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Pressões antrópicas e suas potenciais implicações para a conservação das tartarugas marinhas: estudo de caso em áreas da costa brasileira sob diferentes status de proteção

Flávia Maria Guebert

Recife – PE

2012

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Tese apresentada ao Programa de Pós-Graduação em Oceanografia como requisito parcial à obtenção do título de Doutor em Oceanografia. Área de concentração em Oceanografia Biológica.

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Tese submetida ao curso de Pós-Graduação em Oceanografia da Universidade Federal de Pernambuco, como requisito parcial para obtenção do Grau de Doutor.

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RESUMO

O presente estudo teve como objetivo principal detectar as ameaças que as tartarugas marinhas sofrem em áreas estuarinas e costeiras sob diferentes status de proteção na costa brasileira. A Reserva Extrativista – RESEX Acaú-Goiana (Pernambuco/Paraíba) e áreas adjacentes foram as regiões foco deste estudo no litoral do Nordeste do Brasil. O Estuário de Paranaguá (Paraná) e suas Unidades de Conservação e a Baía da Babitonga (Santa Catarina) também foram abordadas neste estudo no litoral Sul do Brasil, e englobando de uma forma geral áreas protegidas e não protegidas por lei. Através de entrevistas com populações de pescadores tradicionais artesanais foi observado que existe uma sobre-exploração de recursos pesqueiros que afeta a economia de subsistência de todas as vilas de pesca. As tartarugas marinhas estão ameaçadas principalmente pelas atividades pesqueiras, com especial atenção ao uso das redes de emalhe com tamanho de malha maior que 70 mm. A principal causa da morte das tartarugas é o afogamento ou o estrangulamento por estas redes que permanecem pescando no mar por até 12 horas. Para corroborar as informações obtidas pelas entrevistas, um barco pesqueiro que utiliza a rede de emalhe de 70 mm foi acompanhado durante a estação seca (Dezembro/2011 a Março/2012), na porção adjacente ao Estuário do Rio Goiana – PE/PB. Foi observada a captura incidental de quatro indivíduos juvenis da espécie *Chelonia mydas* (tartaruga-verde); além das famílias de espécies alvo da pesca: Ephippidae, Centropomidae, Carangidae e Scombridae. Além disso, outras ameaças importantes foram detectadas nas regiões de estudo. O consumo alimentar das tartarugas ainda é uma importante ameaça, não somente por pescadores que as capturam de forma não intencional, mas também por encomenda de turistas. Quanto à utilização dos habitats, foi detectado que das cinco espécies de tartarugas marinhas que ocorrem no Brasil quatro delas frequentam o litoral dos Estados da Paraíba, Pernambuco, Paraná e Santa Catarina: *Caretta caretta* (tartaruga-cabeçuda), *Chelonia mydas* (tartaruga-verde), *Eretmochelys imbricata* (tartaruga-de-pente) e *Dermochelys coriacea* (tartaruga-de-couro). Através do monitoramento das praias adjacentes aos Estuários do Rio Goiana e Paranaguá foram detectadas a presença de indivíduos juvenis, principalmente da espécie *C. mydas.* Além disso, adultos da mesma espécie foram registrados no litoral do Nordeste, indicando que esta região pode ser uma importante área para cópula e alimentação de adultos. Diferentes medidas para a conservação das espécies são necessidades urgentes como a adoção de procedimentos para reduzir a mortalidade de tartarugas marinhas por pescadores, tais como redes que possam ser monitoradas com maior freqüência evitando as redes com malha grossa e sendo treinados para recuperar as tartarugas marinhas afogadas. Novas opções para as populações tradicionais de pescadores devem ser encorajadas, especialmente aquelas que visem a proteção das tartarugas marinhas como programas educacionais, projetos de conservação e o turismo ecológico. A participação das Unidades de Conservação neste processo é fundamental, gerenciando atividades e capacitando pessoas para tais processos, beneficiando a fauna marinha de forma geral.

Palavras chave: ameaças, pesca artesanal, redes de emalhe, consumo, medidas para conservação.

ABSTRACT

The present study aimed to detect threats that sea turtles suffer in estuarine and coastal areas under different protection status in the Brazilian coast. The Extractive Reserve - RESEX Acaú-Goiana (Pernambuco/Paraíba) and adjacent regions were the focus of this study on the Northeast Brazilian coast. The Paranaguá Estuary (Paraná) and its protected areas and Babitonga Bay (Santa Catarina) regions were also addressed in this study on the South Brazilian coast, comprising protected and unprotected areas. Through interviews with traditional populations of fishers, it was observed that there is an over-exploitation of fishing resources that affects the subsistence economy of all fishing villages. Sea turtles are threatened mainly by fishing activities, with special attention to the use of soak gillnets with mesh size greater than 70 mm. The main cause of death is drowning turtles or strangulation by fishing, especially because these nets remain at sea for up to 12 hours submerged. To corroborate the information obtained by interviews, a fishing boat that uses gillnets of 70 mm was accompanied during the dry season (December/2011 to March/2012), at the adjacent portion of the Goiana Estuary - PE / PB. We observed the incidental capture of four juveniles of the species *Chelonia mydas*, green turtle, besides the families of target species: Ephippidae, Centropomidae, Carangidae and Scombridae. Furthermore, other important threats were detected in the studied regions. Poaching is still an important threat and turtles are consumed not only by the fishers who catch unintentionally, but also on demand by tourists. Habitat use was detected for four of the five species of sea turtles that occur in Brazil at the coasts of the states of Paraíba, Pernambuco, Paraná and Santa Catarina: *Caretta caretta* (loggerhead turtle), *Chelonia mydas* (green turtle), *Eretmochelys imbricata* (hawksbill turtle) and *Dermochelys coriacea* (leatherback turtle). By monitoring beaches adjacent to the Goiana and Paranaguá Estuaries we detected the presence of juveniles, especially the species *C. mydas*. Moreover, adults of the same species have been recorded at the Northeast coast, indicating that this region can be an important area for adults mating and feeding. Conservation measures for sea turtles are urgently needed such as: the adoption of measures to reduce sea turtle mortality by fishers such as monitoring gillnets more frequently, avoiding nets with larger mesh sizes and being trained to recover drowned sea turtles. New options for traditional populations of fishers should be encouraged, especially those aimed at the protection of sea turtles as educational programs, conservation projects and ecotourism. The participation of the Conservation Units in this process is critical, managing activities and enabling people to such processes, benefiting the marine fauna in general.

Key words: threats, artisanal fishery, gillnets, poaching, mitigation measures.

Apresentação

Introdução

As tartarugas marinhas modernas surgiram a cerca de 110 milhões de anos, no Cretáceo, pertencente a mais antiga linhagem de répteis vivos (Spotila 2004). Diversas características são compartilhadas entre este grupo de quelônios, entre elas o número reduzido de vértebras e a fusão das costelas com ossos dérmicos formando a carapaça. Para os grupos que se desenvolveram no ambiente aquático, adaptações como as patas anteriores modificadas em remos e escudos epidérmicos sobre a carapaça os auxiliaram a alcançar sucesso neste ambiente (Wyneken 1997).

Existem sete espécies de tartarugas marinhas no mundo, das quais cinco são registradas no Atlântico Sul: *Caretta caretta,*(tartaruga-cabeçuda) (Linnaeus, 1758), *Chelonia mydas* (tartaruga-verde) (Linnaeus, 1758), *Dermochelys coriacea* (tartaruga-de-couro) (Vandelli, 1761), *Eretmochelys imbricata* (tartaruga-de-pente) (Linnaeus, 1766) e *Lepidochelys olivacea* (tartaruga-oliva) (Eschscholtz, 1829), e que desovam no continente e ilhas oceânicas das regiões do Nordeste e Sudeste do Brasil. Essas espécies também utilizam as regiões estuarina, costeira e oceânica para alimentação e crescimento (Marcovaldi & Marcovaldi 1999). Outras duas espécies têm distribuições restritas: *Lepidochelys kempii* (Gaman, 1880) no Golfo do México e Oceano Atlântico Norte e *Natator depressus* (McCulloch, 1908) no Nordeste da Austrália (Musick & Limpus 1997).

Ocorrem em oceanos tropicais e subtropicais. São nadadoras aptas e conhecidas pela alta capacidade migratória, percorrendo longas distâncias entre áreas de alimentação e reprodução. Possuem um complexo ciclo de vida utilizando extensas áreas geográficas e múltiplos habitats (Márquez 1990). Habitam ambientes marinhos e estuarinos e seu laço com o ambiente terrestre é o momento em que as fêmeas realizam a desova e o período de desenvolvimento e nascimento de filhotes (Spotila

2004). Desde o nascimento as tartarugas seguem rotas oceânicas onde permanecem por anos se alimentando de organismos planctônicos, fase que é chamada de “lost years”, já que são poucas as informações disponíveis. Na fase juvenil (aproximadamente 25 cm de comprimento curvilíneo de carapaça, de acordo com a espécie) recrutam para habitats neríticos e próximos da costa onde buscam alimento e refúgio para o seu desenvolvimento. A fase adulta á marcada por migrações e pela reprodução, quando as fêmeas se tornam residente das áreas de desova (Musick & Limpus 1997). Os distintos ecossistemas marinhos, especialmente estuários e ambientes costeiros, exercem grande importância para as tartarugas marinhas e outros organismos promovendo habitats berçários, de proteção e crescimento, alimentação, cópula e desova (López-Mendilaharsu et al. 2005, Barletta et al. 2010, Guebert-Bartholo et al. 2011a).

Até os séculos XVIII e XIX as tartarugas marinhas eram abundantes nas áreas de alimentação e reprodução em todo Brasil. Atualmente as sete espécies estão catalogadas como em perigo, ou criticamente em perigo, pela Lista Vermelha da União Internacional para Conservação da Natureza (IUCN), além de constarem nos Apêndices I e II da Convenção sobre o Comércio Internacional de Espécies da Flora e Fauna Selvagens em Perigo de Extinção (CITES) (IUCN 2012). Particularmente no Brasil, a partir da década de 1970 foram criadas iniciativas governamentais e não governamentais para a conservação das espécies, inclusive manifestos e acordos internacionais (Marcovaldi & Marcovaldi 1999).

As atividades humanas são o maior impacto para as tartarugas marinhas atingindo todos os estágios do ciclo de vida. A captura não intencional, ou incidental nas atividades pesqueiras (*bycatch*) é descrita atualmente em todo globo como a maior ameaça para a sobrevivência das tartarugas (Peckham et al. 2007, Gillman et al. 2010, Hamann et al. 2010). Mesmo assim, existem poucas informações sobre frotas pesqueiras e seus produtos, sobretudo a pesca com redes de emalhe, e a pesca artesanal de modo geral (Alfaro-Shigueto et al. 2010, Guebert-Bartholo et al. 2011b), o que torna esta ameaça uma questão importante na gestão da pesca mundial e conservação das espécies (Domingo et al. 2006, Fiedler et al. 2012, López-Barrera et al. 2012). Animais pertencentes ao grupo da megafauna (meros, tubarões, tartarugas, aves e mamíferos marinhos) são mais sensíveis a tal impacto principalmente devido às suas características de vida (vida longa, baixas taxas reprodutivas e crescimento lento), o que torna (raros) eventos de captura não intencional uma grande ameaça para a viabilidade populacional destes grupos (Heppell et al. 2000, Lewison et al. 2004, Bearzi et al. 2006, Zydelis et al. 2009).

O desenvolvimento urbano costeiro também tem gerado impactos às populações de organismos marinhos, sendo acompanhado de construções portuárias, dragagens e a intensificação dos usos do solo (aquicultura, agropecuária e agronegócios). Estes processos aumentam o desmatamento gerando a consequente poluição por efluentes domésticos e industriais (Barletta & Costa 2009), além da dispersão do lixo (Ivar do Sul & Costa 2007). Tais atividades possuem grande impacto pela degradação e perda de habitats berçários, de alimentação, crescimento e reprodução de tartarugas marinhas e organismos marinhos em geral (Barletta et al. 2010), incluindo a ocupação das praias com estruturas rígidas e iluminação noturna, que agrava ainda mais a situação de espécies marinhas ameaçadas (Tuxbury & Salmon 2005). A poluição dos mares e estuários por elementos químicos, a propagação do lixo marinho e sua consequente ingestão por tartarugas marinhas também tem sido foco de estudos e pesquisas (Gregory 2009, Guebert-Bartholo et al. 2011a, Lazar & Gracan 2011). Atualmente este é considerado um problema eminente não somente no Oceano

Atlântico (Ivar do Sul & Costa 2007), porém em todo globo (Bjorndal et al. 1994, Casale et al. 2008, Hamann et al. 2010, Moore 2011, Schuyler et al. 2012).

O declínio das populações de tartarugas marinhas no Brasil se deve sobretudo à captura de animais para uso como fonte de alimento e adornos, desde o início da colonização até meados da década de 1970, e assim como em todo mundo (Peckham et al. 2008, Chen et al. 2009, Stiles 2009, Senko et al. 2010). Atualmente esta é uma ameaça de menor visibilidade, especialmente porque ocorre em vilas de populações tradicionais costeiras, sendo que em algumas localidades é observado também o comércio ilegal local e até rotas internacionais (México, Ásia e África) principalmente de subprodutos como a carne, ovos e artesanatos produzidos com a carapaça das tartarugas (Koch et al. 2006, Mancini & Koch 2009).

Levando em consideração que as tartarugas marinhas são grandes migradoras (Lohmann et al. 2008), medidas para a conservação das espécies devem ser elaboradas de acordo com suas trajetórias, devendo ser vistas de maneira ampla e não regional. O Brasil é signatário de tratados e acordos internacionais, principalmente a Convenção Interamericana para Conservação das Tartarugas Marinhas, que contempla medidas de conservação para as espécies e habitats que dependem (DOU 2001). No Brasil existem Unidades de Conservação criadas para proteção das tartarugas (ex. Reserva Biológica do Atol das Rocas – RN, Reserva Biológica de Pirambú – SE, Reserva Biológica de Comboios – ES), no entanto estas áreas abrangem principalmente o estágio de vida na terra quando as fêmeas sobem às praias para desovar e onde ocorre o desenvolvimento dos embriões. Não existem Unidades de Conservação com prioridade para proteção de tartarugas marinhas em áreas de crescimento, desenvolvimento e alimentação (a não ser as concomitantes com áreas de desova, como Fernando de Noronha, por exemplo).

Nestas áreas de ocorrência e alimentação o monitoramento de populações de tartarugas não é realizado, ou é realizado por grupos autônomos de pesquisa e ONGs.

Portanto, apesar de haver leis restritas para a proteção das tartarugas relacionadas à captura, mortalidade e consumo (DOU 1998), não existe fiscalização permitindo que tais crimes continuem sendo uma prática comum em áreas costeiras mais isoladas. Dentro deste contexto, é extremamente importante determinar os fatores que afetam e ameaçam a sobrevivência das tartarugas marinhas, e elaborar a partir daí medidas para minimizar os impactos sobre as populações deste grupo animal que utiliza a costa brasileira em distintos ambientes (estuários, região costeira, oceânica) e fases de vida. Este estudo buscou analisar as regiões do Nordeste e Sul do Brasil sob diferentes aspectos, destacando as características de cada ambiente, a ocorrência de tartarugas marinhas, as atividades antrópicas e sua interação com as tartarugas.

Objetivos

Objetivo Geral

Este estudo teve como principal objetivo identificar e descrever os impactos antrópicos que afetam as espécies de tartarugas marinhas em suas diferentes fases de vida em regiões estuarinas e costeiras do litoral brasileiro, buscando observar se há diferenças nos impactos sofridos pelas espécies em áreas protegidas (Unidades de Conservação) e não protegidas.

Objetivos Específicos

- Caracterizar a atividade pesqueira artesanal da Resex Acaú-Goiana e áreas adjacentes (Nordeste do Brasil) e sua influência na captura incidental de animais não alvo de pesca, incluindo as tartarugas marinhas. Capítulo 1, pag. 18.

- Identificar e qualificar as pressões antrópicas sofridas pelas tartarugas marinhas em regiões com distintos status de proteção em áreas do litoral Nordeste e Sul do Brasil. Capítulo 2, pag. 41.

- Determinar como ocorre a captura incidental de tartarugas marinhas na pesca artesanal com redes de emalhe na região da RESEX Acaú-Goiana (PE/PB) e propor medidas para minimizar este impacto. Capítulo 3, pag. 67.

- Caracterizar os padrões de ocorrência das tartarugas marinhas e causas de mortalidade em regiões com distintos status de proteção no litoral Nordeste e Sul do Brasil. Capítulo 4, pag. 95.

Material e Métodos

Área de Estudo

As áreas investigadas neste estudo estão localizadas nas regiões do Nordeste e Sul do Brasil. As áreas de estudo no Nordeste são ambientes tropicais, onde as variações climáticas são afetadas pela condição de regime de chuvas. Uma das áreas estudadas está localizada na porção norte do Estado da Paraíba, nas imediações da Baía da Traição, que possui áreas urbanizadas e Reservas Indígenas, no entanto municípios em torno desta área não possuem status de conservação (Fig. 1A). A outra área está localizada no Estuário do Rio Goiana, entre os Estados de Pernambuco e Paraíba (Fig. 1B), que possui uma Unidade de Conservação Marinha da categoria Reserva Extrativista (RESEX Acaú-Goiana) (Barletta & Costa 2009). Os habitats são distribuidos ao longo das porções estuarinas e costeiras: rios, bancos arenosos, planícies alagadas, áreas de manguezais, praias arenosas, pradarias de gramas marinhas, recifes de arenito e substratos rochosos.

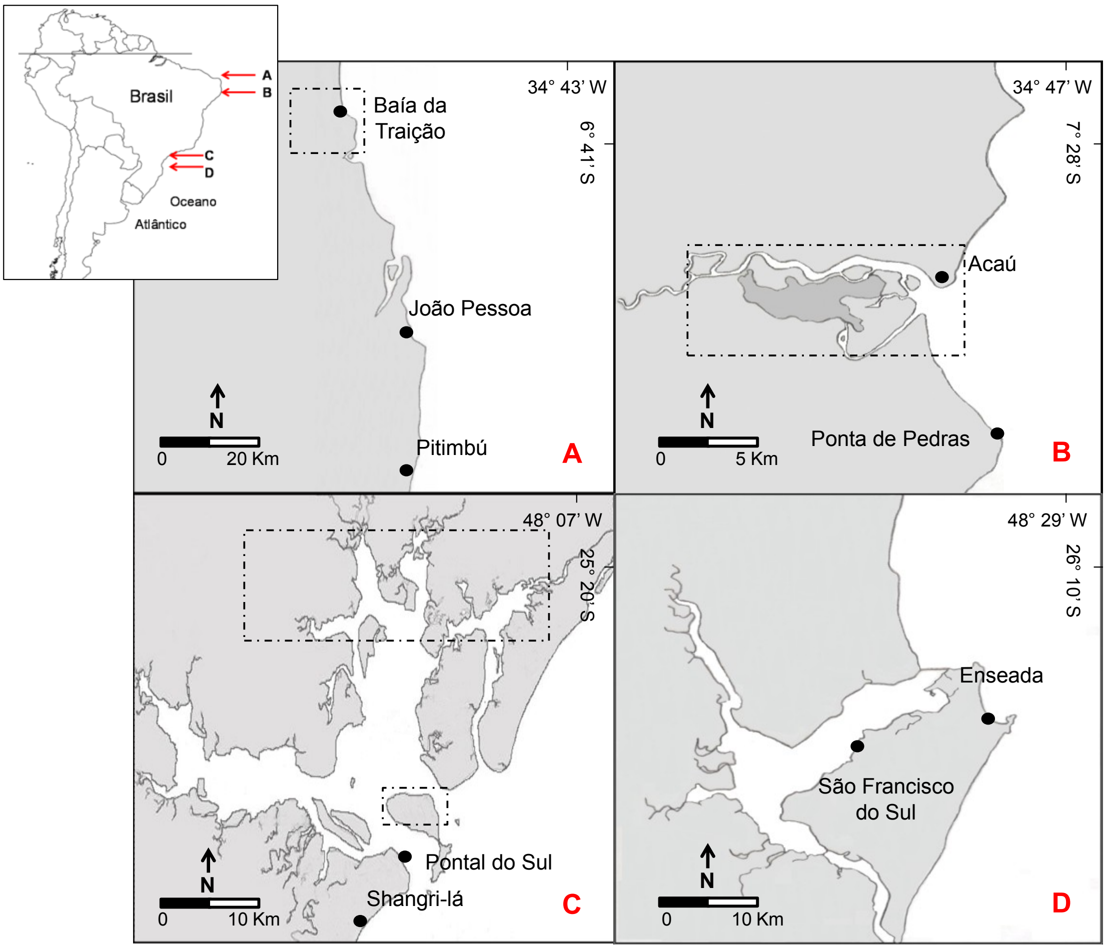

Figura 1: Mapa da área de estudo. Na região Nodeste do Brasil; A: Baía da Traição e regiões adjacentes (litoral centro norte do Estado da Paraíba); B: Estuário do Rio Goiana e áreas adjacentes (litoral norte do Estado de Pernambuco). Na região Sul do Brasil; C: Estuário de Paranaguá (litoral norte do Estado do Paraná); D: Baía da Babitonga (litoral norte do Estado de Santa Catarina). As áreas tracejadas indicam as Unidades de Conservação e Reservas Indígenas, e os pontos pretos indicam as localidades amostradas em cada região.

As áreas estudadas no Sul do Brasil são ambientes subtropicais com fragmentos de Mata Atlântica. Uma das áreas estudadas da região Sul é o Estuário de Paranaguá, localizado na porção norte do Estado do Paraná, que possui um mosaico de Unidades de Conservação: o Parque Nacional do Superagui (PARNA), a Área de Proteção Ambiental (APA) de Guaraqueçaba, a Estação Ecológica de Guaraqueçaba (ESEC) e a Estação Ecológica da Ilha do Mel (ESEC) (Fig. 1C). A outra área é a Baía da Babitonga, localizada na porção norte do Estado de Santa Catarina. Apesar de reconhecidamente importante pela presença de espécies ameaçadas (*Sotalia guianensis* e *Pontoporia blainvillei*) ainda não possui um status de conservação estabelecido (Cremer & Simões-Lopes 2008) (Fig 1D). As regiões estudadas ao Sul são compostas por estuários, florestas de manguezais, planícies alagadas, rios, praias arenosas e ilhas rochosas em torno dos habitats.

Método Amostral

Entrevistas

Foram realizadas entrevistas direcionadas à pescadores das regiões do Nordeste e Sul do Brasil. A estimativa de pescadores entrevistados foi relacionada ao número de pescadores cadastrados nas Colônias de Pesca, sendo amostrado então 10% em cada vila de pesca. Os dados foram coletados em três ocasiões: Setembro de 2009 a Fevereiro de 2010, Junho de 2011 e Agosto de 2011. As entrevistas eram do tipo semi-estruturadas, informais, porém guiadas, dedicadas a pescadores ativos. As perguntas foram separadas em três grupos: atividade pesqueira e interação de animais não alvo de pesca (especialmente tartarugas marinhas) com a pesca; biologia e ecologia das tartarugas marinhas; e ameaças às tartarugas marinhas (Apêndice 1). Os resultados das entrevistas foram subdivididos em três capítulos da tese (1 – pag. 18; 2 – pag. 41 e 3 – pag. 67), de acordo com as regiões entrevistadas e o tema abordado nas entrevistas. Também foram utilizadas fotografias das espécies de tartarugas marinhas como material de apoio.

Dados Biológicos

Para coleta de dados biológicos sobre a pesca, um barco da região adjacente ao Estuário do Rio Goiana (Pernambuco/Paraíba), no litoral do Nordeste, foi acompanhado durante a estação de pesca (estação seca) no período de Dezembro de

2011 a Março de 2012. De acordo com as atividades dos pescadores foi possível monitorar a embarcação realizando três réplicas durante quatro meses nos períodos de dia e noite. A comunidade de peixes/tartarugas foi amostrada com uma rede de emalhe de 70 mm de distância entre nós e 0.8 mm de grossura de fio, utilizada submersa por 12 horas entre 5 e 10 m de profundidade em áreas rochosas, em torno de 5 milhas da costa. A captura por unidade de esforço (CPUE) foi calculada baseada no número de indivíduos capturados (I), área da rede (A) e o tempo de submersão (t):

$$CPUE = I\ (tA)^{-1}.$$

Os resultados referentes a esse método amostral foram apresentados no Capítulo 3 (pag. 67).

Por último, também foram monitorados diferentes trechos de praias arenosas e estuários em busca de carcaças de tartarugas marinhas, durante o período de 2003 a 2004 no litoral Sul, e 2009 a 2012 no litoral Nordeste do Brasil. Em ambas as regiões a metodologia empregada foi a mesma. As praias eram monitoradas e os animais registrados mortos eram coletados e necropsiados, e indivíduos vivos enviados para reabilitação. No laboratório a espécie era identificada e suas medidas coletadas (comprimento e largura curvilíneos da carapaça). Além disso, indicadores externos e internos da causa da morte eram analisados em animais em estágio inicial de decomposição. Os resultados referentes a essa amostragem foram apresentados no Capítulo 4 (pag. 95).

Todas as atividades realizadas durante esta pesquisa foram feitas com licença ambiental cedida pelo SISBIO/ICMbio sob o registro N^{o} 25707-1.

Estrutura da tese

A tese foi dividida em quatro capítulos, de acordo com os objetivos propostos. Os capítulos apresentados estão formatados de acordo com as normas das revistas científicas às quais eles foram ou serão submetidos para publicação.

Capítulo 1: **Fishery and the use of space in a tropical semi-arid estuarine region of Northeast Brazil: subsistence and overexploitation**

Este manuscrito, publicado na revista científica Journal of Coastal Research (ISSN 0749-0208) em 2011 (SI 64, 398-402, 2011) (Apêndice 2), descreve as atividades pesqueiras e o perfil dos pescadores do Estuário do Rio Goiana-PE/PB (RESEX Acaú-Goiana) e áreas adjacentes, e as interações com animais não alvo da pesca, como as tartarugas marinhas.

Capítulo 2: **Threats to sea turtle populations in the Western Atlantic: poaching and mortality in small scale fishery gears**

Este manuscrito, aceito para publicação na revista científica Journal of Coastal Research (ISSN 0749-0208) para publicação na edição especial de 2013 (SI 65, 2013) (Apêndice 3), apresenta as ameaças às populações de tartarugas marinhas em estuários e áreas adjacentes do Nordeste e Sul do Brasil, descritas através de questionários dirigidos à população de pescadores das regiões. Os resultados mais relevantes se referem às ameaças da pesca artesanal utilizando redes de emalhe e ao consumo da carne.

Capítulo 3: **The consequences of artisanal fishery activities on sea turtles` population at the Northeast Brazilian Coast: the case of gillnets allowed by legislation**

Este manuscrito apresenta resultados sobre a pesca artesanal e os impactos das redes de emalhe com tamanho de malha ≥ 70 mm para as tartarugas marinhas. Tais resultados foram obtidos por meio de entrevistas com pescadores e o monitoramento de um barco pesqueiro que utiliza esta rede de emalhe.

Capítulo 4**: Monitoring sea turtles strandings as indicators of anthropogenic activities: the case of two Marine Protected Areas in Brazil**

Este manuscrito, submetido à revista Ocean and Coastal Management (ISSN0964-5691), descreve os padrões de registros de espécies e fases de vida de tartarugas marinhas, além das causas da mortalidade através de indicadores externos e internos, em duas regiões distintas da costa brasileira: o Estuário do Rio Goiana (RESEX Acaú-Goiana) (PE/PB) e o Estuário de Paranaguá (PR), que apresentam diferentes status de proteção.

Conclusões

Apresenta as principais conclusões obtidas neste estudo, recomendações e sugestões de futuras pesquisas a serem desenvolvidas nas áreas estudadas.

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Capítulo 1

Fishery and the use of space in a tropical semi-arid estuarine region of Northeast Brazil: subsistence and overexploitation

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Fishery and the use of space in a tropical semi-arid estuarine region of Northeast Brazil: subsistence and overexploitation

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Running Title: Fishery and the use of space: subsistence and overexploitation.

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ABSTRACT: Fishery activities were described in a tropical estuary of the Northeast Coast of Brazil. Semi-structured questionnaires were applied to fishers (N=263) at three villages of the Goiana Estuary. The average individual income was US$ 329 (SE ± 14.83), and at least 17 (7%) interviewees have an income <U$109 / month, considered a chronic poverty state. Gillnet with small mesh size (<60 mm) was the most cited gear, although others as trap barriers (seasonally), longline, lobster trap, spear diving, hook and line are also used. Lobster is the most profitable catch, and 68 (53%) fishers are dedicated to its capture, especially during rainy season. Seasonal closure for recovering lobsters populations is enforced by law during the late dry and early rainy seasons. However, interviewees frequently admitted to fish for lobster off-season, according to market demands and household needs. Dependent dive for lobster capture is also illegal, yet common. Fishers pointed overexploitation of fish stocks as the main problem in the region, especially for lobster. These preliminary results emphasize the urgent need of further efforts to collect information about fishery gears, production, catchability and mortality of target and non-target species while providing food and income for coastal communities. State and community co-governance of the artisanal fishery is a possible way to reduce the pressure on heavily exploited species whilst ensuring the sustainable use of marine resources along the Northeast Brazilian coast.

ADDITIONAL INDEX WORDS*: gillnet, lobster capture, Goiana Estuary*

INTRODUCTION

Humankind depends on coastal and marine ecosystems in different ways (*e.g.* energy, minerals, aquaculture, transport, tourism and fishing) and these environments are also nursery, foraging, growth, mating and nesting habitats of fish and invertebrate species (Barletta and Costa, 2009; Barletta *et al.*, 2010; Saint- Paul and Barletta, 2010). Estuaries are considered one of the most important aquatic environments for coastal animal life that depends on these habitats and its processes, especially in the earlier developmental stages.

Estuarine fisheries are one of the oldest human activities and have been practiced in the Americas since pre-Colombian times. Fishery gears and strategies developed according to technological advances, societal demands, target species and management techniques. Small-scale fishery (subsistence and artisanal) contributes to the local income, generates an important number of jobs, and plays a fundamental role in the subsistence of a large number of fishing communities in developing countries, including Brazil. This contributes to poverty alleviation and food security where fish is the single most important natural resource. However, most stocks lack information, knowledge about fish species biology and appropriate management have been largely overlooked (Alfaro-Shigueto *et al.*, 2010).

According to Bené (2006), 35 million people worldwide are involved in fishing and fish processing, 80% of those are associated with the small-scale fishery sector. The Brazilian annual fish production in 2007 was 1,072.226 tonnes (t) corresponding to US$ 2 billion, 2% higher than 2006. Extractive marine fishery represents 50% of total fishery production in Brazil and the export of its products is growing, especially for lobster that corresponds to 30% (in US$) of total exportation (IBAMA, 2009).

However, recent problems of fishery management such as the increased spatial distribution of fishery effort, degradation of coastal waters and mangrove ecosystems (Saint-Paul and Barletta, 2010), declined catch rates, overexploitation and depletion of some marine resources, and bycatch of non-target species (Guebert-Bartholo *et al.,* 2011) compromise sustainability of species and communities dependent. The creation of Marine Protected Areas (MPAs) has been seen as a contributor to fishery organization and is an increasingly popular strategy for managing fisheries, conserving biodiversity and influencing the quantity and type of benefits to marine ecosystems (*e.g*. abundance and diversity of fishes and the amount caught and associated level of effort required). MPAs impacts on human welfare are still poorly understood, but they affect the social and political power of fishers, including those marginalised and poor which are most dependent on marine resources (Mascia, Claus and Naidoo, 2010).

In Brazil, five categories of MPAs are commonly used to preserve marine diversity and traditional livelihoods. An Extractive Reserve (RESEX), characterized by community based management decisions at a local level, was created in the studied area.

Traditional communities of the Northeast Brazilian estuaries depend on the different resources (e.g. fish, crustaceans, shellfishes, mangrove wood) and ecological services (e.g. tourism, transport). The increasing of exploration, especially by non-traditional stakeholders (coconut, sand mining, sugarcane and aquaculture producers), threatens biological diversity, traditional livelihoods, culture and values (Barletta and Costa, 2009). Impacts that have effects on estuarine ecology and productivity are: deforestation of the Atlantic Rain Forest and mangroves, soil erosion, effluents discarding, water eutrophication, chemical contamination; most of them are connected to the sugarcane production (Barletta and Costa, 2009).

This study describes the fishery activities, at small coastal traditional communities of the Brazilian Northeast (tropical semi-arid) comparing protected (1) and non protected (2) areas.

METHODS

Study area

The study area comprises the lower Goiana Estuary. The system has an area of 4,700 ha, and ends at the Atlantic Ocean, at the Northeast of Brazil (Barletta and Costa, 2009) (Figure 1). The study area comprises three villages (Ponta de Pedras, Acaú and Pitimbú) of two municipalities. The Acaú-Goiana RESEX was created in 2007 around Goiana Estuary (~ 67 km^2) and has not been structured until now.

The region is a tropical semi-arid estuary and rainfall patterns are responsible for the major seasonal fluctuations. Four seasons characterize the estuarine region: early (March to May) and late rainy (June to August) and early (September to November) and late dry seasons (December to February). The estuarine region is divided by areas according to the salinity patterns: river; upper, middle and lower estuary and coastal waters (Dantas *et al.*, 2010). Fishery at these sites is described as artisanal and some estuarine fish species (catfishes), crustaceans and shellfishes are captured in a sustainable way (Barletta and Costa, 2009).

Data collection by semi-structured interviews as an informal, but guided talk, to fishers took place between September/2009 and February/2010, at three villages boarding the Goiana Estuary: Ponta de Pedras (1), Acaú (2) and Pitimbú (3). Questions were separated into: (1) *social and economic aspects*, with questions about age, income, education and (2) *fishing activities*, with questions about fishing gears, vessels and fishing areas. The best possible estimate of the number of fishers at each village was based on the current records at the three fishers associations. A minimum of 10% of the fishers from each village were interviewed randomly and separately from the group, generally when they were going to or coming from the sea, repairing fishing nets, at the beach. The same person made all interviews.

The Chi-square independent test was used to determine significant differences in the interviewee's information, with a 5% level of significance (Zar, 1999).

RESULTS

A total of 263 interviews were conducted at the three villages. Interviewed fishers were male between 18 and 74 years old. Low level of formal education was detected among fishers (Figure 2).

About 35 (17%) are illiterate. Another 168 (79%) have only 2 to 5 years of formal education. Two hundred and eighteen (88%) interviewees started fishing at an age lower than 15 years, and about 23 (9%) are formally retired by the government (> 65 years old) but still fish as their main activity. Part of interviewees (99, 38%) has a complementary activity working with general services (e.g. construction, seller, boat manager). The average individual income was US$ 329 (SE ± 14.83), and significant differences among villages were detected ($p<0.001$). At least 17 (7%) interviewees have an income lower than US$100 / month.

The fishery fleet showed significant differences among the three villages ($p<0.0001$). Four categories were described, engine boat with 9 m (114 - 43%) and sail boat (87 - 33%) were the most frequently cited (Table 1) (Figure 3). Despite the fact that 96 (42%) interviewed fishers are the boat owners and the other 130 (57%) are employees, no differences were detected between the income of these two categories ($p=0.42$).

Fishery gears differed significantly among areas ($p<0.0001$), and gillnet with small mesh size (<60 mm) was the most cited fishing gear (137 – 52.1%) (Figure 4). This can be used with different fishing strategies (soak, floating, set or drift net), according to the target species. Moreover, other types of fishery gears are also used: lobster trap (49 – 18.6%), longline (26 – 9.9%), diving with spear (19 – 7.2%), gillnet (>60 mm) (17 – 6.5%) and trap barriers (seasonally) (15 – 5.7%) (Figure 4).

Fisheries are explored according to season and eleven important groups of fish and crustaceans were pointed as the most commonly captured at the Goiana Estuary and adjacent areas: Carangidae, Centropomidae, Hemiramphidae, Lutjanidae, Mugilidae, Sciaenidae, Panuliridae and Penaeidae families (Table 1). In general, fishery activities were significantly related to income ($p<0.0001$), and subsistence-related species (*e.g.* catfish, cutlassfish) were more frequently captured by fishers with lower income (88, 40%) (Figure 5). Lobster was considered the most profitable catch, and 68 (53%) fishers were dedicated to its capture, especially from May to December (late rainy and early and late dry seasons). Fishers with higher income (>570 US$) are mostly dedicated to lobster fishery (19, 63%). Dependent dive, even being forbidden for lobster capture, is frequently used in the studied villages, and about 31 (62%) fishers dedicated to lobster capture by diving use it. This technique is used even during the closed season and targets other species (octopus, reef fish).

Coastal and deep waters (48% and 50%, respectively) are more frequently explored than the estuarine region ($p< 0.0001$), especially in Pitimbú (65%) (~70 m), where lobster landings are concentrated. Fishing days out at sea vary from 15 to 20 days for lobster, and 1 to 3 days for other resources, depending on the capacity of the boats ice box (Table 1). Non-target species (sea turtles, dolphins, sharks and rays) are incidentally caught, frequently in gillnets ($p<0.0001$), and their death was related to the characteristics of the gear (Table 2).

DISCUSSION

Artisanal and subsistence fisheries around the Goiana Estuary

Traditional communities around the Goiana Estuary live mostly in a sustainable way, depending on living natural resources for financial income and food. Fishing is the most important activity, considered in a small-scale, and the majority of men are dedicated to it. Even the adolescents and children < 10 years old fish to help keeping the family income. This is the major cause of school drop off.

The description of the artisanal fishery structure shows the importance of Goiana Estuary and adjacent areas for the exploitation of most resources mostly limited to subsistence and small-scale exploitation. The few technologically equipped fleet and the lower investment reflects the resources obtained and consequently the risks for the unsafely forms that fishers work.

The Northeast Coast is the second most productive region in Brazil (IBAMA, 2009). In the studied region (Pernambuco municipality) the Goiana Estuary is responsible for 29% of production (in US$) with 19% of fishery fleet. Although, the area decreased in production from 2006 to 2007 in about 30%, especially for the artisanal fishery (26%) (IBAMA, 2009). Coastal and deep fishing areas were more frequently used, due to the diversity of species and the higher profitability, exploring resources more intensively (Scianidae, Centropomidae and Panuliridae families). The estuarine area was frequently more explored by Acaú fishers, most of them independent and alone, where the captures are most of subsistence species (Ariidae, Trichiuridae, Carangidae and Penaeidae families) using sail boat with no technology.

Lobster Fishing

Lobster capture has an important role in the national fishery sector since the 1960s, and the Brazilian Northeast is the main producer (IBAMA, 2009). Lobster production increased 5% in 2007 and Pernambuco is the largest lobster exporter in Brazil reaching 881tons per year, which represents 43% of the national lobster exportation. The lobster price has been growing in last 6 years, where it was US$ 24,860/t in 2001 and reached US$ 44,300/t in 2007. Nevertheless, in the Brazilian scenario, lobster exportation decreased 4% from 2006 to 2007 (IBAMA, 2009).

Overexploitation of fish stocks, especially lobster, was pointed by all fishers as the main problem in the region due to the intense demand for lobster by the international market and tourism. This is the most rentable activity in Goiana fishery sector and generates direct and indirect jobs. From the biological point of view, the two lobster species explored in the area (*Panulirus argus* and *Panulirus laevicauda*) are suffering a steep decline due to fishing pressure in the last 20-30 years. Depletion of most of this natural resource is the consequence of the open-access nature of fisheries and unmanaged programs along the whole Brazilian coast.

Ecological changes have been reported worldwide (Bearzi *et al*., 2006) of many stocks considered to be outside safe biological limits and/or in a critical state, mostly because the ecosystem do not have the necessary time to recover populations affected by overfishing. Appropriate management and enforcement instruments are capable to be efficient on resources sustainability decreasing the fishing pressure on the subsistence and exportation resources. Therefore, in the study area a seasonal closure for the recovering of lobster populations is enforced by law during the late dry and early rainy seasons. Other measures are establishment of a minimum size (13 cm) and distance from the coast (7.5 km) for capture and limits on the gear (e.g. dependent dive is not allowed). Even though, gear apprehensions, arrests, and fines are applied since fishers insist in unsustainable practices when pressured by market demands and poverty.

Difficulties were found to precisely report rates of lobster catch using dependent dive since some deliberated misreported their activities to avoid confrontation. Nevertheless, the information obtained is relevant enough to argue that innumerable problems are related to this practice. Fishers practice dependent dive with different, sometimes unbalanced, air mixtures, stay more than 3 hours down, go down to 80 m deep, and most of the times do not respect decompression stops. Different problems were reported, most of them related to the decompression sickness (DS): alteration in nervous, motor and circulatory systems and death. Another cause of DS is the tentative to hide it when under police inspection with a diver still down.

Social problems detected in the studied villages are related to the fact that part of fishers receiving the financial support during the lobster closed season do not work. It reduces family income, facilitates alcoholism and the use of illicit drugs. As a result, part of them are lead to poverty and marginalisation.

Bycatch

Bycatch of non-target species events were very common in interviews, especially for gillnets. Sea turtles, dolphins and rays were the most cited captured animals that in most of times are sold, or eaten by the local community. Gillnets catchability have been studied around the world and its non-selective method has received more attention where deterrents to reduce megafauna bycatch have been used (e.g. baits, hooks, on boarder observers), especially for industrial fleet (Lewison *et al.*, 2004). Although, the effect of artisanal fishery bycatch on endangered species, especially sea turtles which utilize the region as nursery, feeding and nesting habitat, is poorly known and has to be urgently investigated. Fishery gears as hook and line were considered by fishers the most selective gear, not capturing non-target species and individual fish lower than the expected size (juveniles).

CONCLUSIONS

Results presented here are a baseline to begin the necessary discussions among stakeholders towards the development of a management plan for the Acaú-Goiana RESEX. This is especially important when the social, economic and health problems concerning lobster fishing. The economically vulnerable situation of every fisher within the estuarine portion of the system is also worrying. Moreover, problems such as deforestation, expanding area of sugarcane plantations, unsustainable aquaculture practices and the massive presence of non-traditional stakeholders in the RESEX should also be discussed and dealt with in the management plan, aiming at a better conservation and sensible use of resources by the traditional communities.

Investments in instruction are absolutely necessary for fishers, both in the form of basic education as well as technical capacity building (*e.g.* GPS use, communication systems, safety equipments and onboard and on land environment friendly practices). The existing measures (closed season and minimum catch size) will not be enough to improve lobster species conservation and its maximum sustainable yield, unless people are also valued as a highly precious resource. Such mentality must prevail among government, private institutions, RESEX management, third sector and all stakeholders. Inspection on lobster regulations obedience should be made not only at the fishers end of the production chain, but also to important costumers as restaurants and traders. Bycatch of non-target species should be investigated, and appropriate techniques experimented and used, when successful.

The existence of fishers associations did not guarantee the groups organization as a mechanism to serve the best interest of a professional. A strong, well-organized and equipped, local fish market could guarantee better prices and relationships that are more reasonable with intermediaries, if necessary. Work diversification including tourism (*e.g.*

boating, dive, sports fishing, lodging) could also be an appropriate way to earn money, as well as engagement on environmental and educational projects managed by the third sector and small businesspersons.

A special and vigorous incentive to children and young people to go to school and complete their education could have a positive effect on communities at a relatively short term (25 years, one generation). A consortium between schools and all the other alternatives cited above must be taken into account in order to include these youngsters in their communities' economic life from an early age, but under tight supervision and better conditions.

Further efforts to collect information about fishery gears, landings, destination and handling of the production, catchability and mortality of target and non-target species are another possible action for researchers and manager alike. A long-term study involving the hot-spots of marine megafauna bycatch and the main fishing gears responsible for it is essential. A management plan must soon be drawn for the protection and conservation of the estuarine ecocline and the adjacent coastal region as a whole, while providing food and income for coastal communities. Therefore, the participation of all stakeholders in this plan and its execution will be necessary to enhance the understanding of particular needs and local economy. This will almost necessarily lead to co-government options for the RESEX and its buffer territories.

ACKNOWLEDGMENTS

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Figure Captions

Figure 1: Goiana Estuary and adjacent areas. The Acaú-Goiana RESEX (solid line) and the buffer area (dashed line). Source: Google Earth and IBAMA.

Figure 2: Fishers formal education (Illiterate/none, Primary and Secondary incomplete), age class (<30, 31-65, >65 years old) and income of each group (in US Dollars).

Figure 3: Main types of fleet used in the studied areas: sail boat (A and B) and engine boat with 9 m (C).

Figure 4: Fishing gears used by fishers at the three studied areas: Ponta de Pedras, Acaú, Pitimbú.

Figure 5: Income (in US Dollars) of artisanal fishers that capture subsistence species and lobster in the three studied villages.

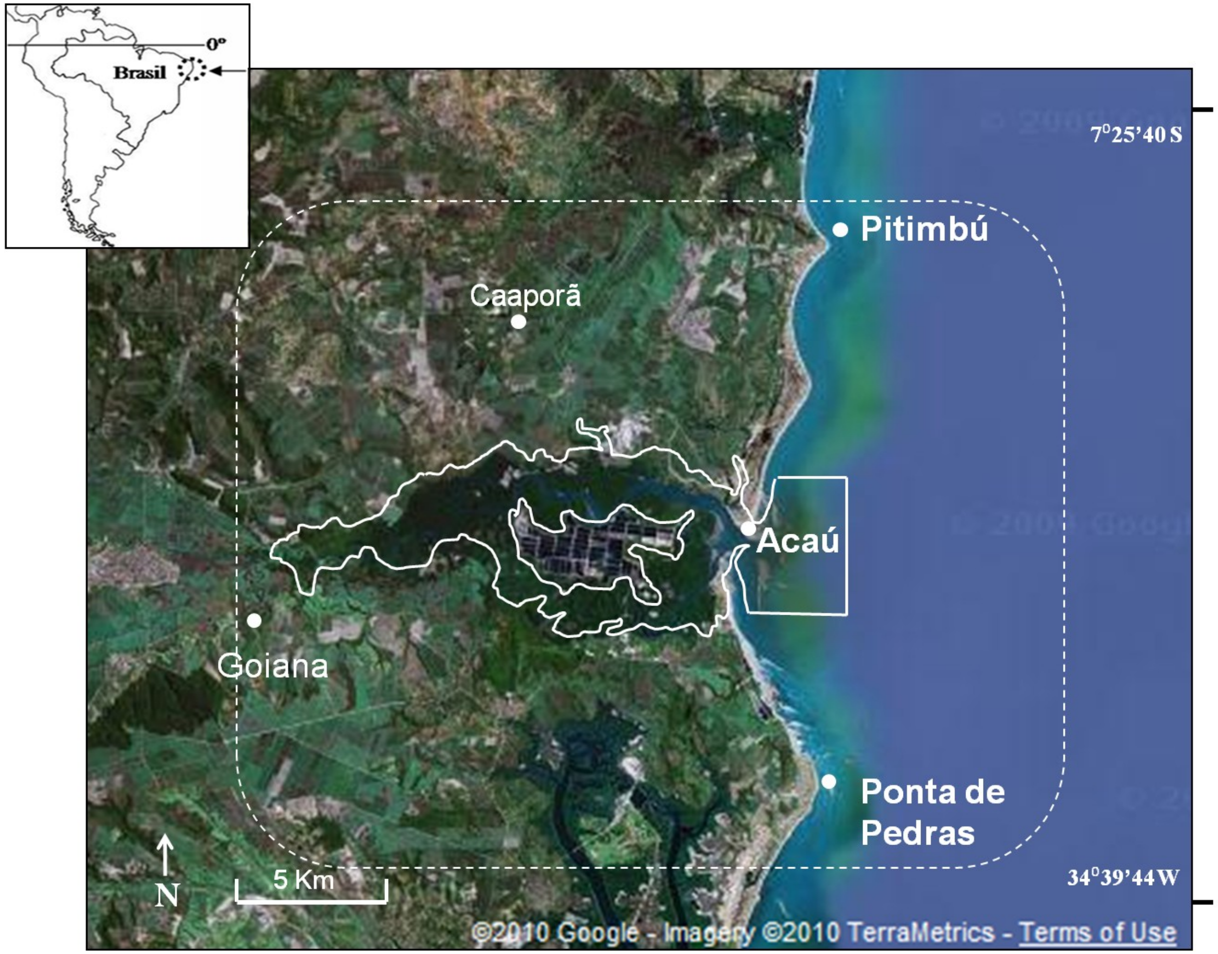
0°
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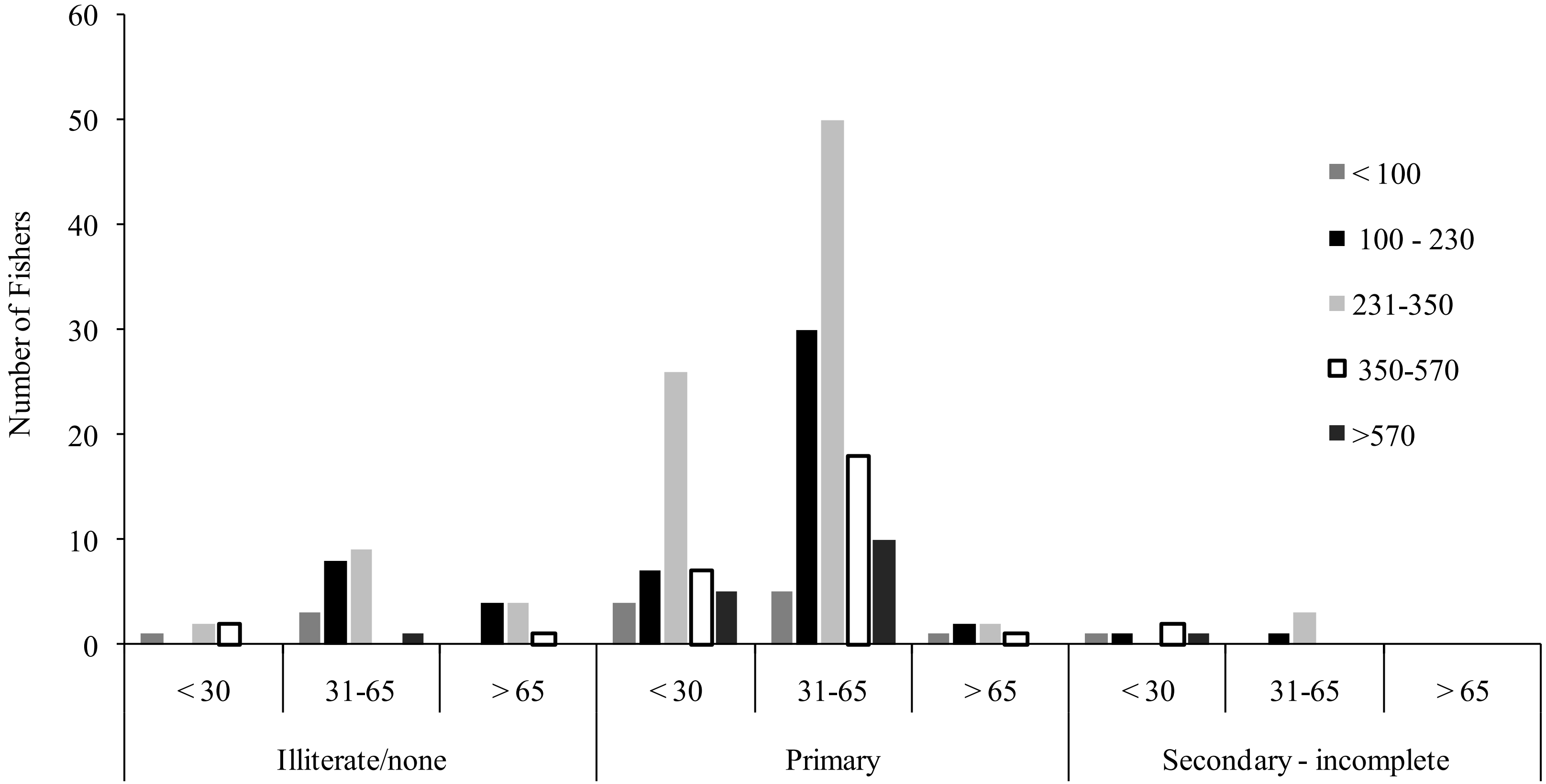
Fig. 1


60
50
40
30
20
10
0
Number of Fishers
< 100
100 - 230
231-350
350-570
>570
< 30
31-65
> 65
< 30
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> 65
< 30
31-65
> 65
Illiterate/none
Primary
Secondary - incomplete

Fig. 2

Fig. 3

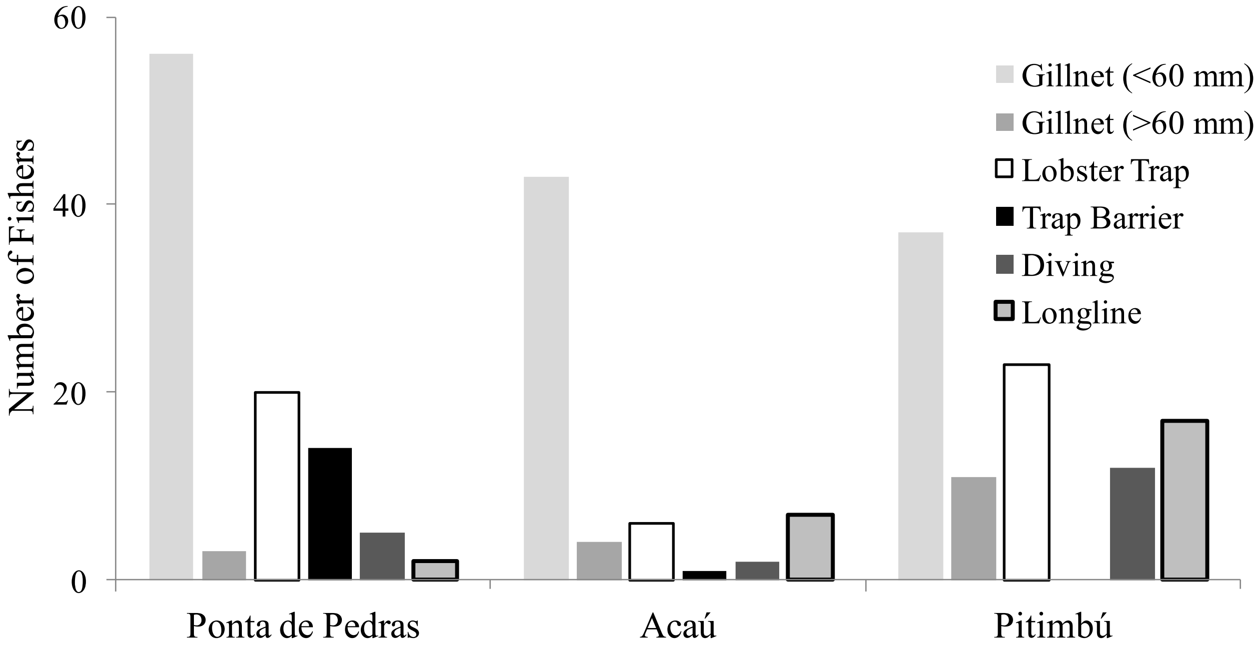
60
40
20
0
Number of Fishers
Gillnet (<60 mm)
Gillnet (>60 mm)
Lobster Trap
Trap Barrier
Diving
Longline
Ponta de Pedras
Acaú
Pitimbú

Fig. 4

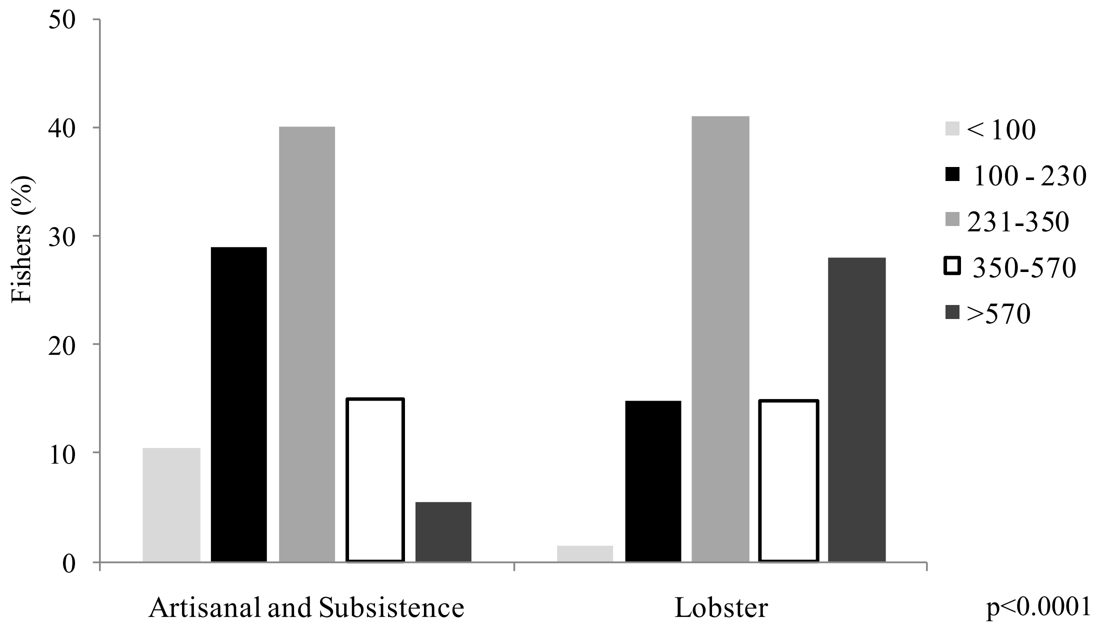
50
40
30
20
10
0
Fishers (%)
< 100
100 - 230
231-350
350-570
>570
Artisanal and Subsistence
Lobster
p<0.0001

Fig. 5

Table 1: Fishing gears, vessel type used and target species according to the interviews at the three studied villages. Vessels type: 1- sail boat, 2- engine boat with 9 m, 3- engine boat with 12 m, 4- small boat with 2m. Fishing area: E- Estuarine, C- Coastal, D- Deeper waters.

Fishing Gear	**Vessel**	**Target family**	**Fishing Gear Characteristics**					**Interview Villages N (%)**		
			Mesh size/diameter (mm)	set/drift net	sunk/floating	Fishing area	Days at sea	P. Pedras	Acaú	Pitimbú
Gillnet	1	Hemiramphidae	13/13	S	F	E	1	7 (7)		
	1	Penaeidae	25/20	S	F	E/C	1	2 (2)	17 (27)	
	1,2	Mugilidae	35/30	S	F	E/C	1	13 (13)	18 (28.6)	3 (3)
	1, 2, 4	Carangidae	40/40	D	F	E/C	1 to 3	21 (21)	6 (9.6)	16 (16)
	1, 2, 3	Carangidae	50/40	D	F	E/C	1 to 3	1 (1)	4 (6.2)	10 (10)
	1, 2, 4	Carangidae	60/50	D	S	E/C	1 to 3	1 (1)	1 (1.6)	7 (7)
	2, 3	Carangidae	70/60	D	S	C/D	1 to 3	1 (1)		1 (1)
	2, 3	Centropomidae, Sciaenidae	80/70	D	S	C/D	1 to 3			1 (1)
	2, 3	Centropomidae, Sciaenidae	90/80	D	S	C/D	1 to 3			1 (1)
	2, 3	Centropomidae, Sciaenidae	100/90	D	S	C/D	1 to 3			3 (3)
	2, 3	Chondrichthyes	200/200	D	S	C/D	1 to 3			
	No boat	Penaeidae	40/3	S	F	C	1	11 (11)		2 (2)
Trawl net	2	Penaeidae	25/18	S	S	C	1	2 (2)	1 (1.6)	4 (4)
Fixed trap	1, 4	Carangidae	30/35	D	S	E/C	1	14 (14)	1 (1.6)	
Lobster trap	2, 3	Panuliridae/ Mullidae	30/35	D	S	C/D	15 to 20	20 (20)	6 (9.6)	23 (23)
Longline	2, 3	Lutjanidae	_	D	S	D	3 to 20		7 (11)	
Hook	2, 3	Lutjanidae, Scombridae	_	D	S	C/D	1 to 10	2 (2)		17 (17)
Dive	2, 3	Panuliridae/ Octopus	_	_	S	C/D	3 to 10	5 (5)	2 (3.2)	12 (12)

Table 2: Non-target species (sea turtles, rays and dolphins) captured by fishing gears found alive and dead by fishers from studied villages.

Non-target species	Fishing Gears N (%)			
	Gillnet (< 60 mm)	Gillnet (> 60 mm)	Lobster Trap	Trap Barrier
Alive	77 (54)	23 (16)	28 (20)	15 (10)
Dead	20 (44)	17 (37)	8 (17)	1 (2)

p value=0.0127

Capítulo 2

Threats to sea turtle populations in the Western Atlantic: poaching and mortality in small scale fishery gears

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Threats to sea turtle populations in the Western Atlantic: poaching and mortality in small-scale fishery gears

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Running Head: Sea turtles: poaching and mortality in fishery gears

ABSTRACT: Interactions between small-scale fishery activities and sea turtles were investigated in coastal fishers' population of the South and Northeast Brazilian coast, Western Atlantic. Data were collected using semi-structured questionnaires (N=418). The presence of four sea turtle species was confirmed in the studied areas: *Chelonia mydas, Caretta caretta, Eretmochelys imbricata* and *Dermochelys coriacea*. Adults are commonly seen in the water, and nesting females and hatchlings on beaches, especially at the Northeast region. The presence of the three most easily distinguishable ontogenetic phases (hatchlings, juveniles and adults) confirms the importance of the estuaries and adjacent areas for sea turtles feeding, gathering, nesting, growing and resting grounds. Fishing was considered the most important threat to sea turtles (77%). Gillnets with small mesh sizes (<60 mm) more frequently interact with sea turtles (65%), and mortality was mostly related to gillnets with larger mesh sizes (>60 mm) (100%) ($p<0.01$). Although poaching is a cultural habit still practiced by many people, fishers did not openly assume it. In addition, most fishers (82%) ($p<0.01$) do not know that it is possible or how to recover sea turtles drowned in fishing gears. Conservation measures should be adopted by fishers to reduce sea turtle mortality such as monitoring soak gillnets more frequently, avoiding nets with larger mesh sizes and thicker threads, and an awareness campaign to provide recovery procedures for drowning turtles in fishing gears. This would be the basis of the design of desirable mitigation actions enhancing conservation efforts and benefiting marine diversity as a whole.

ADDITIONAL INDEX WORDS: *Coastal population, consumption, bycatch, gillnets, conservation efforts, marine diversity.*

INTRODUCTION

Socio-economic growth and the development of human populations have not been accompanied by solutions to their impacts on the marine environment. Innumerable threats to marine diversity and habitat loss have been identified and, nowadays are discussed and analysed: species in the process of extinction (IUCN, 2012), the spread of debris and contamination in marine environments (Guebert-Bartholo *et al.*, 2011a), the decline of nursery habitats and the increased exploitation of fishery resources (Lewison *et al*., 2004) are only a few. Marine megafauna are mostly pan tropical species (*e.g*. sharks, sea turtles, and cetaceans) and have been hit by all of these impacts.

Marine megafauna, especially sea turtles, have been subject to a high level of incidental captures in various fishery gears around the world (Lewison *et al*., 2004). Small-scale fisheries (artisanal, traditional and subsistence fisheries) encompass a great part of coastal activities, especially in developing countries where are critical for food security and a potential route for poverty alleviation. Moreover, this fishing category is highlighted for contributing half of fish caught for human consumption worldwide, being an important sub-sector of the world fish supply (FAO, 2005).

Sea turtles are distributed in tropical and subtropical oceans and during their life cycle they inhabit the ocean basin, from pelagic to estuarine and coastal waters, according to their life stage and species (Bolten, 2003). Nesting occurs exclusively on tropical sand beaches and oceanic islands. Brazilian coast is known to be an important site for sea turtles growing and nesting (Spotila, 2004). Sea turtle products (meat, eggs and shell) can be easily found, not only in Brazil, but also in Caribbean and Asian countries, where this habit still persists as a black market trade with local and international routes (Peckham *et al*., 2008; Mancini and Koch, 2009).

Research and conservation actions are needed to acquire reliable data on the threats to feeding and nesting areas of sea turtle populations and illegal exploitation. As suggested by Hamann *et al*. (2010), one of the priorities sea turtle research is identifying major causes of fisheries bycatch and evaluating practicable mitigation measures for the problem.

Since the 1950s a drastic sea turtle populations decline has been noted, due to intense exploitation (Spotila, 2004). Currently, all sea turtle species are under risk of extinction (MMA, 2008; IUCN, 2012). Even though sea turtles are protected in Brazil under the law n^{o} 1.522 (19/12/1989) which declared their use and harvest as a crime (law no 9.605, 12/12/1998) (IBAMA, 2012), sea turtle products (e.g. meat, eggs, shell) are still strongly and widely appreciated one generation later.

The knowledge acquired through this study provides new insights in the threats to sea turtles. The objective was to understand the importance of the artisanal fishery activities in sea turtle bycatch, mortality and other potential threats. This study was conducted in two distinct regions from South and Northeast of Brazilian coast in areas with Marine Protected Areas (MPA) and unprotected areas. Moreover, ecological aspects of sea turtles are presented, as perceived by traditional populations.

METHODS

Study site

The areas studied in South Brazil are subtropical environments with patches of Atlantic Rain forest. Estuaries have developed mangrove forests, flooded plains, rivers, sandy beaches and rocky islands surrounding the habitats. The two studied areas from the South region are Paranaguá Estuary, located at Paraná State, which has a patchwork of protected areas (*e.g.* Superagui National Park and the Guaraqueçaba Environmental Protected Area); and the

Babitonga Bay, located at Santa Catarina State, which has no protected areas determined, although estuarine habitats have been recognized as important sites for the fransciscana dolphin (*Pontoporia blainvillei*) (Cremer and Simões-Lopes, 2008) (Fig. 1). In these areas fishery is artisanal and concentrated in the estuary and the continental shelf. The main landings are penaeids and fish from coastal areas.

In the studied area of the Northeast Brazil, a tropical ecocline with inland river basins is located along a humid coast where climatic variations are affected by the rain regime condition. One of the studied areas from the Northeast region is Goiana Estuary, located at Pernambuco State (Fig. 1). A Marine Protected Area was created in 2007 at the Goiana Estuary, classified as an Extractive Reserve (RESEX) (Barletta and Costa, 2009). This type of unit is a population-based unit where the management councils are comprised of representatives from the local population (ICMBio, 2012). The other studied area comprises villages surrounding Traição Bay, located at Paraíba State, which have low urbanized areas with an indigenous reserve (Fig. 1). Fisheries at both Northeast areas are artisanal and estuarine fish species are captured for subsistence. In coastal waters lobster is the most captured and profitable resource. Indication of overexploitation of fish stocks have been pointed as one of the main problems at the Northeast region (Guebert-Bartholo *et al.*, 2011b). The entire study area (South and Northeast) is included as an extremely high biological priority region for conservation in the government plan (MMA, 2008).

Field sampling

The best possible estimate of the number of fishers in each area was made based on the current registers of local fishers associations. Four areas from two regions (Santa Catarina= 440 fishers, Paraná= 340, Pernambuco= 1700, and Paraíba= 1800) were sampled and at each village a minimum of 10% of fisher were interviewed randomly and isolated from the group.

Data were collected in three occasions: September/2009 to February/2010, June/2011 and in August/2011. Semi-structured interviews were done, as informal but guided talks, to active fishers. Questions inquired about where sea turtles were seen, species distribution, ontogenetic phases and possible threats; and fishing gears and its interactions with sea turtles as bycatch. Photographs were shown to fishers to identify the species that occur in the four areas. Fishery gears were categorized according to FAO (2012).

To avoid misinformation, interviews were done with the presence of a prominent local fisher. When the interviewee was obviously hiding or giving false information the interview was discarded later. All the interviews were made by the same person.

Statistical analysis

The Chi-square independent test was used to determine significant differences among the interviewees', with a 5% level of significance (Zar, 1999).

RESULTS

A total of 440 interviews were conducted. Considering that fishers and coastal populations attempt to hide information about illegal consumption and bycatch of sea turtles, due to the law enforcement, 4% of interviews were discarded. A total of 418 valid interviews were analysed: 43 in Santa Catarina State (SC), 33 at Paraná State (PR), 163 at Pernambuco State (PE) and 179 at Paraíba State (PB).

The presence of the four possible species of sea turtles was confirmed in the four sampling areas: *Chelonia mydas, Caretta caretta, Eretmochelys imbricata* and *Dermochelys coriacea*. At least 335 (80%, N=418) fishers could recognize one or more species by their local names. Significant differences were detected among their recognition abilities ($p<0.01$), and *E. imbricata* (hawksbill turtle) was identified by 170 (50%, N=335) fishers as the most common species.

Three hundred and eighty three (92%, N=418) interviewees reported that sea turtles are commonly observed in coastal waters, especially near rockery substrates. At the Northeast area interviewed fishers related the presence of nesting females and hatchlings on the beach (Table 1). The three more distinguishable ontogenetic phases (hatchlings, juveniles and adults) were reported by 243 fishers (58%, N=418), and the juvenile phase was the most frequent (50 – 21%, N=243) compared with the two other phases (Fig. 2).

Seventy-seven percent of fishers (295; N=384) recognized that fishing ($p<0.01$), mainly using gillnets with large mesh sizes (>60 mm), is the most important threat for sea turtles ($p<0.01$) (Fig. 3A, B). Other threats were cited in lower proportions: pollution (57, 15%; N=384), especially from industries and debris; boat collisions (21, 5%; N=384) and poaching (11, 3%; N=384) (Fig. 3A).

Fishery techniques differed among areas ($p<0.01$), although 188 (45%; N=418) fishers use gillnet with small mesh sizes (<60 mm). Considering sea turtle catchability 272 (65%; N=418) interviewed fishers affirmed to capture them incidentally in their fishing gears (Fig. 4). Significant differences were detected in sea turtle catchability among areas ($p<0.01$) where gillnets with small mesh sizes were more frequent (139, 51%; N=272). Other gears presented lower catchability rates: gillnets with larger sizes (>60 mm) (55, 20%; N=272), lobster traps (29, 11%; N=272), trawl nets (14, 5%; N=272). However, sea turtle mortality is strongly related to the use of gillnets with large mesh sizes ($p<0.01$), considering that 55 (100%; N=55) fishers that use them affirmed to haul dead turtles (Fig. 4, 5).

When sea turtles are caught alive 270 (98%; N=274) fishers affirmed to release them back to the sea ($p<0.01$). Whereas, when sea turtles are caught dead (N=167) no significant differences were detected ($p<0.01$); 69 (41%) fishers affirmed eating the meat, especially when other fishery resources are scarce and 98 (59%) affirmed releasing them back into the sea. Significant differences were also detected for turtle poaching (meat consumption) ($p<0.01$). One hundred and fifty-two (37%; N=408) fishers affirmed having eaten turtles in the past, 109 affirmed never having eaten (27%) and 147 (36%) affirmed to still do it, occasionally (Fig. 6). Egg poaching was also confirmed by 52 fishers (13.5%, N=384), although all of them affirmed that this activity was frequent only in the past, not practiced anymore.

Significant differences among areas ($p<0.01$) were detected in answers about recovering sea turtles drowned by fishing gears using cardiopulmonary resuscitation, and 343 (82%; N=418) fishers affirmed not knowing that it is possible or how to do it.

DISCUSSION

In general, no differences were detected between the opinions of the populations from the South and Northeast regions, including Marine Protected Areas (MPA) and the unprotected areas. It was observed that most of interviewed fishers from RESEX Acaú-Goiana (protected area) do not know what a MPA classed as RESEX really is, or for what purpose it was created (ICMBio, 2012). In contradiction, they believe that this new status will give them new opportunities for working and for community development. This MPA was created in order to protect traditional fisher folk livelihoods; especially women who access the resource *Anomalocardia brasiliana* (Mollusca; Bivalvia). The MPA conservation plan was not created yet and community participation in management and decisions is apparently ineffective.

Turtle's female nesting and hatchlings on sand were also reported by fishers, and the presence of the three ontogenetic phases (hatchlings, juveniles and adults) shows the importance of the areas for sea turtle populations as feeding, nesting, resting and growing grounds. The interviewed population could recognize four of the five possible species in the studied areas through photographs. The species *L. olivacea* was not recognized by the population in all areas, although it has been seen stranded at the Northeast coast (*pers.obs.*). The characteristics it shares (*e.g.* colour, size) with other turtle species (*C. mydas*) (Márquez, 1990) may have caused confusion in the identification by the fishers.

In general, fishers know about the endangered status of sea turtles, mostly because they have been extensively used as food resources, especially for coastal population and fishers in the last five hundred years (Spotila, 2004), since the beginning of the Caribbean and South America colonization. In this study a significant awareness and declared importance and need for protection of turtles was observed amongst fishers. It was apparent that the repression of the law enforcement is the main cause of this conservationist opinion. Considering this observation seventy-seven percent (295) of interviewed fishers believe that fishing is the main threat to sea turtles in coastal waters, especially the use of gillnets with large mesh sizes submerged for long periods (up to 12 hours). Other threats were also cited, although in fewer proportions: pollution, poaching and vessel collision.

Pollution is currently an important and alarming threat for marine animals. Fishers cited that the main sources of pollution were debris from big cities and chemical contaminants from plants near the estuaries (cement, aquaculture and sugarcane production), blaming the big centres for this problem. The sources of these pollutants are mostly land based activities (plastic debris from urban areas, agricultural run-off, effluents discarding, chemical contamination from sugarcane plantations and alcohol production) (Barletta and Costa, 2009; Liebezeit *et al.*, 2011). Plastic debris in digestive tracts and entangled in sea turtles can cause injuries and even death (Guebert-Bartholo *et al.*, 2011a). Consequences from debris ingestion are diseases and increased vulnerability to fishing gears and vessel collisions.

Gillnets with small mesh sizes (<60 mm) was the category of fishing gear with highest records of sea turtle entanglement, according to the interviewees, principally because it is the most used fishing gear at the studied areas. Gillnets with larger mesh sizes (>60 mm) were more important in sea turtle death, especially because of the stronger mesh and nylon thread that entangles sea turtles. Differently, smaller mesh size gillnets from which turtles can break out, were not significant on death cases. Gillnets have been shown to cause more damaging impacts to sea turtles and other marine megafauna organisms (rays and mammals) than other gears (Casale *et al*., 2004; Peckham *et al*., 2007; 2008; Alfaro-Shigueto *et al*., 2010) especially due to its non-selective capturing method (Gilman *et al*., 2010).

The actual total catch and mortality of sea turtles described by interviewed fishers is likely to be much higher, due both to the unknown fishery efforts in small-scale fisheries, especially regarding the use of gillnets, and to the misinformation of fishers about sea turtle mortality (Koch *et al*., 2006). This information suggests that small-scale fisheries are causing higher mortality rates than previously thought.

The submergence time of the fishing net is also a determinant factor in sea turtle mortality; especially because when turtles are entangled they may drown, first becoming in comatose and eventually dying. When turtles are in a forced apnea, the routine dive time is shorter than usual and their tolerance is further reduced (Casale *et al*., 2004). The longest dive duration reported in sea turtles ranges from 2 to 5 hours, although the routine dive is between 4 to 56 minutes (Lutcavage and Lutz, 1997). In this study, fishers reported gillnets being submerged (soak gillnets) between 8 and 12 hours, occupying the whole range of depths of coastal areas perpendicular set to the currents, acting as a turtle barrier. Thus, all animals that may be captured will have a high probability of death.

Other fishing gears presented lower bycatch rates. Even though some studies point to shrimp trawl nets as a potential bycatch gear (Wallace *et al.*, 2010), we did not observe the same. In this study, 14 fishers (5.2%, N=272) using shrimp trawl nets reported having captured sea turtles as bycatch, with no death of the animal. Lobster traps and longline also exhibited bycatch rates, although cases of turtle death were rare, principally due to their selective methods of target-species capture.

The interview method for understanding the use and capture of sea turtles by fishing gears is suitable for obtaining general data, such as those about fishers' opinion and, if bycatch rates are important sources of impact (death or comatose cases) on the population. Quantitative/reliable data regarding the number of turtles involved in incidental mortality in fishing gears and strandings on beaches could not be assessed for several reasons. On board observers, for example, are not available to obtain reliable data (CPUE), mainly because the safety conditions are precarious. According to fishers, carcasses were not frequently found on the beaches mainly because currents are responsible for transporting dead animals along the coastal areas, stranding them on other beaches far away from the studied areas.

Activities concerning seismic prospection (for oil/gas) occurred at the Northeast region (PE) coinciding 100% with the sampling period. Abnormal stranding records of turtles were found in a 15 km radius (more than 10 animals per week), according to fishers. These activities could be the cause of these strandings, mostly because after this period sea turtle strandings decreased (*pers. obs.*).

Fishers that captured sea turtles admitted not knowing that it was possible and how to recover sea turtles drowned in fishing gears, releasing the animals into the sea as if they were dead, not considering their possible comatose state. Knowledge of animal safety techniques are especially important when sea turtles are found entangled in fishing gears, especially because when they are comatosed, turtles cannot swim and may therefore be unable to surface to breath (Casale *et al.,* 2004).

Poaching was reported, and was considered a cultural habit kept by traditional population in all world, detected on a community level and consumed during special occasions as a delicacy and a luxury item, largely related to traditional values and cultural factors (Campbell, 2003; Mancini and Koch, 2009). However, few fishers affirmed that a local market continues, where sea turtles products are sold (meat and souvenirs) within the population and for tourists around the region, under special request. Moreover, it must be taken into account that a high percentage of fishers were not being totally accurate, due to fear of law enforcement, regarding turtle harvest and use. Considering this fact, the number of poachers must be greater than previously thought and the illegal trade on these coastal areas may remain an important threat for sea turtles during the juvenile and adult stages, difficulting population recovery and growth (Koch *et al*., 2006). The presence of poaching can also justify the rare reporting of events of stranded turtles in the studied areas. Egg poaching was observed in a lower level, and considered a more usual fact in the past (30 to 50 years ago).

In addition, some of the interviewed fishers affirmed that when a turtle is captured by chance the meat is prepared and eaten, and is considered a welcome bycatch. People that do not eat the meat have prejudice and some of them even believe that sea turtle meat can cause a number of diseases. In fact, the presence of bacteria, parasites and chemical contaminants in sea turtle meat can have serious effects on human health such as renal dysfunctions, gastrointestinal problems, neurotoxicity and even death (Aguirre *et al*., 2006; Senko *et al*., 2010).

Countries such as Asian, African countries and Mexico (Senko *et al*., 2010) also have similar traditional values and sea turtles products are frequently explored keeping an illegal consume and trade. Reasons as the lack of other type of reliable protein are not accepted nowadays, since the last 50 years when the access of meat protein has been easily in most countries and remote population. In Brazil, these products had been considered available and easily accessed for coastal and distant population in the last ten years. Brazilian laws for sea turtle protection are relatively new, when compared to elderly fishers interviewed. It is acceptable that new status, activities and laws take a while to be implanted, but the government agency with all stakeholders are responsible for encouraging the community on leaving these habits.

New options for traditional population should be encouraged, especially those aiming sea turtle protection. Conservation projects as well as tourism management could direct fishers being included in social and educational programmes (Wilson and Tisdell, 2001). These activities could be carried out by the MPA managers and all the stakeholders could participate.

Further information is urgently necessary to understand the importance of estuaries of the South American coast to sea turtle populations and to create practical mitigation measures for sea turtle bycatch, considering that this area is used for different sea turtle species and life stages.

CONCLUSION

Conservation measures should be adopted such as an awareness campaign to provide recovery procedures for drowning turtles in fishing gears to fishers; and the development of measures to decrease sea turtles mortality, such as monitoring soak gillnets every 4 hours. The present study recommends immediate collaboration with fishers in conducting experiments to evaluate possible ways sea turtle could avoid gillnets commonly used in estuarine and coastal regions. Moreover, there are important questions that need to be answered: 1) the time of gillnets submersion in coastal water; 2) the identification of the hot spots of sea turtles catchability; 3) the assessment of the effects of the artisanal fishery in terms of number of catch per unit of effort; 4) the identification of trends in seasonality and catchability of sea turtles; 5) the extent of the local consumption and poaching of sea turtles, as well as the probable contamination indexes of meat that usually is ingested.

The participation of the MPAs on these actions will be essential, creating practical measures and emphasizing useful and necessary laws for conserving the fauna and natural resources. Finally, involving the local people in the correct management of protected areas and natural resources would result in locals actively participating in preservation and provide information necessary to further develop successful conservation plans. These recommendations would enhance conservation efforts and probably reduce sea turtle mortality benefiting estuarine, coastal and marine diversity.

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Figure Captions

Figure 1: The two studied areas. In the South region are located Paranaguá Estuary at Paraná State (PR) and Babitonga Bay at Santa Catarina State (SC). In the Northeast region are located the Goiana Estuary at Pernambuco State (PE) and Traição Bay at Paraíba State (PB). The black points are villages where fishers were interviewed.

Figure 2: Number of fishers that recognized sea turtle ontogenetic phases at the four studied areas. N= 243 fishers interviewed.

Figure 3: Fisher's opinion about the most important threats for sea turtles at the four studied areas (A). When the answer was "Fishing" a new question was made about which was the most dangerous fishery gear for sea turtles (B). N= 384 interviewed fishers.

Figure 4: Number of fishers that use fishing gears and number of fishers that capture sea turtles alive and dead in these gears. The category "Others" group mean dive and line and hook. N= 418 interviewed fishers.

Figure 5: *Chelonia mydas* (green turtle) found stranded and dead entangled in a large mesh size gillnet at Paranaguá Estuary, South Brazil. Source: F. M. Guebert.

Figure 6: Fishers information (%) about the frequency of sea turtle meat ingestion at the four studied areas.

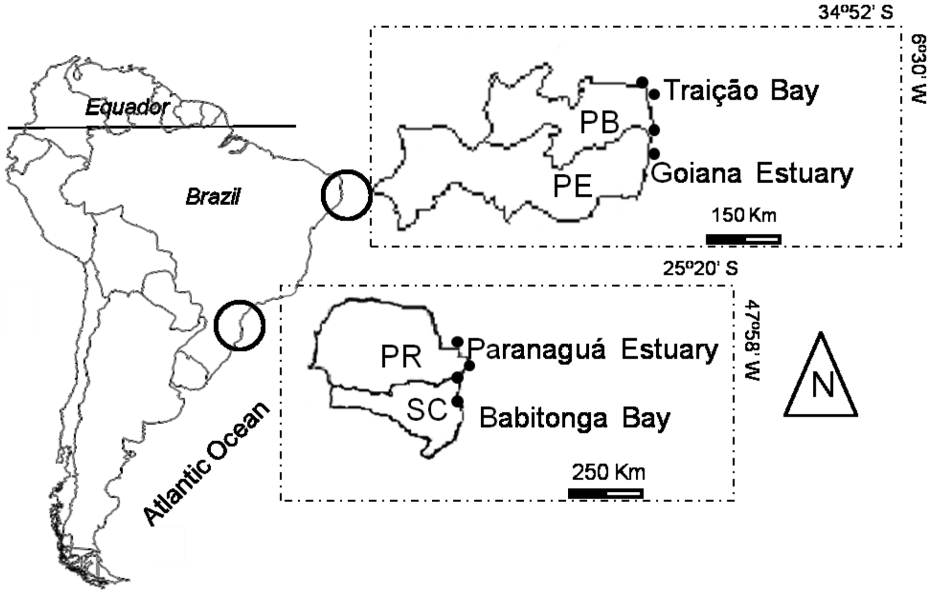
34º52' S
6º30' W
Equador
Brazil
Traição Bay
PB
PE
Goiana Estuary
150 Km
25º20' S
47º58' W
PR
Paranaguá Estuary
SC
Babitonga Bay
250 Km
N
Atlantic Ocean

Fig. 1

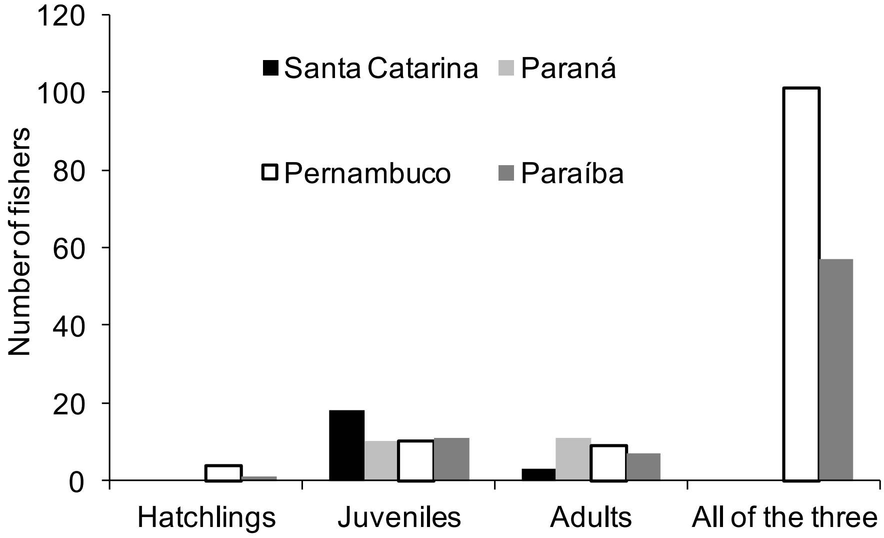
120
100
80
60
40
20
0
Number of fishers
Santa Catarina
Paraná
Pernambuco
Paraíba
Hatchlings
Juveniles
Adults
All of the three

Fig. 2

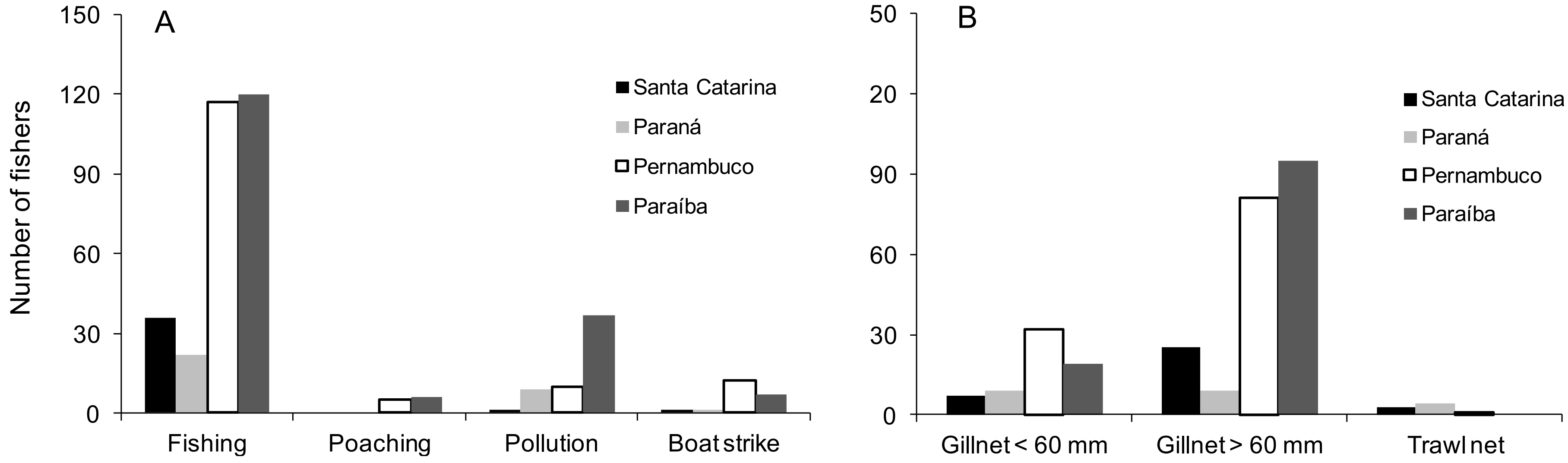
A
Number of fishers
150
120
90
60
30
0
Santa Catarina
Paraná
Pernambuco
Paraíba
Fishing
Poaching
Pollution
Boat strike
B
50
20
90
60
30
0
Santa Catarina
Paraná
Pernambuco
Paraíba
Gillnet < 60 mm
Gillnet > 60 mm
Trawl net

Fig. 3

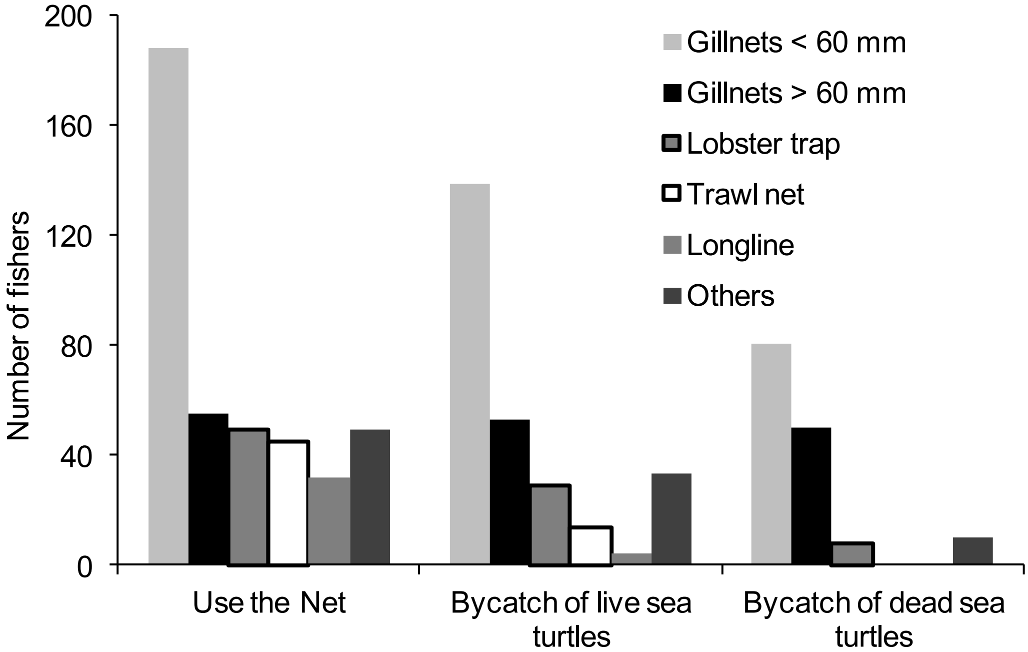
Number of fishers
200
160
120
80
40
0
Gillnets < 60 mm
Gillnets > 60 mm
Lobster trap
Trawl net
Longline
Others
Use the Net
Bycatch of live sea turtles
Bycatch of dead sea turtles

Fig. 4

Fig. 5

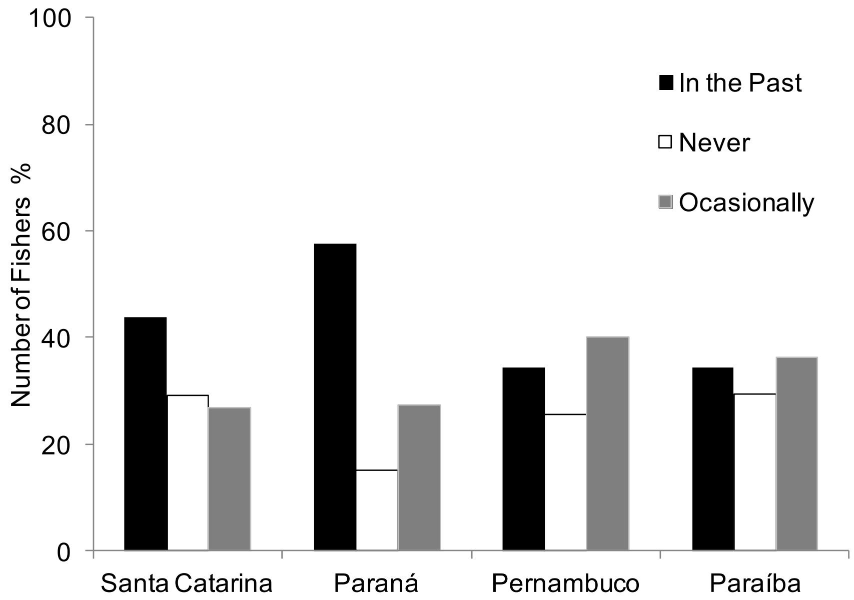
100
80
60
40
20
0
Number of Fishers %
In the Past
Never
Ocasionally
Santa Catarina
Paraná
Pernambuco
Paraíba

Fig. 6

Table 1: Questions presented to fishers regarding observations of sea turtles in water, nesting females and hatchling on sand. NS: non-significant, * p<0.01. N= 418 interviewed fishers.

Questions	N (%)	p
Have already seen a turtle in water	383 (92)	*
Have already seen nesting females	109 (26)	*
Have already seen hatchling in sand	157 (37)	NS

Capítulo 3

The consequence of artisanal fishery activities on sea turtles` population at the Northeast Brazilian Coast: the case of gillnets allowed by legislation

The consequence of artisanal fishery activities on sea turtles` population at the Northeast Brazilian Coast: the case of gillnets allowed by legislation

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Running Head: The consequence of artisanal fishery activities on sea turtles` population.

ABSTRACT: Fishery tools characteristics were assessed in the Northeast coast of Brazil, in an urbanized and traditional villages of indigenous populations area (north), and in a protected area, the RESEX Acaú-Goiana and adjacent villages (south). Fishers affirmed that large mesh size gillnets allowed by the law are the major threat to sea turtles survival. Anchored gillnets with 70 mm mesh size were monitored in adjacent areas of the Goiana Estuary in the dry season, during the day and night periods, for 12 hours near rock points, aiming at sampling the fish community. Ten Families of the fish community were sampled in 16 day-trips, totalling 40 individuals. CPUE values varied from 0 to 0.00061 (mean 0.00017, SE ± 4.43917^{-05}), being higher at night periods. Ephippidae family was the most frequent group of fish represented by the species *Chaetodipterus faber*. Four green turtles (*Chelonia mydas*) classed as juveniles (mean 39.4 SE ± 5.2 cm), were collected as bycatch. External and internal signals of interaction with fishery gears were observed: deep net marks in the neck and flippers indicating the death by strangulation, and the presence of water in the trachea and lungs indicating that they were probably in a comatose stage and swallowed water, dying after that. This research is an initial assessment and characterization of fisheries that interact with sea turtles. Next step is enumerating fisheries management priorities in order to minimize sea turtles bycatch not affecting the socio-economic situation of artisanal fishers' population, depending heavily on enforcement and incentives.

Key-words: Goiana Estuary, Marine Protected Area, bycatch, CPUE, green turtles.

Introduction

Fishery is an important financial activity globally (FAO 2005). It contributes to local income, jobs and play fundamental role in sustainability of a large number of coastal populations in developing countries, especially the artisanal fishery (Allison & Ellis 2001; Guebert-Bartholo et al. 2011a). Currently, a great part of fish stocks are fully exploited, by the industrial and the artisanal fishery, producing catches close to their maximum sustainable limit. As a consequence, not only target species have high catches but also the non-target species are captured as bycatch. This excessive fishing pressure is a growing concern worldwide having profound direct and indirect impacts on the marine environment, causing dramatic ecological changes on coastal ecosystems (Morales-Nin et al. 2010). Added to this, the lack of management and enforcement in fishery industry has been contributing to the environmental imbalance in coastal and oceanic habitats: the incidental captures of non-target species leading them to a threatened status (Fiedler et al. 2012; Lopez-Barrera et al. 2012), fish stock depletion (Bearzi et al. 2006) and habitat degradation (López-Mendilaharsu et al. 2005).

Incidental capture refers to the catchability of marine animals other than the target species for which the fishing gear was set (Lum 2006). Capturing marine megafauna is a common practice, in most cases not intended; however is not a benefiting action for anyone, especially because it negatively impacts local fisheries directly by reducing the productivity of target species, causing bait loss or damaging fishing gears (Silva et al. 2010). Bycatch or the capture of non-important economic resources (unwanted fishes, sharks, rays, sea turtles, birds and marine mammals) has increased in recent years becoming a conservation issue, especially because most of these non-target species are globally endangered (IUCN 2012).

Sea turtles population became vulnerable due to the combination of high incidental capture and its life history (*e.g.*, slow growth, late maturation, long-lived with low rates of population growth). Attempts to correlate fishery activities and sea turtle capture and mortality indicated that juveniles and adult populations are prone to mortality in industrial large-scale fisheries, especially those using bottom-set gear and driftnets (Silvani et al. 1999; Peckham et al. 2007; 2008; Lewison et al. 2009; Fiedler et al. 2012) being captured entangled, in longlines (Gilman et al. 2006; Wallace et al. 2010) and in trawl nets (Tomás et al. 2008; Silva et al. 2010).

Artisanal gillnet fishery is also an important activity in terms of catchability and economic resources in coastal populations. Their use is regulated under the Brazilian laws (MMA 2011), where the smaller sizes are allowed (from 20 to 100 mm of mesh size) and higher mesh sizes (> 120 mm) are forbidden, due to the capture of shark species, marine mammals and turtles. All of these nets are used soak for at least 12 hours (Guebert-Bartholo et al. 2011a) and frequently used in the Northeast coast.

Large mesh size gillnets (>70 mm) target fish families such as Scombridae (*Scomberomorus brasiliensis* and *S. japonicas*), Carangidae (*Caranx latus* and *C. bartholomei*) and Centropomidae (*Centropomus undecimalis*) along the Northeast coast with high economic value (Barletta & Costa 2009). In previous studies, it was observed through interviews to fishers that in some villages of artisanal fishery from Northeast Brazilian coast (Goiana Estuary – Pernambuco/Paraíba in 2009) sea turtles are captured with high frequency by this type of gillnets, 12 hours soak, as allowed by the law (Guebert-Bartholo et al. 2011a). In this context, this paper aimed to report the threats of fishery activities and consequences to sea turtles population, focusing on those gillnets allowed by the law with 70 mm of mesh size.

Material and Methods

Study site

The study area comprises regions from Northeast Coast of Brazil, which have three different status of protection (ICMBio 2012). At the north portion are located an urbanized area and small bays with native American Reserves. The studied areas are Traição Bay, João Pessoa and Pitimbú. The south portion is characterized by the RESEX (Extractive Reserve) Acaú-Goiana around the Goiana Estuary, with an area of ~47 km^2 (Barletta & Costa 2009). The studied areas are the villages Acaú and Ponta de Pedras (Fig. 1). The total area is ~190 km^2 (Fig. 1).

The region is characterized as a tropical area and rainfall patterns are responsible for the major seasonal fluctuations. Four seasons characterize the region: early (March to May) and late rainy (June to August) and early (September to November) and late dry seasons (December to February). Natural resources are explored in different ways. Fishery is described as artisanal and for subsistence (Guebert-Bartholo et al. 2011a) in estuarine and coastal regions. Lobster and octopus are overexploited and are the most profitable resources. Fishery fleet are from two types according to the target species, and the most common are the sail boat used at the south portion and boat with engine (5 and 9 m) at both regions (Guebert-Bartholo et al. 2011a). Land is used for agriculture (farming and sugarcane plantation), aquaculture farms, mining for sand extraction, cement for industry and mangrove woods for fuel (Barletta & Costa 2009). At the south portion a Marine Protected Area (MPA) (RESEX Acaú-Goiana) has been established in 2007, aiming at promoting sustainable practices of marine resources and conservation for traditional populations. The north portion has not any MPA, although traditional populations of native have specific areas for land use.

Data collection

This study was designed in two consecutive steps. Step one involved collecting data with interviews to fishers towards the use of gillnets and interactions with sea turtles. Step two involved monitoring a fishing boat in one fishing season aiming at understanding these interactions with sea turtles.

Interviewing fishers

Semi-structured interviews were conducted as an informal, but guided talk, to fishers between September/2009 and February/2010, and in August/2011, at the North and South areas (Fig. 1). Questions were about fishing activities and interactions with sea turtles in order to quantify whether fishery activity impacts the population of sea turtles. At least 10% of the fishers from each village were interviewed randomly and separately from the group. When a fisher was obviously lying about sea turtles interactions the interview was discarded.

Evaluation of the catchability efficiency of an anchored gillnet

According to previous study about fishing and sea turtles interactions (Guebert-Bartholo et al. 2011a), we monitored one gillnet fishery boat during the dry season from December/2011 to March/2012. This season was chosen due to the water transparency and the higher capture of target families (Scombridae and Carangidae) by fishers. According to the fisher’s activity we could replicate three samples for four months during day and night periods. Fish communities were sampled with gillnets with 70 mm of mesh size, 0.8 mm of twine thickness (70/80), 300 m length and 3.6 m height, monitored at the Goiana adjacent coastal areas (Fig. 1). All gillnets lasted 12 hours soak at 5 to 10 m deep used anchored, always fishing in regions next to rock points and beachrocks, from 1 to 6 miles from the coast. Catch per unit effort (CPUE) was used as an indirect measure of the abundance of the target species. CPUE was calculated based on the data of number of individuals (I), Area (A) and time (t). (eq. 1):

$$\text{CPUE} = \text{Number of Individuals } (tA)^{-1} \quad (1)$$

where (t) is the time of net submergence, and (A) is the Area calculated from:

$$A = Lh \quad (2)$$

where L is the net length and h is the net high.

Statistical analysis

Chi-square independent test was used to determine significant differences in the interviewees' information for fishing tools and sea turtles capture. The test was used with a 5% level of significance (Zar, 1999). ANOVA was used to test differences in fish community among months (December, January, February and March) and periods (day and night). The Levene's test was used to check the homogeneity of the variances. Whenever significant differences were detected the Bonferroni Test was used a posteriori (Quinn & Keough 2002).

Estimation of the bycatch of sea turtles captured in gillnets were made for the role season including the minimum number of boats that operate in the studied areas. This could be done according to the interviews and data about the monitored fishing boat: the number of vessels that used this kind of net in the studied areas. First, we multiplied the observed mean number of turtles caught per boat/per day by the reported minimum number of boats working with the 70 mm gillnet in the two studied areas (North and South), and then by the minimum number of days fished by year (Peckham et al. 2007).

Results

Interviews

In total, 359 fishers were interviewed. However, 5% (17) were discarded because it was detected that this proportion of interviewed fishers attempted to hide information, due to law enforcement. A total of 342 valid interviews were analysed: 179 at the North and 163 at the South areas. A hundred and ninety fishers (55.5%, N= 342) from both areas use gillnets for fishing ($p<0.01$). One hundred and sixty-two fishers from this group use gillnets < 70 mm (47%), where 116 (71%, N= 162) affirmed to capture alive sea turtles, and sixty affirmed to capture dead sea turtles (37%). On the other hand, twenty-eight (8.2%, N= 342) fishers use gillnets > 70 mm, and affirmed to capture sea turtles in both conditions (100%) ($p<0.01$) (Fig. 2).

Gillnet catchability efficiency monitoring

Sixteen fishing days were conducted during four months where forty individuals from ten families of fish and turtles were collected. Capture per unit effort (CPUE) varied from 0 to 0.00061 (mean 0.00017, SE ± 4.43917^{-05}). Significant differences were observed between months and values from captures during the day and night periods, where the captures at night were higher (Fig. 3, Table 1). Ephippidae was the most frequent captured family, represented by the species *Chaetodipterus faber* (Fig. 3; Table 1, 2). In general, higher captures of fish families were during the night (Fig. 3). Other important fish families captured were: Ariidae (*Bagre marinus*, *Arius proops*), Carangidae (*Caranx bartholomei*, *C. latus*, *Trachinotus carolinus*, *Oligoplites saurus*) and Scombridae (*Scomberomorus brasiliensis*) (Fig. 3, Table 2).

Four green turtles (*Chelonia mydas* – Cheloniidae), or 0.25 ± 0.44 turtles/day^{-1} were incidentally captured as bycatch (CPUE= 0.00031). Three of them were collected already dead and one had its death after 12 hours of rehabilitation. Size classes were between 29.5 to 54 cm (mean 39.4, SE ± 5.2 cm), classed as the juvenile phase (Table 3). All of them were captured in rock points.

We estimated minimum seasonal green turtle bycatch based on these four individuals observed on the monitored fishery boat. According to interviews, fishers that use the same type of gillnet (> 70 mm) fish by a minimum of 70 days in the same season (four months - late dry), considering environmental factors. We estimated that in 2011/2012 season at least 300 and 624 marine turtles died in gillnet fishery at North and South areas, with CPUE of 0.0077 and 0.016, respectively (Table 4).

Discussion

This research described the small-scale fishery, with emphasis to the large mesh size gillnets (70 mm or larger), as an important threat for sea turtles conservation, in the Northeast Brazilian coast, already observed in other regions in the world (Hall et al. 2000; Gillman et al. 2010; Hamann et al. 2010; Waugh et al. 2011). Larger gillnets (> 70 mm) are commonly used by a low percentage of fishers of the Northeast Brazil, although its danger is increased by its characteristics. Soak gillnets are nets which act as passive filters that entangle a wide range of organisms, both target and non-target. Commonly used inshore, 5 to 30 m deep, they are used by fishers for 12 to 24 hours soak and anchored with 1 to 4 km of extension targeting Sciaenidae, Centropomidae, Scombridae and Carangidae families. A specific type of gillnet that targets rays and sharks (180 mm of mesh size) is forbidden by the legislation, but used in the studied area, made by fishers. According to them, even though this net is only used by a small percentage of fishers, a high number of dead sea turtles are frequently captured incidentally with this fishing tool (Fiedler et al. 2012). The lack of enforcement and investments in allowed fishing activities are mainly responsible for this problem. Incidental captures of sea turtles in this study were high in comparison to other fishery tools used in the same area pointed by fishers such as lobster traps and trawl nets (11 and 5% of interviewed fisher respectively) (Guebert et al *in press*).

Captured green turtles in the monitored gillnet were juvenile, showing that this size class is the most affected by large mesh size gillnet activities in Goiana adjacent regions. In two cases external evidences of interaction with fishery gears such as deep net marks in the neck and flippers indicating death by strangulation were observed (Fig. 4 and 5). Also, internal signals of interaction with fishery gears were observed in all four individuals, such as the presence of water in the trachea and lungs. These signals indicate that the individuals were probably in a comatose stage because of the capture and swallowed water, dying after that (Table 3). The individual captured in March (54 cm) was highly infected by fibropapilloma tumours also presenting external parasites (leechs and barnacles), low weight, a concave plastron and internal organs in a pallor colour, confirmed by a detailed necropsy. The other three individuals seemed to be healthy with adequate weight.

Considering the analysed data, the frequency of sea turtle interactions with fishing gear depends on the turtles spatial and temporal distribution, the number of individuals of sea turtles and gears, and the type of fishing gear utilized (Peckham et al. 2007; Lewison et al. 2009; Alessandro & Antonello 2010; Wallace et al. 2010). For large-scale fisheries, bycatch rates do not occur randomly across fishing locations where small, persistent areas of high bycatch of sea turtles occur, indicating that certain locations are more likely to result in a bycatch event (Lewison et al. 2009). This condition could be applied to artisanal fisheries at the studied areas, considering that most of the fishers interviewed answered promptly where the main hot spots of turtle bycatch events occur (e.g. sheltered and rock substrate sites), as the monitoring fishing events showed the same. These hot spots are probably important sites for green turtles feeding and resting, especially because this species is herbivorous and eat preferably seagrass and algae (Guebert-Bartholo et al. 2011b), the latter being frequently attached to these structures.

High rates of sea turtles captured in large mesh size gillnets can be observed around the world (Table 5). Moreover, Peckham et al. (2007) estimates that at least 299 loggerheads died in the 2005 season in Baja California. Casale (2008) also suggests that around 16,000 sea turtles have been dead in gillnet fishery in Mediterranean; Pilcher et al (2007) reported 4490 sea turtles dead in 2007 in Malasya and Lazar et al. (2006) pointed until 4,038 sea turtles dead in North Adriatic Sea in 2004. In this study we could estimate that ~900 sea turtles had been dead in 2011/2012 fishing season with gillnets. We must consider that the fishing days are not similar, as the water temperature and winds producing higher or lesser captures.

Recent studies showed that simple alterations in gear configurations can reduce sea turtles bycatch. Avoidance measures for sea turtles have been developed and tested successfully for some modalities of fishing activity (e.g. trawl and longline) (Gillman et al. 2006), which have led to regulated implementation of modified or new fishing gear (Cox et al. 2007). The same has been seen for the use of different baits, hooks, onboard observers, fishers capability and turtle excluder devices (TED) (Watson et al. 2005; Cox et al. 2007), aiming to release sea turtles alive with no injuries. Nevertheless, the effects of fishery gears on sea turtle populations in artisanal (small-scale) fisheries have been overlooked (Koch et al. 2006; Peckham et al. 2007; Alfaro-Shigueto et al. 2010) and are considered a critical knowledge gap that requires detailed assessment (Wallace et al. 2010).

The data collected in this study is an initial assessment and characterization of small-scale gillnets that interact with sea turtles at the Northeast Brazil. A key step in addressing fisheries management priorities is the suggestion of mitigation measures for sea turtles survival. To minimize this impact the gillnet soak time should be reduced, and/or the nets should be revised more frequently, as suggested by other authors that observed the same impact (Gilman et al. 2010; López-Barrera et al. 2012). These measures would facilitate the survival rate of turtles captured with few injuries. Mesh size and twine thickness are also important factors responsible for sea turtles drowning (Alessandro & Antonello 2010), especially because when captured in small gillnets (< 70 mm), green turtles can pass through the nets with no injuries. Although, changing this net design is extremely difficult, especially because these are the main factors that guarantee the high captures of target fish species. In addition, general techniques for turtle handling while onboard and recovering sea turtles drowned are simple and very important measures (Gillman et al. 2010). Another important measure would be changing the fishing points and excluding the hot spots where green turtles are easily captured (near rock points). Moreover, taking into consideration that the area is a Marine Protected Area, managers could create programmes for spatial and temporal restrictions of fishing with large gillnets, especially in locations and periods of high bycatch rates of sea turtles (Gillman et al. 2010).

Fishing effort is an important factor to take into account in considering sea turtles conservation. Reduction of sea turtle bycatch in fisheries worldwide should remain among the top conservation priorities. Effective bycatch mitigation would require actions by stakeholders, scientists and fishers developing new fishing practices, technologies, and agreements with managers and supervisors. Cooperation is essential for bycatch reduction, depending heavily on enforcement and/or incentives, not only on fishers that frequently produce bycatch. When enforcement is low, mitigation effectiveness is also low. Education and outreach are extremely important as a pre and post monitoring of fishery activities. These key ingredients can lead to reduced bycatch of vulnerable species.

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Figure Captions

Figure 1: Map of the study area at the Northeast Brazilian Coast. Fishers were interviewed in villages at the North portion: Traição Bay, João Pessoa and Pitimbú; and the South portion: Acaú and Ponta de Pedras. The native American Reserves, at North, and the Marine Protected Area Resex Acaú-Goiana, at the Goiana Estuary, at South, are indicated. The monitoring fishing activity was conducted at the adjacent coastal areas of the Goiana Estuary (red area).

Figure 2: Number of fishers that use the fishing gears and the number of fishers that capture sea turtles live and dead in these gears. N= 342 interviewed fishers.

Figure 3: Capture per unit effort (CPUE) (mean + SE) of total catch, fish and turtle species: *Chaetodipterus faber*, Ariidae, Carangidae, *Scomberomorus brasiliensis* and *Chelonia mydas*, presented for each sampled month during day and night periods.

Figure 4: *Chelonia mydas.* Dead green turtle captured in January (CCL= 37.5 cm) during the night period. The individual presented a deep mark in the neck as an external sign of interaction with fishery gears (Photo by F.M.G.).

Figure 5: *Chelonia mydas.* Green turtle captured in March (CCL= 54 cm) during the night period. The individual died strangled by the gillnet (Photo by F.M.G.).

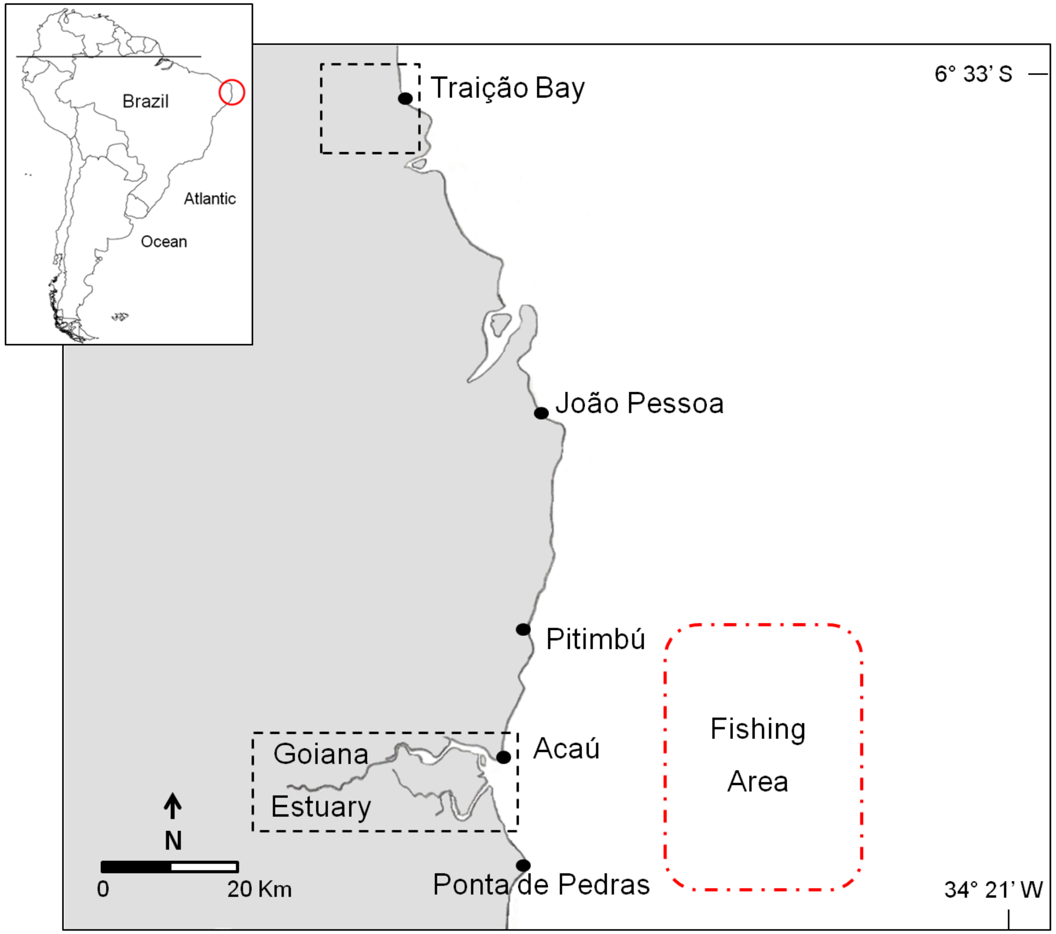
Brazil
Atlantic
Ocean
Traição Bay
6° 33' S
João Pessoa
Pitimbú
Fishing
Area
Goiana
Estuary
Acaú
N
0
20 Km
Ponta de Pedras
34° 21' W

Fig. 1

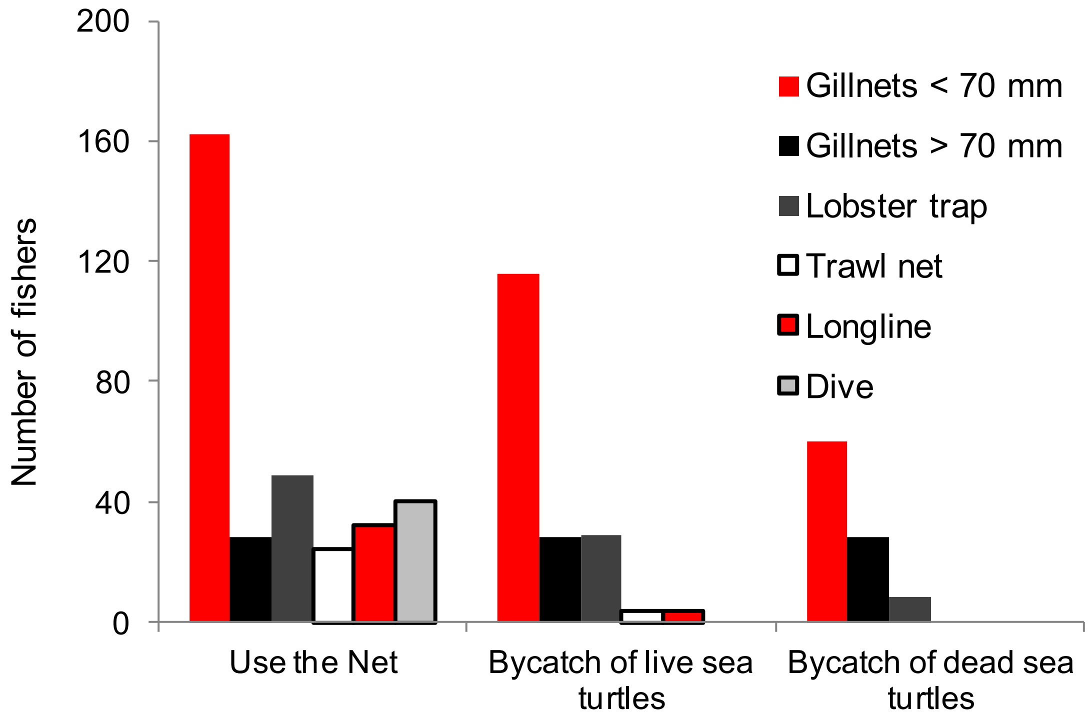
200
160
120
80
40
0
Number of fishers
Gillnets < 70 mm
Gillnets > 70 mm
Lobster trap
Trawl net
Longline
Dive
Use the Net
Bycatch of live sea turtles
Bycatch of dead sea turtles

Fig. 2

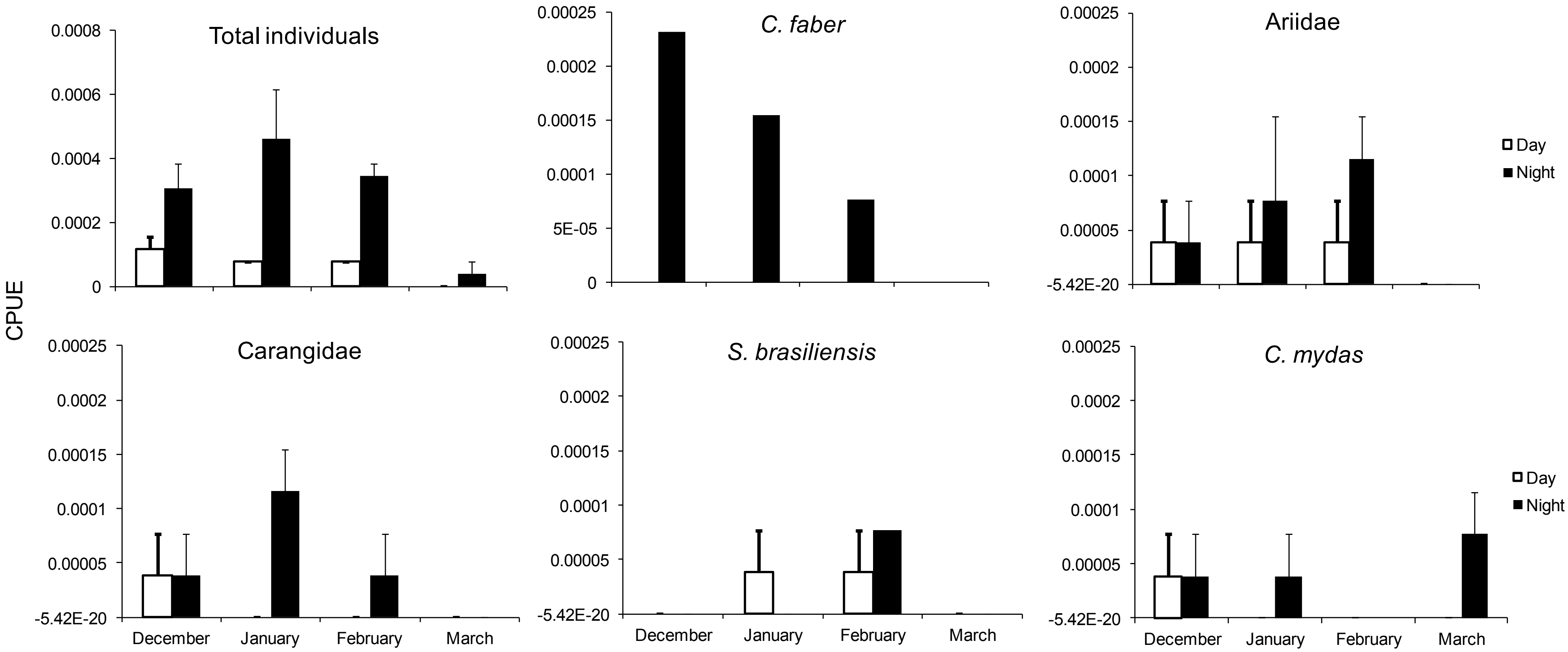
Total individuals
C. faber
Ariidae
Carangidae
S. brasiliensis
C. mydas
CPUE
Day
Night
December
January
February
March
0.0008
0.0006
0.0004
0.0002
0
0.00025
0.0002
0.00015
0.0001
5E-05
0.00005
-5.42E-20

Fig. 3

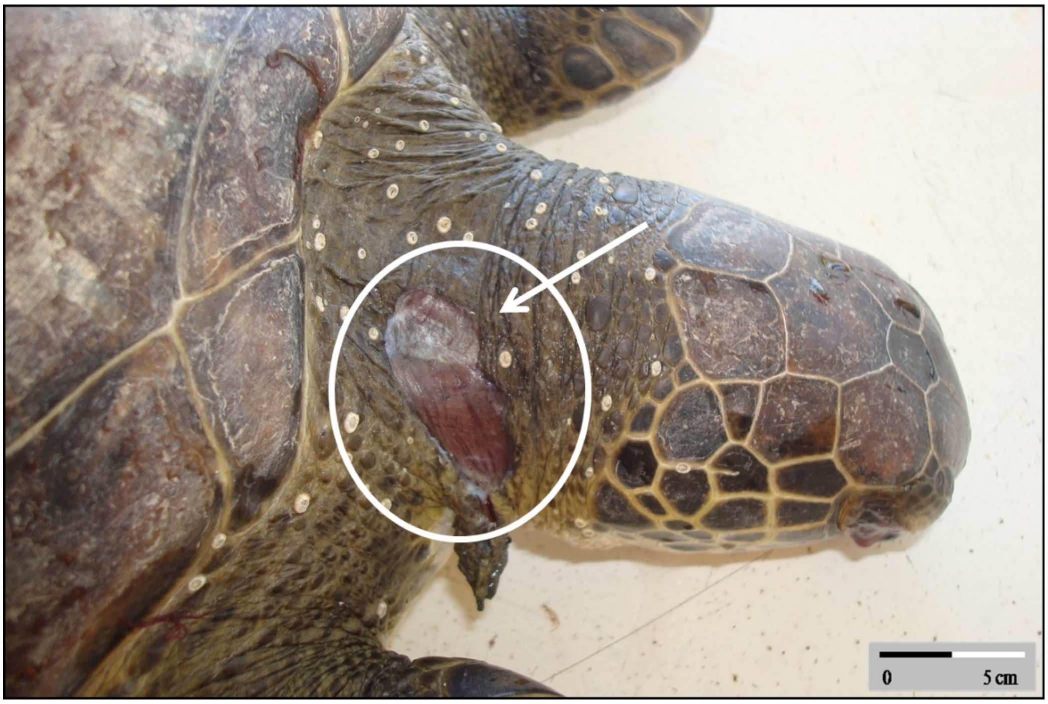

Fig. 4

Fig. 5

Table 1: Summary of the ANOVA for CPUE, total number of individuals and main families captured.

	Source of Variance	
Variables	Months	Period
Total individuals	*	**
Ephippidae	NS	*
Ariidae	NS	NS
Carangidae	NS	NS
Scombridae	NS	NS
Cheloniidae	NS	NS

NS non-significant; * p <0.05; **p <0.01

Table 2: CPUE, Number of individuals, Frequency of Occurrence (FO %), mean and range of standard length (LS) and weight (Wg) of the catch species from the Goiana Estuary adjacent areas collected by the 70 mm anchored gillnet in 16 fishing days.

Species	CPUE	No of individuals	FO (%)	Mean LS (cm)	LS (cm)	Mean Wg (kg)
Chaetodipterus faber	0.00100	13	32.5	18.58	16 - 20	0.4
Acanthurus coeruleus	0.00008	1	2.5	20	20	0.45
Cathorops spixii	0.00008	1	2.5	18	18	0.1
Arius proops	0.00015	2	5	32.8	37 - 51	1.07
Bagre marinus	0.00039	5	12.5	44.33	41 - 51	1.87
Lactophrys bicaudalis	0.00008	1	2.5	42	42	2.2
Caranx latus	0.00015	2	5	45.25	43.5 - 47	2.125
Caranx bartholomei	0.00008	1	2.5	46	46	2.4
Trachinotus carolinus	0.00015	2	5	31.25	30.5 - 32	1
Oligoplites saurus	0.00008	1	2.5	46	46	1.3
Centropomus undecimalis	0.00008	1	2.5	65	65	3.5
Scomberomorus brasiliensis	0.00031	4	10	59.13	51.5 - 63.5	1.97
Anisotremus surinamensis	0.00008	1	2.5	36	36	2
Gerreidae	0.00008	1	2.5	26	26	0.55
Chelonia mydas	0.00031	4	10	39.5	29.5 - 54	7.12
TOTAL	0.00309	40				

Table 3: Characteristics of sea turtles captured during this study: species, weight, curved carapace length (CCL) and width, size class. External and internal signs of interaction with fishery gear were observed; and the characteristics of the bycatch.

	Physical characteristics					Characteristics of the bycatch	
Turtle captured	Weight (kg)	CCL/width (cm)	Size class	External signs	Internal signs	Month	Period
C. mydas	6.5	37 / 34.5	juvenile	No sign	water in airways	December	Day
C. mydas	2.8	29.5 / 28	juvenile	marks in the neck	water in airways	December	Night
C. mydas	6.5	37.5 / 34	juvenile	marks in the neck	water in airways	January	Night
C. mydas	12.7	54 / 47	juvenile	No sign	water in airways	March	Night

Table 4: Estimated seasonal bycatch of green turtles by the anchored gillnets fishery fleet at the two areas (North and South) in the Northeast Brazil presenting 4 four different scenarios according to the number of vessels.

Fishing characteristics	Scenario 1 1 monitored vessel	Scenario 2 1 vessel	Scenario 3 25 vessels (South)	Scenario 4 52 vessels (North)
Day-trips	16	64	64	64
Meters of Net	300	1200	1200	1200
Mean turtles caught	0.25	1	6.25	13
Turtles caught per season	4	17.5	400	832
Turtles caught dead	3	13.15	300	624
CPUE	0.00031	0.00034	0.00772	0.01605

Table 5. Summary of studies of sea turtles incidental captures in gillnets, comparing number of day-trips, turtles caught and the numer of turtles captured per day.

Area	Day-trips	Turtles caught	Turtles/day^{-1}	Author
Baja California	73	11	0.16	Peckham et al. 2007
Baja California	94	28		Peckham et al. 2008
US mid Atlantic	6705	72	0.01	Murray 2009
South Brazil	320	49	0.15	López-Barrera et al. 2011
South Brazil	374	271	0.72	Fiedler et al. 2012
Northeast Brazil	16	4	0.25	This study

Capítulo 4

Monitoring sea turtles strandings as indicators of anthropogenic activities: the case of two Marine Protected Areas in Brazil

Monitoring sea turtles strandings as indicators of anthropogenic activities: the case of two Marine Protected Areas in Brazil

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ABSTRACT: Sea turtles recovered stranded, floating or from interactions with fishing activities were investigated at Paranaguá Estuary, a region within a mosaic of conservation units in the South of Brazil, and at Goiana Estuary, a Marine Protected Area in the Northeast of the country. A total of 194 animals were analysed, 95% of them were dead when stranded and underwent necropsies. Stranding was the most frequent type of sea turtle record, representing 87% of total events examined. Four species were identified: *Chelonia mydas* (179 individuals; 30 to 118 cm CCL), *Caretta caretta* (10 ind.; 37 to 102 cm), *Lepidochelys olivacea* (2 ind.; 63 cm), and *Eretmochelys imbricata* (3 ind.; 35 to 64 cm). Juvenile was the most frequent age group at the South (81%) and adults (> 90 cm) at the Northeast (34%). For 51 individuals, indicators of health and conditioning allowed the possible causes of death to be identified. Bycatch during fishing activities, injuries to the body and malnutrition were the most frequent indicators present. Considering the role of the studied areas for sea turtles foraging, resting and mating, especially for adults at the Northeast, both regions emerge as priority target areas for conservation actions aimed at this animal group. Initiatives next to local fishermen populations are, however, urgently needed. Scientific research using dead

animals should also be encouraged and optimized, especially because this method does not further harm animals and produce results just as good as those using live individuals.
KEY WORDS: green turtle, death causes, *causa mortis*, bycatch.

1. Introduction

Sea turtles are on the IUCN Red List of Threatened Species under different status of danger, according to the species and the distribution area (IUCN, 2012). They display wide areas of occurrence, with a circumglobal distribution in tropical and subtropical oceans (Márquez, 1990). Some populations are recovering under increased official protection (Broderick et al., 2006) from different nations. Green turtle, *Chelonia mydas* (Linnaeus, 1758), is the most frequent species in waters of the Western Atlantic (Spotila, 2004), but is considered *Endangered* since 1982 (IUCN, 2012).

Sea turtles occupy a variety of habitats during the course of their lives, ranging from oceanic to neritic/coastal habits. Since birth, individuals follow routes to oceanic areas where they remain until the juvenile stage, when they move further inwards to coastal and estuarine waters for feeding, resting and growing (Lohman et al., 1996). There, they may remain resident, exploring the available resources and performing minor displacements (Godley et al., 2003). Estuaries and adjacent areas are then extremely important ecosystems, responsible for the balance and maintenance of marine resources used by sea turtles for reproduction, growth, feeding and refuge.

Coastal and estuarine areas are also important sources of anthropogenic impacts to coastal and marine life (Ryan et al., 2009) and, in the last decades, using these areas have become sea turtle's greatest threat (Gregory, 2009). Debris from cities, rivers and beach users (Ryan et al., 2009; Guebert-Bartholo et al., 2011a; Triessnig et al., 2012), deforestation of the Atlantic Rain Forest, soil erosion and degradation (Barletta and Costa, 2009), oil and gas exploitation (Hall et al., 1983; Shigenaka, 2003), chemical contamination by organic and inorganic compounds (Kampalah et al., 2006) and fishermen populations at social risk (Guebert-Bartholo et al., 2011b) are some of the pressures of coastal areas that affect estuarine ecology. Consequently, animals as sea turtles suffer with bycatch (Peckham et al., 2007), poaching (Mancini and Koch, 2009), habitat loss (López-Mendilaharsu et al., 2008) and contact with plastic debris (Guebert-Bartholo et al., 2011a), remaining on the edge of extinction despite public concerns and conservation programs.

Understanding human-animal interactions is primordial for the management of endangered species and to deal with the death of marine organisms. Strandings of dead sea turtles represent an important source of information and different questions concerning their biology, behavior and threats can be answered by close and detailed examination of the carcasses (Casale et al., 2010). Sublethal effects, health conditions and causes of death can be attributed. Specific studies using different tissues can determine chemical contamination (Kampalah et al., 2006; Liebezeit et al., 2011); elemental isotopes and bones analysis can indicate growth (Snover et al., 2007) and diet (Guebert-Bartholo et al., 2011a). These initiatives can help elucidating the persistent puzzle of sea turtles life cycle.

The creation of Marine Protected Areas (MPA) is an important managerial tool to stop (or delay) the unsustainable use of living resources and for conserving biodiversity. This is one of the alternatives for coastal conservation and the preservation of turtle habitat areas under multiple-uses conflict. Turtle habitats are also under the phenomena of *coastal squeeze* and, if not the MPA's priority, monitoring of turtles activities, from nesting to death, can be included as an ancillary actions, aiming not only at the species conservation, but also (and perhaps primarily) as a catch for the public attention towards the other needs and assets of the ecoclines/environments/habitats covered by the MPA's territory.

The present work aimed at identifying stranding patterns of sea turtles in two coastal localities of Brazil where different human activities (ports, tourism, fishing) and protection status (parks, biological reserves, traditional fisherfolk reserves) co-exist. Sea turtles size classes, possible death causes and strandings seasonal patterns are discussed together with the potential implications of anthropogenic pressures for sea turtle survival.

2. Material and Methods

2.1. Study Area

2.1.1 Paranaguá Estuary South Brazil

Paranaguá Estuary (25° 16' to 25° 35' S; 48° 17' to 48° 42' W), has approximately 600 km^2, and is encircled by the one of the last remnants of Atlantic Rainforest (2,071.685 ha). It is considered a Natural World Heritage (UNESCO, 2012) (Fig. 1). Extensive mangrove forests, tidal flats, rocky shores, small patches of seagrass and sandy beaches complete the rainforest-marine ecosystems connectivity, extending for 20 km north and south from the estuary and into the Atlantic Ocean (Noernberg et al., 2004; Sordo et al., 2011). Seasons can be divided according to the rainfall pattern into early (July, August and September) (D1) and late (October, November and December) (D2) dry, and early (January, February and March) (R1) and late (April, May and June) (R2) rainy seasons (Barletta et al., 2008).

Paranaguá Estuary and its adjacent areas are used by artisanal fisheries, port facilities, urban/tourism development (Pierri et al., 2006), sometimes in concurrence with nature conservation. Paranaguá Estuary is included in a mosaic of conservation units, including marine and terrestrial units as a National Park. In this category of MPA the use of natural resources is forbidden, and the area management is made by national authorities. It embraces conservation units of restricted (Superagui National Park, Ecological Stations) and sustainable use (Environmental Protected Area of Guaraqueçaba) (Table 1). The upper reaches of the estuary are relatively better preserved than the lower region. Fishing practices are traditional and in small scale. Fishing grounds are, however, overexploited and fishing efforts are concentrated in the estuary and its adjacent continental shelf (Andriguetto-Filho et al., 2009). The penaeids sea-bob shrimp (*Xiphopenaeus kroyeri*) and white shrimp (*Litopenaeus schimitti*) are the main landings. Among finfish, Serranidae, Sciaenidae and Clupeidae are currently the most important groups. All stocks targeted in this region are presently either overexploited or fully exploited (Haimovici et al., 2006).

2.1.2 Goiana Estuary Northeast Brazil

Goiana Estuary (07° 27' - 07° 36' S; 34° 49' - 34° 55' W) (Fig. 1) has an area of 47 km^2. Habitats within the estuary are sand and mud banks and beaches, flooded plains, small patches of Atlantic Rainforest, mangrove forests and tidal flats. The coastal area is bordered by sandy beaches. The region is tropical, and rainfall patterns are responsible for the major seasonal fluctuations since temperature hardly changes along the year. Four seasons occur: early (March to May) and late (June to August) rainy and early (September to November) and late (December to February) dry seasons (Barletta and Costa, 2009).

The estuary provides different services, mainly fishing. Tourism and agriculture (especially sugarcane) are the main land uses. Mining (sand extraction) and aquaculture farms (shrimp) complete the scenario (Barletta and Costa, 2009). Fishing practices are traditional and in small scale. Boats are simple with very little or primitive technologies. Different gears are used according to the target species (Guebert-Bartholo et al., 2011b). The most exploited living resources by the traditional populations are fish, crustacean (lobster and shrimp) and shellfish (*Anomalocardia brasiliana*) (Barletta and Costa, 2009). Lobster (*Panulirus* sp.) is the most profitable catch. Mugilidae, Sciaenidae, Carangidae and Hemiramphidae are the most important exploited fish families (Guebert-Bartholo et al., 2011b).

The Goiana Estuary is an Extractive Reserve. In this MPA the use of resources is allowed if done in a sustainable way by traditional populations (Table 1). The MPA was created, initially, to protect traditional fishers livelihoods, especially those of women who fish for *Anomalocardia brasiliana* (Mollusca; Bivalvia). The area figures as of high conservation priority both from the biological and social points of view (MMA, 2008). This MPA is characterized by community-based management (ICMBio, 2012). The buffer area of this MPA is still being discussed but it can be as wide as 5 kilometers from its present border. This would extend the beach area under MPA administration in at least the double the present size.

2.2 Field Methods

Strandings were recovered between March 2003 and December 2004 in the South (20 km) and between September 2009 and March 2012 in the Northeast (5 km). Beaches and the estuarine areas were monitored monthly by local agents (totalizing 440 Km at the South and 155 km at the Northeast) who reported back to researchers when a carcass or live animal was found. Stranded and floating sea turtles were recovered and taken to necropsy. Individuals caught as bycatch, both alive and dead, were also recovered from fishers whenever brought ashore and reported. At the laboratory the species was identified (Márquez, 1990), and the measurements taken (curved carapace length CCL and width, cm). Body weight and conditions were examined and systematically noted. Indicators of health or signs that could lead to the identification of the cause of death were external (marks of entanglements by interactions with fishing gears; chemical contamination by tar and oil; fibropapilloma tumours; diseases; skin, flippers and carapace wounds and hematomas) and internal (internal injuries, plastic ingestion and abnormalities). These indicators were used when the stranded dead animals were recovered in the beginning of the decomposition process (in a good condition). When possible, sex was determined according to the sexual dimorphism of the tail.

2.3 Statistical analysis

A Kruskal-Wallis non-parametric test was used to detect significant differences between sea turtle size classes, type of record, indicators of possible cause of death and seasonality of records for the South and Northeast study areas separately. A 5% level of significance was used for all analyses.

3. Results

In total, 194 turtles were used in the present study. At the South area three species occurred: 114 individuals of *Chelonia mydas* ranging from 30 to 100 cm CCL (mean 40.9, SD ± 8.4); 8 *Caretta caretta* ranging from 37 to 92 cm CCL (mean 69.1, SD ± 17.7) and one individual of *Eretmochelys imbricata* with 36 cm CCL (Fig. 2). At the Northeast site four species were recorded: 65 individuals of *C. mydas* ranging from 30 to 118 cm CCL (mean 60.1, SD ± 28.3); 2 *C. caretta* with 94 and 102 cm; 2 *Lepidochelys olivacea* with 63 cm and 2 individuals of *E. imbricata* with 35 and 64 cm (Fig. 2). Significant differences between size classes were detected in the South, where juveniles (30-50 cm) were the most representative group (81%) (Table 2). Adults (> 90 cm) were the main group in the Northeast area (34%) (Fig. 2). Sex could be accurately determined for 50 individuals (26%) in total. In the South, from the 24 individuals sexed 23 were *C. mydas* (1F:1M) and one a female of *C. caretta*. In the Northeast area another 26 individuals being 22 *C. mydas* (1.2M: 1F) (Fig. 3), 2 females of *C. caretta* and 2 females of *L. olivacea* were also sexed.

Considering the kilometres travelled in the whole study, 0.28 turtles/km were recorded at the South and 0.46 turtles/Km at the Northeast regions. The majority of records was of dead sea turtles (95%). Strandings were the most frequent type of record of sea turtles in both South and Northeast areas, representing 87% of total recovery events (Fig. 4, Table 2). Individuals collected floating (8.1%) and as bycatch from fishing activities (6%) represented a small group. In total, 51 individuals (26%) were fresh or in an early stage of decomposition, enabling necropsies and analysis of the indicators of health and diagnosis of the possible causes of death (Fig. 5). One to seven external and internal indicators of poor health, or interactions with fishing gears/boats, were detected in the same individual. Marks from gillnets around the neck and flippers, malnutrition and open wounds were the most frequent indicators (39, 37 and 37%, respectively) (Fig. 6, Table 2). Seven individuals of *C. mydas* were confirmed dead in fishing gears (3 in the South and 4 in the Northeast) because they were handed in by fishers who reported the fact. In two of them no marks or signals of this interaction could be noted. Fishing marks were clearly noted in 19 individuals. Fibropapilloma tumours were present in 2% of the individuals analysed during this study (Fig. 5).

Seasonality of sea turtles carcasses availability through stranding and other forms of recovering was analysed and compared between the South and Northeast sites. Significant differences were detected, and the higher frequency of individuals occurred from July to December at the South (early and late dry seasons - 32% and 44%, respectively) (Table 2). At the Northeast significant differences were detected and the most important season for sea turtles stranding records was between October and March, the late dry season (Fig. 7, Table 2).

4. Discussion

4.1 Species distribution

The Brazilian coast is an important feeding ground for five different species of sea turtles (Marcovaldi and Marcovaldi, 1999). In addition to nesting and hatching along the whole extent of tropical Brazilian beaches, during migrations through shallow and warm waters they feed, rest, grow, and probably mate (Scott et al., 2012). According to the present results it is possible to affirm that both studied regions are important sites for sea turtle populations uses regarding all the above mentioned aspects. At the Northeast, sea turtles were observed at different life stages. Two species (*L. olivacea* and *C. caretta*) were detected in adult stage and one (*C. mydas*) in both small and large juvenile and adult stages. Even though *E. imbricata* was observed only in juvenile and large juvenile stages by strandings, two nests were found in the area in January/2011. The nests were monitored and, when dug, the species *E. imbricata* was confirmed by the examination of stillbirths.

The green turtle was the most frequent species observed at both regions. Small and large juveniles were present, as expected, considering that the Brazilian coastal and shallow waters are well-documented refuges and foraging grounds for this species (Naro-Maciel et al., 2007; Barata et al., 2011). The use of neritic areas of the Northeast by small and large juveniles and adults of green turtles is now confirmed. The availability of food resources, favourable currents and the proximity with preferential nesting sites reinforces this idea (Barata et al., 2011). Adult individuals of green turtles that frequent neritic areas of Brazil are from multiple breeding populations of the Caribbean, French Guyana, Suriname and Ascension Island (Mortimer and Carr, 1987; Lahanas et al., 1998; Lima et al., 2008). In this pool, differential gene patterns from males and females generate a complex population structure that has important implications for sea turtles management and conservation in the tropical Atlantic.

At the South site, the juvenile and large juvenile stages were the most representative indicating that this region is important, especially for green turtles, for resting and growing (Guebert-Bartholo et al., 2011a). The Western Atlantic, including South Brazil, Uruguay and Argentina, is home to young individuals from a common origin in the population structure, with greater contribution from Ascension Island and Suriname (Naro-Maciel et al., 2007; Proietti et al., 2009; Barata et al., 2011).

4.2. Strandings

Stranding was the most representative category for sea turtles carcasses records at both studied areas. As expected, dead individuals were also more frequent. Bycatch and floating were a low proportion of records, although it is clear that the individuals die from different causes, including interactions with fishing gears (Guebert-Bartholo et al., 2011a), before stranding on beaches.

The number of sea turtles washed up on the beaches is probably a small part of the total sea turtles mortality due to anthropogenic impacts and natural causes. Epperly et al. (1996) places this proportion around 7 – 13% of the deaths wash up onto beaches. This is due to varied oceanographic conditions that determine transport through long distances from the actual place of death. Carcasses can also be buried in the sand, intentionally hidden by poachers and scavengers, or remain in the sea (Koch et al., 2006), thus preventing its record and impairing the generation of important data that would contribute to the group's conservation. The absence of strandings from beaches is not a good signal. It does not mean that sea turtles deaths are not occurring, or that they are not dying. Most part of fishers that incidentally capture sea turtles still eat the meat, and throw away the carcass which is then carried by the sea for days or months, until it is unrecognisable.

Strandings is an important type of record to measure sea turtles human impacts, and this is confirmed by others studies along the Brazilian coast. At South region Bugoni et al. (2001) and Silva et al. (2011) recorded 0.051 and 0.12 turtles/Km, respectively. At the Southeast region Bezerra and Bondioli (2011) and Reis et al. (2009) recorded 0.04 and 0.07 turtles/Km, respectively. Comparing these studies with our research we can affirm that at the South (Paranaguá Estuary) and Northeast (Goiana Estuary) regions the stranding patterns are higher (0.28 and 0.46, respectively). This indicates that the mortality at these regions have been more intense, probably due to the bycatch and poaching (especially at the Northeast).

Stranding records are difficult to measure especially because they depend on parameters often unknown such as population mortality rates, interactions with human activities, winds, currents, waves and tides. In addition, their records and calling the researchers to proceed with the recovery and necropsy depend on the level of involvement of the local population and tourists. Being a traditional product that is now legally banned, it can difficult the reporting of the stranding of carcasses by local fishermen. The data obtained in this study do not conform to a scientifically planned sample design because strandings are a random phenomena and carcasses were collected opportunistically. However, sampling and statistical analysis method can be devised taking these conditions into account. Alternatively, these strandings and incidental captures may be treated as subjects of qualitative research, and follow their established criteria.

4.3 Indicators

Sea turtles are endangered in consequences of human interference. The indicators of bad health reflected such interferences in both regions. According to the data of animals captured in fishing gears it is possible to conclude that is not obvious when a turtle dies as bycatch (Casale et al., 2010). Most part of dead animals that strand with no apparent cause of death can be from discarded bycatch. Additionally, three individuals were subject of high level of meat harvest (poaching). Eating the meat and taking the carapace for souvenir is very common, especially in the Northeast (A.S. Alves, *pers. com.*). The probability of more individuals being subject of poaching is high due to the strict environmental regulation. These turtles were probably not actively fished and killed, but incidentally captured as bycatch, and in such case welcomed and used as a food resource (Senko et al., 2010). When the animal is pulled on board in a comatose state it is usually considered dead by the fisher (Casale et al., 2004), who cannot differentiate the two situations. In this case the resource is probably not wasted.

Interaction with fishery activities is by far the most important anthropogenically-driven cause of death at both the Paranaguá Estuary and the RESEX Acaú-Goiana, including the buffer areas. Considering the characteristics of the fishing activities in both regions it can be suggested that gillnets (>60 mm) aimed at the capture of large fish, shark and ray are the main responsible for sea turtles bycatch (Guebert-Bartholo et al., 2011a and b). Death results from drowning by prolonged apnea, and most of them show no external injuries at the necropsy (Casale et al., 2004).

Other indicators were related to bad health and possible sublethal effects that could take the individuals to a poor general condition: fractures in bones, amputations and injuries to flippers, carapace and plastron. These indicators were considered old injuries to the individuals examined, and not necessarily the cause of death. They can be indirect causes by keeping individuals in a lethargic state, facilitation the establishment of epibionts (increased drag), causing malnutrition, difficulty/inability to dive and inflammation of internal organs (Flint et al., 2009). Bycatch could then become the direct cause of death because these individuals were in poor health conditions, and more susceptible to human-related risk factors. Debris ingestion was not observed in this study. However, we cannot affirm that these animals did not eat debris, especially because in some cases of strandings vultures can find the carcasses before and start eating the intestine portion of the individuals, where the debris accumulate (Guebert-Bartholo et al., 2011a).

Chemical contamination was observed at the South after the accident with the Chilean ship *Vicuña*, which exploded after an oil and methanol spill (MMA, 2005) in November 15th, 2004 (Guebert et al., 2005). At the time animals from different groups (*e.g.* marine birds, sea turtles, and dolphins) were recovered both alive and dead. The main indicators of chemical contamination in sea turtles were hematomas, tar on the carapace and flippers, and burns (Shigenaka, 2003). These individuals did not present other indicators. They seemed to be healthy until the contact with oil pollution. Probably, this intense contamination (coating, burning, suffocation) could be the cause of death.

4.4 Seasonality

Sea turtle stranding records were more frequent during the dry season both in the South (July to December) and Northeast (January to March) study areas. This is when the fishing activity is most efficient in both regions since this period is related to the seasonality of the fish stock, deploying large gillnets (>60 mm), the ones that most interact with sea turtles (Guebert-Bartholo et al., 2011b) resulting in a comatose state and death (Casale et al., 2004). The dry season at the Northeast area is also when most of the tourist activity takes place. Tourist activity in the south region lasts from December to March, when it is the rainy season there. The high incidence of sea turtles strandings in late dry season at the South was also caused by the ship's explosion in middle November 2004.

4.5 Marine Protected Areas

Currently, terrestrial MPAs generally have more efficient law enforcement and management than marine ones. Marine MPAs, or the aquatic parts of them, are more vulnerable to the numerous human impacts (Scott et al., 2012). In a MPA the threats to marine fauna should be lower and environmental quality higher. Foraging adult and juvenile green turtles are found in association with MPA's territories more often than expected by chance (Scott et al., 2012). The reason is probably the relatively larger abundance of resources and lower threats. In the studied areas, even though there is a differentiated protected status, human impacts are intense and diverse. No differences in anthropogenic impacts were observed between the studied areas, both included in MPAs and suffering intense human activities. Both studied areas have important coastal habitats for green turtles (mangrove and shallow waters) and feeding resources (algae and seagrass) although human impacts remain high years-decades after the delimitation of the MPAs as a result of slow or missing administrative actions to implement the new protection status.

Considering that the studied areas are foraging, resting and mating grounds for sea turtles, the regions must be conservation targets. Large marine vertebrates face higher risks from anthropogenic impacts in foraging habitats (coastal areas). The sort of indicators and damage recorded in sea turtles strandings can point towards the most necessary action to be taken in the MPA territory and buffer area. Therefore, conservation efforts at these regions using sentinel organisms are a valuable tool for protecting the whole ecosystem. Sea turtles show high fidelity to foraging grounds and remain there for extended periods (2 – 7 years) (Tröeng and Chaloupka, 2007), fulfilling a basic requirement to be elected meaningful sentinels of their habitats. On the other hand, large animals such as sea turtles also have huge home ranges moving to distant regions for long periods in a period of life. This should also be considered when creating MPAs, taking into account buffer regions with conservation status.

Hot spots of sea turtles occurrence (as determined by all sorts of use) must be valued by MPAs managing authorities and count for a differentiated territorial status, special managerial systems and strong law enforcement. Fishing nets for sharks and rays could be restricted for specific areas and seasons, preserving not only sea turtles but also other organisms captured as bycatch (e.g. dolphins and penguins at South).

The value of live animals needs to be scientifically calculated, clearly explained to local populations and taken into account, by managerial authorities, especially MPAs governing bodies. Integration of strandings monitoring into MPA's routines can cause a positive externality in the effects of the MPA (objectives vs. outcomes). Sea turtles are charismatic and their influence in conservation policies can be a strong appeal to mobilize staff, public and even the scientific community towards the role of the MPA. The potential of tourism development based on sea turtle watching by scuba dive at the Northeast study site is feasible. The warm and clear waters and the beachrocks near the coast (~2 km) have high biodiversity and constitute a strong asset for recreational divers. This action could contribute for the new activities portfolio that needs to be built aiming at the sustainability of local populations of fishers (Tisdel and Wilson, 2002). The correct valuing of live animals would also modify the way coastal populations look at sea turtles, not considering them uniquely as food resource anymore, but especially as an attractive for other stakeholders as the general public, volunteers and scientists. The value of live specimens may compensate killing them, not only because of the effort and risk of fishing a turtle but also for having a more balanced ecosystem.

5. Conclusion

Many estuaries are no longer viable habitats for any of the ordinary turtle uses. Although poaching has been reduced through repression and conservations awareness and actions are spread all over, strandings seem to increase. This is probably due to a number of positive and negative factors as increased records (due to increasing coastal population), habitat loss (beach environment occupation), and decreasing food resources availability. However, the regions studied are still important sites for sea turtles foraging in all life stages for at least four of the five species occurring in Brazilian waters. As probably are all coastal MPAs.

These results confirm previous concerns about the high level of anthropogenic participation in the mortality rates of sea turtles in Brazil. Sea turtle strandings, especially derived from bycatch, is not a local peculiarly issue but occurs in different and distant regions, with distinct realities and protection status. Local resident's attitudes are important elements in sea turtles conservation, especially in areas where poaching and bycatch are documented. Sea turtles are charismatic marine megafauna being especially attractive for ecotourism, educational and scientific initiatives involving local communities. In this way, their monitoring should be included in the activities of every MPA where they occur. The signalling of strandings, nests or hatchlings and live animals in the water are simple measures that can be taken by the local community provided they are engaged in the MPA objectives.

Scientific research is necessary for the advance of the knowledge on sea turtles biology, ecology and conservation. To utilize the material available on beaches and accidentally caught by fishermen has been, and will always remain, paramount in this task. It does not harm live animals and produce results as good as those with live individuals, being also complimentary to them. However, the dead or dying individuals are a precious resource and must be treated as such. Effectively monitoring beaches and counting on the local population's collaboration to guarantee the recovering and better use of as many carcasses as possible can make a difference in the understanding of the use sea turtles give to each area. Especially in officially designated MPAs, this type of activity will further guarantee the role of that territory in the conservation of sea turtles.

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FIGURE CAPTIONS

Fig. 1. Goiana Estuary and adjacent areas at the Northeast and Paranaguá Estuary and adjacent areas at the South of Brazil. The Goiana Estuary is part of the RESEX Acaú – Goiana. Mangrove forests are shaded in both areas. *Aq:* Aquaculture ponds; *Sc*: Sugarcane production; *Pf*: Port facilities; *Af*: Atlantic Rain forest. ES: Ecological Station; NP: National Park; AI: Area of Relevant Ecological Interest; PR: Private Natural Reserve; EA: Environmental Protected Area; ER: Extractive Reserve.

Fig. 2. Number of individuals (mean + SE) recovered in South and Northeast Brazil classified by size classes and species.

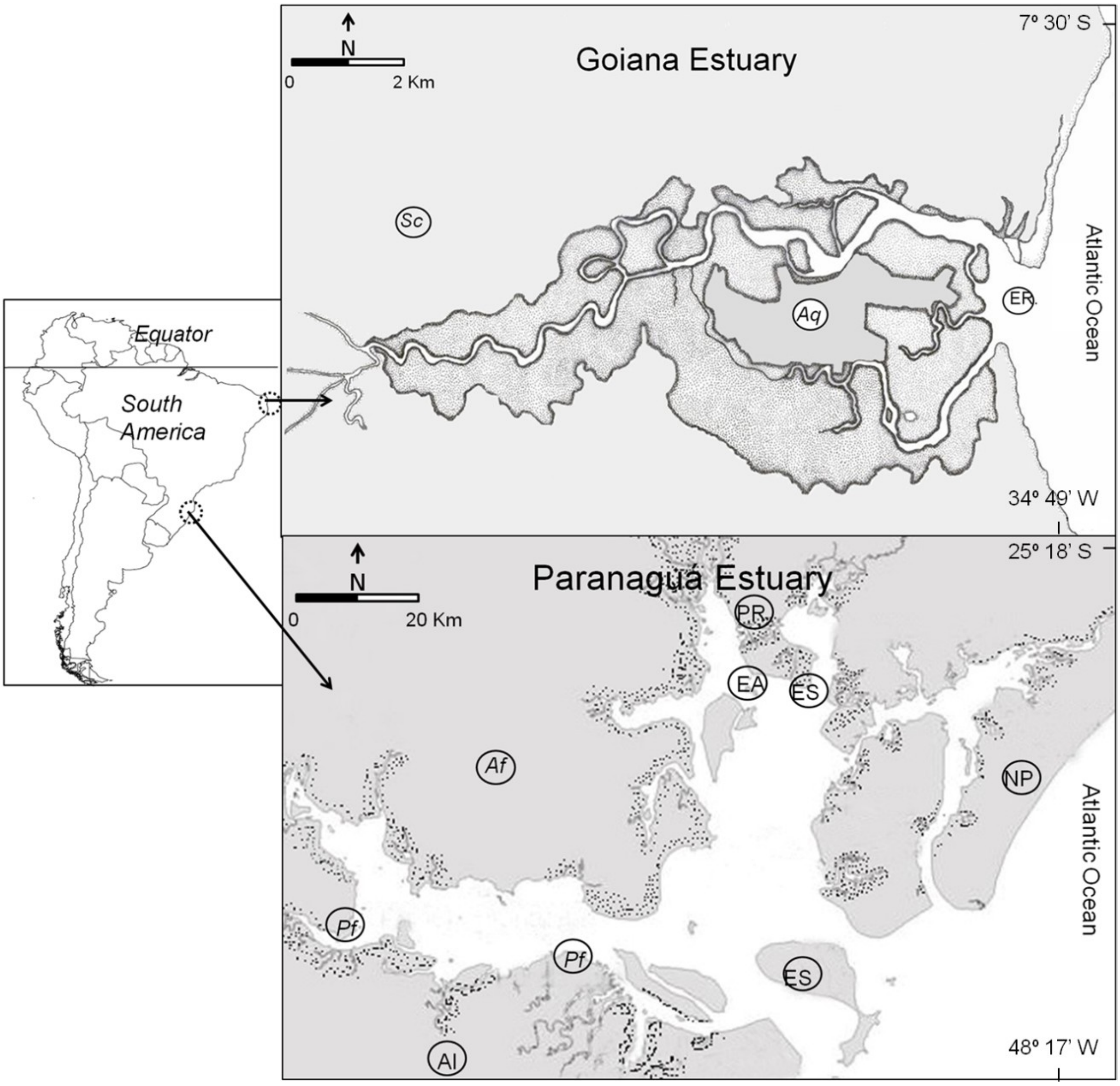
Fig. 3. *Chelonia mydas*, (a) An adult female and (b) an adult male both found dead on the beach at the Northeast study area. Photo by F.M.G.

Fig. 4. Number of individuals (mean + SE) of sea turtles carcasses recovered at the South and Northeast of Brazil, as strandings, floating or bycatch (dead and alive).

Fig. 5. *Chelonia mydas*. (a) Dead individual from fishing activities with a mark in the neck. (b) Dead individual from fishing activities with fibropapilloma tumours. Both from the Northeast study area. Photo by F.M.G.

Fig. 6. Number of individuals (mean + SE) recovered in South and Northeast of Brazil and the indicators of bad health and possible causes of death. FM: Fishing gear Marks; CC Chemical Contamination; In: Injuries and wounds; Po: Poaching; BF: Bone Fracture; Mn: Malnutrition; FT: Fibropapiloma Tumours.

Fig. 7. Number of individuals (mean + SE) recovered in South and Northeast of Brazil and the seasonality of occurrence of the carcasses per season: January to March, April to June, July to September, and October to December.



Goiana Estuary
N
0
2 Km
7º 30' S
Sc
Aq
ER
Atlantic Ocean
34º 49' W
Equator
South
America
Paranaguá Estuary
N
0
20 Km
25º 18' S
PR
EA
ES
Af
NP
Atlantic Ocean
Pf
Pf
ES
Al
48º 17' W

Fig. 1.

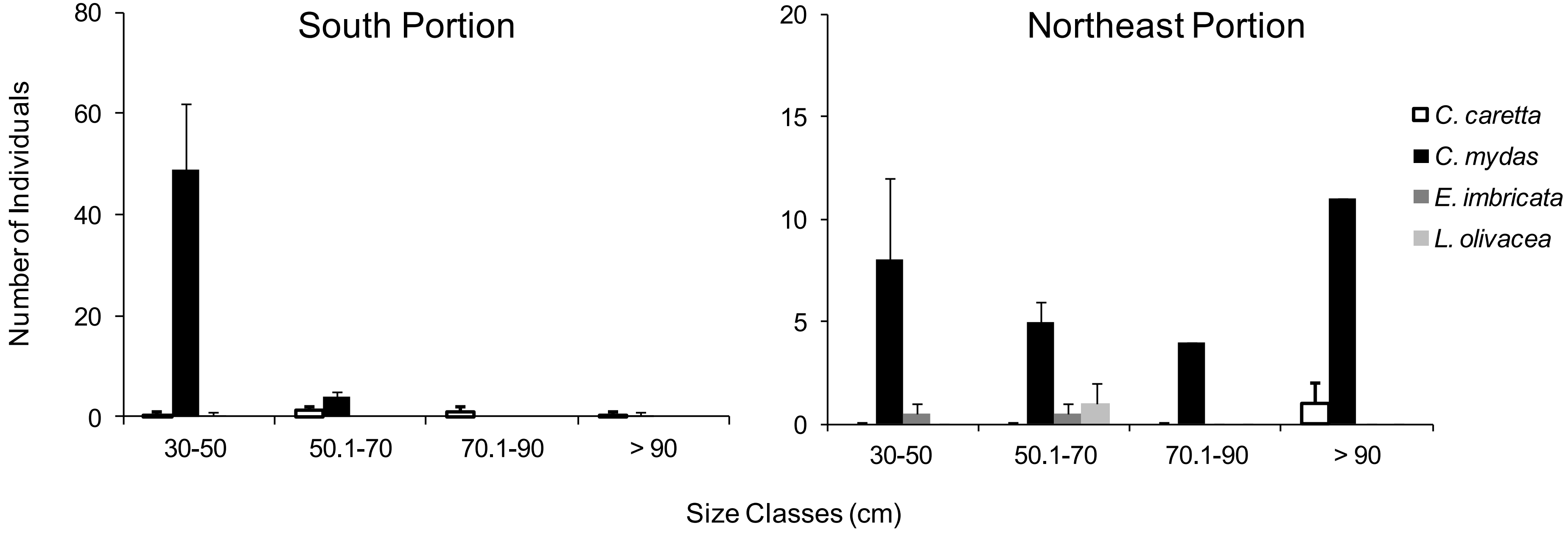

South Portion
Northeast Portion
Number of Individuals
80
60
40
20
0
20
15
10
5
0
30-50
50.1-70
70.1-90
> 90
C. caretta
C. mydas
E. imbricata
L. olivacea
Size Classes (cm)

Fig. 2.

Fig. 3.

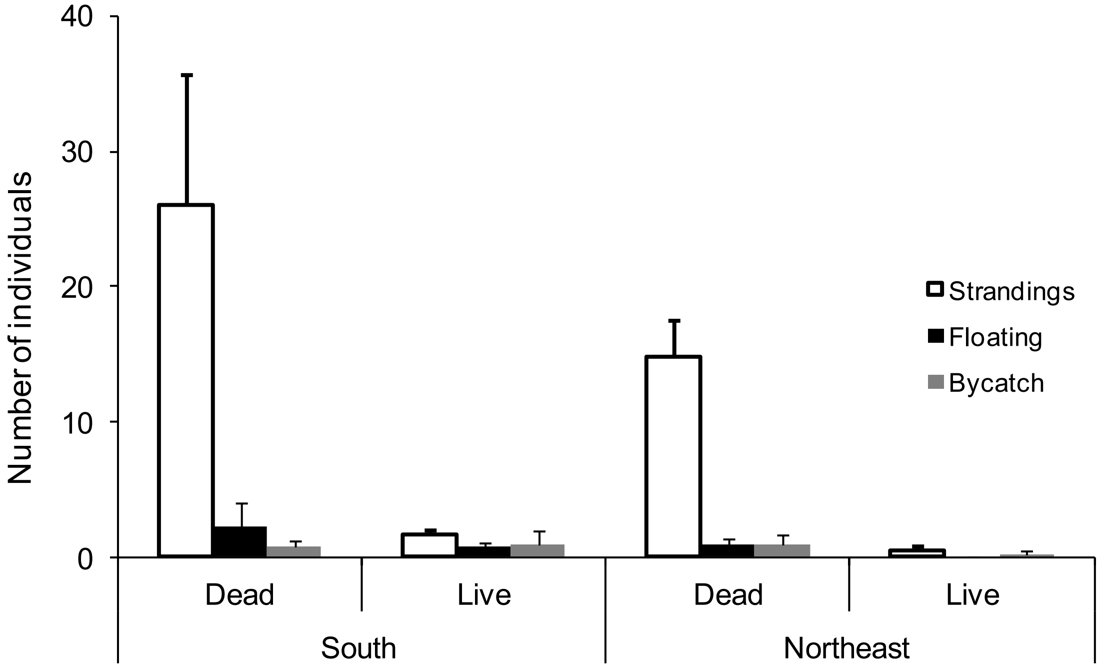

40
30
20
10
0
Number of individuals
Strandings
Floating
Bycatch
Dead
Live
Dead
Live
South
Northeast

Fig. 4.

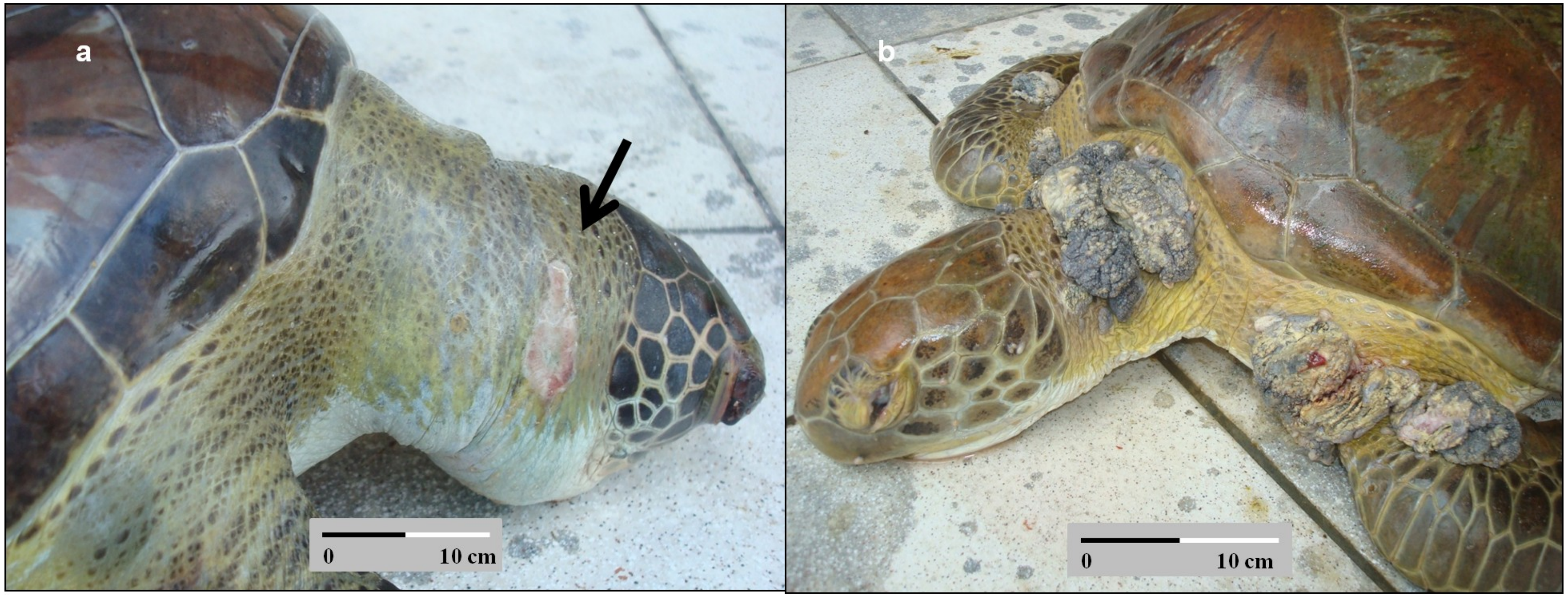


Fig. 5.

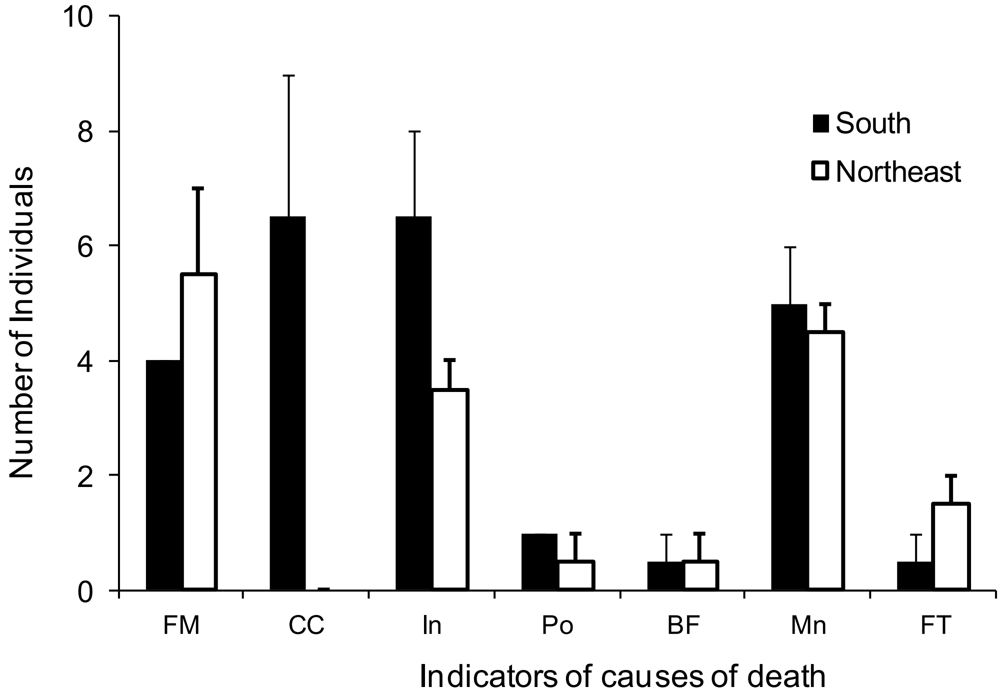

10
8
6
4
2
0
Number of Individuals
South
Northeast
FM
CC
In
Po
BF
Mn
FT
Indicators of causes of death

Fig. 6.

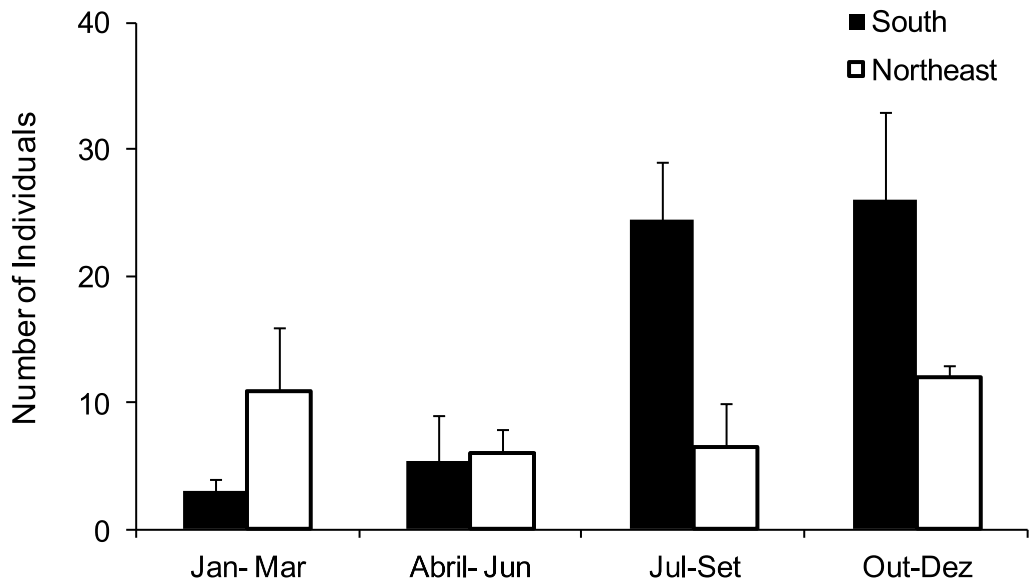

South
Northeast
Number of Individuals
0
10
20
30
40
Jan- Mar
Abril- Jun
Jul-Set
Out-Dez

Fig. 7

Table 1: Classification and characteristics of Marine Protected Areas at the two studied areas.

Characteristics	Paranaguá Estuary					Goiana Estuary
	Ecological Station (ES) Ilha do Mel Guaraqueçaba	**National Park (NP) Superagui**	**Area of Relevant Ecological Interest (AI) Ilhas do Pinheiro e Pinheirinho**	**Private Natural Reserve (PR) Many**	**Environmental Protected Area (EA) Guaraqueçaba**	**Extractive Reserve (ER) Acaú-Goiana (1)**
How many	2	1	1	8	1	1
Total area (km^2)	160	340	1.1	120	3100	67
Responsibility	Federal	Federal	Federal	Private	Federal	Federal
Objectives	Research	Research and education	conservation of regional significance, areas with low occupation	research, education and ecotourism	land use, areas with consolidated occupation	protection of livelihoods of traditional community and sustainable use
Creation process	government	government	government	particular	government	community
Land tenure	public	public	public and private	private	public and private	public and community
Residents	no	no	yes	yes	yes	yes, traditional populations
Government compensation	yes	yes	not mandatory	no	not mandatory	yes
Management council	consulting	consulting	consulting	does not exist	consulting	deliberating
Management	management plan approved, published by the management agency	management plan approved, published by the management agency	management plan	management plan	management plan	management plan
Research	requires prior approval of management agency	requires prior approval of management agency	requires approval	-	-	requires approval
Habitats potentially used by sea turtles	estuarine, coastal	coastal	estuarine, coastal	estuarine	estuarine	estuarine, coastal

Table 2: Summary of the Kruskal–Wallis test results of sea turtles distribution according to size classes, type of record, indicators of causes of death and seasonality (months) in both South and Northeast. Degrees of Freedom are represented by DF, p-value by p.

Variables		Kruskal-Wallis Test		
		DF	H	p
South	Size Classes	3	3.97	*
	Type of Register	2	3.85	*
	Indicators	6	6.64	ns
	Months	3	9.75	*
Northeast	Size Classes	3	6.53	ns
	Type of Register	2	3.97	*
	Indicators	6	10.33	ns
	Months	3	8.85	*

NS, non-significant ($p > 0.05$); * $p < 0.05$

Conclusões

Conclusões

Os objetivos propostos neste estudo foram alcançados. Os métodos amostrais se mostraram eficazes de acordo com seus objetivos específicos. A utilização das entrevistas como método de obtenção de informações gerais é eficiente; como aqueles sobre a opinião dos pescadores e, fontes de impactos para as populações de tartarugas marinhas. No entanto, não é possivel obter dados quantitativos (ex. número de tartarugas capturadas em redes) através deste método, já que avalia somente a opinião de entrevistados. Para garantir a confiabilidade das respostas este método foi aplicado de maneira a deixar os entrevistados à vontade para responder as questões. Para isso, um pescador local e de confiança do grupo de pesca de cada região entrevistada era solicitado como um guia, estando presente durante as entrevistas e auxiliando em dúvidas dos pescadores. Outra função deste pescador acompanhante era de garantir que as informações obtidas neste estudo fossem verídicas, e no caso de respostas não verídicas as mesmas eram excluídas das análises.

Foi amplamente observada e discutida a urgente necessidade de se criar medidas práticas para aumentar os esforços de conservação e reduzir a mortalidade de tartarugas marinhas em Unidades de Conservação Marinhas (UCs) do Nordeste e Sul do Brasil, envolvendo cientistas, populações tradicionais e os órgãos responsáveis pelas UCs.

Atualmente existem 59 Unidades de Conservação Marinhas Federais no Brasil. Sua criação é de extrema importância para a proteção do patrimônio natural e para a sustentabilidade da economia pesqueira. Estas áreas marinhas protegidas, muitas vezes sob diferentes aspectos de jurisdição e categorias, constituem ferramentas essenciais para a promoção e manutenção da diversidade, compatibilizando a conservação da natureza com a utilização dos recursos naturais; valorizando as funções econômicas e sociais, culturais e ambientais das populações tradicionais. Através de estímulos a alternativas adequadas ao seu uso sustentável é possível garantir a sustentabilidade do estoque pesqueiro e o uso correto e responsável do espaço marinho.

Entre as Unidades de Conservação estudadas está a RESEX Acaú-Goiana, criada recentemente pelo decreto presidencial de 26 de setembro de 2007. A Reserva Extrativista é uma área utilizada por populações tradicionais que devem extrair de modo sustentável os recursos do ambiente. Apesar da RESEX Acaú-Goiana ter sido criada em função de proteger os modos de vida tradicionais, especialmente das mulheres pescadoras que extraem de forma sustentável o recurso *Anomalocardia brasiliana* (Molusca, Bivalve), seu status dá condições para que outras espécies ameaçadas que utilizam a área também possam ser preservadas, como por exemplo, as espécies *Epinephelus itajara* (mero), as cinco espécies de tartarugas marinhas e o mamífero *Trichechus manatus* (peixe-boi-marinho).

Foi possível observar que ambas as áreas integrantes ou não de UCs oferecem refúgio para as espécies de tartarugas marinhas. Também são áreas que, independente de sua classificação, possuem intensa atividade antrópica oferecendo uma diversidade de impactos às tartarugas marinhas e outros organismos ameaçados de extinção. Dessa forma, é possível considerar que as tartarugas reagem de forma rápida e drástica aos impactos antrópicos, podendo ser consideradas organismos sentinelas de ambientes impactados. Também foi possível perceber que as áreas estudadas não diferem quanto à diminuição dos estoques pesqueiros e à condição de pobreza das populações tradicionais pesqueiras. De acordo com as entrevistas realizadas com pescadores, os investimentos na pesca artesanal são escassos. Em muitos casos, somado à perda de habitats costeiros, este fato é o principal responsável pela sobrepesca de recursos, uso indevido de redes de emalhe, e pesca em áreas e épocas não permitidas. É clara a insatisfação das populações pesqueiras com seu modo de vida, o que conduz às famílias a problemas sociais como a pobreza extrema, alcoolismo, e o uso de drogas ilícitas, levando-os a marginalização.

Portanto, podemos afirmar que não existem diferenças entre as áreas inseridas ou não em Unidades de Conservação quanto aos impactos sofridos pelas tartarugas marinhas, sendo que a efetividade das UC's, quanto à proteção das tartarugas marinhas, é baixa. É possível afirmar também que a legislação pesqueira não abrange de forma rígida a proteção das tartarugas, sendo este o principal impacto sofrido por elas atualmente.

Ficou evidente que a captura das tartarugas marinhas em redes de pesca, especialmente as rede de emalhar, é um evento incidental e frequente. No entanto, de acordo com as condições sociais e financeiras das populações pesqueiras, a tartaruga marinha pode se tornar um recurso alimentar substituto, ou mesmo utilizado como iguaria em festas e comemorações. Mesmo assim, seu consumo é admitido por poucas pessoas. A venda da carne e subprodutos pôde ser descrita como um evento comum no passado (década de1970 e 1980), e que hoje não acontece com a mesma frequência. Outro fato relevante é o desconhecimento por parte dos pescadores em reconhecer e recuperar tartarugas marinhas desmaiadas/afogadas nas redes de pesca; além de fazerem uso de petrechos relevantes quanto à mortalidade das mesmas.

Para práticas ilegais como a captura, matança, coleta de ovos, consumo e comércio de produtos e subprodutos de tartarugas marinhas são previstas as sanções e penas na Lei de Crimes Ambientais (Lei nº 9605 de 12 de fevereiro de 1998) e no Decreto nº 3179, de 21 de setembro de 1999. No entanto, são raras as ocasiões em que os órgãos fiscalizadores estão presentes. Quanto à captura em redes de pesca, existem leis federais que regulamentam aspectos específicos, e que em alguns casos as tartarugas marinhas são inseridas.

Recomendações Finais

É de extrema importância unir esforços para uma convivência harmoniosa entre as populações litorâneas pesqueiras e os recursos naturais de subsistência e ameaçados de extinção. Novas opções para as populações de pescadores devem ser encorajadas, especialmente aquelas que visem a proteção das tartarugas marinhas levando em consideração as áreas de abrangência dos animais, e os órgãos de manejo e fiscalização. Diferentes medidas para a conservação das espécies são necessidades urgentes, sendo algumas delas propostas neste estudo:

- ✓ Investimentos na atividade pesqueira (embarcações, portos e mercados locais para pesca);
- ✓ Legislação específica para o uso de redes de emalhe em áreas próximas da costa envolvendo regras para a utilização do tamanho de malha, diminuição do tempo de imersão das redes e áreas e épocas de utilização, evitando áreas próximas de costões rochosos e manguezais e épocas de maior ocorrência das tartarugas marinhas;
- ✓ Proibição e fiscalização do uso indevido das redes de emalhe conhecidas como “arraieiras”, dedicadas à captura de tubarões e raias;
- ✓ Programas de treinamento para pescadores sobre o afogamento de tartarugas em redes de pesca, envolvendo cuidados na coleta dos animais presos nas redes e a massagem cardiorespiratória;
- ✓ Monitoramento frequente de tartarugas marinhas como parte do plano gestor das Unidades de Conservação;
- ✓ Estímulos, por parte dos gestores das Unidades de Conservação, à novas oportunidades para populações pesqueiras envolvendo a preservção de recursos naturais, como por exemplo as atividades de ecoturismo e programas educacionais.

A participação das Unidades de Conservação neste processo é fundamental, esclarecendo, gerenciando atividades e capacitando pessoas para tais processos dentro e no entorno de seus territórios, beneficiando assim a fauna marinha de forma geral.

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APÊNDICE 1

QUESTIONÁRIOS

---**PESCA**---

1) Nº Questionário ________________ Data:_____________________

2) Local:_______________________

3) Idade:_______________________

4) Estudou até que série:___________________________

5) Com quantos anos começou a pescar?______________

6) Realiza outra atividade além da pesca? ( ) Sim ( ) Não

Qual? ____________________________________

7) O que faz com pescado? ( ) Consome ( ) Venda direta ( ) Venda intermediária

8) Qual o tipo de embarcação utilizada? ___________________________________

A quem pertence? ( ) Própria ( ) de Terceiros

9) Quanto fatura com a pesca? __________________________________

10) Em que época trabalha na pesca? ______________________________

11) Qual a espécie alvo nesta época? ____

12) Qual o petrecho utilizado para captura? ______________________________________

13) O que pesca durante o resto do ano? ____

14) Quais os petrechos mais utilizados? ____

15) Quais as áreas de pesca? ( ) Estuário ( ) Rio ( ) Mar

16) Qual a periodicidade de pesca?____

17) Quantas horas pescam por dia? ___________________________

18) Existe a captura de outras espécies não alvo? ( ) Sim ( ) Não

19) Quais? ( ) Raias ( ) Tubarão ( )Botos ( ) Tartarugas

( ) Outras ____

20) Em que tipo de rede é mais comum? ____

21) Em que estado o *Bycatch* é encontrado? ( ) Vivo ( ) Morto ( ) Desmaiado

Quando encontrado vivo, o que é feito? ( ) Solta ( ) Mata ( ) Vende

Quando encontrado morto, o que é feito? ( ) Solta ( ) Come ( ) Vende

Se vende, para quem é? ( ) Turista ( ) Restaurante ( ) Outro ____________

Quais partes são vendidas? ____

Qual o valor do produto? ____

22) Há encomenda de 3^os^ dos produtos derivados? ( ) Sim ( ) Não

23) Em que época ocorre maior captura de Tartarugas? ____

24) Em que local ocorre maior captura de Tartarugas? ____

25) Sabe socorrer uma Tartaruga afogada? ( ) Sim ( ) Não

--**ECOLOGIA**--

26) Já viu Tartarugas marinhas? ( ) Sim ( ) Não

Onde ? ____________________________________

27) Qual é a frequência que avista? ____

28) Quais locais as Tartarugas são avistadas com maior frequência?____

29) Qual a espécie mais frequente? ( ) Cm ( ) Cc ( ) Dc ( ) Ei ( ) Lo

30) Como você nomeia as espécies? ____Cm

_________________________________Cc ________________________________Ei

_________________________________Dc _________________________________Lo

31) Qual o tamanho mais observado? ( ) 1 ( ) 2 ( ) 3 ( ) 4

32) Qual o comportamento mais comum? ( ) Respirar ( ) Boiar

( ) Comer ( ) Descansar ( ) Outro_____________________________

33) O que você acha que pode influenciar a presença das Tartarugas no mar? ( ) Correntes ( ) Transparência da água ( ) Outro __________________________

---**AMEAÇAS**--

34) Em sua opinião, quais as ameaças às Tartarugas Marinhas?

( ) Pesca ( ) Consumo ( )Lixo ( ) Outro___________________________

35) Se você considera a pesca uma ameaça, qual é a rede/petrecho?_____________________

36) Qual sua opinião sobre a quantidade de Tartarugas hoje e há 20 anos? ( ) Aumentou ( ) Diminuiu ( )Está igual

37) Qual sua opinião sobre o consumo de Tartarugas hoje e há 20 anos? ( ) Aumentou ( ) Diminuiu ( )Está igual

38) Existe o consumo de Tartarugas na região? ( ) Sim ( ) Não

Qual parte? ( ) ovos ( ) carne ( ) outros_________________________

39) Você já comeu a carne ou ovos/derivados de Tartarugas? ( ) Sim ( ) Não

40) Qual a frequência que consome? (   ) Passado   (   ) Ocasionalmente   (   ) Nunca

41) Existe a fiscalização sobre estes animais?   (   ) Sim   (   ) Não

---**DESOVA**---

42) Já viu Tartarugas desovando nas praias? (   ) Sim   (   ) Não

43) Onde? ____

44) Há quanto tempo? ____

45) Qual espécie mais frequente? (   ) Cm   (   ) Cc   (   ) Ei   (   ) Dc   (   ) Lo

46) Já viu um ninho de Tartarugas?   (   ) Sim   (   ) Não

47) Onde?____

48) Já viu nascimento de filhotes?   (   ) Sim   (   ) Não

49) Quando? ____

Legendas:

Cm: *Chelonia mydas*

Cc: *Caretta caretta*

Ei: *Eretmochelys imbricata*

Dc: *Dermochelys coriacea*

Lo: *Lepidochelys olivacea*

1: filhotes (0-10 cm)

2: juvenil (11-30 cm)

3: sub-adulto (31-70 cm)

4: adulto (71- 110 cm)

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APÊNDICE 2

Fishery and the use of space in a tropical semi-arid estuarine region of Northeast Brazil: subsistence and overexploitation

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ABSTRACT

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Fishery activities were described in a tropical estuary of the Northeast Coast of Brazil. Semi-structured questionnaires were applied to fishers (N=263) at three villages of the Goiana Estuary. The average individual income was US$ 329 (SE ± 14.83), and at least 17 (7%) interviewees have an income <U$109 / month, which was considered chronic poverty state. Gillnet with small mesh size (<60 mm) was the most cited fishery gear, although other types of fishery gears as trap barriers (seasonally), longline, lobster trap, diving with spear, hook and line are also used. Lobster is the most profitable catch, and 68 (53%) fishers are dedicated to its capture, especially during rainy season. Seasonal closure for recovering the lobster populations is enforced by law during the late dry and early rainy seasons. Despite of this, interviewees frequently admitted to fish for lobster even during the closed season, according to market demands and household needs. Dependent dive for lobster capture is also illegal, but very common. Overexploitation of fish stocks was pointed by all the fishers as the main problem in the region, especially for lobster. These preliminary results emphasize the urgent need of further efforts to collect information about fishery gears, production, catchability and mortality of target and non-target species while providing food and income for coastal communities. Joint State and community supervision of the artisanal fishery is a possible way to reduce the pressure on heavily exploited species whilst ensuring the sustainable use of marine resources along the Northeast Brazilian coast.

ADDITIONAL INDEX WORDS: *gillnet, lobster capture, Goiana Estuary*

INTRODUCTION

Mankind depends on coastal and marine ecosystems in different ways (*e.g.* energy, minerals, aquaculture, transport, tourism and fishing) and these environments are also the natural habitat of fish and invertebrate species used as nursery, foraging, growth, mating and nesting habitats (Barletta and Costa, 2009; Barletta *et al.*, 2010; Saint- Paul and Barletta, 2010). Estuaries are the dependent habitats of most of these processes and animal groups are considered one of the most important aquatic environments for animal life, especially in earlier development stages.

Estuarine fishery is one of the oldest human activities and has been practiced in the Americas since pre-Colombian times. Fishery gears and strategies have been developed according to technological advances, society demands, target species and management techniques. Small-scale fishery (subsistence and artisanal) contributes to the local income, generates an important number of jobs, and plays a fundamental role in the subsistence of a large number of fishing communities in developing countries, including Brazil. This contributes to poverty alleviation and food security where fish is the single most important natural resource. However, most stocks lack information, knowledge about fish species biology and appropriate management have been largely overlooked (Alfaro-Shigueto *et al.*, 2010).

According to Bené (2006) 35 million people worldwide are involved in fishing and fish processing, 80% of those are associated with the small-scale fishery sector. The Brazilian annual fish production in 2007 was 1,072.226 tonnes (t) corresponding to US$ 2 billion, 2% higher than 2006. Extractive marine fishery represents 50% of total fishery production in Brazil and the export of its products is growing, especially for lobster that corresponds to 30% (in US$) of total exportation (Ibama, 2009).

However, recent problems of fishery management such as the increased spatial distribution of fishery effort, degradation of coastal waters and mangrove ecosystems (Saint-Paul and Barletta, 2010), declined catch rates, overexploitation and depletion of some marine resources, and bycatch of non-target species (Guebert-Bartholo *et al.,* 2011) compromise sustainability of species and communities dependent. The creation of Marine Protected Areas (MPAs) has been seen as a contributor to fishery organization and is an increasingly popular strategy for managing fisheries, conserving biodiversity and influencing the quantity and type of benefits to marine ecosystems (*e.g.* abundance and diversity of fishes and the amount caught and associated level of effort required). Although, their impacts on human welfare are poorly understood, even because MPAs affect social and political power of fishers, mainly livelihoods, especially those marginalised and poor which are most dependent on marine resources (Mascia, Claus and Naidoo, 2010).

In Brazil the MPAs status are growing up and five categories are more commonly allocated to marine diversity, and the Extractive Reserve (RESEX) status was recently created in the studied area, characterized by a truly community-based MPA, with power and management decisions being taken at a local level.

Traditional communities of the Northeast Brazilian estuaries depend on the different resources (e.g. fish, crustaceans, shellfishes, mangrove woods) and ecological services (e.g. tourism, transportation); and the increasing of exploration, especially for the non-traditional stakeholders (coconut, sand mining, sugarcane and aquaculture producers), threats biological diversity, traditional livelihoods, culture and values (Barletta and Costa, 2009). Main impacts produce effects in estuarine ecology and productivity: deforestation of the Atlantic Rain Forest and mangroves, soil erosion, effluents discarding, water eutrophication, chemical contamination; most of them are connected to the sugarcane production (Barletta and Costa, 2009).

In this context, this study describes the fishery activities, at small-scale coastal communities of the Brazilian Northeast (tropical semi-arid) comparing protected (1) and non protected (2) areas.

METHODS

The study area comprises the lower Goiana Estuary. The system has an area of 4,700 ha, and ends at the Atlantic Ocean, at the Northeast of Brazil (Barletta and Costa, 2009) (Figure 1). The study area comprises three villages (Ponta de Pedras, Acaú and Pitimbú) of two municipalities. The Acaú-Goiana RESEX was created in 2007 around Goiana Estuary (~ 67 Km^2) and has not been structured until now.

The region is defined as a tropical semi-arid estuary and rainfall patterns are responsible for the major seasonal fluctuations. Four seasons characterize the estuarine region: early (March to May) and late rainy (June to August) and early (September to November) and late dry seasons (December to February). The estuarine region is divided by areas according to the salinity patterns: river; upper, middle and lower estuary and coastal waters (Dantas *et al*., 2010). Fishery at these sites is described as artisanal and some estuarine fish species (catfishes), crustaceans and shellfishes are captured in a sustainable way (Barletta and Costa, 2009).

Data collection was conducted by semi-structured interviews as an informal, but guided talk, to fishers between September/2009 and February/2010, at three villages boarding the Goiana Estuary: Ponta de Pedras (1), Acaú (2) and Pitimbú (3). Questions were separated into 2 groups: (1) *social and economic aspects*, with questions about age, income, education and (2) *fishing activities*, with questions about fishing gears, vessels and fishing areas. The best possible estimate of the number of fishers in each village was made based on the current registers at fishers associations at each village. A minimum of 10% of the fishers from each village were interviewed randomly and separately from the group generally when they were going to or coming from the sea or repairing fishing nets, at the beach. All the interviews were made by the same person.

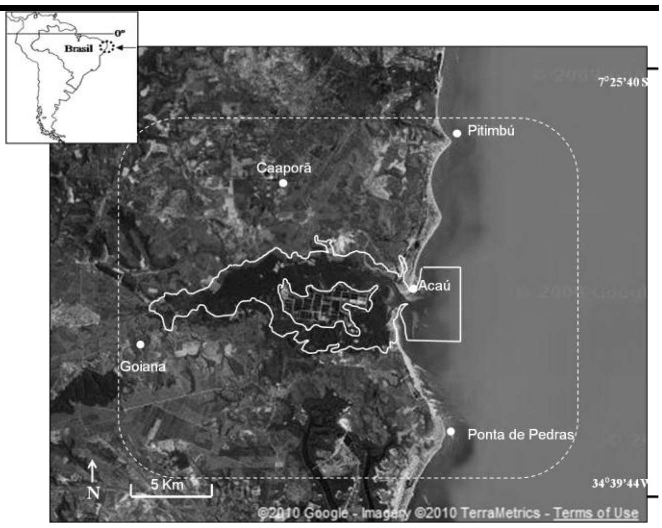

Figure 1. Goiana Estuary and adjacent areas. The RESEX Acaú-Goiana is delimited and the area around is traced. Source: Google Earth and IBAMA.

The Chi-square independent test was used to determine significant differences in the interviewee's information, with a 5% level of significance (Zar, 1999).

RESULTS

A total of 263 interviews were conducted at the three villages. Interviewed fishers were male between 18 and 74 years old. Low level of formal education was detected among fisher (Figure 2).

About 35 (17%) are illiterate. Another 168 (79%) have only 2 to 5 years of formal education. Two hundred and eighteen (88%) interviewees started fishing at an age lower than 15 years, and about 23 (9%) are formally retired by the government (> 65 years old) but still fish as their main activity. Part of interviewees (99, 38%) has a complementary activity working with general services (e.g. construction, seller, boat manager). The average individual income was US$ 329 (SE ± 14.83), and significant differences among villages were detected ($p<0.001$). At least 17 (7%) interviewees have an income lower than US$100 / month.

The fishery fleet showed significant differences among the three villages ($p<0.0001$). Four categories were described, engine boat with 9 m (114 - 43%) and sail boat (87 - 33%) were the most frequently cited (Table 1) (Figure 3). Despite the fact that 96 (42%) interviewed fishers are the boat owners and the other 130 (57%) are employees, no differences were detected between the income of these two categories ($p=0.42$).

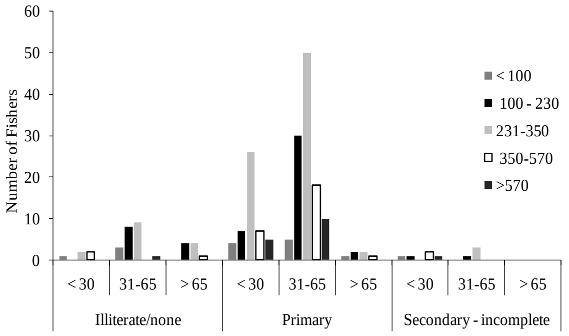

Figure 2. Fishers formal education, age class (<30, 31-65, >65 years) and income of each group (in US$).

Figure 3. Main types of fleet used in the three studied villages: sail boat (A and B), engine boat with 9 m (C).

Fishery gears differed significantly among areas (p<0.0001), and gillnet with small mesh size (<60 mm) was the most cited fishing gear (137 – 52.1%) (Figure 4). This can be used with different fishing strategies (sunk, floating, set or drift net), according to the target species. Moreover, other types of fishery gears are also used: lobster trap (49 – 18.6%), longline (26 – 9.9%), diving with spear (19 – 7.2%), gillnet (>60 mm) (17 – 6.5%) and trap barriers (seasonally) (15 – 5.7%) (Figure 4).

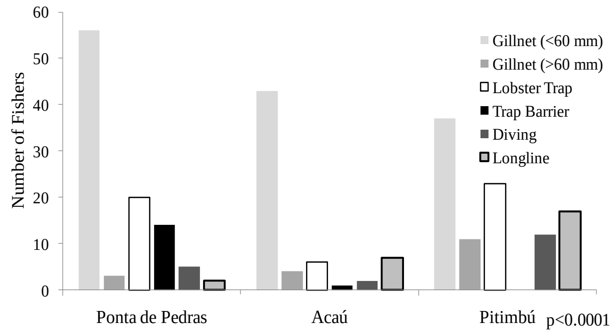

Figure 4. Fishing gears used by fishers at the three studied areas: Ponta de Pedras, Acaú and Pitimbú.

Fisheries are explored according to seasonality and eleven important groups of fish and crustaceans were pointed as the most commonly captured at the Goiana Estuary and adjacent areas: Carangidae, Centropomidae, Hemiramphidae, Lutjanidae, Mugilidae, Sciaenidae, Panuliridae and Penaeidae families (Table 1). In general, fishery activities were significantly related to income (p<0.0001), and subsistence-related species (*e.g.* catfish, cutlassfish) were more frequently captured by fishers with lower income (88, 40%) (Figure 5). Lobster was considered the most profitable catch, and 68 (53%) fishers were dedicated to its capture, especially from May to December (late rainy and early and late dry seasons). Fishers with higher income (>570 US$) are mostly dedicated to lobster fishery (19, 63%). Dependent dive, even being forbidden for lobster capture, is frequently used in the studied villages, and about 31 (62%) fishers dedicated to lobster capture by diving use it. This technique is used even during the closed season and targets other species (octopus, reef fish).

Coastal and deep waters (48% and 50%, respectively) are more frequently explored than the estuarine region (p< 0.0001), especially in Pitimbú (65%) (~70 m), where lobster landings are concentrated. Fishing days out at sea vary from 15 to 20 days for lobster, and 1 to 3 days for other resources, depending on the capacity of the boats ice box (Table 1). Non-target species (sea turtles, dolphins, sharks and rays) are incidentally caught, frequently in gillnets (p<0.0001), and their death was related to the characteristics of the gear (Table 2).

Table 1. Fishing gears, vessel type used and target families according to the interviews at the three studied villages. Vessels type: 1- sail boat, 2- engine boat with 9 m, 3- engine boat with 12 m, 4- small boat with 2 m. Fishing areas: E- Estuarine, C- Coastal, D- Deeper waters.

Fishing Gear	Vessel	Target family	Fishing Gear Characteristics					Interview Villages N (%)		
			Mesh size/diameter (mm)	set/drift net	sunk/floating	Fishing area	Days at sea	P. Pedras	Acaú	Pitimbú
Gillnet	1	Hemiramphidae	2-Dec	S	F	E	1	7 (7)		
	1	Penaeidae	25/2	S	F	E/C	1	2 (2)	17 (27)	
	1,2	Mugilidae	35/3	S	F	E/C	1	13 (13)	18 (28.6)	3 (3)
	1, 2, 4	Carangidae	40/4	D	F	E/C	1 to 3	21 (21)	6 (9.6)	16 (16)
	1, 2, 3	Carangidae	50/4	D	F	E/C	1 to 3	1 (1)	4 (6.2)	10 (10)
	1, 2, 4	Carangidae	60/5	D	S	E/C	1 to 3	1 (1)	1 (1.6)	7 (7)
	2, 3	Carangidae	70/6	D	S	C/D	1 to 3	1 (1)		1 (1)
	2, 3	Centropomidae, Sciaenidae	80/7	D	S	C/D	1 to 3			1 (1)
	2, 3	Centropomidae, Sciaenidae	90/8	D	S	C/D	1 to 3			1 (1)
	2, 3	Centropomidae, Sciaenidae	100/9	D	S	C/D	1 to 3			3 (3)
	2, 3	Chondrichthyes	200/20	D	S	C/D	1 to 3			
	No boat	Penaeidae	40/3	S	F	C	1	11 (11)		2 (2)
Trawl net	2	Penaeidae	25/18	S	S	C	1	2 (2)	1 (1.6)	4 (4)
Fixed trap	1, 4	Carangidae	30/35	D	S	E/C	1	14 (14)	1 (1.6)	
Lobster trap	2, 3	Panuliridae/ Mullidae	30/35	D	S	C/D	15 to 20	20 (20)	6 (9.6)	23 (23)
Longline	2, 3	Lutjanidae	_	D	S	D	3 to 20		7 (11)	
Hook	2, 3	Lutjanidae, Scombridae	_	D	S	C/D	1 to 10	2 (2)		17 (17)
Dive	2, 3	Panuliridae/ Octopus	_	_	S	C/D	3 to 10	5 (5)	2 (3.2)	12 (12)

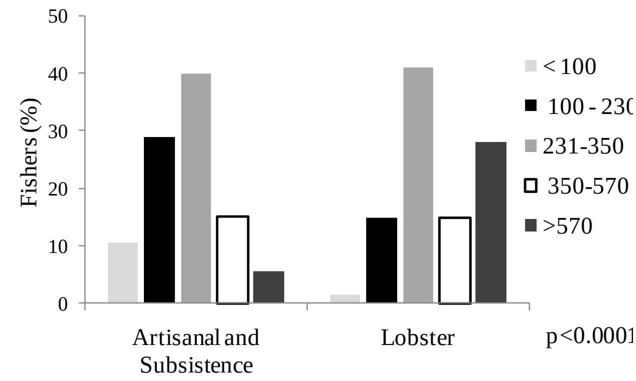

Figure 5. Income (in US$) of fishers that captures artisanal subsistence species and lobster in the three studied villages.

Table 2. Non-target species (sea turtles, rays and dolphins) captured by fishing gears found alive and dead by fishers from the studied villages.

	Fishing Gears N (%)			
Non-target species	Gillnet (< 60 mm)	Gillnet (> 60 mm)	Lobster Trap	Trap Barrier
Alive	77 (54)	23 (16)	28 (20)	15 (10)
Dead	20 (44)	17 (37)	8 (17)	1 (2)
				p=0.0127

DISCUSSION

Artisanal and subsistence fisheries around the Goiana Estuary

Traditional communities around Goiana Estuary live mostly in a sustainable way, depending on living natural resources for financial income and food. Fishing is the most important activity, considered in a small-scale, and the majority of men are dedicated to it. Even the adolescents and children < 10 years old fish to help keeping the family income. This is the major cause of school drop off.

The description of the artisanal fishery structure shows the importance of Goiana Estuary and adjacent areas for the exploitation of most resources mostly limited to subsistence and small-scale exploitation. The few technologically equipped fleet and the lower investment reflects the resources obtained and consequently the risks for the unsafely forms that fishers work.

The Northeast Coast is the second most productive region in Brazil (Ibama, 2009). In the studied region (Pernambuco municipality) the Goiana Estuary is responsible for 29% of production (in US$) with 19% of fishery fleet. Although, the area decreased in production from 2006 to 2007 in about 30%, especially for the artisanal fishery (26%) (Ibama, 2009). Coastal and deep fishing areas were more frequently used, due to the diversity of species and the higher profitability, exploring resources more intensively (Scianidae, Centropomidae and Panuliridae families). The estuarine area was frequently more explored by Acaú fishers, most of them independent and alone, where the captures are most of subsistence species (Ariidae, Trichiuridae, Carangidae and Penaeidae families) with sail boat with no technology.

Lobster Fishing

Lobster capture has an important role in national fishery sector since the 60 decade, and the Northeast Brazilian region is the main producer for market place (Ibama, 2009). Lobster production increased 5% in 2007 and Pernambuco is the most lobster exporter in Brazil reaching 881t, and representing 43% of national lobster exportation. The lobster price has been growing in last 6 years, where it was US$ 24,860/t in 2001 and reached US$ 44,300/t in 2007. Nevertheless, in the Brazilian panoramic the lobster exportation has been decreased in 4% from 2006 to 2007 (Ibama, 2009).

Overexploitation of fish stocks, especially for lobster was pointed by all the fishers as the main problem in the region due to the intense demand for the lobster by the international market and tourism. This is the most rentable activity in Goiana fishery sector and generates direct and indirect employments. On the biological aspects the two lobster species explored in the area (*Panulirus argus* and *Panulirus laevicauda*) are suffering a steep decline from fishing pressure in last 20-30 years, and the depletion of most natural resources are consequences of the open-access nature of fisheries and the non-managed program along the Brazilian coast.

Ecological changes have been reported worldwide (Bearzi *et al*., 2006) of many stocks considered to be outside safe biological limits and/or in a critical state, mostly because the ecosystem do not have time necessary to recover affected population by overfishing. Appropriate management and enforcement instruments are capable to be efficient on resources sustainability decreasing the fishing pressure on the subsistence and exportation resources, not transforming traditional communities on marginalised fishers. Therefore, on study area a seasonal closure for the lobster population recovering is enforced by law during the late dry and early rainy seasons as the capture of individuals lower than 13 cm, fishing close to 7.5 km of coast, fishing with gillnets and dependent dive are forbidden. Even though, innumerable apprehensions, arrests and fees are done and fishers continue with this profitable and forbidden activity that leads to resource degradation.

Lobster catchability is also a risk for fisher's health. Difficulties were found to report rates of lobster catch using dependent dive due to the fact that at least some fishers deliberated misreported their real activity with intent of avoiding stricter regulations. Nevertheless, the information obtained is relevant to argue that innumerable problems are related to this practice. In the order of healthy problems fishers practice dependent dive with different air mixtures not balanced, being more than 3 hours down in water, until 80 m deep, most of the times with no decompression stopping. Different kinds of problems were reported, most of them related to the decompression sickness (DS), as alteration in nervous, motor and circulatory systems and even death. Another cause of DS is tentative to hide its use when under police inspection if a diver is still down.

Social problems were also detected in the studied villages. A great part of fishers that receive the financial support on the lobster closure season do not work in this time being assisted for the family especially for the continuity use of alcoholism and illicit drugs, part of them being lead to poverty and marginalisation.

Bycatch

Bycatch of non-target species events were very common in interviews, especially for gillnets. Sea turtles, dolphins and rays were most cited captured animals that in most of times are sold or eaten by the local community. Gillnets catchability have been studied around the world and its non-selective method has received more attention where deterrents to reduce megafauna bycatch have been being used (e.g. baits, hooks, on boarder observers), especially for industrial fleet (Lewison *et al*., 2004). Although, the effect of artisanal fishery bycatch on endangered species, especially sea turtles which utilize the region as nursery, feeding and nesting habitat, is poorly known and has to be urgently investigated. Fishery gears as hook and line were considered by fishers the most selective gear, not capturing non-target species and individual fish lower than the expected size (juveniles).

CONCLUSIONS

Results presented here could be used as a preliminary baseline to begin the discussion among fishery stakeholders towards the development of management plans for the RESEX Acaú- Goiana. This is especially important if considers the social, economic and healthy problems due to the lobster capture, and the economic situation of fishermen from estuarine portion who lives in a precarious way. Moreover, problems such as forest degradation, sugarcane and aquaculture production, and the high use of non-traditional stakeholders in soil exploration should be included in the RESEX management plan aiming at the conservation and liveable use of resources by the traditional communities.

Instruction and investments should be applied on fisher's capacity building as a higher technology for fishery fleet (*e.g.* GPS, communication system and safety equipment) and ways to improve lobster conservation and its maximum sustainable yield. This should be encouraged among government, private institutions and the management stakeholders. Fishery inspection (for the lobster minimum length and appropriate season) should be not only on fisher's activity but also on important costumers (restaurants and exporting companies). Bycatch of non-target species should be investigated and appropriate technologies and their application could be invested, especially those which reduce bycatch.

A lack of fisher's organization responsible for serve the best interests of this class workers was observed. Social organization among fishers community should be strengthened and encouraged by the government supporting a local fish market objecting valuate the own product not being a middleman dependent anymore. Work diversification could be an appropriate way to earn money including tourism activities (*e.g*. dive, fishing) and engagement on environmental and educational projects. Scholar instruction could be encouraged, especially for children, promoting environmental and conservation lessons. These initiatives would enhance quality work, conservation of natural resources collaborating with the sustainability of their own activities.

These preliminary results emphasize the urgent need of further efforts to collect information about fishery gears, production, catchability and mortality of target and non-target species. A long-term study involving the hot-spots of marine megafauna bycatch and the main fishing gears is essential. A management plan must be drawn for protecting and conserving the estuarine ecocline and the adjacent coastal region while providing food and income for coastal communities. The participation of all stakeholders will be necessary to enhance the understanding of particular needs and local economy. Joint State and community supervision of the artisanal fishery is a possible way to reduce the pressure on heavily exploited species whilst ensuring the sustainable use of marine resources along the Northeast Brazilian coast.

ACKNOWLEDGMENT

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APÊNDICE 3

Threats to sea turtle populations in the Western Atlantic: poaching and mortality in small-scale fishery gears

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ABSTRACT

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Interactions between small-scale fishery activities and sea turtles were investigated in coastal fishers' population of the South and Northeast Brazilian coast, Western Atlantic. Data were collected using semi-structured questionnaires (N=418). The presence of four sea turtle species was confirmed in the studied areas: *Chelonia mydas*, *Caretta caretta, Eretmochelys imbricata* and *Dermochelys coriacea*. Adults are commonly seen in the water, and nesting females and hatchlings on beaches, especially at the Northeast region. The presence of the three most easily distinguishable ontogenetic phases (hatchlings, juveniles and adults) confirms the importance of the estuaries and adjacent areas for sea turtles feeding, gathering, nesting, growing and resting grounds. Fishing was considered the most important threat to sea turtles (77%). Gillnets with small mesh sizes (<60 mm) more frequently interact with sea turtles (65%), and mortality was mostly related to gillnets with larger mesh sizes (>60 mm) (100%) (p<0.01). Although poaching is a cultural habit still practiced by many people, fishers did not openly assume it. In addition, most fishers (82%) (p<0.01) do not know that it is possible or how to recover sea turtles drowned in fishing gears. Conservation measures should be adopted by fishers to reduce sea turtle mortality such as monitoring soak gillnets more frequently, avoiding nets with larger mesh sizes and thicker threads, and an awareness campaign to provide recovery procedures for turtles drowning in fishing gears. This would be the basis of the design of desirable mitigation actions enhancing conservation efforts and benefiting marine diversity as a whole.

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ADDITIONAL INDEX WORDS: *Coastal population, turtle products, bycatch, gillnets, conservation efforts, marine diversity.*

INTRODUCTION

Socio-economic growth and the development of human populations have not been accompanied by solutions to their impacts on the marine environment. Innumerable threats to marine diversity and habitat loss have been identified and, nowadays are discussed and analysed: species in the process of extinction (IUCN, 2012), the spread of debris and contamination in marine environments (Guebert-Bartholo *et al.*, 2011a), the decline of nursery habitats and the increased exploitation of fishery resources (Lewison *et al*., 2004) are only a few. Marine megafauna are mostly pan-tropical species (*e.g*. sharks, sea turtles and cetaceans) and have been hit by all of these impacts.

Marine megafauna, especially sea turtles, have been subject to a high level of incidental captures in various fishery gears around the world (Lewison *et al*., 2004). Small-scale fisheries (artisanal, traditional and subsistence fisheries) encompass a great part of coastal activities, especially in developing countries where they are critical for food security and a potential route for poverty alleviation. Moreover, this fishing category is highlighted for contributing half of fish caught for human consumption worldwide, being an important sub-sector of the world fish supply (FAO, 2005).

Sea turtles are distributed in tropical and subtropical oceans and during their life cycle they inhabit the ocean basin, from pelagic to estuarine and coastal waters, according to their life stage and species (Bolten, 2003). Nesting occurs exclusively on tropical sand beaches and oceanic islands. The Brazilian coast is known to be an important site for sea turtles growing and nesting (Spotila, 2004). Sea turtle products (meat, eggs and shell) can be easily found, not only in Brazil, but also in Caribbean and Asian countries, where consumption habits still persists as a black market trade with local and international routes (Mancini and Koch, 2009; Peckham *et al*., 2008).

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Research and conservation actions are needed to acquire reliable data on the threats to feeding and nesting areas of sea turtle populations and illegal exploitation. As suggested by Hamann *et al*. (2010), one of the priorities in sea turtle research is identifying major causes of fisheries bycatch and evaluating feasible mitigation measures for the problem.

Since the 1950s a drastic sea turtle populations decline has been noted, due to intense exploitation (Spotila, 2004). Currently, all sea turtle species are under risk of extinction (IUCN, 2012; MMA, 2008). Even though sea turtles are protected in Brazil under the law n^{o} 1.522 (19/12/1989) which declared their use and harvest as a crime (law no 9.605, 12/12/1998) (IBAMA, 2012), sea turtle products (e.g. meat, eggs, shell) are still strongly and widely appreciated one generation later.

The knowledge acquired through this study provides new insights in the threats to sea turtles. The objective was to understand the importance of the artisanal fishery activities in sea turtle bycatch, mortality and other potential threats. This study was conducted in two distinct regions of South and Northeast of the Brazilian coast in areas with Marine Protected Areas (MPA) and unprotected areas. Moreover, ecological aspects of sea turtles are presented, as perceived by traditional populations.

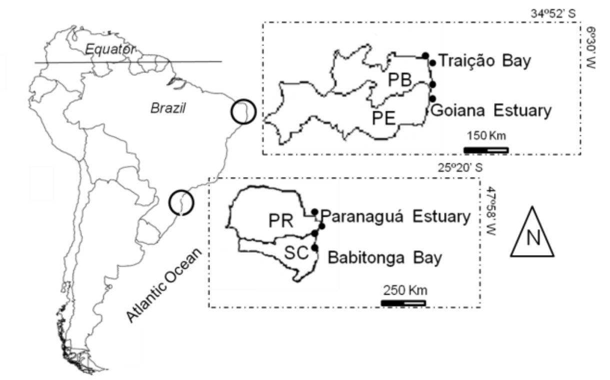

Figure 1. The two studied areas. In the South region are located Paranaguá Estuary at Paraná State (PR) and Babitonga Bay at Santa Catarina State (SC). In the Northeast region are located the Goiana Estuary at Pernambuco State (PE) and Traição Bay at Paraíba State (PB). The black circles are villages where fishers were interviewed.

METHODS

Study site

The areas studied in South Brazil are subtropical environments with patches of Atlantic Rain Forest. Estuaries have developed mangrove forests, flooded plains, rivers channels, sandy beaches and rocky islands surrounding the habitats. The two studied areas from the South region are Paranaguá Estuary, located at Paraná State, which has a patchwork of protected areas (*e.g*. Superagui National Park and the Guaraqueçaba Environmental Protected Area); and the Babitonga Bay, located at Santa Catarina State, which has no protected areas determined, although estuarine habitats have been recognized as important sites for *Pontoporia blainvillei* (fransciscana dolphin) (Cremer and Simões-Lopes, 2008) (Fig. 1). In these areas fishery is artisanal and concentrated in the estuary and the continental shelf. The main landings are penaeid prawns and fish from coastal areas.

In the studied area of the Northeast Brazil, a tropical ecocline with inland river basins develops at a humid coast where climatic variations are affected by the rainfall regime. One of the studied areas from the Northeast region is Goiana Estuary, located at Pernambuco State (Fig. 1). A Marine Protected Area was created in 2007 at the Goiana Estuary, classified as an Extractive Reserve (RESEX) (Barletta and Costa, 2009). This type of unit is a traditional population-based unit where the management councils are comprised of representatives from the local population (ICMBio, 2012). The other studied area comprises villages surrounding Traição Bay, located at Paraíba State, which have low urbanized areas with an indigenous reserve (Fig. 1). Fisheries at both Northeast areas are artisanal and estuarine fish species are captured for subsistence. In coastal waters lobster is the most captured and profitable resource. Indication of overexploitation of fish stocks have been pointed as one of the main problems at the Northeast region (Guebert-Bartholo *et al*., 2011b). The both study areas (South and Northeast) are included as an extremely high biological priority region for conservation in government plans (MMA, 2008).

Field sampling

The best possible estimate of the number of fishers in each area was made based on the current registers of local fishers associations. Four areas from two regions (Santa Catarina = 440 fishers, Paraná = 340, Pernambuco = 1700, and Paraíba = 1800) were sampled and, at each village a minimum of 10% of fishers were interviewed randomly and isolated from the group.

Data were collected in three occasions: September/2009 to February/2010, June/2011 and in August/2011. Semi-structured interviews were done, as informal but guided talks, to active fishers. Questions inquired about where sea turtles were seen, species distribution, ontogenetic phases and possible threats; and fishing gears and its interactions with sea turtles as bycatch. Photographs were shown to fishers to identify the species that occur in the four areas. Fishery gears were categorized according to FAO (2012).

To avoid misinformation, interviews were done with the presence of a prominent local fisher. When the interviewee was obviously hiding or giving false information the interview was discarded later. All the interviews were made by the same person.

Statistical analysis

The Chi-square independent test was used to determine significant differences among the interviewees', with a 5% level of significance (Zar, 1999).

RESULTS

A total of 440 interviews were conducted. Considering that fishers and coastal populations attempt to hide information about illegal consumption and bycatch of sea turtles, due to the law enforcement, 4% of interviews were discarded. A total of 418 valid interviews were analysed: 43 in Santa Catarina State (SC), 33 at Paraná State (PR), 163 at Pernambuco State (PE) and 179 at Paraíba State (PB).

The presence of the four possible species of sea turtles was confirmed in the four sampling areas: *Chelonia mydas, Caretta caretta, Eretmochelys imbricata* and *Dermochelys coriacea*. At least 335 (80%, N=418) fishers could recognize one or more species by their local names. Significant differences were detected among their recognition abilities ($p<0.01$), and *E. imbricata* (hawksbill turtle) was identified by 170 (50%, N=335) fishers as the most common species.

Three hundred and eighty three (92%, N=418) interviewees reported that sea turtles are commonly observed in coastal waters,

Questions	N (%)	p
Have already seen a turtle in water	383 (92)	*
Have already seen nesting females	109 (26)	*
Have already seen hatchling in sand	157 (37)	NS

Table 1. Questions presented to fishers regarding observations of sea turtles in water, nesting females and hatchling on sand. NS: non-significant, * p <0.01. N = 418 interviewed fishers.

especially near rocky substrates. At the Northeast area interviewed fishers related the presence of nesting females and hatchlings on the beach (Table 1). The three more distinguishable ontogenetic phases (hatchlings, juveniles and adults) were reported by 243 fishers (58%, N=418) and the juvenile phase was the most frequent (50, 21%; N=243) compared with the other two phases (Fig. 2).

Seventy-seven percent of fishers (295; N=384) recognized that fishing (p<0.01), mainly using gillnets with large mesh sizes (>60 mm), is the most important threat for sea turtles (p<0.01) (Fig. 3A, B). Other threats were cited in lower proportions: pollution (57, 15%; N=384), especially from industries and debris; boat collisions (21, 5%; N=384) and poaching (11, 3%; N=384) (Fig. 3A).

Fishery techniques differed among areas (p<0.01), although 188 (45%; N=418) fishers use gillnet with small mesh sizes (<60 mm). Considering sea turtle catchability 272 (65%; N=418) interviewed fishers affirmed to capture them incidentally in their fishing gears (Fig. 4). Significant differences were detected in sea turtle catchability among areas (p<0.01) where gillnets with small mesh sizes were more frequent (139, 51%; N=272). Other gears presented lower catchability rates: gillnets with larger sizes (>60 mm) (55, 20%; 272), lobster traps (29, 11%; N=272), trawl nets (14; 5%). However, sea turtle mortality is strongly related to the use of gillnets with large mesh sizes (p<0.01), considering that 55 (100%; N=55) fishers that use them affirmed to haul dead turtles (Fig. 4, 5).

When sea turtles are caught alive 270 (98%; N=274) fishers affirmed to release them back to the sea (p<0.01). Whereas, when sea turtles are caught dead (N=167) no significant differences were detected (p<0.01); 69 (41%) fishers affirmed eating the meat, especially when other fishery resources are scarce and 98 (59%) affirmed releasing them back into the sea. Significant differences were also detected for turtle poaching, especially meat consumption (p<0.01). One hundred and fifty-two (37%; N=408) fishers affirmed having eaten turtles in the past, 109 affirmed never having eaten (27%) and 147 (36%) affirmed to still do it, occasionally (Fig. 6). Egg poaching was also confirmed by 52 fishers (13.5%, N=384), although all of them affirmed that this activity was frequent only in the past, not practiced anymore.

Significant differences among areas (p<0.01) were detected in answers about recovering sea turtles drowned by fishing gears using cardiopulmonary resuscitation, and 343 (82%; N=418) fishers affirmed not knowing that it is possible or how to do it.

DISCUSSION

In general, no differences were detected between the opinions of the populations from the South and Northeast regions, including marine protected areas (MPA) and the unprotected areas. It was observed that most of interviewed fishers from RESEX Acaú - Goiana (protected area) do not know what a MPA classed as RESEX really is, or for what purpose it was created (ICMBio, 2012). In contradiction, they believe that this new status will give them new opportunities for working and for community development. This MPA was created in order to protect traditional fisher folk livelihoods; especially women who access the resource *Anomalocardia brasiliana* (Mollusca; Bivalvia). The MPA action plan still does not exist and community participation in management and decisions is apparently ineffective.

Female turtles nesting and hatchlings on sand were also reported by fishers, and the presence of the three ontogenetic phases (hatchlings, juveniles and adults) shows the importance of the areas for sea turtle populations as feeding, nesting, resting and growing grounds. The interviewed population could recognize four of the five possible species in the studied areas through photographs. The species *L. olivacea* was not recognized by the population in all areas, although it has been seen stranded at the Northeast coast (*pers.obs.*). The characteristics it shares (*e.g.* colour, size) with other turtle species (*C. mydas*) (Márquez, 1990) may have caused confusion in the identification by the fishers.

In general, fishers know about the endangered status of sea turtles, mostly because they have been extensively used as food resources, especially for coastal population and fishers in the last five hundred years (Spotila, 2004), since the beginning of the Caribbean and South American colonization. In this study, a significant awareness, declared importance and need for protection of turtles was observed amongst fishers. It was clear that the repression of the law enforcement is the main cause of this “conservationist” opinion. Considering this observation seventy-seven percent (295) of interviewed fishers believe that fishing is the main threat to sea turtles in coastal waters, especially the use of gillnets with large mesh sizes submerged for long periods (up to 12 hours). Other threats were also cited, although in fewer proportions: pollution, poaching and vessel collision.

Pollution is currently an important and alarming threat for marine animals. Fishers cited that the main sources of pollution were debris from big cities and chemical contaminants from plants near the estuaries (e.g. cement, aquaculture and sugarcane production), blaming the big centres for this problem. The sources of these pollutants are mostly land based activities (plastic debris from urban areas, agricultural run-off, effluents discarding, chemical contamination from sugarcane plantations and alcohol production) (Barletta and Costa, 2009; Liebezeit *et al*., 2011). Plastic debris in digestive tracts and entangled in sea turtles can cause injuries and even death (Guebert-Bartholo *et al*., 2011a). Consequences from debris ingestion are diseases and increased vulnerability to fishing gears and vessel collisions.

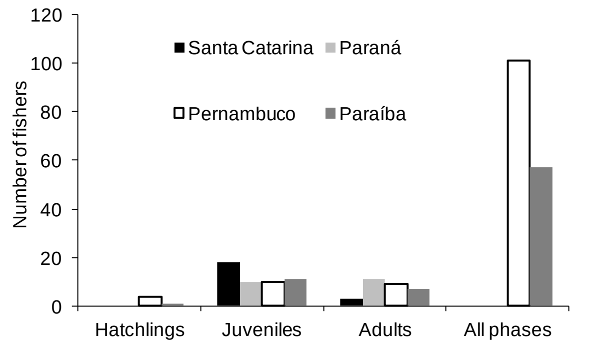

Figure 2. Number of fishers that recognized sea turtle ontogenetic phases at the four studied areas. N = 243 fishers interviewed.

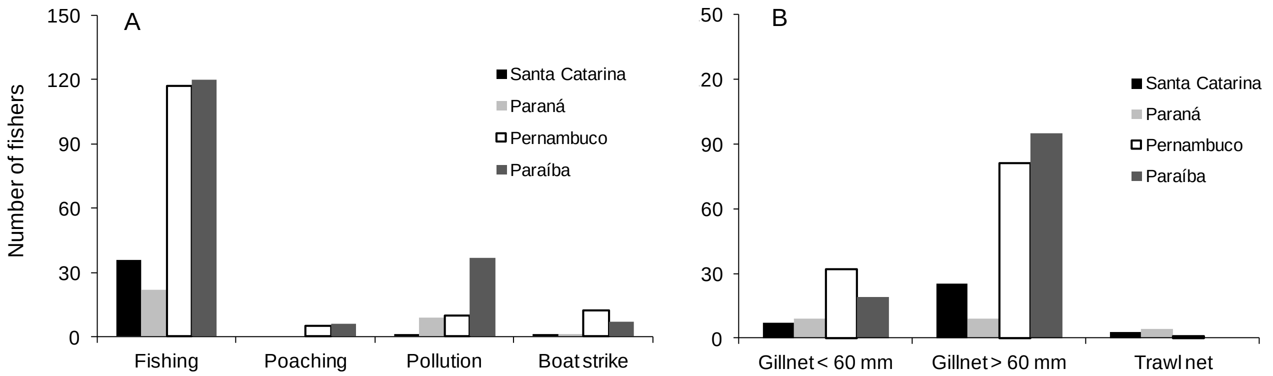

Figure 3. Fisher's opinion about the most important threats for sea turtles at the four studied areas (A). When the answer was "Fishing" a new question was made about which was the most dangerous fishery gear for sea turtles (B). N = 384 interviewed fishers.

Gillnets with small mesh sizes (<60 mm) was the category of fishing gear with highest records of sea turtle entanglement, according to the interviewees, principally because it is the most used fishing gear at the studied areas. Gillnets with larger mesh sizes (>60 mm) were more important in sea turtle death, especially because of the stronger mesh and nylon thread that entangles sea turtles. Differently, smaller mesh size gillnets from which turtles can break out, were not significant on death cases. Gillnets have been shown to cause more damaging impacts to sea turtles and other marine megafauna organisms (rays and mammals) than other gear (Casale *et al*., 2004; Peckham *et al*., 2007; 2008; Alfaro-Shigueto *et al*., 2010) especially due to its non-selective capturing method (Gilman *et al*., 2010).

The actual total catch and mortality of sea turtles described by interviewed fishers is likely to be much higher, due both to the unknown fishery efforts in small-scale fisheries, especially regarding the use of gillnets, and to the misinformation of fishers about sea turtle mortality (Koch *et al*., 2006). This information suggests that small-scale fisheries are causing higher mortality rates than previously thought.

The submergence time of the fishing net is also a determinant factor in sea turtle mortality; especially because when turtles are entangled they may drown, first becoming in comatose and eventually dying. When turtles are in a forced apnea, the routine dive time is shorter than usual and their tolerance is further reduced (Casale *et al*., 2004). The longest dive duration reported in sea turtles ranges from 2 to 5 hours, although the routine dive is between 4 to 56 minutes (Lutcavage and Lutz, 1997). In this study, fishers reported gillnets being submerged (soak gillnets) between 8 and 12 hours, occupying the whole range of depths of coastal areas by set perpendicular to the currents, acting as a turtle barrier. Thus, all animals that may be captured will have a high probability of death.

Other fishing gears presented lower bycatch rates. Even though some studies point to shrimp trawl nets as a potential bycatch gear (Wallace *et al*., 2010), we did not observe the same. In this study, 14 fishers (5.2%, N= 272) using shrimp trawl nets reported having captured sea turtles as bycatch, with no death of the animal. Lobster traps and longline also exhibited bycatch rates, although cases of turtle death were rare, principally due to their selective methods of target-species capture.

The interview method for understanding the use and capture of sea turtles by fishing gears is suitable for obtaining general data, such as those about fishers' opinion and, if bycatch rates are important sources of impact (death or comatose cases) on the population. Quantitative/reliable data regarding the number of turtles involved in incidental mortality in fishing gears and strandings on beaches could not be assessed for several reasons. On board observers, for example, are not available to obtain reliable data (CPUE), mainly because the safety conditions on board are precarious. According to fishers, carcasses were not frequently found on the beaches mainly because currents are responsible for transporting dead animals along the coastal areas, stranding them on other beaches far away from the studied areas.

Activities concerning seismic prospection (for oil/gas) occurred at the Northeast region (PE) coinciding 100% with the sampling period. Abnormal stranding records of turtles were found in a 15 km radius (more than 10 animals per week), according to fishers. These activities could be the cause of these strandings, mostly because after this period sea turtle strandings decreased (*pers. obs*.).

Fishers that captured sea turtles admitted not knowing that it was possible and how to recover sea turtles drowned in fishing gears, releasing the animals into the sea as if they were dead, not considering their possible comatose state. Knowledge of animal safety techniques are especially important when sea turtles are found entangled in fishing gears, especially because when they are comatosed, turtles cannot swim and may therefore be unable to surface to breath (Casale *et al.*, 2004).

Figure 5. *Chelonia mydas* (green turtle) found stranded and dead, entangled in a large mesh size gillnet at Paranaguá Estuary, South Brazil. Source: F. M. Guebert.

Poaching was reported, and was considered a cultural habit kept by traditional populations in all the world, detected on a community level and consumed during special occasions as a delicacy and a luxury item, largely related to traditional values and cultural factors (Campbell, 2003; Mancini and Koch, 2009). However, few fishers affirmed that a local market continues, where sea turtles products (meat and souvenirs) are sold within the population and for tourists around the region, under special request. Moreover, it must be taken into account that high percentage of fishers were not being totally accurate, due to fear of law enforcement, regarding turtle harvest and use. Considering this fact, the number of poachers must be greater than previously thought and the illegal trade on these coastal areas may remain an important threat for sea turtles during the juvenile and adult stages, difficulting population recovery and growth (Koch *et al*., 2006). The presence of poaching can also justify the rare reporting of events of stranded turtles in the studied areas. Egg poaching was observed in a lower level, and considered a more usual fact in the past (30 to 50 years ago).

In addition, some of the interviewed fishers affirmed that when a turtle is captured by chance the meat is prepared and eaten, and is considered a welcome bycatch. Some people do not eat the meat for prejudice, and some of them even believe that sea turtle meat can cause a number of diseases. In fact, the presence of bacteria, parasites and chemical contaminants in sea turtle meat can have serious effects on human health such as renal dysfunctions, gastrointestinal problems, neurotoxicity and even death (Senko *et al*., 2010).

Countries such as Asian, African countries and Mexico (Senko *et al*., 2010) also have similar traditional values and sea turtles products are frequently explored keeping an illegal consume and trade. Reasons as the lack of other type of reliable protein are not accepted nowadays, since the last 50 years when the access to meat protein has been possible including remote populations. In Brazil, these products are considered available and easily accessed for coastal and distant population in the last ten years. Brazilian laws for sea turtle protection are relatively new, when compared to elderly fishers interviewed. It is acceptable that new status, activities and laws take a while to be implanted, but the government agency with all stakeholders are responsible for encouraging the community on leaving these habits behind.

New options for traditional population should be encouraged, especially those aiming sea turtle protection. Conservation projects as well as tourism management could direct fishers being included in social and educational programmes (Wilson and Tisdell, 2001). These activities could be carried out by the MPA managers and all the stakeholders could participate.

Further information is urgently necessary to understand the importance of estuaries of the South American coast to sea turtle populations and to create feasible mitigation measures for sea turtle bycatch, considering that this area is used by different sea turtle species and life stages.

CONCLUSION

Conservation measures should be adopted such as an awareness campaign to provide recovery procedures for drowning turtles in fishing gears to fishers; and the development of measures to decrease sea turtles mortality, such as monitoring soak gillnets every 4 hours. The present study recommends immediate collaboration with fishers in conducting experiments to evaluate possible ways sea turtle could avoid gillnets commonly used in estuarine and coastal regions. Moreover, there are important

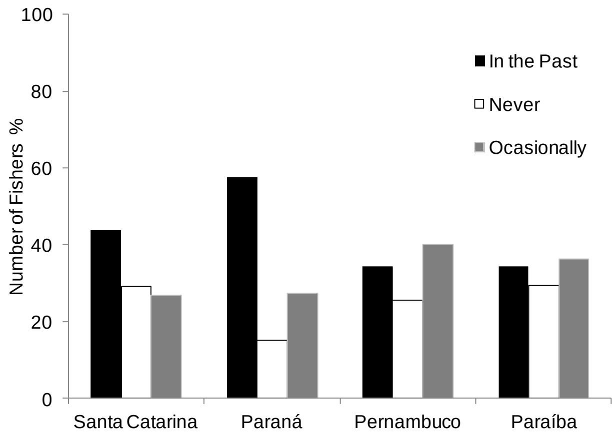

Figure 6. Fishers information (%) about the frequency of sea turtle meat consumption at the four studied areas.

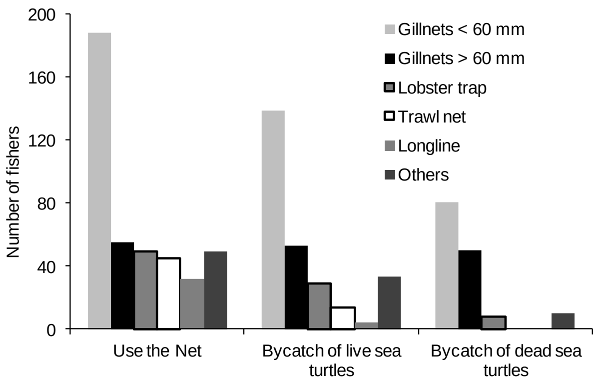

Figure 4. Number of fishers that use fishing gears and number of fishers that capture sea turtles alive and dead in these gears. The category “Others” group: dive and line and hook. N = 418 interviewed fishers.

questions that need to be answered: 1) the mean time of gillnets submersion in coastal water; 2) the identification of the hot spots of sea turtles catchability; 3) the assessment of the effects of the artisanal fishery in terms of number of catch per unit of effort; 4) the identification of trends in seasonality and catchability of sea turtles; 5) the extent of the local consumption and poaching of sea turtles, as well as the probable contamination indexes of meat that usually is ingested.

The participation of the MPA's on these actions will be essential, creating practical measures and emphasizing useful and necessary laws for conserving the fauna and natural resources. Finally, involving the local people in the correct management of protected areas and natural resources would result in locals actively participating in preservation and provide information necessary to further develop successful conservation plans. These recommendations would enhance conservation efforts and probably reduce sea turtle mortality benefiting estuarine, coastal and marine diversity.

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