Munibe Monographs. Nature Series, 1

MARINE TURTLES OF THE NORTH EAST ATLANTIC

Contributions from the First Regional Conference

Nagore Zaldua-Mendizabal • Aitziber Egaña-Callejo
Editors

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Munibe. Suplemento, created in 1973, is a publication of the Aranzadi Society of Sciences of very specific monographic studies corresponding to the areas of knowledge of antrophology and archaeology and natural sciences. In 2012 we decided to create two independent publications called to substitute the earlier *Munibe. Suplemento: Munibe Monographs. Archaeology and Anthropology Series* and *Munibe Monographs. Nature Series.*

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San Sebastian 14-15 November, 2008

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PREFACE

Munibe is the scientific journal of Aranzadi Society of Sciences. Since its creation in 1949, *Munibe* has developed a considerable effort in publishing scientific studies on archaeology, anthropology and natural sciences. As a complement to this effort, *Munibe* created the *Munibe*. *Suplemento*, which were additional issues publishing sets of very specific monographic studies. Until now, *Munibe. Suplemento* were not divided into the corresponding areas of knowledge of the two journals currently existing, i.e. *Munibe Antropologia-Arkeologia*, and *Munibe Ciencias Naturales*. Since the disciplines covered by the two journals are very different, it was considered that this division should be also updated to the *Munibe. Suplemento*. It is because of that, that in 2012 we have decided to create two independent publications called to substitute the earlier *Munibe. Suplemento: Munibe Monographs. Archaeology and Anthropology Series* and *Munibe Monographs. Nature Series.*

I am proud to say that you have now in your hands the first volume of the new series, *Munibe Monographs. Nature Series.* This series aims to publish very specific, monographic issues dealing with all type of disciplines focused on the natural sciences, including Astronomy, Geology and Biology. In this new period that we start now we have also aimed to improve the quality of our publication. To achieve this goal we have established a much more demanding editorial process as well as a more exhaustive process of revision.

I hope that you, as a reader and the final objective of our publications, will feel benefited of this change.

Enjoy it!

Juan Arizaga
Chief Editor of *Munibe Ciencias Naturales*

 

PREFACE

The journey we made to Mexico in 1998 changed our lives forever. The experiences we lived there, with sea turtles, with friends, all led us to a new love for conservation research. Are there any sea turtles here? This is not an easy question to answer, but by trying to do so, we started a new journey in our country. With strong convictions, determination and continuous work, we are gradually being rewarded by these efforts and believe that more positive outcomes are ahead of us.

There was a determining moment in 2007, when the Deparment of Herpetology of the Aranzadi Society of Sciences gave us the opportunity to start the “ITSAS DORTOKA” Project. Since then, we have released numerous sea turtles and opened new ways to study them along the coastline of the Basque Country. This book is a synthesis of our efforts and in many ways reflects the path we have followed.

The Aranzadi Society of Sciences organizes various scientific thematic conferences every year; we took the advantage of one of these gathering and organized the first regional conference on sea turtle conservation. This conference was a great success considering the scope of our research interest. The Basque Country waters, the Cantabrian Sea, the Bay of Biscay or ultimately the North East Atlantic lack the warm waters and the nesting beaches of the tropical regions, getting information on sea turtles in our northern latitudes is a real challenge.

The conference was also the starting point of the book you are holding in your hands. Most of the researchers that approached us, contributed to this publication. Of course, we are also indebted to the all of the other collaborators and supporters that followed us through this wonderful adventure. We sincerely thank them all. Eskerrik asko!

At the conference we discussed the possibilities to work together and carry out more tasks. Because sea turtles are still relatively unknown in our region, we agreed to continue to work together by founding a new team: the North East Atlantic Sea Turtle Group (NEASTG). Challenges lie ahead, but we are convinced to move forward one step at a time.

We hope you like this book and think that there will be more opportunities to promote future cooperation among us.

See you then!!

HITZAURREA

1998. urtean Mexikora eginiko bidaiak gure bizitzak betirako aldatu zituen. Bertan izaniko bizipenek, itsas dortokekiko, lagunekiko, kontserbaziorako ikerketa lanarekiko amodioa piztu ziguten. Ba al dago itsas dortokarik hemen, geurean? Galdera hau erantzutea ez da erraza, baina oztopoak gaindituz, bideari ekin genion eta honek pausoan pausoan sari eta donari ugari eman dizkigu eta ziur gara oraindik ere asko dituela emateke.

Donarien adibide garbia, 2007an, Aranzadi Zientzia Elkarteko Herpetologia Behatokian (Herpetologia Saila gaur egun) ekimen berria martxan jartzeko izan genuen aukera azpimarratuko genuke. Ordutik aurrera poliki baina urrats sendoz “ITSAS DORTOKA” egitasmoak aurrera egin du, Euskal Herrian itsas dortoken berri eman eta hauek aztertzeko bideak irekiz. Liburu hauxe, jende askoren bateratzearen ondorioa ez ezik, emaniko pausoen isla bat gehiago ere bada.

Aranzadi Zientzia Elkarteak urtero antolatzen dituen jardunaldiek, aukera ezin hobea eman ziguten itsas dortoken inguruan lanean eta ikerketan diharduen jendea batzeko eta gaia sustatzeko. Horrela, itsas dortoken inguruko jardunaldiak antolatzeari ekin genion buru belarri, Atlantiar Ipar-Ekialdean ari ziren ikerlariekin harremanetan jarri eta beraien lanak Donostiara gertura zitzaten.

Jardunaldiak arrakastatsuak izan ziren gure lan eta ikerketa eremua zein den kontuan hartuta. Euskal Herria, Kantauri itsasoa, Bizkaiko golkoa edota oro har Atlantiar Ipar Ekialdea ez dira gune bero-tropikalak eta ez dugu errute-hondartzarik, beraz, dortoken inguruko informazioa lortzea ez da batere erraza, hondartzaratutako dortokekin, arrantzaleen laguntzaz eta itsaso zabalean bete beharreko lana da alegia.

Jardunaldi haiek, eskuartean duzun liburuaren hazia izan ziren eta bisitatu gintuzten ikerlari askok beren lanaren berri ematen digute argitalpen xume honetan, baina etorri ez ziren beste askoren laguntza ere izan dugu. Guztioi gure esker ona helarazi nahi dizuegu bihotz bihotzez, emaniko sostengu eta ekarpenengatik, eskerrik asko!

Jardunaldi haietan elkartu ginenon artean, talde ikuspegia ere sortu zen eta guztiok batera gauza gehiago lortzeko aukerez ere hitz egin genuen. Itsas dortokak gure herrialdeetan ezezagunak diren animaliak dira eta horrek ez du laguntzen, ondorioz, aurrerantzean taldean elkarrekin aritzea ere adostu genuen: The North East Atlantic Sea Turtle Group (NEASTG) edo Atlantiar Ipar Ekialdeko Itsas Dortoka Taldea euskaraz. Lan asko dugu egiteke eta bidea erraza ez den arren, pausoka-pausoka bada ere egitasmo honek aurrera egitea nahiko genuke.

Esku artean duzun argitalpena gustuko izatea espero dugu eta etorkizunean ere horrelako elkarlan gehiago sustatzeko aukerak izango direlakoan gaude. Ordurarte!

Nagore & Aitziber

Contents

Basque Turtles? Why?

Several basic questions are posed by this volume

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INTRODUCTION

Why would the Aranzadi Society of Sciences have a two-day special session on marine turtles of the Bay of Biscay and the eastern Atlantic? After all, every year there are dozens of meetings on marine turtles, around the world, in places where these reptiles are well known and for decades have been recognized to be important to the societies and marine environments involved (FRAZIER, 2003). But, since when have marine turtles been important to the Basque?

Why form a North East Atlantic Sea Turtle Group, when in this region these animals are hardly known to the average biologist – much less to the lay public or decision-makers? There are specialist groups that focus on marine turtles in the Mediterranean, NW Atlantic, Caribbean, SW Atlantic, and other regions of the Indian and Pacific Oceans – but why the North East Atlantic?

Why would people travel across the oceans to Basque Country to attend a meeting on marine turtles?

Although such questions may seem simple, almost obvious, they demand answers that are fundamental to understanding not only the natural history of these intriguing chelonians, but also the underpinnings of more basic issues such as how people interact with their environment and the rest of society. In a word: marine turtles are flagship species (FRAZIER, 2005). Although they are “lowly reptiles”, they inspire people of many nations, cultures, religions, ages, and backgrounds to consider human-environmental relations. They promote a sense of responsibility and cooperation that transcends turtles, science, and conservation – reflections that hearten qualities which make people proud of being human.

The publicised objective of the meeting held at the Aquarium de San Sebastián on 14 & 15 November 2008 was to nurture a better understanding of the ecology of marine turtles, and to promote conservation initiatives, particularly in this geographic area. However, far more was accomplished than raising awareness about marine turtle natural history and conservation, and this is thanks to the fact that an enormous, diverse clientele admires these “charismatic marine megafauna”; and diverse people from many nations are dedicated to the protection of these shared resources, which results in activities that far surpass usual research and conservation programmes.

To begin with, the people of Basque country are not recent arrivals, nor are they new to the sea. Their history, while bordering on the mysterious, spans millennia. Moreover, Basque fishermen are – and long have been – accomplished mariners. For example, the importance of Basque whalers in the north Atlantic, on both the eastern and western shores, is well documented from at least the 14th and 16th centuries, respectively (AGUILAR, 1986). At a time when many Europeans considered the earth to be flat, Basque fishermen were sailing across the Atlantic Ocean and setting up summer fishing camps in present day Canada, secretly bringing the dried fish back to Europe for sale (KURLANSKY, 1997). Perhaps Basque success in marine matters was too great, for they are attributed with the development of a very effective fishery for north Atlantic right whales, which eventually lead to the virtual extermination of these cetaceans (AGUILAR, 1986). At any rate, there is a long and rich history of Basque peoples and the sea.

By the same token, marine turtles are not unknown in the northeast Atlantic, a fact made abundantly clear by the classic study of Leo BRONGERSMA (1972). After a meticulous revision of literature, both published and unpublished, he reported written records of marine turtles in European waters that date back to the 1300s, as well as scores of written reports of these reptiles in European waters centuries before marine sciences were formerly established. Decades ahead of his time, BRONGERSMA hypothesized that not all marine turtles that occur in European waters are lost, or waifs, but rather that this marine area is part of the normal distribution of some turtles.

Hence, there is every reason to rekindle these historic bases, especially by nurturing a North East Atlantic Sea Turtle Group, and what more appropriate place to do this than in Basque country? For many reasons, the benefits of this effort will be felt far outside the NE Atlantic. An obvious reason why the impacts of north east Atlantic efforts will be widespread is that marine turtles migrate and disperse over vast distances, often crossing ocean basins.

This migratory characteristic is best known for the leatherback turtle *Dermochelys coriacea* (Vandelli, 1761), whose situation in the Bay of Biscay and northeast Atlantic has been reviewed by ZALDUA-MENDIZABAL *et al.* (this volume). Leatherbacks that are found feeding in and migrating through various parts of this region can only have come from other regions. To continue their reproductive cycle, leatherbacks in the NE Atlantic must migrate back to their nesting beaches that are a long way from Europe. Satellite tracking studies on males captured in Nova Scotia, Canada (JAMES *et al.*, 2005; 2007), provide ample evidence of this well-developed migratory phenomenon between feeding grounds in the north western Atlantic and reproductive areas in tropical and subtropical waters of the western Atlantic. Other satellite tracking studies on nesting females in Trinidad (ECKERT, 2006) and Florida, USA (ECKERT *et al.*, 2006) show similar transoceanic movements, often between low latitude tropical and subtropical nesting areas and high latitude, northern Atlantic, waters for feeding. Some females satellite tagged while nesting in Florida, Trinidad, French Guiana, and the Caribbean emigrated eastward across the Atlantic to spend time in the Bay of Biscay as well as in waters off the Azores, Iberian Peninsula, Canary Islands, Cape Verde Islands and Mauritania (ECKERT 2006; ECKERT *et al.*, 2006; FERRAROLI *et al.*, 2002; 2004; HAYS *et al.*, 2004). Earlier studies using flipper tags showed that nesting females tagged in French Guiana were recaptured in Atlantic waters of France and Spain (GIRONDOT & FRETEY, 1996). Hence, numerous studies, based in different nesting areas, have shown clear links between the north east Atlantic and various parts of the western Atlantic. The case for regular leatherback migrations into the north east Atlantic is further strengthened by records from European Atlantic waters, for example the seasonal occurrence of leatherbacks along the French Atlantic coast (DUGUY *et al.*, 2007) and in the Irish Sea (HOUGHTON *et al.*, 2006), where the turtles are commonly observed feeding on jellyfish. In this light, DOYLE *et al.* (2012) have provided a valuable summary of "jellyfish", their taxonomic, morphological, and ecological characteristics, and how these may relate to leatherback feeding ecology, particularly in the North East Atlantic. Clearly, there is much to learn, but it is clear that by all indications the waters of the north east Atlantic provide important feeding areas for this turtle. P. MORINIERE's presentation at the San Sebastián meeting (2008) leaves no doubt that leatherbacks have been a regular part of the fauna in French Atlantic waters, at least during two decades from 1988 to 2008, with both males and females recorded, many of adult size; live animals are documented mainly between July and September, and strandings of dead animals peak in October and November. Damage to appendages, especially from fishing gear, and ingested plastics – sometimes in large quantities – were recorded in the majority of animals autopsied.

Loggerhead turtles *Caretta caretta* (Linnaeus, 1758) are known to make regular circuits around the north Atlantic, from nesting beaches on the south east coast of the USA and the Yucatan Peninsula, Mexico, to feeding and developmental areas in the north east Atlantic, particularly around the Azores and Madeira (BOLTEN *et al.*, 1998), where there are regular seasonal occurrences of these turtles. While this conclusion is now widely accepted, it was not given much credence half a century ago when BRONGERSMA (1961) did detailed studies of museum specimens and suggested that loggerhead turtles from the Netherlands come from the western Atlantic. In subsequent research involving compilations and analyses of historic information, he went on to suggest that European Atlantic waters are part of the normal geographic distribution of the loggerhead turtle (BRONGERSMA, 1972). More recent studies add further evidence for regular occurrence of loggerheads in this region. F. DELL'AMICO's presentation during the San Sebastián meeting (2008) shows that this species is a regular part of the fauna along the French Atlantic coast, although annual records have varied greatly between 1988 and 2008. Most reports are between January and April, and adult-sized animals are rare. Damage to front flippers was especially common, and autopsies indicated that ingested plastic occurred in nearly 20% of the animals.

The situation with green turtles *Chelonia mydas* (Linnaeus, 1758), Kemp's ridley turtles *Lepidochelys kempii* (Garman, 1880), and hawksbill turtles *Eretmochelys imbricata* (Linnaeus, 1766) that occur in European Atlantic waters is less clear. Individuals of these species may be waifs, lost from their respective populations, although there is a possibility that some of them could survive to return to the respective breeding grounds from which they came and reproduce, contributing to the maintenance of their respective populations. BRONGERSMA (1961) concluded that green turtles in Dutch waters had evidently been thrown overboard from ships, and that there were no records from the British Isles. He also BRONGERSMA (1961) suggested that ridley turtles found off the coasts of Great Britain and the Netherlands came from the western Atlantic or even from Africa via South America. F. DELL´AMICO's presentation at the San Sebastián meeting (2008) is consistent with these earlier studies. Over the period 1988-2008 only 8 green turtles, and 24 Kemp's ridleys were recorded from the French Atlantic coast. The main period of occurrence was between September and March, and December and April, respectively. With one exception, all animals were of immature size. Hawksbills were not reported from the French Atlantic coast during these two decades.

In summary, the Atlantic coast of Europe does not have nesting beaches for any species of marine turtle, and the Kemp's ridley, green and hawksbill turtles that occur in these waters are likely to be waifs. Nonetheless, the region clearly provides areas critical for the life cycles of leatherback and loggerhead turtles, individuals that come from different nesting areas of the western Atlantic.

The beneficiaries of greater appreciation of, and work on, marine turtles in the north east Atlantic will be far more numerous, diverse, and wide-ranging than just the turtles. Clearly, these marine reptiles – the shared resources between the communities and nations of different parts of the Atlantic basin – will be better off with enhanced understanding and conservation activities in a region that is critical to their survival. Additionally, the biologists and conservationists who work in this region will not only have access to more complete, up-to-date information, but they will also find greater collaboration and support from like-minded colleagues who work outside the north east Atlantic region. In turn, researchers and conservationists in other parts of the world will benefit from the experiences, findings, insights, and other work of their colleagues in the north east Atlantic. This is especially true for several specific priorities established by the North East Atlantic Sea Turtle Group which will promote greater worldwide cooperation, namely the creation of a public database, standardization of protocols, enhanced mechanisms of collaboration, and enhanced engagement with diverse sectors outside the marine turtle community. Indeed, depending on how they develop, these regional initiatives could well position the North East Atlantic Sea Turtle Group to take on a global leadership role for marine turtle work.

Important as they are, the points mentioned above still do not contemplate the full importance of nurturing marine turtle work in European Atlantic waters. Because these animals have complex life cycles, the protection of just a single turtle requires adequate management of a wide variety of habitats including beaches, inshore waters, coastal waters, and the high seas – in other words terrestrial, estuarine, benthic, neritic, and pelagic habitats must be considered. Combined with these complex spatial-environmental considerations are challenging temporal issues: a marine turtle may need several decades just to reach maturity, and after that it may need to reproduce for several more decades to increase the chance of making a contribution to the maintenance of its population. Hence, to be effective, research and conservation efforts on marine turtles must be conducted over immense spatial and temporal scales. This approach, the planning and methodologies needed to carry out research and conservation to meet these spatial-temporal demands, present singular challenges: few research horizons are greater than a few years, not to mention the relatively short terms that dominate most political and administrative planning. Promoting true long-term planning and visions is urgently needed – for far more than marine turtle conservation (Frazier, 2007; 2010). Any contribution that the design and implementation of marine turtle research and conservation can have toward institutionalising greater temporal and spatial considerations in all aspects of human endeavour would be a major advancement for all kinds of scientific and policy work.

Beyond the local, regional, and global advantages to marine turtle research and conservation, there are other aspects that transcend turtles. Because these animals have intrinsic value – in conservation terms they are “charismatic megafauna” or simply “flagship species” – many diverse objectives can be met by employing the turtles as attention-getting and validation mechanisms. Research and conservation of north east Atlantic marine turtles requires enhanced understanding of various thematic areas, including: the oceanographic features that affect the dispersion and movements of the turtles, particularly currents (surface and subsurface), temperature, and productivity; the availability in time and space of the turtles’ food (e.g., “jellyfish”) and predators; issues of marine pollution, particularly temporal and spatial occurrence of plastics and other objects that can be ingested by turtles with fatal consequences; and fisheries activities – season, location, gear types, fishing practices – that pose significant threats to marine turtles. This is not to mention the diverse and complex considerations related to cultural, social, and political issues involving the ways that different people, industries, societies, and nations interact with turtles and their habitats. Understanding these many interacting factors will require integrating the research and planning of many disciplines – a much-lauded goal that has so far been elusive. Once again, promoting and nurturing holistic, integrated approaches to research and management through the design of marine turtle work will have positive ramifications on a wide variety of issues, ranging from specific research to general philosophies of management and policy.

In sum, marine turtles serve not only as attractions for the general public and “oceans ambassadors” but also as stimuli to induce diverse components of different societies to explore more profound reflections on the highly complex interactions between humans and their environments. This leads to a better understanding of the many implications – cultural, economic, environmental, historic, political, social, traditional – of our attitudes and actions.

Why Gipuzkoa turtles? To act as human beings, and better understand our role, and act more responsibly.

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A leatherback turtle's guide to jellyfish in the North East Atlantic

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ABSTRACT

Leatherback *Dermochelys coriacea* (Vandelli, 1761) sea turtles, are known to roam across entire oceans in search of high densities of their jellyfish food. Although this predator-prey relationship is well established, considerations of leatherback foraging behaviours are often hampered by a lack of information on the prey available to them in different regions. Therefore, to provide an overview for future studies we synthesise our current knowledge of jellyfish distributions and seasonality throughout the Northeast Atlantic and highlight known hotspots for the turtles themselves.

KEY WORDS: *Dermochelys*, gelatinous zooplankton, medusae, *Rhizostoma*, La Rochelle, *Pelagia* and salps.

RESUMEN

Las tortugas laúd *Dermochelys coriacea* (Vandelli, 1761), se conocen por recorrer océanos enteros, en busca de aprovisionamiento o alimento en zonas con grandes cantidades de zooplancton gelatinoso. Aunque la relación depredador-presa es bien conocida, el comportamiento de esta especie en relación a su alimentación es incompleta, debido a la falta de datos existentes en relación a la disponibilidad que existe de sus presas en las distintas regiones. Para proporcionar una visión general de la información relevante en este ámbito, hemos resumido el conocimiento que se tiene del zooplancton gelatinoso, su distribución y estacionalidad a lo largo del Noreste Atlántico y hemos querido resaltar puntos o zonas de especial importancia para las tortugas.

PALABRAS CLAVES: *Dermochelys*, zooplancton gelatinoso, medusae, *Rhizostoma*, La Rochelle, *Pelagia* y salpas.

LABURPENA

Larruzko dortokak *Dermochelys coriacea* (Vandelli, 1761), ozeanoetan barrena elikatzeko plankton lirdingatsuan aberats diren guneen bila ibiltzeagatik dira ezagunak. Naiz eta harrapakari-harrapakin harremana aski ezaguna izan, bere elikatzeko portaerak utsune handiak ditu oraindik, bere harrapakinen inguruko informazio ezagatik. Gai honekiko ikuspegi zabal bat ematearren, gaur egun zooplankton lirdingatsuaren inguruan dugun informazio esanguratsua laburbildu dugu artikulu honetan, Atlantiko Iparekialdean duen distribuzio eta urtaroaren arabeherako aldaketak eta bereziki itsas dortokentzat garrantzitsuak diren guneak azpimarratu nahi izan ditugu.

GAKO-HITZAK: *Dermochelys*, zooplankton lirdingatsua, medusae, *Rhizostoma*, La Rochelle, *Pelagia* eta salpak

INTRODUCTION

Jellyfish are one of the most abundant and easily recognisable organisms found in our coastal seas. Yet despite this familiarity, there is a general tendency to view such species as peripheral and transient components of marine systems that warrant little attention in their own right. This historical reluctance to understand the intricacies of jellyfish ecology and behaviour can lead to the assumption that all species function in a similar fashion or occupy the same niche within marine food webs. For example, the moon jellyfish *Aurelia aurita* (Linnaeus, 1758) (Fig. 1) is found in all coastal seas of the world and can be described as the quintessential jellyfish. Yet this species is just one of ~1200 species of 'jellyfish' (Costello *et al.*, 2008) that occupy the oceans, many of which are not suitable prey items for leatherbacks as they are simply too small or found at inaccessible depths. Moreover, many jellyfish have distinct habitat preferences and distinct trophic rules in much the same way as fish, so are correspondingly distributed in a far from random fashion (Houghton *et al.*, 2006a; Doyle *et al.*, 2007a). Here we provide an overview of the many different types of jellyfish available to foraging leatherback sea turtles in the Northeast Atlantic (NEA), make some general statements about their distribution and offer insights to biologists interested in jellyfish from a predator's perspective.

For the purposes of this paper, the term 'jellyfish' is used to describe a polyphyletic assemblage of medusae, siphonophores, ctenophores and urochordates (Haddock, 2004). Consequently, jellyfish should not be considered a taxonomic grouping but a disparate group of organisms that share many features such as transparency, fragility and a planktonic existence (Haddock, 2004). Jellyfish vary greatly in size from tiny hydromedusae less than a millimetre in diameter to large scyphomedusae measuring almost 2 metres across and 200 kg in weight (Omori &

Kitamura, 2004). Some jellyfish (siphonophores) have been described as some of the longest animals on the planet measuring 20 metres long (Godeaux *et al.*, 1998, in Bone 1998). This diversity of species is found in all oceans, from surface waters to the aphotic depths, with some eking out an unusual existence lying on the seafloor.

The manner in which jellyfish aggregate also varies markedly between species. Many form spectacular aggregations with many millions of individuals closely grouped, whereas other species are widely dispersed at much lower densities (Graham *et al.*, 2001). Taking this to the extreme, some animals which appear as individuals are in fact colonies such as the Portuguese Man-o-War *Physalia physalis* (Linnaeus, 1758) and *Pyrosoma atlanticum* (Péron, 1804) whilst other species can occur in both singular and colonial forms (e.g. salps). There is also great variation in life history of jellyfish with some species present only in the water column, whilst others with a metagenic life cycle are only brief members of the plankton, spending the rest of their lifecycle on the seabed as hydroids. Such differences between species must clearly be taken into account when considering the challenges facing leatherback turtles during their extensive foraging migrations, and as such we consider each major group in turn.

Fig. 1.- From top left clockwise: a scyphomedusae (*Aurelia aurita*) bloom © Michelle Cronin; large scyphomedusae (*Rhizostoma octopus*) with snorkeler © Thomas Bastian; oceanic scyphomedusae (*Pelagia noctiluca*) swarm © Feargus Callagy; a siphonophore (*Apolemia uvaria*) © Neil Hope; a hydromedusae © Nigel Motyer; a salp chain © Nigel Motyer; a ctenophore (*Beroe*) © Nigel Motyer; and a pyrosome (*Pyrosoma*) with diver © Peter Wirtz.

THE MEDUSAE

There are two types of medusae: scyphomedusae and hydromedusae. Scyphomedusae refers to what are generally known as 'true jellyfish' (Hardy, 1969). True jellyfish are the classic jellyfish (with a distinctive circular bell) typified by *Aurelia aurita* (Fig 1). There are ~127 true jellyfish species spread across three orders: Orders Semaeostomeae, Rhizostomeae and Coronatae (Costello *et al.*, 2008). Most have a large (>10 cm) bell that is typically saucer shaped or hemi-spherical (Russell, 1970). The bell can be very solid and along the margin of the bell, tentacles are normally found. These tentacles can be several metres long. A number of elongate structures (oral arms) hang from the centre of the bell and manubrium (Russell, 1970). These oral arms may be thin and curtain like [as in *Cyanea capillata* (Linnaeus, 1758)] but may also be extremely robust making up 40% of the total mass of the jellyfish [e.g. *Rhizostoma octopus* (Linnaeus, 1758)] (Doyle *et al.*, 2008). As many scyphomedusae form large coastal aggregations (or blooms) with many thousands of individuals, they are probably the most important prey item for leatherback turtles when they are present in near-shore waters.

Most scyphomedusae have a complex life cycle characterised by a benthic polyp phase that periodically produces free swimming medusa during the spring and summer months (Arai, 1997). These polyps are thought to be found on hard substrates such as rocky overhangs, mollusc shells and piers in relatively shallow waters, hence the neritic distribution for most scyphomedusae. An exception to this rule is the holoplanktonic scyphomedusae *Pelagia noctiluca* (Forsskål, 1775) which lacks a benthic polyp and occurs in both oceanic and neritic waters when climatic conditions dictate. *P. noctiluca* may be the most widely distributed scyphomedusae in our oceans, and often forms spectacular widespread blooms located over thousands km^2 in varying densities. Deep-sea scyphomedusae include the coronates (generally <10 cm bell diameter, but *Periphylla periphylla* (Péron & Lesueur, 1810) can grow up to 20 cm) which are likely to occur in most oceanic waters in the NEA (especially in the Rockall Trough area) at maximum abundance between 500 and 1500 m (Russell, 1970; Mauchline & Harvey, 1983; Mauchline & Gordon, 1991). Some coronates conduct diel vertical migrations, coming closer to the surface at night, but generally coronates appear to occur in low abundance (1-2 individuals 1000 m^3, Mauchline & Gordon, 1991). Other deep-water scyphomedusae include the very large *Stygiomedusa gigantea* (Browne, 1910) which has been found in the Bay of Biscay area and can attain bell diameters of 100 cm and oral arms up to 100 cm long (Russell & Rees, 1960; Benfield & Graham, 2010).

Hydromedusae are often referred to as the 'little jellyfish' (Hardy, 1969). There are two broad types: holoplanktonic hydromedusae and meroplanktonic hydromedusae. The meroplanktonic hydromedusae [e.g. *Obelia* spp. and *Phialella quadrata* (Forbes, 1848)] are only found in the water column for short periods whereas their benthic hydroid stage may live for many years. Most are neritic in distribution, probably reflecting the distribution of their benthic hydroids. The holoplanktonic hydromedusae occur throughout the oceans and best typified by *Aglantha digitale* (O.F. Müller, 1776). Both types of hydromedusae are generally >30 mm in size, and unless they occur in enormous blooms are unlikely to represent an important food source for leatherbacks. However, there are a few species of hydromedusae that grow to 10-30 cm in diameter [e.g. *Aequorea* spp. and *Staurophora mertensii* (Brandt, 1838)] that might be considered to be potential prey items. These species can be described in much the same way as the scyphomedusae i.e. they have a large saucer shaped bell with tentacles along the margin of the bell, but do not have oral arms.

SIPHONOPHORES

Siphonophores are colonial jellyfish that combine both polyps and medusae into a single organism. One species common to the North East Atlantic that best describes these organisms is *Apolemia uvaria* (Lesueur, 1815) (Fig. 1). This organism (colony) looks like a frayed rope and may be several metres in length. There are about 134 species of siphonophores and they are some of the longest animals in the world (COSTELLO *et al*., 2008). The majority of siphonophores are extremely fragile breaking into many pieces under the slightest of forces, thus restricting their distribution to oceanic environments where they do not come into contact with coastal hazards (currents, waves and hard substrates). There are some exceptions to this rule, for example *Muggiaea atlantica* (Cunningham, 1892) (and its 3 sibling species) are described as neritic, and are confined almost exclusively to near shore waters (MACKIE *et al*., 1987).

Through a combination of active swimming and perhaps some buoyancy control, many siphonophores are capable of diel vertical migration, especially many epipelagic species (MACKIE *et al*., 1987). Therefore, although siphonophores are certainly consumed by leatherbacks (DAVENPORT & BALAZS, 1991), at times they may be too deep to be accessible to leatherbacks. Indeed, this diel vertical migration of siphonophores [generally located at depth during the day and migrate into surface waters at night (HOUGHTON *et al*., 2008)] has marked effects upon the diving behaviour of leatherbacks in more oceanic regions which typically wait for such prey to ascend to the top 200 m at night where the turtles can more readily feed upon them (HAYS *et al*., 2004; HOUGHTON *et al*., 2008).

There are three orders of siphonophores: Cystonectida, Physonectida and Calycophorida. All three orders have species that could represent prey items for turtles. Chief amongst them are the cystonects, with only two species: the Portuguese Man-O-War *Physalia physalis* and the Blue Bottle *Physalia pacifica*. These organisms have been described as aberrant siphonophores (HADDOCK, 2004) but are probably the most familiar and easily recognisable species. They float on the sea surface and have been reported in the literature as leatherback's prey items. The other two orders are more representative of siphonophores i.e. long, thin and delicate strings of jelly. The calycophorans are generally small (<20 cm long including siphosome) and have no float, whereas the cystonects have numerous swimming bells and a float. Cystonects have been found in the gut contents of leatherbacks and possibly an unidentified calycophoran too (DEN HARTOG, 1980).

CTENOPHORES

There is a great diversity of body sizes and shapes in ctenophores. They can be egg shaped or ribbon-like, while others have large lobes or tentacles (HADDOCK, 2004) (Fig. 1). They range in size from a few millimetres to one metre in length, and can be found in coastal waters and to great ocean depths (HADDOCK, 2004). Many of them are extremely fragile and are therefore little studied given that collection in plankton nets is far from ideal. In contrast to all of the above taxa (i.e. medusae and siphonophores), ctenophores do not have cnidocytes, so do not sting. If tentacles are present they are adhesive. Most ctenophores are transparent and lack colour but most ctenophores are known to produce light (i.e. bioluminescence). It is not known whether ctenophores are a significant prey item for leatherback sea turtles. As many ctenophores are small and extremely fragile they may be unlikely prey for such large, visual predators. However, significant aggregations of ctenophores (e.g. in localised fronts) may offer suitable densities for prey consumption and should not be discounted.

UROCHORDATES

There are three types of urochordates that may represent prey for leatherback turtles. They are the doliolids, the salps and the pyrosomes. A fourth group, the appendicularians [e.g. *Oikopleura dioica* (Fol, 1872)] can be one of the most abundant members of the plankton at times (GORSKY & FENAUX, 1998, in Bone 1998), but are typically too small to be considered as prey items. However, the other three groups all have members that in sufficient densities are certainly worthy of consideration in this context. Doliolids are the smallest taxa, generally no bigger than 40 mm and are predominantly found in the euphotic zone of continental shelf waters (PAFFENHÖFER *et al*., 1995). They are shaped like a barrel and have an extremely complex lifecycle.

At times doliolids can form extremely dense swarms (up to 100 km^2) that last from days to weeks, with peak densities of 1000-5000 individuals m^{-3} (DEIBEL, 1998, in Bone 1998). Thus, although doliolids are small, such densities may offer 25-100 mg C m^{-3} (DEIBEL, 1998, in Bone 1998), which is approximately equivalent to one large *Rhizostoma octopus* medusae per cubic metre (e.g. carbon content is ~10% of dry mass, see CLARKE *et al*., 1992 and DOYLE *et al*., 2007b).

Salps are generally much bigger than doliolids, with some individuals typically 10 cm long but also capable of forming spectacular chains that may be metres long (Fig.

1). They are often so abundant that they dominate the macroplankton with densities of 700 m^{-3} reported off the south west of Ireland in the top 100 m (BATHMANN, 1988). Many salp species are known to make extensive diel vertical migrations, for example *Salpa aspera* (Chamisso, 1819) performs migrations of 800 m amplitude (ANDERSEN, 1988 in Bone), and so in much the same way as siphonophores, their day time distribution may place them beyond the regular reach of leatherbacks.

Pyrosomes are one of the longest animals known, with 20 m long *Pyrostremma spinosum* (Herdman, 1888) having been observed (GODEAUX *et al.*, 1998, in Bone 1998). Generally, most pyrosomes are much smaller (typical sizes reported in literature range from 5 – 24 cm long, see Fig. 1; PERISSINOTTO *et al.*, 2007; DRITS *et al.*, 1992) but the ecology of pyrosomes is little studied. They do occur in warm open waters between 50°N and 50°S in all oceans (VAN SOEST, 1981, in PERISSINOTTO *et al.*, 2007).

TOP FIVE JELLYFISH HOTSPOTS IN THE NEA TO VISIT

***1) Rhizostoma* hotspots**. A recently discovered feature of some coastal embayments along Europe's Atlantic fringe is the large blooms of the barrel jellyfish, *Rhizostoma octopus*, which can contain tens of thousands of individuals (HOUGHTON *et al.*, 2006a). Considering that a single medusae, can measure up to 90 cm diameter and weigh as much as 35 kg it is unsurprising that the distribution of this species and sightings of leatherbacks in the Northeast Atlantic are closely linked (HOUGHTON *et al.*, 2006b). Unfortunately, for wide ranging leatherbacks these blooms do not occur everywhere and are only known to be consistently present in four areas in the NEA: La Rochelle/France, Carmarthen and Tremadoc Bays/Wales and Rosslare Bay/Ireland) (LILLEY *et al.*, 2009). The Solway Firth (UK) is probably another Rhizostoma hotspot but more surveys are required to fully corroborate this finding (HOUGHTON *et al.*, 2006b). Provisional surveys around La Rochelle have revealed the highest densities recorded to date with 178 individuals observed during a 5-minute visual survey (from a 5.1 m Rigid Inflatable Boat) over a linear distance of 4.84 km (and with 7 m survey width) (DOYLE *et al.*, unpublished data). Using bell diameter and wet weight measurements of *Rhizostoma* collected in the same locality (mean size and weight: 72.8 ± 4.6 cm and 21.0 ± 4.3 kg, n = 26), this represents a surface density of ~3730 kg (or 410,500.0 kJ of energy) of jellyfish in 0.3 km^2 (or 30 hectares) (DOYLE *et al.*, unpublished data).

2) *Pelagia noctiluca* swarms. Of an order of magnitude smaller than a mature *Rhizostoma octopus*, an individual *P. noctiluca* may not look like a substantial meal. However, considering the scale and 'swarming characteristics' of this species, a widespread bloom of *P. noctiluca* may represent a considerable feast. For example, recent observations by DOYLE *et al.*, (2008) and BASTIAN *et al.*, (2011) have demonstrated that this species may be located over an area 60,000 - 100,000 km^2, from coastal areas through to oceanic waters. Jellyfish catch weights of 27.1 $kg.ha^{-1}$ were reported by BASTIAN *et al.* (2011). However, localised aggregations within the broader occurrence may provide good foraging conditions for leatherbacks. Indeed, when traversing across Langmuir cells that had recently developed, DOYLE *et al.* (2008) observed *P. noctiluca* aggregated the 2-4 m wide cells with densities of 100 *P. noctiluca* m^{-2}. However, it should be noted that the mean size of *P. noctiluca* individuals was 14.0 mm (DOYLE *et al.*, 2008).

3) Other coastal jellyfish blooms. Many coastal jellyfish species occur in high abundances over a range of scales. For a leatherback, encountering such features may be relatively easy e.g. locate coastline and then swim parallel to coast until a jellyfish bloom is encountered. Considering the patchiness of jellyfish (GRAHAM *et al.*, 2001), encounters with high densities of jellyfish may be infrequent but observations by HOUGHTON *et al.* (2006a) and DOYLE *et al.* (2007) has shown that lower densities of large scyphomedusae may be more frequently encountered and even widespread. For example, surface observations of *Chrysaora hysoscella* (Linnaeus, 1767) and *Aurelia aurita* have been observed right across the Celtic Sea and Irish Sea respectively, at densities of 1300 individuals km^{-2} and 10600 individuals km^{-2} respectively.

4) Mesoscale features? A common feature of oceanic waters in the NEA is the occurrence of large mesoscale eddies. These can be cyclonic or anticyclonic and are typically 50-150 km in diameter (SHOOSMITH *et al.*, 2005). Such features are known to enhance productivity in oceanic waters (ISLA *et al.*, 2004). As there are enhanced levels of productivity in these frontal areas it is likely too that there will be enhanced levels of gelatinous zooplankton. Indeed, a leatherback turtle satellite tracked in the NEA spent ~66 days in and around the edges of such a feature (DOYLE *et al.*, 2008). Such residency in a mesoscale feature for several months implied that there were good foraging conditions. Indeed, such behaviour has been observed by other authors and for other sea turtle species with the conclusion that both warm and cold core eddies are associated with higher prey abundance (SHOOP & KENNEY, 1992; LUTCAVAGE, 1996; LUSCHI *et al.*, 2003; FERRAROLI *et al.*, 2004; HAYS *et al.*, 2006; ECKERT, 2006; POLOVINA *et al.*, 2006). SUÁREZ-MORALES *et al.,* (2002) found that there are significant differences in the gelatinous communities between inside and outside an eddy in the Gulf of Mexico.

5) Large swarms of salps. BATHMANN (1988) described massive swarm of *Salpa fusiformis* (Cuvier, 1804), west of Ireland. This is one of the highest densities of salps ever recorded. It is not known how common or frequent these occurrences are but if they operate in a similar fashion to blooms off the coast of North America where the areal extent of high densities of *S. Aspera* (Chamisso, 1819) was estimated to be ~100,000 km^2

(MADIN *et al.*, 2006), then they may offer a substantial food resource to leatherbacks. Indeed a study by WITT *et al.* (2007) also revealed a high abundance of gelatinous zooplankton (which includes salps) in oceanic waters to the west and north west of Ireland.

GENERAL POINTS OF CONSIDERATION

A physical feature of the Atlantic is that both the continental slope and neritic waters are distributed in relatively narrow linear belts that run parallel to the coastlines of Europe and America (ANGEL, 1993). Within the neritic waters, the gelatinous zooplankton communities are dominated by large scyphozoans that have a benthic polyp stage. These species can be locally aggregated or widespread throughout the coastal seas. Moving from neritic waters to the continental slope and oceanic waters there is a distinct shift in the composition of gelatinous zooplankton communities from large robust scyphomedusae towards salps, doliolids and siphonophores (ANGEL & PUGH, 2000). Furthermore, as we move north or south along these linear belts there may also be a change in species composition, species abundances and diversity. For example, there is a marked discontinuity in the top 1000 m of the North East Atlantic, between the more southerly (latitudes 11-40°) and the northern waters (latitudes 53-60°) with higher numbers of specimens of calycophoran siphonophores in northern section but a greater diversity in the southern section (PUGH, 1986).

The distinct change between near-shore and oceanic gelatinous communities has marked implications for our interpretation of leatherback foraging patterns since leatherbacks have recently been shown to use both near-shore coastal, and open ocean foraging habitats when migrating in the Atlantic ocean (FOSSETTE *et al.*, 2010). Accordingly, we must take care not to bias our perception of their feeding habits towards incidental observations of the species feeding on large surface medusae. For example, HOUGHTON *et al.* (2008) in their study of deep diving in leatherback turtles proposed that post-nesting leatherbacks en route to productive temperate latitudes may feed upon deep, vertically ascending prey (siphonophores, salps, pyrosomes). Deep dives in this context were proposed as periodic speculation dives to visually locate prey patches deep in the water column in the absence of large aggregations of surface medusae (HOUGHTON *et al.*, 2008). The salient point here is that mid-water prey may form a more integral part of leatherbacks diet than once thought, prompting future studies of foraging behaviour in more remote locations.

Some comment must also be made about the seasonality of jellyfish prey available to leatherback turtles. The seasonal presence of leatherback turtles in the NEA is now well established with sightings and evidence from tracking studies suggesting that they are most abundant from late spring through to October. MCMAHON & HAYS (2006) revealed that autumn movements away from temperate latitudes are primarily driven by decreasing water temperatures (i.e. turtles migrate south when waters typically cool below 16°C). However, some consideration of prey availability is also warranted given that species with a metagenic life cycle (i.e. large coastal medusae) are typically absent from the water column during the autumn and winter, surviving to the next year as benthic polyps attached to the seabed. The emerging paradigm is that leatherbacks in the NEA overwinter at intermediate latitudes where oceanic prey such as siphonophores and pyrosomes may still be present (ANGEL & PUGH, 2000), but water temperatures do not present a physiological challenge to the maintenance of body temperature.

SUMMARY

There are approximately 1200 species of jellyfish, however, perhaps only a fraction of this total are regularly consumed by leatherback turtles, the rest being too small, too sparsely aggregated or located too deep. The NEA must be considered as a mosaic of jellyfish landscapes ranging from large local aggregations and broadly dispersed populations of scyphomedusae in coastal areas and shelf seas, through to communities of salps and siphonophores in more oceanic waters. With this prey backdrop in mind it is easier to understand the foraging behaviour and migrations of leatherback sea turtles in the NEA.

	Groups	Nº species	Typical size range	Bloom forming?	Distribution	Species of interest NEA	Evidence of feeding on?
Scyphomedusae	Semaeostomeae	52	10-60 cm	Some	Coastal	*Aurelia aurita, Pelagia noctiluca, Rhizostoma octopus, Cyanea capillata, Chrysaora hysoscella.*	Semaeostomeae (JAMES & HERMAN, 2001)
	Rhizostomeae	56	20-60 cm	Most	Coastal		Rhizostomeae (DURON, 1978; HOUGHON *et al.*, 2006)
	Coronatae	19	<10 cm	No	Mostly deepwater		Coronatae – no evidence.
Hydromedusae	Holoplanktonic	~134	<10 mm		Coastal + oceanic	N/A	Possibly *Aequorea* sp. and *Velella velella*
	Meroplanktonic	100s	<10 mm		Coastal	*Aequorea* sp.	
	Neustonic	1	<10 cm		Oceanic	*Velella velella*	
Siphonophores	Physonect	2	5-20 cm	Some	Neustonic	*Physalia physalis,*	Physonectida – BACOM (1970)
	Calycophorans	30+	5-100 cm long		Oceanic + coastal	*Muggiaea atlantica*	Calycophoran (refs)– BRONGERSMA (1969)
	Cystonectida	30+	5-100 cm long		Oceanic	*Apolemia* sp.,	Cystonectida – BRONGERSMA (1969)
Ctenophores	All groups	90	1-30 cm	Some	Oceanic mostly		Possibly, see COLLARD, 1990
Urochordates	Doliolids	20+	<4 cm	Many	Oceanic	*Doliolum, Salpa, Pyrosoma* sp.	Doliolids – possibly, see COLLARD, 1990
	Salps	15	1-15 cm *				Salps – possibly, see COLLARD, 1990
	Pyrosomes	9	5-20 cm				Pyrosomes (DAVENPORT & BALAZS, 1991)

Table 1.- Jellyfish groups and their presence in the NEA of arrival available were released.

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Suivi des observations de tortues marines sur la côte atlantique française depuis 1988

Sea turtles survey on the French Atlantic coast since 1988

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ABSTRACT

Among the seven species of existing sea turtles, four can be seen in the Bay of Biscay and in the Manche. The leatherback turtle *Dermochelys coriacea* (Vandelli, 1761) and the loggerhead turtle *Caretta caretta* (Linnaeus, 1758) are the most seen species whereas the Kemp's ridley turtle *Lepidochelys kempii* (Garman, 1880) and the green turtle *Chelonia mydas* (Linnaeus, 1758) are seen more occasionally. The monitoring of the sightings done by the Aquarium La Rochelle and its Center of Studies and Cares for Sea Turtles since 1988 allowed us to identify the main characteristics of the sea turtles present on the studied area.

KEY WORDS: French Atlantic Coast, *Dermochelys coriacea, Caretta caretta, Lepidochelys kempii, Chelonia mydas.*

RESUMEN

Entre las siete especies de tortugas marinas que existen, cuatro pueden observarse en el Golfo de Vizcaya y en el Canal de la Mancha. La tortuga laúd *Dermochelys coriacea* (Vandelli, 1761) y la tortuga boba *Caretta caretta* (Linnaeus, 1758) son las más frecuentes, mientras que la tortuga lora *Lepidochelys kempii* (Garman, 1880) y la tortuga verde *Chelonia mydas* (Linnaeus, 1758) se ven ocasionalmente. El seguimiento de avistamientos llevado a cabo por el Aquarium de La Rochelle y su centro de estudios y cuidado de tortugas marinas desde 1988 nos ha permitido identificar las características de las tortugas presentes en el área de estudio.

PALABRAS CLAVE: Costa Atlántica Francesa, *Dermochelys coriacea, Caretta caretta, Lepidochelys kempii, Chelonia mydas.*

LABURPENA

Existitzen diren zazpi itsas dortoka espezieetatik lau, Bizkaiko Golkoan eta Mantxako kanalean ikus ditzakegu. Larruzko dortoka *Dermochelys coriacea* (Vandelli, 1761) eta benetazko dortoka *Caretta caretta* (Linnaeus, 1758) dira ohikoenak, Kemp dortoka *Lepidochelys kempii* (Garman, 1880) eta berdea *Chelonia mydas* (Linnaeus, 1758) aldiz oso noizbehinka ikus daitezkeelarik. La Rochelleko akuariumak eta bere baitan duen itsas dortoken zaintza eta ikerketarako zentruak 1988 geroztik itsas dortoken jarraipen bat egin du eta horri eskerrak ikerketa gunean ditugun itsas dortoken ezaugarriak ezagutu ahal izan ditugu.

GAKO-HITZAK: Frantziar kosta atlantiarra, *Dermochelys coriacea, Caretta caretta, Lepidochelys kempii, Chelonia mydas.*

INTRODUCTION

Les observations de tortues marines ont été initiés et collectées depuis 1968 sur la côte atlantique française à l'initiative de Raymond Duguy (Duguy, 1968), au départ au nom du Musée d'Histoire naturelle de La Rochelle. Le suivi des échouages est assuré, depuis 1972, en collaboration avec l'Aquarium La Rochelle et son Centre d'Etudes et de Soins pour les Tortues Marines (C.E.S.T.M.). Afin de renforcer les efforts de conservation et de gestion en faveur de ces espèces marines protégées, le suivi satellitaire permet d'étudier les mouvements des tortues marines sur de longues périodes (Seney, 2010). Le premier suivi par biotélémétrie depuis la côte atlantique française a été réalisé à partir d'une tortue luth femelle subadulte en 1978 (Duron, 1978). Le premier suivi par satellite depuis la côte atlantique française à partir d'une caouanne juvénile a été entrepris en 2008.

MÉTHODE

Le C.E.S.T.M. recense l'ensemble des échouages et des observations en mer de tortues marines dans le Golfe de Gascogne, dans la mer celtique et en Manche représentant la zone d'étude. Il centralise ces informations dans une base de données informatique consacrée à cet inventaire.

Les échouages de tortues marines sont localisés grâce à un réseau d'échouages réparti le long de la zone d'étude. Ce réseau est constitué de bénévoles et d'aquariums publics formés à cette catégorie d'intervention. Les tortues marines vivantes échouées sont recueillies au C.E.S.T.M. qui les soigne et les relâche lorsque leur état le permet. Chaque tortue relâchée est marquée à l'aide d'une bague métallique MNHN (Muséum national d'Histoire naturelle) comportant un numéro unique « F-n°» permettant d'identifier l'individu en cas d'observation future ou recapture. Les tortues marines mortes échouées sont autopsiées par le C.E.S.T.M., selon leur état de putréfaction, afin de déterminer la cause de leur mort; des échantillons de tissus sont collectés et conservés à des fins scientifiques.

Des observations en mer de tortues marines sont transmises par des plaisanciers et professionnels de la mer dans le cadre de l'opération «Devenez observateurs des Pertuis», lancée depuis 1996 par l'Aquarium La Rochelle en partenariat avec le Centre de Recherche sur les Mammifères Marins (Université de La Rochelle). Des affi-

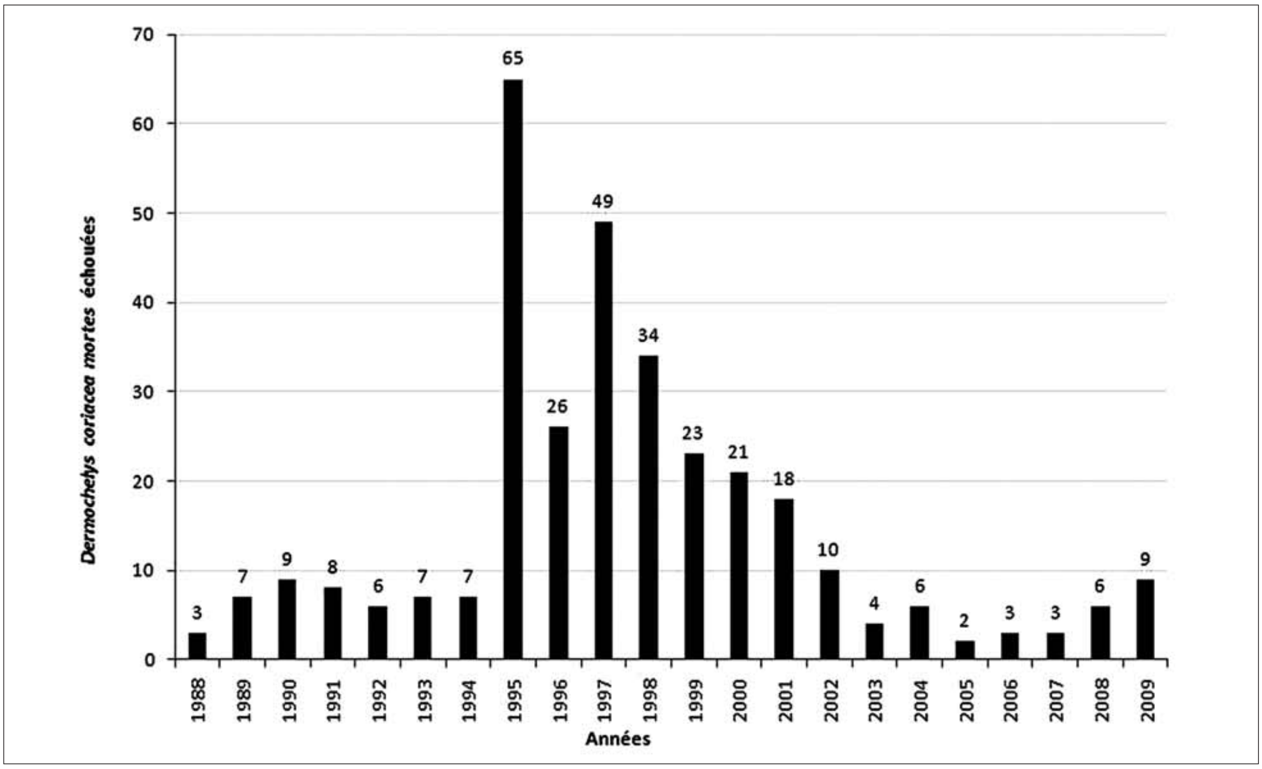

Fig. 1.- *D. coriacea* mortes échouées au cours des années 1988-2009. / Stranded dead *D. coriacea* between 1988-2009.

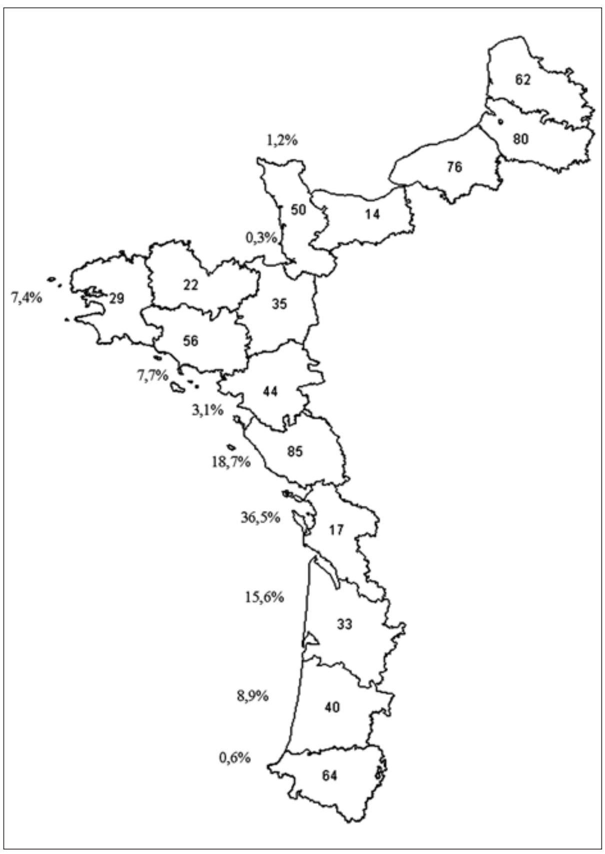

Fig. 2.- *D. coriacea* échouées observées a la cote Atlantique française. / Observed stranded *D. coriacea* in the French Atlantic coast departments.

ches et des fiches d'observation sont distribuées chaque année aux capitaineries et aux centres nautiques localisés sur la zone d'étude dans cet objectif.

Le premier suivi satellitaire a été réalisé à partir d'une jeune *Caretta caretta* (Linnaeus, 1758) (SCL: 34,6 cm), échouée vivante dans le sud du Golfe de Gascogne (Lège Cap Ferret (33)), du 29 juillet 2008 au 17 novembre 2008. L'émetteur a été fixé au point le plus haut de la carapace à l'aide de colle epoxy (Power Fasteners®) selon la méthode décrite par BALAZS *et al.* (1996). L'individu a été localisé grâce au système satellitaire Argos qui répertorie les positions selon 6 classes de précision (3-1 :< 1km, 0, A et B). Il existe une septième classe Z dont les positions ne sont pas valides. Le trajet de la tortue a été retracé à l'aide des positions transmises dont les classes sont comprises entre 1 et 3.

RÉSULTATS

Les observations de *Dermochelys coriacea* (Vandelli, 1761)

Distribution annuelle des échouages

Depuis 1988, 326 individus ont été retrouvés morts échoués sur la zone d'étude. Un pic d'échouage de 65 individus a été enregistré en 1995 (Fig. 1).

Les échouages sont constatés toute l'année et sur l'ensemble de la zone d'étude. Toutefois, 69,3% des échouages sont observés entre les mois de septembre et de décembre et 70,8% des échouages se répartissent entre les départements de la Gironde (33), de la Charente-Maritime (17) et de la Vendée (85) (Fig. 2). 85,2% des individus mesurés présentaient une classe de taille comprise entre 120 et 169 cm de longueur courbe de carapace (SCCL). 56,4% des individus ont été sexés permettant d'identifier 90 mâles et 94 femelles. 83 autopsies ont pu être réalisées dont 42,2% ont mis en évidence la présence de matières plastique dans le tube digestif. Des indications de prise par des matériels de pêche (filets, orins de casiers à Crustacés, cordages…) ont été retrouvées sur 8,6% des individus morts échoués.

Distribution annuelle des observations en mer

Depuis 1988, 1002 observations de tortues luth ont été collectées sur la zone d'étude. Le nombre d'observations a nettement augmenté entre 1996 et 1999 (Fig. 3).

88,7% des observations sont réalisées entre les mois de juillet et de septembre. La zone la plus fréquentée par les tortues luth se situe entre les latitudes 45°40N et 47°N et particulièrement dans le Pertuis breton, zone située entre l'Ile de Ré et la côte, depuis les Sables d'Olonne jusqu'à La Rochelle.

Parmi ces observations, 28 individus ont été signalés capturés dans des engins de pêche ou présentant des marques de capture du type filet, orin, ligne ou encore cordage.

Les observations de *Caretta caretta* (Linnaeus, 1758)

Distribution et caractéristiques des échouages de tortues caouannes

Au cours de la période étudiée, le nombre d'observations de caouannes sur la zone d'étude est de 292: 232 tortues vivantes et 60 mortes. Ces observations comprennent les tortues mortes échouées, les tortues vivantes échouées et celles trouvées en mer puis ramenées à terre. Deux pics d'observation ont été enregistrés en 1990 (35) et en 2001 (48) (Fig. 4).

Les tortues caouannes sont observées toute l'année. Cependant, 60,6% des échouages sont réalisés entre les mois de janvier et d'avril. Elles sont principalement rencontrées dans le sud du Golfe de Gascogne et notamment dans les départements de la Gironde (33), des Landes (40) et des Pyrénées Atlantiques (64) qui enregistrent 64,4% de l'ensemble des observations réalisées (Fig. 5). Sur l'ensemble des tortues mesurées, 66,2% présentaient une longueur droite de carapace (SCL) comprise entre 15 et 24 cm.

Caractéristiques des symptômes observés chez les tortues mises en soin ou autopsiées

Le C.E.S.T.M. a accueilli 181 *C. caretta* depuis 1988. Certains symptômes ont été observés chez les tortues mises en soins: la léthargie, l'hypothermie, la flottaison, des infections oculaires, la présence de plaies au niveau de la tête et de la dossière, des sections et des paralysies au niveau des pattes nageoires. 77 autopsies ont été menées sur des individus morts échoués ou décédés en soins. Ces examens ont mis en évidence la présence de bactéries (genres *Mycobacterium, Aeromonas, Pseudomonas, Flavobacterium, Aerococcus, Vibrio, Photobacterium, Ateromonas, Myroides* et *Klebsiella*), de champignons (*Fusarium*

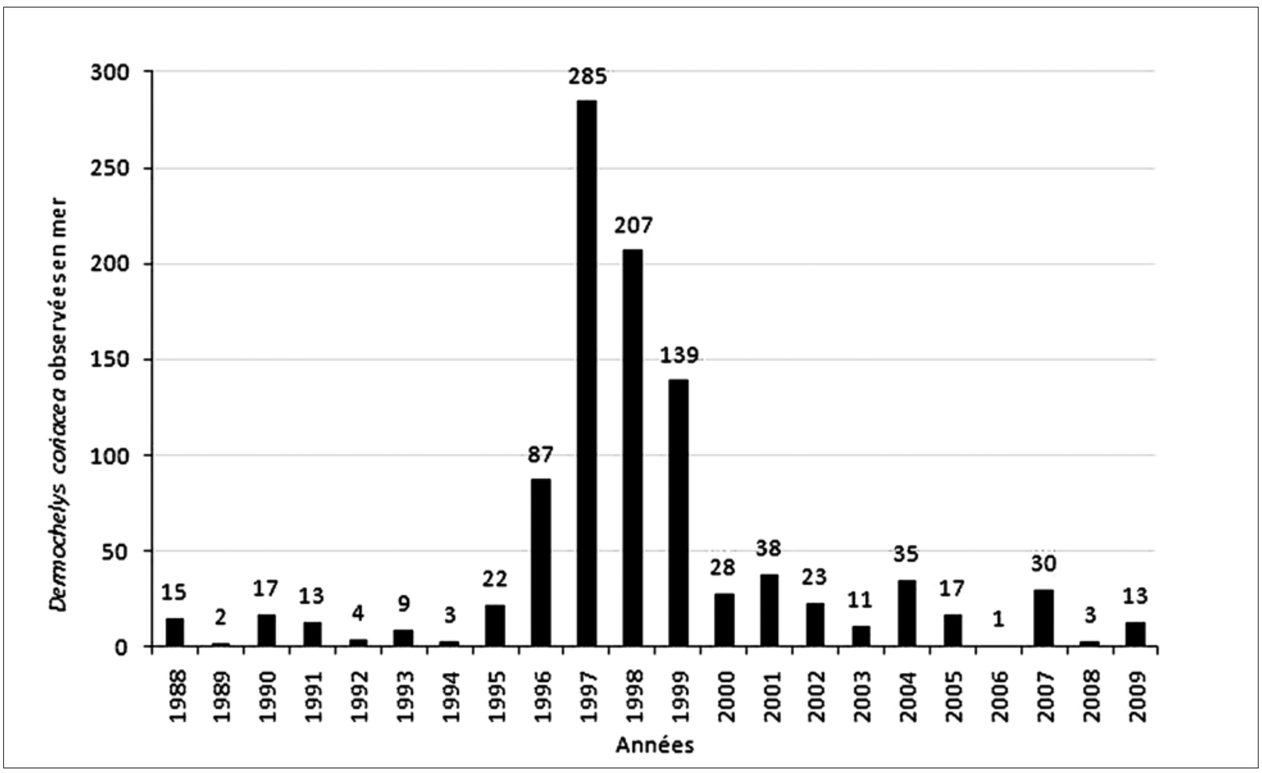

Fig. 3.- *D. coriacea* observées en mer entre 1988 et 2009. / *D. coriacea* observed at sea between 1988-2009.

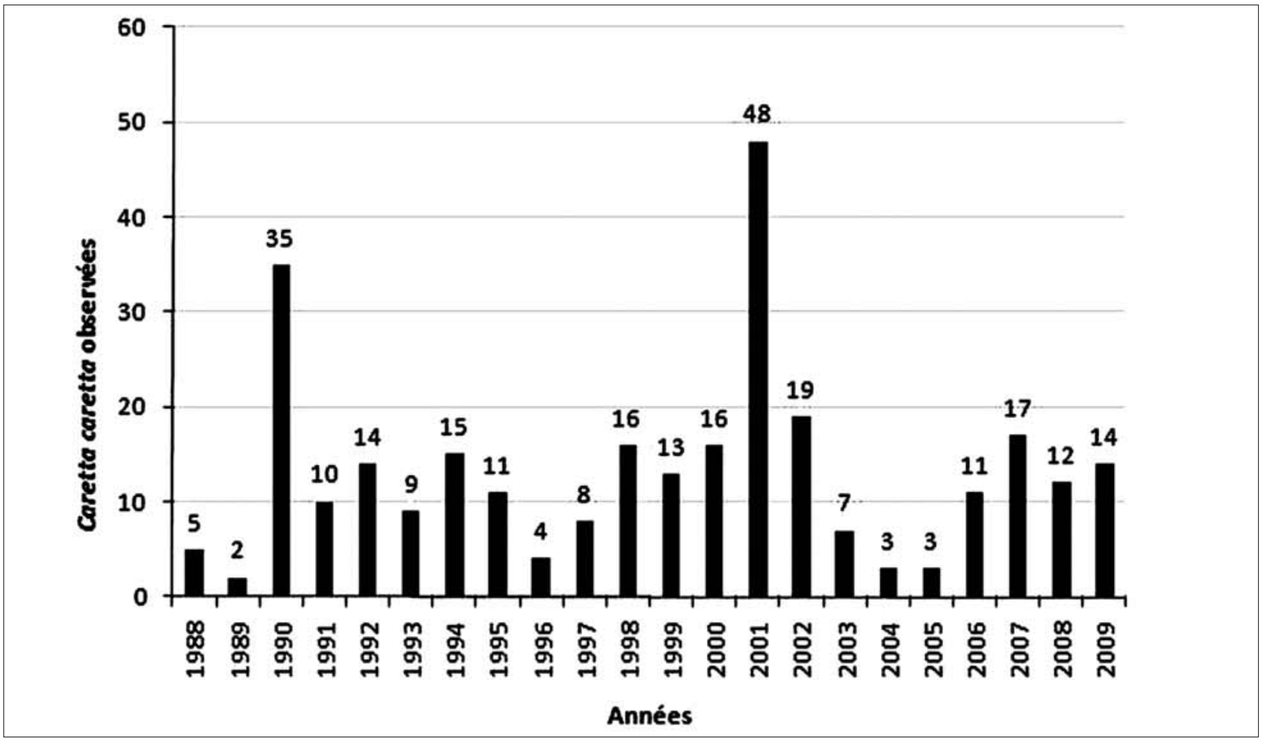

Fig. 4.- *C. caretta* observées en mer entre 1988 et 2009. / *C. caretta* observed at sea between 1988-2009.

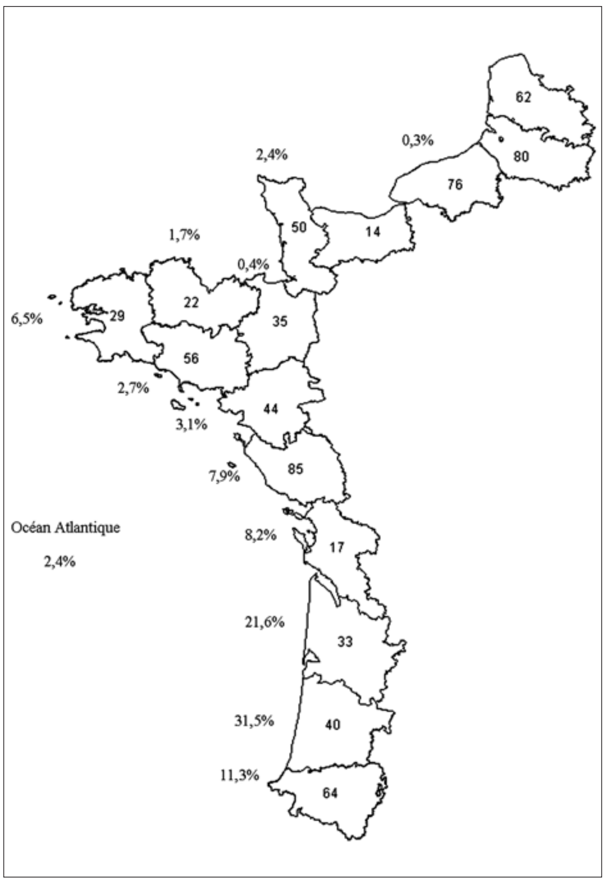

Fig. 5.- *C. caretta* échouées mortes a la cote Atlantique française. / Stranded dead *C. caretta* at different French Atlantic coast departments.

et *Penicillium*) et de parasites (Protozoaires). Des matières plastique et des amas de fil de nylon ont été découverts dans l'estomac et l'intestin de 15,6% des individus.

Remises à l'eau de Caretta caretta

Depuis 1988, 162 caouannes ont été relâchées en mer. Les relâchers ont été effectués jusqu'en 2008 au large de La Rochelle, à la bouée du Sauerland (46°05 N / 1°42 O). Sur l'ensemble de ces relâchers, 18 tortues ont été à nouveau observées et identifiées grâce à leur numéro de bague MNHN. Ces observations ont été faites quelques jours à quelques mois suite à leur relâcher et au sud du lieu de leur remise à l'eau.

En 2009, les relâchers ont été entrepris depuis la pointe Nord-Est de l'Ile de Ré (17) (46°14 N / 01°32 O).

Premier suivi satellitaire

Le premier émetteur satellitaire a été posé sur une jeune *C. caretta* (baguée F-1934) relâchée le 29 juillet 2008 au niveau de la bouée du Sauerland (46°05 N / 01°42 O); et suivie jusqu'au 17 novembre 2008 (45°02 N / 01°28 O), soit pendant 111 jours. Ce premier suivi a mis en évidence le retour à la côte de l'individu directement après son relâcher ainsi que son déplacement très proche de la côte, enfin une orientation globale vers le nord puis vers le sud (Fig. 6). L'individu a été retrouvé le 19 mars 2009 à Getaria en Espagne où il a été recueilli par l'Aquarium de San Sebastian avant d'être reconduit au C.E.S.T.M. Aucune trace de l'émetteur sur sa carapace n'était alors visible.

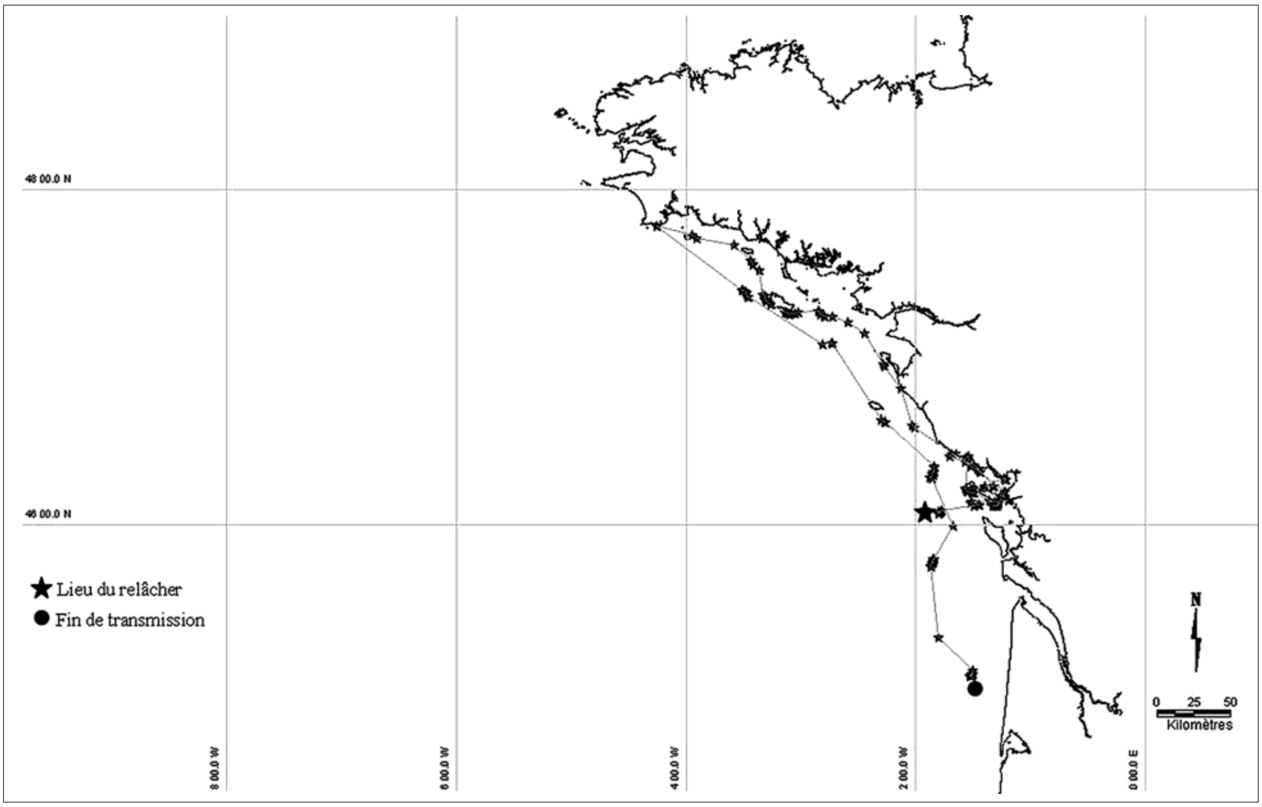

Fig. 6.- Suivi satellitaire de *C. caretta* a la cote Atlantique française en 2010. / Satelite tracking of *C. caretta* in Frenchs Atlantic coast in 2010.

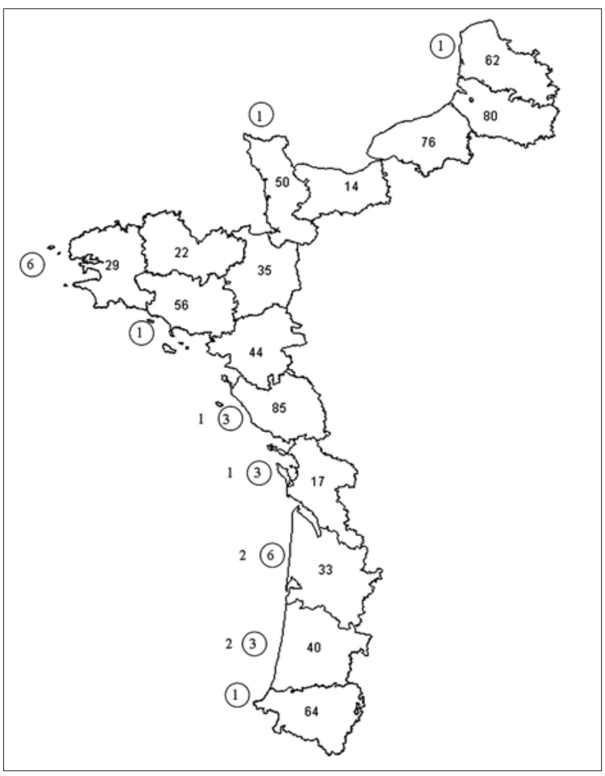

Fig. 7.- *L. kempii* (cercle) et *C. mydas* (sans cercle) échouées mortes a la cote Atlantique française entre 1988 et 2010. / Stranded dead *L. kempii* (circle) and *C. mydas* (without circle) in French Atlantic coast departments since 1988 to 2010.

Les observations de *Lepidochelys kempii* (Garman, 1880) et de *Chelonia mydas* (Linnaeus, 1758)

Lepidochelys kempii

Depuis 1988, 25 *L. kempii* ont été retrouvées sur la zone d'étude. Les échouages ont lieu principalement au cours de la période hivernale (68%) entre les mois de décembre et de février et sur l'ensemble de la zone d'étude. Toutefois, six observations ont été recensées dans le Finistère (29) et six dans la Gironde (33) (Fig. 7). Il s'agit d'individus exclusivement juvéniles dont la longueur droite de carapace moyenne (SCL) est de 30 cm.

Treize tortues ont été accueillies au C.E.S.T.M., quatre d'entre elles ont été relâchées. Quinze autopsies ont été pratiquées sur des tortues retrouvées mortes échouées ou décédées en soin et ont mis en évidence la présence de bactéries (*Pseudomonas* et *Mycobacterium*), de parasites (Nématodes et Trématodes), de champignons (*Fusarium* et *Aspergillius*), de protozoaires (*Hexamitia*) et de matière plastique dans le tube digestif de deux individus.

Chelonia mydas

Six *C. mydas* ont été observées sur la zone d'étude. Les échouages ont été enregistrés en février, en mars et en novembre depuis le département des Landes (40) jusqu'en Vendée (85) (Fig. 7). Il s'agit d'individus immatures dont la longueur droite de carapace moyenne (SCL) est de 38 cm. Deux autres individus ont été accueillis au

C.E.S.T.M. puis relâchés. Quatre autopsies ont été pratiquées et ont révélé la présence de matière plastique dans le gros intestin d'un individu, un œdème pulmonaire et un cas d'infection par *Mycobacterium marinarum*.

DISCUSSION ET CONCLUSIONS

Ce suivi a permis d'une part de mettre en évidence la présence de quatre espèces de tortues marines dans le Golfe de Gascogne, en Mer Celtique ainsi qu'en Manche: *D. coriacea, C. caretta, L. kempii* et *C. mydas* elle a permis d'autre part de présenter les principales caractéristiques de chacune de ces espèces protégées.

L'espèce *D. coriacea* est observée régulièrement dans la zone d'étude depuis 1988. Il s'agit d'individus sub-adultes et adultes (JAMES *et al.*, 2007) observés en mer l'été en train de s'alimenter de Rhizostomes (DURON, 1978; DUGUY *et al.*, 1980) dans la zone des Pertuis charentais et principalement dans la zone du Pertuis breton et quelquefois retrouvés morts échoués en automne et au début de l'hiver, principalement sur les plages bordant les départements de la Charente-Maritime (17), de la Vendée (85) et de la Gironde (33). Dans l'océan Atlantique, les tortues luth entreprennent de longues migrations entre les sites de ponte et les sites d'alimentation (CAUT *et al.*, 2009) et sont observées de façon saisonnière sur la côte est canadienne ainsi qu'en Europe du Nord (DOYLE *et al.*, 2007). Des analyses génétiques réalisées sur des échantillons de muscle de tortues luth échouées mortes sur la côte atlantique française sont en cours d'exploitation par la NOAA (Californie) et permettront d'apporter des précisions sur leur origine. Les matières plastique et les interactions avec les engins de pêche sont les deux principaux facteurs de mortalité mis en évidence par les autopsies de ces individus retrouvés morts échoués (DUGUY *et al.*, 1998 et 2000).

L'espèce *C. caretta* est également régulièrement observée sur la zone d'étude en particulier dans la partie sud du Golfe de Gascogne qui enregistre plus de la moitié des observations (64,4%). Les jeunes individus vivants s'échouent au cours de la période hivernale et au début du printemps et souffrent principalement d'hypothermie. En effet, les symptômes d'hypothermie apparaissent lorsque les eaux descendent en-dessous de 15°C et à 10°C les caouannes étant alors léthargiques et «flottantes» (MILTON *et al.*, 2003) Leur passage au C.E.S.TM. permet de rétablir leur état physiologique avant de les remettre à l'eau en été au large de La Rochelle. Des analyses réalisées à partir de l'ADN mitochondrial ont permis de valider l'hypothèse que les jeunes caouannes retrouvées dans l'est Atlantique sont originaires des plages de ponte situées dans l'Atlantique de l'ouest (LAURENT *et al.*, 1993 et 1998; BOLTEN *et al.*, 1998). Des analyses génétiques, en cours de réalisation par la Estación Biologica de Doñana (Sevilla, Espagne) sur des échantillons de muscle, de sang et de peau de *C. caretta* retrouvées mortes ou vivantes échouées sur la côte atlantique française, permettront de confirmer cette hypothèse.

Le premier suivi par satellite montre que la tortue séjourne dans les eaux littorales de la côte atlantique française pendant plusieurs mois. Le Golfe de Gascogne serait une zone d'habitat et d'alimentation temporaire pour ces jeunes tortues. En 2009, cinq nouveaux suivis satellitaires ont été mis en place. Ils permettront de préciser le temps de résidence de *C. caretta* et les paramètres qui influencent ses trajectoires dans le Golfe de Gascogne.

Les observations de *L. kempii* sont rares. Quelques individus de tortues de Kemp ont été recensés dans le bassin méditerranéen (TOMAS *et al.*, 2003) ainsi qu'en Irlande et au Royaume-Uni (PIERPOINT *et al.*, 2002). La population de la tortue de Kemp est confinée dans le Golfe du Mexique et sur la côte est des Etats-Unis avec un site de ponte principal situé à Rancho Nuevo au Mexique (METZ, 2004). Les observations de tortues vertes sont quant à elles exceptionnelles sur la côte atlantique française ainsi qu'au sud du Royaume-Uni et dans la mer du Nord (PIERPOINT *et al.*, 2002). Ces jeunes individus sont transportés depuis les sites de ponte situés dans l'Atlantique Nord-Ouest par le Gulf Stream et la dérive nord Atlantique vers l'Atlantique Nord-Est (ECKERT *et al.*, 2001; MUSICK *et al.*, 1997).

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Contribution of the Aquarium of San Sebastián to the conservation of marine turtles *Caretta caretta* (Linnaeus, 1758) (Testudines: Cheloniidae)

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ABSTRACT

Since 2000, the Aquarium of San Sebastián (Gipuzkoa, Basque Country) is involved in a sea turtle conservation program that has conducted the tagging and release of 17 specimens of loggerhead *Caretta caretta* (Linnaeus, 1758). Juveniles and sub adults stranded on the beaches or drifting near the Basque coast are the main life stages found by fishermen and citizens that bring them to our facilities where they are examined and diagnosed. Treatment in quarantine of pulmonary infections, hypothermia and dehydration among others is followed until complete recovery. Ready to swim, they are tagged in the Aquarium of La Rochelle (France) with a French tag series and released with other turtles found in the French Atlantic coast.

KEY WORDS: Conservation, loggerhead turtle, recovery, release, tagging.

RESUMEN

Desde el año 2000, El *Aquarium* de San Sebastián (Guipúzcoa, País Vasco) participa en un programa de conservación de tortugas marinas que ha realizado el marcaje y liberación de 17 ejemplares de tortuga boba *Caretta caretta* (Linnaeus, 1758). Los ejemplares recogidos son juveniles y subadultos que aparecen varados en las playas o flotando a la deriva y son rescatados tanto por particulares como por pescadores. En el *Aquarium* las tortugas se examinan, se realiza un diagnóstico y se les aplica el tratamiento adecuado en cuarentenas hasta su recuperación. Una vez recuperadas y preparadas para su liberación se trasladan a La Rochelle dónde, junto con el resto de tortugas recuperadas en la costa atlántica francesa, se marcan con numeración francesa F y se liberan.

PALABRAS CLAVES: Conservación, marcaje, recuperación, suelta, tortuga boba.

LABURPENA

2000. urtetik aurrera, Donostiako aquariumak (Gipuzkoa, Euskal Herria) itsas dortoken errekuperazio programa batean hartzen du parte. Ordutik hona, 17 benetazko kareta *Caretta caretta* (Linneaus, 1758) ale markatu eta askatu ditu. Jaso ohi diren dortokak, dortoka gazteak dira heldutasun garaira iritsi ez direnak. Orokorrean gure hondartzetara osasun egoera kaskarrean iritsitakoak edo eta gure kostaldeko uretan jitoan dabiltzala topaturikoak dira. Guztiak, partikularrek edo arrantzaleek erreskatatutako itsas dortokak dira. Aquariumera iristen direnean, duten osasun egoeraren diagnostikoa egin eta bertan dagokien tratamendua jartzen zaie, bertan osasuna berreskuratzen duten arte. Behin osasun egoera berreskuratu dutela ikustean, La Rochelleko aquariumera eramaten dira bertan, Frantziar Atlantiar kostaldean jaso diren beste dortoka guztiekin batera askatuak izan daitezen. Gurean jasotako dortokak, F letra daramate, zenbaki frantsesekin markatuak izaten dira eta eta ondoren beren habitatean aske uzten dira.

GAKO-HITZAK: Kontserbazioa, benetazko kareta, errekuperazioa, askatzea, markajea.

INTRODUCTION

Caretta caretta (Linneaus, 1758) or loggerhead turtle is the most common turtle species seen in the Bay of Biscay (Penas-Patiño & Piñeiro, 1989). All sea turtles species are in decline, so threatened and listed in the Red List of the IUCN (International Union for the Conservation of Nature). *C. caretta* is listed as endangered. The main threats that loggerheads can encounter in the Bay of Biscay are accidental entanglement in fishing lines, boat propeller injuries and sickness due to low sea water temperatures for juveniles which get astray and are frequently found floating adrift and stranded on the beaches.

Since its foundation, the *Aquarium* has received sea turtles that were brought by fishermen or recreation boats that found them adrift in nearby waters or entangled in fishing lines. In fact one of the first detailed studies of a leatherback turtle, caught accidentally in a tuna fishing line in Mutriku (Guipúzcoa) was undertaken at the Aquarium of the Sociedad de Oceanografía de Guipúzcoa by Navaz & Gómez de Llarena (1951).

In 1996 two Loggerheads were released without tags near San Sebastian coast. Although the number of sea turtles that are recovered at the Aquarium is small, it was decided that it would be essential to tag them before releasing back in the sea. We considered that tagging of this species would help to clarify some doubts about their migratory routes, so it was decided that tags should be obtained. A contact was established with the Aquarium of La Rochelle (France) where they have a programme for Conservation of sea turtles.

MATERIALS AND METHODS

At arrival, sea turtles were registered. A first macroscopic observation was carried out, they were weighed in kilograms and sized: curved carapace length (CCL) and curved carapace width (CCW) in centimetres and accommodated in an independent 450-litre polyester square quarantine tank with temperature control. The diagnosis of specimens was conducted in a veterinarian clinic with x–ray facilities, when necessary a blood sample was taken for its analysis. In the cases where an unknown pathology was present a sample of tissue (skin) was sent to a specialized laboratory (Department of Animal Pathology of the University of Zaragoza). Once sea turtles were diagnosed, appropriate treatment was given to them. The quarantine protocol for the recuperation of loggerheads is shown in Table 1.

QUARANTINE CONDITIONS
- Isolated polyester square quarantine tanks of 450 litres with 20 cm of water column so they will be able to breathe air without much effort.
- At arrival acclimatizing at ambient sea water temperature. After 24 hours a slow increase of the water temperature is achieved until reaching 22-25 ºC which is the recovery temperature.
- Daily water parameters are measured.
- Daily vacuning, water change and disinfection of the tank.
- Photoperiod following natural solar light.
- Feeding is offered twice a day.
- Medical treatment is followed.

Table 1.- Quarantine protocol for sea turtles *C. caretta* at arrival at the *Aquarium* of San Sebastián.

Once they recovered, sea water temperature of the tank was lowered down gradually to equalize with the sea water temperature of the next step, which is a larger quarantine tank of 20.000 litres, before transferring them into the main tank of the Aquarium 1.500.000 litres where they are maintained at 18±1ºC. When sea water temperature is warm (normally month of June) specimens which have recovered satisfactorily at the *Aquarium* are moved to the *Centre d'Études et des Soins des Tortues Marines* located at the Aquarium of La Rochelle (Atlantic French coast). Specimens are tagged with a metal (titanium) flipper tag in the front right flipper (Fig. 1), with French nomenclature F and released back to the sea with other specimens recovered in other aquaria of the Atlantic French coast.

Fig. 1.- Detail of the metal (titanium) flipper tag used for *C. caretta.*

RESULTS

Figure 2 shows the number of loggerheads recorded at the *Aquarium* since year 2000; a total of 15 specimens were rescued from floating adrift and stranded on the beaches mainly on the Guipuzcoan coast. Unfortunately one was dead at arrival and two other died after 24 hours. Mean weight was 2.213,6 ± 1.851,7 kg, CCL 25,57 ± 5,07 cm and CCW 23,20 ± 4,94 cm.

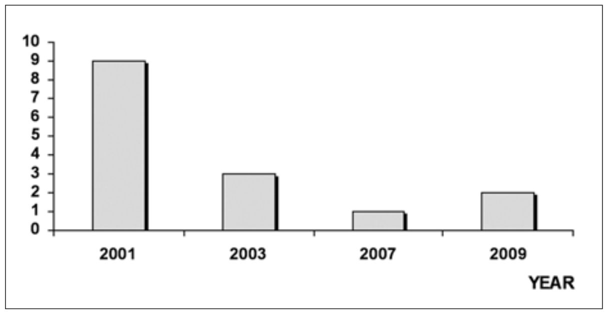

Fig. 2.- Number of specimens of *C. caretta* received at the Aquarium of San Sebastián 2001-2009.

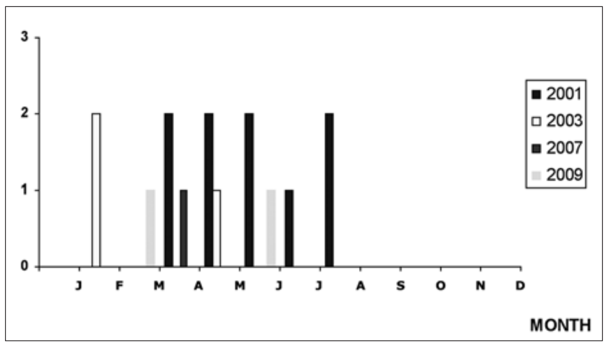

Fig. 3.- Temporal distribution of *C. caretta* entries at the *Aquarium* of San Sebastian.

Figure 3 shows the temporal distribution of loggerhead rescues. Apparently, there is not a clear seasonal pattern, it can be observed that winter and spring months could be the most frequent periods for seeing sea turtles, if it is not taken into account an extraordinary year 2001 when most were rescued in spring and summer.

Diagnostics showed that the most common illnesses found were pulmonary infections, hypothermia and dehydration among others; 46 % of specimens presented lung infection (Bronchopneumonia) showing difficulty in breathing and inability to submerge, 33 % skin infection by *Citrobacter freundii* (Braak 1928) Werkman and Gillen 1932 (Approved Lists 1980) which produced the loss of tissue, 26.6% eyes and mouth infections produced by *Aspergillus* sp. and 13,3% fuel intoxication, due probably to the "Prestige" oil spilling. Table 2 shows the veterinary treatment followed at the quarantine of the *Aquarium* of San Sebastián to recover sea turtles. Loggerheads were fed with sardines (with viscera), squids, mussels, shrimps with vitamins, at least twice a day until recovery.

During the month of June, sea turtles are transported to La Rochelle (French Atlantic coast) where they are tagged and released back to the sea. Figures 4 and 5 show the number of loggerheads tagged and released and their biometrics upon arrival to La Rochelle, respectively. At release mean weight was 10.721,25± 4.327,93kg, CCL 26,78± 6,01cm and CCW 24,525± 5,84cm.

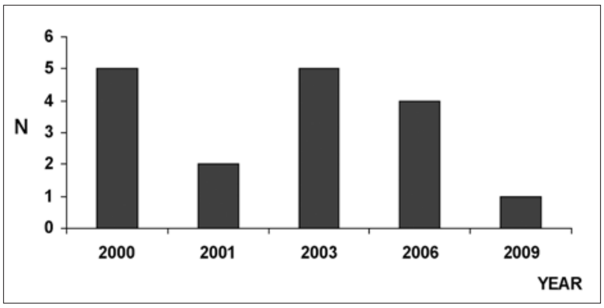

Fig. 4.- Number of *C. caretta* tagged and released at La Rochelle. Note than in year 2000, five sea turtles that were at the *Aquarium* of whom there is not data of arrival available were released.

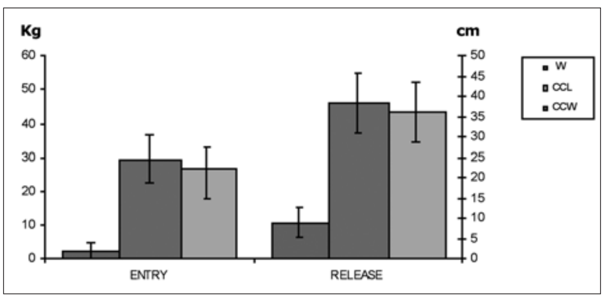

Fig. 5.- Weight in kilograms, curved carapace length (CCL) and curved carapace width (CCW) in centimetres of specimens of *C. caretta* recovered at the *Aquarium* since year 2001, tagged and released at La Rochelle.

DISCUSSION

Sea turtle specimens that are brought to the Aquarium are juvenile or subadult loggerheads (CCL < 25,57 ± 5,07 cm) that wander around in waters of the Bay of Biscay and that can be considered accidentally encountered because they have strayed away from their normal geographic range. Atlantic loggerhead turtles are born in the West Atlantic. After hatching, they disappear to start what is called the “lost year” (Bolten & Balazs, 1995) in which their distribution is unknown and are associated with Sargassum communities (*Sargassum sp.*) adrift. Other studies show that they enter the Gulf Stream current and belong to the pelagic-plantonic communities, which transport them along to the North Atlantic (Bolten *et al.*, 1998).

Sea turtles are not capable of maintaining a constant body temperature. Thus during autumn and winter, mean surface sea water temperature in the Basque coast is 12 ºC (9,2-14,2 ºC), (unpublished data of the last ten years taken at the *Aquarium* of San Sebastián) and sea turtles encounter these waters too cold. Schartz (1978) found that below 15 ºC adults sea turtles decrease quickly their activities and tend to float allowing the currents to transport them. At temperatures below 10 ºC they stop feeding and it is fatal when they stay for relatively long periods. Thus loggerheads that encounter low water temperatures in the Bay of Biscay stop feeding and as a consequence they are weak against infectious agents. Due to the fact that all species of sea turtles breathe air, they are very sensitive to lung infections, as shown by our results. Juvenile specimens of loggerheads found in our waters will die without the chance to contribute to the reproductive populations if they do not receive help. Sea turtles, if caught on time, respond very well to the treatments, in fact the success of recovery was of 85,7 %. Depending on the degree of damage a range from 32 to 92 days is needed. Results show that there is not a clear seasonal pattern for sights of loggerhead in the Basque coast. An extraordinary year was 2001 when 8 specimens were brought to the *Aquarium* during spring and summer. According to Duguy *et al*. (2004) this great number was related to a meteorological factor due to the Portugal current.

Although the number of specimens that arrive at our coast is low, San Sebastián Aquarium has joined a programme of conservation of sea turtles coordinated by the Aquarium of La Rochelle (France), which follows the recommendations for conservation of these species in the Northeast Atlantic (Fretey, 2001). The objective is to recover specimens that are found floating adrift and stranded on the beaches with the aim that they have the chance to reintegrate in the reproductive populations of America or North Africa. Specimens which have recovered satisfactorily in the *Aquarium* of San Sebastián and other aquaria of the Atlantic French coast are tagged and released offshore La Rochelle when sea water temperature is warm, normally during the month of June, so they have all summer to find their way back to their breeding sites. In the past ten years two tagged loggerheads have been found stranded on the beaches of the north coast of Spain; F 136 dead in September in 2003 in Noja (Cantabria) and F1934 found alive in March 2009 in Guetaria (Basque country). Thus the number of loggerheads that have not succeeded to exit the Bay of Biscay is very small compared with the number of specimens tagged and released, see Duguy *et al.* (2000, 2001, 2002, 2004, 2005, 2007) for a review.

Conservation programs for this species are very well established in other areas such as the Mediterranean and the Canary islands, but not in the Cantabrian coast of Spain. It is necessary to have a better flow of information between all the regional communities involved and especially between Vizcaya and Guipuzcoa, both on the Basque coast, since we don’t know what is really happening at the bottom of the Bay of Biscay because the data that we present here is not complete. A uniform criterion among all the institutions involved in recovering sea turtles, their tagging and release is necessary to really understand and help sea turtles in their journey. The *Aquarium* of San Sebastián is the only facility in the Basque coast that have the capability of holding sea turtles until they are tagged and released, so it plays an important role in the conservation of sea turtles at the bottom of the Bay of Biscay.

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The leatherback turtle *Dermochelys coriacea* (Vandelli, 1761) in the Bay of Biscay and the North East Atlantic

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ABSTRACT

This paper is a synthesis of our knowledge on the leatherback turtle *Dermochelys coriacea* (Vandelli 1761) in the Bay of Biscay and in the North East Atlantic. Numerous sightings in these two regions lead us to believe that they are foraging areas for this critically endangered (CR) species (IUCN, 2011). Its conservation does not depend solely and exclusively on mitigating the anthropogenic interactions, but also in the protection and use of its habitat. For this reason we will highlight the importance that Marine Protected Areas (MPA) could have and the need for new areas to be declared along the European Community coastline and within the vast bodies of water of the Bay of Biscay and the North East Atlantic.

KEY WORDS: *Dermochelys coriacea,* leatherback turtle, conservation, Bay of Biscay, North East Atlantic.

RESUMEN

En este artículo pretendemos exponer el conocimiento que se tiene sobre la tortuga laúd *Dermochelys coriacea* (Vandelli, 1761) en el golfo de Bizkaia. Existen zonas en el golfo de Bizkaia y el Atlántico Noreste de gran utilidad para *D. coriacea*, que se pueden definir como zonas de alimentación para la especie en peligro crítico de extinción (CR) (IUCN, 2011). La conservación de la especie no depende única y exclusivamente de la mitigación de las interacciones entre la especie y las actividades antropogénicas directas con ésta sino también con los hábitats y el uso que hagamos de los mismos. Por todo ello, queremos subrayar la importancia que pueden tener las Áreas Marinas Protegidas y la necesidad de que se declaren nuevas zonas en nuestras costas y aguas comunitarias europeas.

PALABRAS CLAVE: *Dermochelys coriacea,* tortuga laúd, conservación, golfo de Bizkaia, Atlántico Noreste.

LABURPENA

Lan honen bitartez, Bizkaiko golkoan larruzko dortoka *Dermochelys coriacea-z* (Vandelli, 1761) ezagutzen dena aurkeztu nahi izan dugu. Bizkaiko golkoan eta Atlantiar Ipar Ekialdean *D. coriacea*-rentzat garrantzi berezia duten guneak aurkitzen dira, desagertzeko arriskuan katalogatua dagoen (CR) (IUCN, 2011) espezie honentzat elikadura gune bezala definitu daitezkeenak. Giza jarduera batzuek espeziearekiko interakzio zuzena badute ere, hauen murriztea edo ekiditzea ez da kontserbaziorako eman beharreko pauso bakarra hain zuzen ere beste jarduera batzuek habitatetan dituzten ondorioak eta berauen erabilerak ere kontuan hartu beharrekoak dira. Guzti hau dela eta Itsas Eremu Babestuek duten garrantzia azpimarratu nahi dugu bai gure kostaldean baita europar batasuneko uretan ere.

GAKO-HITZAK: *Dermochelys coriacea,* larruzko dortoka, kontserbazioa, Bizkaiko golkoa, Atlantiar Ipar Ekialdea.

INTRODUCTION

Sea turtles are species, which are not well-known in the Bay of Biscay and the North East Atlantic. Of the seven species existing in the world, the loggerhead sea turtle *Caretta caretta* (Linnaeus, 1758) and the leatherback turtle *Dermochelys coriacea* (Vandelli, 1761) are the most cited in these areas (Brongersma, 1972; Duguy, 1997; Camiñas, 2004; Cermeño *et al.,* 2006). The former belongs to the Cheloniidae family, which includes a further five species; the latter is the sole survivor of the Dermocheliidae family.

The first mention of *D. coriacea* in the Basque Country was published in 1951, and refers to a specimen captured by a bonito fishing boat in Mutriku (Navaz & Gómez de Llanera 1951). Like the other species of sea turtle, *D. coriacea* has experienced a drastic reduction in many of its populations over the last few decades (Sarti Martínez, 2000 in IUCN, 2011). For this reason, it is currently protected and classified on the International Union for Conservation of Nature (IUCN) Red List. Although an increase in its populations in recent decades as been observed in the Atlantic, mainly in the Caribbean region (Dutton *et al.*, 2005), and its numbers have stabilized in others, its "critically endangered (CR)" classification assigned by the IUCN (Sarti Martínez, 2000 in IUCN 2011) has not been modified. In Spain, this species is included on the red list of threatened species (Camiñas, 2004). The cataloguing and protection of these reptiles in the waters of the Basque Country but also in other communities along the Cantabrian coast are still pending.

DISTRIBUTION AND ABUNDANCE OF THE LEATHERBACK SEA TURTLE IN THE BAY OF BISCAY AND THE NORTH EAST ATLANTIC

Observation of *D. coriacea* adult individuals in the North East Atlantic, including the Bay of Biscay, is relatively frequent, although published data are scarce. According to a compilation of surveys on sea turtles in Galicia and the Cantabrian coast, 518 individuals of five different species were spotted between 1990 and 2005 (CERMEÑO *et al.*, 2006). In this study, *D. coriacea* was the second most commonly-sighted species (40.7 %), after *C. caretta* (55%).

The seasonal pattern of the species in this region was identified by DUGUY (1997) and confirmed by MARTIN (2003). According to these authors, *D. coriacea* visits the Bay of Biscay during the summer (DUGUY, 1997; MARTIN, 2003; WITT *et al.,* 2007a). Tracking of individuals have shown that turtles migrate from areas of reproduction in the Western Atlantic (Caribbean, French Guiana) to the North Atlantic using northern branches of the Gulf Stream or North Atlantic Current (HAYS *et al.*, 2004, 2006; ECKERT, 2006; DOYLE, 2007). These ocean frontal regions are known to be highly productive areas and where leatherbacks are known to forage along with a great variety of marine fauna and the resulting fishing fleets (FERRAROLI *et al.,* 2004).

The presence of Leatherbacks is clearly greater on the Galician coast than on the Cantabrian coast, dropping sharply as one travels eastwards. This is probably due to its closer proximity to the North Atlantic Current and to the presence of major foraging areas such as the Galicia Bank.

The male specimens of *D. coriacea* tend to be mainly adult individuals, and on the Cantabrian coast their average size (Curved Carapace Length, CCL) is 161.5 cm (n=74) (CERMEÑO *et al.*, 2006), which is within the range of the sizes of reproducing females among the Atlantic population (CHACÓN-CHAVERRI, 1999; STEWART *et al.,* 2007).

Other studies take other major foraging areas into consideration in the North Atlantic, such as Nova Scotia (Canada) (JAMES *et al.*, 2005, 2006a, 2007) or the waters north of the Bay of Biscay such as the Irish and Celtic Sea (HAYS *et al.,* 2004, 2006; HOUGHTON *et al.,* 2006; WITT *et al.,* 2007a; FOSSETTE *et al.,* 2010). During the summer, when primary production decreases in the ocean, the continental slope of the Celtic Sea becomes a major area for the production of plankton (GARCIA-SOTO & PINGREE, 1998). The tidal front of the Irish Sea (PINGREE & GRIFFITHS, 1978) is also a significant area for summer plankton production.

The 15 °C isotherm has been described as the northern distribution limit for this species in waters of the North Atlantic, although it may withstand lower temperatures (MCMAHON & HAYS, 2006; JAMES *et al.,* 2006b). Other authors (WITT *et al.,* 2007a) postulate isotherms of 10-12 °C.

A clear choice of habitat on the part of *D. coriacea* has been observed when the abundance of gelatinous organisms increases at the end of summer and early autumn (WITT *et al.,* 2007a). The correlation existing between *D. coriacea* and its prey (mainly gelatinous plankton organisms) has been proven on different occasions in the North Atlantic, both in Canadian waters (JAMES & HERMAN, 2001) and in Irish Sea waters (HOUGHTON *et al.,* 2006; DOYLE, 2007; FOSSETTE *et al.,* 2010) although the effects of environmental conditions on the abundance of prey and predatory behaviour are still unknown (SHERRILL-MIX *et al.,* 2007).

Observation of *D. coriacea* in the North-East Atlantic tends to be concentrated in the summertime (DUGUY, 1997; MARTIN, 2003; PENROSE & GANDER, 2010). In the case of the Cantabrian coast, there is no established coordinated network of strandings or sightings to help put together information and develop relevant regional coastal reports, as it is the case for the British Isles and France (WITT *et al.,* 2007b; PENROSE & GANDER, 2010; DELL´AMICO & MORINIÈRE, 2010) or in the Mediterranean (e.g.: TOMÁS *et al.,* 2008; CASALE *et al.,* 2010).

Leatherbacks have been sighted off La Rochelle (Dell´Amico & Morinière, pers. comm.), where there is evidence of abundant jellyfish (SEBASTIAN *et al.,* 2011), as well as a large number of *D. coriacea* strandings. The French coast is characterized by a major fluvial contribution (e.g. Gironde River) and the presence of tidal fronts (PINGREE *et al.,* 1982), which during the summer increase biological production. The departments of Charente-Maritime and Vendée on the French Atlantic Coast are the areas where this species would seem to be most abundant, both in terms of sighted and stranded specimens (DELL´AMICO & MORINIÈRE, 2010). This fact is explained by local productive processes, which include – among others – the vertical mixture of the continental slope waters and the topographic effects of the banks. Figure 1 shows concentrations of plankton in the mouth of the Gironde, the Cantabrian outcrop and ocean whirlpool region. The concentration of plankton on these structures is greater as one travels further away from the interior of the Bay of Biscay (GARCIA-SOTO *et al.,* 2002).

In a study of *D. coriacea* migratory behaviour using satellite tagging in the North East Atlantic (DOYLE *et al.,* 2007b), an individual increased the time it remained in one of these ocean structures for several months, validating their good foraging conditions. This behaviour has been observed by other authors and in other species of sea turtle, thereby confirming that whirlpools and eddies are associated with a great abundance of prey (SHOOP & KENNEY, 1992; LUTCAVAGE, 1996; LUSCHI *et al.,* 2003; FERRAROLI *et al.,* 2004; HAYS *et al.,* 2006; ECKERT, 2006; POLOVINA *et al.,* 2006). The presence of swoddies or Slope

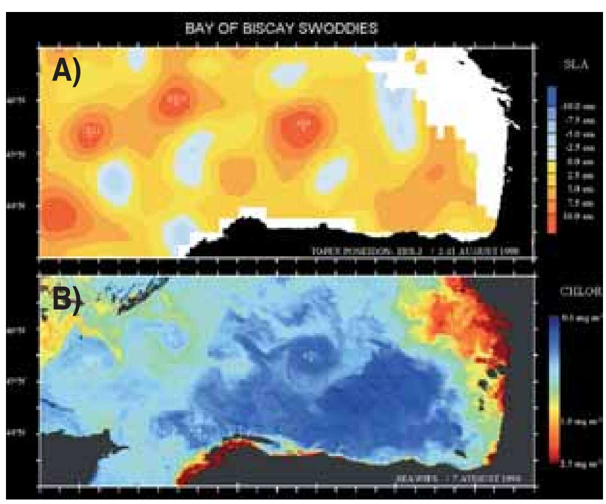

Fig. 1.- *Swoddies* in the Bay of Biscay in August 1998. (A) Sea level (cm) and (B) Concentration of phytoplankton (mg Chlorophyll/m³). (GARCIA-SOTO *et al.,* 2002).

Water Oceanic Eddies common in the south of the Bay of Biscay (GARCIA-SOTO *et al.,* 2002) could explain the increase presence of sea turtles in the area in the summertime.

ANTHROPOGENIC IMPACTS

Traditionally, the main causes of decline of sea turtle populations, has been the loss of nesting beaches and other threats that affect reproduction (LUTCAVAGE *et al.,* 1997). Bycatch during fishing manoeuvres (DUGUY *et al.,* 1998; LEWISON *et al.,* 2004a, 2004b; LEWISON & CROWDER, 2007; PECKHAM *et al.,* 2007; BÁEZ *et al.,* 2007 and 2008; WALLACE *et al.,* 2008), climate change (POLOCZANSKA *et al.*, 2009), the loss of habitat both in egg-laying areas and on the open sea (LUTZ & MUSICK, 1997; BOLTEN & WITHERINGTON, 2003) and sea pollution due to heavy metals and solid residues (DUGUY *et al.,* 1998; MROSOVSKY *et al.,* 2009) are factors responsible for the decline in populations worldwide.

In the specific case of *D. coriacea*, mortality factors identified on the French Atlantic coast have been the ingestion of plastics, collision with vessels and bycatch by fisheries (DUGUY, 1997; DUGUY *et al.,* 1998). On the Basque coast and the rest of the Cantabrian coast, although specific studies are inexistent, similar causes of occasional stranding are most likely to be blamed.

Fishing and bycatch

There is a wide range of examples in the literature regarding bycatch of marine megafauna by different fisheries worldwide: dolphins in purse seine nets caught by tuna fishing boats, albatrosses caught by longline fishing and sea turtles caught by shrimp trawling, or by surface longline fishing (SILVANI *et al.,* 1999; HALL *et al.,* 2000; LEWISON *et al.,* 2004a; LEWISON & CROWDER, 2007; BÁEZ *et al.*, 2007 and 2008; MRAG LTD, 2008).

Although it is quite well documented that large-scale industrial fishing has given rise to a drop in sea turtle populations, not enough attention has been paid to the impact of small-scale fisheries on non-target populations of these species. The great majority (99 %) of the 51 million fishermen in the world fish in coastal waters (within 12 miles), not surprisingly these coastal habitats are also frequented by numerous migratory marine species with a high potential for bycatch. As a result of this overlap, fisheries may constitute one of the greatest threats to endangered species (PECKHAM *et al.,* 2007). Artisanal fisheries would seem as a whole to be responsible for bycatch on a major scale. This decreases the effectiveness of the means for reducing bycatch which is being put into practice by industrial fisheries worldwide (PECKHAM *et al.,* 2007; ALFARO-SHIGUETO *et al.,* 2008; ALFARO-SHIGUETO *et al.,* 2010). Proposals to reduce bycatch would benefit from studies quantifying the bycatch by small-scale fisheries and the impact on habitat of endangered species (SOYCAN *et al.,* 2008).

There are large gaps in our knowledge about bycatch and closer monitoring of this is needed, particularly in less studied regions (CARRERAS *et al.,* 2004; LEWISON *et al.,* 2004b; TOMÁS *et al.,* 2008; WALLACE *et al.,* 2010; ÁLVAREZ DE QUEVEDO *et al.,* 2010). The most recent report by the study group on the bycatch of protected species by the International Council for the Exploration of the Sea (ICES, 2008), refers to the lack of funding for onboard observer programmes and reflects the scant attention paid to bycatch of protected species manifested by most member countries.

A survey conducted systematically with fishermen was carried out for the first time in the Basque Country in 2010 (ZALDUA-MENDIZABAL, 2010) to assess possible interaction between coastal fisheries (47 coastal vessels polled out of a total of 193) and sea turtles in waters of the Bay of Biscay. From the data obtained about bycatch, which referred exclusively to *C. caretta*, and the distribution of the fishing effort during 2009, a Catch per Unit Effort value (CPUE) was obtained of 0.0018 turtles/month/vessel. It should be pointed out that vessels were not boarded and therefore the CPUE values obtained from the survey could not be validated (ZALDUA-MENDIZABAL, 2010). The distribution and summer seasonal presence of *D. coriacea* in the area were also confirmed in during this study (Fig. 2). Furthermore, the existence of hot points of great importance for conservation of this species in the Bay of Biscay and adjacent areas of the North East Atlantic were also identified.

The conclusion drawn from the assessment work carried out on the bycatch of sea turtles by the Basque coastal fishing fleet shows that the density of turtles in waters near the coast is low, which means interaction with fishing fleets operating in these waters would appear to be limited and does not entail a potential threat to stocks in the Bay of Biscay (Table 1). Conversely, the survey reflected a greater density of sea turtles in areas further away from the coast (Galicia Bank, Celtic Sea and Gran Sol), which could be explained by the presence of a larger continental shelf than off the coasts of France and Ireland, which would in turn imply greater availability of food (HOUGHTON *et al.,* 2006; SIMS *et al.,* 2006; WITT *et al.,* 2007a; CAUT *et al.,* 2008; FOSSETTE *et al.,* 2010).

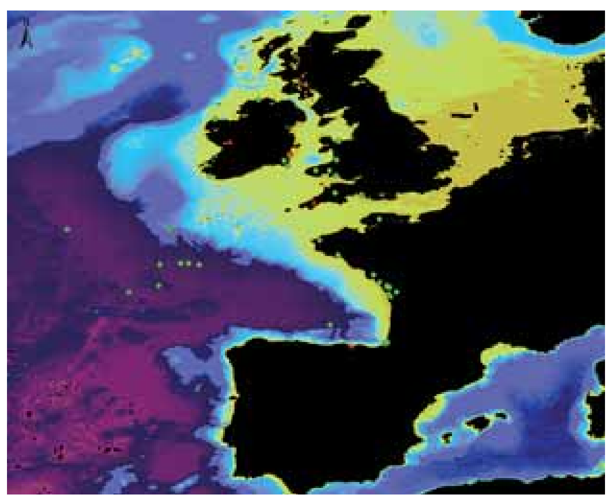

Fig. 2.- *D. coriacea* sightings and strandings in the Bay of Biscay and closest areas in 2009.

2009	Basque Country					
Species	Sightings		Strandings		Bycatch	
	Alive	Dead	Alive	Dead	Alive	Dead
Caretta caretta	1	0	3	1	2	0
Dermochelys coriacea	4	0	0	1*	0	0
Indeterminate	1	0	0	0	0	0
TOTALS	6	0	3	2	2	0

2009	FRANCE					
Species	Sightings		Strandings		Bycatch	
	Alive	Dead	Alive	Dead	Alive	Dead
Caretta caretta	1	0	8	6	1**	0
Dermochelys coriacea	13	0	0	9	0	0
Indeterminate	0	0	0	0	0	0
TOTALS	14	0	8	15	1	0

2009	UNITED KINGDOM & IRELAND					
Species	Sightings		Strandings		Bycatch	
	Alive	Dead	Alive	Dead	Alive	Dead
Caretta caretta	0	0	5	4	0	0
Dermochelys coriacea	15	1	0	5	0	1
Indeterminate	7	1	0	1	0	0
TOTALS	22	2	5	10	0	1

Table 1.- Strandings, sightings and bycatch of sea turtles in the Basque Country, year 2009. Comparative data from France (DELL´AMICO *et al.,* 2010), United Kingdom and Ireland (PENROSE & GANDER, 2010) is also included, in addition to a stranding of *D. coriacea* in Castro Urdiales (Cantabria; Alejandro Gómez Iriberri) (*) and a bycatch of *C. caretta* in France (31st December 2008) (**).

Ingestion of solid residues

Generally speaking, a high mortality rate of sea turtle is due to the ingestion of residues (DUGUY, 1997; DUGUY *et al.,* 1998), although *D. coriacea* is especially sensitive to this threat due to its trophic specialisation (FOSSETTE *et al.,* 2010; JAMES & HERMAN, 2001), with its diet consisting of gelatinous organisms, salpids, jellyfish and others. Plastic bags and residues with a similar appearance to its prey represent a great threat. A sea turtle study carried out on the Basque coast, in which autopsies carried out on 43 individuals, resulted in 22 individuals with plastic residues in their digestive tract (51.1 %). The plastic residues found were of diverse origin, and in some cases very large (DUGUY *et al.,* 1998).

IMPORTANT AREAS FOR CONSERVATION OF THE LEATHERBACK TURTLE IN THE BAY OF BISCAY AND NORTH EAST ATLANTIC

Dermochelys coriacea plays a key ecological role as a major predator of jellyfish and gelatinous zooplankton (GIBBSON & RICHARDSON, 2009; FOSSETTE *et al.,* 2010). The decrease in numbers of this species together with that of other key predators such as some commercially-significant species of fish could have serious repercussions on population control of the species on which they prey and bring about a change that could in turn have unforeseen consequences. Furthermore, they are responsible for passing on nutrients between foraging areas and nesting beaches (BOUCHARD & BJORNDAL, 2000) and play a major role as an oasis in the middle of the oceans where birds and fish can rest and seek protection from predators (PITMAN, 1993). These are just a few examples of the ecological importance of *D. coriacea* in marine and terrestrial ecosystems. We do not know how the reduction in its populations could be affect the ecosystems, whereby plans for its conservation and the protection of habitats where it carries them out are essential. In the case of the Bay of Biscay and the North East Atlantic, there are three foraging areas of great importance to *D. coriacea* (Fig. 3): (1) the Galicia Bank (ECKERT, 2006) (an area being studied as a possible Marine Protected Area), (2) Irish waters (Irish Sea and Celtic Sea; HOUGHTON *et al.,* 2006) to the north of the Bay of Biscay, and (3) a third area that has yet to be confirmed off the coast of La Rochelle, the Pertuis Charentais, which is currently classified as a Site of Community Importance (SCI) in the Gironde estuary, on the French Atlantic coast. This last-mentioned has shown a high number of sighted and stranded *D. coriacea* specimens (Doyle & Morinière, pers. comm.; see Fig. 4), in addition to a high concentration of gelatinous zooplankton (Doyle, pers. comm.), and as facing a potential threat from trawling in the vicinity. This place is actually a Protected Marine Area (http://www.aires-marines.fr/L-Agence/Organisation/Missions-d-etude-de-parc/Gironde-Pertuis) and French Government plans to create a marine nature reserve there.

Generally-speaking, the designation of areas of special importance or especially vulnerable ones (Marine Protected Areas) is considered to be one of the most important tools available for protecting species and habitats. In the specific case of the Cantabrian coast, declaring an area an MPA for inclusion in the Natura 2000 Network has not hitherto been a priority in either autonomous or state administrations. The Cabinet declared the first Marine Protected Area in Spain in 2008 in El Cachucho (Asturias). The Galicia Bank is currently being studied, as this is a major habitat for *D. coriacea*

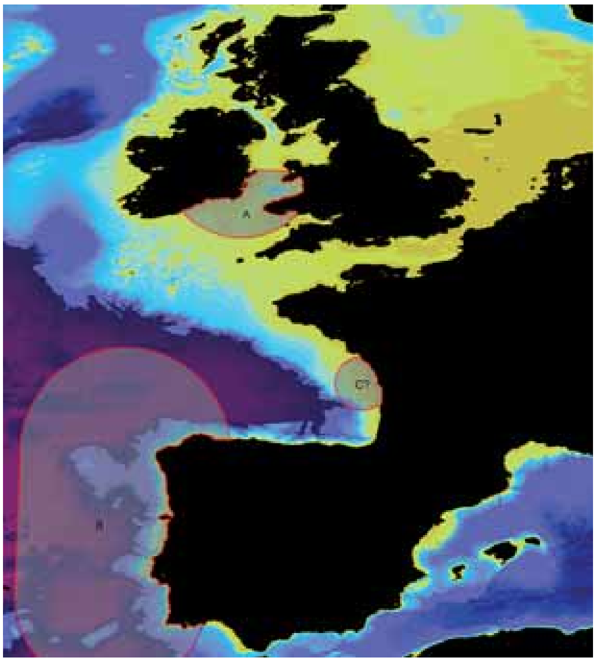

Fig. 3.- *D. coriacea* foraging grounds in the Nord East Atlantic.

(ECKERT, 2006) and many other species, and a place where a great number of fishing fleets operate, with the resulting possibility of bycatch, collisions and destruction of habitat, etc. For all the aforementioned reasons, management plans are needed to integrate ecosystems, resources and endangered species.

CONCLUSIONS

Dermochelys coriacea continues to be an unknown species in the Bay of Biscay and the North East Atlantic. Generally speaking, research into conservation of this species is not at present a priority. This is a predator with very few competitors and, given its trophic specialisation, it is not known whether its absence could alter the trophic network in the foraging areas it frequents. Thus, the influence it has on bringing about changes that would affect these habitats and/or anthropogenic activities carried out in them such as fishing or tourism has not been assessed.

Fig. 4.- *D. coriacea* feeding on a barrel jellyfish *Rhizostoma octopus* in front of La Rochelle coastline, Bay of Biscay in 2007. Photography: Bateau École des Douanes, La Rochelle/Aquarium La Rochelle S.A.S.

Greater knowledge about the oceanography of the Bay of Biscay, its habitats and species is required in order to understand the relationship existing between the physical-chemical and biological complex in this part of the North East Atlantic.

The conservation of biodiversity and habitats must be made a priority. The creation of MPA is not enough, but it is necessary to ensure that ecosystems are recovered and increase their resilience – also in this area of the North East Atlantic.

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Captura incidental de tortugas marinas en la pesquería de arrastre Uruguaya

Incidental capture of sea turtles in the Uruguayan trawl fishery

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ABSTRACT

The Uruguayan coastal pair bottom-trawl fishery interacts frequently with loggerhead turtle *Caretta caretta* (Linnaeus, 1758), green turtle *Chelonia mydas* (Linnaeus, 1758) and leatherback turtle *Dermochelys coriacea* (Vandelli, 1761). To address this issue, in April 2002 we established a conservation program: PROMACODA (On board Tagging and Data Collection Programme). PROMACODA is a participatory program composed of fishermen and researchers, that seeks to increase knowledge about the biology of sea turtles while developing conservation activities to help mitigate the bycatch of these species. From April 2002 to June 2005, 138 sea turtles was incidentally captured, 99 individuals of *Caretta caretta* (54.5 cm – 106.5 cm CCL); 21 individuals of *Chelonia mydas* (31 cm – 71 cm CCL); 17 individuals of *Dermochelys coriacea* (127 cm – 168 cm CCL) and only one individual of *Lepidochelys olivacea* (61 cm CCL). Only 3 captures of the total (n=138) was in winter, 49 captures was in summer, 57 captures was in autumn and 29 captures was in spring. Mortality hold 35,5% (n=49) and from the 89 turtles captured alive, 73 turtles was tagged (82%).

KEY WORDS: Sea turtles, bycatch, trawl fishery, conservation, Uruguay.

RESUMEN

La pesca de arrastre de fondo costero a la pareja de Uruguay interactúa frecuentemente con la tortuga cabezona *Caretta caretta* (Linnaeus, 1758), la tortuga verde *Chelonia mydas* (Linnaeus, 1758) y la tortuga siete quillas *Dermochelys coriacea* (Vandelli, 1761). Para abordar esta problemática, en abril de 2002 se creó un Programa de Conservación: PROMACODA (Programa de Marcaje y Colecta de Datos a Bordo). El PROMACODA es un programa participativo integrado por pescadores e investigadores que busca incrementar el conocimiento sobre la biología de las tortugas marinas y al mismo tiempo desarrollar actividades de conservación que ayuden a mitigar el “bycatch” de estas especies. Desde abril de 2002 a junio de 2005 fueron capturadas incidentalmente 138 tortugas marinas, correspondiendo a 99 individuos de *Caretta caretta* (54,5 cm – 106,5 cm LCC); 21 individuos de *Chelonia mydas* (31 cm – 71 cm LCC); 17 individuos de *Dermochelys coriacea* (127 cm – 168 cm LCC) y un único ejemplar de *Lepidochelys olivacea* (61 cm LCC). Sólo 3 capturas del total (n=138) fueron registradas en invierno, 49 capturas fueron en verano, 57 en otoño y 29 en primavera. La mortalidad alcanzó el 35,5% (n=49) y de las 89 tortugas capturadas vivas, 73 fueron marcadas (82%).

PALABRAS CLAVES: Tortugas marinas, captura incidental, pesca de arrastre, conservación, Uruguay.

LABURPENA

Uruguaiko itsasertz hondoko bikote arrastre-arrantzak maiztasunez itsas dortokekin egiten du topo, bai benetazko dortokarekin *Caretta caretta* (Linnaeus, 1758), bai berdearekin *Chelonia mydas* (Linnaeus, 1758) eta baita larruzko dortokarekin *Dermochelys coriacea* (Vandelli, 1761) ere. Arazo honi aurre egiteko 2002. urtean PROMACODA (itsasontziko markaketa eta datu-bilketen programa) egitasmoa jarri zen abian. Egitasmo hau bateratzailea eta parte hartzailea izateko sortu zen, non bai arrantzale eta ikerlariek itsas dortoken biologiaren inguruan gehiago sakontzea eta kontserbazioa sustatuz nahigabeko arrapaketen gutxitzea du funtsa. 2002ko apirila geroztik 2005 arte, 138 itsas dortoka harrapatu ziren. 99 ale *Caretta caretta* izan ziren (54,5 cm – 106,5 cm OKL); *Chelonia mydas* 21 ale (31 cm – 71 cm OKL); 17 ale *Dermochelys coriacea* (127 cm – 168 cm OKL) eta *Lepidochelys olivacea* (61 cm OKL) ale bakar bat. Urtaroari dagokionez, 138 harrapaketetatik soilik 3 ale harrapatu ziren neguan, 49 udan, 57 udazkenean eta 29 udaberrian. Behatutako hilkortasuna % 35,5ekoa izan zen eta harrapatutako 89 dortoka bizietatik, 73 markatu ziren (% 82).

GAKO-HITZAK: Itsas dortokak, harrapaketa akzidentala, arrastreko arrantza, kontserbazioa, Uruguay.

INTRODUCCIÓN

Las capturas incidentales de tortugas marinas producidas en las pesquerías son una de las amenazas y problemas más graves que atraviesan las poblaciones de estas especies en todos los mares y océanos del mundo (Oravetz, 1999; Hall *et al.*, 2000; Spotila *et al.*, 2000). En la zona del Atlántico Sur Occidental (ASO) habitan 5 especies de tortugas marinas (Domingo *et al.*, 2006), la tortuga siete quillas *Dermochelys coriacea* (Vandelli, 1761), la tortuga cabezona *Caretta caretta* (Linnaeus, 1758), la tortuga verde *Chelonia mydas* (Linnaeus, 1758), la tortuga olivácea *Lepidochelys olivacea* (Eschscholtz, 1829) y la tortuga carey *Eretmochelys imbricata* Fitzinger, 1843, todas las cuales ocurren en aguas uruguayas (Frazier, 1984; López-Mendilaharsu *et al.*, 2006; Estrades *et al.*, 2007).

Censos de playas realizados por el equipo de la ONG Karumbé: Tortugas Marinas del Uruguay permitieron detectar en el año 2001 la ocurrencia de varamientos de tortugas siete quillas *D. coriacea,* cabezona *C. caretta* y verde *C. mydas* a lo largo de la costa uruguaya. Las causas de muerte de estas tortugas en algunos casos pudieron ser determinadas porque presentaban evidencia de colisiones con embarcaciones, restos de redes de pesca y residuos plásticos en su tracto digestivo (LÓPEZ-MENDILAHARSU *et al.*, 2006). Entre 1999 y 2003 se registraron 231 varamientos de tortugas marinas a lo largo de toda la costa uruguaya (ESTRADES, 2003).

En marzo de 2002 un pescador de arrastre uruguayo reportó al Proyecto Karumbé la captura incidental en su buque de una tortuga marina que estaba identificada con una marca metálica. La tortuga reportada por el pescador resultó ser una hembra adulta de la especie *C. caretta*, marcada en la playa de anidación de Arembepe, Bahía, Brasil en 1995 por personal del Projeto Tamar (LAPORTA & LÓPEZ, 2003).

A raíz de esta recaptura, decidimos investigar más en profundidad la interacción entre la pesquería uruguaya de arrastre de fondo costero y las tortugas marinas que utilizan la misma zona. En ese momento se crea un programa de conservación, educación e investigación que tiene como misión abordar dicha problemática, la cual era desconocida hasta entonces. Este programa, denominado PROMACODA (Programa de Marcaje y Colecta de Datos a Bordo), es un programa participativo integrado por pescadores e investigadores que busca incrementar el conocimiento sobre la biología de las tortugas marinas y al mismo tiempo desarrollar actividades de conservación que ayuden a mitigar la problemática de las capturas incidentales en esta pesquería (LAPORTA & MILLER, 2006; LAPORTA *et al.*, 2006).

El objetivo de este trabajo es describir la metodología y los principales resultados obtenidos por el PROMACODA desde su creación hasta el año 2006. El PROMACODA se desarrolla en la zona que opera la flota de arrastre de fondo costero uruguaya dentro de la denominada Zona Común de Pesca Argentino-Uruguaya (ZCPAU) que abarca el estuario del Río de la Plata y aguas del Océano Atlántico adyacentes (Figura1). Este estuario muestra variaciones abruptas y significativas de los niveles de salinidad y temperatura, así como notorias variaciones estacionales (SEVEROV *et al.*, 2003). El estuario juega un rol importantísimo como área de cría y desarrollo para varias especies de peces de interés comercial (LASTA, 1995) y ha sido descrito por ACHA *et al.* (2004) como un área de alta producción biológica la cual sustenta importantes pesquerías artesanales y costeras.

Fig. 1.- Zona de estudio donde opera la flota de arrastre de fondo costero uruguaya. / Study area where the Uruguayan coastal pair bottom-trawl fishery operates.

METODOLOGÍA DEL PROMACODA

Relevamiento inicial de la problemática

Análisis y descripción de las pesquerías de arrastre uruguayas

Con el objetivo de conocer a priori las pesquerías de arrastre uruguayas que interactúan o que tienen potencial de interacción con las tortugas marinas se realizó un estudio teniendo en cuenta las modalidades operativas de cada pesquería de arrastre y la posibilidad de captura incidental de tortugas marinas. Para ello se describieron todas las pesquerías de arrastre uruguayas utilizando la información publicada por la DINARA en diversos informes (DINARA, 2003) y realizando entrevistas con técnicos de dicha institución responsables de la gestión de estas pesquerías. Los datos que se tuvieron en cuenta para el estudio fueron los siguientes: zona de operación, tamaño de flota, dimensiones del arte (apertura horizontal y vertical de las redes, tamaño de luz de malla), profundidades de pesca y tipos de fondos, especies objetivo, tamaño de los barcos y su TRB (Tonelaje de Registro Bruto), duración promedio de los arrastres, velocidad de arrastre y el número de tripulantes de cada barco.

Entrevistas y charlas abiertas con pescadores de arrastre

Paralelamente al estudio mencionado anteriormente, se realizaron entrevistas y se mantuvieron charlas abiertas con pescadores en los diferentes puertos donde operan estas pesquerías. Estas entrevistas y charlas tuvieron como fin obtener información sobre la interacción tortugas marinas – pesca de arrastre. Las preguntas realizadas a los pescadores se dividieron en dos grupos, por un lado preguntas dirigidas hacia la captura incidental de tortugas marinas y por otro lado preguntas dirigidas a entender la modalidad operativa de la pesquería. Las preguntas realizadas a los pescadores se muestran en la Tabla 1.

Preguntas sobre captura incidental de tortugas marinas:
1. ¿Dónde y cuándo capturan incidentalmente tortugas marinas?
2. ¿Cuáles tortugas marinas capturan, qué nombres tienen?
3. ¿Cuántas tortugas estima que se capturan por viaje?
4. ¿Qué hacen con las tortugas marinas una vez capturadas?
Preguntas sobre la modalidad operativa de la pesquería:
1. ¿Cómo es la maniobra de pesca?
2. ¿Cómo es la dinámica de la flota?
3. ¿ Cómo son las zonas de pesca (tipos de fondo, etc.)?

Table 1.- Preguntas realizadas a los pescadores en las entrevistas. / Questions of the interview directed to fishermen.

En base a los resultados del análisis y descripción de las pesquerías, se determinó como prioritario y urgente el desarrollo de esfuerzos dirigidos a la pesquería de arrastre de fondo costero, enfocados en la concienciación de los tripulantes y un mayor abordaje para colectar información y poder así comprender la magnitud del problema y buscar métodos para mitigar la problemática.

Establecimiento del PROMACODA

Talleres de educación y divulgación para pescadores

Con los objetivos de poner en conocimiento la situación y problemática de las tortugas marinas, dar divulgación sobre la existencia del programa y reclutar participantes al PROMACODA, se realizaron talleres en la Escuela Técnica Marítima (UTU del Mar). Esta escuela es un centro de formación técnica de marineros y capitanes de pesca donde acuden muchos pescadores para obtener los títulos de marinero y patrón de pesca de altura. El contenido temático de los talleres fue el siguiente:

1. Biología de las tortugas marinas: se trataron conceptos básicos como la identificación de las especies, el ciclo de vida, los hábitos alimenticios y las migraciones.
2. Conservación de las tortugas marinas: se presentó el status de conservación de las tortugas marinas y sus problemáticas, por qué y cómo conservar a las tortugas marinas y principalmente se hizo hincapié en el rol que tienen los pescadores en la conservación.
3. Interacción de tortugas marinas con artes de pesca y maniobras: se intercambiaron experiencias sobre diferentes pesquerías, sus artes, maniobras y se intentó entender más en detalle el tipo de interacción con cada pesquería.
4. Proyecto Karumbé/PROMACODA (Programa de Marcaje y Colecta de Datos a Bordo): se presentaron las diferentes actividades del proyecto y se invitó a participar a los pescadores en el programa.

Selección de pescadores participantes del programa

Luego de haber finalizado los talleres de educación y divulgación, se realizó una selección de los pescadores más interesados y entusiasmados en participar del programa. Los criterios que se tuvieron en cuenta a la hora de la selección fueron varios: el compromiso ambiental del pescador; la actitud trasmitida de querer participar y ser integrante del programa; estar enrolado en un barco, disposición a participar en talleres de entrenamiento en la colecta de datos y las referencias provistas por pescadores conocidos que ya estaban participando en el programa. Otro criterio importante que se tuvo en cuenta fue el consentimiento del capitán del barco en que se encontraba enrolado el pescador para poder llevar adelante el trabajo con las tortugas. En algunos casos el pescador seleccionado era el mismo capitán.

Otra fuente de reclutamiento de pescadores al programa fue por la iniciativa que tomó el pescador que encontró la marca (chapita, como le dicen los pescadores uruguayos) de la hembra de *C. caretta* marcada en Brasil citada anteriormente. Este pescador, que se interesó en ayudar y participar en el programa desde el primer día en que fue contactado, fue el primer pescador al iniciar el programa y nos contactó con más pescadores interesados y preocupados por la situación de los recursos pesqueros del país, por la práctica de una pesca responsable y las especies en peligro de extinción.

Otra fuente de reclutamiento de pescadores al programa fue por la iniciativa que tomó el pescador que encontró la marca de la hembra de *Caretta caretta* marcada en Brasil citada anteriormente. Este pescador, que se interesó en ayudar y participar en el programa desde el primer día en que fue contactado, fue el primer pescador al iniciar el programa y nos contactó con más pescadores interesados y preocupados por la situación de los recursos pesqueros del país, por la práctica de una pesca responsable y las especies en peligro de extinción.

Entrenamiento a pescadores del programa

El entrenamiento a los pescadores fue realizado personalmente y de forma gradual según la disposición de tiempo de cada pescador. Los entrenamientos fueron realizados en diferentes lugares: en el muelle y en los barcos las horas antes a la salida del barco, en las casas de los pescadores y en reuniones programadas con otros pescadores del programa.

El entrenamiento a los pescadores fue dividido en dos módulos, el primero consistió en trasmitir los fundamentos para la colecta de datos y muestras de carácter biológico y el segundo para la colecta de datos de pesca.

Colecta de datos y muestras biológicas

El entrenamiento en la colecta de datos biológicos consistió en trasmitirles los fundamentos básicos para identificar las diferentes especies de tortugas marinas, utilizando para ello claves de identificación especialmente diseñadas con esquemas, dibujos y fotografías de las especies de tortugas marinas presentes en aguas uruguayas. Con el objetivo de confirmar la especie identificada por el pescador o sí éste tenía dudas en su identificación, se les indicó que tomaran varias fotografías de las tortugas capturadas, utilizando una ficha de referencia en cada foto (con la fecha, hora y nº de fotos), y anotando siempre en un estadillo el nº de fotografías sacadas a cada tortuga (Figura 2). Esto permitió también validar la información colectada por el pescador. Al mismo tiempo, se les entrenó para medir el largo curvo del caparazón (LCC) siguiendo la metodología descrita por Bolten (1999). Para ello se trabajó con caparazones de diferentes especies de tortugas marinas y utilizando cintas métricas de plástico flexible. Para el entrenamiento en el marcaje de tortugas marinas capturadas vivas se practicó con una pinza especial y marcas metálicas seriadas de acero inconel (Inconel 681s, fabricadas por el *National Tag and Band Co.*), colocando la marca en la pinza y presionando sobre una superficie de cartón, verificando en todos los casos que la marca quedara adecuadamente cerrada y colocada correctamente en su posición. Para complementar dicho entrenamiento se proveyó de fotografías y esquemas de tortugas marcadas. Con el fin de realizar estudios genéticos de las tortugas marinas capturadas se entrenó a los pescadores en la colecta de muestras de tejidos. En el caso de tortugas muertas, se les entrenó para realizar una colecta de músculo de tamaño adecuado y en el caso de las tortugas vivas, se les indicó cómo extraer una pequeña muestra de piel del individuo sin ocasionarle una herida grave, utilizando para tal caso pinzas especiales y bisturí. También fueron utilizadas fotografías y videos que mostraban la extracción para ayudar a una mejor comprensión de la metodología. Se les indicó también que las muestras inmediatamente después de ser extraídas debían ser conservadas en etanol al 70%.

Paralelamente al entrenamiento en la colecta de datos biológicos, se desarrollaron talleres para mejorar las técnicas de reanimación de tortugas en estado comatoso o ahogadas. Se estableció un protocolo de reanimación con los aportes de los pescadores y veterinarios del proyecto Karumbé. El mismo consistía en dejar a la tortuga en reposo varias horas (6 a 8) hasta que diera señales de recuperación (por ej. reflejo ocular o retracción de la cola). La tortuga era colocada en un lugar del barco donde no interfiriera con la maniobra, inclinada unos 45º con la boca hacia abajo para que pudiera soltar el agua de sus pulmones y se le cubría con un paño húmedo sobre el caparazón para mantener su humedad y temperatura. Si al cabo de 6 u 8 horas la tortuga no daba ninguna señal de recuperación, se daba por muerta. En algunos casos se mantenía hasta 24 horas en la cubierta para comprobar si realmente estaba muerta (Figura 3).

Colecta de datos de pesca

El entrenamiento en la colecta de datos de pesca consistió principalmente en trasmitirles a los pescadores la importancia y necesidad de registrar los datos básicos para luego poder analizar las capturas. Se les explicó por qué era importante registrar el nº de lance en que fue capturada la tortuga, la fecha de captura y la hora en que se trabajó la tortuga, la posición geográfica (coordenadas) de la liberación (si estaba viva y/o marcada) o del descarte (si estaba muerta).

Fig. 2.- Tortuga cabezona *C. caretta* capturada incidentalmente con ficha de referencia, utilizada para identificar a la tortuga y validar el dato. / Loggerhead sea turtle *C. caretta* incidentally caught with reference sheet, used to identify the turtle and validate the data.

Fig. 3.- Tortuga cabezona *C. caretta* capturada incidentalmente mantenida en la cubierta del barco durante varias horas para recuperarse del estado comatoso. / Loggerhead sea turtle *C. caretta* incidentally caught maintained on ship deck to recover of comatose state.

Material para la colecta de datos

Todos los materiales necesarios para la colecta de datos fueron suministrados a los pescadores por el PROMACODA. A continuación, en la Tabla 2 se describen los materiales utilizados por los pescadores para la colecta de datos biológicos y de la pesca.

Materiales para la colecta de los datos biológicos y de la pesca
Fichas para la identificación de las especies
Estadillos para la colecta de datos biológicos y de la pesca
Fichas para el registro de fotos (fecha, hora y nº de fotos)
Cámara de fotos y rollos sin usar
Cintas métricas
Pinza de marcaje y marcas metálicas de acero Inconel (681s)
Sunchos plásticos para el marcaje de tortugas muertas
Pinzas y bisturí para colecta de tejido
Botes de plástico con tapa rosca con etanol al 70% (para conservación de muestras de músculo o piel)
Bolsas plásticas para colectas de otras muestras (contenidos estomacales, epibiontes, etc.)
Lápices, sacapuntas, gomas, rotuladores, etc.

Table 2.- Materiales entregados a los pescadores para la colecta de datos biológicos y de la pesca de las tortugas capturadas incidentalmente. / Fishermen materials used to collect biological and fishery data of the incidental captured sea turtles.

Reposición del material y recolección de los datos tomados por los pescadores en cada viaje

Para reponer el material utilizado por los pescadores en la colecta de datos y al mismo tiempo recolectar la información recabada en cada viaje, se decidió visitarlos en puerto siempre a la salida de cada viaje. Esta decisión fue tomada debida a que la mayoría de los pescadores al regresar de una marea quieren volver a sus respectivas casas y estar el mayor tiempo que puedan con sus familias. Además, en el día de salida los pescadores disponen de más tiempo para realizar esta actividad. En algunos casos particulares, las visitas fueron realizadas en sus casas.

En cada reunión con un pescador para reponer el equipo y recolectar los datos tomados durante el viaje anterior, se cotejó toda la información colectada por el mismo y se corrigieron algunos errores. También se aclararon dudas, se comentaron problemas a la hora de trabajar las tortugas y tomar los datos y siempre se buscaron soluciones en conjunto para mejorar la dinámica de la colecta de datos. Las reuniones con los pescadores sirvieron al mismo tiempo, como un taller de entrenamiento y capacitación permanente, en el que se podía observar la evolución y mejora en la calidad de los datos colectados por los pescadores.

Incorporación de nuevos pescadores al programa

Los talleres de entrenamiento continuo y las reuniones con los pescadores en el muelle y en sus barcos, sirvieron como motivación para que otros pescadores se acercaran a participar del programa. Paralelamente, los pescadores fueron motivando poco a poco a otros pescadores en sus propios barcos, en sus respectivas parejas y en otros barcos de la flota.

La metodología de entrenamiento para los nuevos integrantes del programa fue la misma desarrollada con los pescadores.

Análisis de los datos de las capturas incidentales

Se utilizaron varios criterios para validar los datos colectados por los pescadores, el primero fue revisar junto a ellos los datos colectados durante cada viaje en la reunión previa a la salida del siguiente viaje y ahí mismo corregir posibles errores o incongruencias. Luego y una vez reveladas las fotos de las tortugas capturadas, se comprobaba que en la ficha de referencia que aparecía en la foto de la tortuga coincidieran fecha y hora en que se trabajó la tortuga con la fecha y hora que estaba en la ficha de colecta de datos del mismo individuo. De este modo, cada tortuga trabajada tenía sus respectivas fotos que a su vez estaban referenciadas a la ficha de colecta de datos.

Una vez validados los datos colectados por los pescadores, se procedía al ingreso de los mismos dentro de la base de datos del PROMACODA para su posterior análisis.

Se analizó la frecuencia de especies de las tortugas capturadas incidentalmente y el rango de tallas (LCC) para cada especie. La mortalidad fue calculada para cada especie, así como también el número de tortugas marcadas. Para analizar la distribución estacional los meses fueron agrupados de la siguiente manera: enero-febrero-marzo (verano), abril-mayo-junio (otoño), julio-agosto-septiembre (invierno) y octubre-noviembre-diciembre (primavera). Todos los registros de capturas incidentales fueron ingresados en un GIS desarrollado con el software ArcGis 9.0.

RESULTADOS OBTENIDOS POR EL PROMACODA

Conocimiento básico sobre las tortugas marinas afectadas

Desde abril de 2002 a junio de 2005 participaron en el proyecto PROMACODA 10 barcos de pesca y 70 pescadores. En este período de tiempo fueron capturadas incidentalmente 138 tortugas marinas. La especie con mayor frecuencia de captura incidental fue la tortuga cabezona *C. caretta* con 99 individuos y rango de tallas de 54.5 cm – 106.5 cm LCC; seguida de la tortuga verde *C. mydas* con 21 individuos y rango de tallas de 31 cm – 71 cm LCC (Figura 4) y por último, la tortuga siete quillas *D. coriacea* con 17 individuos y rango de tallas de 127 cm – 168 cm LCC. Según estos rangos de talla, se observa la presencia de individuos inmaduros para la especie *C. mydas* y de inmaduros y adultos para las especies *C. caretta* y *D. coriacea,* dentro de la zona de pesca donde opera esta pesquería. Sólo un único ejemplar de tortuga olivácea *L. olivacea* de 61 cm LCC, fue capturado durante el período analizado. En lo que se refiere a la distribución estacional, sólo 3 capturas del total (n=138) fueron registradas en los meses de invierno, mientras que 49 capturas fueron en verano, 57 en otoño y 29 en primavera. La mortalidad alcanzó el 35,5% (n=49) y de las 89 tortugas capturadas vivas (7 reanimadas a bordo), 73 fueron marcadas (82%). Se obtuvieron 2 recapturas de juveniles de tortuga cabezona *C. caretta* dentro del área de operación de la flota y una recaptura de una hembra anidadora de la misma especie proveniente de Brasil.

En el siguiente mapa de la Figura 5, se observan las distribuciones de las capturas incidentales de tortugas marinas durante el período analizado (abril 2002 a junio 2005).

A continuación se describen otros resultados obtenidos en el PROMACODA:

• Disminución de la mortalidad post-captura gracias a un mayor cuidado de las tortugas a bordo y mejores técnicas de reanimación. Antes del PROMACODA las tortugas capturadas incidentalmente que venían en estado comatoso, eran descartadas inmediatamente al mar, lo cual puede provocarles la muerte por ahogamiento. Al tener los pescadores conciencia y saber cómo reanimar-

Fig. 4.- Juvenil de tortuga verde *C. mydas* siendo liberado por un pescador del PROMACODA luego de ser capturado incidentalmente. / Juvenile green turtle *C. mydas* being released by a PROMCADA fisherman after being incidentally captured.

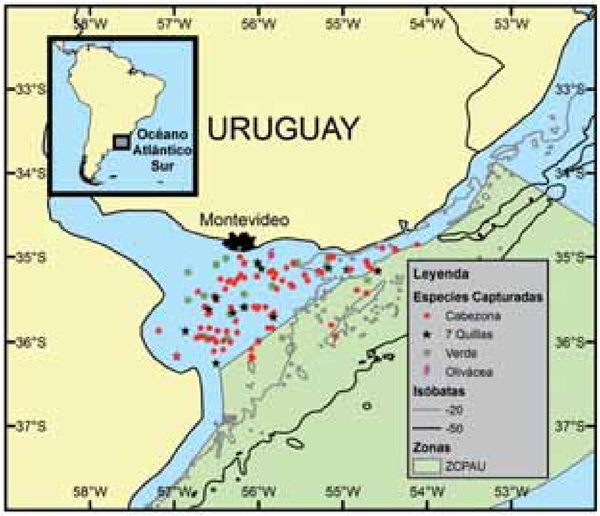

Fig. 5.- Mapa de la ZCPAU con las distribuciones de las capturas incidentales de tortugas marinas durante el período analizado (abril 2002 a junio 2005). / ZCPAU Map´s with the sea turtles incidental captures distribution occurred during the analyzed period (April 2002 to June 2005).

las, las tortugas que subieron comatosas fueron reanimadas, recuperadas y liberadas vivas al mar.

• Recuperación de tortugas muertas descartadas marcadas con identificaciones plásticas a bordo de los barcos y recapturadas en las playas por la Red de Varamientos del proyecto Karumbé (MILLER *et al.*, 2006).

• Mayor conocimiento sobre movimientos migratorios a partir de recapturas (LÓPEZ-MENDILAHARSU *et al.*, 2006) (Figura 6).

• Confirmación de la presencia ocasional de la tortuga olivácea *L. olivacea* en nuestras aguas. Identificación de haplotipos para la tortuga cabezona *C. caretta*, confirmando la costa de Bahía (Brasil) como las playas de anidación que contribuyen al stock de esta especie que utiliza las aguas costeras uruguayas (CARACCIO *et al.*, 2008). Identificación de fauna megabentónica local (nativa y exótica) y especies de peces del descarte de la pesquería de arrastre en contenidos estomacales de tortuga cabezona *C. caretta* capturadas incidentalmente (ESTRADES *et al.*, 2007).

• Revalorización de los pescadores como profesionales de la pesca y confirmación de que su rol es fundamental en la conservación de las tortugas marinas. Se presentaron trabajos y se dieron conferencias por los pescadores del PROMACODA en el Simposio Anual de Biología y Conservación de Tortugas Marinas (LAPORTA & MILLER, 2006; MILLER *et al.,* 2007; VIDAL *et al.*, 2008; LAPORTA *et al.*, 2008) y en la I, II y III Reunión de Investigación y Conservación de Tortugas Marinas del Atlántico Sur Occidental (VIDAL *et al.*, 2004).

• Mayor compromiso y participación de los pescadores en el programa e incremento de la conciencia sobre la problemática del bycatch en esta pesquería. En abril de 2002 comenzó el PROMACODA con 1 pescador, a bordo de 1 barco y con 1 tortuga trabajada. En noviembre de 2005 el PROMACODA se expandió a 70 pescadores a bordo de 12 barcos y habiendo trabajado más de 140 tortugas capturadas incidentalmente.

• Fortalecimiento de la participación de los armadores en el programa e incremento de su conciencia sobre esta problemática. Los armadores de los barcos que estaban participando del PROMACODA dieron su total apoyo al trabajo de los pescadores a bordo de los barcos y al de los investigadores en el muelle. Al mismo tiempo, facilitaron el embarque de los investigadores para trabajar juntos con los pescadores a bordo de los barcos.

• Incorporación de una nueva problemática: la captura incidental de delfín del Plata o Franciscana *Pontoporia blainvillei* (Gervais & d'Orbigny, 1844) y lobos marinos *Otaria flavescens* Shaw, 1800, lo cual dio inicio al trabajo de otros grupos de investigación en esta pesquería.

Fig. 6.- Pescador del PROMACODA verificando la presencia de una marca PIT en una tortuga siete quillas *D. coriacea.* / PROMACODA fisherman´s scanning for the presence of a PIG tag on a leatherback turtle *D. coriacea.*

DISCUSIÓN

Los resultados y productos del PROMACODA fueron posibles gracias a la filosofía y metodología de trabajo empleada, basada en:

• Un intercambio de conocimientos entre pescadores e investigadores para la generación de un conocimiento colectivo.

• Una integración y participación activa de los pescadores en el desarrollo del programa y en la toma de decisiones.

• Importancia del “sentido de pertenencia” al programa y conciencia de su aporte a la conservación de las tortugas marinas a nivel local, regional y global.

• Participación de los pescadores del programa en otras actividades de investigación y conservación del proyecto Karumbé.

• Presencia constante de los investigadores en cada salida de los barcos, en el muelle y visitando las casas de los pescadores.

La metodología de trabajo y aproximación a esta problemática del *bycatch* en este tipo de pesquería es similar a la aplicada anteriormente por ROBINS *et al.* (2002) en Australia. MARCOVALDI *et al.* (2002) y ARAUZ *et al.* (2008)

han aplicado una metodología similar para abordar esta problemática en otros tipos de pesquerías (por ej: de palangre o de arrastre con portones) y en otros países, obteniendo el mismo éxito en sus respectivos programas de conservación.

En nuestro caso, el acercarnos a los pescadores en el puerto, y a sus barcos y para hacerles saber qué estamos haciendo ahí, porque queremos trabajar con ellos y porqué necesitamos de su colaboración, fue fundamental para alcanzar el éxito del programa. La transparencia, la sinceridad, el respeto y la valoración de sus conocimientos, permitió construir confianza y que ellos creyeran en nuestro trabajo (LAPORTA & MILLER, 2005).

La motivación que tuvieron los pescadores para formar parte del PROMACODA surgió gracias al énfasis que pusimos para que se sintieran parte del equipo y en el surgimiento de una identidad colectiva vinculada directamente al PROMACODA. Otro factor de motivación, fue el hecho de compartir con ellos toda la información generada por el programa y que apreciaran la utilidad y contribución de la misma al conocimiento de la biología y conservación de las tortugas marinas.

La participación de los pescadores en el programa, no significa únicamente entrenarlos y proporcionarles equipo para tomar datos. Participación significa que los pescadores tomen parte en el desarrollo y elaboración de las herramientas y técnicas de trabajo, así como también en la toma de decisiones.

Una experiencia muy positiva para los pescadores y también para nosotros mismos, fue su participación en los congresos y reuniones, tanto internacionales como regionales sobre investigación y conservación de tortugas marinas. En estos eventos ellos pudieron dar a conocer su trabajo y que éste fuera valorado por investigadores de otros países y al mismo tiempo recibir el conocimiento y experiencias de esos investigadores, generándose así un *feedback* positivo entre ambas partes que contribuye a la conservación de las tortugas marinas.

Para acercarnos a comprender la dimensión del problema que provoca la pesca de arrastre costero uruguaya en las tortugas marinas que utilizan esta zona, es necesario, en el futuro cercano, incluir en el análisis de los datos, el esfuerzo de pesca y calcular la CPUE.

Creemos que para alcanzar el éxito de un programa de conservación es fundamental trasmitirles a los pescadores cuán esencial es su experiencia, su participación y su rol dentro del programa.

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Revisión de los conocimientos actuales sobre las tortugas marinas en el Archipiélago de Cabo Verde

Review of current knowledge about sea turtles in the Archipelago of Cape Verde

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ABSTRACT

Sea Turtles in Cape Verde were almost invisible to scientific World until the last decade. During the last 12 years, scientific studies and conservation works about the loggerhead *Caretta caretta* (Linnaeus, 1758) nesting population and other sea turtle species of Cape Verde have been conducted. Nowadays, their contribution starts to give interesting results. This article pretends to compile the most actual relevant scientific information published. Moreover, a global vision of sea turtle actual context, their conservation status and present protection in Cape Verde Archipelago are given to the reader.

KEY WORDS: Cape Verde, sea turtles, loggerhead, conservation, biology.

RESUMEN

Las tortugas marinas en Cabo Verde han sido prácticamente invisibles al mundo científico hasta esta última década. En los últimos 12 años, se han iniciado varios estudios científicos y trabajos de conservación sobre la población nidificante de tortuga boba *Caretta caretta* (Linnaeus, 1758) así como otras especies de Cabo Verde que empiezan a aportar sus primeros resultados interesantes. En este trabajo se pretende recopilar la información científica de mayor relevancia publicada hasta el momento sobre el tema. Además, se pretende dar al lector una visión global del contexto actual en el cual se encuentran las tortugas marinas en este país, su estatus de conservación y su preservación.

PALABRAS CLAVES: Cabo Verde, tortugas marinas, tortuga boba, conservación, biología.

LABURPENA

Cabo Verdeko itsas dortokak ikerketa mailan ikustezinak izan dira ia azken hamarkada honetara arte. Azken 12 urtetan, zenbait ikerketa lan eta kontserbazio ekimen ezberdin jarri dira abian benetazko dortokaren *Caretta caretta* (Linnaeus, 1758) errute populazioaren inguruan, baita beste zenbait espezieren inguruan ere. Gaur egun ikerketa lan hauen lehen emaitza esanguratsuak argitaratzen ari dira. Lan honen funtsa itsas dortoken inguruan sorturiko informazio esanguratsuena biltzea eta irakurleari itsas dortokek herrialde honetan duten kontserbazio estatusa eta kontserbazioaren ikuspegi zabal bat aurkeztea da.

GAKO-HITZAK: Cabo Verde, itsas dortokak, benetazko dortoka, kontserbazioa, biologia.

LA TORTUGAS MARINAS EN CABO VERDE

Cabo Verde es un archipiélago formado por diez islas y varios islotes de origen volcánico, situado en la región de la Macaronesia a aproximadamente 500-900 km de Senegal (15º59'45.09''N, 24º00'24.20''O) (Fig.1). Las islas del archipiélago se dividen en: las islas de Barlovento en el norte (Santo Antão, Saõ Vicente, Santa Luzia, Saõ Nicolãu, Sal y Boavista) y las islas de Sotavento en el sur (Brava, Fogo, Santiago y Maio). El clima en Cabo Verde es tropical templado, con escasas lluvias y de influencia sahariana. Las islas orientales son bastante planas y desérticas mientras que las islas occidentales tienen una orografía escarpada y más humedad y vegetación.

En el archipiélago caboverdiano se han observado 5 especies de tortugas marinas: la tortuga boba *Caretta caretta* (Linnaeus, 1758), la tortuga carey *Eretmochelys imbricata* (Linnaeus, 1766), la tortuga verde *Chelonia mydas* (Linnaeus, 1758), la tortuga olivácea *Lepidochelys olivacea* (Eschscholtz, 1829) y la tortuga laúd *Dermochelys coriacea* (Vandelli, 1761) (López-Jurado *et al.*, 2000a). Las tortu-

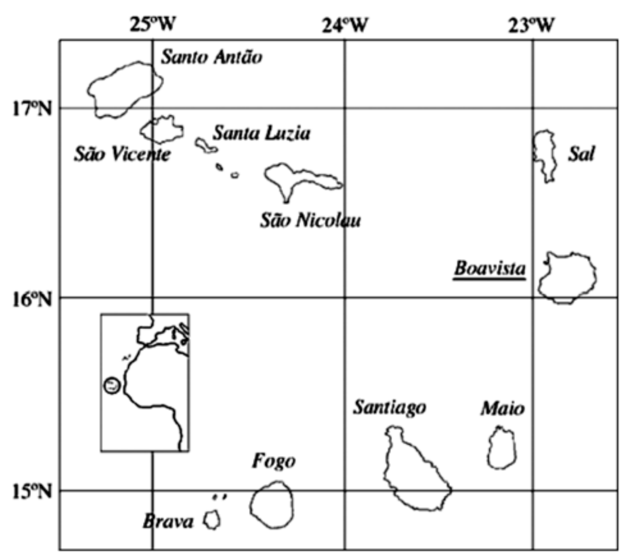

Fig. 1.- Archipiélago de Cabo Verde. / Cape Verde archipelago.

gas olivácea y laúd se encuentran de paso en aguas del archipiélago y son difíciles de observar, mientras que juveniles de las tortugas carey y verde se encuentran con frecuencia alimentándose en aguas neríticas. La tortuga boba es la más abundante, y es sin duda la tortuga caboverdiana por excelencia, ya que encuentra en las playas de Cabo Verde su lugar de reproducción. Machos y hembras se pueden ver copulando en aguas cercanas a la costa a partir de abril-mayo, justo antes de la época de anidación (junio-octubre); y la emergencia de las crías ocurre desde finales de agosto hasta diciembre. Ha sido en esta última década cuando se han empezado a realizar estudios científicos para conocer la biología y estado de conservación de esta importante población nidificante. Otros trabajos científicos sobre el origen de las agregaciones de juveniles de tortuga verde y carey se han realizado recientemente. Los estudios genéticos realizados en juveniles de tortuga verde presentes en el archipiélago han revelado que no pertenecen a una única población, sino a distintas poblaciones ampliamente dispersas en el Atlántico. Más de un 30% de esta agregación corresponde a tortugas nacidas en el continente americano, realizando una migración transatlántica para alcanzar Cabo Verde (MONZÓN-ARGÜELLO *et al*., 2010c). Por otro lado, los resultados genéticos del análisis de la agregación de juveniles de tortuga carey presentes en estas islas destaca la pertenencia mayoritaria a poblaciones aún no caracterizadas genéticamente y probablemente africanas (MONZÓN-ARGÜELLO *et al*., 2010b).

LA TORTUGA BOBA CABOVERDIANA

En 1999, a partir de los estudios realizados por el equipo de científicos dirigido por el Dr. Luis Felipe López-Jurado de la Universidad de Las Palmas de Gran Canaria, la población nidificante de tortuga boba de Cabo Verde se dio a conocer en el mundo científico de forma definitiva (LÓPEZ-JURADO *et al*., 2000a; LÓPEZ-JURADO *et al*., 2000b; CABRERA *et al*., 2000; CEJUDO *et al*., 2000). Antes de estos estudios, y de forma contemporánea, sólo existían notas que recogían citas de la presencia de anidación y consumo humano de tortugas marinas en el archipiélago caboverdiano (ver revisiones bibliográficas en LÓPEZ-JURADO 2007 y LOUREIRO & TORRÃO 2008; y LAZAR & HOLCER en 1998). En siglos anteriores, los únicos registros de tortugas marinas en el archipiélago aparecían como descripciones biogeográficas históricas poco precisas en los libros de viajes de los descubridores del archipiélago caboverdiano desde el siglo XV al XIX (ver revisión en LÓPEZ-JURADO 2007 y LOUREIRO & TORRÃO 2008).

Actualmente, la población nidificante de tortuga boba de Cabo Verde está considerada como la segunda población más abundante del Atlántico y la tercera a nivel mundial para la especie después de las de Florida y Omán (LÓPEZ-JURADO *et al.,* 2007) (Fig. 2). Además, está catalogada como una de las 11 poblaciones reproductoras de tortugas marinas más amenazadas del planeta (WALLACE *et al*., 2011). La presencia de tortuga boba se ha corroborado en todas las islas y algu-

Fig. 2.- Hembra reproductora de tortuga boba *C. caretta* de Cabo Verde (Isla de Boavista). Fotografía: Manu Océn. / Breeding female loggerhead *C. caretta* Cape Verde (Boavista Island). Photography: Manu Océn.

nos islotes del archipiélago, pero con una abundancia muy diferente. En torno al 90% de la anidación que existe se encuentra concentrada en la isla más oriental, Boavista, donde se estima una abundancia entre 2007 y 2009 de entre 12.000 y 21.000 nidos anuales (Marco *et al.*, 2010a; Marco *et al.*, 2010b; Marco *et al.*, 2012). Las islas de Maio, Sal y São Nicolau albergan un número mucho menor de nidos, con alrededor de un máximo de 300-1000 nidos anuales por isla (Lino *et al.*, 2010; Cozens, 2009). En el resto de islas del archipiélago, la anidación es muy inferior y se estima menor a 150 nidos anuales por isla (Loureiro, com. pers.).

La tortuga boba de Cabo Verde tiene una estructura genética distinta respecto al resto de poblaciones de tortuga boba del Atlántico y Mediterráneo, lo que indica un aislamiento reproductor importante con un escaso flujo genético, Monzón-Argüello *et al.* (2010a). El análisis filogeográfico muestra que la población de tortuga boba de Cabo Verde es más próxima a las poblaciones del Noreste de Florida a Norte de Carolina y Brasil (Monzón-Argüello *et al.*, 2010a).

A pesar de que algunas tortugas presentan una alta fidelidad al lugar de desove (con reanidaciones frecuentes en la misma playa en la misma o diferente temporada), hay tortugas que han sido vistas realizando dos nidos consecutivos en distintas islas separadas más de 70 km de distancia y por aguas de más de 1.000 metros de profundidad dentro de una misma temporada de anidación (Abella *et al.*, 2010b). Estas observaciones son consistentes con los resultados genéticos encontrados al realizar análisis de estructura poblacional dentro del archipiélago por Monzón-Argüello *et al.* (2010a), en los cuales no se observan diferencias genéticas entre madres reproductoras de distintas islas. Existe una gran plasticidad en la dispersión de la anidación y el flujo de hembras entre islas existe, y por lo tanto genéticamente se puede considerar a todo el archipiélago caboverdiano como una única unidad de conservación. Sin embargo, a pesar de su aislamiento geográfico y reproductor, existe un alto nivel relativo de variabilidad genética de la población.

Mediante los análisis de marcadores moleculares de microsatélites, se ha podido valorar el nivel de multipaternidad de esta población de *C. caretta*. Se ha encontrado en Boavista la mayor tasa de multipaternidad conocida hasta la fecha en esta especie. En el estudio realizado por Sanz *et al.*, en 2008, el 66.7% de los nidos que se analizaron estaban fecundados por más de un padre. El número medio de padres por nido encontrado es de 2,2; y en el 70% de los nidos que presentaron multipaternidad, un solo macho fertiliza a más de la mitad de las crías. Estos resultados sugieren que la población de machos adultos es abundante, a pesar de la persecución a la que están sometidos por los cazadores furtivos (algunas partes de su cuerpo son consideradas supuestamente afrodisíacas).

Sin embargo, el estado de conservación de la población de la tortuga boba caboverdiana es delicado. En Cabo Verde la captura y consumo de carne de tortuga es una práctica tradicional extendida, junto con el consumo ocasional de huevos, la caza de machos en busca de afrodisíacos y el uso de caparazones para artesanía (Cabrera *et al.*, 2000; Loureiro & Torrão, 2008). A pesar de que el gobierno caboverdiano intentó regular la caza de tortugas marinas durante la época de desove en 1987 (Decreto 97/87), y posteriormente en el año 2002, se prohibió la caza durante todo el año (Decreto Nº7/2002); en Cabo Verde la posesión, caza, consumo y explotación de las tortugas no fue explícitamente perseguida por la ley caboverdiana hasta el 2005 (artículo 40 del Decreto 53/2005). Esto ha favorecido el declive de las tortugas en el archipiélago caboverdiano durante décadas (Cabrera *et al.*, 2000; Loureiro & Torrão, 2008); pero en los últimos daños, un desarrollo turístico costero no planificado y no respetuoso con el medio ambiente, amenaza su hábitat de anidación. Además, el dramático declive de la anidación en otras islas, el uso generalizado de vehículos todo terreno y la llegada de multitud de trabajadores del continente para las obras de nuevos hoteles con sueldos muy bajos, ha acentuado la presión de caza sobre las tortugas durante su desove en los últimos años. La crítica situación alcanzada en 2007 a causa de la descontrolada matanza ilegal de hembras en playa (Marco *et al.*, 2010a; Marco *et al.*, 2012), promovió un mayor compromiso e implicación por parte de organizaciones nacionales, regionales e internacionales para la conservación de las tortugas marinas en el archipiélago. El esfuerzo de protección y sensibilización de los últimos tres años parece estar dando algunos frutos incipientes, pero hay que incrementar las iniciativas de protección y cooperación al desarrollo sostenible de la población para garantizar la supervivencia de esta población atlántica tan emblemática.

La tortuga boba caboverdiana presenta una característica particular al compararla con otras poblaciones de la misma especie. Mientras que lo habitual es la anidación dispersa en miles de kilómetros de litoral (Florida, Caribe, Golfo de México, Brasil, Mediterráneo oriental), la gran mayoría de la anidación de esta población en todo el Atlántico oriental se encuentra concentrada en pocos kilómetros de playa (40 km aproximadamente). Diez kilómetros de playa en el sureste de la isla albergan el 60 % de la anidación de toda la isla y posiblemente contengan la mayor densidad de anidación para la especie a nivel mundial, con más de 1,6 nidos por metro lineal de playa en tramos de más de 800 metros. Este hecho hace que estas playas de anidación tengan una enorme fragilidad ante cualquier desastre natural (marea negra, tormentas tropicales, etc.), o impacto artificial (urbanización, infraestructuras lineales, iluminación artificial, ocupación turística masiva) poniendo en peligro la supervivencia de la población y la especie.

En cuanto a su biología reproductiva, la tortuga boba caboverdiana es singular por tener un tamaño pequeño de reproducción. La media anual del largo curvo del caparazón de las hembras nidificantes está en torno a los 82 cm (Rango: 70-106 cm; Ballell-Valls & López-Jurado, 2004; Varo-Cruz *et al.*, 2007). Este tamaño es sutilmente mayor al encontrado en poblaciones de tortuga boba mediterránea (Grecia, Turquía y Chipre), que posee el mínimo tamaño reproductor encontrado para la especie (ver revisión en BALLELL-VALLS & LÓPEZ-JURADO, 2004). La profundidad media de los nidos está en torno a los 48 cm (Rango: 29-96 cm; VARO-CRUZ *et al.*, 2007; MARTINS *et al.*, 2008). La tasa de fertilidad encontrada en los nidos fue del 93,8% (Rango: 75%-100%; ABELLA *et al.*, 2006). El éxito de puesta (número de nidos respecto al número total de rastros) en las playas de anidación de mayor relevancia es variable entre playas, pero anualmente está comprendido entre un 26% y 44% (DÍAZ-MERRY & LÓPEZ-JURADO, 2004; LÓPEZ *et al.*, 2003; VARO-CRUZ *et al.*, 2007), y la media anual del tamaño de puesta varía entre años en torno los 84 huevos (Rango: 24-143; LOZANO-FERNANDEZ & LÓPEZ-JURADO, 2004; VARO-CRUZ *et al.*, 2007). El tiempo de incubación de los nidos oscila entre los 45 y 74 días de incubación (VARO-CRUZ *et al.*, 2007), según la playa, época del año o temporada de anidación. La media del éxito de emergencia anual de los nidos naturales en las principales playas de anidación está alrededor del 40%, aunque el éxito de emergencia puede variar del 0% a más del 90% según el lugar de ubicación del nido (GARCIA-CARCEL & LÓPEZ-JURADO, 2004; DEL-ORDI *et al.*, 2003; VARO-CRUZ *et al.*, 2007). Este dato es relativamente bajo comparado con los encontrados en otras poblaciones de tortuga boba del mundo (ver revisión en GARCIA-CARCEL & LÓPEZ-JURADO, 2004). Las principales causas de este bajo éxito de emergencia natural de los nidos son: la depredación de huevos por el cangrejo fantasma *Ocypode cursor* (Linnaeus, 1758) (DA-GRAÇA *et al.*, 2010) (Fig. 3 y 4), la inundación de nidos por la marea, y el alto contenido en arcilla que se encuentran en algunos sustratos de incubación (MARCO *et al.*, 2008). En el trabajo de DA GRAÇA *et al.* (2010) se recoge que la tasa de depredación de nidos por cangrejos puede ser superior a un 67%, aunque el cangrejo causa en torno a una media del 50% de mortalidad. En las playas principales de anidación, la fauna terrestre es escasa y prácticamente no existen mamíferos depredadores de huevos, no obstante es posible ver algún gato o perro salvaje. Si bien el cangrejo fantasma es el depredador principal de huevos, otros depredadores secundarios como los cuervos aprovechan las destrucciones ocasionadas en los nidos por los cangrejos para alimentarse de ellos. Por otra parte, en los nidos de tortuga de Cabo Verde se ha identificado colonias del hongo, *Fusarium solani* (Mart.) Saccardo (1881) que en determinadas situaciones puede actuar como patógeno (MARCO *et al.*, 2006; ABELLA *et al.*, 2010a). Una vez nacen las crías, cangrejos fantasma y cuervos también son los principales depredadores terrestres de neonatos, aunque en ocasiones también se ven gatos salvajes rondando los nidos.

Fig. 3.- Nido depredado por el cangrejo fantasma *Ocypode cursor* (Linnaeus, 1758). Fotografía: Manu Océn. / Nest predated by the ghost crab *Ocypode cursor* (Linnaeus, 1758). Photography: Manu Océn.

Fig. 4.- Cangrejo fantasma *Ocypode cursor*. Fotografía: Manu Océn. / Ghost Crab *Ocypode cursor*. Photography: Manu Océn.

La temperatura de incubación de los nidos es variable según los años, la época de incubación dentro de una misma temporada de anidación y el lugar de puesta. Pero la temperatura media anual de la arena a 45 cm de profundidad está comprendida entre un rango de 26,5ºC a 30,6ºC (Abella *et al*., 2007; Abella *et al*., 2008). Según la media de la temperatura de incubación durante el periodo de determinación sexual de la especie (segundo tercio de incubación), se estima que la razón de sexos que se produce en las principales playas de anidación de esta población es de un 71,9% sesgado hacia las hembras (Abella *et al*., 2007). Delgado *et al.* (2007) encontró resultados muy similares al realizar análisis histológicos a partir de crías muertas encontradas en playa. Estos datos indican que a pesar de tener una alta producción de hembras, se produce un número considerable de machos en relación a otras poblaciones atlánticas estudiadas de la misma especie, donde se estima que el porcentaje de crías hembra que nacen es aproximadamente del 90%.

Se han identificado juveniles de tortuga boba de Cabo Verde en áreas de alimentación de Canarias, Madeira, Azores y Mediterráneo occidental (Monzón-Argüello *et al*., 2009). Su presencia en estas zonas de alimentación es compartida con juveniles de la misma especie de otras poblaciones atlánticas y/o mediterráneas. A pesar de que la dispersión de los juveniles de Cabo Verde hacia el norte es clara, en el trabajo realizado por Monzón-Argüello *et al.* (2010a) se concluye que aproximadamente un 43% de los juveniles caboverdianos permanecen todavía sin asignar a zonas de alimentación conocidas. Recientemente, en aguas de Brasil, en un área cercana a la costa de Ceará, se ha encontrado un ejemplar juvenil que presenta un haplotipo identificado únicamente hasta día de hoy en Cabo Verde (Cardinot-Reis *et al*., 2009), siendo probable que este individuo sea caboverdiano. Esto indica que es necesario realizar estudios genéticos en otras zonas de alimentación del Atlántico oeste, y/o que todavía existen zonas de alimentación de juveniles para tortuga boba por descubrir. No se descarta que una parte importante de la dispersión juvenil de esta población sea hacia aguas americanas y/o también hacia el sur, hacia aguas cercanas al Golfo de Guinea.

Las hembras adultas encuentran en aguas de la costa atlántica africana su área de alimentación. Gracias a los datos obtenidos a través del seguimiento por satélite de ejemplares adultos, sabemos que las hembras, y posiblemente también los machos (Cejudo *et al*., 2007), se desplazan cerca de las costas comprendidas entre Mauritania y Sierra Leona para alimentarse durante épocas no reproductivas, periodos entre temporadas de anidación (Hawkes *et al*., 2006). Además, se ha observado una dicotomía en el comportamiento migratorio de las hembras. Individuos de mayor tamaño migran al sur a zonas de alimentación bentónicas de la costa de Guinea y Sierra Leona, mientras que hembras de talla pequeña se desplazan hacia el norte a aguas oceánicas más al norte desde Mauritania a Guinea Bissau (HAWKES *et al.*, 2006).

Los epibiontes de las tortugas marinas han sido propuestos como indicadores biogeográficos. Según la ruta migratoria que siguen las tortugas, las especies de organismos que se adhieren a ellas estarán relacionados con los hábitats marinos o terrestres que éstas frecuenten. En las hembras nidificantes de la tortuga boba caboverdiana se han identificado las siguientes especies: de la flora epizoica, el género más importante encontrado es el *Polysiphonia*; y de la fauna, el grupo más abundante es el de los crustáceos, del cual se han encontrado dos especies de cirrípedos, *Lepas anatifera* Linnaeus, 1758 y *Conchoderma virgatum* Spengler, 1789, una especie de balano, *Chelonibia testudinaria* (Linnaeus, 1758), muchos organismos del orden Amphipoda (Caprellidae, Gammaridae), un importante número de Isopódos y también representantes del orden Tanaidacea (LOZA & LÓPEZ-JURADO, 2008). Otro grupo epizoico encontrado es el Hydroidea, representado por *Obelia geniculata* (Linnaeus, 1758) (LOZA & LÓPEZ-JURADO, 2008).

A día de hoy, los 20 km de playa de mayor densidad de anidación del archipiélago (donde anida aproximadamente un 75% de la población total de tortuga boba caboverdiana), está protegida por la ONG caboverdiana Cabo Verde Natura 2000, formada por miembros caboverdianos y españoles. Desde 1998, esta ONG junto con la Dirección General de Ambiente de Cabo Verde, la Universidad de Cabo Verde, la Cámara Municipal de Boavista, el Gobierno de Canarias, el Cabildo de Fuerteventura, el Instituto Canario de Ciencias Marinas, la Universidad de Las Palmas de Gran Canaria, la Junta de Andalucía y la Estación Biológica de Doñana (CSIC), vienen desempeñado arduos trabajos de conservación e investigación de las tortugas marinas en la isla de Boavista. Se han desarrollado programas de voluntariado internacionales para la protección y estudio científico de las tortugas marinas (campamentos de trabajo), que además funcionan como centros de formación para el manejo de las tortugas marinas de estudiantes caboverdianos y europeos, así como centros de educación y sensibilización ambiental (principalmente dirigidos a la población local). A nivel gubernamental, la ONG Cabo Verde Natura 2000 (Fig. 5) ha ejercido un papel determinante como asesor e impulsor para la elaboración e implementación de leyes y planes ambientales para la conservación no sólo de las tortugas marinas, sino de toda la biodiversidad caboverdiana. En las playas protegidas por la ONG Cabo Verde Natura 2000, hasta la temporada de anidación de 2009 se han marcado e identificado más de 8000 hembras adultas. Se patrullan las playas por la noche para proteger a las hembras de los cazadores furtivos, con una tasa de mortalidad de hembras cazadas menor de un 1% en las playas protegidas. Diariamente se realizan conteos de nidos en toda la zona de estudio y controles de nidos naturales en playa, para obtener un mejor conocimiento de la especie y su estado de conservación. El rescate de hembras adultas perdidas al amanecer ha permitido salvar más de 70 hembras reproductoras por temporada. Además, en los últimos 5 años, se ha establecido un vivero de tortugas marinas que actualmente tiene una capacidad total de 700 nidos. Desde el inicio del programa de traslocación de nidos a vivero, han sido liberadas más de 90.500 crías al mar.

Fig. 5.- Trabajos de conservación realizados por la ONG Cabo Verde Natura 2000 en las playas con mayor anidación del archipiélago caboverdiano. Isla de Boavista. Fotografía: Manu Océn. Conservation work carried out by the NGO Cabo Verde Natura 2000 in the largest nesting beaches of Cape Verde archipelago. Boavista Island. Photography: Manu Océn.

Estos programas de conservación de las tortugas marinas llevan implícitos acciones sociales en el país, como la participación de jóvenes estudiantes universitarios caboverdianos (participación anual de 30-40 estudiantes) para la formación y desarrollo de actividades ambientales en su país, como el ecoturismo o vigilancia ambiental. La realización de actividades de sensibilización y educación ambiental dirigidas a la población local se desarrollan con visitas de niños, jóvenes y adultos a los campamentos de conservación de las tortugas, y otros actos sociales como charlas, exposiciones, encuentros, etc. en los poblados (Espírito-Santo *et al.*, 2010). Otros proyectos de cooperación internacional han sido posibles gracias a las labores de conservación de las tortugas marinas (reconstrucción de escuelas, mejora de la producción caprina, obtención de un camión cuba para el abastecimiento de agua a la población local, etc.).

Fig. 6.- Actividades de sensibilización a la población local realizadas por la ONG Cabo Verde Natura 2000. Isla de Boavista. Fotografía: Manu Océn. / Awareness raising local people carried out by the NGOs Cape Verde Natura 2000. Boavista Island. Photography: Manu Océn.

A partir de 2008, otras organizaciones internacionales se han instalado en Cabo Verde para desarrollar programas de conservación de las tortugas marinas en otras zonas de anidación del archipiélago (Roder, 2009; Cozens, 2009). Confiamos que con el esfuerzo de todos, la participación cada vez más activa de las comunidades locales (Fig. 6 y 7), el aumento de la cooperación internacional y la suma de multitud de ayudas solidarias, la recuperación de las tortugas marinas en Cabo Verde sea una realidad en los próximos años.

Fig. 7.- Zona de reubicación de nidos. Fotografía: Manu Océn. / Nest relocation area. Photography: Manu Océn.

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Habitat alteration and mortality of adult leatherback turtles in Gabon, Central Africa

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ABSTRACT

The Republic of Gabon (Central Africa) hosts the largest nesting aggregation in the world for the leatherback turtle *Dermochelys coriacea* (Vandelli, 1761) with the Guianas in South America. A research on its reproductive ecology was carried out during three consecutive seasons (2005/2008) at the beach of Kingere in Pongara National Park. This is a wild beach where no previous studies had been undertaken before and one of the main objectives was to determine the main threats to the species at the site. We found that there can be a considerable mortality of adult females caused by the many stranded logs (or lost timber) on the beach. The position of the logs constitutes sometimes a lethal trap for nesting leatherbacks that die from the shock or dehydration without being able to return to the sea. During the course of 2006/2007, local NGO staff performed more than 30 rescue operations allowing trapped females to return alive to the sea. This is certainly one of the major environmental problems on the coast of Gabon not only in terms of habitat alteration but also for the conservation of *Dermochelys coriacea*.

KEY WORDS: Gabon, Leatherback, Pongara National Park, Kingere, nesting beach, stranded logs, *Dermochelys coriacea*, sea turtle conservation.

RESUMEN

La República de Gabón alberga uno de los puntos más importantes en todo el mundo para la anidación de la tortuga laúd, *Dermochelys coriacea* (Vandelli, 1761). Entre los años 2005 y 2008, se llevó a cabo un estudio sobre el estado de conservación de esta especie en una playa hasta ahora desconocida para la comunidad científica, dentro del Parque Nacional de Pongara. Uno de los hallazgos más destacados fue la alta mortalidad de hembras adultas debido a los troncos varados en la playa. Estos troncos, de enormes dimensiones, proceden de la industria maderera y constituyen una trampa mortal para las hembras anidantes. Durante la temporada 2006/2007, se llevaron a cabo cerca de 30 operaciones de rescate a cargo de los guardas locales del Parque Nacional , permitiendo devolver a las hembras con vida al mar. Este es un problema medioambiental grave, que afecta no sólo a las tortugas marinas, sino también al hábitat costero en general.

PALABRAS CLAVES: Gabon, laúd, Pongara National Park, Kingere, playa de anidación, troncos varados, *Dermochelys coriacea*, conservación de tortugas marinas.

LABURPENA

Gaboneko Errepublika mundo mailan *Dermochelys coriacea* (Vandelli, 1761), larruzko dortokaren errute hondartza gune garrantzitsuenetako bat da. 2005-2008 urte bitartean, espeziearen kontserbazio egoeraren inguruko ikerketa bat burutu zen, komunitate zientifikoak orain arte ezagutzen ez zuen Pongara Parke Nazionaleko hondartza batean. Aurkikuntza adierazgarrienetariko bat, errutera irteten ziren emeen heriotze tasa altua izan zen, hondartzaratuta zeuden enborretan kateatuak geratzen bait ziren. Enbor ikaragarri hauen jatorria, egur-industria da eta tranpa hilkorra bertan erruten duten emeentzat. 2006/2007 denboraldian, 30 erreskate ekimen burutu zituzten Parke Nazionaleko zaindariek. Hau ingurugiro arazo larria da eta itsas dortokei ez ezik kostaldeko habitatari ere erasaten dio oro har.

GAKO-HITZAK: Gabon, larruzko dortoka, Pongara National Park, Kingere, errute hondartza, hondartzaratutako enborrak, *Dermochelys coriacea*, itsas dortoken kontserbazioa.

INTRODUCTION

Along with the Guianas, the Republic of Gabon (Central Africa) hosts the largest nesting aggregation in the world for the leatherback turtle *Dermochelys coriacea* (Vandelli, 1761) (Witt *et al.*, 2009), yet there is still a paucity of detailed knowledge of many key aspects about reproductive ecology at the site (Fretey *et al.,* 2007). Pongara National Park is one of the main protected areas along the coast. The beach of Kingere, with an estimated 170 to 450 nests per kilometer, remains almost virgin and can be considered as a hotspot for this species in Gabon (Ikaran, 2010). From 2005 to 2008, a study on the nesting ecology of *D. coriacea* was conducted at Kingere so as to determine and quantify the main natural and/or anthropogenic threats to the species at the different life-stages.

Fig. 1.- (a) Location of the country of Gabon in Central Africa (in red) and (b) the 13 National Parks in Gabon, including Pongara, the study site.

METHODS

The research was carried out at the beach of Kingere in Pongara National Park (0º18´N, 9º18´E; Fig.1) during 3 consecutive seasons (2005/2008). The nesting season for the leatherback in Gabon spreads from November to march, with a peak of activity during December and January. Local NGO *Gabon Environnement* provided logistic support at a beach-based research camp. Basic monitoring activities included night patrols for female identification and *in situ* nest marking as well as early morning track counts. These were carried out by local guards of the NGO and the National Park that had been specifically trained in marine turtle manipulation techniques.

RESULTS

We identified an unusual source of adult female mortality at the beach of Kingere caused by the high incidence of stranded logs originated from timberland activities. The logs were positioned in such a way that they constituted lethal traps for the females, that get caught in between them and cannot go back to the sea. If rescue operations by the local guards were not performed in time, females would die from dehydration or the shock. During the month of November 2006, we counted 15 dead females at Kingere among the logs (Fig. 2). This happened because the guards were not on duty yet. Once the monitoring activities started, we performed 28 rescue operations during the rest

Fig. 2.- (a, b, c, d) Dead females among stranded logs.

of season 2006/2007. These were sometimes complicated, due to the weight of the female and the position in which the female was usually found. The best technique to release the female, was by passing harnesses below the armpit; two people pulled the female this way, while a 3rd or 4th person would push forward from the back (Figure 3). The female should not be pulled by the caudal projection, as this is a very fragile part of the body. Sometimes females had to be pushed until they reached the sea, because they were already very debilitated and not able to crawl on the sand. However, the contact with seawater seemed to reanimate them as they instantly started to swim offshore. Some females, would also get injured by the logs (Figure 4), as these have oxidized metal rings attached. We were able to identify such scars in the head, flippers and carapace of several nesting females.

Fig. 3.- (a, b) Rescue operations: the technique of passing harnesses or pulling from below the armpits.

Fig. 3.- (c, d, e) Rescue operations: sequence of the release of a female that was trapped among the logs.

Fig. 4.- Female showing injuries in the head due to the oxidized metal rings.

DISCUSSION

The high incidence of logs at the beach of Kingere was found to be a major hazard to nesting females and is probably one of the major environmental threats to the coastal area in general. During this study, we also found that there is an equal or even higher amount of buried logs beneath the sand (IKARAN, 2010). Hence, the visible stranded logs might be only the tip of the iceberg of the problem. Buried logs slowly decompose and represent a source of organic material as well as an attraction point for invertebrates and microorganisms, that might be negatively affecting the incubation of nests (IKARAN, 2010).

The logs are originated from inland timberland activities (LAURENCE *et al*., 2008). Harvested logs are transported via rivers on barges or cabled together into floating rafts to open sea and then the major ports (see references in LAURENCE *et al*., 2008). During transport, some of these logs, that can measure up to 15 m in length and 120 cm diameter, might be accidentally or intentionally (because being defective) lost and end up on the stranded on the coast. LAURENCE *et al.* (2008) quantified the occurrence of logs all over the coast of Gabon and confirmed the magnitude of this problem not only as a threat to sea turtles but also as an economic waste. The incidence of logs seems to be particularly high at Pongara, blocking up to 30% of the beach at some critical points.

This problem has a difficult solution because of legal and logistic conditions. First, it is not possible, by law, to exploit *in situ* this wood because, the logs are already owned by the forestry companies. Second, the removal of logs would only be possible with heavy machinery and this would cause a negative impact on the coastal habitat. Considering that the presence of logs is generalised all along the coast of Gabon and probably the neighbouring countries (LAURENCE *et al*., 2008), the numbers of dead adult females every season may reach alarming numbers at a regional scale. A similar mortality has been described in the Guianas, where nesting females can get trapped in between the logs originated from the mangroves behind the beaches (FRETEY, 1977; FRETEY, 1981). In this case, however, this is due to natural coastal dynamics processes during which mangroves are eroded away by the sea (Jacques Fretey, pers. comm.).

As far as management and conservation are concerned, rescue operations alone justify by far the need of regular surveillance of the beach by local guards, because it implies saving adult females. These should be maintained and extended to neighbouring beaches until the problem of logs is solved.

CONCLUSIONS

The high incidence of stranded logs on the beach is the main threat to *D. coriacea* and has an anthropogenic origin.

By patrolling the beaches regularly, the staff from local NGOs, can save substantial numbers of females every season. Female rescue operations alone are well worth the cost of running a conservation project because it implies saving adult individuals that have a higher reproductive value than eggs.

The problem of logs should be considered from two perspectives; the first one involving the elimination of the existing logs on the beaches and the second one involving the eradication of the source of the problem.

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The Renatura sea turtle conservation program in Congo

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ABSTRACT

Renatura, is a non profit organization protecting and studying sea turtles in Congo-Brazzaville. Congo waters host five species of sea turtles. The leatherback turtle and the olive ridley turtle come to nest on Congo beaches from September to April. Juvenile Green turtles and Hawksbill turtles are also feeding and growing nearshore. Main threats weighing on sea turtles in Congo are i) egg harvesting and female poaching, ii) by-catch in both traditional and industrial fishing gears, iii) erosion of beaches, iv) urban/industrial development of the coastline. To fight against these threats, Renatura has developed a nest monitoring program and a by-catch release program. More than 1,500 sea turtles incidentally caught in traditional fishing nets are released every year. To find a reliable solution on the long term, a study is in progress to design fishing gears and practices able to reduce the by-catch risk. Nest monitoring and release programs did not improve the trends of sea turtles populations in Congo. Eight years of follow-up shows a dramatic decrease of leatherback and olive ridley nesting activities on the Congo's beaches. To try to improve this situation, a new program has been launched in 2010 to address by-catches in industrial fishing nests.

KEY WORDS: Sea turtles, Republic of Congo, *Dermochelys coriacea, Lepidochelys olivacea, Chelonia mydas, Eretmochelys imbricata*, bycatch, Renatura, wildlife conservation.

RESUMEN

Renatura es una organización sin ánimo de lucro para la protección y el estudio de tortugas marinas en Congo-Brazzaville. Las aguas congoleñas albergan cinco especies de tortugas marinas. La tortuga laúd y la tortuga olivácea anidan en las playas de Congo entre septiembre y abril. Los juveniles de tortugas verde y carey se alimentan y crecen también en las aguas costeras. Los peligros que acechan a estas especies en esta zona son: el saqueo de nidos y robo de huevos, la captura accidental tanto en la pesca artesanal como en la industrial, la erosión de las playas de anidación y la construcción desmesurada, tanto industrial como urbana, en el litoral. Para hacer frente a estos peligros, Renatura ha puesto en marcha diversos mecanismos, como el programa de monitoreo de anidación y también el programa de liberación de las capturas accidentales. Más de 1500 tortugas son liberadas cada año, con la ayuda de los pescadores artesanales que participan en el programa de liberación de las capturas accidentales. Para encontrar una solución definitiva al problema, se está llevando a cabo un estudio sobre aparejos y prácticas pesqueras que reduzcan el riesgo de captura accidental. Los programas puestos en marcha en Congo, tanto el monitoreo de nidos como el de liberación de las capturas, no han mejorado la tendencia de las poblaciones de tortugas marinas en Congo. El seguimiento de los últimos ocho años indica un decrecimiento dramático de la anidación de laúdes y loras en estas playas. Para intentar mejorar esta situación acaba de ponerse en marcha en 2010 un nuevo programa para disminuir la captura accidental en la pesquería industrial.

PALABRAS CLAVES: Tortugas marinas, República del Congo, *Dermochelys coriacea, Lepidochelys olivacea, Chelonia mydas, Eretmochelys imbricata,* captura accidental, Renatura, conservación de vida silvestre.

LABURPENA

Renatura, itsas dortoken ikerketa eta babeserako Kongo-Brazzavillen sortutako irabazi gabeko elkartea da. Kongoko itsas eremuak, bost itsas dortoka espezie ezberdinei egiten die harrera, hauetako bik bertan dituzte errute hondartzak: larruzko dortoka eta oliba dortokak Iraila eta Apirila bitartean hain zuzen ere. Bestalde, karei eta dortoka berde gazteak kostako uretan elikatu eta hazten dira. Inguru honetan espezie guzti hauek pairatzen dituzten arriskuak asko dira: habien arrapaketa eta arraultzen lapurreta, arrantza artisauaren baita industrialaren harrapaketa akzidentala, errute hondartzen higadura eta itsas bazterrean osoan zehar ematen ari den neurriz kanpoko erainkuntza bai industrial baita urbanoa ere. Arrisku hauei aurre egin ahal izateko, Renaturak zenbait egitasmo jarri ditu abian, hala nola: errute garaiko monitoreo programa, baita dortoken arrantza akzidentalean eroritako aleen askapenak. Azken honetan urtero urtero 1500 dortoka baino gehiago askatzen dira arrantza tradizionalean jarduten diren arrantzaleen laguntzaz. Arazo honi behin betiko konponbidea emateko, arrantza teknika aparailuak eta praktikak ikertzen hasiak dira.

GAKO-HITZAK: Itsas dortokak, Kongoko Errepublika, *Dermochelys coriacea, Lepidochelys olivacea, Chelonia mydas, Eretmochelys imbricata*, arrantza akzidentala, Renatura, basa bizitzaren kontserbazioa.

INTRODUCTION

Renatura is a NGO that was created in France in 2001 and in 2005 in the Republic of Congo (Congo-Brazzaville, hereafter Congo). Renatura's main goal is sea turtle conservation. It promotes sea turtle protection and research, through local sustainable development in Congo.

The Republic of Congo is a country in Central Africa, surrounded by Gabon, Cameroon, the Central African Republic, the Democratic Republic of Congo (DRC) and Angola. The Congolese coastline stretches for 170 km and its waters host five species of sea turtles. Two sea turtle species nest regularly on Congo's beaches: the leatherback *Dermochelys coriacea* (Vandelli, 1761) and the olive ridley *Lepidochelys olivacea* (Eschscholtz, 1829). Thousands of green turtles *Chelonia mydas* (Linnaeus, 1758) - mainly juveniles and subadults - are present at sea, as well as hundreds of hawksbill turtles *Eretmochelys imbricata* (Linnaeus, 1766) and some occasional loggerheads *Caretta caretta* (Linnaeus, 1758).

THREATHS AFFECTING SEA TURTLES IN CONGO

Sea turtles in Congo are exposed to many threats, mostly linked to human activities: (1) Nesting females are hunted for their meat, (2) eggs are collected from nests and (3) to a lesser extent, turtles are also used to produce handicraft on shells and for traditional medicine.

Some indirect threats are also weighing on sea turtles in Congo, such as coastal development, and pollution by industrial and domestic wastes. Sea turtle are often captured incidentally in fishing gear of traditional and industrial fisheries.

REGULATORY ARSENAL IN CONGO

The Republic of Congo voted a new law in November 2008 to manage wildlife resources. Renatura participated in the government discussions regarding this list, advocating for the inclusion of all marine turtle species present in the country.

An application decree published in April 2011 (n°6075, April 9, 2011) details the list of animals fully or partially protected by this law. All the sea turtles species are now fully protected in Congo.

The Congo has signed international conventions dealing with sea turtle protection: The Convention on the Conservation of Migratory Species of Wild Animals (CMS-Bonn convention), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Memorandum of Understanding Concerning Conservation Mesures for Marine Turtles of the Atlantic Coast of Africa, Abidjan, Côte d'Ivoire (1999).

Unfortunately, law enforcement is very poor in Congo and international conventions have not been transposed in national laws.

Congolese traditional beliefs represent another lever to protect sea turtles. For example, in ancient times sea turtles were respected in the local Vili culture since they were considered the soul of the sea world.

RENATURA ACTIONS

Since 2001, Renatura has been active in several different ways: (1) Protection and research both on nesting beaches and off shore, (2) Intensive environmental awareness and education sessions in schools, and (3) development of a community based eco-tourism program.

Nesting site protection and follow-up

Protection

Since 2003, Renatura field teams have been conducting daily patrols during the nesting season at two strategic sites for leatherback and olive ridley nesting. The goal is to collect accurate data to permit the description of leatherback and olive ridley nesting in Congo and to ensure protection of females, nests and hatchlings on the beaches. In addition, the permanent presence of field technicians drastically reduces human predation. Ten years ago, human predation rate was as much as 100%. Today, the presence of field teams (Congolese employees recruited among fishermen in local villages), combined with outreach and education has led to a decrease of hunting and harvesting activities to less than 5%.

Assessing overall sea turtle nesting activities in Congo

Non-intensive surveys of nesting activities are undertaken at three additional sites, where a dedicated team carries out regular nest counts once every three weeks. Daily monitoring and non-intensive survey sites are evenly spaced along the coastline. Thanks to the collaboration with Prof. Marc Girondot of France's Orsay University, data from intensive and non-intensive monitoring were used to model the nesting seasons' trends (GODGENGER *et al.*, 2009). In fact, modelling can be used to assess nesting abundance along the entire Congolese coastline and to determine trends for leatherback and olive ridley nesting over time.

Analysis of a seven-year dataset, shows a dramatic decrease of olive ridley nest numbers on Congolese beaches (Fig. 1A, 1B), despite Renatura's activities and our unquestionable success in terms of decreasing egg harvesting and female hunting. A longer-term survey is needed to discern trends in leatherback nesting activity.

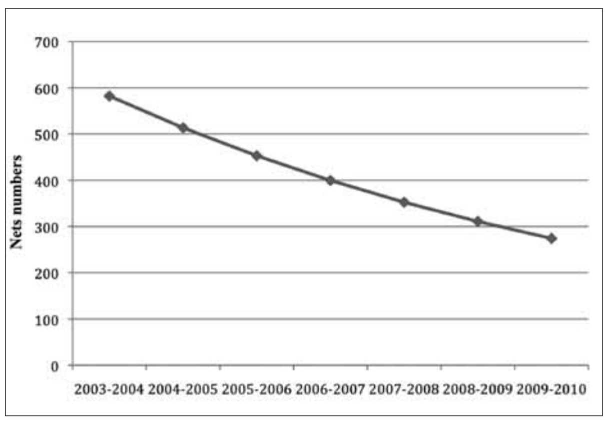


Fig. 1A.- Olive ridley nesting trend on Congo beaches (2003-2010).

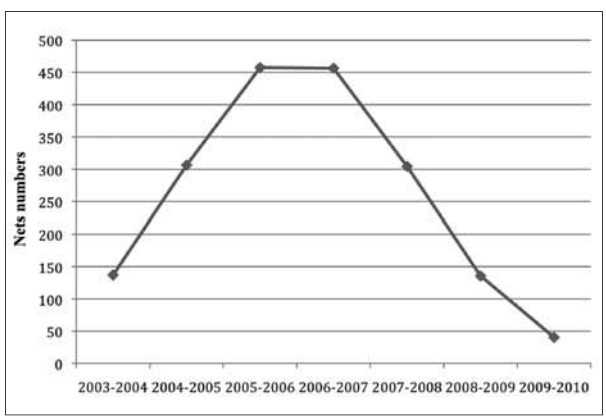


Fig. 1B.- Leatherback nesting trend on Congo beaches (2003-2010).

Environmental education

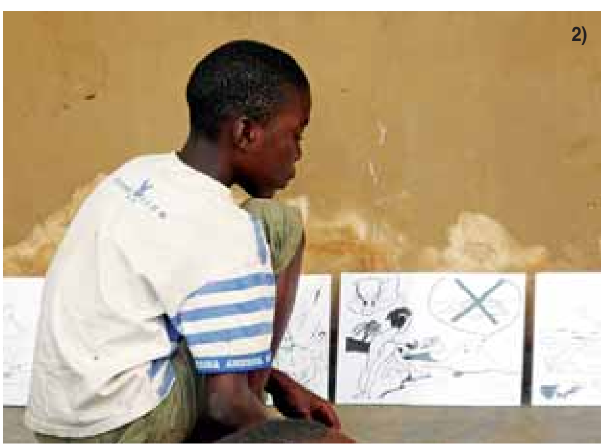
Outreach and education about the environment in general and sea turtles in particular are important priorities of our conservation work. Since 2005, Renatura has developed an environmental education program in coastal villages and in the town of Pointe Noire (the main harbour and the biggest town of Congo). Awareness is raised among adults thanks to mobile exhibitions, movie projections, conferences in town halls and marketplaces.

To bring environmental education to children and youth, the actors of tomorrow's Congolese society, our education team implements interactive methods in private and public schools and through leisure activities in coastal villages during holidays (Fig. 1). Every session is built according to the David Kolb pedagogical method, based on interaction and adapting the information delivery to each type of learner. A large variety of activities are implemented in each session (working groups, testimonies, theatre sketches, games) (Fig. 2, 3). Results are assessed through questionnaires undertaken before and after each education session. In addition, during summer holidays the Renatura education staff organises environmental games and leisure activities in remote villages for children and youth, as well as movie projections at night.

1)

Fig. 1, 2, 3.- Leisure activities in coastal villages during holidays.

2)



3)

Release of turtles accidentally caught in fishing nets

Each year, high numbers of sea turtles are incidentally caught in fishing nets, (Fig. 4) mainly gill nets. Previously turtle meat used to be sold in market places to compensate for the cost of fixing the fishing nets damaged by turtles. From 2005, Renatura has developed - in collaboration with fishermen - a community-based program to accompany them in the release of incidentally captured turtles.

Renatura has implemented a release process when a turtle is captured in a traditional fishing net. Fishermen contact the Renatura release team. The team goes on site to check if the capture is real and if the turtle is alive and in good condition. Field technicians in charge of this program also collect data about the capture, take measurements and tag the turtle before releasing it.

Damage to the fishing nets is evaluated by Renatura's team, which is composed of local employees who where previously fishermen. In return for releasing the turtle, Renatura provides the necessary amount of net line bobbin (for little damage) or net pieces (in the case of a large damage) to fix the fishing gear (Fig. 5).

Thanks to this program, more than 1500 turtles have been released each year since 2005 (Fig. 6, 7, 8). The importance of the release program is manifold:

Fig. 4.- Leatherback cought in the fishing net.

Fig. 5.- Damage to the fishing nets is evaluated and the necessary amount of net provided.

Fig. 6.- Release of a leatherback turtle accidentally caught in fishing nets.

Fig. 7.- Green turtle accidentally caught in a fishing net waiting for its liberation.

Fig. 8.- Release of green turtles accidentally caught in fishing nets.

- Implements concrete actions to reduce sea turtle loss due to bycatch in artisanal fisheries;
- Reduces commercialisation of turtles;
- Motivates fishermen to become responsible for the sustainable management of their natural resources;
- Enables tracking of by-caught turtles through recaptures, each individual being tagged, identified and measured before release.

Thanks to the release program, a large set of data has been collected throughout the year on four species of sea turtles, including juveniles, sub-adults, adult females and males (Table 1). Results from the release program highlight the presence of an important feeding ground and a developmental area in Loango Bay for green and hawksbill turtles.

Total recorded capture events	9044
Of known species	9035
Releases	8133
Unreleased	902
Captured *Chelonia mydas*	5842
Released	5438
Captured *Dermochelys coriacea*	1185
Released	1045
Captured *Lepidochelys olivacea*	1551
Released	1270
Captured *Eretmochelys imbricata*	457
Released	380

Table 1.- Sea turtle capture events recorded by Renatura (2005-2010) in the Republic of Congo.

Ecotourism

Since May 2009, Renatura proposes several tourist activities to discover sea turtles in the field. A portion of the income from tourism is used to fund some of the NGO activities. The other portion is used to promote micro-projects chosen by the local communities. This programme has already enabled one of the villages to fix a water-pump and ensure a regular water supply. School books were also purchased for the local school. Thanks to this approach, sea turtles are thus considered a value for the community.

Future development

Renatura has recently already launched two new projects,

• Development and testing, with local fishermen, of alternative fishing techniques and gears (shape of the net, depth, fishing hours and methods, etc.) to reduce incidental capture in the long term.

• Further studies on the Loango bay feeding ground. Renatura plans to create a marine protected area managed with local communities.

In the near future, we will also develop a program to reduce incidental by-catch by industrial fishing vessels. In fact, the observed decrease of olive ridley nesting, despite the encouraging conservation results Renatura has obtained on the beaches, could be due to sea turtle by-catch in industrial fishing gear. A large number of industrial fishing boats operate in Congolese waters, some are legal but others are fishing illegally (without authorisation, without a flag, or using illegal fishing techniques such as paired boats or proximity to the shore).

An initial meeting with legal industrial boat owners will be held in Pointe Noire during the first half of 2011 to launch a study on sea turtle and cetacean by-catch by trawlers and industrial fishing gear in Congolese waters, and to raise awareness among fishing boats owners.

A second phase will involve:

• encouraging industrial fisheries to adopt techniques reducing by-catch, such as Turtle Excluder Devices.

• and fighting against Illegal Unregulated Unreported (IUU) Fishing.

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An overview of fisheries and sea turtle bycatch along the Atlantic coast of Africa

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ABSTRACT

Some of the most productive and diverse marine ecosystems found anywhere in the world are located along the Atlantic coast of Africa. Industrial fishing fleets from Africa and foreign nations exploit the commercially valuable fishing resources in coastal exclusive economic zones (EEZs) and on the high seas. Small-scale artisanal fisheries operate extensively in coastal areas, catching a wide variety of species for subsistence and local trade. Incidental capture of sea turtles in the world's fisheries poses an urgent challenge to conservation and management efforts, and Atlantic Africa is no exception. The region supports important nesting and foraging grounds for five species of sea turtles—loggerheads *Caretta caretta* (Linnaeus, 1758), green turtles *Chelonia mydas* (Linnaeus, 1758), leatherbacks *Dermochelys coriacea* (Vandelli, 1761), hawksbills *Eretmochelys imbricata* (Linnaeus, 1766), and olive ridleys *Lepidochelys olivacea* (Eschscholtz, 1829). This study characterizes the predominant fisheries in the region and compiles the available information on sea turtle bycatch in 21 countries between Mauritania and Namibia; intentional take is also described. Despite the active fisheries in the region, detailed information on sea turtle-fisheries interactions is sparse for most African countries in the eastern Atlantic, highlighting an urgent need to address this gap.

KEY WORDS: Sea turtles, bycatch, West Africa, longlines, trawls.

RESUMEN

Uno de los ecosistemas marinos más productivo y diverso del mundo se encuentra en la costa atlántica africana. Los recursos pesqueros de la zona económica exclusiva (ZEE) y de alta mar, son explotados tanto por la flota pesquera industrial africana como por las extranjeras. Las pesquerías artesanales operan a lo largo de toda la zona costera, capturando una gran variedad de especies para la subsistencia y el comercio local. La captura accidental de tortugas marinas es un reto urgente a nivel global, para la conservación y gestión de sus poblaciones y la zona atlántica de África no es una excepción. Esta región presenta importantes playas de anidación y zonas de alimentación para cinco especies de tortugas marinas: tortuga boba *Caretta caretta* (Linnaeus, 1758), tortuga verde *Chelonia mydas* (Linnaeus, 1758), laúd *Dermochelys coriacea* (Vandelli, 1761), carey *Eretmochelys imbricata* (Linnaeus, 1766), y olivacea *Lepidochelys olivacea* (Eschscholtz, 1829). Este trabajo describe las pesquerías que se llevan a cabo en la región y reúne la información disponible de la captura accidental de tortugas marinas en 21 países entre Mauritania y Namíbia; la captura intencionada también es descrita. A pesar de toda la pesquería que se desarrolla en la zona la información detallada sobre las interacciones entre tortugas marinas y las pesquerías es escasa en la mayoría de los países de la costa atlántica africana, destacando la urgencia de tomar medidas al respecto.

PALABRAS CLAVE: Tortugas marinas, captura incidental, África oeste, palangre, arrastre.

LABURPENA

Mundu mailan den itsas ekosistema anitzenetarikoa eta emankorrenetarikoa Afrikar kostalde atlantiarrean aurkitzen da. Zona ekonomiko esklusiboko (ZEE) eta ur ozeanikoetako arrantza baliabideak, bertako naiz kanpoko arrantza industrialeko flotek ustiatzen dituzte. Artisau arrantzan diharduten arrantzaleak aldiz kostaldean aritzen dira, espezie ezberdin ugari harrapatuz bai norbanako biziraupenerako baita bertako merkataritzaren sustapenerako ere. Itsas dortoken kontserbazio eta populazioen kudeaketa egokia egiteko harrapaketa akzidentala ekiditzeko nahia, mundu mailako erronka bilakatu da baita Afrikako Atlantiar kostaldean ere. Eskualde honetan, itsas dortoka espezie ezberdinentzat errute hondartza eta elikatzeko gune garrantzitsuak aurkitzen dira bai benetazko dortoka *Caretta caretta* (Linnaeus, 1758), dortoka berdea *Chelonia mydas* (Linnaeus, 1758), larruzko dortoka *Dermochelys coriacea* (Vandelli, 1761), karei dortoka *Eretmochelys imbricata* (Linnaeus, 1766) eta oliba dortoka *Lepidochelys olivacea*-rentzat (Eschcholtz, 1829). Lan honetan, eskualdean burutzen diren arrantza mota ezberdinak ezagutzera ematen dira, eta harrapaketa akzidentalaren inguruan, 21 herrialde ezberdinetan, eskuragarri den informazioa bateratu da, Mauritanian hasi eta Namibiara arte; nahitako harrapaketa ere kontuan hartu da. Arrantza jarduera handia izanagatik ere itsas dortoken eta arrantza jardueren arteko interakzioaz informazioa murritza da Afrikako atlantiar kostako herrialde guztietan, beraz argi nabarmentzen da gai honen inguruan neurriak hartzeko beharra.

GAKO HITZAK: Itsas dortokak, harrapaketa akzidentala, Afrika mendebaldea, tretza, arraste.

INTRODUCTION

The Atlantic coast of Africa supports some of the most productive and diverse marine ecosystems found anywhere in the world. The powerful Canary, Guinea, and Benguela Currents each create concentrated areas of marine productivity, where populations of seabirds, sharks, marine mammals, and sea turtles converge to feed in the rich waters (Ukwe *et al*., 2003; Ukwe *et al*., 2006). Due to major upwelling in the Canary Current Large Marine Ecosystem (LME), stocks of sardine (*Sardina* spp., *Sardinella* spp.), herring (*Ilisha* spp.), anchovy (*Engraulis* spp.), mackerel (*Scomber* spp.), and other small pelagic fish flourish and are heavily exploited in the relatively cool waters from Morocco to Guinea Bissau. The fishing activity in this area landed 1.8 million metric tons (mt) in 2006 (Sea Around Us Project 2010) and consists primarily of industrial fleets subsidized by the European Union (Project Global West Africa Assessment 2008). In the more tropical waters of the Guinea Current LME, seasonal upwelling and mixing of waters from the Guinea, Angola, and Benguela currents create zones of high productivity from Guinea Bissau to Angola. With 888,079 mt landed in 2006 (Sea Around Us Project 2010), the area supports a wide range of industrial and artisanal fisheries—trawlers, longlines and purse seine vessels target small pelagics, tuna species and the commercially valuable bonga shad *Ethmalosa fimbriata* (Bowdich, 1825); mixed gear artisanal fleets catch a variety of coastal species. The Benguela Current LME, characterized as one of the strongest known wind-driven upwelling systems (NOAA, 2003), supports fisheries for horse mackerel (*Caranx* spp.), hake (*Urophycis* spp., *Merluccius* spp.), anchovies and other small pelagic in the waters from Angola to South Africa (Project Global West Africa Assessment 2008). Total fisheries landings for the Benguela Current LME in 2006 totaled 901,870 mt (Sea Around Us Project 2010) and overexploitation of resources is a concern for the region.

These regions sustain a year-round presence of both foreign and domestic fishing vessels, with marine fisheries landings from the Eastern Central and Southeast Atlantic regions totaling 4.7 million tons in 2008 (FAO, 2010). Industrial fleets from many nations (e.g., the European Union, Iceland, Russia, Korea, Japan, China, Taiwan, Latvia, Lithuania Trinidad and Tobago) operate in international waters and within the exclusive economic zones (EEZs) of nearly every African country in the Atlantic, harvesting fish and crustaceans using a variety of techniques and gear types (MOSES, 2000; ZEEBERG *et al*., 2006; CATRY *et al*., 2009). Artisanal fisheries are believed to comprise over 95% of the world's fishermen (MOORE *et al*., 2010), and Atlantic Africa supports a large and widespread artisanal fisheries. Artisanal fishing efforts predominate in coastal waters, lagoons, and estuaries, and often provide the principal source of protein and employment in coastal villages (UKWE *et al*., 2006; CHUKWUONE *et al*., 2009). Additionally, illegal, unreported, unregulated (IUU) fishing by foreign and domestic vessels alike contributes to fisheries landings off the West African coast (FALAYE, 2008; Environmental Justice Foundation < http://www.ejfoundation.org/>). Even in countries with existing legislation or fishing permit requirements, efforts to set quotas and reduce bycatch are undetermined by IUU fishing (FALAYE, 2008).

Incidental capture in fisheries, or bycatch, is widely acknowledged as posing an urgent and significant threat to sea turtle populations everywhere (LUTCAVAGE *et al*., 1996; SPOTILA *et al*., 2000; KOTAS *et al*., 2004; LEWISON *et al*., 2004; CARRANZA *et al*., 2006; PETERSEN *et al*., 2008; SIMS *et al*., 2008). Along the Atlantic coast of Africa, 5 species of sea turtles are known to occur —loggerheads, *Caretta caretta* (Linnaeus, 1758); greens *Chelonia mydas* (Linnaeus, 1758); olive ridleys, *Lepidochelys olivacea* (Eschscholtz, 1829); hawksbills, *Eretmochelys imbricata* (Linnaeus, 1766); leatherbacks, *Dermochelys coriacea* (Vandelli, 1761)— and this region supports globally important nesting and foraging populations (FRETEY, 2001; FORMIA *et al*., 2003; WITT *et al*., 2009; MARCO *et al*., 2011). Incidental sea turtle capture in African fisheries is widely acknowledged but poorly studied; as a result, detailed information on bycatch for each country's fisheries in the literature ranges from minimal to nonexistent (KELLEHER, 2005; MOORE, 2008; LEWISON *et al*., 2011; STEWART *et al*., 2011). The problem is particularly difficult to monitor in artisanal fisheries, where many of the boats are currently not listed and the number of active boats is unknown. Also artisanal fisheries often operate in remote fishing villages and are not required to keep reliable records of captures including bycatch. Furthermore, intentional take of turtles by fishermen is also widespread along the African coast and remains largely unmonitored and unquantified (FRETEY, 2001).

Recent studies have synthesized global sea turtle bycatch data, including observed fishing effort and bycatch comparisons across gear types (Project Global West Africa Assessment 2008; WALLACE *et al*., 2010). This study contributes to these efforts and the objectives are to characterize the predominant industrial and artisanal fisheries currently operating along the Atlantic coast of Africa from Mauritania to Namibia and to compile the available information on sea turtle bycatch in the region as exhaustively as possible; intentional take of sea turtles in the artisanal fisheries is also highlighted. The general paucity of information on the incidental and intentional capture of turtles in fisheries represents a great void in the scientific knowledge that is crucial to the conservation and management of sea turtle populations. This paper aims to emphasize the intensity of fishing activity in this region and how little is known about sea turtle bycatch from this extensive coastline.

METHODS

The fisheries data were compiled from the published literature, conference proceedings, regional reports, and fisheries databases (e.g., FAO, ICCAT, FishBase, Project Global, Sea Around Us Project). This report focused on the target species of each fishery, gear types used, and distinctions made (if any) between industrial and artisanal fleets.

Sea turtle bycatch data were also compiled from the published literature, conference proceedings, regional reports, and various databases (i.e., FAO, ICCAT, Project Global). Intentional take of sea turtles in the artisanal fisheries is also described when available. The 21 countries described in this paper range from Mauritania to Namibia and include the Cape Verde Islands and Sao Tome and Principe (Fig. 1); Morocco and South Africa were excluded because their coastlines include the Mediterranean Sea and Indian Ocean, respectively, which are outside the scope of this paper.

RESULTS

Characterizing the Fisheries

Industrial Fisheries

Industrial fishing vessels operate within Exclusive Economic Zone (EEZ) waters as well as farther offshore of every country along the coast of Atlantic Africa. A mixture of domestic and international fleets fish in these waters using a wide variety of gear types, including trawls (bottom and mid-water), longlines, and purse seines. The catch composition, target species, and occurrence of bycatch vary for each country and specific gear type. Fo-

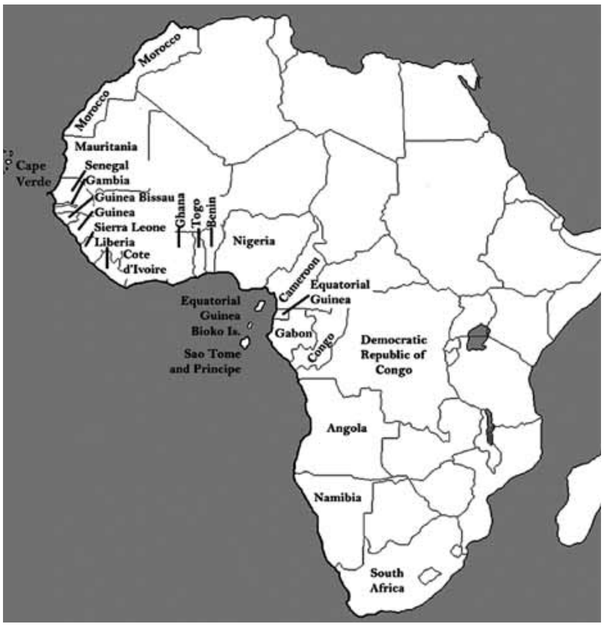

Fig. 1.- Map of the Atlantic coast of Africa

reign vessels represent a number of different countries (e.g., France, Iceland, Ireland, Italy, Japan, China, Taiwan, Latvia, Lithuania, the Netherlands, Portugal, Russia, South Korea, Spain, and Uruguay) (Fonteneau *et al.*, 2000; Carranza *et al.*, 2006; Ukwe *et al.*, 2006; Zeeberg *et al.*, 2006; Sea Around Us Project 2010).

Trawlers

Industrial trawl activity consists of mid-water, bottom (demersal), shrimp, and crab trawls. Pelagic trawlers have been operating in coastal EEZ waters from Western Sahara to Senegal since the 1960s, targeting clupeoids such as sardine [*Sardina pilchardus* (Walbaum, 1792)], sardinella [*Sardinella aurita Valenciennes,* 1847; *Sardinella maderensis* (Lowe, 1838)] and mackerels [*Scomber japonicus* Houttuyn, 1782; *Trachurus trecae* Cadenat, 1950; *Trachurus trachurus* (Linnaeus, 1758)] (Binet, 1997; Ter Hofstede *et al.*, 2006). Zeeberg *et al.* (2006) also documented industrial trawl activity in the Mauritanian EEZ by European (Dutch and Irish), Lithuanian, Russian, and Icelandic vessels, which primarily target sardines, sardinella, and horse mackerels. Industrial bottom trawling for demersal fish such as soles (Cynoglossidae), seabreams (Sparidae), croakers (*Pseudotolithus* spp.), threadfins (*Galeoides* spp., *Pentanemus* spp. and *Polydactylus* spp.) and African sicklefish (*Drepane* spp.) occurs in Angola (ICCAT 2005). The incidence of industrial shrimp and crab trawling is highest in coastal, estuarine regions near river deltas, such as those in Guinea-Bissau, Liberia, Côte d'Ivoire, Benin, Cameroon, and Nigeria (FAO 1989; Project Global 2008; Catry *et al.*, 2009; Sea Around Us Project 2010; Vogt *et al.*, 2010). Commercial trawling for fish also occurs in Nigerian waters (Falaye, 2008) as well as in the waters of Gabon and Congo. Industrial trawling is illegal in the EEZ of the Cape Verde Islands, but limited enforcement does not effectively exclude foreign fleets (López-Jurado *et al.*, 2003).

Longliners

Commercial longlining efforts mostly target large, commercially valuable pelagics that are shipped abroad to international markets in the European Union, the United States, and Japan. Pelagic longlines target species such as swordfish *Xiphias gladius* Linnaeus, 1758, blue shark *Prionace glauca* (Llinnaeus, 1758), and tunas [*Thunnus albacares* (Bonnaterre, 1788); *Thunnus obesus* (Lowe, 1839); *Thunnus alalunga* (Bonnaterre, 1788)] (Ryan *et al.*, 2002; Carranza *et al.*, 2006; Petersen *et al.*, 2007). Bottom-set longlines exploit demersal species such as croakers, threadfins, soles, marine catfish (*Arius* spp.), brackishwater catfish (*Chrisichthys* spp.), snapper (*Lutjanus* spp.), grunters (Pomadasyidae), and groupers (*Epinephelus* sp.) (Chukwuone *et al.*, 2009). Longline vessels are prominent in the waters of Mauritania, Cape Verde, Gabon, Angola, Namibia, and South Africa, targeting swordfish, tunas, sharks, and billfish (ICCAT 2005; Petersen *et al.*, 2007).

Seine nets (Seiners)

Different purse seines types in the region target tunas and small pelagics such as sardines and anchovies in coastal waters from Mauritania to South Africa, specifically in the Guinea Current Large Marine Ecosystem area extending from Guinea-Bissau to Angola (Project Global 2008). In Côte d'Ivoire, tuna are caught commercially using tuna purse seines (ICCAT 2005), and the Ghanaian industrial fleet uses purse seines to catch sardinella and tuna (Falaye, 2008).

Artisanal Fisheries

For many countries along the African coast, artisanal fisheries constitute the majority of the national fleet and like their industrial counterparts target a variety of organisms. Pelagic fish (sardines, sardinellas, mackerels, bonga shad) as well as demersal species (croakers, African threadfin, soles, catfish, and snappers) are important components of the artisanal catch. While most countries engage in both industrial and artisanal fishing with varying gear types and target species for each sector, it appears that Senegal, The Gambia, Sierra Leone, Ghana, and Nigeria have predominately artisanal fleets (Cormier-Salem, 1994; Lae *et al.*, 2004; Sylvanus, 2007; Brinson, 2009; Baio, 2010). The gear types in use include a variety of nets (seines, driftnets, hand trawls, and set gill nets), as well as traps, hand lines, pole lines, and some longlines (ICCAT 2005, Sea Around Us Project 2010); there is also a higher incidence of mixed gear use among artisanal fisheries compared to industrial fleets (Moore *et al.*, 2010). Artisanal fishery products are often consumed locally, and fishing activity is typically spread along coastlines and throughout inland waters (Moore *et al.*, 2010).

Trawls

The broad 'trawl' category includes mid-water, bottom, and shrimp and crab trawls. Shrimp trawl activity is especially concentrated near estuaries and areas of high productivity in The Gambia, Guinea-Bissau, Liberia, Côte d'Ivoire, Benin, Cameroon, Nigeria, and the Democratic Republic of Congo (FAO 1989; Project Global 2008; CATRY *et al.*, 2009; Sea Around Us Project 2010; VOGT *et al.*, 2010). Mid-water trawling targeting sardinella, bonga shad, mackerels, and other small pelagics also occurs in every country from Senegal to Namibia (ICCAT 2005).

Longlines

The Gambian fishery targets bonga shad, sardine, sardinella, European anchovy, and mackerels using handlines and longlines (ICCAT 2005). The shrimp fisheries in Nigeria, Cameroon, Gabon, and the Democratic Republic of Congo also target demersal fish using similar gear types (MOSES, 2000; LAE *et al.*, 2004; ICCAT 2005; Project Global 2008). In Angola, artisanal handlines and longlines target seabream species, grouper species, Angola croakers *Miracorvina angolensis* (Norman, 1935), Angola dentex *Dentex angolensis* Poll & Maul, 1953, hakes *Merluccius* spp., and pelagic fish such as sardine and horse mackerel (HONIG *et al.*, 2008).

Seines and Gillnets

Western Africa has the highest density of gillnet vessels found anywhere in the world (STEWART *et al.*, 2011). Artisanal fishermen utilize a wide variety of net types, including stownets, drift nets, surrounding nets, and seines in addition to the ubiquitous gillnet. The Gambian fishery targets bonga shad, sardine, sardinella, European anchovy, and mackerel using drift nets and gillnets (ICCAT 2005). FAO data indicate that artisanal purse seine fishing in Liberia captures mainly sardinella (60% of total catch in 1986). Fishermen in Sierra Leone use mostly nets (65.4% of total gear) to capture bonga, sardine, and barracuda (*Sphyraena*) (BAIO, 2010). In Ghana, an artisanal drift net fishery targets sailfish and other billfish, tunas, and sharks (BRINSON *et al.*, 2009). Small pelagics are exploited in EEZ waters from Ghana to the Democratic Republic of Congo using purse seines, gillnets, mid-water net trawls, and driftnets (CHUKUWONE *et al.*, 2009). In Nigeria, bonga shad is harvested using artisanal gill nets and semi-industrial purse seines (VAKILY, 1992; MOSES *et al.*, 2000). Similar to industrial crustacean fisheries, artisanal shrimp and crab fishing is practiced in estuaries and inshore systems. Shrimp is harvested in The Gambia estuary using stownets, drift nets, gillnets, surrounding nets, handlines and longlines, accounting for 23% of the total artisanal catch for the 2001-2002 seasons (LAE *et al.*, 2004). The shrimp fisheries in Nigeria, Cameroon, Gabon, and the Democratic Republic of Congo also target demersal fish using similar gear types (MOSES, 2000; LAE *et al.*, 2004; ICCAT 2005; Project Global 2008).

Weirs, Traps, Hand lines, Pole lines, etc

A number of artisanal fisheries operate using gear types other than the ubiquitous lines and nets. BAIO *et al.* (2010) reported that 13.5% of the gear used by the Sierra Leone artisanal fleet comprises non-net gear types (i.e, crab pots, traps, etc.). Fleets in Ghana, Nigeria, Cameroon, Gabon, and Democratic Republic of Congo utilize traps in their subsistence fisheries for sardinella, bonga shad, and shrimp (Nigeria) (MOSES, 2000; ICCAT 2005; SYLVANUS, 2007; BAIO *et al.*, 2010).

Sea Turtle bycatch

Quantitative data on sea turtle bycatch are rare for eastern Atlantic waters, although several studies have surmised that given the degree of fishing activity in close proximity to nesting and foraging areas, sea turtle bycatch rates are probably high (LEWISON *et al.*, 2004b; MOORE *et al.*, 2010; WALLACE *et al.*, 2010). Accurate and reliable bycatch data are difficult to achieve, as direct observation rates are low (<1% of total fleets) and statistics from the region's many small-scale fisheries are still largely incomplete (KELLEHER, 2005; MOORE *et al.*, 2010; WALLACE *et al.*, 2010). Given the limited number of quantitative studies on sea turtle bycatch in the industrial and artisanal fisheries along the Atlantic coast of Africa, information on bycatch is compiled here from several sources that may impart valuable knowledge, including anecdotal accounts, interviews, as well as reports of strandings, entanglements, and injuries that are strongly suspected to be fisheries related. Anecdotal accounts of sea turtle bycatch contain minimal to no information on fishing effort and numbers or species encountered, but do suggest areas that could benefit from future bycatch studies. Interviews with fishermen have been shown to be useful tools in identifying areas and gear types with high probable bycatch rates (GILMAN *et al.*, 2009; LEWISON *et al.*, 2011). Here we summarize all reports of incidental and intentional take of turtles as exhaustively as possible for each country in this region (Table 1).

Mauritania

In observing 1,424 trawl sets in the industrial Dutch trawl fishery of Mauritania from 2001 to 2005, ZEEBERG *et al.* (2006) recorded the bycatch of 8 sea turtles—leatherback, hawksbill, and loggerhead—but did not provide bycatch rates for each species. Sea turtle bycatch accounted for 1% of total pelagic megafaunal bycatch, and the percentage of days observed monthly ranged from 4 - 88% throughout the five years of the study. Data presented in TER HOFSTEDE *et al.* (2006) suggests that bycatch in the Dutch pelagic trawl fishery off Mauritania comprises less than 10% of the total catch. Lobster fishermen from Brittany, France, were known to catch hawksbills along the coast between Cap Timiris and Saint-Louis, in nets placed at depths of 8 – 15 m; between 1970 and 1975, each boat captured 2 to 3 individuals (< 40cm in carapace length) during the fishing season (MAIGRET, 1983). Other capture records from Mauritania include: 2 loggerheads (45 cm and 80 cm in length) in fishing nets from the Bay of Levrier and Pointes des Crabes on 7 May 1980 and 14 July 1981, respectively (MAIGRET, 1983); one leatherback, weighing 600 kg, in a pelagic trawl on 22 May 1981 in the Bay of Levrier (MAIGRET, 1983; ARVY *et al.*, 1996); and 17 green turtles (16 females and 1 male) weig-

Country	Gear Type	Artisanal/Industrial Fishery	Species Caught	References
Mauritania	Pelagic trawl	Industrial	DC, CC, EI	ZEEBERG *et al.* 2006
Mauritania	Net	Industrial	EI, CC,	MAIGRET 1983
Mauritania	Pelagic trawl	Industrial	DC	MAIGRET, 1983; ARVY *et al.* 1996
Mauritania	Purse seine	Artisanal	CM	MAIGRET, 1983; ARVY *et al.* 1996
Mauritania	Net, harpoon	Artisanal	CM	MAIGRET 1975; MAIGRET & TROTIGNON 1977; LE TOQUIN *et al.* 1980; J. Fretey pers. comm.).
Senegal	Purse-seiners	Industrial	DC	STRETTA *et al.* (1996)
Senegal	--	Artisanal	CC, LO, DC, EI, CM	CADENAT 1949; MARCOVALDI & FILIPPINI 1991
Senegal	Beach seine	Artisanal	CM	SABINOT 2003
The Gambia	Net	Artisanal	LO, EI	BARNETT *et al.* 2004; HAWKES *et al.* 2006
Cape Verde	Net	Artisanal	CM	LOUREIRO 2008
Cape Verde	Net	Artisanal	CC, CM	LÓPEZ-JURADO *et al.* (2003)
Cape Verde	--	--	DC	M. de Ponte Machado *pers.comm.* in Fretey 2001
Guinea Bissau	--	Artisanal, semi-industrial	UI	AGARDY 1990; BARBOSA *et al.* 1998; FORTES *et al.* 1998; CATRY *et al.* 2002
Guinea Bissau	--	Industrial	UI	FRETEY 2001
Guinea	Net	Artisanal	DC	Tissandier *pers. comm.* in Fretey 2001;
				M. Camara Soumah *pers. comm.* in Fretey 2001
Sierra Leone	Gillnet, purse seine	Artisanal	CM, EI, CC, DC, LO	MOORE *et al.* 2010
Sierra Leone	Net	Artisanal	DC, CC, EI, LO, CM	MOORE 2008; MOORE *et al.* 2010
Liberia	--	Artisanal	UI	A. Topka *pers. comm.*
Côte d'Ivoire	--	--	UI	See Table 2
Côte d'Ivoire	--	Artisanal	CC, LO	GROOMBRIDGE & LUXMORE 1989
Côte d'Ivoire	Net	Artisanal	DC, LO, CM, EI	Poisson *pers. comm.* in Fretey 2001; Gomez *pers. comm.* in Fretey 2001; Gomez Penate *et al* 2007
Ghana	Purse-seiners	Industrial	UI	STRETTA *et al.* 1996
Ghana	--	Artisanal	CM	TOMAS *et al.* 2001
Ghana	Gillnet	Artisanal	DC, LO, CM	AMITEYE & MØLLER 2000
Benin	Gillnet, shark net, seine	Artisanal	LO, CM, DC	DOSSA *et al.* 2007
Benin	--	--	UI	See Table 2
Togo	Net	Artisanal	CM, DC, EI, LO	Y. Acakpo-Addra pers. comm. in Fretey 2001
Nigeria	Gillnet	Artisanal	DC, CC, EI, CM	MOORE *et al.* 2010
Nigeria	Net	Artisanal	UI	FRAZIER *et al.* 2007
Nigeria	Beam crawl	Artisanal	EI	AMBROSE *et al.* 2005
Cameroon	--	--	CM	FRETEY 1999a
Cameroon	Net, line	Artisanal	LO	FRETEY 1999a
Cameroon	Gillnet, longline	Artisanal	CM, EI, LO, DC	MOORE *et al.* 2010
Cameroon	--	Artisanal	CM, LO, EI, DC	AYISSI *et al.* 2008
Cameroon	Trawl	--	LO	FRETEY 1998a
Cameroon	Harpoon	Artisanal	EI	FRETEY 1998a
Cameroon	Net	Artisanal	DC	FRETEY 1998a
Equatorial Guinea	--	--	CM	TOMAS *et al.* 2001
Equatorial Guinea	Net, harpoon	Artisanal	LO, CM	FRETEY 1998b; MBA *et al.* 1998
Equatorial Guinea	--	Artisanal	CM, EI	FORMIA *et al.* 2008
São Tomé and Príncipe	--	Artisanal	DC	FRETEY *et al.* 1999
São Tomé and Príncipe	Net, spear	Artisanal	CM, LO	Graff 1995a, 1995b
São Tomé and Príncipe	--	Artisanal	LO	J. F. Dontaine & O. Neves *pers. comm.* in Fretey 2001
São Tomé and Príncipe	Net	Artisanal	EI	JUSTE 1994
Gabon	--	--	UI	See Table 2
Gabon	Trawl	Industrial	UI	BELL & MASSALA 2006
Gabon	Trawl	Industrial	LO, DC	PARNELL *et al.* 2007
Gabon	--	Artisanal	CM	TOMAS *et al.* 2001
Gabon	--	--	EI	BELLINI *et al.* 2000
Gabon	--	Artisanal	CM, EI	FORMIA *et al.* 2003
Congo	Net	Artisanal	EI	FRETEY 1998c
Congo	Gillnet, trawl, beach seine	Artisanal	CM, LO, EI, DC	BAL & BRÉHERET 2006; BAL *et al.* 2007; BAL & BRÉHERET 2008; BRÉHERET & ADELL 2009; FASQUEL & BRÉHERET 2010; BRÉHERET *et al.* 2011
Congo	Drift net	--	LO	Maloueki (*pers. comm.* in FRETEY 2001)
Congo	Trawl	--	LO	PARIS *et al.* 1997
Dem. Rep. of Congo	Net	Artisanal	UI	OCPE 2006; Verhage 2007
Angola	Longline	Artisanal	CC, LO, EI, DC	WEIR *et al.* 2007
Angola	Net	Artisanal	UI	WEIR *et al.* 2007
Angola	--	--	LO, DC	WEIR *et al.* 2007
Angola	Net, handline, beach seine	Artisanal	UI	CARR & CARR 1991
Namibia	Trawl, nets (gillnet, driftnet), beach seine, longline	--	CM, DC, CC, EI	BIANCHI *et al.* 1993
Namibia	Pelagic longline	Industrial	UI	HONIG *et al.* 2008
Gulf of Guinea	Pelagic longline	Industrial	DC, LO	CARRANZA *et al.* 2006
Benguela Current LME	Pelagic longline	Industrial	UI	HONIG *et al.* 2008
Atlantic Ocean	Pelagic longline	Industrial	DC, CC	LEWISON *et al.* 2004

Table 1.- Summary of reported sea turtle take in the fisheries from Mauritania to Namibia. Gear type is indicated when available. (DC= *Dermochelys coriacea*; CC = *Caretta caretta*; CM = *Chelonia mydas*; EI = *Eretmochelys imbricata*; LO = *Lepidochelys olivacea*; UI = unidentified species).

hing 40 – 50 kg in an artisanal purse seine on 27 September 1980 at Marguerite Island (MAIGRET, 1983; ARVY *et al.*, 1996). At Banc D'Arguin, which supports one of the most important foraging areas for green turtles (FRETEY, 2001), Imagruen fishermen have long been documented to catch turtles with nets and harpoons for consumption (MAIGRET, 1975; MAIGRET and TROTIGNON, 1977; LE TOQUIN *et al.*, 1980; J. Fretey *pers. comm.*).

Senegal

STRETTA, *et al.* (1996) reported sea turtle bycatch by French and Spanish tuna boats along the West African coast and only 1 leatherback was caught in Senegalese waters, but bycatch by trawlers is known to occur and has not been quantified (SABINOT, 2003). In February 2009 the United States' National and Oceanic Atmospheric Administration conducted an observer training workshop in Dakar, which gave the Senegalese government the necessary training and skills to evaluate bycatch in their industrial fisheries. Captures of loggerheads, olive ridleys, leatherbacks, hawksbills and green turtles by shark fishermen were reported between 1945 and 1950 (CADENAT, 1949). Between April 2001 and September 2002, at least 21 green turtles were captured by beach seines in Palmarin, and between 1995 and 2000, hundreds of green turtles were reported to have been captured in this region (SABINOT, 2003). Intentional take of sea turtles for consumption by fishermen commonly occurs in Senegal (SABINOT, 2003). Some of the sea turtle take may be affecting turtles migrating from waters as far away as Brazil; a juvenile hawksbill tagged in Atol das Rocas, Brazil, in January 1990 was captured and killed in Dakar in July 1990 (MARCOVALDI & FILIPPINI, 1991).

The Gambia

Bycatch in the artisanal fishery and by trawlers has been stated as a threat to sea turtle populations in the Gambia (BARNETT *et al.*, 2004). Two dead juvenile green turtles bearing injuries indicative of interactions with the nearby gillnet fishery were recorded on morning surveys in 2006 (HAWKES *et al.*, 2006).

Cape Verde

Exploitation of sea turtles in the Cape Verde Islands for meat and traditional dates back several centuries (LOUREIRO TORRÃO, 2008). Today, incidental and intentional captures of sea turtles are still considered serious threats to sea turtles in Cape Verde (LAZAR HOLCER, 1998; LÓPEZ-JURADO *et al.*, 2003). LÓPEZ-JURADO *et al.* (2003) recorded the entanglement of 10 loggerhead turtles in an abandoned trawl net on Boavista Island in the Cape Verde archipelago; these turtles measured 62 – 89 cm in curved carapace length. On the island of Santiago, LOUREIRO (2008) noted landings of 4 juvenile green turtles by artisanal fishermen. The capture of a leatherback was reported by fishermen in May 1999 (M. de Ponte Machado *pers.comm.* in FRETEY, 2001). A study to evaluate bycatch in the artisanal fisheries has recently been launched in the islands (E. Abella Perez *pers.comm.*).

Guinea Bissau

Bycatch of sea turtles in the demersal fisheries for shrimp, fish and squid in the region, and semi-industrial and artisanal fisheries for shark, barracuda and other large fish may be a significant source of mortality in Guinea Bissau (AGARDY, 1990; BARBOSA *et al.*, 1998; FORTES *et al.*, 1998; CATRY *et al.*, 2002). Between 1000 and 2000 turtles were estimated to be killed in the commercial shrimp fishery annually (FRETEY, 2001). Twelve turtles tagged on the nesting beach in 2006/2007 were caught over the next 2 years by fishermen in the Gulf of Guinea (Ghana, Cameroon, Gabon, and the continental territory of Equatorial Guinea) (TOMÁS *et al.*, 2010).

Guinea

In Guinea, artisanal fishermen accidentally capture sea turtles in their nets, and 85% of the fishermen indicated that they do not actively hunt for turtles (LÉTOURNEAU, 1996). Other capture records in local nets include: a 142 cm leatherback at Conakry on 27 July 1989 (Tissandier *pers. comm.* in FRETEY, 2001) and a 183 cm leatherback at the landing site of Téminétaye on 23 June 2000 (M. Camara Soumah *pers. comm.* in FRETEY, 2001).

Sierra Leone

Interviews (n = 693) with artisanal fishermen in 2006 and 2007 throughout Sierra Leone reported that 45% of sea turtles recorded as bycatch were caught in gillnets, which make up 50% of the artisanal gear (followed by purse seines (37%) and longlines (26%)) (MOORE *et al.*, 2010). The species caught, though unconfirmed, were said to include greens turtles, hawksbills, leatherbacks, loggerheads, and olive ridleys. Currently, an extensive study is underway by the Conservation Society of Sierra Leone to evaluate sea turtle bycatch in the artisanal fisheries of Sierra Leone. Bycatch evaluation in the industrial fisheries of Sierra Leone is in the development phase.

Liberia

Little information is available on sea turtle bycatch in Liberia, although it is known to occur (A. Topka *pers. comm.*). The Liberian Sea Turtle Project managed by the local NGO Save my Future Foundation (SAMFU) is launching a study in 2011 to evaluate sea turtle bycatch in the artisanal fisheries. Meanwhile, fishermen and communities participating in the sea turtle project are encouraged to release turtles caught in their nets. In May 2011, the United States' National and Oceanic Atmospheric Administration conducted an observer training workshop in Monrovia, which will help the Liberian government evaluate and address bycatch issues in their industrial fisheries.

Côte d'Ivoire

The FAO has reported large catches of unidentified marine turtle species from Côte d'Ivoire since 2000 (Table 2). Incidental catch of adult leatherbacks and olive ridleys and immature greens and hawksbill in nets is common (Gómez Penate *et al.*, 2007). Other reports include a leatherback captured in local nets at San Pedro port on 6 January 1984 (Poisson *pers. comm.* in Fretey, 2001) and an adult male ridley captured by fishermen on 26 April 2000 at Monogaga (Gómez *pers. comm.* in Fretey, 2001). Groombridge Luxmore (1989) describe a turtle fishery operation out of Abidjan that caught mainly loggerheads and olive ridleys—516 turtles were landed in 1967 and 797 in 1968.

Ghana

Stretta *et al.* (1996) reported capture of 3 unidentified sea turtles by French and Spanish tuna boats along the Ghana coast. In several coastal villages in Ghana in 2000, 12 leatherbacks, 4 olive ridleys, and 1 green turtle were either observed captured in fishing nets or discovered dead, having drowned in nets; no data on fishing effort were recorded (Amiteye & Møller, 2000). Tag returns from fishermen in Ghana provide evidence for the incidental capture of post-nesting green turtles migrating from Bioko Island, Equatorial Guinea (Tomás *et al.*, 2001). Bycatch studies in artisanal fisheries are currently being initiated in Ghana (P. Allman *pers. comm.*), and in April 2008, the United States' National and Oceanic Atmospheric Administration conducted an observer training workshop in Accra, so that the industrial fisheries could begin quantifying their bycatch.

Benin

Dossa *et al.*, (2007) observed 705 fishing sets from 21 groups of fishers from November 2004 to February 2005 and recorded bycatch of 33 olive ridleys, 2 greens, and 1 leatherback, predominantly in shark nets and gillnets (80.6% and 19.5%, respectively); overall capture rate of the sets was 5.1%. Currently, NGO Nature Tropicale is monitoring bycatch around Grand Popo (J. Fretey *pers. comm.*). The FAO has reported catches of unidentified marine turtle species since 2000 (Table 2).

Togo

Accidental captures of green turtles, leatherbacks, hawksbills, and ridleys in fishing nets has been observed (Y. Acakpo-Addra *pers. comm.* in Fretey, 2001). Currently, the local NGO Agbo-Zegue is surveying for bycatch along the Togo coastline (J. Fretey *pers. comm.*).

Nigeria

In a survey of the artisanal shrimp beam-trawl fishery in Nigeria from January to December 2002, 2 hawksbills were recorded as bycatch in a total of 62 landings from 5 canoes (Ambrose *et al.*, 2005). Unidentified sea turtles have been reported stranded entangled in plastic fishing mesh (Frazier *et al.*, 2007). Interviews (n = 648) with artisanal fishermen throughout Nigeria in 2006 and 2007 showed that 71% of turtle bycatch (leatherbacks, loggerheads, hawksbill, and green turtles) occurred in gillnets, though gillnet use was reported as the second highest among the gear types (33%), behind that of purse seines and stow nets (50%) (Moore *et al.*, 2010).

Cameroon

Accidental and intentional captures of green turtles less than 78 cm in size are common in Cameroon year round, and during the nesting season fishermen caught female olive ridleys with a net or a line (Fretey, 1999a). Between 1999 and 2001, 400 turtles (green, olive ridley, hawksbill, and leatherback) were caught incidentally in coastal artisanal fisheries in Cameroon; however, detailed information on bycatch rates for each species or fishing effort is not available (Ayissi *et al.*, 2008). Interviews (n = 904) with artisanal fishermen in Cameroon in 2006 and 2007 showed that gillnets were used most (53% of gear), followed by longlines (36%), and that sea turtle bycatch rates (for leatherbacks, olive ridleys, hawksbills, and greens) corresponded accordingly (60% for gillnets, roughly 30% for longlines) (Moore *et al.*, 2010). Trawlers are known to illegally fish close to shore and bycatch of turtles is high (Fretey, 1999b); carapaces of 2 olive ridleys caught in a shrimp trawler were on display at a bar in Douala and one of them was 82 cm in length (Fretey, 1998a). The young fishermen of Lolabe III were reported to harpoon many juvenile hawksbills in front of their village (the smallest measured about 30 cm), whereas other fishermen complained about leatherbacks getting entangled in their nets and destroying them (Fretey, 1999a). A study quantifying bycatch in the artisanal fisheries is currently underway in Cameroon (I. Ayissi *pers. comm.*).

Equatorial Guinea

The FAO reported catches of unidentified species of marine turtles in 2001, with no additional catches reported since (Table 2). Though fishing effort was not quantified, tag returns from fishermen in Equatorial Guinea provide evidence for the incidental capture of post-nesting green turtles migrating from Bioko Island, Equatorial Guinea (Tomás *et al.*, 2001).

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Benin20*	5	1	2	1	1	1	1	0	0	
Côte d'Ivoire	50	71	0	0	0	0	0	0	0	0
Equatorial Guinea	1*	1*	1*	1*	2*	2*	2*	3	5	2
Gabon	51	238	843	1107	25	34	36	5	4	4*
Total	**122 t**	**315 t**	**845 t**	**1110 t**	**28 t**	**37 t**	**39 t**	**9 t**	**9 t**	**6* t**

Table 2.- Countries with reported sea turtle catch in the FAO database (FAO Fishery Statistical Collections 2011; http://www.fao.org/fishery/statistics/global-capture-production/4/en). Catch is reported in metric tons (t). Asterisk (*) indicates that the value is based on calculated estimate.

Intentional take is common and in northern mainland Equatorial Guinea many olive ridleys were reported to be captured by Iduma fishermen, often 6 to 7 animals at a time with nets of large mesh size; capture of green turtles was also recorded (FRETEY, 1998b). On the islands of Corisco and Cabo San Juan, fishermen use special nets (8 x 14 m with a mesh size of 0.5 m) to catch green turtles; 2 or 3 of these nets apparently can catch 30 turtles in a month, although this number should be cautiously interpreted (MBA *et al.*, 1998). Surveys by FRETEY (1998b) indicated that approximately 60 green turtles (sometimes other species as well) are captured by net or harpoon each year around Corisco. FORMIA *et al.* (2008) estimated that 300-500 turtles (green turtles and hawksbills) are captured annually by the Benga fishermen in Corisco Bay that straddles Equatorial Guinea and Gabon to meet the growing demands for turtle meat in the cities. Efforts to quantify bycatch in the artisanal fisheries are underway in Equatorial Guinea (A. Formia *pers. comm.*).

Sao Tome and Principe

Juvenile leatherbacks measuring between 14 cm and 21 cm have been accidentally captured in the artisanal fisheries around the waters of Ilheu Cabras and Boné de Jóquei (FRETEY *et al.*, 1999). However, intentional take is quite widespread. Fishermen use special turtle nets, spears, or just mask and snorkel to capture green turtles and olive ridleys (GRAFF, 1995a, 1995b). In Ilheu Cabra, the capture of 15 olive ridleys (mostly females) by local fishermen was recorded between early September and early December 1998 (J. F. Dontaine & O. Neves *pers. comm.* in FRETEY, 2001). Based on local surveys, JUSTE (1994) estimated that at least 100-150 reproductive adult hawksbills are killed each year in the nets and on the beach.

Gabon

The FAO has reported catches of unidentified species of marine turtles since 2000 (Table 2). In 1982, FAO fisheries statistics recorded a catch of 2 tons of unidentified sea turtles in Gabon (GROOMBRIDGE LUXMORE 1989), STRETTA *et al.* (1996) reported on sea turtle bycatch by French and Spanish tuna boats along the Gabon coast. In a recent observer program in Gabon supported by the FAO, 2 unidentified sea turtle species were recorded on an industrial trawler fishing between 14 March 2006 and 8 April 2006 in 175 hauls (LETOCKA BELL MADOUNGOU MASSALA, 2006). Bycatch data noted by Gabon's Direction Générale de Pêche et l'Aquaculture for artisanal and industrial fisheries combined from 1996 to 2003 varied from no bycatch in 1996 to over 1000 tons of sea turtle bycatch in 2003; the species indicated included loggerheads and leatherbacks combined, although identification of loggerheads might be erroneous.

In stranded turtles recorded in southern Gabon and northern Congo in 2005 and 2006, 1 olive ridley and 2 leatherbacks were found to have wounds consistent with fisheries related interactions (PARNELL *et al.*, 2007). Though fishing effort was not quantified, tag returns from fishermen in Gabon provide evidence for the incidental capture of post-nesting green turtles migrating from Bioko Island, Equatorial Guinea (TOMÁS *et al.*, 2001). Interestingly, a hawksbill tagged in Fernando do Noronha, Brazil, in November 1994 was captured by a fisherman in April 1999 at Cap Esterias (BELLINI *et al.*, 2000).

Republic of the Congo

Accidental capture of a hawksbill, about 40 cm in length, in the net of a fisherman from Mvandji, was reported in the late 1990s by FRETEY (1998c). Maloueki (*pers. comm.* in FRETEY, 2001) reported the catch of 24 female olive ridleys in driftnets in 1999 in Madingou (from the lagoon of Mvandji to the lagoon of Conkouati). PARIS *et al.,* (1997) reported the accidental capture in trawls of 9 olive ridleys whose carapace length varied from 60-76 cm.

More recently a release program for turtles caught incidentally in artisanal nets initiated by project RENATURA has documented large numbers of sea turtle bycatch since the program was launched on 17 September 2005 in Loango Bay, Congo. Within one year of the program's implementation, a total of 1,326 turtles were released alive, but fishing effort was not recorded (BAL *et al.*, 2007). Of the turtles released, 48 % (n = 632) were green turtles (mean CCL = 59.1 cm, range = 8 – 130 cm; SD = 10.0, n = 631); 32 % (n = 431) olive ridleys (mean CCL = 65.9 cm, range = 24 – 81 cm; SD = 8.2, n = 429); 13 % (n = 168) hawksbills (mean CCL = 58.6 cm, range = 31.5 – 77 cm; SD = 9.0, n = 167); 7% (n = 92) leatherbacks (mean CCL = 134.3 cm, range = 89 – 180.3 cm; SD = 20.2, n = 50); and 3 unidentified species, but the description suggested loggerheads (BAL & BRÉHERET, 2006; BAL *et al.*, 2007). During the 2006/2007 nesting season, 1,093 turtles were released in Longo Bay and Pointe-Noire Bay between October and March, of which 209 were leatherbacks, 360 were olive ridleys, 432 green turtles, and 92 hawksbills (BAL BRÉHERET 2007). Between January and July 2008, BAL BRÉHERET (2008) released 637 accidentally captured turtles in Loango Bay and Pointe-Noire Bay between October and March, of which 48 were leatherbacks, 106 were olive ridleys, 477 were green turtles, and 6 were hawksbills. BRÉHERET ADELL (2009) reported the accidental capture of 1486 turtles between August 2008 and July 2009 around Loango Bay and Pointe-Noire Bay. FASQUELL BRÉHERET (2010) reported that 1467 accidentally captured turtles were released in the same bays between August 2009 and July 2010 (8 leatherbacks, 5 olive ridleys, 1426 green turtles, and 28 hawksbills). From September 2010 to February 2011, 1233 turtles were accidentally captured (5 leatherbacks, 21 olive ridleys, 1204 green turtles, and 3 hawksbills) (BRÉHERET *et al.*, 2011). It is important to note that the number of sites at which accidental captures were monitored varied among years.

Democratic Republic of the Congo

Accidental captures of sea turtles occur in the artisanal fisheries, and fishermen often sell the turtles to recover the costs of net repair due to turtle entanglement (OCPE 2006; Verhage, 2007). Apparently, there is no longer an industrial fishery in the country because of the civil war and economic problems (J. Fretey *pers. comm.*).

Angola

While sea turtle bycatch data is not officially recorded for Angola, there is evidence for widespread sea turtle bycatch in artisanal fisheries (Formia *et al.*, 2003; Petersen *et al.*, 2007; Weir *et al.*, 2007; Honig *et al.*, 2008; Moore, 2008). Weir *et al.*, (2007) reported instances of hawksbill, loggerhead, leatherback, and olive ridley interactions with the artisanal longline fishery in the Namibe Province of Angola; the year-round fishery is small and bycatch of sea turtles is reported to be 2-3 animals per month. In Palmerinhas, 48 strandings recorded had evidence of net marks (Weir *et al.*, 2007); discarded fishing nets were also observed to entangle 'several' olive ridleys and a leatherback in the same area (Weir *et al.*, 2007). There does not appear to be a directed take fishery for sea turtles, but incidentally caught individuals in small-mesh gill-nests, hand lines, or beach seines are consumed (Carr & Carr, 1991; Weir *et al.*, 2007). Fishermen at the coastal village of Mucuio are reported to care for injured and incidentally caught turtles and then return them to the sea (Weir *et al.*, 2007; Honig *et al.*, 2008).

Namibia

Bianchi *et al.* (1993) confirmed that green turtles, leatherbacks, loggerheads and hawksbills are incidentally caught in shrimp trawlers, gillnets, set nets, beach seines, longlines, and/or driftnets. The Namibian industrial pelagic longline fle*et al*one is estimated to claim 700 turtles per year (Petersen *et al.*, 2007). Data collected by an onboard observer in 2006 from the Namibian pelagic longline fleet recorded 38,000 hooks (18 sets), but no sea turtle bycatch data were officially recorded for the fleet (Honig *et al.*, 2008).

Regional bycatch records

Carranza *et al.* (2006) documented incidental capture of both leatherbacks (16 individuals, CPUE 0.38) and olive ridleys (9 individuals, CPUE 0.64) during 18 sets (23,400 hooks total) in the Gulf of Guinea by pelagic longlines. When sea turtle bycatch is not specifically measured in commercial fisheries, known fishing effort (i.e. number of hooks, sets, etc.) can be extrapolated to arrive at probable estimates of yearly incidental capture. Lewison *et al.* (2004) calculated that 30,000-60,000 leatherbacks and 150,000-200,000 loggerheads were taken as bycatch in the Atlantic as a whole in 2000. Pelagic longline fleets operating in the southern and central regions of the Benguela Current LME (which includes Angola, Namibia, and South Africa) are estimated to catch 4,200 sea turtles every year (Petersen *et al.*, 2007). Using extrapolations from published longline effort and bycatch rates, Honig *et al.* (2008) give a range of 7,600 to 120,600 incidentally caught each year in pelagic longline fisheries in the Benguela Current LME.

Observers occasionally present on board the French purse seiners in the eastern Atlantic (Gulf of Guinea) recorded captures of 3 species of sea turtles and a few unidentified turtles from 2006-2007—green turtles, olive ridleys, and Kemp's ridleys *Lepidochelys kempii* (Garman, 1880); their occurrence per set varied between 0 -1.87% and all turtles were released alive during observer trips (Chassot *et al.*, 2009).

CONCLUSIONS

Despite very active fisheries in the region, overall bycatch data are quite sparse and even nonexistent for some countries. Nevertheless, bycatch is probably extensive and quite high in the region and the impact of the different fisheries needs to be urgently evaluated so that mitigation measures can be subsequently developed.

It is generally agreed that bycatch rates are best obtained by consistent onboard observation of fishing activity. On industrial fleets, governments can enforce extensive observer coverage, but in small-scale fisheries, which according to the FAO incorporates >95% of the world's fishermen, implementation of onboard observation in artisanal fleets comes with substantial challenges. Many boats in developing countries are simply too small to accommodate onboard observers (Moore *et al.*, 2010; Lewison *et al.*, 2011). Also, small-scale fisheries tend to operate diffusely, increasing the cost of maintaining adequate observer coverage and sampling. Fishing villages and ports can be remote and difficult to travel to and from, further increasing the costs of a consistent observer program. Moore *et al.* (2010) have suggested that interviews show promise as a cost-effective tool to assess bycatch, especially if scientific studies can simultaneously gather similar information on fishing effort and bycatch rates to confirm the statistical robustness of the interviews.

Intentional take by fisheries is widespread and conservation programs in the various countries need to actively work towards minimizing this source of mortality and finding alternative sources of protein when necessary as well as compensation for prohibiting turtle take. Finally, prevalence and gravity of IUU fishing in African waters is not to be underestimated as it puts additional pressure on stocks that are already being fished at unsustainable levels, complicating stock management and bycatch monitoring efforts. While most IUU fishing is done by foreign industrial fleets (of non-African origin, usually from Asian countries), vessels from the West African countries themselves are also part of the problem: neighboring countries often cross each other's EEZs or venture inside the five nautical mile coastal zone reserved for artisanal fishing (Vogt *et al.*, 2010).

Given that the Atlantic coast of Africa supports globally important nesting and foraging areas for endangered sea turtles, it is essential to quantify bycatch in each of the major fisheries in the region, implement existing laws protecting turtles, minimize IUU fishing, and estimate and address intentional take of turtles in the local fisheries. Efforts must be directed to address the paucity of regional data so that wise and effective conservation and management strategies may be adopted for maintaining fish stocks and reducing bycatch.

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Importance of modeling in sea turtle studies

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ABSTRACT

Sea turtles spend most of their life in the water where they are almost inaccessible. Therefore, monitoring of these species uses various kinds of statistical and mathematical tools to reveal their hidden life. In this paper I describe two models applied to marine turtles. The sex determination in marine turtles is dependent on eggs incubation temperature. A mechanistic model that mimics sex determination in loggerhead turtle *Caretta caretta* (Linnaeus, 1758) is described. It permits to illustrate the use of simulation in sea turtle ecology. The other model permits to describe and analyze nesting season of marine turtles. It permits to quantify the number of nests during a season but also to analyze the phenology of nesting season. The use of quantitative models is absolutely necessary in the context of marine turtle studies.

KEY WORDS: Marine turtles, model, nesting season, sex determination, temperature, simulation

RESUMEN

Las tortugas marinas pasan la mayor parte de sus vidas en el mar, donde son casi inaccesibles. Por esta razón, el seguimiento de estas especies se hace mediante distintos tipos de herramientas estadísticas y matemáticas para revelar su vida oculta. En este artículo describo dos modelos que se aplican en el estudio de las tortugas marinas. En las tortugas marinas el sexo de las crías lo determina la temperatura de incubación de los huevos. Aquí se describe el modelo mecánico que imita esta determinación en la tortuga boba *Caretta caretta* (Linnaeus, 1758). Este modelo permite ilustrar el uso de la simulación en la ecología de tortugas marinas. Un segundo modelo permite describir y analizar la época de anidación de las tortugas marinas. Permite cuantificar el número de nidos durante la época de anidación pero también analizar la fenología de la época reproductora. El uso de modelos cuantitativos es absolutamente necesario en el contexto de los estudios sobre tortugas marinas.

PALABRAS CLAVES: Tortugas marinas, modelo, época de anidación, determinación sexual, temperatura, simulación.

LABURPENA

Itsas dortokek uretan ematen dituzte bizitzako ordurik gehien, beraien inguruko ezagutza oztopatuz. Baina badira beren bizitza ezkutua ezagutzera emateko eta hauen jarraipena egiteko erabili ditzakegun zenbait tresna, hala nola estadistika eta matematika hain zuzen ere. Artikulu honetan itsas dortoketan erabili ohi diren bi modelo deskribatuko ditut. Sexu zehaztapena itsas dortoketan, arrautzek duten inkubazio tenperaturen baitan ematen da. Hemen modelo mekaniko batek, benetazko dortokaren *Caretta caretta* (Linnaeus, 1758) sexu zehaztapena nola imitatzen duen deskribatu da. Hala itsas dortoken ekologian simulazioak nola ematen diren ikusiz. Bigarren adibideak itsas dortoken errute garaia aztertzeko eta deskribatzeko aukera ematen du; habiak zenbatu eta era berean errute garaiaren fenología aztertzeko aukera. Modelo kuantitatiboen erabilera beharrezkoa da itsas dortoken ikerketen testuinguruan.

GAKO-HITZAK: Itsas dortokak, modelo, errute garaia, sexu zehaztapena, temperatura, simulazioa

INTRODUCTION

In multidisciplinary Universities, students in Ecology can be easily recognized, as they are often clothed to be ready for field trip, sometimes even with binocular as necklace to observe birds. These students are often frustrated when they realize that scientific ecology is probably the biology field, which uses the most statistics, mathematics and various kinds of modeling. For example, a search in GoogleScholar with the two words Model and Ecology gives 1,280,000 outputs (Model and “Cellular biology” give only 226,000 outputs). We will see in this short review why ecologists, and particularly those studying marine turtles, use models.

Ecology is the scientific study of the distributions, abundance, share affects, and relations of organisms and their interactions with each other in a common environment (Begon *et al.,* 2006). Contrary to other field of biology, where the individuals are maintain out of the experience of variability of external conditions, ecology has an interest in organisms experiencing complex situations and interactions. The uses of model in ecology is intractably linked with the high level of complexity of the studied situations.

Mathematical descriptions of ecological system may be made for two quite different purposes, one practical and the other theoretical (Smith, 1974). Description with a practical purpose, have been called 'simulations'. If, for example, one wished to know how temperature will affects sex ratio in marine turtles, we need a good description on the effect of temperature on the growth of embryos, how temperature will affect the sexual phenotype of individual but also time series of temperatures. Then simulations can be built to anticipate the changing condition of the environment. For example in the context of global change, meteorologists produce models of earth temperature in 100 years and how populations will answer such a change will require model. We will see how the effect of temperature will affect the sex ratio of marine turtles using such a simulation.

The value of such simulations is obvious, but their utility lies mainly in analyzing particular cases. A theory of ecology must make statements about ecosystems as a whole, as well as about particular species at particular times, and it must make statement which are, true for many different species and not just for one. Any actual ecosystem contains far too many species, which interact in far too many ways, for simulation to be a practicable approach. In analyzing any complex system, the crucial decision lies in the choice of relevant variables.

Different kinds of mathematical description, which may be called model, are called for. Whereas a good simulation should include as much detail as possible, a good model should include as little as possible. A model cannot be used to predict the future behavior of whole: ecosystems, or of any of the species composing it. In Ecology, a model can be used when only a fraction of the studied system is known. For marine turtles, this situation is the most frequent. For example, males, juveniles and subadults are rarely seen, females are seen easily when they come to nest but they do not nest each year. And even when they nest, they can decide to deposit their eggs in a remote non-monitored beach. Then, even if "saturation tagging" program is done for one nesting place (RICHARDSON *et al.*, 2006), it does not remove the necessity to the use of modeling to take decision. Furthermore, tagging individuals is not probably free of consequence for the tagged individuals (NICHOLS *et al.*, 1998; NICHOLS & SEMINOFF, 1998). Then, it could be safer to tag a fraction of the population and to infer the global status based on a model. We will see how the nester density can be estimated from only a sampling a nesting females.

Other authors have made different kinds of categories in the model or simulation used in ecology, for example taking into account the kind of mathematical tools that are used (statistical models, differential equations) or if the model is deterministic or stochastic (MCCALLUM, 2000). The exact way the model or the simulation is done could be also dependent on constraints exterior to the biological system studied: the knowledge or habit of the researcher, limitation in computing time, available data in literature to gather data.

MARINE TURTLES FACE A HOT WORLD

In this section, I will not make a list of recipes on how turtles have been cooked along the ages, but rather describe a simulation used to study the impact of temperature on sex ratio.

Many species of oviparous reptiles, including crocodilians, a majority of turtles including all marine turtles, some lizards and the two closely related species of *Sphenodon* have displayed temperature-dependent sex determination (TSD). In these species, the differentiation of gonads into ovaries or testes depends on the incubation temperature of the embryo during a critical period of embryonic development designated the thermosensitive period (TSP) (MROSOVSKY & PIEAU, 1991; YNTEMA & MROSOVSKY, 1982). This period begins with the appearance of gonad during embryogenesis and encompasses the middle third of embryo development. It is approximately the same embryonic stages for any TSD species (BULL, 1987; FERGUSON & JOANEN, 1983; LANG & ANDREWS, 1994; PIEAU & DORIZZI, 1981; WEBB *et al.*, 1987).

Most of the data about relationship between temperature and sex determination in reptiles with TSD has been obtained from artificial incubation at constant temperatures. Whereas it has been demonstrated long time ago that TSD occurs also in natural conditions (PIEAU, 1974), the relationship between a time series of changing temperatures and sex ratio has been rarely investigated and when it was, rather crude relationship between some proxies of nest temperature and sex ratio have been used (GIRONDOT *et al.*, 2010).

Ample information indicates that reptile embryo developmental rate is dependent on incubation temperature (BOOTH, 2006). The growth of internal organs is also dependent on incubation temperature as the mass of most organs in turtles scaled to body size (PACKARD *et al.*, 2000). The main difficulties were to integrate the variation of incubation temperatures during the 15 days when the temperature influence sex determination. It has been solved using exponential recurrence equation (GIRONDOT *et al.,* 2010). The simulation is synthesized on figure 1.

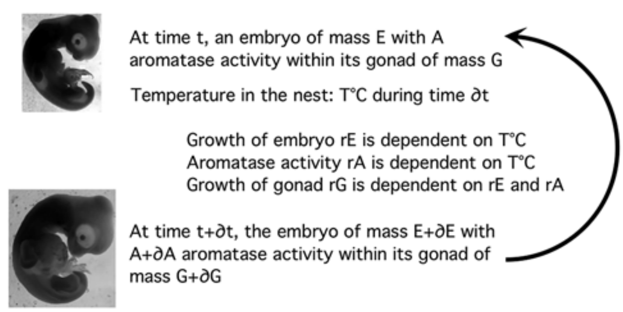

Fig. 1.- Recurrence used to simulate the growth of turtle embryos and the dependency of sex determination to temperature (adapted from DELMAS *et al.*, 2008).

The model fitted for the European pond turtle *Emys orbicularis* Linnaeus 1758 sex determination necessitates 36 parameters. It has been adapted to the slider turtle *Trachemys scripta* Schoepff 1792 to create a phenocopy of sex determination for this species (DELMAS, 2006). A phenocopy is an individual whose phenotype under a particular environmental condition is identical to the one of another individual whose phenotype is determined by the genotype (GOLDSCHMIDT, 1935).

Here I construct a new phenocopy of sex determination for *Caretta caretta* (Linnaeus, 1758) based on data from Greece in Mediterranean (MROSOVSKY *et al.*, 2002). In this study, 184 eggs incubated at 9 constant incubation temperatures were sexed. The best model describing these data is a symmetric logistic model (GODFREY *et al.*, 2003) with a pivotal temperature equal to 29.3°C (SE 0.1°C) and a slope describing the rate of change of sex ratio according to change of temperature equal to -0.26 (SE 0.06). The model cannot be rejected to fit the data (p= 0.94).

By manipulating the threshold of gonadal estrogen to feminize an embryo in the model and the variability of aromatase activation by temperature feminize (ra parameter in DELMAS *et al*., 2008), it has possible to mimic the pattern of sex determination of Mediterranean *C. caretta* (Fig. 2). Using this phenocopy of *C. caretta* sex determinaton, it is thus possible to mimic change of incubation temperature and analyses the output on sex determination. Fluctuating regime of incubation temperatures has been computer-generated from a mean temperature of 23°C to 30°C. For each regime, the mean daily temperature was obtained randomly around the mean temperature (SD 5°C) and the nycthemer change of temperature was less than 1°C (KASKA *et al.*, 1998; MAXWELL *et al.*, 1988). Two examples of computer-generated traces of temperature are shown in figure 3A. Hundred regimes were generated for each mean temperature and 100 eggs were incubated for each simulated regime. The male proportion for these 10000 eggs is shown in figure 3B along with the male proportion if they were incubated at the same constant temperature. Clearly the introduction of variability in the nest temperatures feminizes the sex ratio. Such a conclusion is important because the future climate change will include both an enhancement of the variability of temperatures as well as increasing of temperatures. Both factors will contribute to feminization of marine turtle populations.

Finally, the comparison of both curves in figure 3B clearly shows that the curve of sex ratios obtained at constant temperatures must not be used as a guide when analyzing the incubation temperature from natural nest with changing temperatures (contray to IKARAN SOUVILLE, 2010 for example).

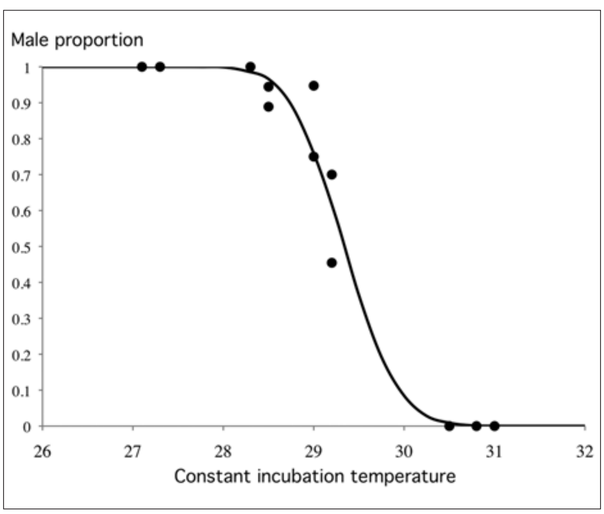

Fig. 2.- Male proportion in two nests of *Caretta caretta* from Greece incubated at various constant temperature (black points; MROSOVSKY *et al.*, 2002) and output of a mechanistic model of sex determination for *Caretta caretta* that reproduced these sex ratios (solid line).

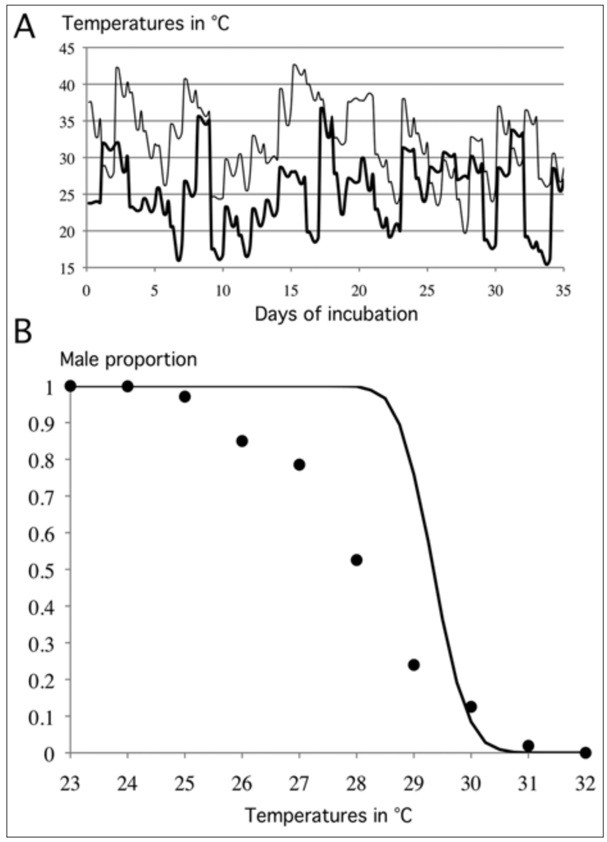

Fig. 3.- Two examples of computer-generated nest incubation temperature traces with mean temperature being 25°C (bold) or 32°C (faint). (B) Points represent the male proportion for 10000 eggs incubated in fluctuating temperatures regime with varying mean temperature (see A). The curve represents male proportion if the eggs were incubated at the same constant temperature.

FIELD WORKERS FACE A HUGE WORLD

To my knowledge, the number of beach kilometers used by marine turtles around the world has never been calculated, but it is huge for sure. Monitoring such a huge world is impossible whereas our knowledge of the status of marine turtles are directly linked to this monitoring (see for example SEMINOFF, 2002). This problem is usually solved, by taking a number of samples from around the habitat, making the necessary assumption that these samples are representative of the habitat in general. To better visualize this idea, imagine an 8x8 checkerboard. Put some pieces on the board and ask somebody else how many pieces are present. Various strategies can be used to answer the question. If you want an exact number, the observer has no other choice than explore entirely the board and count how many squares are occupied. Then you will obtain an answer free of error, but you will wait to get this answer. Alternatively, the observer can choose X squares, count how many pieces N are present on these X squares and then the best estimate of the number of pieces is 64.(N/X). Doing such a strategy, he will answer fast if X is not large but he will make an error especially if X is small relative to 64. Now imagine that the checkerboard is a beach and pieces are turtle nests: exactly the same strategy can be used. We can use also other strategies to estimate the abundance of turtles on nesting beaches. Indeed, the decision-making process in sampling must be viewed as a flexible exercise, dictated not by generalized recommendations but by specific objectives (KENKEL *et al.*, 1989). Generally for marine turtles, the specific objective is not to estimate the number of nests for one particular night but at the scale of the entire nesting season.

In most part of the world, the marine turtles are not present on nesting beach all along the year. The temporal distribution of nests during a season tends to be bell- shaped. This pattern permit to gain information because when the number of nests is known for a day D, the temporal autocorrelation can be used to get information on the number of nests for day D±x. Various authors have proposed solutions to estimate the number of nests for a nesting season based on sampling of night counts during the season (GIRONDOT *et al.*, 2006; GRATIOT *et al.*, 2006; WHITING *et al.*, 2008) but all these models suffer from weakness (reviewed in GIRONDOT, 2010). Recently, a new model has been proposed that solves these weaknesses (GIRONDOT, 2010). The bell-shape is rendered with a combination of two sinus functions and the distribution of nests around is modeled with a negative-binomial distribution.

To illustrate here the advantage of this model, data gathered for leatherback turtles *Dermochelys coriacea* (Vandelli, 1761) on Yalimapo beach (French Guiana) in 2003 are used. Two categories of patrols were done: seventy-eight 4-hours night patrols and seven 6-hours night patrols all centered on the peak of high-tide. These two categories of patrols were obtained from a same nesting season and then a single model to describe nesting season shape has been used. Only the scaling factor (Max) is fitted separately for the two categories. The fitted nesting season is shown on figure 4. The Max value for the 4-hours patrols is 40.61 (SE 2.49) and the Max value for 6-hours patrol is 52.56 (SE 6.58).

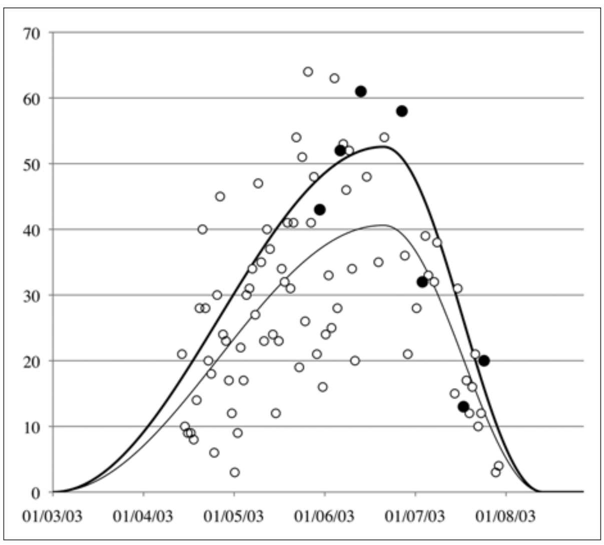

Fig. 4.- Male proportion in two nests of *Caretta caretta* from Greece incubated at various constant temperature (black points; MROSOVSKY *et al*, 2002) and output of a mechanistic model of sex determination for *Caretta caretta* that reproduced these sex ratios (solid line).

Thus we can conclude that the 4-hours patrols were missing 22% (confidence interval at 95%: 10-31%) of the nesting turtles as compared with the 6-hours patrols.

The software that implements this model can be downloaded freely here: http://www.ese.upsud.fr/epc/conservation/Girondot/Publications/Marine_Turtles_Nesting_Season.html.

It has been used to compare nesting season between two beaches (GIRONDOT, 2010) or between years and species (GODGENGER *et al.*, 2009).

CONCLUSION

The two examples used in this paper fit well the two categories defined by SMITH (1974): the simulation used to describe sex determination uses 36 parameters only for the biology part and complex time series of temperatures; on the other hand, the nesting season of marine turtles can be described with only 4 parameters. But many other models have been used in sea turtle studies. For example, a large number of papers have been published that use various population dynamic models, from very simple to very complicated ones (CHALOUPKA & BALAZS, 2007). Anyway, sea turtle ecologists must have a mathematical and statistical culture to solve more and more complex problems.

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Succeeding in sea turtle conservation: not just counting the decline

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ABSTRACT

Marine turtle conservation is complex and requires long-term interventions. Long-term projects require large investments in terms of finance, physical resources and human capital, and the decadal time-frames provide the opportunity for population loss even in the face of conservation action. Compounding this sea turtles evoke a range of personal responses from conservationists and scientists which often blur the objectivity of conservation initiatives, and projects and programmes across the globe frequently document the decline of turtle populations without implementing appropriate conservation action. Herein I reflect on the value and commonplace of documenting population downward trends, and use a non-exhaustive series of examples of effective measures with relatively rapid conservation outcomes as examples of what may be required for marine turtle conservation to succeed.

KEY WORDS: Sea turtles, conservation actions, population loss.

RESUMEN

Las acciones de conservación de tortugas marinas son complejas y requieren intervenciones a largo plazo. Los proyectos a largo plazo, a su vez, requieren grandes inversiones en términos económicos, de recursos materiales y capital humano. Los periodos decenales permiten constatar los declives en las poblaciones, incluso en actuaciones de conservación. Para agravar la situación, las tortugas marinas evocan una serie de respuestas personales de los conservacionistas y los científicos que a menudo pierden la objetividad de las iniciativas de conservación y los proyectos y programas en todo el mundo con frecuencia documentan la disminución de las poblaciones de tortugas, sin aplicar las medidas adecuadas para su conservación. En este artículo, se refleja el valor de documentar las tendencias de disminución de las poblaciones y el uso de las series no exhaustivas de ejemplos de medidas efectivas con resultados relativamente rápidos en cuanto a conservación, como ejemplos de lo que las tortugas marinas pudieran requerir para su éxito de conservación.

PALABRAS CLAVES: Tortugas marinas, actuaciones para la conservación, declive poblacional.

LABURPENA

Itsas dortoken kontserbaziorako ekintzak, konplexuak eta epe luzera begirakoak behar dute izan. Hau dela eta epe luzerako egitasmoek ere inbertsio ekonomiko handia behar izaten dute, bai gizakiei baita ornigaiei dagokienez ere. Hamarkadek, populazioen gainbeherak ikusteko aukera ematen dute baita kontserbaziorako egitasmoetako ekintzetan ere. Gainera egoera hau gehiago nabarmentzen da zientzilari eta naturzaleek ikuspegi objetiboaz aldendu eta kontserbaziorako neurririk hartu gabe gainbehera hauek azpimarratzen dituztenean. Artikulu honetan, itsas dortoken populazioen gainbeherarako joerak dokumentatzeak nolako garrantzia duen azpimarratzen du baina baita kontserbazioari dagokionez, beste neurri eraginkor batzuek izan dituzten emaitza azkarrak ere, itsas dortokek, beren kontserbaziorako beharko lituzketen neurrien adibide gisa.

GAKO-HITZAK: Itsas dortoka, kontserbaziorako ekimenak, populazioen gainbehera.

INTRODUCTION

Not so long ago I was in a country discussing the potential for sea turtle conservation with a group of people from various agencies when a well-known and respected local ‘turtle’ person exclaimed “But Nick, we have been working for twenty-seven years and yet our turtle populations continue to decline alarmingly! What should we do?” So I said “Whatever it is you’re doing now, I’d stop. If it isn’t working, there’s not much point in continuing…” Looking back this seems a bit abrupt, but it got me thinking about what makes conservation approaches for turtles significant and of great impact while others simply continue to document population declines.

Numerous projects and programmes across the globe ‘document the decline’ of turtle populations without really taking appropriate conservation action. Malaysia documented the leatherback population decline in Terengganu until it disappeared (Chan & Liew, 1996). Pakistan has seen their olive ridley population practically disappear and the green population substantially diminished (Asrar, 1999; Kabraji & Firdous, 1984). I could go on… I would argue that counting turtles alone does not save them, and that bold and decisive measures, which often take considerable courage and determination to implement, can make a significant difference. I understand fully that many conservation measures take years to implement and show results. These programmes work in cases where the conservation resources are sufficient and available over long periods, and turtle populations are sufficiently robust to withstand continued threats until conservation measures have the intended effect. Meeting both requirements is often impossible: either resources dry up or turtles do. Sometimes what started out being the reason for initiating a conservation intervention stops being a priority, and other interventions are needed. Long-lasting programmes need continued reevaluation, both of their objectives and their outcomes, because often what was a problem one decade is no longer the next. I do not disregard or disrespect any of the protection measures and awareness programmes and beach monitoring programmes currently out there, although I will admit that the implementation of these seems at times arbitrary. Rather, I use a series of examples to highlight how conservation can be substantially accelerated through courageous, even audacious actions, decisions and/or programmes which have lead to a well-documented difference. After reading of population declines, I thought it was time for some good news.

Here I look at some of what I call 'bold steps' that have been taken by individuals, agencies and organisations, which have had substantial immediate and long-term effects on turtle populations. I have no 'scientific' measure for what 'substantial' entails, but used the following criteria as my personal guideline: 1) turtle population(s) prior to the activity were declining, often at alarming rates and/or were under great threat; 2) the activity was clearly defined and recognizable for being a unique, standalone action rather than the result of cumulative and complementary activities; 3) subsequent to the action turtle population(s) enjoyed a reversal of trend(s) and were stable; and 4) today are recovered or recovering at a rapid rate. This paper is not a thorough examination of everything that has ever been done for sea turtles, and it is concerned more with processes than specific populations. I hope the examples I list herein provide impetus for individuals, agencies and organisations that face declining turtle population trends with ideas and (hopefully) catalyse a renewed approach to turtle conservation.

Marine turtles are highly valued marine species that arguably are essential to ocean health, and which have garnered the attention of conservationists, government officials, the public and the media. They support substantial aspects of many economies through tourism, they confer indirect benefits which ensure that local fisheries are sustained, and they aesthetically enhance coastal seascapes. They are also marine substrate engineers, and nutrient transporters (PREEN, 1996; BOUCHARD & BJORNDAL, 2000). Sea turtles and their products have been used by mankind for thousands of years as an important food source as well as a host of other uses. Sea turtles play valuable ecological roles in marine ecosystems as consumers and prey among other roles (LANYON *et al.*, 1989; BJORNDAL, 1996; BJORNDAL & JACKSON, 2003), and they are indirectly linked to seabed and fisheries stability (TELUCKSINGH *et al.*, 2010). They function as key individuals in a number of habitats, and can be indicator species of the relative health of habitats that have a tangible value to society. These habitats support commercial fish and invertebrates (found in seagrass beds, open oceans and coral reefs, among others) that are valued by mankind. For example, green turtles crop seagrasses and maintain the health of these important habitats. Seagrass beds can also be developmental grounds for shrimp and other larvae, which are the building blocks of economically-valuable shrimp and fin-fisheries industries. Today, turtles also have non-consumptive uses such as tourism, education and research. They posses endearing qualities which evoke considerable passion amongst native peoples, conservationists and most people with whom they come in contact. In many parts of the world, sea turtles and humans share cultural links that can elicit deep-rooted reactions to conservation action (CAMPBELL, 2003).

Being long-lived (HEPPELL *et al.*, 2003) and of late maturation (MILLER, 1997) they face a multitude of threats over long periods of time. These threats include mortality in mechanized and artisanal fisheries, egg and turtle consumption, and habitat degradation and loss, amongst others (LUTCAVAGE *et al.*, 1997). Sea turtles are evolutionarily prepared to suffer high mortality rates in the early life stages, but their large juveniles and adults have substantially high reproductive and population maintenance value (CROUSE *et al.*, 1987, HEPPELL *et al.*, 2007). The loss of a small proportion of eggs or hatchlings may be compensated by their demography, but the loss of a older animals can have substantial negative effects on population size (CROUSE *et al.*, 1987). Compounding this, population structure whereby turtles comprise distinct genetic stocks (MORITZ, 1994) or management units (WALLACE *et al.*, 2010) precludes substantial interaction of stocks and restricts gene flow. In practice this means that turtle populations that have been decimated are not about to rebound through massive immigration from outside populations. Hatchling sex is dependent on temperature during incubation, particularly during the middle of the incubation period (MILLER & LIMPUS, 1981; MILLER, 1985), a critical biological adaptation that often comes into play in conservation schemes. Additionally, hatchling sea finding and orientation are guided by visual stimuli (WITHERINGTON & BJORNDAL, 1990) whereby altered ambient lighting may disorient turtles and cause high levels of mortality. To complicate matters, hatchlings disperse into open ocean areas, adult turtles migrate great distances between foraging and nesting habitats, and juveniles and adults can occupy multiple foraging grounds at different stages of their life cycle (MUSICK & LIMPUS, 1997).

Given these biological characteristics and the myriad threats they face, conservation of sea turtles is a massive challenge. Management plans for marine turtle conservation and/or recovery run into dozens of pages and address hundreds of actions. Since the 'conservation awakening' for sea turtles by Archie Carr in the 1960s and thereafter (e.g. CARR, 1967; 1986a,b) and his pioneering work in Costa Rica, conservation programmes have struggled to meet the varied threats, and costs have grown exponentially. The challenges have been taken up across the globe and while some interventions have worked wonders, others have been left lacking.

DOCUMENTING THE DECLINE

Documenting the decline in populations is unfortunately a major part of modern science. Many turtle workers rally around beach monitoring programmes that faithfully count fewer and fewer turtles each year. The sea turtle scientific literature is littered with scientific descriptions of population declines: Malaysia's decline of the leatherback is a good example (CHAN & LIEW, 1996), and the 90% decline of the green turtle in the early part of the 20th century in Sarawak (LEH, 1985) was equally alarming. BJORNDAL *et al*. (1993) report on the decline of hawksbill turtles at Tortuguero. WITHERINGTON *et al*. (2009) document the decline of loggerhead nests in Florida. Laura Sarti and colleagues recorded the early decline of the leatherback in Mexico (SARTI *et al*., 1996), and SPOTILA *et al*., (2000) summarise the precipitous decline of the leatherback across the Pacific. Luckily for turtles, these people know what to do with the information they gather to influence conservation. The documentation phenomenon is not only restricted to sea turtles – it is prevalent in a wide diversity of fields: KRYSKO & SMITH (2005) highlight how Kingsnakes *Lampropeltis getula* (Linnaeus, 1766) declined until disappearing completely from Florida. The Steller's sea cow *Hydrodamalis gigas* (Zimmerman, 1780) was hunted to extinction (ANDERSON, 1995) while hunters and scientists documented the dwindling numbers. The African manatee *Trichechus senegalensis* Link, 1795, was counted for years until it reached the brink of extinction (NAVANZA & BURNHAM, 1998), and WHITE (1995) describes how species after species of frogs disappeared from Australia amidst countless research programmes. GARBER & BURGER (1995) highlight a 20-year decline in wood turtles *Clemmys insculpta* (Fitzinger, 1835) as a result of human recreation, and BIESMEIJER *et al*. (2006) report on declines in pollinators and link this to declines in insect-pollinated plants, while LUNDMARK (2008) describes lessons learnt from declines in species diversity in forest studies.

I realise that this process drives subsequent conservation action in an area, but in many ways, documenting the decline is becoming synonymous with conducting wildlife research. Ben Rawson, a primatologist with Conservation International, commented in an interview in 2007 with Krista Mahr, a reporter from Time/CNN, that primate surveys in Southeast Asia had turned into a process of "documenting the decline of these species for science". But documenting a population decline should only be considered a catalyst to spring into action, not a conservation activity in itself. Assessment of population trends and threats are critical to understanding conservation needs and for forming conservation strategy. The problem lies when these are conducted exclusively, in the absence of any conservation action. In many cases, while beach patrol units are out there counting turtles, their numbers often just continue to decline, in need of some effective strategy to reverse the trend. More often than not, immediate impacts are needed to stem the declines before the populations collapse.

OFF-TARGET CONSERVATION APPROACHES

All too often I come across cases where the conservation activities being implemented are not addressing the key threats. I do not have a global overview of who does what, but my travels through the Indo-Pacific and many other parts of the globe have left me in no doubt that while many projects and programmes work well, others are off-target. For instance, in one place where fisheries bycatch was an obvious threat (hundreds of shrimp trawlers sitting just offshore) erosion of the nesting beaches was being addressed. In another, a concern over egg poaching drove a massive egg-relocation effort when again fishery pressure was the key issue. In neither of the projects had anyone considered assessing fishery bycatch. Sometimes these off-target efforts, though well-intentioned, are linked to a basic lack of grounding in turtle biology, but often they are the 'low hanging fruit' option – the easier problem to tackle. Very often projects implement piecemeal efforts with no longer-term strategy, no link to data needs, or no clear cause-effect linkages. Some projects tag some turtles in a season, with no follow-up plans for monitoring recaptures. A simple look at recapture rates for long-term saturation tagging projects highlights just how many tags one would have to put out to hope for a realistic return rate. Other projects deploy satellite transmitters but never follow up with the country where their turtles end up. While still others relocate thousands or clutches of eggs to hatcheries when there are no major poaching or predator threats – or where these could be addressed through more efficient beach patrols or nest protection schemes. All too often the turtle populations at these sites continue to decline (there are a few exceptions!) suggesting to me that the piecemeal approach, of efforts here and there that are not necessarily aligned, and which often take decades to implement, is not the best recipe for turtle conservation, and that effective, and sometimes aggressive and audacious interventions are needed. Indeed, a look at some examples of these supports this claim.

THE BOLD AND THEIR CONSERVATION OUTCOMES

Given the criteria outlined above, I turned up a suite of what I would describe as bold initiatives, which can be categorised into three key groupings: 1) Major turtle-related policy shifts with long-lasting impacts; 2) Direct interventions by Governments or individuals; and 3) Simply trying something new, even when there were wide misperceptions about the chances of success.

In the 1950s, one of the forefathers of the modern-day turtle conservation movement, Dr. Archie Carr, came across a black sandy beach some 50 miles north of Limon, on the Caribbean coast of Costa Rica, where hundreds upon hundreds of green turtles laid their eggs. But local poachers had long been aware of the location of the site, turtles and eggs were a valuable commodity, and the population was in steep decline. Turtles were harvested, consumed and traded to international markets. Dr. Carr and the Caribbean Conservation Corporation (the organization Dr. Carr helped form to carry out the annual nest monitoring and protection program at Tortuguero) suggested to the Costa Rican government that all of Tortuguero beach be set aside as a National Park and that turtle hunting be banned in the country. And so, it was that with the help of a great many people and institutions, as well as the people of Tortuguero, these recommendations came to pass in 1975 (Law 5680) with the creation of the Tortuguero National Park and in 1999 with the complete ban on turtle hunting in Costa Rica. Today, the Tortuguero green turtle colony (by far the largest remaining in the Western Hemisphere) has made a remarkable recovery. While foraging ground mortality still occurs (CAMPBELL & LAGUEUX, 2005) this does not seem to have impacted the steady growth in nesting numbers (BJORNDAL *et al.*, 1999), highlighting just how important it is to protect turtle nesting grounds. Tortuguero is one of the two largest remaining green turtle rookeries in the world (TROËNG & RANKIN, 2005), thanks to key interventions by an inspirational leader, and his many supporters and collaborators that precipitated decisive action on the part of the government and people of Costa Rica.

On a remote beach in Tamaulipas, on Mexico's Gulf coast, once nested thousands upon thousands of Kemp's ridley *Lepidochelys kempii* (Garman, 1880) sea turtles. An amateur video in 1947 documented an *arribada* style nesting event, where tens of thousands of turtles crawled and bumped over each other to lay eggs at the same time. But by the 1960s Kemp's ridley nesting had declined by some 80% and showed no signs of stopping. The turning point came about when Mexico's Instituto Nacional de Investigaciones Biológico-Pesqueras started patrolling the beaches in 1966, and in 1977 when the key nesting beach was protected with armed guards to deter egg poachers (MARQUEZ *et al.*, 1999), with a concurrent prohibition of fishing in nearshore waters off the reserve. By declaring the area a national reserve and fiercely protecting the turtle nests and simultaneously reducing bycatch offshore, these activities prevented the extinction of the Kemp's ridley. Today the Kemp's ridley is staging an amazing comeback (MARQUEZ *et al.*, 2001; CROWDER & HEPELL, 2011), and would likely have been lost to humanity if it were not for the timely and bold intervention of the Mexican people.

Pushing the boundaries even further, and in the face of widespread egg consumption and traditional uses, the 1990 complete ban on harvest of sea turtles and their eggs in Mexico was another bold and effective move by the Mexican government, in my opinion. In May 1990 the President of Mexico Carlos Salinas de Gortari announced a total and permanent ban on the capture and trade of all sea turtle species and related products in Mexico's waters (ARIDJIS, 1990). Working tirelessly behind the scenes to make this happen were countless inspiring individuals, among them Georgita Ruiz, Rene Márquez, Raquel Briseño, Daniel Rios, Alberto Abreu-Grobois, and many others. As a result, in La Escobilla, there has been a dramatic increase in olive ridley *Lepidochelys olivacea* (Eschscholtz, 1829) nests from 50,000 in 1988 to over 700,000 in 1994 to more than a million nests in 2000 (MÁRQUEZ *et al.*, 2002). If the government had waited until everyone was in agreement about such a ban, chances are we would still be waiting. With this decision in the background, Mexican conservation agencies added a legal foundation upon which to address bycatch, poaching and illegal consumption.

In the early 1970s populations of turtles in Malaysia were all suffering dramatic declines. In peninsular Malaysia turtles had crashed, with reported declines of up to 99% (IBRAHIM, 1993). The Terengganu leatherback *Dermochelys coriacea* (Vandelli, 1761) was well on its way to local extirpation, the Sarawak green turtle *Chelonia mydas* (Linnaeus, 1758) egg harvest was drying up, the olive ridley, was fast disappearing from Malaysian shores. The turtles in Sabah were facing a similar fate. The government over there had tried closed seasons, purchasing eggs from the traders, and had enacted legislation to protect turtles, but nothing seemed to work. That was when the Sabah State government stepped in and purchased the islands outright from the local inhabitants and turned them into a protected area (BASINTAL & LAKIM, 1993). In its day this was a bold and very expensive move, but today the Turtle Islands Park boasts the only robust and growing population of turtles in all of Southeast Asia (SHANKER & PILCHER, 2003).

Cuba was once a willing partner in the trade in hawksbill *Eretmochelys imbricata* (Linnaeus, 1766) shell. With access to large tracts of the hawksbill's Caribbean range, Cuba amassed huge stockpiles of shell over the years (CARRILLO *et al.*, 1999). But when it first reduced, and then eliminated, all legal take of hawksbills, the impressive move contributed to strong population recoveries region wide. The Cuban turtle fishery was closed in 1994 at all but two traditional harvest sites (Isla de la Juventud and Nuevitas). A 2008 moratorium prohibited the catch in these last two sites, creating a nation-wide ban for an indefinite time. Concurrently, the main nesting and feeding areas for turtles gradually came under special protection, most of them as National Parks (e.g. Peninsula de Guanahacabibes, Jardines de la Reina, San Felipe Key and Cayo Largo). Genetics research by BOWEN *et al.* (2007), originally used to support arguments for the cessation of Cuban trade (MORTIMER *et al.*, 2007) link the Cuban hunting grounds with key nesting grounds throughout the Caribbean, and today these linkages are demonstrating how the Cuban end to legal harvests is helping regional nesting aggregations achieve astonishing comebacks. For example, at Mona Island in Puerto Rico, nesting numbers are up 700% in the last 20 years, and continue to rise there 10-20% annually (DIEZ & VAN DAM, 2006; DNER, 2010). Similarly over in the Yucatan peninsula, population recovery has been evident since then (GARDUÑO-ANDRADE *et al.*, 1999), and in Barbados (BEGGS *et al.*, 2007), and while the jury is still out on a definitive cause-effect relationship, Cuba's bold and very effective move is suggestive of great regional impacts, originally negative, and subsequently positive.

Similarly bold, Indonesia designated green turtles as a protected species in 1999 despite controversial use of green turtles in religious ceremonies and through cultural traditions in Bali, and historical take of adult turtles from both nesting and foraging areas across many parts of the archipelago. The sheer size and diversity of Indonesia poses a variety of challenges for turtle conservation: there are 33 provinces comprising over 17,000 islands covering spread over some 6 million km^2. National legislation is enforced at a provincial level, with varying degrees of autonomy and success. Massive exploitation of green turtle eggs took place since the 1900's, when turtle eggs were used as royal gifts (such as in the Derawan Islands), but which later developed into large-scale, unregulated collection of eggs for commercial purposes. Based on records from the local office of Marine Affairs and Fisheries, some two to two and a half million green turtle eggs were collected at just about every island each year from 1985 to 2000 (ADNYANA, 2003). Prior to 2000, an estimated >30,000 turtles were traded legally in Bali alone using a quota system. But then all turtle species were protected by the Peraturan Pemerintah Republik Indonesia No. 7 & 8 passed in 1999 through which all forms of turtle trade are prohibited, and while there are still many hurdles to overcome, this decisive move set the legal scene for greater control and management than was ever possible previously in Indonesia.

Along the same lines, Hawaii's listing of its endemic green turtles in 1975 under State Division of Fish and Game Regulation 36 (BALAZS, 1976; BENNETT & KEUPER- BENNETT, 2008), a few years before green turtles were listed under the US Endangered Species Act (ESA), led to near-complete cessation of harvest, a bold move which was likely the main cause for the recovery of the Hawaiian green turtle stock. The Hawaiian green turtle population had been harvested in the 19th century during expeditions to the Northewestern Hawaiian Islands (AMERSON, 1971; BALAZS, 1980) and the pressure persisted at foraging grounds of the main Hawaiian islands until the mid-1900s. Commercial harvest began in the mid-1940s in part due to restaurant demand and tourism which increased significantly in the 1960s and early 1970s (BALAZS, 1980; WITZELL, 1994; CHALOUPKA & BALAZS, 2007). Compounding this there was additional unregulated traditional harvest by native Hawaiian and other Pacific Islander communities in Hawaii. By the mid 1970s, the Hawaiian green turtle population was over-exploited and reduced to approximately 20% of pre-exploitation numbers, but since the enactment of state and federal ESA protections in the 1970s the number of nesting green turtles has increased dramatically over the past thirty years with an estimated annual growth rate of 5.7% per year (BALAZS & CHALOUPKA, 2004; CHALOUPKA *et al.*, 2008). Despite the cessation of harvesting and protection under State and Federal laws, occasional illegal harvesting of green turtles still occurs in Hawaii, but this does not appear to be hindering population recovery.

A few bold moves that had indirect impacts on sea turtles are also noteworthy. The promulgation of the US Endangered Species Act (Public Law 93-205) in 1973 with its specific enforcement penalties was a critical step in providing legal protection to species, turtles included, and established the foundation upon which conservationists and government agencies grounded their turtle-related protection activities. Dr. Russell Train was appointed by President Nixon to draft the ESA, and he and his team incorporated new principles and ideas into the landmark legislation which transformed environmental conservation in the United States. Without the ESA, there would likely be no turtle excluder devices (TEDs), no lawsuits to close fisheries in which bycatch is an issue (such as the Hawaii longline closure), no nest relocation in the face of natural and anthropogenic threats (such as during the recent Gulf of Mexico oil spill), nor any restrictions on harvests and domestic trade (as noted earlier for Hawaii). The ESA was very bold move to comprehensively address wildlife conservation, and unfortunately and surprisingly, not all turtle range countries have anywhere near such stringent legislation.

Turtles require several key habitats to survive. They need beaches to lay eggs, but they also need vast expanses of marine habitats in which to feed and grow. So it was bold indeed when farther across the Pacific, the establishment of the Great Barrier Reef Marine Park by the Commonwealth of Australia (Great Barrier Reef Marine Park Act 1975), created the then largest marine park in the world spanning 344,400 km^2 in a tremendous step that resulted in the protection of vast tracts of turtle nesting and foraging habitat. This was further supported by the Park's World Heritage listing in 1981 (sea turtles were a specific value identified in the WH listing process). Today the park, located in the Coral Sea off the coast of Queensland in northeast Australia, is managed by the Great Barrier Reef Marine Park Authority to ensure that it is used in a sustainable manner through a combination of zoning, management plans, including co-management plans with indigenous peoples, permits, education and incentives, all of which have helped turtle populations flourish.

A commonly raised cause for concern with sea turtles is the ubiquity of plastic in our oceans. With alarming frequency sea turtles mistakenly ingest plastic bags because they resemble sea jellies (MROSOVSKY, 1981) and hard plastics when fouled and disguised by goose barnacles and macro algae (WITHERINGTON, 1994). More than a million birds, tens of thousands of whales, seals and turtles and countless fish worldwide are killed by injesting plastic rubbish every year (LAIST, 1997). So it is bold indeed when countries take drastic moves and ban the use of plastics entirely. In March 2002, Bangladesh declared an outright ban on all polyethylene bags after they were found to have been largely responsible for the floods that submerged two-thirds of the country by choking the drainage systems in 1988 and 1989. On the 4th of March 2005, the President of Eritrea announced a full ban on plastics of any kind in the country, citing blocked gutters, choked farm animals and marine wildlife, soil pollution and aesthetic reasons. In 2009 Papua New Guinea joined the fray, and the import, manufacturing, sale and use of non-biodegradable plastic shopping bags was banned. On the 5th of January 2011, Italy followed suit, even though it received a wave of backlash by critics who were worried it could not be done. To date, at least Australia, Belgium, Bhutan, Botswana, China, Eritrea, Ethiopia, Germany, India, Ireland, Italy, Japan, Kenya, Malta, Maui (US), Papua New Guinea, Philippines, Samoa, San Francisco (US), Singapore, Somalia, South Africa, South Korea, Sweden, Turkey, Uganda, and Zanzibar (Tanzania) all have some form of plastic bag ban in place. These bans are bold indeed, and surely a good move for sea turtles.

Over the years, it has been interesting to see people try something new, bold and even audacious even, where concerns over the novelty and viability were ignored and from which exciting new approaches to conservation evolved. The Seychelles islands host one of the five largest remaining populations of hawksbills in the world, although in the latter half of the 20th century their numbers declined alarmingly (MORTIMER, 1984, 1998). Confronted with this, the Seychellois government gradually implemented all the right measures: stopping people from killing turtles on the beaches, revegetation of nesting beaches, implementing an artisan compensation and re-training scheme for those involved in the shell trade, honouring its international commitments (such as to CITES), providing legal protection and conducting thorough monitoring and research programmes to inform decision-making. But it was probably the 1998 public burning of its stockpile of raw hawksbill shell during the 1998 Miss World Pageant that got the world's attention. From the late 1960s to the early 1990s, most of the nesting females had been killed at the nesting beaches, often before laying any eggs (MORTIMER, 1984). The turtles were slaughtered for their shell, destined for the curio markets in Japan. In 1993 the government banned the sale of hawksbill shell products, and some 2.5 tons of raw hawksbill shell were purchased from local artisans (COLLIE, 1995). Then, in November 1998, in conjunction with the Miss World Pageant, the government publicly burned the stockpile to demonstrate it felt the turtles had far greater value as live animals than as dead shells (MORTIMER, 1999). The government was of the opinion that live hawksbills would bring more revenue to Seychelles (as a tourist attraction), and had made a public demonstration that poaching of hawksbills would not be tolerated. Turtle conservationists were of two minds as to the value of the event and the loss of the shell stockpile, but one thing is for sure: it was different, it was bold, and it got everyone's attention.

By the late 1970s the Kemp's ridley population at Rancho Nuevo was down to an estimated <500 nesting turtles and while beach protection was underway on key beaches in Mexico, the population continued to decline. So a US and Mexican team comprising the Instituto Nacional de la Pesca of Mexico, the U.S. Fish and Wildlife Service, the National Park Service, the National Marine Fisheries Service and the Texas Parks and Wildlife Department designed an audacious and controversial headstart project, which incubated eggs and reared the hatchlings until they were a year or so old. The idea back then was to allow the turtles to grow beyond a size at which natural mortality decreased substantially. Some 20,000 eggs were brought up by plane over ten years from Mexico to Padre Island, Texas, and then the hatchlings were imprinted on the beach and in nearshore waters at South Padre before being reared in tanks (KLIMA & MCVEY, 1982; MANZELLA *et al.*, 1988). The small juveniles were then tagged as they were released, in the hopes of documenting the establishment of a new nesting colony. While some argued the project had no way of determining success and others that it was a mitigation measure for existing threats, one thing is for sure: the headstart project was bold and ingenious for its time, and spurred greater research and conservation efforts for the Kemp's ridley along the way (BYLES, 1993). It took some creative thinking to put it together, and trialed a relatively small number of eggs (minimal risk) in the hopes of devising a strategy to rapidly repopulate depleted turtle populations (maximum returns). The jury is still out on how successful the project was at a population level, but today there are more and more headstarted Kemp's ridley turtles nesting on Padre Island (SHAVER, 1996; SHAVER & RUBIO, 2007).

Similarly alarming further south in the Americas, Brazil's turtle populations in the 1970s were all undergoing precipitous declines. But the creation of Projeto TAMAR-IBAMA, which involved local communities as key protagonists in conservation activities and expanded the protection of key nesting beaches to some 1100 km of the coastline, was a bold stroke of genius. Prior to the 1970s conservation of coastal and marine natural resources in Brazil was nonexistent, and nearly all loggerhead *Caretta caretta* (Linnaeus, 1758) eggs and nesting females along the Brazilian coast were taken (MARCOVALDI *et al.*, 2005). Turtles were threatened by marine debris (BUGONI *et al.*, 2001) and coastal gillnet and pelagic longline fisheries (SOTO *et al.*, 2003; KOTAS *et al.*, 2004). Turtles in Brazil faced an uphill battle. TAMAR needed to design an approach that generated buy-in from low-income coastal communities with few alternatives, and that relied on egg collection for consumption and sale. They did this by creating a collaborative and all-inclusive system that included direct employment; environmental and public outreach campaigns including educational and health-related projects; research; internships; work at visitor centres, shops and museums; production of handicrafts; development of ecotourism guides, and participation in cottage industries, sports activities, kindergartens, community vegetable gardens, provision of technical assistance to various fisheries, as well as a suite of other local activities. TAMAR was not a just turtle conservation project, it was a complete livelihoods package using sea turtles as flagship species. Each year some 14,000 turtle nests are protected along Brazil's mainland and islands, and hundreds of turtles are released alive from fishing gear, a massive endeavor lead successfully by local fishers and other stakeholders (MARCOVALDI *et al.*, 2005). Today in Brazil, all four species are recovering, and likely would have been locally extirpated without the intervention of TAMAR and its visionary leaders.

The Grupo Tortuguero de las Californias network took a truly bold approach to address turtle poaching and bycatch at Mexico´s Baja California peninsula, an important foraging and nesting area for five turtle species. When by the mid 1990s Mexico´s ban on sea turtle harvest had had little effect on the isolated Baja California peninsula, the Grupo Tortuguero transformed turtle poachers into turtle protectors by celebrating their considerable turtle knowledge, and together they assessed turtle population trends through a standardised regional monitoring network. Lifelong turtle hunters alienated by the ban found positive outlets for their considerable hunting prowess, and dozens became proud leaders of turtle conservation in their communities. By assembling turtle hunters and other stakeholders through festivals and annual regional meetings plus engaging fishermen in participatory research, the network has greatly reduced sea turtle traffic, consumption and bycatch. To address loggerhead bycatch, the network took the ostensibly outrageous approach of convening a series of tri-national fishermen's exchanges, uniting delegations of Japanese, Hawaiian, and Mexican fishermen to share bycatch solutions. The exchanges inspired a large contingent of Mexican fishermen to switch to turtle friendly gear in 2007, sparing 100s to 1000s of loggerheads each year since (Peckham *et al.*, 2011). The exchanges also led to bycatch mitigation solutions for the Japanese poundnet fishery through demonstration trials involving fishermen, fisheries managers, gear manufacturers, academics and public media. Largely through the Grupo Tortuguero's work and partnerships, loggerheads at two critical habitats in the Pacific are today the focus of effective conservation strategies. Other networks in Baja California have since ensued, addressing the same issues throughout the ranges of their turtles – following green turtles to mainland Mexico and loggerheads to their Japanese nesting sites. Bold was initially bothering at all when experts said the turtle populations were already hopelessly depleted, then involving supposedly worthless poachers, followed by facing down corrupt officials with quiet tenacity and facts.

SOME FINAL THOUGHTS

Clearly, there are many good stories to tell. My research on the subject has left me in no doubt that these steps were amongst those responsible for the turnaround of not only the individual turtle (and human) populations at stake, but also for the global reversal of sea turtles' fortunes. I am convinced that the bold moves I present above (used as a group of representative examples rather than a comprehensive register) set the scene and can provide the encouragement and impetus for the development of countless other great initiatives that have made huge differences across the globe. From the early days, when Archie Carr led a delegation to Mexico to discuss bans on the slaughter of turtles with industry leaders – recounted in his famous "Encounter at Escobilla" piece in the MTN (Carr, 1979), and the informal discussions amongst prominent turtle conservationists in the 1980s with the Japan Bekko Association to find solutions to the hawksbill shell trade (MTSG, 1993), there have been, and continue to be, some very charismatic people and some very important personal linkages that have made a difference.

Policy changes, as a result of research into mortality factors, have also come along strongly: the requirement to use circle hooks in the U.S. Atlantic pelagic longline fishery and the Hawaii shallow-set fishery for swordfish, the net ban on the east coast off Florida and Georgia, and the Queensland government's complete protection of Mon Repos, the major rookery for loggerheads in the South Pacific, are great examples. Novel thinking and a willingness to try something new, even in the face of public opposition, continue to emerge: an electric fence to keep pigs from leatherback nests in West Papua (Suganuma, 2005), or the culling of thousands of feral pigs from north Queensland to reduce predation on flatback *Natator depressa* (Garman, 1880) and ridley turtles (Queensland Government, 2010), come to mind.

Legal instruments, multi-national institutions and greater access to funding have all contributed to turtle wellbeing and recovery efforts. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) had a massive impact on international trade starting in the 1980s, and was largely responsible for the halt in the decline of hawksbills, then heavily traded for their shell (Meyland & Donnelly, 1999). The creation of the Marine Turtle Conservation Fund through the Marine Turtle Conservation Act (Public Law 108-266) in the US has created a stable and growing funding platform for countless small-scale conservation projects across the globe, by providing financial resources for projects that conserve the nesting habitats, marine turtles in those habitats, and other threats to the survival of marine turtles. A few of these projects are described within this report.

The Wider Caribbean Sea Turtle Network (WIDECAST) brought together 43 countries to actively collaborate on sea turtle conservation, much to a suite of detractors in its early days. Over the years it has been successful in engaging all countries in dialogue, getting laws changed, habitats protected, trade stopped, turtles saved, people involved, training imparted, funds raised, and inspiration imparted at a large regional scale (around the entire Caribbean sea) fraught with political complexity. WIDECAST has linked scientists, conservationists, resource managers, resource users, policy-makers, industry groups, educators and other stakeholders together in a collective effort to develop a unified management framework, and brought the best available science to bear on decision-making. The network has been instrumental in creating conservation models, encouraging community involvement, and raising public awareness, and in sharing this approach with other regions of the world, to broader benefit (Widecast, 2010).

Protection of turtle habitat is crucial. Without this protection, we would have said goodbye to many turtle populations a long time ago. Today, critical habitats have been protected that have set the scene for tremendous population recoveries. For instance, nesting beaches have been protected in La Réunion (Bourjea *et al.*, 2007), in South Africa (Hughes, 1993), in Turkey (Whitmore *et al.*, 1990), in the Seychelles and in Mexico and in Malaysia and throughout the Caribbean, as noted above, and just about everywhere turtles exist.

A common link amongst many emerging successful conservation programmes of today is partnership with local communities. Papua New Guinea has a very successful community-based conservation programme, as do Sierra Leone, Australia, Costa Rica, Mexico, and loads of others. In Papua New Guinea the use of finance incentive schemes to promote community buy-in has been a particularly effective strategy (Pilcher, 2007). These grassroots projects are becoming the mainstream conservation initiatives of the 21st century.

So it should come as no surprise that I feel turtles have fared well given all this attention. I know that most conservation initiatives make gradual impacts over long periods of time. But turtles may not have the luxury of that timeframe, and for this reason I think that stepping out of the ordinary and trying something new, which can accelerate the recovery of turtle stocks, should still be recognised for what it can do.

As to how one tops the examples listed above, I'm sure there are still loads of opportunities. One might contemplate some level of sustainable take as a way of balancing human and turtle needs and promote greater buy-amongst communities, or use novel financial measures to influence conservation behaviour, such as micro-credit schemes, payments for ecosystem services, incentive mechanisms that drive behavioural change. I imagine even green or blue carbon credits all have their place in turtle conservation of the future. And I think that we should not be so quick to dismiss something new and untested, so long as the foundations upon which it is designed have been carefully thought out, researched and grounded in the best available science, and it does not threaten recovering wild populations. I look forward to this turtle conservation future.

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Las tortugas marinas y el cambio global

Global change and sea turtles

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ABSTRACT

Global changes product of human activities, such as global warming, changes in land use, sea level rise, alterations of frequency and intensity of storms, increased pollution of marine ecosystems and so on, have affected the phenology and survival of many species of plants and animals. This article is a bibliographical revision about the effects of global change on the remaining species of sea turtles. During last century, turtles have suffered because of the growing levels of human consumption and contamination. Hundreds of thousands of sea turtles have been injured or killed by interaction with commercial fisheries. The oceans are accumulating large amounts of highly persistent plastics and sea turtles seem to be particularly vulnerable to this problem by confusing them with jellyfish and eat them massively. Pollution from accidental spills of fossil fuel also causes a higher impact of mortality of wildlife, including sea turtles. The accumulation of organic debris on beaches, from forest deforestation, alters nesting and hatchling survival. There are direct impacts such as systematic hunting of breeding females and juveniles for human consumption or as an aphrodisiac, or the manufacture of products including jewelry, among others. Other important impacts are the destruction and urbanization of the nesting beaches and egg harvest for human consumption. The over-exploitation of beaches by tourism, traffic, or light pollution alters nesting, incubation and hatchling success. All of these impacts have caused and are still causing the decline of most populations worldwide and the inclusion of six from the seven living species of sea turtles in the red list as *critically endangered, endangered* or *vulnerable* by the International Union for the Conservation of Nature. Finally, it is discussed the advances and limitations of the current conservation programs.

KEY WORDS: Conservation, global warming, sea level rise, marine reptiles, management programs, marine pollution, human impacts.

RESUMEN

Los recientes cambios globales producto de las actividades humanas, tales como: alteraciones del clima, cambios en el uso de la tierra, aumento del nivel del mar, variación en la frecuencia e intensidad de las tormentas, aumento de la contaminación de los ecosistemas marinos, etc. han afectado la fenología y supervivencia de muchas especies de plantas y animales. En este artículo se exponen con detalle los efectos del cambio global sobre las especies supervivientes de tortugas marinas. Durante el último siglo, las tortugas han sufrido el incremento en los niveles de consumo y contaminación de los humanos. Cientos de miles de ejemplares han sido heridos o muertos por la interacción con pesquerías comerciales. Los océanos están acumulando grandes cantidades de plásticos de muy alta persistencia y las tortugas marinas parecen ser especialmente vulnerables a este problema al confundirlos con medusas e ingerirlos masivamente. La contaminación por derrames accidentales de combustibles fósiles, es también uno de los impactos con mayor mortalidad de fauna, incluidas las tortugas marinas. La acumulación de residuos vegetales en playas, producto de la deforestación de los bosques, altera la anidación y la supervivencia de los recién eclosionados. Existen impactos directos como la caza intencionada y sistemática de hembras reproductoras y juveniles para el consumo humano, como afrodisíaco o para la elaboración de bisutería y otros productos manufacturados. Otros impactos importantes son la destrucción y urbanización de las playas de anidación y el expolio masivo de huevos para consumo humano. El uso excesivo de las playas por el turismo, el tráfico rodado, o la iluminación artificial alteran la anidación, incubación o éxito de las crías. La suma de todos estos impactos ha causado y sigue causando el declive de la mayoría de las poblaciones del mundo y la inclusión de seis de las siete especies vivientes de tortugas marinas en la lista roja de especies amenazadas como *críticamente amenazadas, amenazadas* o *vulnerables* por la Unión Internacional para la Conservación de la Naturaleza. Finalmente, se comentan los avances y limitaciones de los programas actuales de conservación.

PALABRAS CLAVES: Conservación, calentamiento global, incremento nivel del mar, reptiles marinos, programas de manejo, polución marina, impactos humanos.

LABURPENA

Giza jardueren ondorioz berriki ematen ari diren aldaketa globalak, hala nola: klima aldaketak, lurraren erabileraren inguruko aldaketak, itsas mailaren gorakadak, ekaitzen maiztasunaren eta intentsitatearen aldaketak, itsas-ekosistemen kutsadurak eta abar luze batek, espezie askoren fenologian eta biziraupenean eragin dute. Artikulu honetan, bizirauten duten itsas dortoka espezieetan aldaketa globalak duen efektua azaltzen da. Azken mende honetan, itsas dortokek gizakiagandik kontsumo eta kontaminazioaren hazkuntza bat pairatu dute. Ehundaka mila dortoka zaurituak edo hilak izan dira arrantza jardueren ondorioz. Ozeanoak, plastikozko zabor ikaragarriak pilatzen ari dira eta arazo hau bereziki azpimarragarria da dortoketan, hain zuzen ere beren elikagaiekin, marmokekin, nahasten bait dituzte eta kantitate handitan barneratzen dituzte. Erregai fosilen isurtzea, fauna heriotze handienetarikoa duen eragile bat da eta bertan noski itsas dortokak barneratzen dira. Basoen soiltzeak ere hondartzetan hondakin begetal ugari pilatzea dakar eta itsas dortoken errutean eta gaztetxoen jaiotzean ondorio kaltegarriak. Eragin edo inpaktu zuzenak ere badira, hala nola itsas dortoken ehiza, errutera hondartzaratzen diren emeena edo eta itsasoan garatzen dabiltzan gazteena, giza kontsumorako, bai kutixi afrodisiako gisa edo eta apaingarri eta bitxiak sortzeko ere. Beste inpaktu bat, haien ekosistemaren suntsitzea da, errute hondartzak urbanizatzea eta arrautzen lapurretak. Hondartzen erabilera turistikoak, bertan dabiltzan ibilgailu kopuru handiak eta hauetan izaten den argiztapenak, hondartzaratzeak, erruteak, arrautzen inkubazioa eta jaiotzen diren dortoken arrakasta baldintzatzen ditu. Inpaktu guzi hauen ondorioz, munduko itsas dortoken populazioek beerakada izan dute eta bizirik dirauten zazpi espezieetatik sei, Natura eta Baliabide Naturalak Kontserbatzeko Nazioarteko Batasunak (NKNB) arriskuan dauden animalien zerrenda gorrian barneratu ditu *arrisku kritikoan, arriskuan* eta *kaltebera* izendatuak izan direlarik. Azkenik, gaur egun, aurrera eramaten ari diren kontserbazio programen aurrera pauso eta dituzten mugak azalduko dira.

GAKO-HITZAK: Kontserbazioa, berotze globala, itsas mailaren igoera, itsas narrastiak, kudeaketa egitasmoak, itsas poluzioa, giza inpaktuak.

La existencia de las tortugas marinas desde hace millones de años (HIRAYAMA, 1998) demuestra su capacidad para desplazar sus lugares de anidación y desarrollar nuevas rutas migratorias, adaptándose a fuertes cambios climáticos (HAWKES *et al.*, 2009). Sin embargo, las alteraciones actuales del clima están ocurriendo de una forma mucho más acelerada que en el pasado (IPCC, 2001). Además, las poblaciones de tortugas marinas sufren actualmente una serie de impactos de origen antrópico que no existieron anteriormente (JRIBI *et al.*, 2008; SELKOE *et al.*, 2008; MAZARIS *et al.*, 2009). Por lo tanto, su resiliencia frente al cambio climático actual puede ser menor que en el pasado y se desconoce la capacidad de las tortugas marinas para adaptarse a ellos (FUENTES *et al.*, 2009).

Cambios globales que incluyen el aumento del nivel del mar, de las temperaturas del aire y del agua y de la frecuencia e intensidad de las tormentas (IPCC, 2001), pueden suponer pérdida total o parcial de playas de anidación (DICKSON *et al.*, 2007; PIKE & STINER, 2007b) y disminución del éxito de eclosión en los nidos de las tortugas marinas. El aumento del nivel del mar, puede tener efectos negativos sobre los ecosistemas costeros de anidación, como alteraciones en la redistribución de sedimentos a lo largo de la línea de costa, pérdida permanente o excesiva acumulación del volumen de arena y aumento del nivel freático (BAKER *et al.*, 2006; FUENTES *et al.*, 2009). Por ejemplo, un incremento de 0,5 m en el nivel del mar, causaría la desaparición de hasta el 32% del total de la superficie actual de playa en el mar Caribe, siendo las playas más angostas las más vulnerables (FISH *et al.*, 2005). El aumento en la frecuencia e intensidad de las tormentas tropicales, previsiblemente alterará los ciclos de inundación de los huevos en desarrollo (PIKE & STINER, 2007b, a). El aumento de la temperatura en las masas de aire y agua está correlacionado con el aumento de temperatura de la arena donde se incuban los huevos (FUENTES *et al.*, 2009). Los embriones se desarrollan con éxito solo dentro de rangos concretos de temperatura y humedad (MILLER, 1985) y el aumento de ambos factores hacia los límites superiores del rango pueden causar una disminución del éxito de eclosión (MILLER, 1985). Por otra parte, el sexo de las crías está determinado por las temperaturas de incubación en el tercio medio de desarrollo embrionario (MROSOVSKY & YNTEMA, 1980; YNTEMA & MROSOVSKY, 1980; DALRYMPLE *et al.*, 1985) y aumentos en las temperaturas de incubación generan un desbalance en la proporción de crías de cada sexo (HAYS *et al.*, 2003; GLEN & MROSOVSKY, 2004; RAHMSTORF *et al.*, 2007). Mayores temperaturas implican mayor proporción de hembras (CHAN & LIEW, 1995; DAVENPORT, 1997). Así, la producción de machos puede verse severamente comprometida en zonas importantes de anidación si se confirman las previsiones de calentamiento del clima (HAWKES *et al.*, 2009). Se desconocen los efectos posibles de este desbalance sobre la historia de vida de las tortugas. Sin embargo, debido a la determinación del sexo por la temperatura de incubación junto con la filopatría al lugar de nacimiento, es previsible que el calentamiento del clima comprometa seriamente la supervivencia de muchas poblaciones de tortugas (DAVENPORT, 1997; WEISHAMPEL *et al.*, 2004). Es necesario, por tanto, conocer las temperaturas actuales en playas de anidación y desarrollar modelos predictivos de variación térmica y sus implicaciones en la razón de sexos de las crías en el futuro (figura 1) (PATINO-MARTINEZ *et al.*, 2012a).

Fig. 1.- Tortuga laúd anidando. Fotografía: Elena Abella. / Leatherback nesting. Photography: Elena Abella.

La humedad de la arena depende especialmente de la frecuencia e intensidad de las tormentas, del nivel de las mareas y del nivel freático del suelo (Ackerman, 1997). El ambiente hídrico de los nidos de tortugas marinas, varía en el espacio y en el tiempo (Ackerman, 1997) y puede tener efectos importantes sobre el intercambio de gases, el éxito de eclosión, la elección del sitio de puesta, la duración de la incubación, el fenotipo, el sexo y la calidad de las crías (Ackerman, 1981, Hewavisenthi & Parmenter, 2000, 2002; Leblanc & Wibbels, 2009). Las alteraciones climáticas globales pueden, además de modificar las condiciones óptimas de incubación de los nidos, alterar factores bióticos como el crecimiento desproporcionado de hongos u otros microorganismos en el entorno de los huevos (Phillott *et al*., 2004).

Los cambios globales en el uso de la tierra y las inadecuadas prácticas de explotación maderera, impactan la biodiversidad y generan una gran cantidad de desechos orgánicos que son arrastrados por los ríos hacia el mar (Fredericksen & Putz, 2003; Foley *et al*., 2007; Fitzherbert *et al*., 2008). Este desplazamiento de troncos y otros residuos orgánicos puede causar impactos colaterales sobre múltiples ecosistemas (Putz *et al*., 2000; Thiel & Gutow, 2004). Uno de esos ecosistemas es la arena de la playa donde se acumulan los desechos que arrojan las corrientes oceánicas y forman barreras paralelas al mar (Velander & Mocogni, 1999). Un exceso de este tipo de residuos vegetales puede alterar la anidación de las tortugas marinas y la supervivencia de los recién eclosionados en su camino desde el nido hasta el mar (Laurance *et al*., 2008; Bourgeois *et al*., 2009). Sin embargo, estudios detallados sobre el efecto de la materia orgánica acumulada en playas sobre el comportamiento de anidación y la supervivencia de nidos y crías de tortugas marinas, son aún tan escasos como necesarios en playas de anidación (Patino-Martinez, 2010).

El aumento exponencial de la población humana en las últimas décadas, ha traído consigo un aumento en la producción de desechos, que en muchos casos terminan en los ecosistemas marinos. La ingestión de plásticos es un fenómeno emergente de especial gravedad (Bugoni *et al*., 2001; Tomás *et al*., 2002), pues los océanos están acumulando grandes cantidades de plásticos de muy alta persistencia y las tortugas marinas parecen ser especialmente vulnerables a este problema al confundirlos con medusas e ingerirlos masivamente (Mrosovsky, 1981; Barreiros & Barcelos, 2001). En 408 autopsias se encontraron plásticos en el sistema digestivo del 34% de los individuos (Mrosovsky *et al*., 2009). Aunque hay muestras desde 1885, la primera tortuga con este tipo de residuo data de 1968. La ingestión de bolsas plásticas es causante de la muerte de ejemplares de diferentes edades, llegando a ser en algún caso, junto a la pesca incidental, la principal causa de muerte (Duguy *et al*., 1998).

La contaminación de los ecosistemas costeros a consecuencia de los derrames accidentales de combustibles fósiles, es también uno de los impactos con mayor mortalidad de fauna incluidas las tortugas marinas (Hall *et al*., 1983, Mignucci-Giannoni, 1999). La mortalidad embrionaria aumenta al contacto con combustibles fósiles, entre otros motivos por la disminución en el intercambio de gases (Phillott & Parmenter, 2001b). En general es muy difícil la recuperación de tortugas marinas afectadas por contacto directo con hidrocarburos (Mignucci-Giannoni, 1999).

La vida pelágica de las tortugas durante la mayor parte de su ciclo vital puede explicar los bajos niveles generales de contaminantes en sangre y huevos (Guirlet *et al*., 2008). Sin embargo, en estudios toxicológicos realizados en la costa atlántica de Francia se han encontrado niveles muy altos de metales pesados en el páncreas. Concentraciones medias de Cadmio detectadas en el riñón han sido de 30,3 µg g^{-1} en peso fresco, cifra muy elevada en comparación con otros estudios previos (Caurant *et al*., 1999). El cadmio como otros contaminantes parecen ser más abundantes en las medusas que en otras especies marinas. Se han detectado niveles relativamente elevados de PCBs y concentraciones elevadas de sigma clorobifenilos (47 a 178 mu g/kg de peso fresco) en tejido adiposo (Mckenzie *et al*., 1999; Orós *et al*., 2009). Estos niveles de contaminantes pueden contribuir a serios problemas de salud, inmunosupresión y disrupción endocrina. Las concentraciones de metales pesados en los huevos no cambian en sucesivas anidaciones de la misma hembra, pero los niveles de plomo en sangre aumentan en las hembras a lo largo de la estación reproductora (Guirlet *et al*., 2008), debido probablemente, a los altos requerimientos de calcio durante la formación de los huevos que moviliza el plomo de forma concomitante (Guirlet *et al*., 2008).

Además de los impactos antrópicos causados indirectamente por la alteración de los factores medioambientales en las playas de reproducción y en el mar, existen impactos directos como la caza intencionada y sistemática de hembras reproductoras y juveniles para el consumo humano (Eckert & Eckert, 1990; Fretey, 2001), como afrodisíaco (Spotila, 2004) o para la elaboración de bisutería y otros productos manufacturados (Fosdick & Fosdick, 1994). Las altas tasas de mortalidad juvenil y adulta en algunas poblaciones podrían estar reduciendo significativamente la longevidad real de las tortugas y su productividad. Otros impactos importantes son la destrucción y urbanización de las playas de anidación por asentamientos humanos (Antworth *et al*., 2006) y el expolio masivo de huevos para consumo humano y para la alimentación de animales domésticos (Kamel & Mrosovsky, 2006; Chacón-Chaverri & Eckert, 2007). El uso excesivo de las playas por el turismo, el tráfico rodado, o la iluminación artificial alteran la anidación, incubación o éxito de las crías (Witherington, 1992; Salmon & Witherington, 1995; Kudo *et al*., 2003; Tuxbury & Salmon, 2005; Foley *et al*., 2007; Hernandez *et al*., 2007; Bourgeois *et al*., 2009). Especies domésticas como perros o cerdos causan severos daños en los nidos (Fig. 2) y las crías de las tortugas en el entorno de asentamientos humanos (Engeman *et al*., 2003; Engeman *et al*., 2005), aumentando sustancialmente las tasas de mortalidad.

Fig. 2.- Tortuga laúd poniendo huevos. Fotografía: Elena Abella. / Leatherback laying eggs. Photography: Elena Abella.

Durante el último siglo, las tortugas han sufrido el incremento en la demanda de pescado para consumo humano, que ha causado la muerte accidental de cientos de miles ejemplares en pesquerías comerciales (FERRAROLI *et al.*, 2004; HAYS *et al.*, 2004; SPOTILA, 2004). Además, la colisión con embarcaciones les causa heridas graves y es otra de sus amenazas en el mar (LEWISON & CROWDER, 2007). La suma de todos estos impactos ha causado y sigue causando el declive de la mayoría de las poblaciones anidantes del mundo (CHAN *et al.*, 2007; SEMINOFF & SHANKER, 2008; DETHMERS & BAXTER, 2011) y la inclusión de seis de las siete especies vivientes de tortugas marinas en la lista roja de especies amenazadas como críticamente amenazadas, amenazadas o vulnerables por la Unión Internacional para la Conservación de la Naturaleza (IUCN, 2011). Uno de los ejemplos más dramáticos de declive es el caso de Terengganu en Malasia. La población de tortuga laúd en esta zona se redujo de 10.000 hembras anidantes por año en los años cincuenta a menos de 100 en 1995. Lo que implica una pérdida del 99% de la población en medio siglo (CHAN & LIEW, 1996). En algunos casos estos declives han sido paliados gracias a una gran variedad de programas efectivos de conservación, que incluyen la reducción de las capturas incidentales en pesquerías (FERRAROLI *et al.*, 2004; HAYS *et al.*, 2004), la recuperación o conservación de hábitat críticos (TROENG & RANKIN, 2005), la protección de las hembras y nidos (ECKERT & ECKERT ,1990; PILCHER & ENDERBY, 2001; BAPTISTOTTE *et al.*, 2003; SARTI *et al.*, 2007), las campañas de concienciación para disminuir el consumo de carne y huevos (TROENG & RANKIN, 2005), el refuerzo de la cooperación regional entre países (FOSSETTE *et al.*, 2008), la cría en cautividad (FOSDICK & FOSDICK, 1994; FONTAINE & SHAVER, 2005) y la repoblación o reintroducción en nuevas playas (SHAVER, 2005).

Una de las prácticas más difundidas en programas de conservación en playas consiste en el traslado de nidadas completas a viveros vigilados y protegidos, para mitigar la pérdida por consumo humano, depredación por animales domésticos y por inundación o erosión natural (CHAN *et al.*, 1985; GARCIA *et al.*, 2003; BASKALE & KASKA, 2005; ABELLA *et al.*, 2007; PATINO-MARTINEZ *et al.*, 2010). Algunos estudios realizados durante varios años consideran que los resultados de la traslocación de huevos han sido positivos para la conservación (WYNEKEN *et al.*, 1988; ECKERT & ECKERT, 1990; GARCIA *et al.*, 2003; DUTTON *et al.*, 2005; CHACÓN-CHAVERRI & ECKERT, 2007) y para difundir las campañas de educación al público (QUINONES *et al.*, 2007; PIKE, 2008). El efecto positivo inmediato de la protección de nidos en viveros consiste fundamentalmente en garantizar la incorporación de un número importante de crías a la población (PATINO-MARTINEZ *et al.*, 2008; TOMILLO *et al.*, 2008).

Sin embargo, se han detectado algunos problemas asociados a los programas de traslocación de nidos a viveros, como la fluctuación intra e interanual de las tasas de eclosión (PIEDRA *et al.*, 2007), la disminución del éxito medio de eclosión de los nidos (PINTUS *et al.*, 2009), sesgos en la proporción de sexos de las crías (MORREALE *et al.*, 1982; CHAN & LIEW, 1996) y asincronía en la emergencia (KOCH *et al.*, 2008).

Entre las diferentes causas de la disminución del éxito, se han descrito la mortalidad embrionaria inducida por el movimiento de los huevos (LIMPUS *et al.*, 1979) y el mayor riesgo de contagio por hongos y otros microorganismos debido a una mayor densidad de nidos en los viveros (SHANKER *et al.*, 2003; OZDERMIR & TURKOZAN, 2006). En general, la mortalidad embrionaria durante la incubación puede estar asociada con características intrínsecas de los huevos (genéticas y fenotípicas) y también por las condiciones de incubación y manipulación de los huevos (BONACH *et al.*, 2003). El crecimiento de hongos sobre los huevos de tortugas marinas ha sido demostrado solo en algunas especies y en localidades concretas (CHAN & SOLOMON, 1989; PHILLOTT & PARMENTER, 2001a; PHILLOTT *et al.*, 2004), pero no se ha establecido con certeza si ocurre una mayor contaminación de los huevos en nidos trasladados al vivero. Estudios científicos para conocer bien los mecanismos de la alta mortalidad embrionaria en huevos, los efectos del transporte, la manipulación y la incubación en viveros, son indispensables para mejorar los programas de conservación en playas (PATINO-MARTINEZ *et al.*, 2012b). Los programas de conservación deben considerar, también, las dinámicas poblacionales, su estructura genética, la distribución y preferencias de hábitat, las fuentes de mortalidad en los diferentes estadios de vida y las proporciones naturales de sexos para implementar programas de manejo integrales y eficaces. Sin embargo, conviene recordar que los programas de manejo y conservación, son sólo planes de emergencia frente a impactos severos que deben ser revertidos para garantizar la estabilidad de las poblaciones de tortugas marinas.

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BAY OF BISCAY AND NORTH EAST ATLANTIC SEA TURTLES CONFERENCE CONCLUSIONS

On the 14-15th November 2008 a workshop organized by the Observatory of Herpetology (Herpetology department) of the Aranzadi Society of Sciences, gathered a range of researchers and stakeholders from different European Nations at the Aquarium of San Sebastian (Basque Country, Spain) to discuss the conservation and research objectives for marine turtles in the north-eastern Atlantic.

Sixteen oral presentations from Ireland to Cape Verde, included the French Atlantic coast, the Iberian Peninsula and the islands of Portugal and Spain plus a by-catch case-study from Uruguay demonstrated the importance of Europe's Atlantic fringe for marine turtles, highlighting a number of exceptional opportunities to investigate key questions in the open-ocean and coastal seas. For example, this geographical area provides foraging grounds for the oceanic-pelagic stage of several species and encompasses the third largest nesting rookery of loggerhead turtles in the world (Cape Verde Islands). At the conclusion of the workshop a list of research and conservation priorities was produced by the combined researchers, NGOs and government bodies under an overall objective of further integrating sea turtles into the European Marine Strategy. Although only provisional, and subject to further review, these priorities fall may be summarized as follows:

1. To work towards a public database for at-sea sightings and stranding of marine turtles in the NE Atlantic.

2. To ascertain the present threat to migrating and developing sea turtles posed by open-ocean fisheries.

3. To quantify the importance of the Bay of Biscay as a foraging ground for migrating leatherback turtles.

4. To standardize protocols for estimating sex ratios throughout the NE Atlantic, and investigating the disparity between indirect estimates from nesting beaches and direct observations of pelagic juveniles.

5. To consider the potential threat to key rookeries (such as Cape Verde) posed by global sea level rise.

6. To investigate the foraging ecology of pelagic juvenile loggerhead turtles around southerly Atlantic islands.

7. To increase international collaborations between NGO's, academic institutions and government stakeholders throughout the wider NE Atlantic region.

8. In terms of public awareness, it was additionally decided that, politicians, stakeholders and public in general should be made aware of the main threats to marine turtles, i.e., we need to translate what we know into common language regarding how important turtles are in the NE Atlantic.

All the participants left San Sebastian with the collective commitment to work closer together and to develop future priority initiatives in order to improve knowledge and contribute to marine turtle conservation in this area. At times of global climate change and habitat loss, the salient point to emerge from the meeting was that 'together we are in a position to make a contribution globally to understand marine turtles ecology'.

NEASTG
North East Atlantic Sea Turtle Group.
17th November 2008

Fig. 1.- Invited lectures to the Bay of Biscay and North East Atlantic sea turtles conference (left to right): Florence Dell'Amico, Jonathan Houghton, Mari Luz (Argi) Parga, Claudia Delgado, Amalia Martínez de Murguía, Thomas K. Doyle, Nagore Zaldua-Mendizabal, Ana Liria-Loza, Elena Abella, Raúl Castro, Martín Laporta (Negro), Pierre Morinière & Josep M. Alonso. Xabier Murelaga was also invited lecture but had to leave before take this picture. Photography: Aitziber Egaña-Callejo

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