# EXAMINING TRENDS IN TASTE PREFERENCE, MARKET DEMAND, AND ANNUAL CATCH IN AN INDIGENOUS MARINE TURTLE FISHERY IN SOUTHWEST MADAGASCAR

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TO THE UNIVERSITY HONORS COLLEGE:

As thesis advisor for Kristin Jones,

I have read this paper and find it satisfactory.

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# TABLE OF CONTENTS

# LIST OF FIGURES AND TABLES

## Figures



## Tables

**Abstract**

Marine turtles have been exploited worldwide throughout human history. Products gleaned from marine turtles include decorations and tools from their carapaces, leather from their skin, and food from turtle eggs and meat. Because of overexploitation and a combination of relatively newer threats such as pollution, habitat loss, and incidental fisheries take, all marine turtle species are considered to be threatened or endangered. The hunting of marine turtles is an ancestral tradition among Madagascar's coastal inhabitants that has increased in economic value within the last century. Although Madagascar's marine turtles have been legally protected from exploitation since the country ratified CITES in 1973, hunting continues due to lack and difficulty of enforcement. Marine turtle fishing has been monitored in the village of Ifaty in the Tulear region of southwest Madagscar by the UK NGO Reef Doctor since 2008 through the present year. Using an analysis of this annual catch data as an indication of fishing trends, I conducted a pilot taste preference study as a means to gauge local demand for turtle meat, the main product used from marine turtles in the region, and to ascertain the existence of a relationship between meat preference and demographic characteristics of participants. Accompanied by my on-site advisor who also functioned as my translator, I conducted interviews over a period of one week in the village of Ifaty. Results of these interviews indicated turtle as the 4$^{th}$ most preferred among 8 of the most commonly available meat sources. By age group, turtle meat was ranked 4$^{th}$ by participants in age groups 18-26, 27-35, and 36-50. Participants in the age group 50 and older ranked turtle meat as their 3$^{rd}$ most preferred meat. The annual catch of marine turtles averaged over 2008-2010 revealed an average of 134 (±32.60) turtles caught per year with the majority of these being female green sea turtles 50-90 cm in straight carapace length, trending toward the capture of turtles greater than 70 cm. Estimations for marine turtle populations in the area are nonexistent. The high growth rate of the human population and the increasing number of coastal migrantscoupled with an unchanging demand for turtle meat, however, may suggest future increases in demand on the marine turtle fishery.

## 1. Introduction

The divide between biological knowledge and conservation success has led to an increased awareness among scientists that the principal determinants of conservation success or failure are often social factors (Mascia et al. 2003). Conservation researchers have thus become well-aware of the need for the incorporation of social science into natural resource science and biological methods to manage conflicts between humans and wildlife (Drury et al. 2010). The recognition that conservation requires as much attention to people as it does to wildlife and ecosystems is a significant and necessary shift in the conservation field as conservation practices are essentially social in nature in their dependence on changes in human behavior (Mascia et al. 2003). The primary purpose of this study is to explore the importance of local taste preference and adaptation of traditions in an increasingly global economic climate in relation to the illegal, uncontrolled harvest of marine turtles in an indigenous fishing community in southwest Madagascar. The secondary aim of this study is to ascertain links between demographic characteristics of the local human population and taste preference and to discuss these in

the context of current annual catch rates in the marine turtle fishery as a means to project future harvest trends and their sustainability. The consumption and preparation of food are important cultural activities common among all humans that vary by society (Rose 2001). According to numerous studies, the consumption of wildlife is largely determined by deeply rooted traditions and cultural taste preferences (Apaza et al. 2002, Shenck et al. 2006, Fa et al. 2002); thus, societal taste preferences are an important consideration in local conservation.

## 2. Study Site: The Republic of Madagascar and the Village of Ifaty

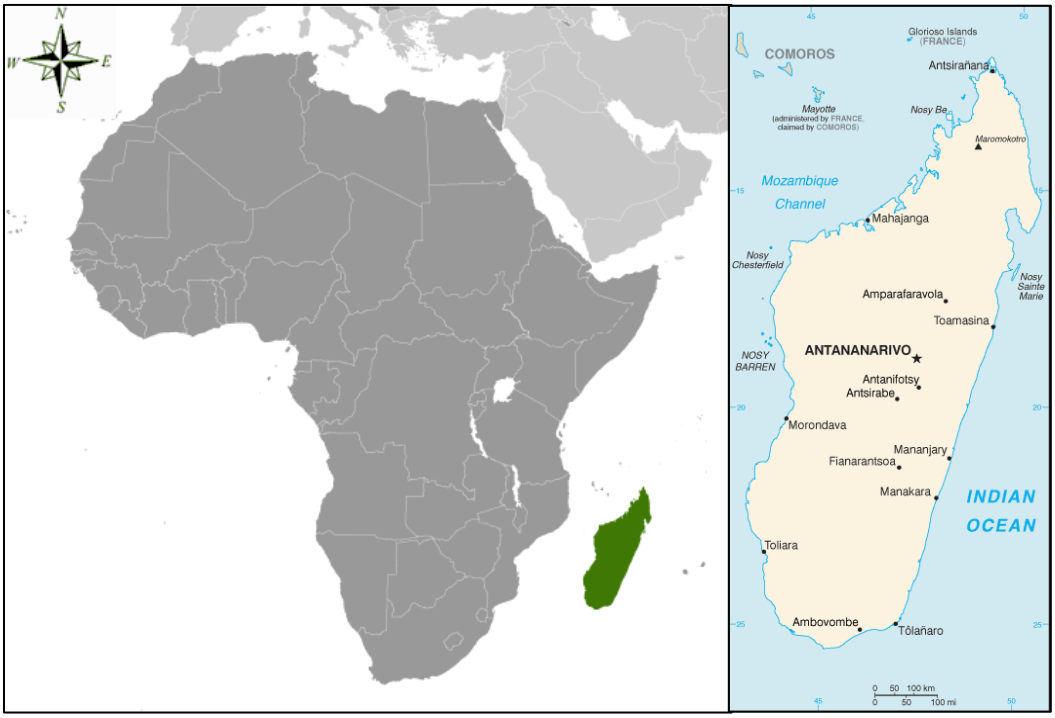


*Figure 1. Location of Madagascar off of the southeast coast of Africa (left), Map of Madagascar including regional capitals and surrounding islands (right). CIA World Factbook, 2011.*

The world's fourth largest island with a surface area of 594, 150 km², Madagascar is located 400 km off of the south-east coast of Africa across the Mozambique Channel. One of the most biologically diverse areas in the world, Goodman and Benstead (2005) have estimated rates of endemism to be above 80% on the island for both floral and faunal groups such as terrestrial vertebrates, invertebrates, and vascular plants. Madagascar is the only place in the world in which lemurs, prosimian primates of

the order Strepsirrhini, occur. In fact, excluding bats and introduced mammals, 100% of the mammal species found on Madagascar are endemic. Similarly high rates of endemism (90%) have been observed among the island's amphibian and reptile groups (Goodman and Benstead 2005). Madagascar is also classified as a developing nation and is ranked among the eleven poorest countries in the world with 85% of the population living below the poverty line and an annual population growth rate of nearly 3% (CIA World Factbook). In addition, because of human activities such as slash-and-burn agriculture, only an estimated 10% of natural habitats that existed before human colonization remain. All of these factors combined have earned Madagascar the highest ranking among the world's eight 'hottest' biodiversity hotspots, or areas exhibiting high concentrations of endemic species and experiencing exceptional loss of habitat, and made it a top conservation priority (Myers et al. 2000).

The village of Ifaty is located in southwest Madagascar, 27 km north of Tulear, the regional capital (Figure 3). With a population of 2,500, it is situated in one of the island's poorest regions. Ifaty occurs along the southern extent of the Bay of Ranobe, a subsection of the Grand Recif of Tulear, the fourth largest coral reef system in the world. The Grand Recif is a barrier reef 1.1-2.9 km wide, 18 km long, and consists of lagoonal areas and coral reefs stretching over 600 km along Madagascar's southwest coast (Laroche and Ramanarivo 1995; Belle et al. 2009). The Bay of Ranobe is one such lagoonal area. Enclosed by a 32 km fringing reef, it extends for 8 km at its widest point and contains several ecosystem types, including seagrass beds, reef flats, patch reefs, a fragmented curtain mangrove

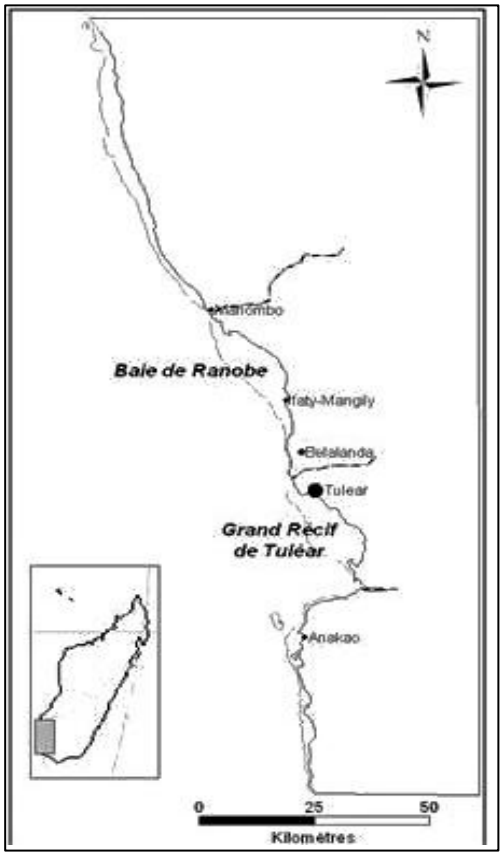


*Figure 2. Map of Madagascar's southwest coast depicting the location of the village of Ifaty in relation to the Bay of Ranobe. Courtesy of ReefDoctor.*

in the south, and an estuarine mangrove in the north (Belle et al. 2009).

While only four species of marine turtles occurring in the Indian Ocean have been known to nest on the island, all five species feed along the entirety of the Madagascar coast (Mbindo 1996). Hughes (1974) has reported the southern end of Madagascar to have the island's highest concentration of marine turtles, both Hughes (1974) and Rakotonirina and Cooke (1994) identifying the Bay of Ranobe as an important feeding ground for juveniles and adults of all five Indian Ocean species.

The Bay of Ranobe was made unique as a study site by the presence of Reef Doctor, a U.K. non-governmental organization, which established itself in the area in 2002 for the purpose of marine monitoring and research. Thus far, two marine protected areas have been implemented in the area as community managed reserves under FIMIHARA, an organization of local fishermen established with the help of Reef Doctor in 2006 (Belle et al. 2009). A second organization, the *Miamby Fano* or Turtle Guardian Project, was established in 2008 by Reef Doctor in association with the Institute for Marine Sciences and Fisheries in Tulear, FIMIHARA, and local village elders. Its objectives were to create a database on the distribution of marine turtle species in the Bay, determine population composition in terms of age, sex, and species, and identify population threats in the Bay of Ranobe.

Through the implementation of a number of programs geared towards socio-economic development such as school restoration and marine education, promotion of the use of solar cookers to reduce deforestation, and alternative livelihood initiatives for villagers to alleviate poverty in the community, ReefDoctor has also succeeded in gaining the trust of the local people. This prior established trust was integral to the study in the willingness of study participants to share information regarding the marine turtle fishery.

## 3. The Turtles

### *3.1. Marine Turtle Biology and Ecological Importance*

Five out of the eight known species of marine turtles occur in the Indian Ocean. Four of these species, the green sea turtle (*Chelonia mydas*), the hawksbill (*Eretmochelys imbricata*), the loggerhead (*Caretta caretta*), and the olive ridley (*Lepidochelys olivacea*), belong to the family Cheloniidae, the hard-shelled sea turtles, and are characterized by the horny scutes covering their carapaces and plastrons. The fifth species found in the Indian Ocean, the leatherback turtle (*Dermochelys coriacea*) is the sole member of the family Dermochelyidae and is characterized by a broad, ridged shell lacking epidermal scutes (Vitt and Caldwell 2009). All four turtles in the Cheloniidae family occurring in the Indian Ocean are known to nest on Madagascar, with the greatest population concentrations found in the south of Madagascar (Hughes 1974; Seminoff and Shanker 2008).

Marine turtles, despite spending the vast majority of their lives at sea, are air-breathing vertebrates which return to land in multi-annual cycles to lay their eggs. Highly migratory, they often travel thousands of kilometers to nest at natal grounds, even where suitable nesting sites are near and available (Meylan 1995). All species exhibit high fecundity with clutches of approximately 100 eggs laid 3-7 times per nesting season (Carr 1995). After approximately two months of incubation, young hatch, surface from the underground nest, and scramble together to the sea. Every nesting is not successful, however, as eggs may fail to hatch due to infertility or unsuitable nesting conditions. Though hatching success of sea turtle egg clutches is typically high (80% or more), hatchlings may also fail to exit the nest (Lutz and Musick 1996). These unsuccessful hatchlings are a major source of energy and nutrients to the beach and dune ecosystems in which they are laid, allowing growth of healthy vegetation which thus provides habitat for other inhabitants of these ecosystems (Bouchard and Bjorndal 2000). The period following the hatchling stage is often called the “lost years,” for after entering the sea, young turtles appear to maintain a pelagic existence for anywhere from several months

to several years, during which their activities were largely a mystery until recently (Levinton 2001). Researchers now believe that hatchlings continue swimming out to sea for the first few days of their lives until they find their prime foraging grounds: drifting islands of seaweed teeming with small plants and animals, oases in a vast, mostly deserted, open ocean (Spotila 2004).

Both the hatchling and the "lost years" stages are characterized by high mortality because of predation from various terrestrial, aquatic, and aerial predators such as mongooses, crabs, sharks, and gulls (Stancyk 1995). Elements such as variable nest predation and unpredictable environmental events such as tropical storms probably cause a fair amount of variability in hatchling survival from year to year but the overall number of hatchlings surviving their first year may be assumed to be relatively small (Lutz and Musick 1996). Juvenile turtles also face significant anthropogenic pressures such as indirect fishing take, debris ingestion and entanglement from pollution, and worldwide habitat loss from coastal development (Bolten 2003). Survivorship to adulthood among sea turtles range has been estimated to be anywhere from 0.2 to 1% (Frazer 1986; Heppel et al. 2003). In other words, assuming an approximate hatching rate of 75-80% and negligible mortality in yearlings, 20,000 eggs might produce between 30-150 yearling turtles (Ehrenfeld 1974). In terms of the r- and K-selection continuum, an important paradigm in the study of the life-history evolution of organisms and an element often referred to in wildlife management (Reznick et al. 2002), sea turtles embody traits of both strategies. Their large body size, long life spans, and length of time to maturity (5-35 years) suggest K-selection while high rates of reproduction and mortality indicate an r-selected life history strategy. The combination of slow growth rates and high juvenile and hatchling mortality means that though survival rates increase with age and are relatively constant in adult and subadult marine turtles, most turtles will not survive to breeding age. In addition, longer generation times resulting from delayed sexual maturity result in slow population growth and a certain inflexibility in response to sustained pressures on the survival of adult and juvenile populations (Heppell et al. 2003).

Following the hatchling and pelagic stages, juvenile turtles move into bays and estuaries to feed until sexual maturity (Levinton 2001). Feeding strategies and diet items vary widely amongst marine turtles; from the nearly complete herbivory of the green sea turtle, which primarily eats sea grasses and seaweeds, to leatherbacks which feed on jellyfish, and loggerheads which consume items such as algae, fish, and mollusks (Levinton 2001; Hughes 1974). With such an array of feeding strategies, marine turtles thus play important ecological roles as consumers and ecosystem engineers. Hawksbill turtles, for example, through their spongivory, facilitate the growth of coral reefs by releasing corals from sponge-related competition. Similarly, leatherbacks are one of the top predators of jellyfish, which, due to overfishing of other jellyfish predators such as tuna and sharks, are slowly replacing once-abundant commercially important fish species (OCEANA 2010). The green sea turtle is integral to the maintenance of healthy seagrass ecosystems all over the world, preventing overgrowth and the spread of disease through grazing of seagrass beds (McClenechan et al. 2006). These beds are the primary sites of development and breeding for many species of shellfish, crustaceans, and fish, species which not only form the basis for marine food chains but are also important products to human consumption and commerce (Heck et al. 2003).

### *3.2. Marine Turtle Conservation and Its Implementation in Madagascar*

Marine turtle populations in the Indian Ocean were believed to be steadily declining as early as the late 20$^{th}$ century (Kar and Bhaskar 1995). The IUCN Red List of Threatened Species currently lists green turtles, olive ridleys, and loggerheads as endangered and hawksbills and leatherbacks as critically endangered. Declines have been caused by pressures such as incidental capture in fishing gear, degradation of nesting sites and marine habitats due to pollution and coastal development, disease, and direct consumption at all life stages by humans (Campbell 2007). Species and/or populations are given endangered status based upon calculated population declines over three generations. Because of lengthy generation times, however, and the fact that estimations are based primarily on nesting

populations, the reliability of current marine turtle population estimates is unknowable. In addition, populations are often monitored through nesting populations which provide counts of hatchlings and females, excluding the male and juvenile components of populations (Seminoff and Shanker 2008). Similarly, long generation times contribute to the difficulty of projecting population sustainability as the effects of current pressures may not be seen for several decades and generation cycles often far exceed the average research funding cycle (Gladstone et al. 2002; Heppell 1998).

Life history information concerning marine turtles is often insufficient to formulate population management plans. Current methods for analyzing populations involve the construction of population matrices and simple life tables based on fecundity, age-specific survival rates, and growth probabilities. Gathering this information is difficult for a group such as marine turtles which exhibit widespread migratory patterns and a series of ontogenic shifts in which they occupy a variety of locations and habitats throughout their life cycle. These movements severely limit the success of tracking and monitoring attempts (Heppell 1998). They also complicate the design and implementation of management plans and conservation laws since migratory routes remain largely unknown and species' ranges transcend political scales and spatial boundaries (Campbell 2007). The widespread nature of marine turtle distribution also complicates their IUCN listing status due to the fact that one or more populations of a species may actually be increasing in some areas (Seminoff and Shanker 2008).

Nonetheless, all marine turtle species are currently afforded international protection under CITES, the Convention on International Trade in Endangered Species of Wild Flora and Fauna, an international treaty ratified in 1973 to regulate trade in certain wildlife species. Thus far, 116 countries have made the import and export of marine turtle products illegal (CITES 2011). CITES was ratified in Madagascar in 1975 (Decree 75-014). In 1998, Decree 88-243, though only explicitly mentioning leatherback turtles, functioned to grant all marine turtle species absolute protection from exploitation (Mbindo 1996). Sea turtle hunting was thus made and continues to be illegal throughout Madagascar.

The law, however, is not domestically enforced, and is ignored by both authorities and fishermen (Walker et al. 2004). In 2001, governments in the Indian Ocean and South East Asia, under the United States Convention on the Conservation of Migratory Species of Wild Animals, made a commitment to the conservation of marine turtles and created a Memorandum of Understanding. In 2003, Madagascar became a part of this organization and signed what has come to be known as the IOSEA Marine Turtle MoU, which includes a conservation and management plan focused on the reduction of marine turtle mortality, international cooperation, habitat protection, education awareness, research and monitoring, and the promotion of implementation to guide participating countries (IOSEA 2011). Because of a combination of the strong cultural and traditional ties associated with the consumption of sea turtles, little to no enforcement of regulations due to corruption and/or indifference, and continued demand, marine turtle hunting still continues in Madagascar (Lilette 2006).

## 4. The People

### *4.1. The People of Southwest Madagascar*

The Vezo, the dominant group of people occupying the coastal belt extending from south to north southwest Madagascar, are often described as a semi-nomadic seafaring people of the western coast of Madagascar who “struggle with the sea and live on the coast” (Corbett 2010; Astuti 1995). Although there exist several variants of the translation of 'Vezo,' there is almost unanimous agreement on the literal translation of the word from Malagasy as the imperative of the verb *mive*, to row. This expresses the action of rowing a fishing vessel and the utilization of a dugout canoe as one's mode of transportation (Lilette 2006). Vezo fishermen engage in artisanal fisheries reliant on the use of non-motorized fishing vessels called pirogues, *lakana*, which are canoes made by hollowing out a large log and powered by sail and paddle. The majority of fishing takes place close to shore, men fishing with spears, lines, and nets while women collect and sell the fishermen's catch in addition to searching the reef flats with children for sea cucumbers and octopus (Muttenzer 2007).

Vezo culture is riddled with spiritual traditions practiced widely throughout Madagascar. Ancestor worship is a central idea to island beliefs, as well as the pervading presence of taboos, locally called *fady*, which guide daily life. Taboos may be related to everything from food and customs, *fomba*, to wildlife and areas of land. Malagasy peoples even have taboos related to the passage of time, with certain activities forbidden on certain days and some days considered more auspicious than others. Building on the concept of taboos, the existence of sacred places is also common (Cinner 2007). Perhaps most important to understanding how the Vezo view their environment is their belief in the openness and inexhaustibility of the sea. The quantity of their catch depends on the generosity of the spirits that live in the sea; it is a gift (Tolojanahary 2007). For them, the extinction of species that currently exist is unimaginable. They believe that the sea, their main source of income and sustenance, is rich and will always be there to provide for them (Corbett 2010).

### *4.2. The Vezo and the Tradition of Marine Turtle Hunting*

Vezo people have a long history and tradition of hunting marine turtles. The marine turtle represents for the people of the sea a sacrificial animal comparable to the zebu, the most valued animal for terrestrial dwellers in Madagascar in terms of both spiritual significance and utility (Lilette 2006). Traditionally, the wealthiest families in coastal villages and those that are often the most respected belong to sea turtle fishermen.

Both *fomba* and *fady* have traditionally been strongly associated with the slaughter and consumption of marine turtles. For example, it is still necessary in Vezo society to consume turtle meat in order to become *razana*, an ancestor. Revering the ancestors and ascending to this level one's self is one of the most important components of Malagasy spiritual beliefs. Consuming turtle meat also marks the transition between village elder and *hazomanga*, or spiritual intermediary between the community and the ancestors. Traditionally, the sale of marine turtle products was forbidden, the animal's slaughter considered a gift to the community with the best meat being reserved for elders or “amulet

bearers" (Walker and Fanning 2003). Consumers of the turtle meat were forbidden to touch the meat, necessarily eating with their hands tied behind their backs or being fed by another member of the community. Fishermen, more specifically the harpooner, carved the turtle on the beach before an altar, not severing the turtle's aorta until the very last moment to maintain the animal's life force throughout the carving. If this custom was broken, the fisherman would never hunt turtles again (Lilette 2006).

Traditions regarding marine turtle hunting continue to be observed by older fishermen in remote villages but are shown little respect by younger generations (Walker 2003; Lilette 2006; Walker and Roberts 2005). The capture and sale of marine turtle products has now become a business. Turtles not used for consumption are transported to nearby markets and sold, fetching prices up to $70 USD

*Figure 3. Women in Ifaty, Madagascar preparing various parts of a sea turtle for consumption (left), Vezo men carving meat from a turtle shell (right). Photographs courtesy of ReefDoctor.*

depending on its size (Lilette 2006). In addition, instead of being targeted by exclusive turtle fishermen, marine turtles are a part of a multi-species fishery made up of opportunistic or occasional fishermen (Walker and Fanning 2003). Modern methods used to catch turtles including diving with use of a speargun, long-line fishing, coastal gill nets, and poisoning (Gladstone et al. 2002; Rakotonirina and Cooke 1994). Products gleaned from marine turtles include meat, eggs, and stuffed carcasses and carapaces which are sold as ornaments. Meat is the primary product for which turtles are hunted in southwest Madagascar. As markets are generally far away and many turtle products are perishable, 2

out of 3 turtles are consumed domestically (Hughes 1974). Egg collection has nearly reached cessation due to overharvest and the market for turtle ornaments is relatively small and mostly limited to the tourist sector (Mbindo 1996). With the dilution of traditions regarding the consumption of turtle meat, marine turtles thus appear to serve primarily as a source of protein and secondarily as a source of supplementary income (Hughes 1974).

## 5. The Problem

### *5.1. The Sustainability of Marine Turtle Fishing in a Shifting Economy*

Local economies all over Madagascar are currently experiencing a shift from a barter-based system to a cash-based system. Traditionally a people of trade, sale of marine products and tourism now supplement local income for the Vezo (Harris 2007). Increased fisheries export from Madagascar has brought several international companies to the region such as the Italian company Copefrito and Murex, a Canadian company. The purchases of marine products by these companies has increased overall demand for fish and strengthened the cash economy (Astuti 1995).

Presently, over 50% of fishermen in Madagascar operate in the Tulear region. This number is steadily growing with an increasing number of coastal migrants drawn to the sea by high rates of unemployment, minimal agricultural success in such an arid climate, and the lucrative opportunities presented by the sale of marine products such as lobster, shrimp, and marine turtles (Laroche and Ramanarivo 1995). Coastal migration has increased the availability of terrestrial sources of meat such as pigs, cattle, and goats as inland peoples bring their animals with them to their new settlements. Migration has also led to an increasing number of people adopting fishing activities and employing newer technologies to increase fishing success, some of which, such as beach seining or dynamite fishing, are highly destructive to reef and littoral habitats (Belle et al. 2009). The increase in fishing effort combined with increases in tourism, sedimentation (from deforestation), and pollution almost certainly mean trouble for Tulear's coral reef systems and their sea turtle populations.

Indeed, Petit (1930) reported population declines in marine turtles in Madagascar as early as 1930 due to fisheries activities. Rakotonirina and Cooke (1994) found marine turtles to still occur in substantial numbers, but believed that a reduction and/or cessation of nesting had occurred in some areas. They also suggested the reduction in size and numbers of animals caught to be indicative of a major decline. Similarly, Walker and Roberts (2005) noted the disappearance of several nesting populations of marine turtles in the region due to intensive pressure from egg collecting and hunting of nesting females, fishermen stating that turtle catch rates and general abundance had decreased progressively over the last 10 years. Estimations for marine turtle populations in the southwest Madagascar are currently nonexistent, making it difficult to determine the sustainability of marine turtle fishing in the region. Previous research conducted by Kar and Bhaskar (1995) and Rakotonirina and Cooke, however, suggests the unsustainability of marine turtle harvest in the Indian Ocean. Because of life history traits such as high mortality in early life stages and delayed sexual maturity, marine turtles can generally be considered to be unsuitable for even moderate harvest levels, especially if populations have already been reduced (Heppell et al. 2003).

## 6. Methods

### *6.1. Taste Preference and Market Demand*

Conducted over a period of seven days in April 2011, this study was intended to be a pilot pseudo-replication of work conducted by Garland and Carthy (2010) in an indigenous marine turtle fishing community in Caribbean Nicaragua and will be implemented by ReefDoctor throughout the southwest coast in the near future. In consideration of ethical standards concerning research with human subjects, an IRB Action form was submitted to and approved by the School for International Training Institutional Review Board prior to the beginning of the study.

To gauge meat preference, I used a ranking exercise similar to that used by Garland and Carthy (2010) to collect interval-level data and to determine any existing differences among age groups. Data

was also gathered on ethnic identity, gender, and number of children per individual. Participants were chosen randomly in a process that included surveying one house in every second compound within the village. Because I overestimated the number of compounds in the village and needed more participants, however, it was necessary to change compound selection approximately three days into the study to every other house, regardless of compound. The types of meat available during the study period and meat prices were determined through local informants.

Age was specifically selected for as a variant in regards to taste preference because of little variation amongst variables such as religion, income level, level of education completed, or socioeconomic status in Ifaty. For example, general assumptions can be made that the level of education completed is low if any has been completed at all, household size is large in accordance with a high national population growth rate of 3%, and income level is low as 85% of Madagascar's population are reported to live below the poverty line as of 2007 (CIA 2011). Occupations for the region are largely limited to fishing, tourism, and vending. In addition, it is considered rude in Ifaty to discuss subjects such as income or other indicators socioeconomic status. Because it is common knowledge that turtle fishing is illegal and locals fear punishment, direct association with the turtle fishery was not a question posed to participants to maintain willingness to participate in the study.

Each person interviewed was asked for their age, ethnicity, number of children, and the frequency of their meat consumption. Laminated cards were used in ranking exercises concerning meat preference and perceived cost. I chose this pictographic method to eliminate potential sampling bias against illiterate and/or uneducated participants and to facilitate comprehension of the exercise. Eight flash cards were used in total to depict meat sources of known availability in Ifaty, four

*Figure 4. Interview participant completing the taste preference and cost ranking exercises surrounded by other compound inhabitants in Ifaty, Madagascar, April 2011.*

terrestrial animals; zebu, goat, chicken, duck, and four marine animals; fish, octopus, squid, and sea turtle. The pictures used were from collections of images available on the internet. I chose images with the goal of being most recognizable to villagers. For example, the fish image chosen was one of a squirrel fish (*Sargocentron xantherythrus*), a fish commonly available in Ifaty. Participants were then asked to rank each animal in terms of consumption preference and price by ordering the cards, the first being the most preferable/costly protein item, the last being the least preferable/costly. I created a portable placemat made of butcher paper depicting numbered squares and descending arrows that was used in most exercises to further facilitate understanding of the exercises, the highest square on the placemat for the most preferred/costly item and the lowest/last square the least preferred/costly (Figure 4). In particularly windy situations, the placemat was forgone and the cards were simply inserted into the sandy ground. Interviews were conducted in Malagasy and French, recorded by hand, and lasted between 10-15 minutes each. Responses were translated into English by the project advisor when needed.

To determine trends in meat preference and cost ranking, I averaged the ranks given to each meat source by participants to create an overall score for each item. I then used these scores to assign a rank to each item, i.e. the lower the score, the higher the preference. In addition, I used a Polytomous

Universal Model (PLUM), also known as ordinal regression, in R software version 2.14.1 (R Development Core Team, R Foundation for Statistical Computing, Vienna, Austria) to evaluate meat and fish consumption frequencies in regards to ethnicity, sex, age, and number of children, as it accepts both continuous and categorical independent variables. The dependent variable was consumption frequency per week as a ranked categorical variable.

In Ifaty, marine animals are not thought to be classified as "meat," or the same as terrestrial meat sources; thus, when asking participants about the frequency of their meat consumption marine and terrestrial meat sources were considered separately. Participant responses to the frequency of their meat consumption included: never, 1-2 days per week, 3-4 days per week, every day, 1 day every 1-2 weeks, 1 day every 1-2 months, when they were able to afford it, and only at celebrations (such as weddings, funerals, and national holidays). I then classified responses into six categories to simplify comparison: never, very rarely, rarely, occasionally, often, and very often. A response of consuming meat only at celebrations or 1 day every 1-2 months was classified as very rarely while a response of consuming meat when the participant has money or 1 day every 1-2 weeks was classified as rarely. Participants reporting meat consumption 1-2 days per week were classified as consuming meat occasionally. Responses of meat consumption 3-4 days per week were classified as often while a response of every day was classified as often.

Spearman's rank correlation coefficient was used to determine the strength of correlation between local perceptions of meat prices and actual prices

$$p = 1 - \frac{6\sum d_i^2}{n(n^2-1)};\ d_i = x_i - y_i$$

where *p* is the correlation coefficient, *x* is meat source, *y* is cost, and *n* is the number of categories (Ambrose et al. 2002).

### *6.2. Catch Data Analysis*

Marine turtle fishing was monitored by the *Miamby Fano* Project from 2008 through the time of the study period. With the occasional help of local and international volunteers, chief scientific researcher and marine biologist Emma Gibbons collected data through direct observation of turtle catch and subsequent slaughter and sale, fishermen themselves acting as informants of their catch. Community members and fishermen have been used similarly in other studies by Humber et al. (2010), Walker and Fanning (2003), and McVean et al. (2006) to aid in fisheries monitoring. Data collected for each turtle captured included biological information such as species, sex, and size, as well as capture location, the name of the fisherman who caught the turtle, and the price given by the collector for each turtle. Species, sex, and size information were collected to track catch demographics, including the number of turtles caught throughout the year, the frequency with which each species was caught, sex ratios, and the proportion of juvenile versus breeding adults captured (using size as an estimate of maturity). Understanding stock demographic characteristics such as these is essential to fishery management (Levinton 2001). Price was used to indicate trends in market demand and capture locations were used to determine any differences in fishing effort exerted in different areas of the bay.

Marine turtles were identified to species using distinctive characteristics such as pre-frontal head scale number and fixed vertebral/costal carapace scute ratios. Other indicators include general size, body shape, and coloration patterns that have been established for each species (Hughes 1974; Pritchard and Mortimer 1999). These methods have been shown to be effective and have been used in marine turtle identification in studies such as those conducted by Ballorain (2003) and Allison (2008). Size measurements were taken with measuring tape and included curved carapace length (CCL), straight carapace length (SCL), and straight carapace width (SCW) (Figure 4). These measurements were used as an indicator of maturity (Casale et al. 2011) and fecundity (Hays and Speakman 1991). External sexual identification has proven difficult in turtles below six years of age though invasive

techniques such as laparotomy, karyotyping, and radioimmunological techniques have proven time-intensive and potentially life-threatening to the turtle (Owens 1995); not to mention the extreme unlikelihood of being able to perform such technologically-intensive techniques in a setting such as Madagascar. Other methods of external identification include front-flipper claw length, plastron size, and the extent to which a carapace is domed. Yet another useful method and the one used primarily in collecting the data analyzed in this study is sexing by tail length, males averaging a longer tail length as a means to grasp onto the female during mating (Hughes 1974). Sex was further confirmed with examination of the presence or absence of internal sexual structures (i.e. gonads) upon each turtle's slaughter.

*Figure 5. Captured sea turtles being measured, sexed, and identified to species by Emma Gibbons, Chief Scientific Researcher and marine biologist at ReefDoctor (left) and community volunteers in Ifaty, MD (right). Photographs courtesy of ReefDoctor.*

## 7. Results

### *7.1. Taste Preference and Market Demand*

*Table 1. Demographic characteristics of interview participants in Ifaty, MD, 2011.*

| Participants | | Total N (%) 54 (100%) | Men N (%) 26 (48.15) | Women N (%) 28 (51.85) |
|---|---|---|---|---|
| Age ranges | 18-26 | 12 (22) | 8 (67) | 4 (33) |
| | 27-35 | 16 (30) | 5 (32) | 11 (69) |
| | 36-50 | 13 (24) | 6 (46) | 7 (54) |
| | 50 and older | 13 (24) | 7 (54) | 6 (46) |
| Percentage that eat turtle | | 50 (93) | 22 (85) | 28 (100) |
| Percentage Vezo | | 46 (85) | 21 (46) | 25 (54) |
| Percentage other ethnicities | | 8 (15) | 5(63) | 3(38) |
| Mean age | | 39.42±14.39 | 39.23±15.36 | 39.96±13.58 |
| Mean number of children | | 4.85±3.51 | 4.19±3.66 | 5.46±3.32 |

The distribution of participants was nearly even between both age and age groups with the greatest amount of participants being women 27-35 years of age (Table 1). The number of participants that claimed to be Vezo was 46 (85.19%). Eight (14.81%) participants reported to be of an ethnic grouping other than Vezo; of these, 1 (12.5%) was Tandroy, 1 (12.5%) was Mafahaly, and 6 (75%) were Masikoro. The mean age of interviewees was 40 and the mean number of children per person was 4.85 (Table 1).

*Table 2. Frequency of terrestrial and marine meat source consumption reported by interview participants in Ifaty, MD.*

| Frequency | Terrestrial meat sources | Aquatic meat sources |
|---|---|---|
| | Participants N (%) | |
| Very often | 1 (1.85) | 47 (87.03) |
| Often | 2 (3.70) | 3 (5.56) |
| Occassionally | 14 (25.93) | 2 (3.7) |
| Rarely | 10 (18.52) | 1 (1.85) |
| Very rarely | 27(50.0) | 0 |
| Never | 0 | 1 (1.85) |

Of the 54 people interviewed, 50 (92.59%; 100% of women and 84.62% of men) reported eating turtle meat (Table 1). Three out of the four participants who did not consume turtle meat did not

do so because they considered the animal to be *fady*. One participant explained that turtle meat was *fady* because he had relatives who had died from its consumption. Similarly, another participant reported that he did not eat seafood because it could sometimes be lethal. All 4 (7.40%) participants that reported not eating turtle meat were male whereas all 28 female interviewees (100%) reported eating turtle meat (Table 1). When examined by age group, the mean number of children decreases with age range. The percentage of participants that eat turtle meat remains relatively constant over all age groups with over 85% of participants in each age group reporting their consumption of turtle meat and 100% of participants in the age interval 18-26 consuming turtles.

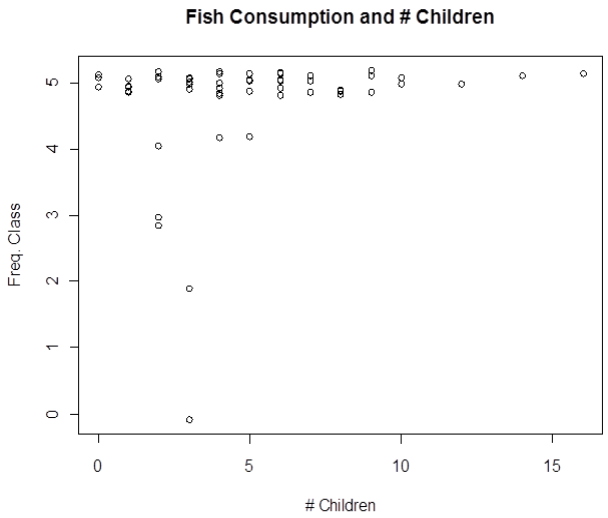


*Figure 6. Jitter plot of PLUM model for marine meat source consumption frequency with number of children as a predictor.*

*Table 3. Participant reported average preference ranking of meat sources in Ifaty, MD, 2011. The lower score, the lower the rank, the higher the preference.*

| Calculated Score | Assigned Rank | Meat Source |
|---|---|---|
| 2.85±1.85 | 1 | Zebu |
| 2.93±2.03 | 2 | Chicken |
| 3.65±1.89 | 3 | Fish |
| 4.24±2.58 | 4 | Turtle |
| 4.7±2.08 | 5 | Duck |
| 4.98±2.18 | 6 | Goat |
| 5.57±1.86 | 7 | Squid |
| 5.65±1.89 | 8 | Octopus |

The majority of participants (47/54; 87.03%) reported eating marine meat sources every day while only 1 participant (1.85%) reported eating terrestrial meat sources as often. Most participants (27; 50.0%) reported only eating terrestrial meat sources on celebratory occasions (Table 2). PLUM models using participant age, sex, gender, and number of children as predictors found no significant relationship between these demographic variables and the frequency with which meat or fish was consumed. Thus, meat and fish consumption were both relatively insensitive dependent variables. One model (fish consumption

frequency with number of children as a predictor) (Figure 6) was nearly significant (p=0.085) but the low explanatory power ($R^2$=0.078) does not give evidence of a strong relationship.

Seven participants (12.96%) reported turtle as their most preferred meat amongst the choices available, and 24 (44.44%) participants gave turtle meat a ranking of 4 or higher (out of a total of 8

*Table 4. Participant reported average preference ranking of meats by age group in Ifaty, MD.*

| Assigned Rank | Calculated Score | 18-26 (12) | Calculated Score | 27-35 (16) | Calculated Score | 36-50 (13) | Calculated Score | 50 and older (13) |
|---|---|---|---|---|---|---|---|---|
| 1 | 2.75±1.82 | Chicken | 2.56±1.90 | Zebu | 2.3±1.65 | Chicken | 2.77±1.64 | Chicken |
| 2 | 3.33±1.87 (1.78) | Zebu/ Duck | 3.69±2.6 | Chicken | 2.62±1.45 | Zebu | 3±2.20 | Zebu |
| 3 | * | * | 3.88±2.36 | Fish | 3.38±2.66 | Fish | 3.54±2.47 | Turtle |
| 4 | 4.5±2.32 | Fish | 4.56±2.45 | Turtle | 4±2.83 | Turtle | 4±2.08 | Goat |
| 5 | 4.83±2.72 | Turtle | 4.88±2.06 | Goat | 4.92±2.02 | Octopus | 4.77±1.36 (2.52) | Duck/ Fish |
| 6 | 4.92±1.56 | Squid | 5.13±1.96 (2.06) | Octopus/ Duck | 5.15±1.95 | Squid | * | * |
| 7 | 5.67±2.23 | Goat | * | * | 5.38±2.53 | Duck | 6.08±1.61 | Octopus |
| 8 | 6.67±1.56 | Octopus | 5.69±1.85 | Squid | 5.46±2.26 | Goat | 6.46±1.85 | Squid |

** Equal preference/cost somewhere amongst the meat sources, thus producing an unfilled rank.*

available meat sources). Overall, turtle meat was assigned an average ranking of 4 (Table 3). Examining taste preference by participant age, turtle meat was also assigned a rank of 4 in the age intervals 18-26, 27-35, and 36-50. Participants that were 50 years of age and older assigned an average ranking of 3 to turtle meat (Table 4).

The average price ranking was relatively consistent with actual prices. The Spearman rank correlation indicates a statistically significant correlation between participant perception of the prices of available meats and their actual prices ($r_s$= .804; n=8; $p<0.025$). Turtle meat was the most expensive available meat source followed by zebu (cattle) and duck meat. Octopus meat was the least expensive (Table 5).

*Table 5. Participants' perceived price ranking and actual price ranking of available meat sources (1=most expensive, 8=least expensive). Prices given are averaged for Ifaty (USD). All items were ranked by price per kilo except chicken and duck. Chicken and duck are sold by individual size; for these items price was divided by estimated average weight of one animal (1.5 kg).*

| Available meats ranked by price (per kilo) | | | |
|---|---|---|---|
| Calculated Score | Assigned Rank | Participant Perceived Price | Actual Price |
| 1.92±1.3 | 1 | Zebu | Turtle (2.50) |
| 2.53±1.97 | 2 | Turtle | Zebu (2.25) |
| 3.74±1.78 | 3 | Goat | Duck (2.16) |
| 4.21±1.49 | 4 | Chicken | Goat/Squid (2.00) |
| 4.6±1.42 | 5 | Duck | * |
| 4.96±1.68 | 6 | Squid | Chicken (1.38) |
| 6.81±1.16 | 7 | Octopus | Fish (1.25) |
| 6.89±1.56 | 8 | Fish | Octopus (1.00) |

### *7.2. Catch Data Analysis*

*Table 6. Number of individuals and sex composition of observed turtle catch in Ifaty, MD, 2008-2010.*

| Year | Number of turtles caught | Female N (%) | Percent N (%) |
|---|---|---|---|
| 2008 | 100 | 63 (63) | 37 (37) |
| 2009* | 165 | 141 (86) | 22 (13) |
| 2010 | 137 | 113 (83) | 24 (17) |

*Sex undetermined for some individuals

respectively, with an average between the three years of 134 (±32.60) turtles. Over 60% of the turtles caught each year were females, the percentage over 80% in the past 2 years (Table 6).

The majority of turtles caught were green sea turtles, followed by hawksbills. Loggerheads and olive ridleys were rarely caught; only 4-5 individuals were recorded for each species over the 3 years.

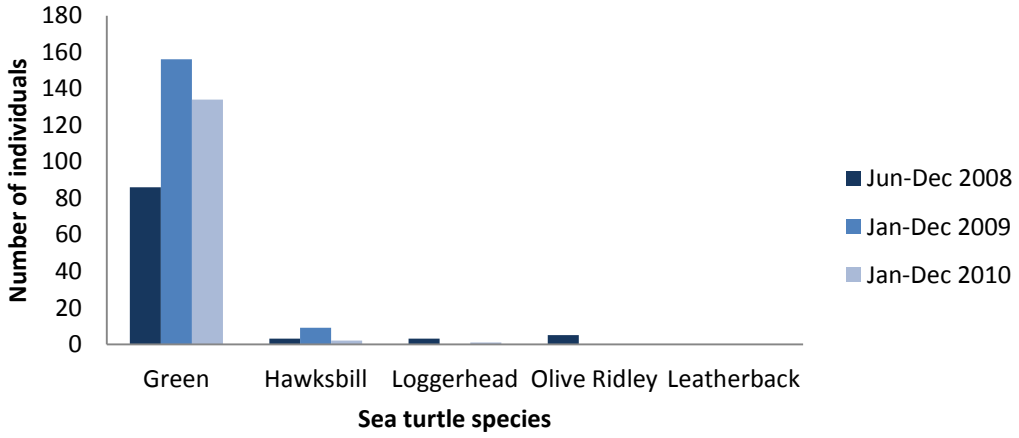


*Figure 7. Species distribution of turtle catch in Ifaty, 2008-2010.*

No leatherback sea turtles were caught for the duration of the catch monitoring (Figure 7).

Captured turtles generally had straight carapace lengths between 50 and 100 cm (Figure 8). The size of captured turtles increased steadily from 2008 to 2010 with an increased frequency of SCLs greater than 80 cm and a near complete cessation of turtles caught below 50 cm by 2010.

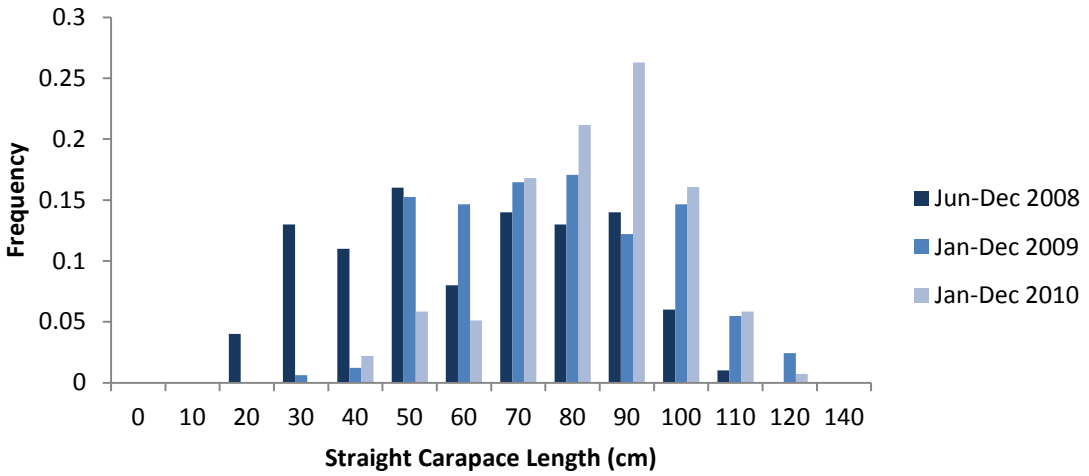


*Figure 8. Size class frequency distribution of turtle catch in Ifaty 2008-2010.*

The average price given by collectors for marine turtles in 2009 was 18.30 (±30.46) USD and 18.83(±24.70) USD in 2010. Price data was unavailable for 2008.

## 8. Discussion

### *8.1. Taste Preference and Market Demand*

The majority of interview participants were Vezo with a mean age of 40 (±14.39) years. The mean number of children per individual was 4.85 (±3.51). The sample was relatively evenly distributed between male and female community members with an even spread among age intervals. Of these, over 90% reported eating turtle meat. Most interviewees reported eating marine meat sources every day while terrestrial meat sources were rarely eaten and marine turtles appeared to be a preferred source of meat for over 50% of participants. Turtle meat was also the most costly meat available in Ifaty at 2.50 USD/kg, followed by zebu (2.25 USD) and duck meat (2.16 USD). Compared to terrestrial meat sources, the other marine meat sources (i.e. fish, octopus, and squid) were relatively inexpensive.

The marine turtle fishery in Ifaty appears to have been altered by the commoditization of marine turtles, integration of rural communities into the cash-based economies of larger cities, and a greater desire for material wealth. The sale of marine turtles and their products was historically considered *fady* but younger generations, especially those living near larger cities, now largely ignore such traditions (Rakotonirina and Cooke 1994). Village elders remembered times when perhaps 1 or 2 turtles were caught in a week instead of the recent trend of eight or more turtles caught per day (Pers. Comm. Emma Gibbons). Rose et al. (2001) and Wilkie and Carpenter (1999) detailed similar situations in the African bush where the introduction of foreign economics and technology has undercut myth- and tradition-based conservation practices. As indigenous people adopt modern hunting technologies, they essentially abandon traditional norms. For example, instead of using condoms provided by aid organizations for their intended purpose, fishermen in Madagascar often used them to waterproof flashlights to fish at night. Although a great example of indigenous ingenuity, this allowed the fishermen access to nocturnal fish stocks in addition to the already heavily exploited day stocks, increasing overall fishing pressure on the coral reef. In addition, mosquito nets were used in lieu of other materials for fishing nets as fish found it more difficult to escape the smaller openings characteristic of mosquito nets. This resulted in a by-catch of juvenile fishes that would not have the chance to breed and replenish their respective populations. Furthermore, demand by international companies such as Copefrito and Murex for marine products like octopus in an increasingly cash-based economy undercuts traditional subsistence fishing patterns and fuels incentives for fishermen to land the largest catches possible, thus contributing to declines in fish populations and coastal ecosystem health.

No significant increase or decrease in preference for turtle meat was observed across age groups. Turtle meat was ranked consistently across age intervals 18-26, 27-35, and 36-50 as the 4$^{th}$ most preferred meat among the 8 choices of meats known to be widely available in the village. Turtle

meat was ranked 3rd on average by participants 50 and older. Older participants may have exhibited a greater preference for turtle meat because of continued attachment of strong spiritual values to its consumption, whereas younger generations have been exposed to other types of more non-traditional Vezo meat sources such as chicken and goat for a greater period of their lives and thus are more familiar with their consumption. Indeed, in a bushmeat taste preference study conducted in Gabon, Central Africa, Schenck et al. (2006) concluded that culturally mediated factors such a tradition, familiarity, and prestige play significant roles in the consumption of wildlife in addition to influences such as taste and price. This conclusion has also been supported by several other studies in similar situations with stakeholders of similar socio-economic circumstances on mainland Africa (Shepherd 1999, Fa et al. 2002, and Mfunda et al. 2010). Garland and Carthy (2010) also found turtle meat to decrease in preference among younger generations in Caribbean Nicaragua and posited ease of acquisition and convenience, both regularly cited as important factors in determining preference for one food item over another and frequency of consumption, to be the driving causes. In terms of convenience, the decreasing preference for turtle meat in younger generations may therefore indicate that turtle meat was not acquired as easily in the past. This seemed to be supported by accounts of village elders that, in the past, sea turtles were caught once or twice a week instead of one or more per day. Additionally, younger generations in Ifaty and throughout Madagascar commonly seek to migrate to cities for employment and education opportunities unavailable to them in rural communities. One may assume that they are thus more exposed to other types of meat and foods than older generations, which probably alters their taste preferences.

Across all age groups, the 1st and 2nd most preferred meats were terrestrial sources, more specifically chicken and zebu (although duck was assigned the same 2nd rank as zebu in the age interval 18-26). This could have been an early indication of decreased quantity and/or quality of these marine products and/or a type of prey-switching for the people in the village of Ifaty as coastal migration

continues and terrestrial meat sources become increasingly available. Though Ifaty is primarily a Vezo settlement, a second addition to the village has grown within the past couple of decades. This adjunct collection of compounds was largely comprised of other ethnic groups from further inland such as Masikoro, Mahafaly, and Antandroy. The traditional livelihoods for these groups are animal breeders, cattle herders, and farmers. Migrating to the coast due to the difficulties of farming and raising animals in such an arid climate, they often bring their animals with them. Indeed, while walking around the village gathering interview data, domestic livestock such as zebu, pigs, chickens, and goats were a common sight. The fluidity of the Vezo ethnicity facilitates this migration, as anyone who learns the ways of the Vezo and demonstrates proficiency (namely in seafaring and fishing) can become Vezo. Traditionally, the Vezo's primary source of sustenance was marine products. With the increased availability of terrestrial meat sources, however, interviewees reported preferring these over more traditional sources; even people in the age interval 50 and older assigned an average ranking of 1 to chicken. Notably, however, interview participants often referred to sea turtles as "cows," reinforcing the idea that the marine turtle is still considered to be an animal of sacrifice comparable to the size, spiritual, and monetary value of a zebu. Though the traditions regarding the hunting and consumption of sea turtle meat might have been largely diluted, it seemed that sea turtle meat continued to hold a sense prestige in the community. This may indicate a foundation on which to initiate further community conservation efforts based on a common desire to ensure that this particular component of their cultural heritage is available for generations of Vezo to come. It also suggested a possible culturally acceptable alternative to sea turtle meat.

Despite the apparent preference for terrestrial meat sources over marine meat sources or the appreciable mixture of the two among assigned rankings, the trend in the frequency of their respective consumption was very clear. Though participants exhibited a preference for terrestrial meat sources, very few claimed to consume them often, with over 60% reporting that they ate them rarely to very

rarely. In contrast, 47 (87.03%) reported consuming marine products very often, the majority of these responses "every day." It was these unbalanced response rates among interview participants which primarily contributed to the insignificance of the predictive power of the demographic characteristics surveyed on the frequency of meat and fish consumption. Thus, future research may reveal other factors behind the frequency of terrestrial and marine meat consumption (such as socio-economic status). Additionally, a larger sample size might yet reveal trends that could not be observed with any significance in the pilot study. The fact that one PLUM model (fish consumption frequency as predicted by number of children) was nearly significant ($p=0.085$) may, for example, indicate that participants with more children eat marine products more often or that they eat terrestrial meat sources more often, suggesting, with the assumption that residents with less children have more money at their disposal, an influence of price (marine products being the cheaper source) on meat source consumption frequency.

Though people in the village of Ifaty may have preferred terrestrial sources such as chicken and zebu, they still overwhelmingly consumed marine products. This was most likely due to the ease of acquisition of marine products from the Bay of Ranobe and the generally higher price of terrestrial meat sources. Rozin (1996) noted that "price [of food] is a major practical determinant of what is effectively available, and hence intake". As mentioned previously, southwest Madagascar is one of the island's poorest regions, with many of its inhabitants living in what would be considered extreme poverty; thus, most could not afford to eat high priced items such as zebu or duck with any frequency. Affordability, it seemed, did not determine preference in Ifaty but did determine intake. Schenck et al. (2006) suggested that once consumers become accustomed to alternative (domestic) meat sources they may choose to eat less wildlife; thus, since sources of meat such as chicken and zebu were consistently the most preferred among all age groups, price may be the largest barrier preventing the inhabitants of Ifaty from consuming these instead of marine turtles.

Rozin (1996) noted social factors such as culture and ethnic group to be some of the most influential determinants of food habits and taste preferences. Of the 54 people surveyed, 4 (7.41%) reported that they did not eat turtle meat. The most common reason given was that turtle meat was *fady*. One participant explained that turtle meat was *fady* because one of his ancestors had died from its consumption and another stated that it was his custom not to eat any type of seafood because it can be lethal. Notably, all participants who reported not eating turtle meat were male, which may be due to the fact that women traditionally adopt the taboos and customs of their husbands whereas men retain the taboos and customs of their parents. It could then be assumed that since the majority of interviewees ate turtle, women either continue or begin eating turtle meat upon marriage. Forty-six (85.19%) of participants claimed to be Vezo, the primary ethnic grouping in the area, while 8 (14.81%) claimed to be Tandroy, Mahafaly, or Masikoro. Three out of the 4 people that did not consume turtle meat were of these other ethnicities while only one was Vezo. Another *fady* mentioned by a Vezo woman was against the consumption of goat by a Vezo woman. Pork was also noted as a general *fady* in the village. Further study is needed to ascertain the presence and extent of *fady* to gain a clearer understanding of village views on wildlife and domestic animal consumption.

### *8.2. Local Annual Marine Turtle Catch*

The majority of marine turtles caught in Ifaty were female green sea turtles. The average number of turtles caught between 2008 and 2010 was 134 (±32.60). Loggerhead turtles and olive ridleys were the two other marine turtle species caught most often in the fishery. The SCL range of captured turtles was generally 50-100 cm but trending heavily towards SCLs greater than 80 cm. The average price for marine turtles was 18.57(±0.37) USD.

The Bay of Ranobe is a little studied area of Madagascar, estimates of its marine turtle populations nonexistent; however, several studies conducted along the southwest coast (Rakotonirina and Cooke 1994; Walker and Roberts 2005; Frazier 1975) have indicated a major population declines.

In some cases, nesting populations have been extirpated due to overexploitation (Walker and Roberts 2005). Green sea turtles have historically been the most exploited in the Tulear region (Hughes 1974). Loggerheads were moderately represented among individuals caught while hawksbills were rarely caught (Rakotonirina and Cooke 1994). The finding that green turtles have been the most exploited in the Tulear region was consistent with study results, the species representing over 80% of the catch in Ifaty each year from 2008 to 2010. In contrast with Rakotonirina and Cooke's findings on the species distribution of the catch in the Tulear region, hawksbills were the second most represented species followed by olive ridleys and loggerheads. The difference between the numbers caught of the latter two species was so small, however, that it may simply have been due to annual variation in presence of species in the Bay of Ranobe. Hughes (1971) estimated annual catch in southwest Madagascar to be in the thousands for each of the five occurring species of marine turtles. Without specific estimates and an analysis of turtle catch in nearby villages though it is impossible to state how an average annual catch between 2008 and 2010 in Ifaty of 134 (±32.60) turtles might contribute to these estimates.

The fact that females comprised the majority of marine turtle catch was consistent with previous findings in the region by Rakotonirina and Cooke (1994) and Walker and Fanning (2003). Rakotonirina and Cooke reported the mean carapace size of turtles caught in Anakao in 1989 to be between 40 and 82 cm while the mean carapace length range found by Walker and Fanning (2003) in 2002 was between 84 and 106 cm. SCL data collected in Ifaty places the size range for turtles caught over the study period between 50 and 100 cm on average with a minimum of 17 cm and a maximum of 112 cm. Each year, marine turtle catch in Ifaty was made of larger individuals with a near cessation in 2010 of turtles caught below 50 cm. The first shift trending towards larger turtles in 2008-2009 was a direct result of the decision by village elders heading the Miamby Fano Project, guided by biological information provided by ReefDoctor, indigenous knowledge, and a desire to conserve an important piece of their cultural heritage, to implement a minimum size (50 cm SCL) limit. The reasoning behind

this decision was to reduce fishing pressure on a segment on the juvenile segment of the population, the "children," that have not had the chance to breed yet. An almost complete adherence to this agreement was more clearly observed in the size frequency catch data from 2010.

Although there exists some dissension (Hughes 1974; Broderick et al. 2003), fecundity has often been found to positively correlate with size in marine turtle females, larger females laying more eggs per clutch (Van Buskirk and Crowder 1994; Hirth 1980; Hays and Speakman 1991). The segment of the population on which village elders decided to focus their conservation efforts, small juveniles, may thus not be the most effective means to reducing fishing pressure on and ensuring the continuation of the local population. Evidence has, however, been presented by Mazaris et al. (2005) that protection and/or control of loss of marine turtles at earlier life stages could effectively prevent declines in populations through increasing annual cohort size, thus increasing the number of animals at later life stages. Additionally, no conclusive figures have been established for growth rates or the length of time needed for marine turtles to reach sexual maturity for any species. Some studies have suggested that growth is distributed in intervals throughout the ontogenic shifts characteristic of a sea turtle's life cycle while others have made a case for polyphasic growth (Heppell et al. 2003), but there seems to be no uniform or minimum size at which marine turtles reach sexual maturity. This means that size may not yet be used as a reliable indicator of breeding status or maturity (Lutz and Musick 1997); therefore, a management strategy geared towards the smaller turtles may yet produce effects.

Above all, Ifaty was a testament to the effectiveness of initiating local conservation through the incorporation of indigenous knowledge and traditional hierarchies. Through the use of village elders in the production of catch limits, local fishermen responded rapidly. Within two years, virtually no turtles were caught below 50 cm. This may also have been indicative of local understanding of the need for marine turtle conservation and a desire to preserve a natural resource important to their cultural heritage and for sustenance. Indeed, a second regulation was set by village elders in December 2010 to

increase the minimum size for turtle catch to 70 cm with a 4-month closed season planned to be implemented in the future.

**9. Management Implications**

The fact that turtle meat was the most costly meat available in the village at 2.50 USD per kilo was indicative of its traditional value and continued local demand. No significant relationship was observed between age and preference for turtle meat in the village of Ifaty. Turtle meat was consistently ranked mid-range ($3^{rd}$ or $4^{th}$) overall and in each of the age intervals 18-26, 27-35, and 36-50. Ethnicity and gender exhibited some bearing on taste preference but a larger sample size would be needed to extrapolate any definitive conclusions. Despite a strong preference for terrestrial meat sources over more traditional marine sources, the high prices of terrestrial meat coupled with extreme poverty and ease of acquisition of marine products appeared to ensure the community's continued reliance of on the sea for their meat. Apaza et al. (2002) suggested that meat prices are an important factor in consumers' decisions regarding meat consumption and that wildlife exploitation for consumptive purposes may be reduced by lowering the price and/or increasing the supply of livestock products. This conclusion has been supported by various other studies in tropical regions of similar socio-economics, including South and Central America (Wilkie and Godoy 2001), Central Africa (Wilkie et al. 2005; Willcox and Nambu 2001), and Equatorial Guinea (East et al. 2005) where the consumption of wildlife is important to local economies and for nutrition (protein). It is not unlikely that as more Malagasy continue to migrate to the coast, the supply of domestic livestock will increase in Ifaty and prices will lower. Due to an already established preference for these meat sources, this may eventually lead to decreased fishing pressure in coastal ecosystems; but this appears tenable only if fishermen engage in some sort of alternative livelihood in order to maintain household income.

The current process of the dilution of traditional knowledge, the commercialization of turtle meat, increasing coastal migration, and a national population growth rate of 3% suggest an increase in

future demands on the marine turtle fishery in Ifaty if the consumption of domestic terrestrial sources does not also rise. Because no estimates of population numbers for marine turtles in the Bay of Ranobe currently exist, the sustainability of current annual harvest or of this possible future trend is unknowable. Low reproductive potential and delayed sexual maturity, however, in addition to current harvest tends towards large females of high reproductive potential, may place marine turtle populations in southwest Madagascar in danger of overexploitation. It is thus of the utmost importance to launch a program to directly determine the number of marine turtles in the Bay of Ranobe, ascertain seasonal and annual variation in movements and occurrence, and to determine their composition in terms of sex, species, and maturity instead of relying solely on catch data as a means to monitor population status. Such population estimates will provide a more reliable framework by which to assess the sustainability of Ifaty's marine turtle fishery.

## 10. Recommendations for Future Study

Though all age groups were relatively evenly represented, the overall sample size of this study (N=54) was fairly small, making extrapolation of trends difficult. A larger sample size would allow for a better assessment of links between taste preference and demographic characteristics of the people of Ifaty. In addition, sampling method in terms of selecting participants should be changed to every 2-3 houses as surveying one house in every two compounds overestimated the number of compounds in the village and would result in the exclusion of a fair portion of the population. Interview participants may also need to be blocked according to the location of their house and compound in order to account for variation among the predominantly Vezo part of Ifaty closer to the seashore and the newer part of Ifaty that is primarily comprised of migrants from other ethnic groupings that may not as familiar with the concept of marine turtles as a source of meat.

To gather more information on other factors that might affect an individual's consumption of turtle meat, some additional questions to add to interviews might be: 1) What is your occupation? 2) How much schooling have you had? and 3) How many children do you plan to have? Though the responses to these questions may be relatively uniform, they might provide useful information as to other trends among consumers of sea turtle meat. In addition, though I was told that it might not be culturally acceptable, I would also pursue more direct questioning as to income and involvement in the marine turtle fishery contingent upon the degree of positive or negative responses of the first few interviewees. This would facilitate a more direct evaluation of demographic characteristics with involvement in the sea turtle trade.

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**Literature Cited**

Allison, G. 2008. De la ponte à l'éclosion : suivi de la reproduction de deux espèces menacées de tortues marines, la tortue verte et la tortue imbriquée, sur l'île de Nosy Iranja, Madagascar. Master Biodiversité des Ecosystèmes Tropicaux, Université La Réunion, Nosy Iranja, Madagascar. [In French.]

Ambrose II, H. W., D. J. Emlen, K. P. Ambrose, and K. L. Bright. 2002. A handbook of biological investigation. Sixth edition. Hunter Textbooks Inc., Winston-Salem, NC, USA.

Apaza, L., Wilkie, D., Byron, E., Huanca, T., Leonard, W., Perez, E., Reyes-Garcia, V., Vadez, V., and R. Godoy. 2002. Meat prices influence the consumption of wildlife by the Tsimane' Amerindians of Bolivia. Oryx 36.

Astuti, R. 1995. 'The Vezo are not a kind of people'. Identity, difference and 'ethnicity' among a fishing people of western Madagascar. American ethnologist 22: 464-482.

Ballorain, K. 2003. Etude comportementale des tortues marines de N'Gouja (Mayotte). Suivi effectué à Itsamia du 26 février au 12 mai 2002, Mayotte. [In French.]

Belle, E. M. S., G. W. Stewart, B. De Ridder, R. J. L. Komeno, F. R. B. Remy-Zephir, and R. D. Stein-Rostaing. 2009. Establishment of a community managed marine reserve in the Bay of Ranobe, southwest Madagascar. Madagascar Conservation and Development 4: 31-37.

Bolten, A.B. 2003. Variation in sea turtle life history patterns: neritic vs. oceanic developmental stages. Pages 243-257 in P.L. Lutz, J. Musick and J. Wyneken, editors. The Biology of Sea Turtles, volume II. CRC Press, Boca Raton, FL.

Bouchard, S. S., and K. A. Bjorndal. 2000. Sea turtles as biological transporters of nutrients and energy from marine to terrestrial ecosystems. Ecology 81: 2305-2313.

Broderick, A. C., F. Glen, B. J. Godley, and G. C. Hays. 2003. Variation in reproductive output of marine turtles. Journal of Experimental Marine Biology and Ecology 288: 95-109.

Campbell, L. M. 2007. Local conservation practice and global discourse: A political ecology of sea turtle conservation. Annals of the Association of American Geographers 97: 313-334.

Carr, A. 1995. Notes on the behavioral ecology of sea turtles. Pages 19-26 *in* K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, USA.

Casale, P., Mazaris, A. D., and D. Freggi. 2011. Estimation of age at maturity of loggerhead sea turtles Caretta caretta in the Mediterranean using length frequency data. Endangered Species Research 13.<http://www.int-res.com/articles/esr_oa/n013p123.pdf>. Accessed 3 February 2012.

Cinner, J. E. 2007. The role of taboos in conserving coastal resources in Madagascar. SPC Traditional Marine Resource Management and Knowledge Information Bulletin. No. 22. December 2007: 15-23.

Central Intelligence Agency [CIA]. 2011. CIA World Factbook. Africa: Madagascar. <https://www.cia.gov/library/publications/the-world-factbook/geos/ma.html>. Accessed April 2011.

Convention on International Trade in Endangered Species of Wild Flora and Fauna [CITES]. 2011. <http://www.cites.org/>. Accessed 2 May 2011.

Corbett, C. 2010. All at sea. Africa Geographic. March 2010: 61-65.

Drury, R., Homewood, K., and S. Randall. 2010. Less is more: the potential of qualitative approaches in conservation research. Animal Conservation 14: 18-24.

East, T., Kumpel, N. F., Milner-Gulland, E. J., and J. M Rowcliffe. 2005. Determinants of urban bushmeat consumption in Rio Muni, Equatorial Guinea. Biological Conservation 126: 206-215.

Ehrenfeld, D. W. 1974. Conserving the edible sea turtle: can mariculture help? Commercial husbandry does not necessarily protect endangered species. American Scientist 62: 23-31.

Emma Gibbons, Personal Communication, 21 April 2011.

Fa, J. E., Juste, J., Burn, R. W., and G. Broad. 2002. Bushmeat consumption and preferences of two ethnic groups in Bioko Island, West Africa. Human ecology 30: 397-416.

Fowler, J., L. Cohen, and P. Jarvis. 1998. Practical statistics for field biology. Second edition. John Wiley and Sons Ltd., West Sussex, England, UK.

Frazer, N. B. 1986. Survival from egg to adulthood in a declining population of loggerhead turtles, *Caretta caretta*. Herpetologica 42: 47-55.

Frazier, J. 1975. Marine turtles of the Western Indian Ocean. Oryx 13: 164-175.

Garland, K. A., and R. R. Carthy. 2010. Changing taste preferences, market demands and traditions in Pearl Lagoon, Nicaragua: A community reliant on green turtles for income and nutrition. Conservation and Society 8: 55-72.

Gladstone, N., F. Andriantahina, and B. Soafiavy. 2002. Marine turtle conservation and research in southeast Madagascar. Report on activities and findings in the 2001-2002 nesting season. Azafady Project Fanomena. Toalagnaro, Madagascar.

Goodman, S. M. and J. P. Benstead. 2005. Updated estimates of biotic diversity and endemism for Madagascar. Oryx 39: 73-77.

Harris, A. 2007. “To live with the sea” development of the Veliondrake community-managed protected area network, southwest Madagascar. Madagascar Conservation and Development 2: 43-49.

Hays, G. C., and J. R. Speakman. 1991. Reproductive investment and optimum clutch size of loggerhead sea turtles (*Caretta caretta*). Journal of Animal Ecology 60: 455-462.

Heck, K. L., Jr., Hays, G., and R. J. Orth. 2003. Critical evaluation of the nursery role hypothesis for seagrass meadows. Marine Ecology Progress Series 253: 123-136.

Heppell, S. S. 1998. Application of life-history theory and population model analysis to turtle conservation. Copeia 2: 367-375.

Heppell, S. S., Snover, M. L, and L. B. Crowder. 2003. Sea Turtle Population Ecology *in* P. L. Lutz, J. A. Musick, and J. Wyneken., editors. The Biology of Sea Turtles. Volume 2. CRC Press, Boca Raton, Florida, USA.

Hirth, H. F. 1980. Some aspects of the nesting behavior and reproductive biology of sea turtles. Amer. Zool. 20: 507-523.

Hughes, G. R. 1971. Sea turtle research and conservation in south east Africa. Pages 57-67 *in* Proceedings of the 2nd working meeting of marine turtle specialists. Survival Service Commission, IUCN. Morges, Switzerland.

Hughes, G. R. 1974*a*. The sea turtles of south east Africa. I. Status, morphology, and distributions. Investigational Report No. 35. South African Association for Marine Biological Research. Oceanographic Research Institute. Durban, Republic of South Africa.

Hughes, G. R. 1974*b*. The sea turtles of south east Africa. Thesis, University of Natal, Natal, South Africa.

Humber, F., B. J. Godley, V. Ramahery, and A. C. Broderick. 2010. In press. Using community members to assess artisanal fisheries: the marine turtle fishery in Madagascar. Animal Conservation.

Indian Ocean – South-East Asian Marine Turtle Memorandum of Understanding [IOSEA MoU]. 2011. <http://www.ioseaturtles.org/>. Accessed 27 April 2011.

Kar, C. S., and S. Bhaskar. 1995. Status of sea turtles in the Eastern Indian Ocean. Pages 365-372 *in* K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, USA.

Laroche, J., and N. Ramananarivo. 1995. A preliminary survey of the artisanal fishery in the coral reefs of the Tulear region (southwest Madagascar). Coral Reefs 14: 193-200.

Levinton, J. S. 2001. Marine biology: function, biodiversity, ecology. Second edition. Oxford university press, Inc., New York, New York, USA.

Lilette, V. 2006. Mixed results: conservation of the marine turtle and the red-tailed tropicbird by Vezo, semi-nomadic fishers. Conservation and Society 4: 262-286.

Lutz, P. L., and J. A. Musick, editors. 1997. The biology of sea turtles. CRC Press, Boca Raton, Florida, USA.

Mascia, M. B., Brosius, J. P., Dobson, T. A., Forbes, B. S., Horowitz, L., McKean, M. A., and N. J., Turner. 2003. Conservation and the social sciences. Conservation Biology 17: 649-650.

Mazaris, A. D, O. Fiksen, and Y. G. Matsinos. 2005. Using an individual-based model for assessment of sea turtle population viability. Population Ecology 47: 179-191.

Mbindo, C. 1996. The status of sea turtle conservation in Madagascar. Proceedings of the Western Indian Ocean Training Workshop and Strategic Planning Sesssion on Sea Turtles. The World Conservation Union/ United Nations Environment Program, 12-18 November 1995, Sodwana Bay, South Africa.

McClenachan, L., Jackson, J. B. C., and M. J. H. Newman. 2006. Conservation implications of historic sea turtle nesting beach loss. Ecology 4: 290-296.

McVean, A. R., R. C. J. Walker, and E. Fanning. 2006. The traditional shark fisheries of southwest Madagascar: A study in the Toliara region. Fisheries Research 82: 280-289.

Meylan, A. 1995. Sea turtle migration-evidence from tag returns. Pages 91-100 *in* K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, USA.

Mfunda, I. M., and Roskaft, E. 2010. Bushmeat hunting in Serengeti, Tanzania: an important economic

activity to local people. Biodiversity and Conservation 2: 263-272.

Myers, N., Mittermeier, R. A., Mettermeier, C. G., da Fonseca, G. A. B., and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

Mortimer, J. A. 2009. Aldabra turtle monitoring protocol: beach surveys to count turtle tracks - Part 1: Field Work and Data Sheets. Seychelles Island Foundation: 1-26.

Muttenzer, F. 2007. 'Different kinds of people of the sea': écologie, mobilité et ethnicité chez les Vezo de Madagascar, etude de gouvernance locale des tortues marines aux îles Barren, Maintirano. Rapport scientifique intermediaire de l'etude sociale. [In French.]

OCEANA. 2010. Why healthy oceans need sea turtles: the importance of sea turtles to marine ecosystems. < http://na.oceana.org/en/news-media/publications/reports/why-healthy-oceans-need-sea-turtles-the-importance-of-sea-turtles-to-marine-ecosystems>. Accessed 17 April 2011.

Owens, D. W. 1995. The role of reproductive physiology in the conservation of sea turtles. Pages 39-44 *in* K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, USA.

Petit, G. 1930. Petit, Gabriel. L'industrie Des Pêches À Madagascar. Société d'éditions géographiques, maritimes et coloniales, Paris, France. [In French.]

Pritchard, P. C. H., and J. A. Mortimer. 1999. Taxonomy, External Morphology, and Species Identification in K. L. Eckert, K. A. Bjorndal, F. A. Abreu-Grobois, M. Donnelly, editors. Research and Management Techniques for the Conservation of Sea Turtles, IUCN/SSC Marine Turtle Specialist Group Publication No. 4.

Rakotonirina, B., and A. Cooke. 1994. Sea turtles of Madagascar- their status, exploitation, and conservation. Oryx 28: 51-61.

Reznick, D., Bryant, M. J., and F. Bashey. 2002. r- and K-selection revisited: the role of population regulation in life-history evolution. Ecology 83: 1509-1520.

Rose, A. 2001. Social change and social values in mitigating bushmeat commerce. Pages 59-74 *in* Bakarr, M., G. da Fonesca, R. Mittermeier, A. Rylands, and K. Painemilla, editors. Hunting and bushmeat utilization in the African rain forest: Perspectives toward a blueprint for conservation action. Washington, DC: Conservation International.

Rozin, P. 1996. The socio-cultural context of eating and food choice. Pages 83-104 *in* H. Meiselman and H. MacFie, editors. Food choice, acceptance and consumption. Chapman and Hall, London, UK.

Schenck, M., Effa, E. N., Starkey, M., Wilkie, D., Abernethy, K., Tefler, P., Godoy, R., and A. Treves. Why people eat bushmeat: results from two-choice, taste tests in Gabon, Central Africa. Human Ecology 34: 433-445.

Seminoff, J. A., and K. Shanker. 2008. Marine turtles and IUCN Red Listing: A review of the process, the pitfalls, and novel assessment approaches. Journal of Experimental Marine Biology and Ecology 356: 52-68.

Shepherd, R. 1999. Social determinants of food choice. Proceedings of the Nutrition Society 58: 807-812.

Spotila, J. R. 2004. Sea turtles: a complete guide to their biology, behavior, and conservation. Johns Hopkins University Press, Baltimore, Maryland, USA.

Stancyk, S. E. 1995. Non-human predators of sea turtles and their control. Pages 139-152 *in* K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, USA.

Tolojanahary, R. 2007. Pêche, migration et économie de consumation à Ampasimandroro, district de Maintirano, Région Melaky (ouest malagasy). Diagnostic Environnemental et Social Autour des Tortues marines dans le sud-ouest de l'Océan Indien. DESAT. Universite d'Antananarivo, 1-15. [In French].

Walker, R., and E. Fanning. 2003. Artisanal and traditional turtle resource utilisation in South West Madagascar. Frontier-Madagascar Environmental Research Report 2 . Society for Environmental Exploration, UK and the Institute of Marine Sciences, University of Toliara, Madagascar.

Walker, R. C. J., and E. Roberts 2005. Notes on the status and incidental capture of marine turtles by the subsistence fishing communities of southwest Madagascar. Western Indian Ocean Journal of Marine Science 4: 219-255.

Walker, R. C. J., E. Roberts, and E. Fanning. 2004. The trade of marine turtles in the Toliara region, southwest Madagascar. Marine Turtle Newsletter 106: 7-10.

Wilkie, D. S., and J. F. Carpenter. 1999. Bushmeat hunting in the Congo Basin: an assessment of impacts and options for mitigation. Biodiversity and Conservation 8: 927-955.

Wilkie, D. S., and R. A. Godoy. 2001. Income and price elasticities of bushmeat demand in lowland Amerindian societies. Conservation Biology 15: 761-769.

Wilkie, D. S., Starkey, M., Abernethy, K., Effa, E. N., Tefler, P, and R. Godoy. 2005. Role of prices and wealth in consumer demand for bushmeat in Gabon, Central Africa. Conservation Biology 19:268-274.Van Buskirk, J., and L. B. Crowder. 1994. Life-history variation in marine turtles. Copeia 1994: 66-81.

Willcox, A. S., and D. M. Nambu. 2001. Wildlife hunting practices and bushmeat dynamics of the Banyangi and Mbo people of Southwestern Cameroon. Biological Conservation 134: 251-261.

Vitt, L. J., and J. P. Caldwell. 2009. Turtles. Pages 483-504 *in* Herpetology: an introductory biology of amphibians and reptiles. Third edition. Elsevier Inc., London, U.K.