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Movement of sea turtle between nesting sites and feeding grounds in the South West Indian Ocean: regional migratory knowledge and interaction with open sea fisheries for management issues

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INTRODUCTION AND BACKGROUND

In the year 2000, countries bordering on the West Indian Ocean (WIO) requested assistance in the management of the living resources and associated habitats of their shared marine ecosystems. In response, the World Bank initiated the development under the Global Environmental Facility (GEF) and the Fond Français pour l'Environnement Mondial (FFEM), of a multi-national fisheries management and development programme called the South West Indian Ocean Fisheries Project (SWIOFP) including 9 different countries: Kenya, Tanzania, Comoros, Mozambique, Seychelles, Madagascar, South Africa, Mauritius and La Reunion (France) and composed of 6 different components. The Component 6 of this Programme is related to non consumptive resources: ***Mainstreaming biodiversity in national and regional fisheries management*** that includes marine turtles (*Chelonia mydas*). As a specific contribution to the GEF Biodiversity Focal Area, this component lead by Mauritius will investigate relationships between fisheries, biodiversity processes and species diversity and elaborate how these relationships could be better managed at national and regional levels. This component underscores the fact that future decision support to fishery development could be flawed and compromised unless based on an ecosystem approach, for example:

- A regional approach to by-catch assessment and reduction in all fishery types
- Identification of biodiversity "hotspots" such as spawning aggregations and nursery areas
- Understanding the possible impacts of fisheries on seed populations and larval transport
- Ecological implications of selective removal of target species, such as top predators
- Potential impact of changes in fishing technology, including FADs

Under this component, France is leading an activity related to sea turtle interaction with open sea fisheries within an ecosystem approach to fisheries management that is coordinated by Ifremer La Réunion.

Marine turtles occur mainly in tropical and subtropical waters worldwide and have had a long history of human exploitation in all oceans, with some stocks now extinct and others in decline (Frazier, 1980; Witzell, 1994). In most rookeries, the mean annual number of nesting females has decreased by 48 to 67% over the past few centuries (Seminoff, 2004a). The life history traits of green turtles make them vulnerable to human exploitation and habitat destruction at both feeding and breeding sites. They are highly migratory, long-lived species with delayed sexual maturity and high adult survival but low hatchlings survival (Hamann *et*

al., 2003). Because of its biological characteristics, early signs of population changes are visible only after several decades, and by the time population decline is realized, chances of recovery are usually slim (Congdon *et al.*, 1993). Thus, the species has been classified as endangered globally (**Annex I of Washington convention** (CITES), Word Conservation Union (IUCN) **Red List** (Seminoff 2004), **CMS aegis)** with the hope of conserving the remaining populations as well as their important role in maintaining both marine and terrestrial ecosystems (Bouchard & Bjorndal, 2000).

Five species of marine turtles are documented from the Western Indian Ocean (Marquez, 1990; Ratsimbazafy, 2003; Seminoff, 2004). Of these, the green turtle (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) are most widely distributed, most numerous, and have been the most severely impacted by directed exploitation (Hughes, 1974; Frazier, 1980, 1982). Loggerheads (*Caretta caretta*) and leatherbacks (*Dermochelys coriacea*) used to be abundant along the South African waters, but less common in the rest of the region, and have had little importance in commerce and directed exploitation (Hughes, 1974). Relatively little has been documented about the olive ridley (*Lepidochelys olivacea*). The most abundant species in the SWIO is the green turtle (Hughes 1973, Frazier 1975, Mortimer 1984, 1985, Le Gall *et al.* 1986, Bourjea *et al.* 2006, 2007a, Lauret-Stepler *et al.* 2007) that nests mainly on smalls islands scattered along the Mozambique Channel such as Mayotte, Mohéli, Aldabra and most of the Eparses Islands, and uses to forages in these island by mainly in the east coast of Africa and west coast of Madagascar. This region is particularly interesting for this species as it is composed of 2 distinct genetic stocks: the south of the Mozambique Channel, being part of the Atlantic genetic stock and the north part of the Indo-Pacific one (Bourjea et al. 2007b).

Even if locally, the marine turtle behaviour is well known during the feeding and the reproduction phase**, the lack of global vision of the replacement and the favourite frequenting of successive sites cannot permit to take appropriated conservation measures at the regional level**. In deed, even though it is present on different countries of the area, for feeding and nesting, we still not know very well the spatial dynamics of their migrations which can be periodically on hundreds of kilometres between the feeding grounds and the nesting sites.

Sea turtles worldwide are under pressure from a number of natural and anthropogenic factors, both in the terrestrial phase of their life cycle as well as in the marine environment. Conservation efforts will only succeed if the major threats can be managed. Little has been done in the South Western Indian Ocean to identify and quantify the relative importance of various human pressures. Hughes (1974), the National Reports to the Indian Ocean South East Asian Sea Turtle Memorandum of Understanding (IOSEA) and FAO report on the interactions between Sea Turtles and Fisheries within an Ecosystem Approach to Fisheries Management (FAO 2006) provide the best overview of impacts in this region. These national reports have highlighted the fact that fisheries interactions with sea turtles constitute a major threat (IOSEA Database): (1) coastal interaction (Nets, Trawlers) and open sea interaction during the migration phase (Longline and Pure Seine). Furthermore, given the trans-boundary nature of sea turtle populations, a regional approach, such as the one adopted by the SWIOFP, is essential and overdue.

AIMS OF THE PROJECT

Scientific aims

- Identification of **sea turtle 'Hotspots'** in the south west Indian Ocean (SWIO) and **assessment of the main populations** based on existing data
- **Regional migration routes** of the sea turtles
- Understanding **migration behaviour** of the sea turtles according to environmental conditions (currents, SST…) and available genetic data (haplotypes frequencies and structure)
- Building a **migratory map** for those population in the South West Indian Ocean

Application aims:

- **To set up a classification of risk's areas** for the species, according to the interaction with the open sea fishing activities (longline and pure seine).
- To propose **local and regional mitigate measures of management** for the sea turtles bycatches, according to population abundance and migratory behaviour, which can be compatible with the local lasting development, as the eco-tourism
- To **contribute to the Marine Turtle Task Force (MTTF) in the creation of a reliable research and application network** dedicated to sea turtles

Based on sea turtle satellite tracking by Argos system, this French (La Réunion) proposal will focus on French territories sea turtle populations (Eparses Islands – Europa, Juan de Nova, Glorieuses and Tromelin; Mayotte and La Réunion). **Other countries of the SWIOFP are clearly invited to join this project** in order to have the better assessment as possible of the migratory behaviour and interaction with open sea fisheries in the South West Indian Ocean.

Expected collaborations and contacts already engaged:
- AUSTRALIA: Fishery department
- TANZANIA: SeaSens
- MOZAMBIQUE: Maluane project
- KENYA: Keskom and Kenya Marine and Fisheries Research Institute
- COMOROS: ADSEI
- SEYCHELLES: Environment Ministry and Turtle Action Group of Seychelles
- MAYOTTE: Collectivité de Mayotte

OVERVIEW OF THE METHOD

1. Expected Sites*:*

- *Nesting sites* : French territories sea turtle populations (Eparses Islands – Europa, Juan de Nova, Glorieuses and Tromelin; Mayotte and La Réunion), South Africa (Kwazulu Natal), Seychelles (Cousin, Cosmoledo), Comoros (Mohéli), Tanzania (Mafia), Mozambique (Maluane)
- *Open sea:* marine turtle bycatches in La reunion longline fishery, prospecting to capture sea turtle under drifting FADs (Pure Seine, Seychelles)

Biological model and satellite tracking: As the green turtle is the most frequent marine turtle species nesting in the Eparses Islands and Mayotte, we will chose this species as biological model. However, according to countries facilities, all the 5 marine turtle species green (*Chelonia mydas* L.), hawksbill (Eretmochelys *imbricate* L.), olive ridley (*Lepidochelys olivacea* Eschscholtz), loggerhead (*Caretta caretta* L.) and leatherback (*Dermochelys coriacea* Vandelli) will be studied. On the one and, at least **12 satellite transmitters** will be attached on **nesting females** at the end of the nesting peak (austral summer for the south of the Mozambique Channel, and austral winter for the north). Some satellites tags will be equipped of depth sensor in order to estimate the mean depth dive during the migration and its occurrence. This will help in the assessment of the impact of a fishery according to its fishing characteristics (for instance, the mean depth per set of the hooks).
For Open sea marine turtles, loggerhead, Green, olive ridley and hawksbill are expected to be tagged.
We estimated that at least 100 satellites tags will be deployed in the South West Indian Ocean.

2. Fixing the transmitter:

IFREMER of La Réunion and The Sea Turtles Survey and Discovery Centre (CEDTM) have a large experience on sea turtle satellite tracking by Argos system (Pelletier *et al.* 2003; Girard *et al.* 2006) and **showed the interest of such technique to study oceanic movement of green turtles**. All previous and ongoing projects allow developing **an efficient protocol to attach the satellite transmitter** on the carapace of the sea turtle. This technique uses only standard and cheap equipment.

3. Other data collection:

Available environmental and oceanic data (Sea Surface Temperature, currents, wind…) will be collected at the same time in collaboration with specialized institutes (Ex: IRD and Météo France for the French institute). Past data will also be obtained with these institutes. Longline and Pure seine effort per 5° square in the area will be obtained via the Indian Ocean Tuna Commission (IOTC); available regional data on by-catch per fishery will be also collected

4. Working group :

In order to coordinate the project, a workshop will be organised in 2009 at La Réunion for:

a. The compilation of the regional data available
b. The identification of the Hotspots and mains patrimonial nesting and foraging site per zone for the field phase – identification of the sites for the study
c. The homogenisation of the satellite tag fixing protocol for each site, identification of the field time periods according to sea turtle nesting seasonality and in general for the coordination of the releases
d. The specific training to fix the satellite tags.
e. The training in the French sea turtle monitoring (aerial survey, tagging, beach monitoring…)

5. Spatial data analysis:

A statistical analysis of the spatial oceanic movement of the tagged marine turtles will be realised according to **environmental and fisheries data**, and **this in order to establish a maps of risk's zones** per species.
Developing assessment methods for the rate and impact of fisheries bycatch on populations of marine turtles will enhance the ability of conservation bodies to identify the key threatening processes and devise methods of mitigation that effectively target the problem. This project will assess the risk of bycatch of sea turtles in a variety of fisheries and quantify the risk to individual populations. This model of analysis developed by Australia uses a probabilistic approach to the overlap of space and time use by the marine turtles and the commercial fisheries. This will allow us to determine the hotspots of bycatch and apportion bycatch to individual populations and quantify the risk to these populations by use of a stochastic age-structured model. This has universal application to other ocean basins for sea turtles and for any issue of bycatch.

EXPECTED OUTPUTS

Scientific level

- Assessment of the mains migratory ways between nesting sites and foraging grounds
- Improve the knowledge on trans-oceanic movements of marine turtles in the SWIO and impact of environmental variations on the navigation process.
- Assessing the open sea interaction with fisheries

Regional level

- Mapping of the mains risk's zones for marine turtles, based on by-catch data, fishery efforts, and seasons.
- Bring together the different institutes and organisms working on sea turtle of the Region on a first common project.
- As expected by the MTTF, to wide from a current local management to a future regional management

Year 1 (2008-2009): Current status of the local sea turtles knowledge, training and identification of targeted area

1- Reviewing available Local – Regional data on :
   a. Population assessment by rockeries and by habitat (nesting and foraging grounds): monitoring performed, species, abundance, evolution through time, genetic stock…
   b. Available knowledge on migratory behaviour within the South West Indian Ocean
2- Sourcing of published information on SWIO from peer-reviewed journals, grey literature, conference proceedings and FAO manuals
3- Assessing the type of storage for the data and the quality of the various data types, and their compatibility
4- Workshop (5 days) for the preparation, coordination and training for Year 2 of the project (venue : La Réunion):
   a. Compilation of the regional data available
   b. Identification of the Hotspots and mains patrimonial nesting and foraging site per zone for the field phase – identification of the sites for the study
   c. Homogenisation of the satellite tag fixing protocol for each site, identification of the field time periods according to sea turtle nesting seasonality
   d. Training to fix the satellite tags.
   e. Training in the French sea turtle monitoring (aerial survey, tagging, beach monitoring…)

Year 2 (2009-2010): Coordination of the field time

1- The fixing of the satellite transmitter will be realised during the nesting season peak (regarding each country), and this in order to have homogeneous releases between the countries.
2- Centralization and coordination of the live satellite tracking. The French team, via La Réunion team, proposes to coordinate this from La Réunion.

Year 3 (2010-2011): Data analysis and regional overview of the migration routes and interaction with fisheries

1- Statistical analysis of the oceanic movement of sea turtles released.
2- Attached the satellite data with other available data: genetic structure, oceanographic data (Sea Surface Temperature, ASLME…), by-catch and fisheries effort data (IOTC, TAAF…).
3- Mapping all the data found and used – type GIS. Definition of risk's zones
4- final Workshop including scientists and managers

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