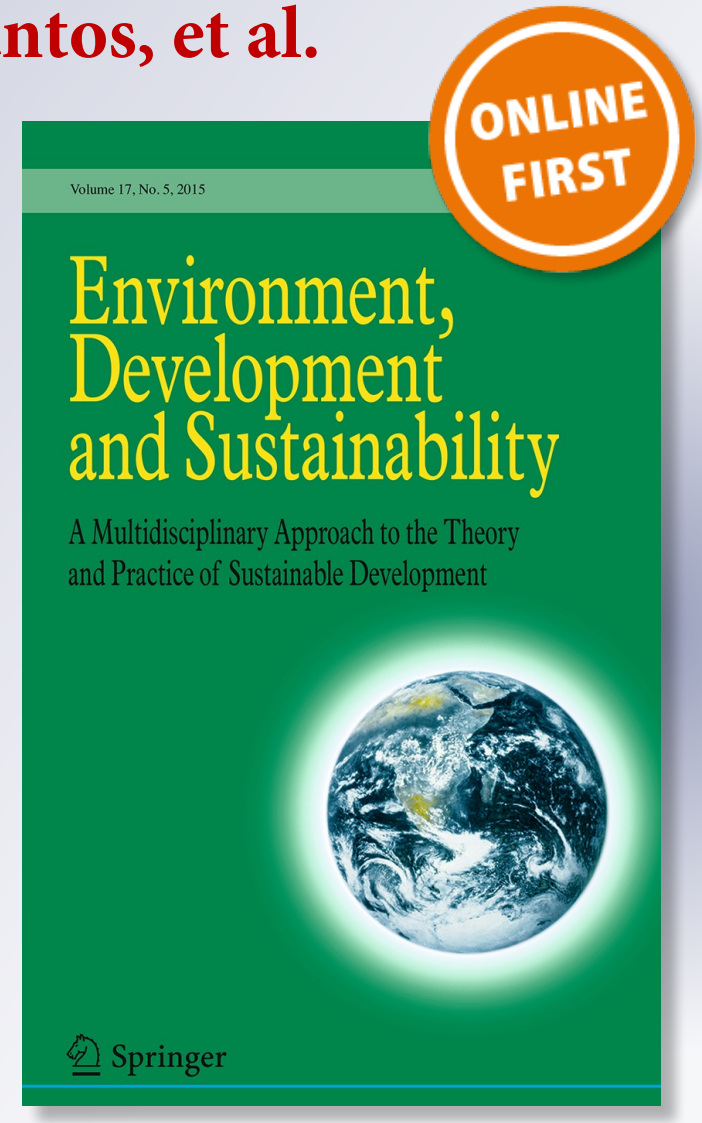
Adaptive threat management framework: integrating people and turtles

Valéria R. F. da Silva, Sylvia F. Mitraud, Maria L. C. P. Ferraz, Eduardo H. S. M. Lima, Maria Thereza D. Melo, Armando J. B. Santos, et al.

Environment, Development and Sustainability
A Multidisciplinary Approach to the Theory and Practice of Sustainable Development

ISSN 1387-585X

Environ Dev Sustain
DOI 10.1007/s10668-015-9716-0



Springer

Environ Dev Sustain
DOI 10.1007/s10668-015-9716-0

REVIEW

Adaptive threat management framework: integrating people and turtles

Valéria R. F. da Silva[1] · Sylvia F. Mitraud[2] · Maria L. C. P. Ferraz[3] · Eduardo H. S. M. Lima[4] · Maria Thereza D. Melo[4] · Armando J. B. Santos[5] · Augusto César C. D. da Silva[6] · Jaqueline C. de Castilhos[6] · Jamyle A. F. Batista[6] · Gustave G. Lopez[1] · Frederico Tognin[1] · João Carlos Thomé[7] · Cecília Baptistotte[7] · Berenice M. Gomes da Silva[3] · José Henrique Becker[3] · Juçara Wanderline[8] · Fernanda de Vasconcellos Pegas[9] · Gonzalo Róstan[1] · Guy Guagni dei Marcovaldi[1] · Maria Ângela G. dei Marcovaldi[1]

Received: 1 April 2015 / Accepted: 23 September 2015

Abstract In the 35 years since its inception, the Brazilian National Program for the Conservation of Marine Turtles (TAMAR) has had great success in protecting the five species of sea turtles that occur in Brazil. It has also contributed significantly to worldwide scientific data and knowledge about these species' biology, such as life cycles and

✉ Valéria R. F. da Silva
valeria@tamar.org.br

Sylvia F. Mitraud
smitraud@gmail.com

Maria L. C. P. Ferraz
malu.camargo@gmail.com

Eduardo H. S. M. Lima
eduardo.lima@tamar.org.br

Maria Thereza D. Melo
thereza.damasceno@tamar.org.br

Armando J. B. Santos
armando@tamar.org.br

Augusto César C. D. da Silva
cesar@tamar.org.br

Jaqueline C. de Castilhos
jaqueline@tamar.org.br

Jamyle A. F. Batista
jamyle@tamar.org.br

Gustave G. Lopez
guslopez@tamar.org.br

Frederico Tognin
fred@tamar.org.br

Published online: 06 October 2015

migration patterns. TAMAR's conservation strategies have always relied on a variety of environmental education and social inclusion (EESI) activities highly adapted to the socio-environmental evolving contexts of its 25 locations distributed across nine states. Diversity and flexibility are critical to enable timely and effective local responses to existing or potential threats to sea turtles. The intuitive, locally adapted, decentralized, and independent way EESI activities have been carried out have generated positive results in the resolution of specific and evolving local problems through the course of the project. This article brings EESI under the same conceptual framework that underlies its conservation approach by adopting an adaptive threat management framework to organize and qualify its educational and social inclusion interventions according to the main categories of threat addressed by TAMAR.

Keywords Brazil · Community-based development · Conservation · Environmental education · Sea turtle · Social inclusion · TAMAR · Threat management

1 Introduction

1.1 Sea turtle conservation in Brazil: early years

Five of the seven known sea turtle species worldwide reproduce in Brazil: green *Chelonia mydas*, loggerhead *Caretta caretta*, hawksbill *Eretmochelys imbricata*, olive *Lepidochelys olivacea*, and leatherback *Dermochelys coriacea*; all considered threatened of extinction (Marcovaldi and Marcovaldi 1999). The first comprehensive survey of sea turtles in Brazil was sponsored by the Brazilian government and carried out between 1980 and 1981

João Carlos Thomé
jocathome@tamar.org.br; joca.thome@icmbio.gov.br

Cecília Baptistotte
cecilia@tamar.org.br; cecilia.baptistotte@icmbio.gov.br

Berenice M. Gomes da Silva
bere@tamar.org.br

José Henrique Becker
curupira@tamar.org.br

Juçara Wanderline
ju@tamar.org.br

Fernanda de Vasconcellos Pegas
f.pegas@griffith.edu.au

Gonzalo Róstan
gonzalo@tamar.org.br

Guy Guagni dei Marcovaldi
guy@tamar.org.br

Maria Ângela G. dei Marcovaldi
neca@tamar.org.br

[1] Fundação Pró Tamar, Nacional Headquarters, Rua Rubens Guelli, 134 Sala 307, Salvador, Bahia CEP 41815-135, Brazil

(Marcovaldi and Albuquerque 1983), marking the beginning of the Brazilian National Program for the Conservation of Marine Turtles—TAMAR (Marcovaldi and Marcovaldi 1999). It showed that in nearly all areas of occurrence sea turtles were under heavy human predation and used for subsistence, commercialization, and cultural traditional practices. In what is now the three-mile beach stretch with the country's highest olive turtle nesting density (da Silva et al. 2007), predation was so intense that villagers told researchers they had not witnessed a turtle hatch for over 15 years. Furthermore, most local youth had never seen a hatchling and could not associate a hatchling turtle with a turtle egg and did not associate the importance of the eggs they harvested for the future survival, or lack thereof, of nesting sea turtles (Marcovaldi et al. 2005).

By 1986, TAMAR's efforts had led to new policy prohibiting sea turtle and egg harvesting (SUDEPE Ordinance N-05, 31/01/1986). In 1988, the nonprofit Pro-TAMAR Foundation was created to comanage TAMAR with the TAMAR Center, part of the Federal Institute for Biodiversity Conservation. This partnership enabled considerable increase in protection staff, community involvement, and sea turtle research.

TAMAR conservation activities are now carried out in reproductive and feeding areas distributed along 1100 km of coastline and two oceanic islands through 25 locations in nine states (Fig. 1). Since 1982, TAMAR has released over 15 million hatchlings into the ocean and the populations of all species are now considered under recovery (ICMBIO 2011). Given sea turtles' 25–30 years of life cycle from birth to sexual maturity, nesting now observed on beaches protected by TAMAR's earliest activities begin to reflect TAMAR's conservation efforts.

Over the years, TAMAR has accrued a wealth of scientific information on the species' biology (e.g., life cycle, feeding habitats), contributing significantly to global knowledge (Marcovaldi et al. 2010; Reis et al. 2010; Almeida et al. 2011; da Silva et al. 2011; Marcovaldi et al. 2012; Naro-Maciel et al. 2012; Proietti et al. 2014). This knowledge is maintained in a systematic and standardized database (i.e., SITAMAR database) that enables TAMAR to carry out IUCN Red List assessments (ICMBIO 2011). The latest assessment led to the enactment of the 2011 National Action Plan for Sea Turtle Protection—PAN (Marcovaldi et al. 2011).

[2] SEPS EQ 709/909 Lote A (CMJA), Sala 409A, Brasília, DF CEP 70390-095, Brazil

[3] Fundação Pró Tamar, Rua Antonio Athanazio da Silva, 273 – Itaguá, Ubatuba, SP CEP 11680-000, Brazil

[4] Fundação Pro-Tamar, Acesso Projeto Tamar, 151 – Alto Alegre, Almofala, Ceara CEP 62592-000, Brazil

[5] Fundação Pró Tamar, Alameda do Boldró, s/no, Fernando de Noronha, Pernambuco CEP 53990-000, Brazil

[6] Fundação Pró Tamar – Oceanário de Aracaju, Av. Santos Dumont no 1010 Orla da Praia da Atalaia 2a etapa – Atalaia, Aracaju, Sergipe CEP 49037-475, Brazil

[7] Centro TAMAR-ICMBio, Av. Nossa Senhora dos Navegantes 451/Ed. Petro Tower, Sala 1601, Enseada do Suá, Vitória, ES CEP 29050-030, Brazil

[8] Fundação Pró Tamar, Rua Professor Ademir Francisco, s/n, Barra da Lagoa, Florianópolis, SC CEP 88061-160, Brazil

[9] Environmental Future Research Institute, Griffith University, Gold Coast Campus, Southport, QLD 4222, Australia

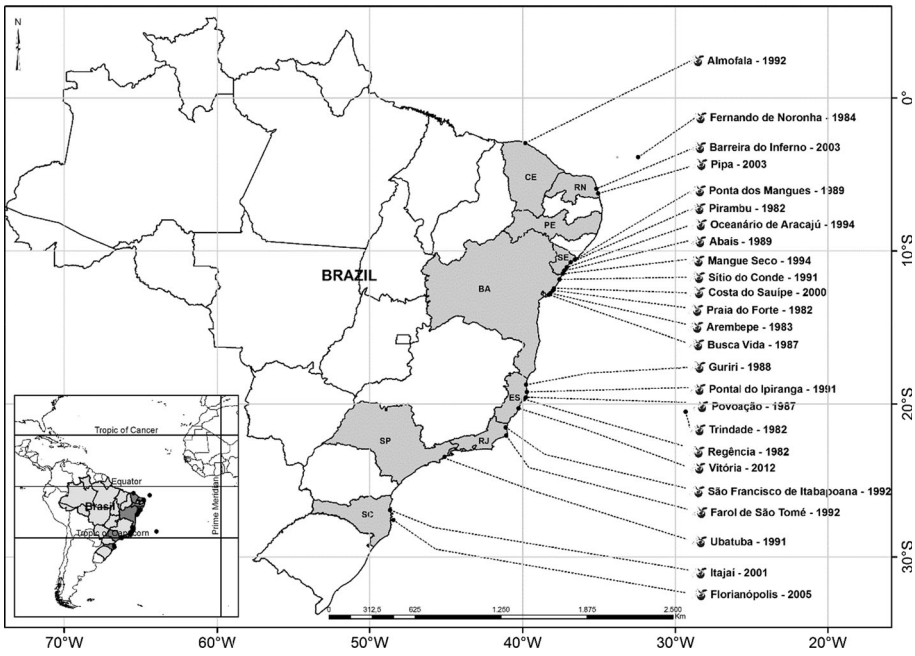


Fig. 1 Location of TAMAR bases and year of establishment in Brazil

1.2 Community integration in sea turtle conservation and the adaptive environmental management approach

Social integration and collaboration initiatives have been intrinsic to TAMAR's conservation strategy. Since 1982, conservation and research activities are guided by the understanding that conservation success is dependent upon TAMAR's ability to work with local communities and beach users. This means enhancing local understanding about sea turtles and their habitats and finding ways to help create viable economic alternatives to turtle and egg harvesting (Marcovaldi et al. 2005; Liles et al. 2014). TAMAR has also worked to improve the well-being of local communities, having developed extensive and innovative educational and socioeconomic activities that have contributed significantly to achieving sea turtle conservation goals.

The defining characteristic of TAMAR's community integration interventions is responsiveness to the perception of threats or the possible formation of threats due to evolving social interfaces with sea turtles. These interfaces are influenced by highly localized socioeconomic, political, geophysical, and ecological factors, among others. Responses have thus been specific to each TAMAR base, flexible in approach and design, and highly adaptable through time. Research and monitoring data show that community integration efforts have helped TAMAR achieve its conservation goals. However, decentralized design and implementation have made analysis of the breadth and depth of the social impacts of community integration efforts difficult, where social impacts are understood as the socioeconomic and cultural changes associated with TAMAR's activities, especially at scales beyond the social groups that work directly with TAMAR.

Through time, the continued growth in number and diversity of perceived local socioeconomic and cultural changes associated with TAMAR's work, the increased involvement of its staff with local communities, and the growing demand to identify and analyze these impacts across scales have generated an organizational need to systematize the myriad community integration initiatives. In the mid to late 2000s, TAMAR began classifying community integration activities under two broad categories—environmental education and social inclusion (EESI). TAMAR also created a database, denominated SIGRE database, to register and follow monthly the implementation of conservation and EESI activities.

These advances have enabled TAMAR to monitor its EESI interventions nationally. However, these protocols do not provide a methodological framework to integrate the systematic analysis of the social impacts of their EESI interventions with their analysis of conservation impacts and overall planning for sea turtle conservation at both the local and national levels. This article proposes TAMAR's adoption of a methodological framework based on the adaptive environmental management approach (AEMA) (Holling 1978; Walters 1986) focused on its EESI program.

The AEMA was proposed in the 1970s by ecologists concerned with the need to manage natural resources in the context of high ecological uncertainty and socioeconomic pressure. For AEMA proponents, uncertainty is inherent to complex ecological systems, so management policies must not be developed haphazardly, based on limited or unreliable knowledge, and led by the immediate needs and interests of managers and stakeholders. The AEMA is a learning process guided by the systematic identification of alternative management solutions (hypotheses) and analysis of potential risks and benefits based on the best existing knowledge. This is followed by planning, controlled experimentation, monitoring, evaluation, and adjustment through time of ecological management practices and policies. The approach is carried out with the participation of managers, researchers, and stakeholders (Walters 1986; Hilborn and Silbert 1988).

The growth of demand for participatory environmental management, combined with the "appealing nature of adaptive management as a theoretical construct" (Gregory et al. 2006: 2411) has led to the adoption of the approach in a variety of contexts to manage not only ecological systems, but also increasingly conservation and development programs, with less focus on experimentation and more focus on stakeholder participation (Hutton and Leader-Williams 2003; Mog 2006; Jacobson et al. 2009), including sea turtle management with the participation of local communities (Smith and Otterstrom 2009).

While the AEMA emerged from a tradition of science-based environmental management to become an important framework for the design of participatory conservation and development, for TAMAR the adoption of a framework based on the AEMA would enable the integration of social science-based analysis into their decades-long EESI initiatives. The results of TAMAR's efforts to protect sea turtles in Brazil are both well documented and highly successful, whereas its socioeconomic impacts are also perceived as highly successful, but are poorly documented and analyzed. Furthermore, an AEMA-based EESI methodological framework is consistent with TAMAR's adoption in 2010 of a threat matrix (Wallace et al. 2011) to define sea turtle protection priorities nationwide, in particular because currently the main threats to sea turtles are associated with fishing practices and coastal development (Sales et al. 2008; Lopez et al. 2014).

After briefly discussing TAMAR's operations and strategies, the article outlines the conceptual adaptation of the AEMA framework to TAMAR's EESI initiatives, which are then classified using a four-category threat management typology. For each main category, the threat is discussed through a notable case. The article concludes by providing further

strategies as to how TAMAR may further develop the adaptive threat management framework for its EESI initiatives.

1.3 TAMAR operations and strategies

TAMAR has eight regional coordination bases that operate and hold activities in 25 locations and in two oceanic islands (Fig. 1). These bases were initially created to protect turtle nesting areas but gradually began to also target feeding areas. Eleven locations are integrated with visitor centers, which offer opportunities for the staff to have direct contact with local residents, students, visitors, and sea turtles. These bases are important avenues for the implementation of environmental education, sensitization mechanisms, and revenue sources for TAMAR's financial sustainability. In 2014, TAMAR's visitor centers received 914.667 registered visitors and an estimated total 1,500,000 visitors, of which 63.497 were students and 5.694 were teachers from 1.842 different schools (Fundação Pró-Tamar 2014). In 2014, revenue from visitor centers and stores financed nearly half of the TAMAR's budget.

In 2011, following an international trend among sea turtle researchers and conservation initiatives, TAMAR began to map the main threats to sea turtles in Brazil (Wallace et al. 2011) (Table 1). Degree of threat has since become one of the main criteria to define TAMAR's conservation priorities (Marcovaldi et al. 2013). Currently, the main threats to sea turtles are incidental capture in fishing gear (bycatch) in feeding areas and coastal development in nesting areas (Sales et al. 2008; Lopez et al. 2014). The mapping of threats enables the optimization of TAMAR's conservation actions in each base (e.g., EESI initiatives) by taking into consideration events according to the species' life stages and the degree of threat weighted according to whether they are a direct (e.g., fisheries bycatch) or indirect (e.g., coastal development) threat to sea turtles (Table 1).

TAMAR operates through five complementary strategies. The *protection strategy* monitors beaches and feeding grounds, protects in situ nests, moves nests to open air hatcheries when necessary, rescues and treats stranded turtles, among other activities. The *research strategy* systematically collects standardized long-term sea turtle biometric, genetic, and telemetric data and increases biological and ecological knowledge about sea turtles and their habitats in Brazil. The *EESI strategy* works with various public stakeholders and helps raise awareness and generate ecologically sound jobs for local communities as strategies to address existing threats and prevent the emergence of future ones. The *policy strategy* provides techno-scientific data and subsidizes public policies (e.g., participation in protected area and other government councils, public hearings, specialized forums, and initiatives by the federal environmental agencies such as ICMBio) that strengthen sea turtle conservation efforts in Brazil. The *sustainability strategy* aims to increase organizational financial autonomy, enable TAMAR's efforts to expand its capacity to generate jobs and income, and carry out environmental education and awareness activities with local communities. These strategies are interconnected across bases with considerable overlap in staff, which enhances the organizational dynamism and adaptability in their implementation of each strategy at each base.

2 Methods

The adoption of an *adaptive threat management framework* for TAMAR's EESI strategy across bases, through time, and in the broader context of TAMAR's threat management approach may offer the same benefits AEMA offers natural resource managers.

Table 1 Threats per sea turtle species per TAMAR regional coordination

Regional coordination	Habitat[a]	Species[b]	Threats[c]
Ceará (CE)	FG	CC, EI, LO, DC, CM	BC—fishing weirs
			BC—gillnet
			HP
Pernambuco & Rio Grande do Norte (PE/RN)	NA/FG	CC, EI, LO	CD
		CM	HP
			BC—gillnet
Sergipe (SE)	NA/FG	EI, LO, CC	CD
		LO, CM	BC—shrimp trawl
Bahia (BA)	NA/FG	EI, LO, CC, CM	CD
		CM, EI	BC—gillnet
		LO	BC—shrimp trawl
Espírito Santo (ES)	NA/FG	CM (Trindade Island), EI, LO, CC, DC	CD
		CC, CM, EI, DC	BC—gillnet
Rio de Janeiro (RJ)	NA/FG	CC, EI, LO	CD
		CC, EI, LO, CM	BC—gillnet
São Paulo (SP)	FG	CC, CM, DC, LO	HP
		CC, CM, EI, LO	BC—pound net
		LO, DC	BC—longline
		EI, CM	BC—gillnet
		CC	BC—shrimp trawl
Santa Catarina (SC)	FG	CM	HP
		CC, EI, CM	BC—pound net

[a] NA, nesting areas; FG, feeding grounds

[b] CM, *Chelonia mydas*; CC, *Caretta caretta*; EI, *Eretmochelys imbricate*; LO, *Lepidochelys olivacea*; DC, *Dermochelys coriacea*

[c] BC, incidental capture (bycatch); HP, harvesting and egg poaching (sporadic cases); CD, coastal development

Specifically, significant advances in sea turtle conservation approaches could occur through systematic data collection; generation and accumulation of knowledge on TAMAR's social intervention and impacts; increased analytical capacity within TAMAR and with partners and stakeholders regarding its social and educational interventions; improved strategy and policy design; and ultimately a greater degree of sustainability in sea turtle conservation.

Furthermore, the conceptual integration of TAMAR's conservation strategy and EESI under the umbrella of *threat management* enables (1) prioritization of EESI intervention according to the degree and immediacy of threats vis-à-vis TAMAR's conservation strategy; (2) improvement of the effectiveness of TAMAR's EESI interventions in the resolution and/or prevention of threats related to society-sea turtle interfaces; and (3) increase of the sustainability of local community development, thus gaining local allies for sea turtle conservation.

Under an adaptive threat management framework, TAMAR's EESI strategy has four characteristics. First, TAMAR bases enable *place-based threat identification and response design and implementation*. Second, TAMAR is responsive to the *evolution of threats*. The

perception of threats and the degree to which they are addressed evolve according to various factors: (1) scientific knowledge; (2) TAMAR's organizational capacity; (3) government's enforcement capacity; (4) changes in regional contexts, including the configuration of stakeholders; and (5) the effectiveness of TAMAR's threat management efforts. Third, EESI activities are developed in partnership with the different stakeholders: local permanent residents of different age groups and occupations (e.g., fishers and their families, students, and teachers); non-permanent residents (e.g., tourists, seasonal residents); and the general public. This is carried out in direct association with individual stakeholders, members of communities (including many who are TAMAR staff at various levels), representative organizations such as fishers' associations, associations of tourism operators, school councils, among others. Lastly, EESI activities are *developed in consonance with and validated by social policies* at the local, state, and national levels.

Until the development of the sea turtle threat matrix in 2010 (Wallace et al. 2011), EESI activities were developed as local responses to the emergence of threats. Since then, all actions are analyzed and prioritized in reference to the national threat matrix. Presently, TAMAR's EESI strategy has four threat management lines of actions. Two lines of action address the main present and immediate threats to sea turtles in Brazil: *incidental capture* and *coastal development*. The others are designed to prevent the emergence of new threats: *social inclusion* and *long-term preventive cross-cutting capacity building and education* initiatives (Fig. 2).

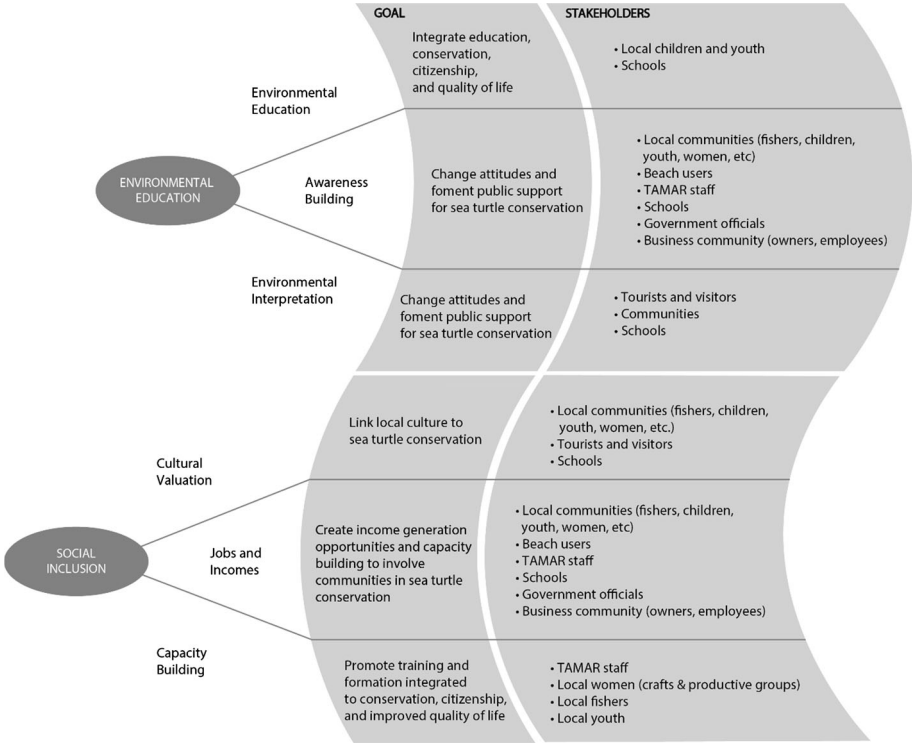


Fig. 2 EESI strategy

3 Results

3.1 Line of action (1): threat of incidental capture (bycatch)

Sea turtle incidental bycatch in longline, gillnets, driftnets, and trawls is one of the greatest threats to sea turtles worldwide (Wallace et al. 2011). In Brazil, it is currently considered the greatest and most pressing threat to sea turtles. TAMAR's primary strategy to reduce sea turtle bycatch threats has been the development of integrated protection and educational activities. These include substitution of large circular hooks (18/0) for "J" hooks in longlines and the development of a Sea Turtle Revival Protocol to train fishers on the reanimation of turtles caught on nets and fishing hooks (Marcovaldi et al. 2002; Lima et al. 2010), both with significant results. For instance, the introduction of "J" hooks has been associated with a 55 % reduction in loggerhead bycatch and 60 % leatherback bycatch (Sales et al. 2010).

In areas where bycatch associated with coastal fishing is particularly acute, TAMAR implements the "Not all caught in the net is fish" initiative (NANF) in combination of research and protection activities. The NANF is a portfolio of environmental education activities aimed at building awareness among artisanal fishers about the importance of returning sea turtles caught in fishing gear alive to the ocean. Although TAMAR bases have adapted the program to their local contexts, some strategies are universal nationwide, for example meetings with fishers and community leaders; fisher training on the revival protocol; and development of educational events targeting the community and fishers, such as talks in schools, fishing workshops, presentations, expositions, puppet shows, campaigns, local sociocultural activities, among others.

One of the most successful experiences of the NANF program has been implemented at the Ubatuba base, in São Paulo. This base monitors an important feeding area for green turtles. Local beaches are also used as fishing grounds by 12 communities distributed along 80 km of coastline. The base launched the program soon after its establishment in 1991, starting with a series of studies in partnership with fishers to understand local fishing practices and identify ways to reduce bycatch and mitigate its impacts. Fishers accompanied the TAMAR research team in trips to plot traditional fishing areas, practices, and species caught at different seasons using GPS technology.

One study carried out in partnership with the National Oceanic and Atmospheric Administration (NOAA) focused on a practice that uses pound nets. Results indicated that while the gear traps a large number of turtles, gear-related mortality is negligible as turtles are not hurt and breathing is not impeded (Giffoni 1996). Instead, mortality was caused by fishers who killed captured turtles for consumption. Hence, researchers integrated fishers in the protection activities, collecting biometric data and participating in experiments to increase understanding on the impacts of fishing practices on sea turtles (Ottoni-Neto et al. 2011). In turn, TAMAR supported the creation of fisher-owned muscle farms to reduce fishing pressure on critical areas for sea turtles.

Over the years, the NANF program became the focus of a broader partnership with fishers and their communities. Fishers are now involved in activities of all TAMAR strategies, while TAMAR is involved in local sociocultural activities. The Ubatuba base experience exemplifies the complementarity of TAMAR's conservation strategies and illustrates the diversity of EESI activities carried out by each base. As a result of combining EESI, research, and protection strategies to address the bycatch threat in Ubatuba, over 10,000 sea turtle juveniles caught in fishing gear have been returned alive to the ocean since the beginning of the NANF program (SITAMAR database).

Another notable experience with the NANF program has been carried out since 1993 in the community of Almofala in Ceará. The Almofala region is an important feeding ground for the five sea turtle species that occur in Brazil. Researchers and local fishers began monitoring sea turtle capture in fishing weirs, the main local fishing gear which captures all the five species. (Marcovaldi 1993; Lima et al. 1999; Godley et al. 2003; Lima et al. 2003; Marcovaldi et al. 2010; Lima et al. 2013).

Between 2010 and 2013, 12–15 fishing weirs were monitored and data on captured turtles registered. In 2012, the introduction of degree of threat as TAMAR's main protection intervention criterion led the base to reduce the number of monitored fishing weirs to two. Nonetheless, in the last two seasons fishers have continued to deliver turtles captured in non-monitored fishing weirs to TAMAR. Fishers also voluntarily share their GPS data with TAMAR to monitor fishing routes. The partnership between the TAMAR and fishers in Ceará has registered and saved over 5,000 sea turtles of all ages of the five species that occur in Brazil.

The NANF program has now been implemented differently in bases in the states of Ceará (CE), Rio Grande do Norte/Pernambuco (RN/PE), Bahia (BA), Espírito Santo (ES), Rio de Janeiro (RJ), São Paulo (SP), and Santa Catarina (SC). The initiative has been introduced as a continuous program, a one-time campaign, or as an intermittent activity when the TAMAR team observes a resurgence of fishing incidental captures. Overall, between 1990 and June 2014, TAMAR's efforts nationwide have helped save 14,023 sea turtles of all species (SITAMAR database); intensified the partnership between fishers and TAMAR; increased understanding in the community regarding the rules and obligations of various government agencies involved in sea turtle protection and enforcement; and disseminated mitigation practices among coastal gillnet fishers.

3.2 Line of action (2): threat of coastal development

Coastal development has become the most immediate threat in nesting areas that are not inside protected areas that prohibit direct natural resource use (ICMBIO 2011). The increase in real estate development, beach resort complexes, beach use by people and motorized vehicles, and pollution (both from lights and garbage) represent increasingly significant direct (e.g., motorized vehicles on beaches) and indirect (e.g., light pollution) threats to turtles, nests, and hatchlings. If not addressed, they may compromise in situ nest protection, one of the TAMAR's greatest historical accomplishments nationwide. Over 80 % of sea turtle nests are protected where they are originally placed and with no human interference. This is a conservation achievement and a direct result of TAMAR's EESI actions (Lopez et al. 2014).

One of the hot spots for coastal development in Brazil that overlaps with sea turtle reproductive areas is the northern coast of the state of Bahia, monitored by the Praia do Forte base staff. In this region, pressure on sea turtle habitat comes mainly from residential beachside condominiums and all-inclusive resort development. State plans for the region show that nearly every real estate available to the north of Praia do Forte has already been purchased for one of these types of venture (Governo do Estado da Bahia 2014).

The Praia do Forte TAMAR base monitors 30 km of beach, where over a thousand sea turtle nests are recorded per season. A 16-km beach stretch is under intense anthropic pressure: accelerated beachside construction, intense beach use during the reproductive season (September to March), irregular artificial illumination, and use of motorized vehicles on the beach. In the past 10 years, the availability of tourist rooms, which excludes condominiums, has increased by 300 % (Lopez et al. 2014).

With this rapid growth in beachside development, it was essential that TAMAR adapted its awareness raising 2010. By the end of the 2012/2013 season, 14 condo complexes had adjusted their external illumination systems to fit TAMAR's recommendations and seven were carrying out the recommended adjustments. Complexes that have completed their adjustments receive a certificate to symbolize their partnership with TAMAR and to provide incentive for other complexes to do the same. Since then, there have been no reports of hatchling disorientation in the area, which has led TAMAR to resume in situ nest protection on 5 km of beach where previously they had to move nests to incubation areas due to photo-pollution. Some associations of condo complexes have united against the use of ATVs on beaches, carrying out their own campaign against them. TAMAR offers training sessions for security personnel and other condo and hotel staff. Tamar has also received an average of 60 calls per season from condo employees and residents to report new nests, hatchings, and turtles stranded on the beach.

Other bases are also adapting the "Our beach is Alive" program to their own socioeconomic contexts and the particular expression of the coastal development threat to sea turtles in their areas of influence, especially the bases in the state of Sergipe, other bases in Bahia, the Ubatuba base in São Paulo, and the bases in Ceará and Fernando de Noronha. Another important initiative to deal with the threats of coastal development concerns the a cooperation between TAMAR and the federal environmental agency Chico Mendes Institute for Conservation and Biodiversity (ICMBio) to monitor large projects along the coast for environmental licensing. Sea turtle specialists assess projects and their implementation and provide guidance to insure minimum impact in nesting and feeding areas.

3.3 Line of action (3): social inclusion

Historically, the small coastal communities where TAMAR operates have faced problems of disenfranchisement, scarce professional opportunities, and poor income distribution. These problems are sources of social tension that may disrupt conservation and sustainable development efforts. Hence, developing ecologically and socially sustainable alternatives has been a fundamental and continual challenge for TAMAR (Patiri 2002; Marcovaldi et al. 2005).

When the TAMAR Project began in the early 1980s, turtle harvesting and egg poaching (i.e., direct use) were by far the greatest threats to sea turtles in Brazil. Recognizing the importance of these activities for local livelihoods, TAMAR's protection strategy was intuitively and seamlessly intertwined with a community integration strategy based on the creation of alternative income opportunities and capacity building for fishers and their families. Most opportunities were in fact to work in protection activities, such as jobs for fishers to monitor beaches and rescue nests from potential poaching (Marcovaldi et al. 2005).

Direct sea turtle harvesting occurrences are now so rare as to be insignificant in the context of monitoring data. For example, in the 2012/2013 season, TAMAR recorded 214 harvested nests in all bases, compared to 24,214 recorded harvested nests, or about 1.3 million hatchlings. As such, the likelihood that direct use will reemerge as a significant threat to sea turtles in Brazil is believed to be negligible. In 35 years of continuous presence of TAMAR staff in these communities, nearly two generations have grown up in an environment where sea turtle protection is the norm and a stable part of local socioeconomic and cultural life. The policy framework that now protects sea turtles in Brazil is extensive, largely consolidated, and continues to evolve due to TAMAR's work.

Social inclusion remains an important component of TAMAR's EESI adaptive threat management framework as a preventive strategy for three reasons. First, working with

TAMAR is a highly effective way to continue fostering the Project's sea turtle and overall conservation messages to local residents and their families. Second, social inclusion activities have become important for local economies. TAMAR bases generate many direct jobs—in 2014, 698 positions at visitor centers, TAMAR stores, production of T-shirts and research bases (Fundação Pró-Tamar 2014). In tourism, TAMAR's presence is also associated with significant creation of indirect jobs, as invariably the Project is a focal tourist attraction (Pegas et al. 2013; Pegas 2014). Third, various social inclusion initiatives have become an organic part of Pró-Tamar Foundation's sustainability strategy along with visitor center entrance fees, as is discussed next.

Two of the most important socioeconomic and cultural initiatives of social inclusion developed by TAMAR are to support T-shirt manufacturing groups and other productive groups formed by members of local fisher communities that have had a cultural tradition of turtle and egg harvesting, especially in non-tourist destinations. The main premise of these initiatives is that the generation of income for coastal communities with which TAMAR interacts will help improve their quality of life through a direct tie to sea turtle conservation. These initiatives have become crucial at the Regência (Espírito Santo) and Pirambu (Sergipe) bases, where communities suffered great restrictions in natural resource use with the creation of Biological Reserves, in part because of their importance for sea turtles.

First in Regência and later in Pirambu, TAMAR hired local seamstresses and youth from fisher families to form local T-shirt manufacturing groups. The T-shirts produced by these groups are a symbol of TAMAR, the most important and popular product sold at TAMAR stores. Because these manufacturing groups are managed by TAMAR, it is able to control the source of materials used. Hence, all materials are made in Brazil and provided by businesses engaged in social and environmental responsibility initiatives. TAMAR also supports the commercialization of crafts that valorize local culture as a source of economic value, thus strengthening these communities' self-esteem and identity. TAMAR supports productive groups in eight communities in four states (Table 2), involving 107 women in 2014.

Table 2 Women's productive groups supported by TAMAR in 2014

Group	Community	State	# Women employed
Loom crafts group	Regência	ES	10
Loom crafts group working with beads at indigenous village (Tupiniquim Nation)	Comboios		8
Loom crafts group at indigenous village (Tupiniquim Nation)			25
Embroidery group	Pirambu & Ponta dos Mangues	SE	33
Birlô lace group	Almofala	CE	17
Seamstresses group			4
Embroidery group			4
Seamstresses group	Camburi	SP	6
		Total	107

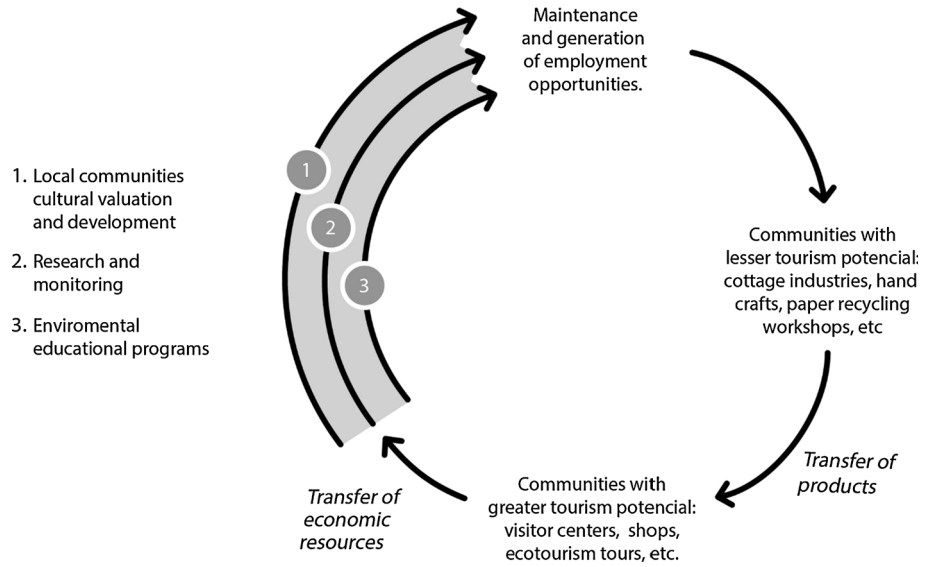


Fig. 3 TAMAR's socio-productive chain

These activities are at the core of TAMAR's socio-productive chain (Fig. 3), whereby bases with lesser tourism potential provide products that are sold at the bases with greater tourism potential (Marcovaldi et al. 2005: 55). In addition to the socioeconomic and cultural benefits for these communities and TAMAR more generally, this strategy has fostered a virtuous cycle in the interaction between local communities and TAMAR. For example, sea turtles are now perceived as more valuable alive than dead by the local communities and the number of local engagements in TAMAR's protection efforts has increased from four in 1982 to 1300 in 2014.

Other socio-environmental benefits include promotion of associations and cooperatives as a form of social organization; inclusion of women and youth in productive activities; reduction in youth outmigration to cities; dissemination of knowledge, ideals and practices of sea turtle conservation; and the use of natural or low environmental impact raw materials. These benefits make communities close partners of the TAMAR Project.

Another social inclusion strategy is the intensification of a social group's cultural expression and identification with the local natural environment in the spaces built by TAMAR. This positive appreciation is determinant in both appropriation and conservation behavior (Marin et al. 2004). In the state of Sergipe, where this particular strategy has been widely adopted, and for the longest period, the turtle has become the "godmother" of cultural groups composed of children, youth, adults, and senior residents in neighborhoods around the TAMAR research bases. Sergipe's base supports four cultural groups in addition to the productive group listed in Table 2.

3.4 Line of action (4): long-term capacity building and education for conservation

Long-term capacity building and educational programs target mostly children and youth in the communities where TAMAR works. These programs provide socio-environmental

experiences complementary to formal education, which support a process that contributes to the improvement of the youth's relationship with the local environment and their engagement in the construction of their communities' sustainable development (Sauvé 2005). As a result, TAMAR's education program contributes to the achievement of the National Environmental Education Policy (Brasil-Presidência da República 1999).

The strategy comprises various activities that range from a semester to 5 years in duration and are carried out in opposing shifts to school terms (morning and afternoon). Priority is given to public schools and local residents from fisher families. Activities are carried out at visitor centers or spaces maintained by TAMAR at communities. All activities are registered at the Social Service and the Rights of Children and Adolescents municipal councils and follow the national Child and Adolescent Statute.

One of the TAMAR's most important educational activities is the *Tamarzinhos* Program ("Junior Tamar Program"), which was first implemented in 1995 at the Praia do Forte base (Vieitas et al. 1999). Although in 20 years the *Tamarzinhos* Program has evolved and grown in scope, its structure remains similar. The Program continues to be a year-long environmental education initiative for children 10–14 years old, and selection criteria include school attendance, local residence status, family ties to the local community, social vulnerability, and parents' permission to attend the program. It adopts the Planning, Process, and Product method (Pádua 1997) to continually obtain data on indicators of efficacy of the strategies employed and assess each program stage. Pre- and posttests are applied for each activity to identify participants' changes in emotions, behavior, and knowledge. The evaluation process becomes an important environmental education vehicle, contributing not only to improve the quality of TAMAR's conservation initiatives, but also to the credibility of environmental education as a conservation strategy.

The Program provides these children an opportunity to understand their local environment using sea turtles as the common conduit for diverse activities that emphasize cultural appreciation, sustainable practices, and the preservation of the various ecosystems of which the Praia do Forte village is part (Pegas et al. 2012). The *Tamarzinhos* Program is managed by a full-time TAMAR employee who was herself in the program.

Activities are integrated into the protection operations, including sessions with TAMAR technical staff; structured lessons on the environment and human–environment interactions (Tomazello and Ferreira 2001), such as changes in the environment, interpretive trails, and storytelling; talks about garbage disposal and pollution; workshops (puppet theater, crafts, cooking, fishing); music lessons and participation in the Sea Choral; accompanying TAMAR's beach monitoring team; surfing lessons; and participation in events of the local commemorative calendar. *Tamarzinhos* are required to periodically submit proof of good academic standing and performance at school. They receive transportation and snacks while at TAMAR.

Tamarzinhos often continue their association with TAMAR, either as employees or as Junior Apprentices. TAMAR's Praia do Forte base has about 150 employees, of which 15 are former *Tamarzinhos*, including the manager of the *Tamarzinho* Program, and TAMAR also provides partial educational grants to motivate former *Tamarzinhos* to attend college in areas relevant to marine conservation. By 2014, 760 children had attended the initial course, 226 had graduated from the program, 14 Young Apprentices had worked in the program, one former *Tamarzinha* had graduated from college (Hotel Services), and six were attending college.

Variants of the *Tamarzinhos* Program are implemented in other bases, such as the *Ecological Brigade* of children and adolescents in Almofala (Ceará); the *Tamarzinhos* in Fernando de Noronha (Pernambuco); the *Sea Turtle United Capoeira Group* in Pirambu and Ponta dos Mangues (Sergipe); and the *Our Role in the Future* program in Ubatuba

(São Paulo). These activities are adapted to the local contexts and social inclusion needs and are carried out in conjunction with other activities designed to promote long-term support to sea turtle and marine conservation. Integrated activities developed for local realities demonstrate the importance of respecting each region's cultural and economic diversity in order to achieve positive and deep-rooted results in the formation of new generations committed to the preservation and sustainability of the environment where they live (Pegas et al. 2012).

4 Discussion

Since its inception in 1980, The TAMAR Project has experienced great success in protecting sea turtles in Brazil. The populations of the five species that occur in Brazil are in recovery due to the increase in the number of nests and over 15 million hatchlings have reached the ocean. Tamar is now likely protecting the reproduction of some of those early successful hatchlings. This success reflects not only TAMAR's research and protection strategies, but just as much its initiatives to bring fishers and local communities into its efforts to protect sea turtles.

Community integration has been part and parcel of TAMAR's conservation approach from its first steps to protect sea turtles in Brazil, traditionally carried out at the regional base level. This has enabled bases to design EESI interventions adapted to local socioeconomic and environmental characteristics and to respond timely and flexibly to evolving contexts while maintaining the focus on the ultimate goal of sea turtle conservation. Conversely, this decentralization has also made it difficult for TAMAR to document and analyze its education and social inclusion impacts above and beyond the results observed in sea turtle conservation.

This article uses an adaptive threat management framework to bring EESI strategies into the same conceptual nexus that orients TAMAR's sea turtle protection and research strategies. This framework enables TAMAR to visualize and prioritize EESI investments in synchrony with protection and research priorities according to degree of threat at the national level, without compromising regional bases' ability to respond to local socio-environmental evolving contexts. As a result, TAMAR is able to determine what threats to address in light of the national situation, while regional coordination bases and local bases plan and implement site-specific interventions in its five strategies—protection, research, EESI, policy, and sustainability.

The further development of TAMAR's adaptive threat management EESI methodological framework will enable TAMAR to fully operationalize the integration of the EESI strategy into TAMAR's overall conservation framework, from planning to monitoring implementation to assessing results and impacts. The first step toward that result is to develop a unified monitoring system for EESI interventions. A participatory effort of TAMAR regional teams should design mid- to long-term goals and questions pertaining to socioeconomic impacts and their contribution to the sustainability of sea turtle conservation at the regional and national levels. Assessment mechanisms should then be designed to enable systematic and comparable collection of socio-cultural and economic data across all bases and EESI initiatives. The existing EESI database should be expanded to encompass the new monitoring system and to generate reports to support the assessment of results and evaluation of impacts at the national, regional, and local levels, for various operational and research purposes.

Second, TAMAR should carry out an evaluation of the sociocultural and economic impacts (positive and negative) of its decades-long EESI efforts, with the dual objective of identifying TAMAR's contribution for the well-being of communities where it operates and assessing the strengths and weaknesses of their contribution to the sustainability of sea turtle conservation in Brazil. By further developing the EESI adaptive threat management framework, TAMAR expects to be able to expand its analytical capability, which thus far has been primarily focused on the environmental aspect not only to the social and economic aspects, but most of all to the combined interactions among the three aspects. In turn, TAMAR's experience will provide a valid contribution on how the AEMA may be used to increase the application of social science in all stages of conservation and development programs that rely primarily or even exclusively in participatory analysis and planning to strengthen their potential to achieve high and sustainable socio-environmental results.

Acknowledgments Special thanks to Garry Brewer, knowledgeable and supportive of the TAMAR Project, contributions at work. We welcome TAMAR staff working in communities with dedication and sensitivity promoting the participation and involvement of society in conservation of sea turtles. The TAMAR Project has official sponsorship of Petrobras.

References

Almeida, A. P., Eckert, S. A., Bruno, S. C., Scalfoni, J. T., Giffoni, B., López-Mendilaharsu, M., & Thomé, J. C. A. (2011). Satellite-tracked movements of female *Dermochelys coriacea* from southeastern Brazil. *Endangered Species Research, 15*, 77–86.

Brasil-Presidência da República. (1999). Lei 9.795 de 27 de abril de 1999—Política Nacional de Educação Ambiental. Presidência da República, Casa Civil.

da Silva, A. C. C. D., de Castilhos, J. C., Lopez, G. G., & Barata, P. C. R. (2007). Nesting biology and conservation of the olive ridley sea turtle (*Lepidochelys olivacea*) in Brazil, 1991/1992 to 2002/2003. *Journal of the Marine Biological Association of the United Kingdom, 87*, 1047–1056.

da Silva, A. C. C. D., dos Santos, E. A. P., Oliveira, F. L. D., Weber, M. I., Batista, J. A. F., Serafini, T. Z., & de Castilhos, J. C. (2011). Satellite-tracking reveals multiple foraging strategies and threats for olive ridley turtles in Brazil. *Marine Ecology Progress Series, 443*, 237–247.

Fundação Pró-Tamar. (2014). *Relatório Anual de Atividades—2014*. Salvador: Fundação Pró-TAMAR.

Giffoni, B. B. (1996). *Artes de Pesca que Capturam Tartarugas Marinhas na Região de Ubatuba-SP*. Monografia: Universidade Federal do Rio de Janeiro.

Godley, B. J., Lima, E. H. S. M., Kesson, S. Ã., Broderick, A. C., Glen, F., Godfrey, M. H., et al. (2003). Movement patterns of green turtles in Brazilian coastal waters described by satellite tracking and flipper tagging. *Marine Ecology Progress Series, 253*, 279–288.

Governo do Estado da Bahia. (2014). *Programa de Desenvolvimento do Turismo no Nordeste para o Estado da Bahia*: *Prodetur NE II/BA* http://www.setur.ba.gov.br/programas-e-projetos/eixo-estrategico-qualificacao-dos-servicos-e-do-destino/prodetur/. Accessed September 29, 2014.

Gregory, R., Ohlson, D., & Arvai, J. (2006). Deconstructing adaptive management: Criteria for applications to environmental management. *Ecological Applications, 16*, 2411–2425.

Hilborn, R., & Silbert, J. (1988). Adaptive management of developing fisheries. *Marine Policy, 12*, 112–121.

Holling, C. S. (1978). *Adaptive environmental assessment and management.* The Blackburn Press (Reprint of the 1978 Edition by International Institute for Applied Systems Analysis): Caldwell, NJ.

Hutton, J., & Leader-Williams, N. (2003). Sustainable use and incentive-driven conservation: Realigning human and conservation interests. *Oryx, 37*, 215–226.

ICMBIO. (2011). Avaliação do Estado de Conservação das Tartarugas Marinhas no Brasil. *Biodiversidade Brasileira, Ano 1*, 1–48.

Jacobson, C., Hughey, K. F. D., Allen, W. J., Rixecker, S., & Carter, R. W. (2009). Toward more reflextive use of adaptive management. *Society and Natural Resources, 22*, 484–495.

Liles, M. J., Peterson, M. J., Lincoln, Y. S., Seminoff, J. A., Gaos, A. R., & Peterson, T. R. (2014). Connecting international priorities with human wellbeing in low-income regions: Lessons from

hawksbill turtle conservation in El Salvador. *Local Environment*, 1–22, 2014. doi:10.1080/13549839.2014.905516.

Lima, E. H. S. M., Lagueux, C. J., Barata, P. C. R., & Marcovaldi, M. A. (2003). Second record of a green turtle (*Chelonia mydas*) tagged in Brazil and captured in Nicaragua. *Marine Turtle Newsletter, 101*, 27.

Lima, E. H. S. M., Lagueux, C. J., Castro, W. D., & Marcovaldi, M. A. (1999). From one feeding ground to another: Green turtle migration between Brazil and Nicaragua. *Marine Turtle Newsletter, 85*, 10.

Lima, E. H. S. M., Melo, M. T. D., & Barata, P. C. R. (2010). Incidental capture of sea turtles by the lobster fishery off the Ceará Coast, Brazil. *Marine Turtle Newsletter, 128*, 16–19.

Lima, E. H. S. M., Melo, M. T. D., Godfrey, M. H., & Barata, P. C. R. (2013). Sea turtles in the waters of Almofala, Ceará, in Northeastern Brazil, 2001–2010. *Marine Turtle Newsletter, 137*, 5–9.

Lopez, G. G., Lara, P. H., & Salies, E. (2014). Pursuing coastal conservation in Northeast Brazil as a shared responsibility. *State of the World's Sea Turtles (SWOT) Reports, 9*, 42–43.

Marcovaldi, M. A. (1993). A new initiative to protect green turtles at an important foraging ground in Ceará, Brazil. *Marine Turtle Newsletter, 63*, 13–14.

Marcovaldi, G. G., & Albuquerque, J. C. B. (1983). *Trabalhos de proteção a desova, avaliação quali-quantitativa e marcação nas praias de Pirambu (SE), Forte (BA), Comboios (ES) e Ilha da Trindade—Relatorio Parcial de 17/01/83 a 19/01/83*. Rio Grande: IBDF-Projeto Tartaruga Marinha.

Marcovaldi, M. A., Lopez, G. G., Soares, L. S., Lima, E. H. S. M., Thomé, J. C. A., & Almeida, A. P. (2010). Satellite-tracking of female loggerhead turtles highlights fidelity behavior in northeastern Brazil. *Endangered Species Research, 12*, 263–272.

Marcovaldi, M. A., Lopez, G. G., Soares, L. S., & López-Mendilaharsu, M. (2012). Satellite tracking of hawksbill turtles *Eretmochelys imbricata* nesting in northern Bahia, Brazil: Turtle movements and foraging destinations. *Endangered Species Research, 17*, 123–132.

Marcovaldi, M. A., & Marcovaldi, G. G. (1999). Marine turtles of Brazil: The history and structure of Projeto TAMAR-IBAMA. *Biological Conservation, 91*, 35–41.

Marcovaldi, M. A., Patiri, V. J. A., & Thomé, J. C. (2005) Projeto TAMAR-IBAMA: Twenty five years protecting Brazilian sea turtles through a community-based conservation programme. *MAST, 3*(2) and *4*(1), 39–62.

Marcovaldi, M. A., Santos, A. S., & Sales, G. (Eds.). (2011). *Plano de Ação Nacional para Conservação das Tartarugas Marinhas*. Brasília: ICMBio.

Marcovaldi, M. A., Thomé, J. C., Dias da Silva, A. C. C., Wanderlinde, J., Sales, G., Giffoni, B. B., Gomes, B. M., Baptistote, C., Lima, E., Santos, A. J. B., Santos, A. S., López-Mendilaharsu, M. & López, G. G. (2013). Projeto TAMAR: Matching threats and conservation priorities for sea turtles in Brazil. In T. Tucker, L. Belskis, A. Panagopoulou, A. F. Rees, M. Frick, K. Williams, R. LeRoux, & K. Stewart (Eds.), *Proceedings of the thirty-third annual symposium on sea turtle biology and conservation* (pp. 53). NOAA Technical Memorandum NMFS-SEFSC-645.

Marcovaldi, M. A., Thomé, J. C., Sales, G., Coelho, A. C., Gallo, B. M. G., & Bellini, C. (2002). Brazilian plan for reduction of incidental sea turtle capture in fisheries. *Marine Turtle Newsletter, 96*, 24–25.

Marin, A. A., Oliveira, H. T., & Comar, V. (2004). Reconstituição histórica como instrumento de resgate cultural e de educação ambiental. *Revista Eletrônica do Mestrado em Educação Ambiental, 13*, 101–114.

Mog, J. M. (2006). Managing development programs for sustainability: Integrating development and research through adaptive management. *Society and Natural Resources, 19*, 531–546.

Naro-Maciel, E., Bondioli, A. C. V., Martin, M., de Pádua Almeida, A., Baptistotte, C., Bellini, C., et al. (2012). The interplay of homing and dispersal in green turtles: A focus on the southwestern Atlantic. *Journal of Heredity, 103*, 792–805.

Ottoni-Neto, G. F., Becker, J. H., Giffoni, B. B., Alvarenta, F. S., Tavares, R. I. S., Brito, M. K. & Gallo, B. M. G. (2011) Influência da Luminosidade na Captura Incidental de Tartarugas Verdes (*Chelonia mydas*) e de Peixes nas Redes de Emalhe Costeira em Ubatuba/SP. In A. S. O. Rede (Ed.), *V Jornada sobre Tartarugas Marinhas do Atlântico Sul Ocidental* (pp. 171–174). Florianópolis.

Pádua, S. (1997). Uma pesquisa em educação ambiental: A conservação do mico-leão-preto *Leontopithecus chrysopygus*. In C. Valladares-Pádua & R. E. Bodme (Eds.), *Manejo e Conservação da Vida Silvestre no Brasil* (pp. 52–69). Belém: CNPq.

Patiri, V. J. A. (2002) *Projetos Ecológicos e o Desenvolvimento Local*: *Estudo de Caso do Projeto TAMAR*. MBA dissertation, Universidade Federal da Bahia.

Pegas, F. (2014). From dinner plate to T-shirt logo: The changing role of a flagship turtle species in one of Brazil's most popular tourism destinations. In K. Markwell (Ed.), Channel View Publications (forthcoming), Bristol.

Pegas, F., Coghlan, A., & Rocha, V. (2012). An exploration of a mini-guide program: Training local children in sea turtle conservation and ecotourism in Brazil. *Journal of Ecotourism, 11*, 48–55.

Pegas, F., Coghlan, A., Stronza, A., & Rocha, V. (2013). For love or for money? Investigating the impact of an ecotourism programme on local residents' assigned values towards sea turtles. *Journal of Ecotourism, 12*, 90–106.

Proietti, M. C., Reisser, J., Marins, L. F., Rodriguez-Zarate, C., Marcovaldi, M. A., Monteiro, D. S., et al. (2014). Genetic structure and natal origins of immature hawksbill turtles (*Eretmochelys imbricata*) in Brazilian waters. *PLoS One, 9*, e88746.

Reis, E. C., Soares, L. S., Vargas, S. M., Santos, F. R., Young, R. J., Bjorndal, K. A., et al. (2010). Genetic composition, population structure and phylogeography of the loggerhead sea turtle: Colonization hypothesis for the Brazilian rookeries. *Conservation Genetics, 11*, 1467–1477.

Sales, G., Giffoni, B. B., & Barata, P. C. R. (2008). Incidental catch of sea turtles by the Brazilian pelagic longline fishery. *Journal of the Marine Biological Association of the United Kingdom, 88*, 853–864.

Sales, G., Giffoni, B. B., Fiedler, F. N., Azevedo, V. G., Kotas, J. E., Swimmer, Y., & Bugoni, L. (2010). Circle hook effectiveness for the mitigation of sea turtle bycatch and capture of target species in a Brazilian pelagic longline fishery. *Aquatic Conservation: Marine and Freshwater Ecosystems, 20*, 428–436.

Sauvé, L. (2005). Educação ambiental: Possibilidades e limitações. *Educação e Pesquisa, 31*, 317–322.

Smith, R., & Otterstrom, S. (2009). Engaging local communities in sea turtle conservation: Strategies from Nicaragua. *The George Wright Forum, 26*(2), 39–50.

Tomazello, M. G. C., & Ferreira, T. R. C. (2001). Educação ambiental: Que critérios adotar para avaliar a adequação pedagógica de seus projetos? *Ciência & Educação (Bauru), 7*, 199–207.

Vieitas, C. F., Lopez, G. G., & Marcovaldi, M. A. (1999). Local community involvement in conservation: The use of mini-guides in a programme for sea turtles in Brazil. *Oryx, 33*, 127–131.

Wallace, B. P., DiMatteo, A. D., Bolten, A. B., Chaloupka, M. Y., Hutchinson, B. J., Abreu-Grobois, F. A., et al. (2011). Global conservation priorities for marine turtles. *PLoS One, 6*, e24510.

Walters, C. J. (1986). *Adaptive management of renewable resources.*The Blackburn Press (reprint of first edition): Caldwell, NJ.