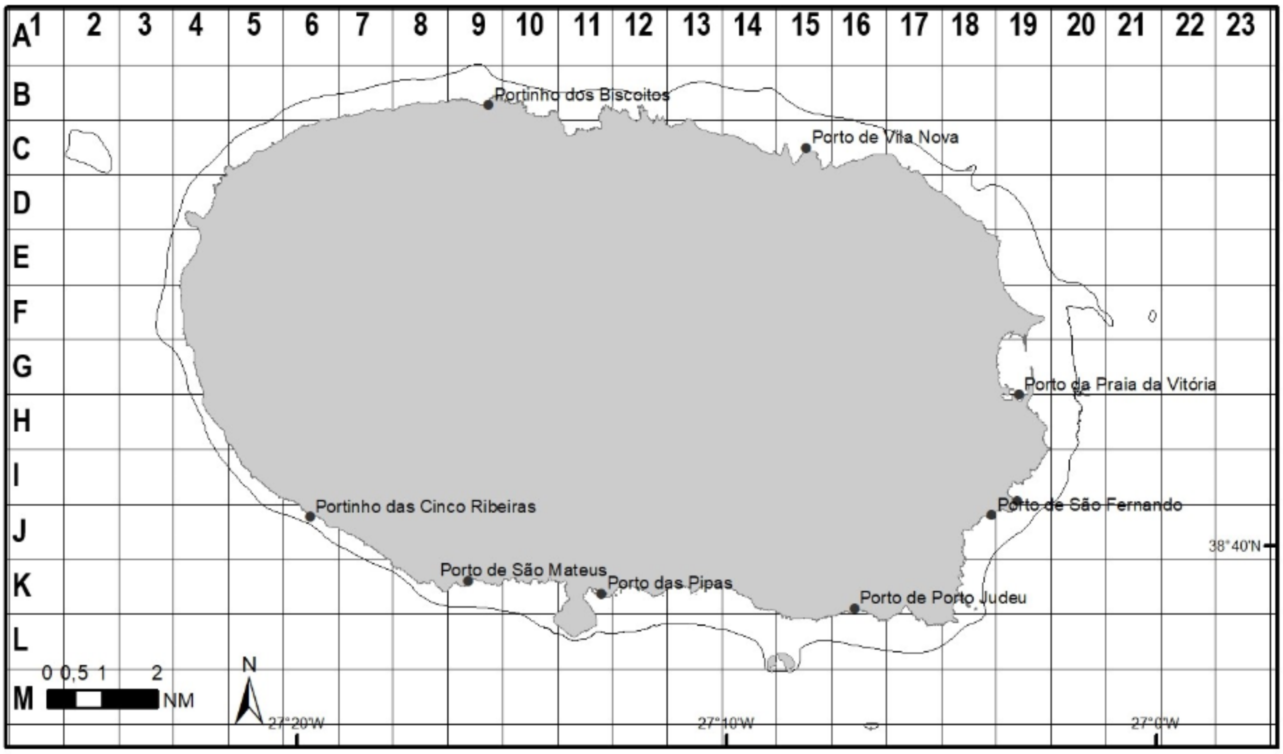

Figure 36 Map of Terceira Island with grid table.

Figure 37 Picture sent by an interviewee of a green turtle (Chelonia mydas) nearshore Pico.

Figure 38 Picture sent by an interviewee of a green turtle (Chelonia mydas) nearshore Terceira.