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"Modelos Ecológicos e Processos de Decisão entre Pescadores Artesanais do Guarujá, SP"

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ÍNDICE

Índice de Tabelas

Índice de Figuras

Resumo

O enfoque deste estudo está centrado na dinâmica da pesca artesanal de caráter comercial da Praia do Perequê, Guarujá, SP, sob a perspectiva da ecologia comportamental humana e da análise do processo de decisão por parte dos pescadores. Assim, o objetivo geral foi avaliar a dinâmica da pesca artesanal local, comparando-a a outras pescarias artesanais brasileiras, levando em conta seus aspectos sócio-econômicos, ecológicos e comportamentais, a fim de fornecer subsídios básicos, mas essenciais, para o manejo dos recursos pesqueiros locais. Os resultados de quatorze meses de estudos de campo são integrados ao longo de três capítulos através de conceitos derivados da ecologia evolutiva, tais como otimização e territorialidade, e conceitos que provêm da Teoria dos Comuns, como regimes de propriedade. Os métodos utilizados incluem entrevistas semi-estruturadas para o levantamento sócio-econômico (n=51), acompanhamento de desembarques (n=424) e de viagens de pesca (n=21) e mapeamento (pontos georreferenciados) e etnomapeamento (identificação pelos pescadores) dos principais pontos de pesca. O primeiro capítulo traz uma caracterização sócio-econômica da comunidade, analisando as similaridades e diferenças entre os dois principais grupos de pescadores: os pescadores de camarão (camaroeiros) e os pescadores de peixes. Foram registradas as principais e poucas espécies de camarão (n=2) e peixe (n=5) de interesse para a pesca, os equipamentos utilizados (e.g.: arrasto de fundo e rede de espera), a influência da migração de pescadores de outros estados para o local, especialmente os vindos da região Sul, e as interrelações econômicas e familiares que direcionam a vida local (e.g: economia centrada na pesca e comércio do camarão). O segundo capítulo aborda a pesca e o processo decisório por parte do pescador. O esforço de pesca é analisado sob a perspectiva temporal, mostrando a influência de fatores sazonais (e.g.: vento) em decisões que governam, por exemplo, o simples fato de ir ou não pescar diariamente. Além disso, é uma área de livre acesso, onde nem regras locais nem o poder público fiscalizam e limitam a exploração dos recursos, contribuindo para que o processo de decisão se dê apenas em nível individual e não comunitário. Apesar disto, alguns conflitos em função da sobreposição entre as áreas de pesca de camaroeiros e demais

pescadores podem ser observados. O ultimo capítulo traz uma análise a partir da Teoria do Forrageio Ótimo, testando-se se o pescador obtem a maximização (otimização) calórica e financeira. Foram encontradas evidências de sobre-exploração de peixes, já que o pescador precisa ir cada vez mais longe para conseguir espécies que normalmente são pescadas próximas à costa. Além disso, o fato de ambos os grupos de pescadores obterem a otimização de seus ganhos calóricos e financeiros sugere um comportamento que visa somente o retorno a curto prazo, uma estratégia claramente não conservacionista. O levantamento de alguns pontos principais ao longo deste estudo no que concerne à pesca no Perequê (como migração de pescadores, conflitos sobre o direito de acesso às áreas de pesca, exploração não controlada, intensa dependência de poucos recursos) subsidia e mostra a relevância de se adotar medidas de manejo imediatas, que visem coibir ou diminuir o impacto ambiental e social que uma eventual crise dos recursos locais poderia causar. Entre tais medidas de manejo, cita-se a aplicação efetiva da legislação existente, o desenvolvimento de acordos locais próprios que visem diminuir conflitos e tornar a exploração mais sustentável, e principalmente a reforma das instituições formais e informais, as quais facilitariam a efetivação de tais medidas.

ABSTRACT

This study focus on the dynamics of the commercial, but still artisanal fisheries in Perequê Beach, Guarujá, SP, under the perspective of human behavioral ecology and decision-making processes analyses by local fishermen. Its main goal was to evaluate the conditions of the local fisheries, comparing it to other artisanal fisheries in Brazil, taking into account social-economic, ecological and behavioral factors, in order to provide basic but essential information to local fisheries management. The results of 14 months of fieldwork are integrated throughout three chapters using concepts from evolutionary ecology, such as optimization and territoriality, and concepts from the Commons Theory, such as property regimes. The methods used include semi-structured interviews applied to the social-economic characterization, fish landings samplings (n=424), participant observations in some fishing trips (n=21) and fishing spots mapping (georeferenced spots) and ethnomapping (identified by the local fishermen). The first chapter brings up a social-economic portrait of the community, showing the similarities and differences between the two fishing systems: shrimp trawl and gillnet fishery. Few targeted shrimp (n=2) and fish (n=5) species were identified. The kinds of equipment used (bottom otter trawl and gillnet), the importance of fishermen migration from other Brazilian states to the place, especially from the south region, and the economic and family based interrelations that lead the local life (economy based on fishing and commerce of shrimp) were also studied. The second chapter addresses the local fisheries and fishermen's decision-making processes. Fishing effort is analyzed under a temporal perspective, investigating the influence of seasonal factors (e.g.: wind) in decisions that rule, for example, the simple daily act of going fishing or not. In addition to that, Perequê represents an open access area, where neither local rules nor government enforces the existing laws or curtails the resource exploitation, which makes the decision making processes be solely at the individual level and not at the community level. Despite that, some conflicts due to the overlap of fishing areas between trawlers and gillnetters can be observed. The last chapter brings up an analysis based on Optimal Foraging Theory, testing if a fisherman tries to maximize (optimization process) his caloric and financial returns. Pieces of evidence concerning fish overexploitation were found, as the fisherman needs to go further to fish species that are usually caught close to the coast. Moreover, the fact that both fishing groups aims at maximizing their financial and caloric return suggests a kind of behavior that is directed towards the short term return, a strategy clearly non-conservationist. The main points showed by this study concerning Perequê's fishing (fishermen's migration, conflicts over the rights to use the fishing spots, non regulated exploitation, intense dependence on a few fishing resources, etc.) ground and show the need of adopting immediate management measures, aiming at restricting and decreasing the environmental and social impacts caused by an eventual resource crises. Among them, it is suggested the fleet control, the effective enforcement of existing regulations, the development of local agreements that aim to decrease conflicts and to make resource exploitation more sustainable, and mainly the restructuring of formal and informal institutions, which would make the application of such measures easier.

Introdução Geral

O presente estudo analisa a pesca artesanal realizada na Praia do Perequê, município do Guarujá, Estado de São Paulo, utilizando abordagens de ecologia humana. Como objetivo central, buscou-se aqui uma análise da condição da pesca artesanal local, comparando-a a outras pescarias artesanais brasileiras, levando em conta seus aspectos sócio-econômicos, ecológicos e comportamentais. A finalidade principal é fornecer subsídios básicos, mas essenciais, para o manejo dos recursos pesqueiros locais. Tópicos como ecologia comportamental humana (através do uso de modelos ecológicos de forrageio), territorialidade e acesso aos recursos são abordados ao longo de três capítulos. De forma geral, pretendeu-se que com estas abordagens distintas, mas interligadas, estabelecer um perfil mais claro da situação vivida pelos pescadores do Perequê. Quem são estes pescadores, quão homogêneos eles são, que recursos pesqueiros exploram e de que forma, quais são seus conflitos no uso destes recursos, como se inserem no mercado local e regional são algumas das perguntas abordadas e respondidas ao longo desta tese.

A pesca tem uma relevância fundamental como um recurso natural e economicamente explorado no Brasil, portanto, entendê-la em seus múltiplos aspectos é fundamental para a sua continuidade (Abdallah & Sumaila 2007, Diegues 1999). A complexidade de tal sistema é ainda exacerbada num contexto tropical, onde pescarias multi-específicas que fazem uso de uma grande variedade de técnicas de pesca num ambiente imprevisível são a regra (Johannes 1998). Ademais, frente às atuais políticas pesqueiras do Brasil, as quais incentivam o crescimento da frota sem nenhuma consideração científica (Abdallah & Sumaila 2007), tornam-se preemente estudos de abordagem rápida que busquem generalidade de resultados nos aspectos ecológicos, econômicos e sociais da pesca artesanal. É neste contexto, que a ecologia humana destaca-se pela sua interdisciplinaridade, podendo contribuir de modo relevante na resolução de questões que não se restringem a uma única área de conhecimento, como é o caso da pesca (Begossi *et al.* 2004a). Como veremos neste estudo de caso, o grau de exploração do recurso pesqueiro (aspecto ecológico) depende de variáveis econômicas e sociais, portanto o entendimento do quadro completo é não só relevante como essencial para o desenvolvimento de políticas de manejo adequadas.

A comunidade estudada ao longo desta tese tem elementos peculiares, como o grande aporte de migrantes vindos da região sul do país, atraídos pelo abundante camarão sete-barbas (*Xyphopenaeus kroyeri*, Heller 1862). Embora outros estudos tenham analisado efeitos desta pesca de camarão, por exemplo, na fauna acompanhante (Branco & Fracasso 2004, Graça-Lopes *et al.* 2002; Severino-Rodrigues *et al.* 2002), há menos estudos abordando outros impactos ecológicos e mesmo sociais e econômicos que possam eventualmente ser causadas por ela (Leite Jr. & Petrere 2006, MacCord *in press*). No entanto, o impacto da pesca de arrasto e os problemas causados por ela em pescarias ao redor do mundo retrocedem ao início do século XIV (Jones 1992). A mortalidade de peixes durante o arrasto é apenas uma das conseqüências indiretas desta atividade, embora talvez a mais estudada, assim como as mudanças permanentes na fauna. Como conseqüências diretas, podem ser citadas alteração do substrato, suspensão de sedimentos, destruição do bentos e descarte de resíduos (Jones 1992). Desde o início da utilização de técnicas de arrasto na pesca, outros pescadores passaram a reclamar seja pelo efeito direto na pesca ou pelos danos que tais métodos causam aos outros equipamentos de pesca, como redes, evidenciando a congruência de fatores sociais (Shimbira & Mwatha 1995). Todos estes aspectos tendem a apontar para uma pescaria ecológica e socialmente insustentável[1] a longo prazo, que merece maior atenção e conhecimento, especialmente em países em desenvolvimento onde a legislação e fiscalização são normalmente pouco eficazes (Abdallah & Sumaila 2007, Pomeroy 1999).

Entretanto, a pesca realizada com outros métodos também não está livre de críticas. Diversos autores têm demonstrado que mesmo o uso de métodos de pesca aparentemente menos impactantes, tal como anzol e linha, podem ter impactos significativos na estruturação de

[1] Sustentabilidade é aqui definida como a continuidade dos aspectos econômicos, sociais, culturais e ambientais da sociedade humana. É a busca do preenchimento das necessidades humanas atuais e futuras sem comprometimento dos ecossistemas e da diversidade biológica.

comunidades biológicas, resultando, por exemplo, na redução na abundância de peixes predadores (Pet-Soede *et al.* 2001). O grau deste impacto vai depender do local onde a pesca é realizada, seletividade do método, estágio de desenvolvimento do peixe capturado e intensidade do esforço (McClanahan & Mangi 2004). Da mesma forma, a escolha de onde, quando e como pescar podem ser, por sua vez, ser determinados por variáveis sócio-economicas. Ainda assim, mesmo que haja sustentabilidade sob o ponto de vista ecológico, isto não implica que esta será estável ou permanente quando não há sustentabilidade econômica e social (Glaser & Diele 2004).

A presente tese insere-se neste contexto multidisciplinar trazido pela ecologia humana, buscando a análise de fatores ecológicos associados a fatores sócio-econômicos. De forma geral, o conhecimento gerado por esta tese tem potencialmente aplicação imediata no auxílio do desenvolvimento de práticas de manejo para a pesca artesanal em geral e especificamente para a pesca artesanal de camarão, na medida em que oferece informações básicas mas cruciais para tal. Além de objetivar mostrar quem são os pescadores locais, quanto eles e suas famílias dependem da pesca e como a pesca ocorre ao longo do ano, ainda objetiva-se analisar os potenciais conflitos existentes entre os dois grupos distintos de pescadores (camaroeiros e pescadores que utilizam redes). Ao trazer informações que vão desde as condições da pesca até o comportamento efetivo do pescador, este trabalho visa contribuir para o conceito de manejo que vem sendo adotado ao longo das últimas duas décadas, na qual o pescador, e não somente o recurso explorado, é um dos elementos chaves na busca da sustentabilidade (Pomeroy 1995, Pomeroy *et al.* 2001).

Ao longo das próximas páginas, um arcabouço teórico básico será traçado para os principais temas abordados nesta tese: ecologia comportamental humana, forrageio ótimo e territorialidade e formas de acesso ao recurso. Estes tópicos quando usados de forma complementar ajudam a traçar um quadro detalhado do processo de tomada de decisão, conjugando análises quantitativas e qualitativas.

Ecologia comportamental humana

O uso da ecologia evolutiva para se entender comportamento humano começa já com Charles Darwin (1871), não apenas em função da sua teoria de Seleção Natural, mas porque ele próprio dedicou muito do que escreveu a este tópico (Laland & Brown 2002). A Ecologia Comportamental Humana concretamente surgiu num momento em que uma série de idéias teóricas a respeito de evolução em geral fervilhava mundo afora e de certa forma se agregavam formando um arcabouço único e coerente. Hamilton havia publicado em 1964 sua teoria sobre seleção de parentesco e valor adaptativo inclusivo, logo seguido pelo livro de Williams (1966) "Adaptation and Natural Selection", que exemplificou de forma clara os diversos níveis hierárquicos (gene, indivíduo, população, espécie, ecossistema) nos quais eram mais prováveis de se ocorrerem adaptações (veja Tabela 1 para definição dos termos evolutivos).

As idéias surgiram de todos os lados e algumas similares apareceram praticamente ao mesmo tempo. É neste mesmo ano, em 1966, que MacArthur & Pianka e também Emlen publicam aqueles que seriam os primeiros artigos usando modelos econômicos em estudos de comportamento animal, seguidos posteriormente por Eric Charnov (1976). Estes autores aplicam a idéia de otimização ao processo de busca de alimento (forrageamento), analisando os custos e benefícios desta atividade de forma objetiva e mensurável. Seguindo esta mesma tendência, Trivers publica uma série de artigos hoje clássicos abordando altruísmo recíproco, investimento parental e conflitos entre pais e suas crias (1971, 1972, 1974). As idéias de Trivers ajudaram a derrubar um dos maiores empecilhos para os ecólogos evolutivos, o altruísmo puro e simples, o qual não se encaixava na idéia de que os organismos sempre agiriam de forma egoísta visando sempre o maior sucesso adaptativo individual.

A abordagem evolutiva selecionista moldando adaptações já estava em voga desde o início da década de 60; o que muda a partir deste ponto é o foco no comportamento como um resultado de seleção natural. Estudos empíricos usando as novas teorias abordaram diferentes taxa, de artrópodes a mamíferos. Entre estes últimos incluem-se os primatas, um grupo animal normalmente estudado por antropólogos, o que acabou trazendo esta mesma linha de pesquisa evolutiva para estudos de comportamento humano.

Irons & Cronk (2000) apontam o artigo de revisão de Richard Alexander em 1974 como o primeiro a sumarizar a teoria evolutiva da socialidade e como esta poderia ajudar a entender diversos pontos do comportamento humano. Este também é o momento do lançamento do tão criticado, celebrado e controverso livro “Sociobiologia: uma nova síntese” (Wilson 1975). Esse livro trouxe abordagens interessantíssimas, muitas baseadas nas idéias de Trivers. Entretanto, estas idéias não chamaram tanto a atenção quanto àquelas desenvolvidas ao longo do seu último capítulo, no qual Wilson (1975) aplicava os mesmos preceitos desenvolvidos nos capítulos anteriores sobre animais para entender o comportamento social humano. Entre alguns dos seus argumentos especulativos estavam explicações evolutivas para as diferenças de papéis entre os sexos, agressividade e religião. De acordo com Wilson (1975) a sociobiologia tinha como meta reformular as ciências sociais em direção à uma abordagem evolutiva.

No ano seguinte, Dawkins (1976) traduz para o público leigo todas as teorias apresentadas acima representando o arcabouço da teoria evolutiva da época e sugerindo também sua aplicação no entendimento do comportamento humano. A diferença é que Dawkins (1976) inova ao afirmar que a cultura, através de suas pequenas unidades transmitidas à semelhança de genes, os memes, também exerceriam um importante papel, associado à bagagem genética, no delineamento do comportamento humano.

Evidentemente a Ecologia Comportamental Humana (ECH) não se estagnou e evoluiu com novas idéias ou da Ecologia Evolutiva pura ou idéias que se originaram dela própria, como as teorias que abordam a Co-evolução entre genes e cultura (Feldman & Cavali-Sforza 1976, Boyd & Richerson 1983), sugerindo como estes dois fatores interagem e se adaptam um ao outro, alterando o ambiente adaptativo (Laland & Brown 2002). As vantagens em se utilizar tais tipos de modelos originados principalmente da ecologia evolutiva estão na sua generalidade e realidade. Eles são desenvolvidos para prever o comportamento que se espera que tenha evoluído em resposta às condições do ambiente. As hipóteses geradas são claras e podem ser facilmente aceitas ou refutadas, muitas das quais não seriam evidentes se testadas de outra forma (Smith & Winterhalder 1981).

Entre os tópicos abordados pela ECH estão a procura de alimentos (forrageio) e a garantia, através da defesa, de acesso aos recursos (territorialidade). Muito embora forrageio e territorialidade já fossem tópicos explorados muito antes do desenvolvimento da própria ecologia evolutiva em geral, esta, e também a ECH deixam de se preocupar apenas com qual seria a função do forrageio ou da territorialidade (causa proximal) (Winterhalder 1981). Passa-se a buscar respostas que expliquem a evolução de tais comportamentos. No caso da territorialidade esta passa a ser, por exemplo, como explicar a diversidade de formas territoriais (Brown 1964), enquanto no caso do forrageio pressupões-se que os indivíduos buscarão a otimização, já que a busca de um comportamento ótimo deve ser favorecida pela seleção natural (Winterhalder 1981). Abaixo, estes dois tópicos são abordados de forma mais detalhada.

Forrageio ótimo

A Teoria de Forrageio Ótimo (TFO) deriva da ecologia evolutiva e lida basicamente com hipóteses sobre os diferentes comportamentos esperados para a busca de alimento (forrageio) sob condições ambientais diversas. Muitas destas hipóteses são não intuitivas ou vão contra o senso comum, como por exemplo o fato de se esperar que um forrageador deixe o seu local de forrageio mais rapidamente quando o retorno.é bom do que o faria se o seu retorno não fosse tão satisfatório.

Por otimização entende-se um uso eficiente do tempo ou das reservas energéticas para o desenvolvimento de outras atividades como aquisição de alimentos, reprodução e evitação de predação. A melhor moeda para medir o sucesso da otimização seria o valor adaptativo do indivíduo (*reproductive fitness*), mas isto é extremamente difícil de ser medido, especialmente entre humanos, os quais contam com um ciclo de vida bastante longo. Tendo em vista esta limitação, boa parte dos estudos de forrageio pressupõem que o valor adaptativo está direta e positivamente relacionado com a taxa de aquisição de energia, o que ocorre durante o forrageio

(Krebs & Davies 1993). Isto pode nem sempre ser verdade no contexto humano em função de metas socioculturais (religião, educação, etc.) que permeiam todo o comportamento humano, mas é certamente uma medida aproximada útil e fácil de ser aplicada. Em outras situações, nutrientes, e não calorias, podem ser considerados a "moeda" de otimização, tanto entre humanos quanto entre os outros animais em geral, se há um motivo para se crer que haja maior déficit de nutrientes específicos do que calóricos (Keene 1981, b, Pulliam 1975).

Os modelos de forrageio ótimo abordam desde os itens que devem ser inclusos numa dieta ótima, escolha de local de forrageio e tempo de permanência nele até o tamanho ótimo de grupos de forrageadores. Nesta tese, apenas o modelo que lida com o tempo ótimo de permanência na mancha (Forrageio a Partir do Lugar Central) será utilizado (Capítulo III).

Winterhalder (1981) mostra que a variabilidade genética observada entre indivíduos não tem provavelmente nenhuma conseqüência no estudo do comportamento de forrageio humano em busca de padrões gerais. Adaptações comportamentais de maior sucesso são copiadas de forma consciente ou não por outros indivíduos e esta variante comportamental selecionada será passada adiante culturalmente através dos pais e outras formas de transmissão (ver Boyd & Richerson 1985 para mecanismos de transmissão cultural).

O uso da TFO não implica em pressupor que organismos sempre atingirão um ótimo. Diversas razões podem evitar que isto aconteça: as pré-adaptações necessárias podem não existir, limitações históricas, mudanças ambientais constantes ou conflitos adaptativos em função de metas múltiplas (ex.: reproduzir ou evitar a predação?) podem ocorrer. Entretanto, justamente neste ponto, quando a teoria mostra que os organismos não necessariamente agem de forma ótima, é que ela se torna mais interessante, pois é capaz de sugerir os fatores limitantes que impedem a otimização.

É evidente que os modelos de forrageio ótimo podem apresentar falhas e super simplificações. Por exemplo, boa parte deles foi desenvolvida para forrageadores solitários, que só se preocupam com o seu sucesso individual ou que simplesmente não armazenam informação, o que certamente não é verdade para grupos humanos, que forrageiam, por exemplo, para a manutenção da família (Hawkes *et al.* 1991). Também é verdade que a partir do final da década de 70 muitos outros modelos mais elaborados, com características estocásticas, foram desenvolvidos, permitindo, por exemplo, a inclusão do processo de aquisição de informações (Mangel & Clark 1983, Stephens & Krebs 1986), um pressuposto simples, evidente (forrageadores aprendem as características de um local com o tempo através das atividades realizadas lá), mas de caráter dinâmico. Entretanto, os modelos simples ainda encontram aqueles que os defendem em função da maior generalidade e praticidade de aplicação (Stephens & Krebs 1986, Smith & Winterhalder 1981), já que muitos modelos, apesar de sua simplicidade, se mostram suficientes para explicar situações arqueológicas ou etnográficas complexas. Bliege Bird & Bird (1997), por exemplo, utilizam o modelo de Forrageio a Partir do Lugar Central e o transporte de alimentos específicos entre aborígenes atuais para explicar a formação e composição de sambaquis antigos encontrados em ilhas do Pacífico.

O que nos parece mais razoável é a utilização de modelos básicos num primeiro momento e, se a situação requerer, modelos mais elaborados podem ser aplicados ou mesmo desenvolvidos para o entendimento de uma situação específica. Entretanto, simplesmente porque o modelo utilizado demonstra um comportamento sub-ótimo do forrageador não justifica sempre mudar para um outro modelo ou desenvolver um próprio. Como bem demonstrado por Maynard-Smith (1978), buscar por um modelo que aponte a otimização do comportamento mostra o quão difícil é para o pesquisador aceitar que o comportamento é sub-ótimo ou uma maladaptação. Aliás, este é um dos pontos muito enfocados pela Psicologia Evolutiva, a de que o comportamento atual estaria repleto de exemplos de maladaptações em função de um atraso evolutivo. O ambiente mudaria de forma mais rápida que as adaptações, criando um atraso entre o indivíduo e a situação que o mesmo encontra ao seu redor, de forma que o que observamos seriam adaptações passadas e obsoletas, portanto não perfeitas para as condições atuais (Laland & Brown 2002). Boyd & Richerson (1985) também sugerem e modelam como processos mal adaptativos poderiam surgir através de mecanismos de transmissão cultural onde aspectos não relevantes são copiados de modelos relevantes, através do chamado *runaway process*. Por exemplo, australopitecos desenvolveram um sistema locomotor que privilegia andar e não correr, o que é interpretado como forma de avistar os locais de possíveis presas de forma mais efetiva que outros animais (ex.: tigres) que se movem mais rapidamente, mas tem um espectro de visão mais limitado. Embora humanos atuais tenham herdado tal sistema, hoje em dia pouco se locomovem, ter carro é símbolo de status almejado por todos, resultando em problemas de saúde adicionais (Godesky 2005).

Embora a definição de forrageio abranja inicialmente a busca por alimentos não produzidos (cultivados ou criados), muitos estudos têm utilizado de forma produtiva a TFO para ajudar a entender a agricultura e a criação de animais. Nestes casos, muitas vezes a TFO é utilizada de forma a entender o padrão de distribuição de recursos adotados ou a movimentação do forragedor humano entre diferentes manchas. Por exemplo, como os campos de cultivo são distribuídos ou como um pastor movimenta seu rebanho de forma a obter o maior retorno calórico ao fim de um período (de Boer & Prins 1989, Keegan 1986). Fica claro que o forrageador que otimiza suas atividades tem metas de curto prazo, se ele precisa comer, o recurso tem que estar disponível de forma imediata (coleta, caça e pesca) ou após um curto período (colheita, abatimento de animal de corte). Neste ponto, os modelos ecológicos trazem informações relevantes, como a não preocupação do forrageador ótimo em conservar os recursos, que podem contradizer o senso comum, tal como a idéia de que populações tradicionais são sempre conservacionistas, tendo implicações na adoção de práticas de manejo.

Não é incomum encontrar na literatura relatos de grupos humanos que aparentemente se comportam de forma conservacionista, o que foi romanceado por alguns autores como uma estratégia para preservar recursos para o futuro, ou simplesmente através da visão do “bom selvagem” (*noble savage)*. Não descartando a possibilidade de que isto ocorra como será visto durante a discussão de territorialidade, os modelos de forrageio têm mostrado que os forrageadores podem estar apenas maximizando seus ganhos. Muitas vezes o fato de não exaurir totalmente os recursos em um determinado local, mudando-se para outro e permitindo que aquele remanescente se recupere é simplesmente a melhor estratégia. Por exemplo, pode ser que continuar explorando o mesmo local seja mais dispendioso energeticamente do que se mudar para um outro que ainda tenha seus recursos intactos (Aswani 1998).

As implicações para manejo são claras, forrageadores ótimos podem não estar conservando de forma intencional e caso o recurso seja diminuído (mudanças climáticas, pressões de grupos humanos competidores, etc.), eles possivelmente vão intensificar sua exploração. Este aspecto é abordado no último capítulo desta tese. Apesar disto, condições para conservação não intencional podem surgir quando há um uso exclusivo do recurso, o que permite que o forrageador atrase a época de forragear em função de um retorno futuro, ainda que provavelmente dentro do seu período de vida (ver trecho sobre territorialidade, a seguir).

Territorialidade e outras formas de acesso e defesa dos recursos

Embora o termo territorialidade venha sendo empregado há um longo tempo, apenas após o clássico artigo de Brown (1964) este conceito foi deslocado da visão funcional e descritiva vigente ainda na época para uma visão evolutiva. Territorialidade implica na demonstração de algum comportamento agressivo (ou a potencialidade de tê-lo) a fim de se defender um recurso. O recurso a ser defendido pode ser qualquer coisa que contribua para o valor adaptativo do indivíduo: alimento, companheiros para acasalamento ou espaço. Ser territorial em relação a espaço não implica em ser territorial em relação aos demais recursos (Dyson-Hudson & Smith 1978).

Brown (1964) foi o primeiro a argumentar que para que a territorialidade tenha sido favorecida por um processo de seleção natural, deveria haver alguma vantagem relacionada a esse comportamento, como o aumento das taxas de sobrevivência ou de reprodução. Isto só ocorreria se os custos em se defender o recurso em questão fossem menores que os benefícios ganhos em se manter o recurso de uso exclusivo, o que tornaria o recurso *economicamente* defensável. Recursos seriam mais economicamente defensáveis quando fossem agrupados e previsíveis em sua localização. Neste caso, os benefícios em defendê-los aumentariam com o aumento da competição. Por outro lado, competição intensa aumenta os custos da defesa e dependendo de quão intensa, não há razões para se manter a territorialidade. De acordo com Brown (1964), estas duas condições, ser defensável e haver competição, são absolutamente necessárias para evolução da territorialidade. Por exemplo, não há porquê se defender um recurso agrupado, mas extremamente abundante ou um recurso não tão abundante, mas que ninguém mais o quer, por ter baixo valor adaptativo por exemplo.

Além disso, as estratégias adotadas não são fixas (Davies 1976) e podem variar temporalmente de acordo com as duas condições especificadas acima: abundância/previsibilidade do recurso e competição. Os custos em se defender a área também variam de acordo com o tamanho da mesma (Mitani & Rodman 1979).

Dyson-Hudson & Smith (1978) foram dos primeiros a fazer uso dos conceitos de territorialidade para explicar diferentes formas de acesso a recursos entre grupos humanos. Boserup (1965), ainda anterior a estes autores, também usou argumentos semelhantes (abundância, defensabilidade, agrupamento dos recursos) para explicar a transição de recursos de acesso comum para recursos usados individualmente de acordo com o aumento da densidade populacional, quando os recursos se tornam menos abundantes e vale a pena defendê-los. Cashdan (1992) mostra que este quadro nem sempre é tão simples para humanos: recursos muito escassos para os quais os custos de defesa são à primeira vista extremamente elevados (como água no deserto de Kalahari) podem ser defendidos. Segundo Cashdan (1992), além de a água ser um recurso de alto valor local, humanos ainda contam com uma complexa rede de comunicação que permitiria ao dono do território saber rapidamente se algum competidor o invadiu, diminuindo os custos da defesa.

Como primeiro argumentado por Boserup (1965) entre humanos, mas já previsto por Brown (1964) para aves, há um gradiente de sistemas de territorialidade, que vai desde a defesa absoluta do recurso até a total ausência dela, alterando-se de acordo com as características dos recursos. Entre humanos, há recursos considerados de livre acesso, propriedades comuns, privadas e estatal (Tabela 2), além da existência de todo um gradiente entre estas categorias (Berkes *et al.* 2001, Feeny *et al.* 1990).

As formas de acesso ao recurso são mais claramente abordadas no Capítulo II desta tese. Assim como os modelos de forrageio, entender os padrões de acesso a recursos entre grupos humanos tem implicações práticas para se desenvolver, alterar e adaptar as práticas de manejo (Berkes 2006). A abordagem da teoria dos “Comuns” começou pelo famoso artigo “The Tragedy of the Commons”, escrito por Garrett Hardin em 1968. De acordo com Hardin (1968), se não fosse por meios da propriedade privada ou estatal, os recursos seriam inevitavelmente consumidos à sua exaustão, já que o recurso poupado por um seria utilizado por outro. Ou seja, na ausência de um sistema de propriedade que limite a exploração, o indivíduo tem incentivos para utilizar o recurso da forma mais rápida possível. Como cada indivíduo compartilha a mesma lógica egoísta, o resultado é um fracasso coletivo.

Entretanto, muitos exemplos de comunidades locais que se organizam para controlar o acesso aos recursos, através de normas, restrições ao uso dos recursos impostas pela própria comunidade e mesmo a exclusão de usuários não pertencentes ao grupo começaram a surgir na literatura científica e ainda hoje vários exemplos são descritos, assim como as causas que levam a adoção de uma ou outra forma de manejo comumitário (Pomeroy *et al.* 2001, mas veja também Finlayson & McCay 1998 para exemplos de insucesso deste tipo de manejo). Ostrom (1990) mostra que em muitos casos o manejo exercido pela comunidade (*community-based management*) é mostrado como exemplo de sucesso não porque eles conseguem realmente conservar o recurso, mas porque perduraram diversas crises. Isto sugere a existência de sistemas resilientes[2], com adaptações e mudanças ocorridas através de cada crise (Folke *et al.* 2002). O fato de existirem tantas formas de se controlar o acesso ao recurso (Tabela 2) não implica na não existência do recurso de livre acesso, o qual tem muito mais probabilidade de sofrer a Tragédia dos Comuns. Por outro lado, o fato de um determinado recurso ser de livre acesso não implica que outras formas de manejo não possam ser alcançadas, seja por iniciativas próprias das comunidades ou conjuntas com órgãos de instâncias governamentais ou sociais, como ONG’s (Organizacoes Não Governamentais) (Nathanael & Edirisinghe 2002). A

[2] Resiliência é a capacidade de um ecossistema de absorver mudanças e ainda persistir. É uma forma de medida da flexibilidade do sistema para manter sua estrutura e funcionamento (Berkes *et al.* 2001).

literatura sobre os recursos comuns mostra que regimes de propriedades e regras estabelecidas e reguladas coletivamente surgem em situações em que há uma alta dependência do recurso ou quando este é muito limitado (por exemplo, devido à sobre-exploração) (Ostrom 1990). Algumas vezes, a natureza do problema exige soluções comunitárias e de alta adesão por parte dos membros, pois as individuais são insuficientes (Berkes *et al.* 2006).

Pesca e o uso de Conceitos Ecológicos Comportamentais e Evolutivos

A pesca tanto artesanal quanto industrial tem servido como modelo de estudos para diversos dos conceitos de ecologia comportamental e evolutiva (Whitehead & Hope 1991). Não sem razão, uma vez que mesmo quando realizada em escalas comerciais e industriais o padrão comportamental do pescador é, a grosso modo, o mesmo padrão de atividade exibido em uma escala de subsistência (e.g: procura da presa - peixe, permanência em manchas de recurso, deslocamento entre manchas, troca de informações, disputa pelo domínio de áreas produtivas). (Abrahams & Healey 1990, Beckerman 1983, Ruttan 2003).

A pesca tem sido constantemente investigada através de abordagens ecológicas que se complementam no seu nível de análise (Castro 2004). Por exemplo, muito embora modelos como forrageio ótimo preocupam-se com decisões individuais, estas são afetadas por níveis de organização mais elevados, tal como a família. O forrageador humano, neste caso o pescador, raramente vai pescar apenas para si próprio, mas vai também em busca de alimento para seus filhos, esposas e demais parentes. Os motivos para isto, embora citados brevemente quando da definição de seleção de parentesco e altruísmo recíproco, fogem do escopo desta tese (Gurven *et al.* 1985, Kaplan & Hill 1992). Não somente suas decisões são afetadas por suas necessidades familiares, como elas também têm conseqüências em esferas que atingem níveis ainda mais elevados, como a comunidade em que vive, na medida em que tais decisões vão resultar em comportamentos que explorem o peixe de modo sustentável ou não, afetando a todos aqueles que dependem dele (Aswani 1998).

Da mesma forma, o problema dos recursos de propriedade comum está tão intrinsicamente relacionado à pesca que é até mesmo conhecido como o “problema dos pescadores” (Berkes 2006). A pesca, especialmente a industrial, é tida como de livre acesso, respeitados (mas nem sempre) apenas os limites fronteiriços entre países (Miller 2000). O que um pescador não pescar hoje será capturado por um outro amanhã, prevalecendo a lógica individualística (Berkes *et al.* 2006). No entanto, a própria natureza agregada do recurso pesqueiro favorece, em alguns casos, a evolução de territórios ou de formas de apropriação do espaço de pesca (*pesqueiros*) (Begossi 2004). Este é um tópico bastante complexo, na medida em que envolve uma variedade de formas de apropriação, que vão desde a existência de práticas como respeito e trocas de informação até o fechamento da área com exclusão de pescadores de fora (Cordell 1978, McGrath *et al.* 1993). Além disso, a forma de apropriação, excluindo-se a ação estatal, pode se dar tanto no nível individual, com pescadores específicos possuindo suas próprias áreas, quanto comunitário, com pesqueiros pertencentes a todos que fazem parte do grupo em questão (Begossi 1998, McGrath *et al.* 1993).

Assim sendo, o conteúdo desta tese permeia os conceitos ecológicos destrinchados ao longo desta introdução, mas tendo a pesca como objeto de estudo, uma vez que esta se apresenta como uma situação adequada e completa para a análise de diferentes tópicos em ecologia comportamental e evolutiva.

OBJETIVOS

Objetivos Gerais

Esta tese aborda pontos distintos, mas intrinsecamente relacionados à questão da pesca na comunidade da Praia do Perequê, Guarujá, SP. A pergunta inicial era o quão artesanal, em termos de petrecho, tempo dedicado a pesca e importância para a subsistência, esta pesca ainda seria em relação aos grupos pesqueiros já estudados no país, especialmente demais comunidades caiçaras. Respondido este ponto, as perguntas subseqüentes visariam explorar a intensidade desta pesca e o quão comercial (dentro da definição de pesca de pequena escala) ela seria, já que este ponto define a importância em se adotar e o tipo de estratégia de manejo a ser adotada para o local. Para isto foi utilizada uma abordagem interdisciplinar, na qual a pesca é estudada sob a sua perspectiva sócio-econômica (caracterização dos pescadores, análise institucional dos regimes de propriedade) e biológica (dinâmica da pesca e análise comportamental). Baseado nisto, os objetivos gerais podem ser assim colocados:

1. caracterizar a pesca local, através da descrição dos dois principais sistemas de pesca (rede de espera e arrasto de camarão), abordando conjuntamente aspectos ambientais e sócio-econômicos. Dentro deste objetivo inclui-se toda a descrição da frota pesqueira, das características ambientais e do sistema econômico gerado pelo comércio de peixes e camarão realizados localmente.
2. investigar o processo de tomada de decisão por parte do pescador participante em um dos dois sistemas de pesca (de peixe ou de camarão), através da análise do seu esforço de pesca, fatores ambientais que o levam a pescar ou não e mudanças sazonais que influenciam estas decisões. A análise do processo decisório inclui ainda uma análise do sistema de acesso ao recurso (territorialidade ou acesso livre) e os conflitos gerados pelo atual sistema.
3. analisar o comportamento de pescadores, através de modelos ecológicos de forrageio ótimo, considerando não apenas a busca de alimentos em função do seu retorno calórico, mas também em função de seu retorno financeiro.

Objetivos Específicos

De forma específica, esta tese investigou as seguintes perguntas ou hipóteses dentro de cada capítulo:

1. Estrutura ecológica, econômica e social da pesca (Capítulo I)

a) Camarões e peixes são os principais recursos no Perequê. No entanto, o Perequê é uma comunidade mista em que pescadores caiçaras, reconhecidos pela alta dependência do peixe como forma de subsistência (Begossi 1996a, Silvano 2004), mesclam-se a pescadores provenientes da região sul do país, na qual a pesca do camarão tem alta importância econômica (Branco *et al.* 2006, Seixas & Troutt 2003). A principal pergunta a ser respondida neste capítulo é o quanto esta comunidade ainda se insere num contexto de pesca de pequena escala, com poucas variáveis econômicas relevantes, de forma ainda a se assemelhar à comunidade caiçara original ou o quanto a entrada de migrantes dominou o contexto local da pesca e suas relações econômicas.

2. Processo de tomada de decisões (Capítulo II)

Uma vez identificado o caráter comercial da pesca do Perequê e a importância da pesca do camarão na definição da comunidade local em seus aspectos econômicos, algumas hipóteses que dizem respeito a esta situação específica surgem.

a) Na medida em que prevalece o interesse comercial na pesca, espera-se que o pescador explore ao máximo seu recurso, não visando apenas a subsistência. Com isto espera-se por exemplo que ele busque a compensação de suas perdas durante períodos de restrição (ex.: defeso, situações ambientais adversas), através da intensificação da pesca.

b) A existência de migrantes disputando o mesmo espaço de pesca e fazendo uso do arrasto de camarão deve levar a conflitos no acesso ao recurso. Os conflitos não devem se dar pelos recursos em si, já que se tratam de recursos distintos (camarão e peixe), mas sim pelo espaço. Uma vez confirmada esta hipótese, resta ainda a pergunta sobre a possível existência de limitações e normas locais estabelecidas entre os dois grupos.

3. Forrageio Ótimo num contexto econômico (Capítulo III).

a) Em função de um caráter mais comercial da pesca detectado durante o desenvolvimento dos capítulos anteriores, espera-se que ambos os grupos de pescadores busquem a otimização de seu retorno financeiro e não apenas calórico. A maximização calórica é possível, mas espera-se que ela ocorra somente quando quantidades capturadas estiverem positivamente relacionadas aos lucros obtidos através da venda do produto, o que nem sempre é verdade em função da variação de preços e demandas de mercado.

Área de Estudo

A planície litorânea, onde se localiza o município do Guarujá (SP), domínio da Floresta Tropical conhecida como Mata Atlântica, compreende um mosaico de diferentes tipos de vegetação, incluindo formações não florestais (formações arbustivas de dunas, restingas e mangues) e florestais (ombrófila densa, ombrófila mista e estacional semidecidual) (Heringer e Montenegro 2000, Assis 1999). Segundo a classificação de Koeppen (1948), o clima da região é do tipo AF, tropical chuvoso, com diminuição da pluviosidade durante o inverno, sendo que a temperatura do município em questão pode variar de 11 a 35ºC.

O município do Guarujá localiza-se na Ilha de Santo Amaro (23°59'S/46°15'W), limitando-se ao norte com o canal que separa Santos e Guarujá (Canal de Bertioga), a oeste com o canal do estuário de Santos, e ao sul e a leste com o Oceano Atlântico. Sua área total é de 139 km^2 (mapas podem ser vistos nos Capítulos I e II). O relevo acidentado, com morros com altitudes médias entre 130 e 160m, atingindo até 300m, dificultaram a ocupação no início do período de colonização. A hidrografia da ilha é marcada por rios de pequena extensão, como os rios Santo Amaro, Crumaú, Icanhema, do Meio, Perequê, da Pouca Saúde, entre outros. Apesar da ocupação urbana referente ao último século, especialmente pela alta sociedade paulista, ter se dado pela orla em função do potencial paisagístico, as áreas mais afastadas passaram a ser intensamente povoadas a partir de Santos (famílias que saíram dos morros de Santos) e também por famílias vindas do interior e de outros Estados (Jakob 2003).

A praia do Perequê, localizada ao norte da Ilha de Santo Amaro, está no interior de uma baía e tem a sua frente algumas pequenas ilhas, que contribuem para o mar calmo, que favorecia no passado um tipo de pesca bastante comum em comunidades caiçaras, o arrasto de praia, e hoje favorece o arrasto de camarão. O presente estudo foi realizado na região central da praia (aproximadamente dois quilômetros de extensão), ocupada pelos pescadores, embora o bairro do Perequê se estenda por cerca de mais dois quilômetros de área intensamente habitada, chamada localmente de "vila" ou "invasão", já que se constitui de fato numa área invadida mais recentemente. Embora alguns moradores desta área invadida dependam da pesca, esta não é a principal atividade econômica local, motivo pelo qual optou-se por restringir a amostragem à região central. Aproximadamente oito mil pessoas habitam o bairro como um todo, e cerca de 300 famílias moram na região delimitada para o estudo. O número de pescadores foi estimado pela Colônia de Pescadores local (Z-23) em 200, mas provavelmente é bem superior a isto, se forem considerados aqueles que pescam mais esporadicamente como ajudantes de pesca e que não são oficialmente cadastrados. A área de estudo será apresentada em maiores detalhes ao longo dos capítulos.

METODOLOGIA

Ao longo de toda a tese serão utilizadas de forma complementar informações mais ou menos entremeadas de três diferentes métodos de coleta de dados, a serem detalhadas em cada capítulo. O primeiro deles foi um conjunto de entrevistas semi-estruturadas realizadas com a ajuda de uma mestranda que também coletava seus dados na área, Arlaine Francisco, nos meses de maio e junho de 2004 (Anexo 1). Nesta primeira etapa, 51 pescadores (14 pescadores que utilizam redes e 37 camaroeiros) foram entrevistados. Estas foram entrevistas bem detalhadas que trouxeram uma série de informações relevantes agrupadas no primeiro capítulo desta tese e que também ajudaram a nortear o desenvolvimento da pesquisa de campo posterior. As questões desta primeira entrevista abordaram as características sócio-econômicas do pescador (idade, escolaridade, família, renda, etc.), os equipamentos de pesca individual (tipo de barco, motor, rede, etc.) e os principais aspectos da pesca (principais espécies almejadas, técnicas de pesca, época de captura das principais espécies, tipo de comercialização, etc.) (Anexo 1).

Os desembarques pesqueiros foram acompanhados por mim ao longo de 13 meses consecutivos[3] (Anexos 2 e 3). Os desembarques de peixes, muito mais esporádicos, eram amostrados no período da manhã e no fim da tarde, enquanto os desembarques de camarão sempre ocorriam a partir das 15h, podendo se estender até às 21h. Os peixes, por virem sempre em menor quantidade, foram quase sempre pesados por mim (algumas vezes o peso foi estimado pelo pescador), incluindo os peixes vindos como fauna acompanhante nos desembarques de camarão. Já o camarão foi sempre pesado nas salgas (fábricas de processamento do camarão), já que o pescador chegava e ia diretamente vendê-lo. Como era comum a chegada de vários pescadores ao mesmo tempo, que comercializavam o seu produto em diferentes salgas, nem sempre era possível observar a pesagem. Neste caso, o pescador mostrava o seu registro de venda do camarão (não era solicitado que mostrassem, eles o faziam para checar a quantidade exata antes de responder). Quantidades menores de camarão doadas ou retiradas para consumo eram pesadas por mim ou tinham seu peso estimado pelo pescador.

Além das quantidades de pescado, os pescadores também respondiam a uma entrevista estruturada sobre seus horários de partida e chegada, local de pesca, gastos com combustível, gelo e manutenção, valor pago pelo quilograma de produto, além de perguntas específicas a cada tipo de pesca, tais como número de arrastos no caso dos camaroeiros, e quantidade e tamanho de redes empregadas, malhagem e horários de checagem das mesmas, no caso dos pescadores que utilizavam redes, dentre outras (Anexos 2 e 3).

Ademais, 21 viagens de pesca de camarão foram diretamente acompanhadas ao longo de 2005 e 2006 por mim (apenas duas) e, principalmente, por Allan George Ferreira, então aluno da graduação da Universidade Estadual de São Paulo, campus de São Vicente. Durante estas

[3] Os desembarques de camarão não foram amostrados durante o período de defeso, entre março e maio de 2005. Não houve pausa na amostragem dos desembarques de peixe.

viagens foram demarcados os principais pontos de pesca com auxílio de um GPS, além de ser acompanhado o trajeto realizado pelos pescadores, as quantidades de pescado capturadas, a duração de cada arrasto e o número de arrastos realizados por viagem (Anexo 4).

Em fevereiro de 2007, dois grupos contendo três pescadores de peixe e quatro pescadores de camarão respectivamente receberam cópias de cartas náuticas simplificadas (mas com as isóbatas mantidas) apenas do trecho compreendido entre a Praia da Enseada (ao sul do Perequê) e Boiçucanga (praia na região sul de Bertioga). Este recorte foi escolhido por incluir todos os pontos de pesca que haviam sido amostrados ao longo dos 13 meses de coleta. Os pescadores então demarcaram os principais pontos de pesca (camarão e peixe) e trechos de arrasto de camarão, gerando etnomapas (Seixas 2005). Estes etnomapas foram utilizados de forma complementar aos pontos georreferenciados anotados durante o acompanhamento das viagens de pesca.

ESTRUTURA DA TESE

Esta tese está dividida em três capítulos em formatos de artigo científico. Optou-se por escrevê-los em inglês para facilitar o processo de correção e submissão dos mesmos para periódicos internacionais. No entanto, por se tratarem de capítulos independentes, mas que possuem aspectos em comum, tais como a área de estudo e parte da metodologia, alguns pontos serão redundantes ao longo dos três capítulos, mas as peculiaridades de interesse a cada um serão ressaltadas. Cada capítulo aborda um dos objetivos da tese.

Desta forma, o primeiro capítulo aborda a estrutura da pesca, definida por suas características sócio-econômicas e ecológicas, utilizando basicamente os dados coletados através das primeiras entrevistas semi-estruturadas aplicadas. O foco está no contexto sócio-econômico da pesca, os ganhos provenientes da mesma e a organização da comunidade em torno desta atividade. O segundo capítulo versa sobre os processos de tomada de decisão e o acesso e apropriação dos recursos pesqueiros. Para tal, são utilizados os dados de desembarque e do acompanhamento da pesca. O último capítulo, assim como o segundo, se baseia numa abordagem comportamental, fazendo uso da Teoria do Forrageio Ótimo e levando em conta aspectos financeiros além dos aspectos nutricionais. As Conclusões Gerais buscam os pontos conclusivos de cada capítulo e tentam analisá-los de forma integrada.

Tabela 1 – Breve definição de alguns dos conceitos evolutivos empregados no texto (Hamilton 1964, Irons & Cronk 2000, Trivers 1974).

Conceito	Definição
Seleção Natural	É o processo no qual características herdáveis favoráveis se tornam mais e mais abundantes em populações sucessivas de indivíduos com reprodução sexuada, enquanto as desfavoráveis se tornam menos abundantes. A seleção natural atua no fenótipo (características visíveis do indivíduo). Indivíduos com fenótipos com características desejáveis têm maior chance de sobreviver e se reproduzir.
Adaptação	Refere-se a uma característica positiva apresentada por um indivíduo que foi selecionada pelo processo de seleção natural, tornando-o mais adequado ao ambiente em que está. Evidentemente, trata-se de um processo de longo prazo.
Fitness – Valor adaptativo	Descreve a capacidade de um indivíduo que tenha um certo genótipo de se reproduzir. Quando se fala em valor adaptativo inclusivo, considera-se também o fato de que genes não são exclusivamente passados através de descendência direta (de pais para filhos), mas também através de parentes, os quais compartilham mais ou menos genes de acordo com o grau de parentesco.
Altruísmo recíproco	É uma forma de altruísmo na qual o indivíduo espera que o beneficiário da boa ação retribua-a se e quando necessário. Não fazê-la implica em suspensão de ações altruísticas futuras e, algumas vezes, em punição, tal como o ostracismo em populações humanas.
Seleção de Parentesco	Indivíduos vão muitas vezes agir de forma a favorecer o sucesso reprodutivo de seus parentes, mesmo que às vezes isto se dê às custas de sua própria reprodução ou sobrevivência. Isto se dá pois, conforme explicitado em "Valor Adaptativo Inclusivo", parentes compartilham genes em maior ou menor grau e a seleção de parentesco também será tão mais intensa quanto maior for o grau de proximidade entre os parentes.

Tabela 2 – Os diferentes regimes de propriedade de acordo com a definição de Berkes 1989 e Feeny *et al.* 1990

Regime de propriedade	Definição
Acesso livre (*Open Access*)	Acesso aos recursos não é regulado, todos podem utilizá-los.
Propriedade Privada	Indivíduo ou grupo de indivíduos tem o direito de regular o acesso aos recursos. O direito ao uso é geralmente exclusivo e transferível, sendo que normalmente tal direito é garantido pelo Estado.
Propriedade comum (*Common Property*)	Os recursos são controlados por uma comunidade cujos usuários são conhecidos. A comunidade controla o acesso por parte de pessoas de fora, enquanto os que fazem parte têm direito teoricamente ao acesso livre e igualitário. Os direitos comunitários podem ser legalmente reconhecidos pelo Estado ou simplesmente baseados na tradição (*de facto*).
Propriedade estatal	O direito de acesso aos recursos pertence ao governo,o qual por sua vez decide quem pode utilizá-los e como.

CAPÍTULO I

Artisanal commercial fisheries at the southern coast of São Paulo State, Brazil: ecological, social and economic structures

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Running title: Brazilian artisanal commercial fisheries.

Abstract

We analyzed a case study where a fish-oriented community in São Paulo coast (SE Brazil), is being replaced by southern shrimp trawlers. Focusing on their current social-economic characteristics we describe the two fishing systems, gillnet and shrimp trawl fisheries. We found out that local fishermen (n=51) have a high average income compared to other Brazilian fishermen (R$1.370,00 ± R$821.00), explained by the fact of them having secondary jobs. Fisheries are not as multi-specific as tropical fisheries use to be, as they target at only 17 species (Shannon *H'*=2.31) being two shrimp species. The family is the main unit of production for trawlers, but gillnetters work on their own. The local economy is commanded by the shrimp processing plants. Fishermen (49%) explain the southern migration as a consequence of a former shrimp fail in their original region. Management measures are necessary if negative environmental and social consequences brought about by a new shrimp fail are to be prevented.

Key words: small-scale fishery, shrimp fishery, gillnet fishery, Brazilian coast, fishery management, coastal fisheries.

Introduction

World overfishing is not a recent concern. Since the 1970s, fisheries scientists and different institutions (e.g.: Food and Agriculture Organization) have been alerting the world about current and future problems with the decline of important fish stocks (Myers *et al,.* 1997; Pauly *et al.,* 2002). This is relevant for South America, where fisheries have been playing an important role in economy and food security. Fisheries production has been increased quite steadily from 1950 onwards (time series on FAO FISHSTAT, FAO, 2002) in the region, but with an important fail during the 1970s due to the Peruvian anchoveta (*Engraulis ringens*) collapse (Klyashtorin, 2001). In Brazil, fisheries production accounts for more than 50 percent of the fish landings (Cetra & Petrere, 2001), contributing with 40-60% of marine fish production (Diegues, 1999), and employing more than 390.000 fishermen (SEAP, 2007), who usually inhabit economically poor and small communities. It is evident that a fail in this fishing system would result in drastic consequences for thousands of families whose subsistence and small-scale economy are completely dependent on aquatic resources.

In São Paulo coast, fisheries are practiced in different scales, from the subsistence to the industrial level. Many studies have approached the role of the "caiçara" fishing, referring to communities originated from the miscegenation of indigenous and Portuguese who inhabit the Brazilian Atlantic Coast, especially the Southeast (Begossi, 1996; Nehrer & Begossi, 2000; Ramires & Barrella, 2003). These communities used to base their economy on artisanal fisheries, and, in a second instance, during periods of economic stagnation, on slash-and-burn cassava cultivation (Adams, 2000). They are usually technologically limited, using paddle or motorized canoes or aluminum boats, which restrict how far they can go fishing (Begossi, 2006a). As a consequence of exploiting close fishing spots, some of them have evolved an informal marine tenure system in different places along the Brazilian coast that has been stable along the last decades (Begossi, 2001).

Currently, we observe two different tendencies in relation to Brazilian small-scale fisheries. In some communities, fisheries are being reduced to subsistence, being displaced by real state development and tourism (Diegues, 2006; MacCord & Begossi, 2006). In others, fisheries are becoming more commercial (Masumoto, 2004), increasing the pressures over the local resources, usually without any scientific or management support (MacCord, *in press*).

Both social and economic organizations of fishermen are factors that can influence on the way they exploit the resources (Camargo & Petrere, 2001). Management decisions should consider the complex interaction network existent among physical, biological and social factors (Pomeroy, 1995). Fisheries management in place in Brazil is not commonplace yet, especially if one considers initiatives where users have the right to suggest measures. Even when such co-management arrangements take place, aspects such as insufficient knowledge of the economic system and non-congruence between different institutional scales, may cause such initiatives to fail (Kalikoski *et al,.* submitted), demanding a deep knowledge of the fishery system approached. However, achieving a sufficient knowledge of the dynamic of tropical fisheries is a hard task, given the complexity of nature and the multi-specific /multi-gear aspect of fisheries. Based on that, Johannes (1998) claims for a data-less management approach, where information comes from similar systems and from fishers as well. Special attention should be given to systems where the environmental impacts caused by the fisheries methods in place are known to be significant, as it is the case of bottom trawling (Jones, 1992).

In this study, we focused on a fishing community on the southern coast of São Paulo (Perequê) to accomplish two objectives, namely to build a profile of the ecological and social-economic aspects of this community trawl and gillnet fisheries and to undertake a preliminary assessment of the dynamics of these fisheries. The relevance of understanding such fisheries is crucial to the proposal of any future management alternative, as we do not expect similar management measures to work similarly for both fishing systems. By providing a characterization of the local fisheries and local fishing practices, we intend to offer some initial but broad support for local based management alternatives, as our study addresses a kind of tropical fishery where knowledge is scarce and alternatives for its rational exploitation are necessary.

Study site

Perequê Beach lies on the north of Santo Amaro Island (Guarujá municipality) (23°59'S/46°15'W) (Figure 1), in the Atlantic Forest Domain. According to the Fishermen's Organization estimate, about 8.000 people live in this neighborhood. The beach is in a bay sheltered by some small islands. Nowadays up to 200 hundred boats, especially bottom otter trawl boats, can be anchored close to the beach.

The first "caiçaras" to live in the place built their houses on the beach sand, close to small streams and rivers. The families that first arrived during the migration process occupied the remaining of the land, limited by the mangrove and the mountains. People who arrived during the 1990s built wooden house supported by sticks in the mangrove, which keep the houses above the regular water level. Such demographic growth was not followed by investments in infrastructure. The dwellers do not have sewage treatment, being the sewage discharged into the mangroves or into the streams. Despite such conditions, many dwellers say to prefer to live at the mangrove than on the land, since they can leave their canoes in front of their houses, making it easier to go fishing. As an outcome of such conditions, lack of hygiene and other health and social problems, such as violence and drug traffic, concern both tourists and local residents.

Methodology and Data analyses

We interviewed 51 fishermen in May and June, 2004, corresponding to 25% of the local fishermen, estimated by the Fishermen's Organization in 200 people. We interviewed all the fishermen older than 20, residing in Perequê for more than 10 years and who depended on fishing as their main economic activity. We used a semi-structured questionnaire containing questions about their social-economic features (age, birth place, educational level, family features, etc.) and about fishing, such as equipment used, main species caught and their last fishing trip (Annex 1). The existence of two groups of fishermen was clear since the first interviews, one that uses bottom otter trawl (hereafter referred to as trawlers) to catch shrimp and the other that uses gillnets to catch fish (hereafter referred to as gillnetters).

A *Multiple Regression (Stepwise, Backwards)* analysis was used to identify the variables that better explain the fishermen's average income (R), measured in Brazilian money, *Real* (1US$ = R$ 3.10 in May, 2004). The independent variables of the regression model were:

A = other activities besides fishing (yes/no); categorical variable.

H = engine power (hp); numeric variable.

C = boat length (meters); numeric variable

M = another fisherman help on the boat? (yes/no) (the interviews showed that usually fishermen fish alone or with just one helper); categorical variable

T = experience as a fisherman (years); numeric variable.

K = estimated amount captured in the last fishing trip (kg); numeric variable

This leaves the initial model as:

$R = u + A + H + C + M + T + K + H*M$, where u represents the equation intercept and $H*M$ the interaction between the length of the boat and the power of the engine. The interaction was initially used to check if the two factors together, boat length and engine power, were influencing fishermen's income.

We also tested in a first model if being a trawler or a gillnetter would influence in the result (type of fishermen = categorical variable). If so, we would not be able to consider both groups in the same regression model and we would need to consider specific variables for each group, such as net size for gillnetters. However, the result was not different and this variable was not proven to be relevant ($t = -0.5449$; $p = 0.59$).

Part of the data was grouped into: 1) social and 2) fishery fleet data and subjected to two *Discriminant Function Analyses*, followed by a *Canonical Analysis*. These analyses would show if trawlers and gillnetters have enough distinct features to be considered different groups when considering their social aspects or fleet characteristics. The variables included in the social analysis were: age, having a secondary job, experience as a fisherman, literacy, state of origin, marriage and average income. Having another job and being married are binary categorical variables, meaning that only yes or no answers were allowed in the model. The fleet analysis included boat length, engine power (numerical variables) and if the boat was owned by the fisherman (binary variable).

Results

Bottom otter trawl (towed by a single boat) is practiced by 73% (37) of the interviewees while gillnets (mainly set gillnets but also driftnets) is used by 23% (14). Most *caiçara* fishermen were gillnetters (68% of 23) while people who came from the Brazilian south were trawlers (95% of 21), as they used to perform this same kind of fisheries in their original region. However, some *caiçaras* gillnetters have all the equipment to trawl (23%) and claim to switch to this activity when gillnet fishery is not profitable, while 11% of the trawlers said to use hand lines sporadically. Instead of switching to a different method, trawlers switch their nets for a bigger mesh size one, if they think there is some chance of catching the high-valued white shrimp (*Penaeus schimitti*).

Socio-economic characterization of Perequê artisanal fisheries

The 51 fishermen interviewed aged from 23 to 61 years old (average = 41 ±11), skewed toward old ages, and half of them (24) were born in São Paulo State (Figure 2). The average time living in the region for the ones that were not born in Guarujá was 22 years (±11.3) (n=32). About half (51%) of these migrants came to Guarujá searching for better job conditions, especially due to the shrimp fail in the south, according to the fishermen (49%) or came with their parents (30%), as their parents were also looking for better job conditions. Perequê's fishermen have been fishing for a long time (25.78 years ± 12.45), even when it is only considered the time fishing on the area of the study (20.26 years ± 12.04).

Fishermen's monthly income was difficult to be estimated due to its high variability. Some fishermen received unemployment benefits paid by the government (R$ = 260,00 on May 2004) during the shrimp closed season, others did not. Most of them also worked to recreational fishermen on the weekends, renting their boats and taking tourists to the best fishing spots (R$ 150 to R$ 200/day). Considering all these additional aspects, the average income value was roughly estimated in R$ 1,370.00/month (SD = ± R$ 821.00; Range: R$ 100.00 to R$ 4,500.00), a high value for Brazilian patterns, even when compared to the average value of São Paulo state, the highest income state of the country (R$ 912,50 in IBGE, 2004). Trawlers had a slightly higher average income (R$ 1439.00) than gillnetters (R$ 1118.00), but this difference was not significant (Mann-Whitney U = 197.5; p = 0.19). The regression model showed that 22% of their income was explained by having complementary jobs and by the boat length ($R = 770.81 + 296.96A + 64.38C$, $r^2=0.22$, $p < 0.01$, g.l.=50), showing the importance of diversifying (getting a second job) and intensifying (having a bigger boat) their economic activities.

The majority (72%) of the families were counting on some other member's income besides the fisherman's, which represented about 29% of the families' income (R$ 394,00 ±R$260,00). This contribution was usually done by the wife, who would work either in the shrimp processing plants or in the fish stores. Fishermen's older sons would usually work in the local sea food restaurants, suggesting an economy totally based on fisheries. About 33% of the fishermen also counted on the direct support of their sons who sporadically fished with them to learn the work and to help them out in the shrimp season. Daughters and wives would clean the shrimp out at home, if the fishermen believed they could sell their product for higher prices than the ones practiced by the shrimp processing plants or fish stores.

The two fishermen's group were separated in the *Discriminant Analysis* by features as fishermen age (gillnetters are older), the practice of another activity besides fishing (trawlers usually work on the weekends for recreational fishermen) and experience as a fisherman (trawlers has less experience). Literacy, marriage, average income and, surprisingly, state of origin were not enough to be included in the significant model. Even being significant, the model shows that the two groups overlapped (overlapped curves) concerning such aspects, resulting in a high Wilk's lambda, with a low overall discriminant power (Wilk's λ = 0.712; F (3.47) = 6.33; p = 0.0011; eingenvalue = 0.404) (Figure 3). However, part of this overlap might be attributed to high heterogeneity within gillnetters, as can be seen by the two peaks observed in Figure 3.

Fleet characterization and resource extraction

Almost all the fishermen (82%) had their own boats, which were usually small (average = 8.8m) (Figure 4). There was no difference in the size of the boats used by trawlers and gillnetters (t=1.75; p>0.05). Motor engines range from 10 to 90 hp, with the majority (64%) lying between 18 and 22 hp (average = 25hp). Shrimp boats have usually more powerful engines (Mann-Whitney = 95.5; $p < 0.05$), as they are constantly used when trawling. The size of the boat is correlated with the engine power, regardless if it is used for fish or shrimp fishing ($r_s = 0.75$; $p < 0.0001$).

The fleet data Discriminant Analysis could not separate clearly trawlers and gillnetters, suggesting again that both groups share many features. However, the model was still significant, showing that both the boat length and the fact of being the owner of a boat were relevant features to separate the groups (Wilk's λ = 0.84; F (1.48) = 4.53; p = 0.016; eingenvalue = 0.404) (Figure 5).

Some interviewees were either not working during the sampling time (12%) or working for other fishermen (20%) in a profit/expense-sharing arrangement. Shrimp processing plants could also be the owners of these boats. Among the ones who have their own boats (n=38), 33% have helpers, who are mainly relatives (other than wives and sons) (71%) included in the profit/expense-sharing deal. A gillnetter, regardless of his return, would always need someone to help him, due to the size of the nets used.

Local fishermen targeted a few species (n=17), even when considered the diversity caught by both fishermen's group (Shannon *H'*=2.26; Evenness = 0.80) (Table 1). However, both fishermen groups would end up bringing a more diversified catch due to bycatch, low method selectivity, or just because different species can be grouped under the same name (e.g.; shark), with this final product eventually entering the market chain. The species that were cited for more than five fishermen as their main target are listed in Table 1, with their main fishing season and gear used in their capture.

Initial estimates based on their catch in the last fishing trip, suggested a high average fish and shrimp return but also highly variable (Shrimp = 110 kg ± 126 kg; Fish = 80 kg ± 106 kg). Such high return can be attributed to sea bob shrimp (*Xyphopenaeus kroyeri*), mackerel (*Scomberomorus brasiliensis*) and mullet (*Mugil platanus*), which are also the most unpredictable fishing resources (high standard deviation) (Figure 6). The diversity index calculated for the amount of fish and shrimp caught in the fishermen's last fishing trip shows a low value for both groups of fishermen (Shannon H'_{shrimp}=1.53; Evenness = 0.67 ; Shannon H'_{fish}=2.26; Evenness = 0.91).

Most fishing trips take place close to the Perequê beach, in the region that comprehends the municipality of Guarujá and a nearby northern town, Bertioga. Trawlers fish in Bertioga region a few times a year, when, according to them (84%), they follow the shrimp migration. In these rare distant trips, fishermen keep fishing for a week before returning home. Gillnetters said to perform most of the fishing trips outside Perequê Beach and even when fishing in closer beaches, they would prefer to stay anchored there and to sell the fish where they were in order to save money that would be spent in oil otherwise. The gillnetters that go on a one-day fishing trip (n=14) said to sell their product to the fish stores in Guarujá (37.5%), restaurants and beach kiosks (62.5%) or commercialize it from home (19%), when in small amounts.

Shrimp was mainly sold to the shrimp processing plants (according to 86% of the 37 trawlers). Trawlers that had their own boats could switch their buyers based on the opportunity costs, looking for better deals. However, trawlers affirmed to be loyal to their buyers, sporadically accepting better offers if they were made on the beach when they arrived, either by costumers or by commercial buyers. With the exception of fishermen that worked for a boat owner, all of them said to commercialize the white shrimp with no middleman. This shrimp is caught in smaller amounts and reaches up higher prices, being more advantageous to sell it to individual customers or restaurants (R$ 12,00 to R$ 30,00/ kg in 2004, prices gathered on local markets).

Discussion

Fisheries practiced on this region of São Paulo coast is differentiated from some others practiced by Brazilian small coastal communities, which are usually marked by local populations with old roots and land ties. This can be seen in the higher income level (about five minimum wages; one minimum wage=US$108,00 in May 2004) in comparison to other fishing communities where this value varies from US$165,00 to US$282,00 (between two and 3.4 minimum wages in May 2004) (Hanazaki, 1997). However it is worth considering that typical fishing communities in Brazil usually gather and harvest other resources in their environment, which certainly contributes to the decrease of the family's expenses, while Perequê's inhabitants harvest no more than their animal protein from the sea. Their better wages are due to the still relatively high shrimp production and to the opportunity of working to the recreational fishermen during the weekends. Such attractive incomes in relation to other coastal communities help to explain why people still move to the area.

Brazilian coastal fishing communities are usually smaller and composed by related families who inhabit the same places for many generations and use more rudimentary fishing methods, resulting consequently in a smaller scale fishery (Begossi, 1995; Hanazaki & Begossi, 2000; Mendonça *et al.,* 2000; Ramires & Barrella, 2003). This makes Perequê more similar to other urban fishermen, such as the ones that we can still find in Rio de Janeiro city (Nehrer & Begossi, 2000). The flux of fishermen to the area certainly shaped the community profile and probably contributes to the observed lack of community cohesion. There is no consistent political organization. Despite the fact that fishermen's cooperative are usually seen in the position to make more equitable decisions and enforce more reasonable regulations than governments (Jentoft, 1989), Perequê's local association is apparently distrustfully seen by the fishermen (based on informal talks with fishermen).

In some western African countries, fishermen's migration occurs over country borders (Diaw & Haakonsen, 1992). In these places, there are some attempts to recognize that fishermen not always follow political boundaries. This can result in positive consequences, such as the production and supply of animal protein, the creation of employment and technological progress, but also in negative outcomes, such as conflicts and political prejudice, when such fishermen are subjected to different laws for being foreigners (Diaw & Haakonsen, 1992). In a case study about the Ghanaian canoe fisheries, it was shown that migration is not only the consequence of local overfishing, but economic (e.g. life costs) and political (e.g fuel subsidies) circumstances (Overa, 2000). Even though cross country migration is not the same as migration between the states of a same country, they are indeed comparable as long as Brazil shows large social and cultural discrepancies between its regions.

Kinship ties are apparently important to define how Perequê fishermen work. Families are the basic unit of production and they are totally dependent on shrimp in the case of the shrimp trawlers. The contraposition is made by the gillnetters' families, whose sons also work as fishermen's helpers, but the wives are usually housewives, although they used to be responsible for the cassava and other subsistence crops in the past (Marcílio, 1986).

Diversification through greater economic flexibility may be a resilient alternative to external changes, such as the ones brought about by migration and its associated technological changes in fisheries (Begossi, 2006b; McCay, 1978). By adapting to new situations, these groups can partially keep the characteristics that define them. On the other hand, there is also intensification of fisheries through more efficient methods, which can reduce the resilience of the system by focusing solely on one activity: fisheries. This is also true for example for some northern coastal communities from São Paulo (Picinguaba, Ubatuba), usually taken as traditional (Masumoto, 2004). Such small scale fishing communities use to target their fisheries at specific species, determining a low diversity index in relation to the subsistence fisheries observed in 'caiçara' communities elsewhere (Hanazaki & Begossi, 2000; Ramires & Barrella, 2003). In other countries, such as Bangladesh, Brunei Darussalam, Indonesia, Malaysia, Thailand, Sri Lanka, Vietnam and Philippines, the so considered artisanal fisheries use diversified technology aiming at multiple species, which does not necessarily imply in sustainable exploitation (Silvestre & Pauly, 1997). In Perequê, there are then two opposite processes that can lead to completely different outcomes. If, on one hand, diversification contributes to the resilience of the system, intensification certainly reduces it. The final result can be just observed in the long run, with the prevalence of one of the strategies.

Final considerations and management implications

The high dependence of the studied community on shrimp makes necessary the adoption of management strategies, considering that shrimp stocks have been extensively overexploited elsewhere in the country and also in the geographic region of this study (southeastern Brazilian coast) (D'Incao *et al.,* 2002; Leite Jr. and Petrere Jr., 2006). Despite that, fishermen mentioned and the researchers also observed that new fishermen are still settling in the place usually invited by their relatives that fish in the area. This is probably due to the lack of clear signs of stock decrease, as the productivity is still high based on their last fishing trip return, even though they claim that it has decreased along the years. This is likely to happen due to an increase in the overall fishing effort, not noticed by the community as a whole but perceived by some individuals.

The non adoption of management alternatives that protect the fisheries and, consequently, the fishermen, may result not only in overfishing but also in the collapse of this community. This situation is probably true for many other similar communities in Brazil and elsewhere, which base their economy solely on one product, as it is the case of the coastal and estuarine environments (bonga fish *Ethmalosa fimbriata*) and in the freshwater sector of Nigeria (catfish *Chrysichtys nigrodigitatus*) (Moses *et al., 2*002). Gómez *et al.* (2006) analyzed the causes for the decline of the artisanal fisheries in the northwestern Mediterranean, taking into account the same social-economic factors we considered here. The authors found out that trawling increased its relevance with the decline of other artisanal fishing methods. Unfortunately, they also showed that after a certain point, even the establishment of marine protected areas does not assure the reversal of poor artisanal fishing conditions (Gómez *et al.,* 2006).

Not acting to prevent such problems may lead to another human migration cycle as fishing resources are being locally overexploited. This special case presented here is tricky, we cannot rely on local practices because of the advent of southern migrants with their own habits. However, as pointed out by other authors (Overa, 2000), migration might be seen as a fishermen's strategy, whereby they try to make the best of a social, environmental and cultural condition, thus deserving further attention and deserving to be treated as part of the fishing dynamic. Through this rapid assessment, we could identify two distinct fishermen's groups, gillnetters and trawlers, who cannot be subjected to the same management measures, as they target different species and are involved in different economic schemes. It is also relevant to consider the information on time of the year that they exploited each species more intensively, as this might be related to biological abundance, species migration pattern and, in the case of sea bob shrimp, to the high productivity in winter soon after the opening of the closed season (between March and May in 2004). More attention should be given to the level of shrimp exploitation, which is apparently high in the region and non-effectively regulated in Brazil as a whole (D'Incao *et al,.* 2002). Other communities in Brazil and in other tropical countries could benefit of rapid approaches such as the one carried out here, which bring up a non-detailed but still thorough picture of fishing communities, where information is limited or non existent. Larger data series are indeed more appropriate to devise management schemes, but as pointed out by Johannes (1998), few data is still better than no data at all. The information gained from the social-economic analyses carried out here can certainly be used by government or any other interested institution to draw up plans for interventions following fishermen's local features and needs.

Acknowledgments

We are grateful to the Graduation Program in Ecology/UNICAMP for logistical support and FAPESP for supporting P. Lopes' thesis (04-07073-4) and A. Francisco's dissertation (04/11977-6). Finally, we thank all the Perequê's fishermen and their families for their collaboration and patience during this time.

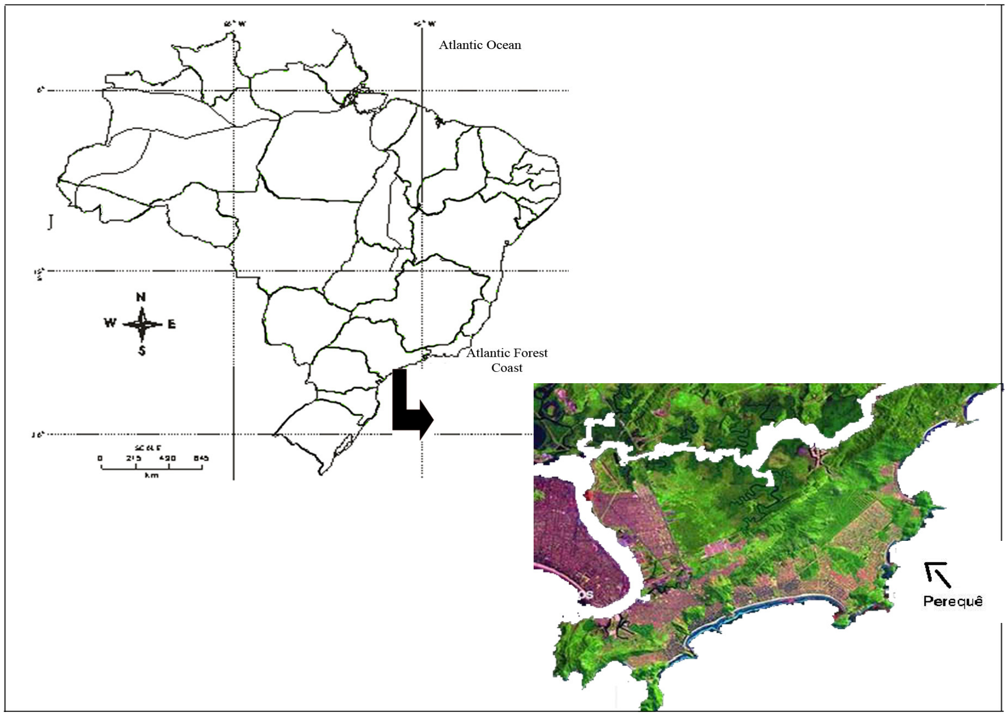

Figure 1 – Map of Santo Amaro Island, municipality of Guarujá, São Paulo State, Brazil, indicating Perequê beach, the studied site.

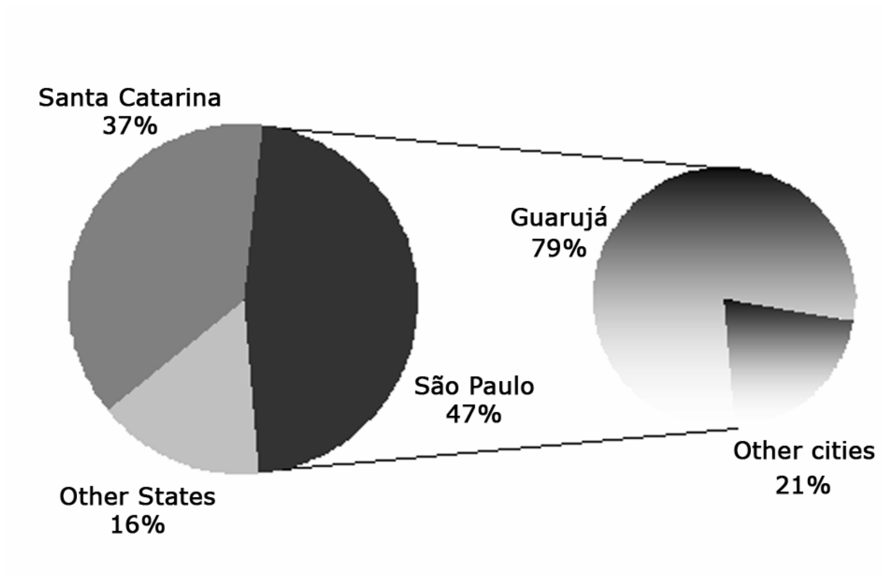

Figure 2 – Region of origin of the interviewed fishermen (n=51)

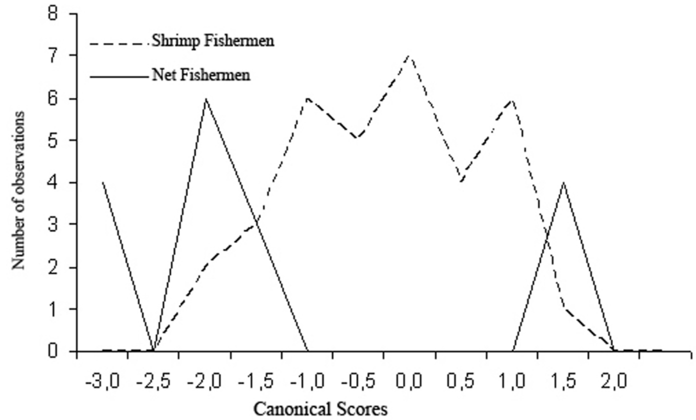

Figure 3 – Canonical scores distribution for trawlers and gilnetters' social data. The more the canonical scores are overlapped the more similar the groups are (n.

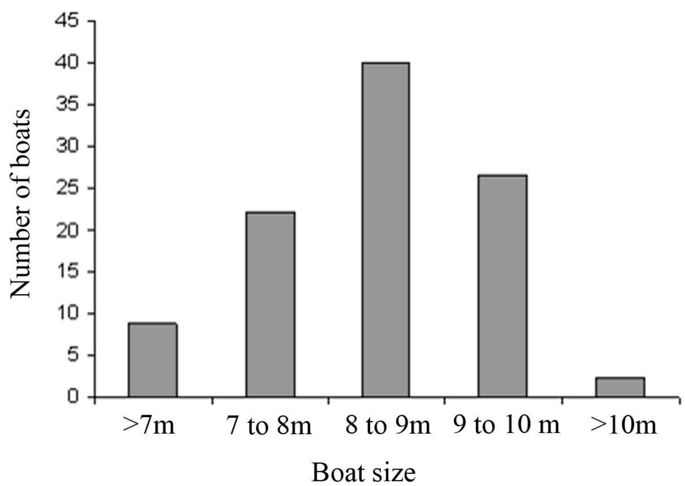

Figure 4 – Frequency distribution of boat sizes used in the net and shrimp fishery (n=44 boats). Three fishermen had two boats each, while the remaining had just one.

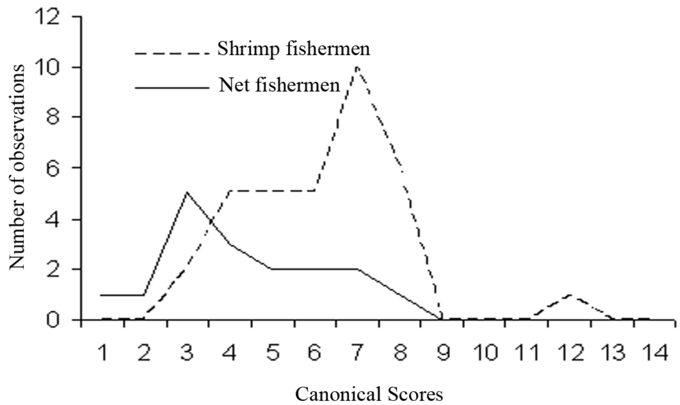

Figure 5 – Canonical scores distribution for trawlers and gillnetters' fleet data. The more the canonical scores are overlapped the more similar the groups are ($n_{trawlers}$=37; $n_{gillnetters}$=14).

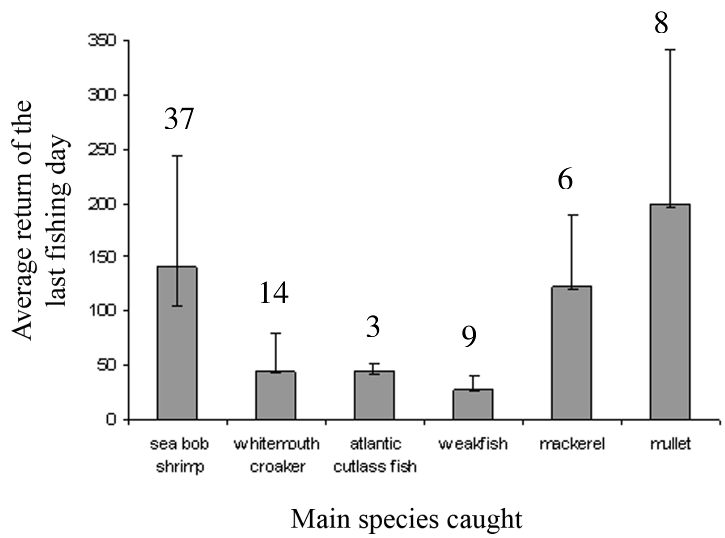

Figure 6 – Average return (kg) of the fishermen's last fishing trip before the interview, considering just the main species caught (n= 51 interviewees). Numbers above the bars correspond to the number of interviewees who cited each species.

Table 1 – Main targeted species, fishing method employed and main fishing season, according to fishermen's citation. Only species that were cited at least five times were included in the table. Number next to each citation represents the percentage of fishermen who mentioned each piece of information in relation to the total of interviewess (N).

Family	N	Scientific name	Local name	Gear used	High fishing season
Peneaidae (Shrimps)	37	*Xyphopenaeus kroyeri*	Sete-barbas	Trawl (100%)	Winter
	37	*Penaeus schimitti*	Camarão branco	Trawl (100%)	May-July (winter) (41%)
Carcharhinidae and Shyrnidae	14	*Carcharhinus* spp.; *Sphyrna* spp.	Cação	Gillnet (100%)	Summer and winter (29%)
Mugilidae	14	*Mugil* platanus.	Tainha	Gillnet (100%)	Winter (58%)
Sciaenidae	51	*Micropogonias furnieri*	Corvina	Hook and line (22%)	May-July (winter) (22%)
	14	*Cynoscion* spp.	Pescada	Gillnet (100%)	Summer (36%)
Scombridae	14	*Scomberomorus brasiliensis*	Sororoca	Gillnet (100%)	Winter (43%)
Trichiuridae	51	*Trichiurus lepturus*	Espada	Gillnet and Hook and line (9.8%)	Year-round (4%)

CAPÍTULO II

Decision-making processes among fishermen in a Brazilian fishing community (Perequê, Santo Amaro island)

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Running title: Decision making processes in Brazilian fisheries.

Abstract

In this paper we analyze the fishing effort allocation of shrimp trawlers and gillnetters in the small-scale fisheries of Perequê (Brazilian Southeast Coast). Using an integrated framework we attempt to identify the biological, economic and social mechanisms that rule fishermen's decision making within the two types of fishermen. We sampled 325 shrimp trawl and 93 gillnet fish landings along 13 sampling months. Trawlers target at sea bob shrimp (*Xyphopenaeus kroyeri*), while gillnetters target at other 12 fish species, although weakfish (*Cynoscion* spp) comprises 30% of what was caught in the period. We observed differences among the monthly CPUE (Kruskal-Wallis, $H_{trawl} = 34.5$; $p < 0.0001$; $H_{gillnet} = 22.79$; $p < 0.01$), but not among the seasons. Wave height is an important factor determining the number of fishing trips a day for both fishing groups (multiple linear regressions, $p < 0.001$), with trawlers going fishing more often on highly unpredictable return days. Fishermen live in a de facto open access situation, hence conflicts between the two groups are real, as trawlers fish too close to the coast where gillnetters set off their nets, damaging them. Decision-making processes occur only at the individual level and concern how long to fish, when and where to go fishing and to whom to sell the fish /shrimp. These factors change according to the seasons and are also influenced by economic variables, such as the price paid by the shrimp processing plants or by chances of commercializing their product without a middleman. Understanding such primary and complex reasons governing fishermen's decision making and consequently their effort allocation is essential to develop management strategies, especially in places where there is no tenure system and resource exploitation tends to end up in overfishing.

Key words:

small-scale fishery, decision making, open access, resource conservation, common-based management, Human Ecology

Introduction

Common property of natural resources is a topic that has attracted a great deal of attention from researchers of different areas (Aswani 1999, Bailey & Zerner 1992), initially in response to the polemic Garret Hardin's article "The Tragedy of the Commons" (1968), and followed by researchers studying fisheries (Berkes 1989, McCay & Acheson 1987). According to Hardin (1968), unregulated access to a common property resource may eventually result in overexploitation, due to a selfish behavior when each individual tries to gather the most he can before the resource is depleted by others. Although logical from an ecological evolutive reasoning, further studies showed that resource depletion, however possible (e.g; collapse of many commercial fisheries, Pauly *et al.* 2002), was not always the case (Amarasinghe & de Silva 1999, Burke 2001), even in situations where there was no apparent external control or private property. This was mainly due to the difference between common property and open access resources, something not foreseen by Hardin (1968), but later demonstrated to be a key factor in resource conservation or depletion (Aswani 1999, Berkes 2006, Feeny *et al.* 1990).

By common property is implied the existence of regulations and norms to support and control the access to the resource, which is owned not by the individual but by the community (Feeny *et al.* 1990, Silva 2004). This is a relatively common situation in subsistence-based economies, where regulations on resource extraction can be more easily applied and the return of such control can also be easily perceived (Levieil & Orlove 1990). On the other hand, open access systems fit Hardin's definition better, since there is no property regime and the resource may be used by anyone.

Aquatic environments usually have an open access nature, which apparently has resulted in overfishing and resource depletion around the world (Pauly *et al.* 2002). Other studies have demonstrated that many local communities keep or claim the authority to regulate the resources they exploit. These regulations may be incipient, such as the existence of systems of marine tenure, where fishing spots are inherited or acquired by constant use and then defended against other's invasion through social norms (respect, ostracism, gossip, etc.) (Begossi 2006a, Cordell 1978). Sometimes, however, the interactions between invaders and invaded people may be initially aggressive, until the control of the resource is finally asserted to one of the claimants (McGrath *et al.* 1993).

Common management is widely approached in the fisheries management literature, with most papers focusing on local management systems that aim to prevent overexploitation, through their local rules associated or not to scientific, governmental and non-governamental (NGO's) institutions (Siry 2006, White *et al.* 2006). On the other hand and in a lesser extent, some studies have approached the practical actions that underpin such management practices. In this category, we can include the studies concerning fishermen's behavior, fishing effort, gears and techniques employed, which respond for all the fishermen's decision making processes (Béné & Tewfik 2001, Eales & Wilen 1986, Guest 2003, Silvano & Begossi 2001). The importance of understanding fishermen's decision making processes is no longer ignored (Hilborn 1985). There is a complex relationship between catch (fish abundance) and fish effort (fishermen's behavior) that will influence the CPUE (Capture per Unit of Effort) (Voges *et al.* 2005). Designing management initiatives without considering the fishermen's individuality and personal goals means ignoring the most complex element of a chain that will indeed be responsible for how much is exploited or left of a resource. Without such knowledge, management is almost inevitably faded to fail (Salas & Gaertner 2004). Moreover, asserting control to local groups without knowing their features is by no means a warranty of management success.

This chapter can be better fitted under this last categorization, which includes bioeconomic models and not only marine tenure, even though it is not simple to trace a limit separating the multiple factors that are involved in fishermen's decisions. As pointed out by Branch *et al.* (2006), no bioeconomic analysis (of fleet dynamics for example) would be complete if one does not consider the common property characteristic of fisheries.

Here we investigate the decision-making processes that govern fishing effort and fishermen's behavior of two distinct kinds of fisheries, shrimp trawl and gillnet fishery, in a southeastern Brazilian coast scenario, where the open access nature of tne fishery is evident, and where initial conflicts between the two groups can be observed. By measuring fishing effort systematically over a period that comprehends all the year's seasons, we suggest that explanations of behavior (fishing effort) change with the temporal scale and environmental condition (represented by different seasons) considered. Such circumstances, given by local fishermen's behavior in terms of effort, spatial distribution of effort and the resulting conflicts among different fishermen's groups can result in a future common property regime, as observed elsewhere (McGrath *et al.* 1993). However, this study focused one step behind this process, pointing out the current characteristics of this system, which can be relevant to ground future government supported or co-management initiatives.

Study site

The Brazilian coast belongs mostly to the domains of the Atlantic Forest, a tropical forest that covered 1.100,000 Km^2 in the past, now restricted to 7.5% of its original area (Myers *et al.* 2000). The studied island (Santo Amaro Island, municipality of Guarujá - 23°59'S/46°15'W), has about 265.000 inhabitants, but its population can reach up to one million people in the high season (December to February) (IBGE, Censo 2000). Its total area is 139 km^2 (Figure 1). The region was intensively occupied after the XVI and XVII centuries, due to the port activities in the nearby city, Santos. The island hydrograph is characterized by small rivers.

The sample site (Perequê) is the most densely inhabited beach on the island (approximately 8 thousand people). Localized on the north of the island, this beach is in the inner part of a bay, sheltered by smaller islands that assure the calm sea, which was important to the beach seine fishery, a typical fishing method for local coastal community in the past. However, the arrival of people interested in the high shrimp abundance, without infrastructural planning, led to an intense demographic growth resulting in changes in the place and also in the local inhabitant's lives. Beach seine fishery is, for instance, not possible anymore, since up to 200 boats (especially shrimp boats) use to be anchored on the beach.

This unplanned growth resulted in subsets of slums that grew inside the mangrove area. The first dwellers built their houses on the sand, in front of the beach and always close to streams and creeks. The next coming families followed building their houses on the few available plots and subsequently started to build wooden houses on the mangroves. Each slum nucleus seems to reflect the region where these families came from. One of these groups is formed almost exclusively by families who came from the Brazilian south, who depend utterly on shrimp trawl fishery. Another bigger nucleus that goes further in the mangrove is mainly composed by families coming from the Brazilian northeast and most dwellers make a living off of something other than fishing.

Although they have electricity and telephones, there is no sewage collection and conveyance system and all the residues are discharged in the mangrove. Some of the fishermen say to prefer to live in these wooden houses than in brick and mortar houses on the land, as this facilitates going fishing, by letting their canoes and the fishing equipment behind their houses. In addition to health problems common in unprepared places like these, violence is also a relevant problem that afflicts both tourists and local people.

Methods

After two months of initial survey and sampling of social-economic data, when we applied semi-structured interviews drawing on fishermen's families' features, boat and fishing equipment, and market chains (Chapter 1), we followed the fish landings of 32 fishermen (25 shrimp trawlers and seven gillnetters) from July 2004 to July 2005 during five days each month. We did not sample shrimp landings between March and May (shrimp closed season). We chose the fishermen based on criteria such as age (older than 20), experience (working as a fisherman for more than 10 years), availability and willingness to take part in the study. The shrimp was always weighted in the shrimp processing plants, while we usually weighted the fish ourselves, due to the usual smaller amounts of fish caught. Other 15 fishermen were also included in the interviews for being working together with the selected fishermen. After each fish landing, we interviewed the fisherman about the name of the fishing spot, type and size of net, time fishing, return in kilogram, sale price and expenses with oil, ice and repairing as well. We collected some fish and shrimp for identification every month. In addition to the fish landings, we followed about 21 fishing trips in a participant observational method, where the number of times a fisherman trawled and the total amount caught was registered. The fishing spots were also mapped with GPS during these trips. Using the ethnomapping methodology (Futemma & Seixas 2008, Seixas 2005), two groups of three and four fishermen (the ones who fished the most during the sampled period) worked together on a map containing their main fishing spots and fishing areas, complementing the information we gathered through the observational method.

Statistical Analyses

In order to normalize the data, all data was transformed in $\log_n +1$, being used non-parametric tests when normalization was not reached after transformation. Following the criteria of normality, we did not define the same Capture per Unit of Effort for both kinds of fisheries; it was chosen the CPUE series that had a normal distribution among a set of correlated series (Petrere 1978). For gillnet fisheries, we tested for: 1) Return (kg) * net size (m)$^{-1}$; 2) Return (kg) * Time fishing (min) $^{-1}$ and 3) Return (kg) * (net size * time fishing) $^{-1}$. Since the correlation between the series was high (above 80%), it was chosen the only series that best fits the normality criteria (*Gillnet CPUE = Return (kg) * net size (m)*$^{-1}$).

In case of trawl fisheries, we tested the correlation between the following series: 1) Return (kg) * Trawl area size (m2) $^{-1}$ * no. of consecutive trawling^{-1}; 2) Return (kg) * number of consecutive trawling^{-1}, 3) (Return (kg)/ crew number) * time fishing^{-1}; 4) Return (kg) * crew number^{-1}, 5) Return (kg) * time fishing^{-1}. The CPUE chosen (*Trawl CPUE = Return (kg)* * number of consecutive trawling^{-1}) suits the normality criteria.

The CPUE was compared month by month for both trawl and gillnet fisheries separately through a Kruskal-Wallis test and also among seasons. The same test was used to check if there was any difference among the average time fishing in each season (Spring, Summer and Winter) in the case of trawlers (non-normal data). For gillnetters we used a One-Way Anova, given the variance homogeneity and normal distribution of gillnetter's time fishing. Fall (March to May) was also considered in the gillnetter's case, as there is no closed season for them.

In order to understand which environmental factors (publicly available at CPTEC website: www.cptec.inpe.br) influenced the number of daily fishing trips, we carried out two multiple linear regressions for both trawl and gillnet fisheries. We assumed that all the variables were relevant and through a *Stepwise* (*Backward*) method, we selected the optimal model containing only the significant ones. The initial model was defined as:

Dependent Variable:

T = number of fishing trips a day

Independent variables:

M = wave height (m);

V = wind speed (m/s);

TM = maximum temperature registered (ºC);

TA = minimum temperature registered (ºC);

U = air humidity (%)

F = moon phase (categorical variable representing tide variations).

The initial model is then:

$T = u + M + V + TM + TA + U + F$, where u represents the equation intercept.

To calculate the profit per trip per fisherman, we used the equation:

$P = \sum C_i ti - G_t$, where C_i refers to the money made from the capture of each species per trip (ti) and G_t is the sum of total expenses.

We also used a Spearman Correlation to test for possible relations between the monthly shrimp and weakfish price per kilogram (R$/kg) and monthly availability (kg) of these products (through fishermen's catches). We chose only the most important commercial product for each fishery kind: sea bob shrimp and weakfish. The same correlation was used to test the relation between time fishing and return in quilogram and profits for both trawling and gillnet fisheries.

A brief overview of the local fishing features

There are no regular studies concerning the history and evolution of fishing in the studied place. Most of what is known about the fisheries is based on oral stories collected during the fieldwork, preliminary interviews carried in 2004, and similar situations in other communities along the Brazilian coast. Until late 1970s, the island was occupied mainly by "caiçaras", descendents of Indians and Portuguese who used to make a living off of small-scale fishing and cassava flour regional commerce. By this time, shrimp trawlers from the south region started to migrate to this island due to the crisis of the shrimp fisheries in their original region. They brought their methods and equipment to catch shrimp, which showed to be highly productive in the region attracting an increasing number of people. Northeastern people are another common migrant group. They found in Guarujá the chance of learning a new profession as a fisherman, especially as a trawler, which seems to require fewer skills than gillnet fishery and sometimes no capital investment, since they can work for other boat owners.

Both kinds of fisheries are structured in a family base, older sons usually fish together with their fathers, while wives and daughters may either sell the fish or clean and process the shrimp. Processing the shrimp at home is not common, most fishermen prefer to sell it as it comes in the nets with some debris by a lower price to the shrimp processing plants.

The kinship relationships are also present in the information exchange system. Fishermen that had a successful day may share the information about good spots with their relatives and close friends. Sometimes this is done through radios or hand signs while still fishing, and, in this case, to protect the content of the information, they use codes that are familiar to just some of them. Cheap talks[4] are also common after a fishing day, on the beach, bars and streets and also during the visits that they pay to each other (information gathered through observations along 13 months).

Since most of the fishermen in the community are trawlers (76.5%), the whole local economy is based on shrimp and dependent on shrimp processing plants. Such plants are responsible for the commercialization of 86% of the shrimp caught, and hire some fishermen to work on their boats and women to process the shrimp. This dependence generates some loyalty from the fishermen: they seldom choose a different plant to sell their shrimp.

[4] It is a sort of communication which usually carries no cost, for example, fisherman will have any loss for doing it. The concept is widely used in game theory as a pre-play phase, where each player announces the action they intend or would like to take (Robson 1990).

A fishing day usually starts between 5 and 6 am during most part of the year for shrimp trawlers (hereafter just trawlers); they then return to the beach between 3 and 5 pm to sell the shrimp until 6 pm. After that, fishermen usually return to their boats to make any necessary repair and to leave part of the ice to the next day when in great amounts and, in this case, the rest of the ice is taken home until the next day, when he goes fishing. During a regular week, shrimp trawlers work from Monday to Friday, although sometimes they do not fish for many consecutive days when the weather is not good (rough sea or very windy days). Weekends are not synonymous of resting, since these are usually the most profitable days. Some fishermen use the weekend to rent their boats to recreational fishermen, working as captain and fishing together, although all the fish caught go to the person who rented the boat. This is a kind of work that depends on the fame of the boat owner as a good captain; some people always have this alternative job on the weekends while others rarely do.

Other fishermen, the ones that use gillnets (hereafter just gillnetters), have a different routine. Some of them fish just close to the beach, setting their nets in the early morning between 7 and 10 am, checking them and setting other kinds of nets in the afternoon between 4 and 7pm. Gillnets are only set again in the afternoon to be checked in the next morning if there is some prospective of good fishery. During the interval between 10 and 4 pm they fix the nets and the boats or work in their small fish stores. Others prefer to fish in other beaches and, in this case, they return home generally after three or four days. However, the same routine of setting the nets in the morning and in the afternoon is followed in these places. The interval is also used for repairing the equipment or for leisure. Gillnetters can also work on the weekends to the recreational fishermen, although this is less common and they usually fish in a regular way on Saturdays, resting on Sundays.

Results

Among the 424 fish landings sampled, 325 represent shrimp fisheries, 93 net fisheries, and six hand line fisheries. Hand line fishery is not included in the subsequent analysis due to the low number sampled. However, they refer to the capture of 22 kg of whitemouth croaker (*Micropogonias furnieri*), used for consumption and 49 kg of grouper (*Epinephelus marginatus*), sold by R$ 707, 00 (December 2004 1US$ = R$ 2.72) (Annex 7). Even though they usually sell high priced species caught with hand line, this fishery is just faced as a leisure activity.

Sea bob shrimp (*Xyphopenaeus kroyeri*) comprised 95% of the trawlers' capture, although part of what is sold as sea bob shrimp includes at least five other species in smaller amounts (Penaeidae*: Artemisia longinaris, Rimapenaeus constrictus;* Hippolytidae: *Exhippolysmata oplophoroides;* Alpheidae: *Alpheus* spp.*;* Solenoceridae: *Pleoticus muelleri*) (Annex 5). Gillnetters have a wider array of targeted species but focus on just a few of them. With the exception of weakfish (*Cynoscion* spp), which comprises 30% of the total fished in the sampling period, no other species among the 12 registered in the period (excluding mixing), is relevant (Annex 6).

Only 1% of what is caught in the shrimp fishery is used for family consumption and about 3% is donated to relatives, neighbors, friends and people in the neighborhood. Most donations (70%) refer to bycatch, which has no significant monetary value. In 27% of the cases, it was not a real donation, but an exchange of fish for helping with transport of shrimp and equipment from the beach to the village. Poor people from one of the local slams, who do not work on fishery, help the fishermen and get the bycatch as payment. Later this bycatch is sold at the poorest region of the neighborhood. Gillnetters consume 8% of the total fish caught and all the donation observed (100%) was for relatives, friends and especially to the fisherman's helper. Here the donation refers to a mix of small low-valued fishes (68%).

Trawlers caught on average 103.2 kg trip^{-1}, with a low coefficient of variation (CV = 0.73), while gillnetters had a lower average return (19.3 kg trip^{-1}; CV = 0.83). Fishing trips with no return were not common (n=3), just happened during trawl trips, and the few times that they were observed were due to the canceling of the trip before trawling, either due to equipment damage or bad weather. Frequency distribution of capture are clearly distinct to both kinds of fisheries, with shrimp trawl fisheries being highly skewed towards higher returns (kg) (Figure 2a; Shapiro-Wilk test, p=0.02), while gillnet fishing frequency distribution of fish catches (kg) follows a normal distribution (Figure 2b; Shapiro-Wilk test, p=0.41).

Effort and Capture per Unit of Effort

The comparison of the Trawl CPUE among the months showed significant differences, especially due to the lower values for July 2005 (Kruskal-Wallis, H = 34.5; p < 0.0001), but we did not observe any difference among the three considered seasons (Spring, Summer and Winter) (H = 4.14; p >0.05), although warmer months (from November to February) tend to have higher values. Gillnet fishery also showed differences in CPUE among the months, even though it is not clear which month(s) is responsible for such differences (H = 22.79; p <0.01). Similarly, we did not observe differences among the four seasons (H =1.1; p > 0.5) (Figure 3a,b). We then investigated if fishermen would be spending more time fishing when their return was lower. However, correlations were non significant for neither return in kilogram (Spearman r = 0.11; p = 0.31) nor profit (Spearman r = 0.16; p = 0.12).

Time dedicated to fishing is highly variable along the year, with trawlers spending more time on fishing during the winter in relation to the summer (H = 11.6; p<0.05), while gillnetters spend more time fishing in the summer than in the spring (One-Way Anova F = 4.1; p< 0.001). Again, we checked any possible relation between time fishing and their return and we observed that, conversely to trawlers, the longer the time fishing the longer their return in kilogram (Spearman r = 0.99; p < 0.001) and the higher their profits (Spearman r = 0.76; p < 0.001).

Fishermen consider environmental factors to be decisive in the fishing activities. When we tested if some of these factors would influence the number of trips per day, we ended up with a model showing that only wave height and wind speed matter, two factors that may not be independent. These are indeed the most expected influential factors, since they influence on the safety of the trip. Moreover, the fishermen argue that rough sea is not appropriate for catching shrimp, since shrimp would prefer calm seas, hiding during rough conditions. After testing for the collinearity of the variables, the final model included only the intercept and “wave height” (*M*) as responsible for 40% of the variation in the number of trips per day (T = 15.59 - 3.2M, r^2=0.4, p < 0.001, g.l.=37).

In gillnet fisheries "wave height" was again the most relevant factor in the complete model, besides "maximum temperature". Again, after removal of collinear variables, only the intercept and "wave height" (M) influence on their decision of fishing in the final model (T= 1.86 - 0.62M, r^2=0.18, p < 0.01, g.l.=47). The results are not so clear though, since the r^2 value shows that only 18% of the variability in the number of fishing trips per day is explained and this value is mainly given by the intercept, other things being equal.

We also observed a high positive correlation between the variance in the daily return in kilogram (Spearman correlation: r=0.72; p<0.001, n=30) and profits (r=0.65; p<0.001, n=30) with the number of trawlers going fishing on a given day. As this relationship was positive, apparently such trawlers adopt a risk-prone behavior going fishing when the chances of success are higher, but also when there is a higher chance of losses. We took into account the fact that a fisherman could go fishing based on his and his friends's last day's success. For that, we also performed a correlation between the variance in the previous day and the number of trawlers and the correlation was also positive, with very similar results (r=0.68; p=0.002, r=0.76; p=0.002, n=18)[5]. Another possibility was that a fisherman would go fishing if he saw someone with a high return either in kilogram or in money on the previous day, which also turned out to be true. The number of trips on a given day would be higher the higher the maximum return observed on the previous day (Return in Kg: r=0.71; p<0.001, Return in R$: r=0.81; p<0.001, n=18). We did not perform the same analysis for gillnetters as we did not have enough data to calculate variance for most of the days.

Fishermen's income is highly variable along the year (Figure 3c). Even though the shrimp fishing has higher returns in relation to gillnet fishing, this last one never had losses, although the return is always low. Despite the higher chances of good return, trawlers incur in greater expenses, especially with oil and ice. Both kinds of fishery can be only compared in relation to their similar maintenance repair costs (Figure 4).

[5] The number of cases are different as it was only considered the days that had the variance of the day before.

There is no correlation between the amount of shrimp caught and the price paid for kilogram (*rs* = -0.4; p >0.05), although we would expect a negative correlation, the lower the monthly catch the higher the price (Figure 5a). The shrimp plants use to practice very similar prices among them (from R$ 1,50 to R$ 2,20 kg in 2004), when buying shrimp from the fisherman, which do not really change according to the market demands (though the final consumer observes a high variation in the shrimp price along the year – from R$ 7,00 to R$ 18,00 in the local markets in 2004). Even though shrimp is a high priced product for the final consumer, the price paid to the fishermen for each kilogram is sometimes lower than the oil liter value (average price: R$ 1,71/ liter). The comparison “shrimp kg x oil l” is commonly used by the fishermen, since this is a high oil consumption fishing method (24.6 l ± 50 l). Only weakfish catch was considered in the correlation for gillnet fishing, since this was the main commercialized species in the sampled period. No correlation was observed here either between the amount of fish caught and the price paid for it (*rs* = 0.4; p >0.05), and, in fact, the weakfish price rarely fluctuated (Figure 5b).

At first glance, when analyzing gillnet fishing one can think that winter is the least productive season while spring, the subsequent one, is the best one, as the return in the spring (kg) is 69% higher than in the winter. However, fishermen do not travel far and does not stay fishing for a long time in the winter, which may be due to adverse environmental conditions. But at the same time they have indeed the highest return in kilogram per hour (almost 3 times higher than in spring) or in currency per hour (almost 6 times higher than in spring, H=10.06; g.l.=3; p=0.02), which is probably due to the arrival of seasonal high valued species, such as mullet (*Mugil platanus*). Trawling is slightly more productive in the winter, both in kilograms and in financial return, but only significant differences can be seen among the travel time (trawlers travel for a shorter time in summer; H=11.15; g.l.=2; p=0.004) and profits made (they also make less money in summer; H=7.68. g.l.=2; p=0.02) (Table 1).

Resource access

There is no clear system of exclusion or access control to the area and its fishing resources besides a government decree establishing a closed season (three months) for shrimp fisheries. During the study time, this season was established between March and May (Decree 74, February 13, 2001), which was intensively refuted by the fishermen, who believed that during this time sea bob shrimp was not reproducing (Ferreira *et al.* 2006). In 2006, a new decree (Normative Instruction no. 91, February 6, 2006) established that the closed season would be based on data existent about sea bob reproduction[6], between October and December. In fact, there is not a clear enforcement of this regulation, and some fishermen allege it is not all the local trawlers who respect this period, fishing during the night, and still receiving the government's support paid during the closed season. On the other hand, many fishermen complain that the government's support is just paid months later, when they are already back to work, forcing them to find alternative ways to make money during the closed season, and sometimes fishing is the only activity they are prepared for.

There are other federal and state regulations regarding trawling and the use of gillnets, but similarly to what happens to the law about the shrimp closed season, none of these norms is effectively enforced (Table 2). Currently, other coastal regions of the state have established rules taking fishermen's voice into account, having zones where trawling is allowed without necessarily depending on shallowness, as trawlers argue that sea bob shrimp is mainly caught in a range from 5 to 20 m deep (Seixas & Futtemma *submitted*). Representatives of the region where Perequê lies in (*Baixada Santista*) are also working on this State Coastal Management Plan (State Law N. 10.019), which will clarify the limits for trawling.

Although all the local fishermen claimed that there are no particular fishing areas and that they can fish wherever they want, just respecting the first comer's right (interviews data, n=51), some incipient conflicts were mentioned by the interviewees and observed by the researchers between trawlers and gillnetters. The fishing areas are the same for both fishermen groups, according to the mapping of their spots and to the interviews realized during the fish landings (Figure 6), which seems to be the main cause of their conflicts. According to gillnetters, they signalize their nets with lights and flags, but they are not respected by the trawlers that cross these places, damaging the nets.

[6] The former decree was established based on pink shrimp (*Farfantepenaeus* spp.) reproduction, an important commercial species but with a totally distinct biology.

Discussion

The fisheries

The history of fishermen from this island is peculiar to the Brazilian coast, due to its shift to a totally commercial fishing, changing most of their artisanal features into a market economy. Coastal Brazilian communities, when under some pressure to change their lifestyle, tend to answer adapting their livelihoods to other sources of income, such as tourism. They can either keep some of their old lifestyle features (kinship ideologies, religious festival, some diet habits, etc.) (MacCord & Begossi 2006a, Ramires & Barrela 2003) or these cultural features can disappear completely, through a process of marginalization and inclusion in the poorest layers of the Brazilian society (Diegues 1999). In this region, probably due to its unique characteristics, such as the presence of people from different regions where market has been playing a role for a long time, they are adapting to an urban context but keeping their dependence on fishing.

The high economic influence on Perequê's fisheries can be seen for example in the low number of targeted species by both trawl and gillnet fisheries, but especially in the high dependence on one resource: shrimp. Usually a few sampled fish landings in the Brazilian Southeast coast result in the record of more than 50 fish species (Ramires & Barrella 2003, Seixas & Begossi 2000, Hanazaki & Begossi 2000), while in Perequê samples over 13 months resulted in 16 species plus a mix of different small species (Annex 5 to 7[7]). Even in the southeastern local communities where shrimp has been always an important resource, shrimp fishery is usually practiced by low technology methods (canoes and hand held trawling nets), being a multi-specific fishery (Begossi 1992).

However, some Brazilian southern fishing communities can show exactly the same features (similar kind of boats and equipment, the presence of dealers and fish processing plants) and a high dependence on sea bob shrimp (Branco *et al.* 2006). This suggests that the migrant fishermen brought not only their knowledge and techniques, but a whole system that mimics the

[7] Even though sea bob shrimp comprises a bulk of six different species, here we are just considering *Xiphopenaeus kroyeri*, as the others contribute in a non-significant value to the total catch.

situation they were used to in the 1970s at their place of origin. They not only started exploiting a resource neglected until then by the “caiçaras”, but they also inundated the place with their habits and own economy. How this affected “caiçara” culture and social customs is beyond the scope of this paper, but this can be indeed one more factor contributing to local conflicts. Other urban fishing groups that target shrimp in São Paulo coast have different characteristics: they usually use other fishing methods simultaneously to trawling and are inserted in a bigger market chain that commercialize all the fishing products and not only shrimp (Vianna & Valentini 2004).

Unfortunately, quantitative comparisons regarding the fisheries situation with other studies are not an easy task, due to the variability in the data collection (Guest 2003). Such differences are inevitable due to the huge variation among coastal communities around the world. If, on one hand, most of them are small-scale fishing communities struggling to survive the economic growth and the technological changes, which they can barely afford, on the other hand cultural and social discrepancies result in different resource exploitation strategies (Acheson 1998, Cheong 2003, Maurstad 2000, Ruddle 1993). Social-cultural aspects also explain why fishermen not necessarily follow the profitability logic, which results sometimes in non-congruence with the bioeconomic models (Durrenberger 1997)

It is not a surprise that many people were and still are attracted to Perequê to catch shrimp. Regardless of the high exploitation rate, it is still a relative profitable activity, with a higher average return when compared to the gillnet fishery returns. Although more profitable than the gillnet fishery, the shrimp fishery also implies in higher costs, and a bad fishing day means expense accumulation, which is not true for gillnetters, who hardly use any oil and ice.

Effort and Capture per Unit of Effort

The fact that the best Trawl CPUE series (according to the normality criteria: CPUE = Return (kg) * number of consecutive trawling^{-1}) was the one that considered the number of times they trawl points out two other factors in the effort definition. The first one is time, since more trawling attempts usually imply in more time fishing. The second factor that might be associated to time is the place where they fish, since each time trawling may occur in a different place. Depending on the success of each attempt, the fisherman may opt to keep fishing in a straight line back and forth or to navigate to a different location, but we have no observational data to quantitatively confirm this.

In the case of gillnetters, net size defines better the CPUE, which agrees with other studies (Silvano & Begossi 2001). Even though we have not tested the factors that predict the CPUE, the determinants of the number of trips per day (Multiple Regression) may shed some light on it. A calm or rough sea may influence the amount caught, which is also annecdotically told by these fishermen. Moses *et al.* (2002) studying fisheries in Nigeria, showed that hydroclimatic seasonal factors affect the CPUE, though his study was conducted in an estuarine environment where fresh water was the main influent factor. Other studies have also shown the relevance of technical features, such as boat size and engine power, which were not taken into account here as these factors did not change along the studied period (Maynou *et al.* 2003).

Trawlers' workload is determined by biological and social factors or the interrelation between them. They often stay fishing for until 12 h during the winter, which they explain by the fact of this being the season when shrimp is more abundant and also because it is right after the closed shrimp season, when they are short of money. This greater abundance may be the outcome of the closed season, since studies about the same species suggest higher abundance and biomass along the fall and summer months, and not necessarily in the winter (Branco 2005). Gillnetters work harder in the summer time, which corresponds to the weakfish season, the main target species.

There is no correlation or delayed correlation (using the previous month catch) between the prices paid and the monthly capture of shrimp and fish. Having the product in stock may contribute to the low price even when the fish/shrimp supply is not high. This is not always the case in the Brazilian shrimp market. Seixas & Troutt (2003), for example, demonstrated that the pink shrimp (*Farfantepenaeus* spp.) price in the south is delineated by market supply and demand, shrimp size and buyer type. Such differences may be explained by the amount of shrimp caught in both places. These authors showed that the amount of pink shrimp caught in a week by all studied fishermen (about 200 kg) is sometimes lower than the amount caught by one Perequê's fisherman in a good day, which might be also due to different technologies, as pink shrimp was caught using cast nets in their study. The weakfish price in Perequê is almost constant since it just takes part in a local market demand, commercialized without middlemen. The only price variation occurs when it is processed to filet, which is not associated to fish abundance.

Resource access

The Perequê trawl fishery has an apparent unsustainable character in the long run. The government control over it is incipient and restricted to a non-enforced closed season and non-enforced laws concerning minimum allowable size of capture and there has been no attention to the growing number of fishermen continuously integrating this fishery. Traditional norms and local fishing restrictions were not observed.

However, territorial conflicts between trawlers and gillnetters are becoming apparent, and even though this study just qualitatively approaches this topic through mapping and ethnomapping of the fishing spots, local observations and talks with fishermen suggest that this is a delicate matter. The sea seems to be treated as an open access resource, but since one group (trawlers) started to cross the limits of respect (e.g. damaging the nets) of the second one (gillnetters), conflicts and claims are natural to happen. Gillnetters retaliate by threatening to report trawlers who fish in the closed season to the environmental police, besides threatening to cut the nets off and release the trawls during the night. Being caught by the environmental police means to lose the nets and all the shrimp fished, besides paying a fine, which reached up to R$ 5000,00[8] in 2004.

Similar conflicts are becoming widespread on the southeastern Brazilian coast (Begossi 1995b, Seixas & Begossi 2000). In a small *caiçara* community (Almada Beach, São Paulo State), Futemma & Seixas (2008) observed complaints about the negative impacts of trawl fisheries done by outsiders and local fishermen on other fisheries, through damage of the sea bottom and catch of small fishes. This suggests that conflicts and lack of tenure system (any form of control of an area) inside the community are not necessarily the outcome of outsiders' migration and

[8] This value is established by the judge according to the social situation of the fishermana, antecedents and environmental impact caused by his activity (Decree 3.179, September 21, 1999).

shifting from subsistence to a more economic based system, it can be a common situation on the Brazilian southeast coast, whose causes may vary from place to place.

Begossi (2001) carried out a research on territories comprising many different communities along the Brazilian coast, concluding that even in the absence of formal or informal institutions, implicit territoriality assures that the limits of one community are respected by the others. We did not test for such assumption, as the neighboring communities were not fishing communities, but the mapping of local spots shows that Perequê's fishermen also have fishing spots in a neighboring town (Bertioga). This town has trawlers as well, who fish in the same areas of Perequê's fishermen, including Perequê bay, suggesting that the open access situation cross the limits of one community and of a town.

Disputes and conflicts like the ones reported here are commonplace in other parts of the world as well. Berkes (1986), for instance, tells about the existence of conflicts between these two same fishing groups in Turkey. Other countries, such as Ghana, Liberia and Sierra Leone, show exactly the same kind of complex cultural-economic modifications brought about by the arrival of new fishermen from different regions, resulting sometimes in violent conflicts, even though this African region is more affected by political conflicts and civil wars than conflicts purely over natural resources (Overa 2000). In Malaysia, the government tried to forbid the trawl fishery after realizing the damages to the fish stocks in inshore waters and to the livelihood of traditional fishermen. However, as such action was only implemented when trawling was already a common practice, such prohibition just resulted in illegal trawling and the government decided later to lift the ban (Talib & Alias 1997).

Silvestre and Pauly (1997) point out how the question of who should have access to coastal fishery resource might be a primary consideration in fisheries management. In the Philippines, for example, these authors recommend increased management and the resolution of the conflicts in favor of the artisanal non-trawling sector, due to social inequalities and greater potential loss caused by trawling. In Perequê, both fisheries are artisanal but they differ in a great deal in their impact on the environment, which demands different measures (e.g.: fishing zones and regulations about closed period decided in agreement with local fishermen) for each one.

Conflicts of the nature reported here can be the first step for the evolution of rights, rules and norms (Begossi 1998), but since over-exploitation is a real threaten, there is no available time to wait for a natural adjustment process to happen. Trying a reconciliation between the two groups with specific non-overlapping areas for each one and effort control (by controlling the number of fishermen and mesh size for example) is a necessary step to achieve local rational exploitation avoiding another shrimp overexploitation and migration cycle.

The decision-making processes

The decision-making processes addressed in this research occur in different but all individual levels and are differentiated according to the type of fishery. Migration for example, observed by the researchers and mentioned by the fishermen, is a decision that just pertains to shrimp trawlers and it seems to be motivated by economic reasons (aiming at better profits or just at making a living - data from preliminary interviews) resulted from direct interference in the environment (resource overexploitation in their homeland).

The second type of decision is common to both groups, the decision of fishing or not fishing and how long to stay fishing. The economic rationale here seems to denote the most important role. Fishermen will fish longer hours if they anticipate good profit opportunities (both kinds of fisheries) and/or if they want to compensate the loss of the closed season (trawlers). However, in the case of gillnetters, a higher CPUE and productivity (which happens in the winter) will imply in more expenses with oil (Spearmn Correlation, $r=0.34$; $p=0.001$), but it is still worth fishing longer as this is the season with the highest net profits. Trawlers, on the other hand, once fishing, must assess his actual and prospective catch and compare to his fuel consumption weighing the advantages of trawling a little more or not. In the case of a gillnetter, his expenses and the alternative use of his time will be weighted in relation to the advantages of checking the nets more times a day. Whether such decisions are conscious or sub-conscious are not clear, although they do decide consciously to trawl longer if they consider they had a good return in the last time they trawled or to set the net again if they are catching a lot of fish. At this instance, environmental factors (higher productivity in some seasons) are associated to personal fisherman's decision and environmental factors seem to rule the final outcome, as the highest CPUE's are not associated to the highest monthly fuel expenses (Spearman Correlation; r=0.06; p>0.05). As pointed out by Boyd and Richerson (1985), humans infer about their world through rational choices that have some probability distribution (with averages and variances) based on their previous experience. So even though they know about their world and they can be experienced about it, there is always some chance of failing. Other studies have shown, however, the impossibilities of carrying out all the mental calculations involved in such decisions (Quinn 1978).

Trawlers also make risk-proneness choices when deciding to go or not fishing. This is suggested by the positive correlation between variance of the return and profit with the number of fishermen going fishing on a given day. This probably happens because trawlers observe their fellows with good catches on the previous day, which they understand as a possibility of success on the next day. However, such choice also implies in higher chances of loss. Risk proneness is not a common behavior among human groups, as such behavior is just expected when the person does not meet his daily minimum requirement in caloric terms (Winterhalder *et al.* 1999). This is not a specific case of caloric maximization, as these fishermen hardly ever consume what they fish. Their risk proneness strategy might be related to their monetary maximization. Begossi (1989), for example, demonstrated that the choice of fishing gears by islanders in São Paulo coast, with highly variable return, will depend on the currency being maximized. If the fisherman intends to maximize his caloric return, he will opt for a low variance fishing method, doing otherwise when maximizing his financial return.

Cultural factors can be the primary determinant in not fishing on Sundays, which would not be a deliberate decision process, just a widespread habit, as also observed elsewhere (Guest 2003). However, nowadays economic factors also seem to play the most important role. Sunday is the day that fishermen, especially trawlers take recreational fishermen to the sea, assuring easier and safer money, which depend less on their ability in finding fish, though recreational fishermen will indeed prefer the ones who can take them to the best fishing spots. Such kind of economic-cultural decision may help moderate effort, since recreational fishermen target different species. Weather is another determinant in not going fishing; fishermen will not risk their lives and boats when they think it is not safe.

Another type of decision showed here is related to pre-processing the shrimp (cleaning out the debris) or selling it in its crude conditions. Processing implies in selling it for a higher price, but it also implies in spending more time that could be allocated to fishing longer or coming back home earlier. Such decisions seem to be based primarily on the amount of shrimp being caught. If they are having a good fishing day, they prefer to fish longer than spending time in processing. We compared the costs and benefits of processing the shrimp and we showed that fishermen who partially process the shrimp in the boat do better in economic terms, but most of them choose otherwise, for considering this activity too boring (MacCord & Begossi 2006b). However, they will always do it when shrimp is scarce and they need to get the most of what they caught.

Finally, trawlers still have to decide to whom to sell the shrimp. Most of the time, they will choose their customary buyer, as they can be considered untrustworthy if they keep changing their buyers. The processing plants may choose to not buy from a specific unreliable fisherman as a punishment. This does not prevent however, some smaller negotiations on the beach with the final consumers. White shrimp, on the other hand, is subjected to a completely different market chain, avoiding middlemen most of the time. As commercializing the fish is not a profitable activity for middlemen due to its subsistence character, most of the gillnetters' deals are done involving no middlemen.

We can see here how economic decisions seem to govern fishermen's effort and other subsequent decisions, and understanding effort is indeed relevant to prevent fish and shrimp overexploitation or to adopt management measures. Guest (2003), in his study of an Ecuadorian community, showed that increasing effort of the existent fishermen can have worse consequences than increasing effort by adding new fishermen to the fishing system every year. This is a very important point to be considered in management initiatives, especially in places like Perequê, where both factors, increasing effort of existent fishermen and the arrival of new fishermen, play a role.

Understanding the fishermen decision-making processes helps anticipate fishermen's behavior concerning environmental, economic and social change, which is thus critical to design management plans (Béné & Tewfik 2001). It is not new that a better understanding of the fisheries science requires both the analysis of fishermen behavior and fleet dynamics (Hilborn 1985, Opaluch & Bockstael 1984). Among the most important behavior to be understood is how they allocate effort (Opaluch & Bockstael1984), which has been shown to be a complex and dynamic variable. Béné & Tewfik (2001), for example, showed that Caribbean fishermen from the British West Indies switch between lobster and conch fishery, allocating different effort to them, according to economic constraints, but other factors such as individual skills and the desire of a better social acceptance and status also play a role. Béné (1996) also showed that shrimp fishery effort in the French Guiana results from a combination of stock availability, crew remuneration system and market constraint. Another example shows that pink shrimp trawlers in California decide on where to fish based on the fleet position on the preceding day (Eales & Wilen 1986). Factors like risk-avoidance or risk-reducing can also govern such decisions, as it occurs among the Oregon fishermen (Hanna 1992). Also among the Oregon fishermen, Ruttan (2003) showed through the study of logbook data, how sharing information can influence on CPUE. Studies of logbooks of whalers fishing in the Galapagos region showed that fishermen in the 19th century would decide on where to fish, achieving an ideal free distribution in some circumstances, probably due to information exchange as well (Whitehead & Hope 1991). Such studies spread throughout different regions and different times may have aspects in common, but they all shown their peculiarities, proving how complex the decision-making process can be, so that considerable variation in the behavioral strategies can be observed (Salas & Gaertner 2004; Voges *et al.* 2005).

Most of the decision-making processes identified here regard decisions made at the individual level. The lack of community-level decisions is certainly ruled by the lack of a tenure system. Open-access situations prevent people of being part of decision-making processes that take place in a scale that cross the sole individual interests. In an open-access regime, individuals will rationalize in favor of their best selfish interests, which is not always the best choice for individuals themselves or to the environment. Seixas & Troutt (2003), for example, showed that Brazilian southern fishermen will not act to prevent overfishing or that they will keep fishing juveniles even if it is less profitable than waiting for shrimp to grow. This happens if there is a lack of enforcement of existing regulations: if he does not go fishing, others certainly will. In places such as Japan, however, high community cohesion makes effective the use of social mechanisms (social ostracization, lowered social status and community disapproval) to manage conflicts and increase community-level decisions compliance (Salz 1998). Such communal fishing rights prevent Japanese fishermen of being in a de facto open access situation, curtailing abuses.

In Perequê, fishermen are influenced by economic constraints and opportunities, environmental unpredictable factors, such as wind and consequently wave height, and also by cultural-social reasons, such as the different migrant groups and institutional arrangements that place them in an open-access regime. Such complex situation determines their effort and, consequently, the way the resource is extracted, demanding special attention if such fishery is to be managed.

Acknowledgments

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Table 1 – Seasonal totals for catch (kg), fishing trip (hour), fishing time (hour) and fishing return (R$, kg). Ns = non-significant. In bold the value that is responsible for the significant value of the Kruskal-Wallis test.

Fishing method	Season	Total amount caught (kg)	Travel time (hour)	Fishing (residence) time (hour	Per capita return rate (kg/hour)	Total gross revenue (R$)	Per capita return rate (R$/hour)
Gillnet fishery (n = 93)	Winter	322.9	47.9	93.9	2.28	1.913,25	**13.8**
	Spring	546.1	118.8	597.6	0.78	1.615,90	2.4
	Summer	434.7	91	318.5	1.08	1.524,70	3.6
	Fall	531.3	141.3	279.3	1.26	1.438,00	3.6
Kruskal-Wallis test		Ns	Ns	Ns	Ns	Ns	H=10.06;g.l.=3, p=0.02
Shrimp fishery (n = 323)	Winter	13346.4	414.8	727.6	11.4	24.142,31	21.0
	Spring	11299.8	584.0	684.4	9.0	23.822,88	18.6
	Summer	8870.3	**289.1**	596.0	10.2	**15.877,60**	18.0
Kruskal-Wallis test		Ns	H=11.15; g.l.=2; p=0.003	Ns	Ns	H=7.68; g.l.=2; p=0.02	Ns
Total		35351.4	1686.8	3197.3		63.842,80	

Table 2 – Federal and State laws and decrees regulating fisheries on São Paulo coast.

Law/Decree	Content
SUDEPE n° N-54, November 20th, 1984	Forbids bottom otter and pair trawling by boats bigger than 10 GT (Gross Tonnage) in areas closer than 1.5 nautical miles
IBAMA n° N-56, December 20th, 1984	Forbids the catch of sea bob shrimp with mesh sizes smaller than 24 mm knot to knot
IBAMA n° N-55, December 20th, 1984	Forbids the catch of white shrimp smaller than 90 mm
IBAMA n° 008/03-N, March 20th, 2003	Regulates the technology employed and the minimum allowed size for capture for most of the commercial species, including weakfish (30 cm)

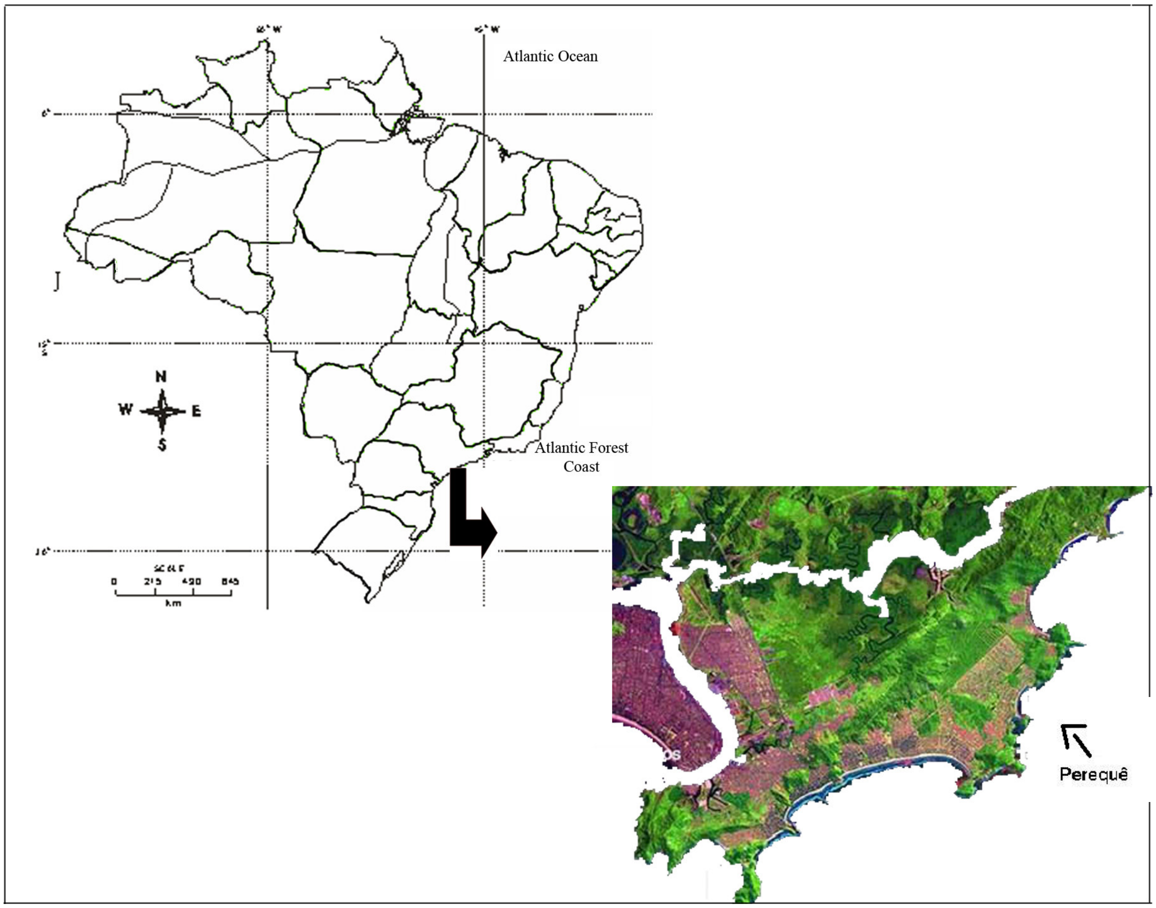
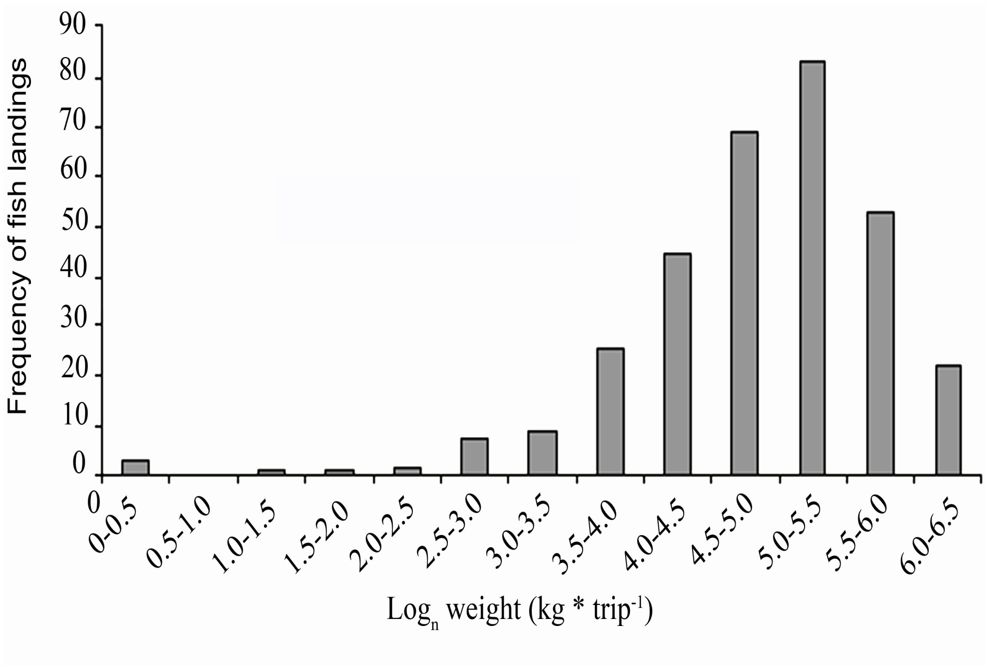
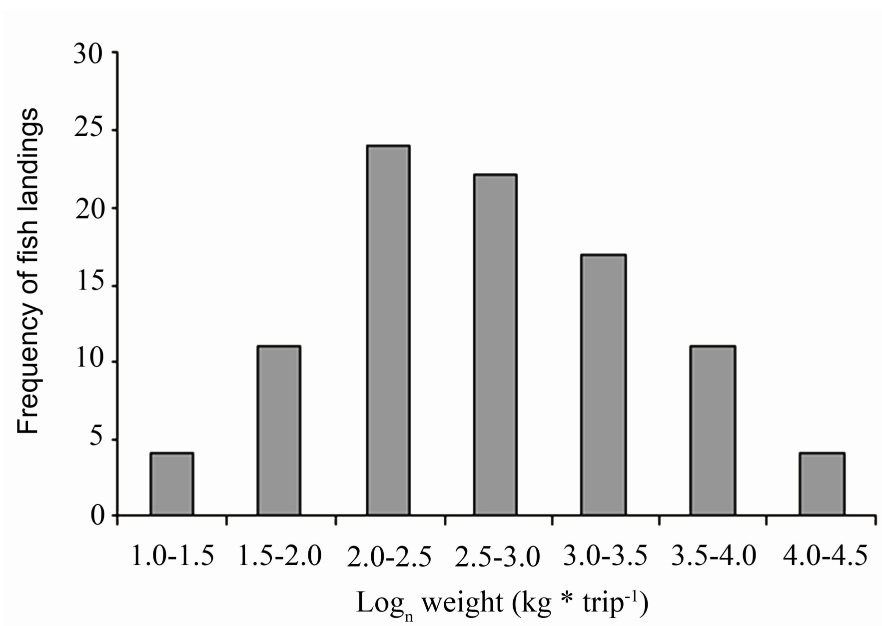


Figure 1 – Map of Santo Amaro Island, municipality of Guarujá, São Paulo State, Brazil, indicating Perequê beach.

a)



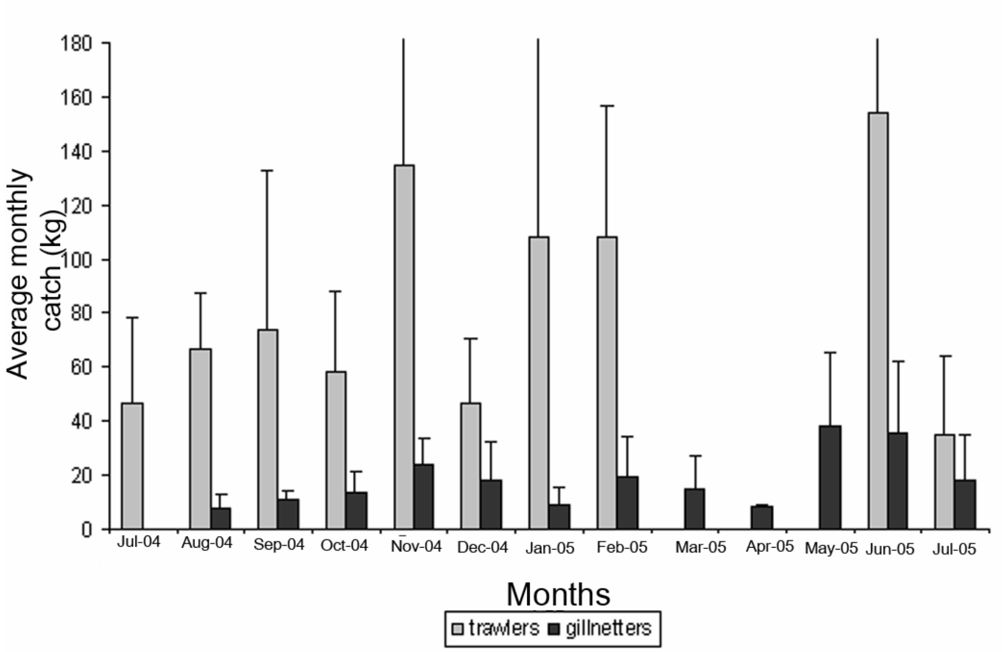
b)



Log	Kg
0-0.5	0.1-0.65
0.5-1.0	0.7-1.7
1.0-1.5	1.8-3.4
1.5-2.0	3.5-6.3
2.0-2.5	6.4-11.3
2.5-3.0	11.4-19
3.0-3.5	19.1-32.1
3.5-4.0	32.2-53.5
4.0-4.5	53.6-89
4.5-5.0	89.1-147.4
5.0-5.5	147.5-243.6
5.5-6.0	243.7-402

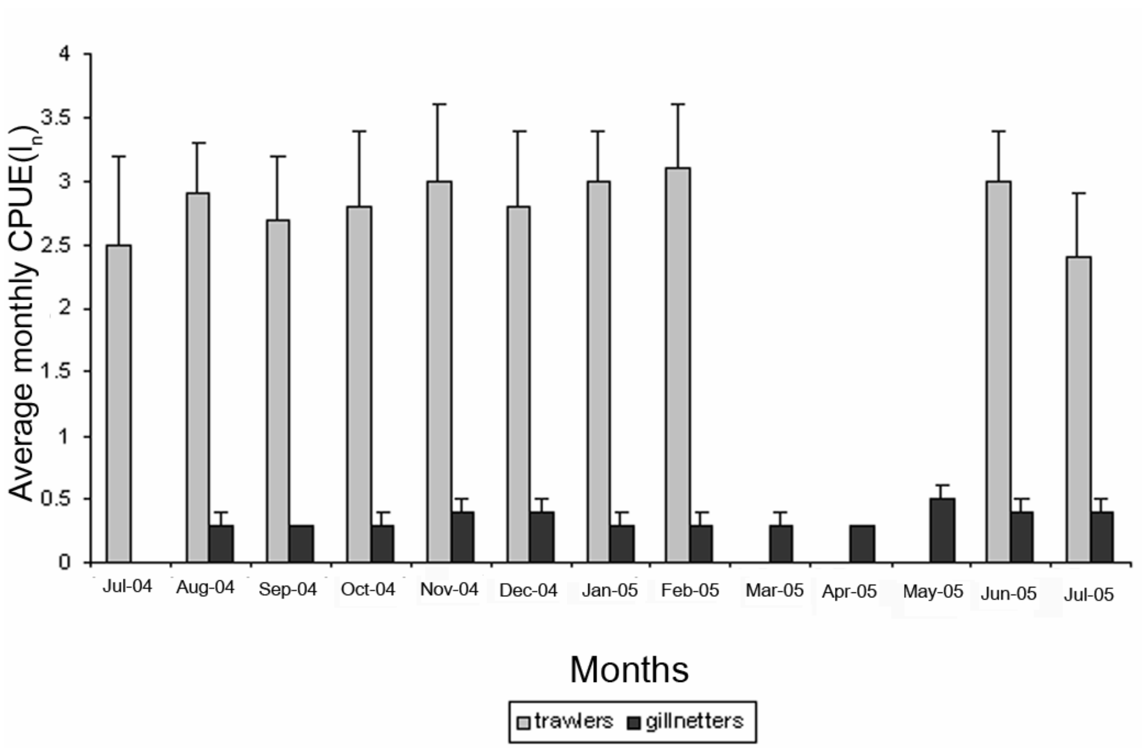
Figure 2 – Frequency of distribution of a) shrimp (n=325) and b) fish caught (n=93). The table shows the correspondent values in kilogram of the natural logarithm used in the graphs.

a)



Average monthly catch (kg)
180
160
140
120
100
80
60
40
20
0
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Months
trawlers
gillnetters

b)



Average monthly CPUE(I$_n$)
4
3.5
3
2.5
2
1.5
1
0.5
0
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Months
trawlers
gillnetters

c)

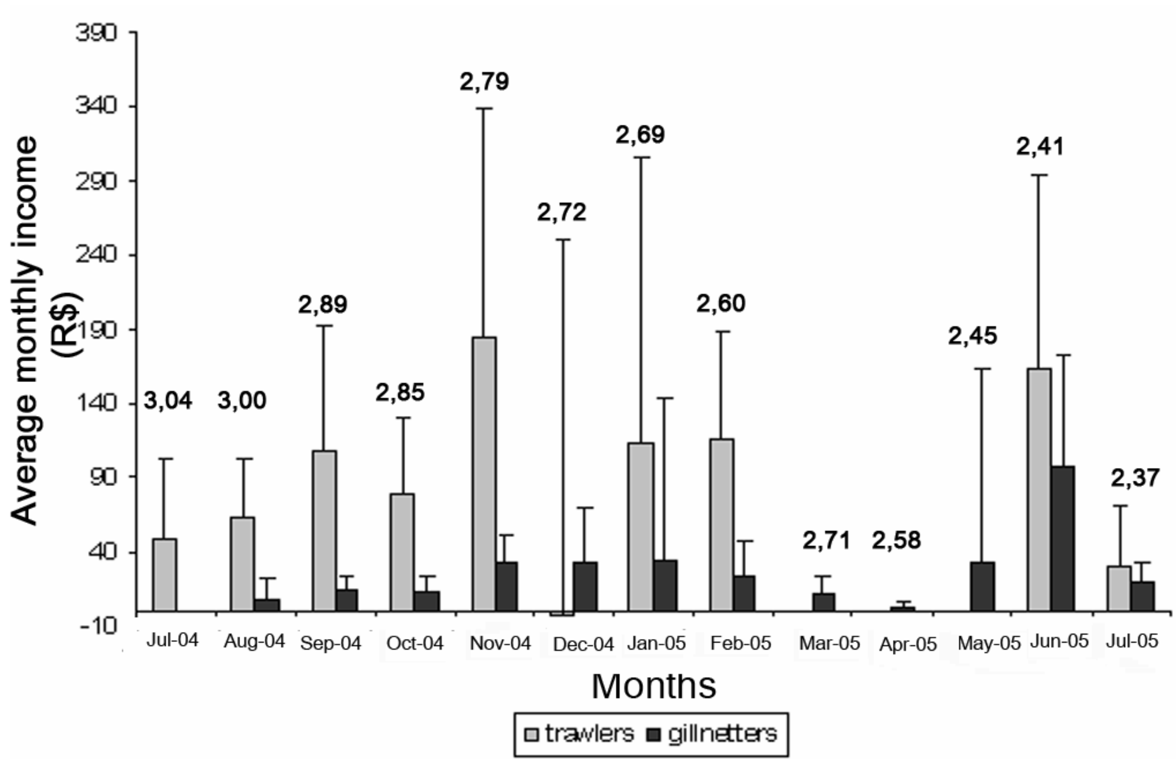
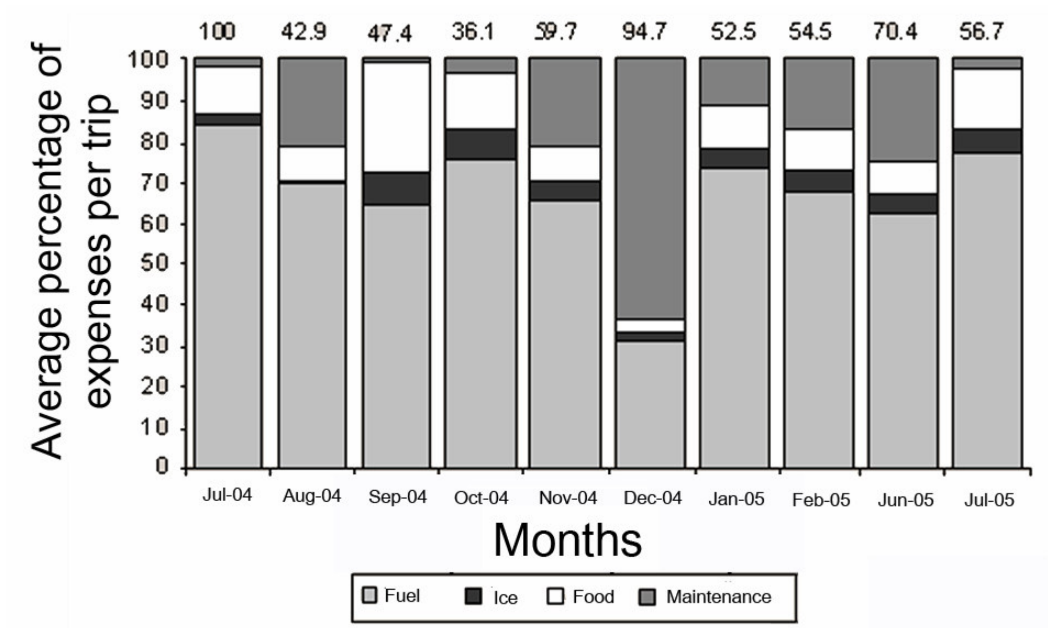


Figure 3 – Monthly average a) catch (kg), b) CPUE ($\log_n$), c) average net income (R$) made per fisherman (money earned from fisheries) and dollar price in each month. The profit of each trip was calculated through the equation: $L = \sum C_i vi - G_t$, where C_i refers to the price paid to each species and G_t is the total expenses;it represents the net income. Numbers above the bars in Figure c represents the average dollar (1US$) for its respective month. Months with no bars correspond to the closed season in case of trawlers or to insufficient data in case of gillnetters.

a)



b)

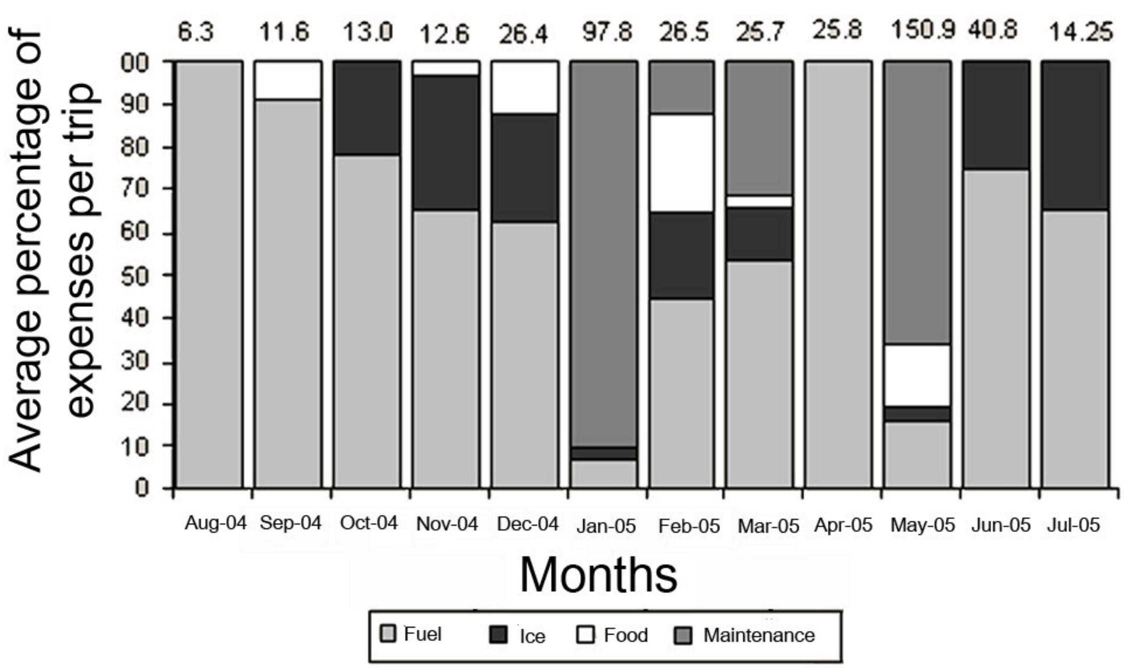
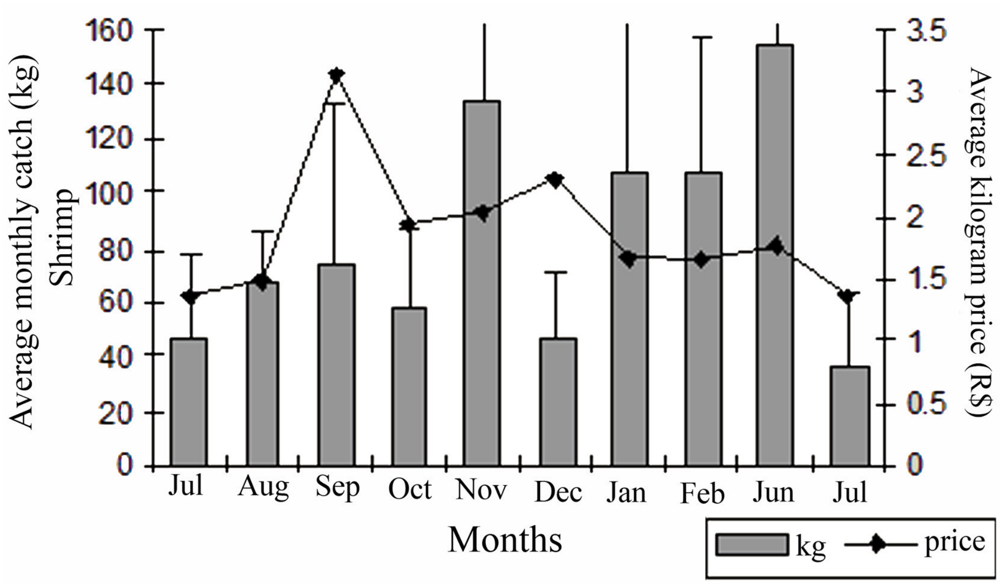


Figure 4 - Distribution of the different kinds of expenses along the months for a) shrimp and b) fish. Numbers above the bars correspond to the average amount of Brazilian money spent on each trip in the specific month.

a)



b)

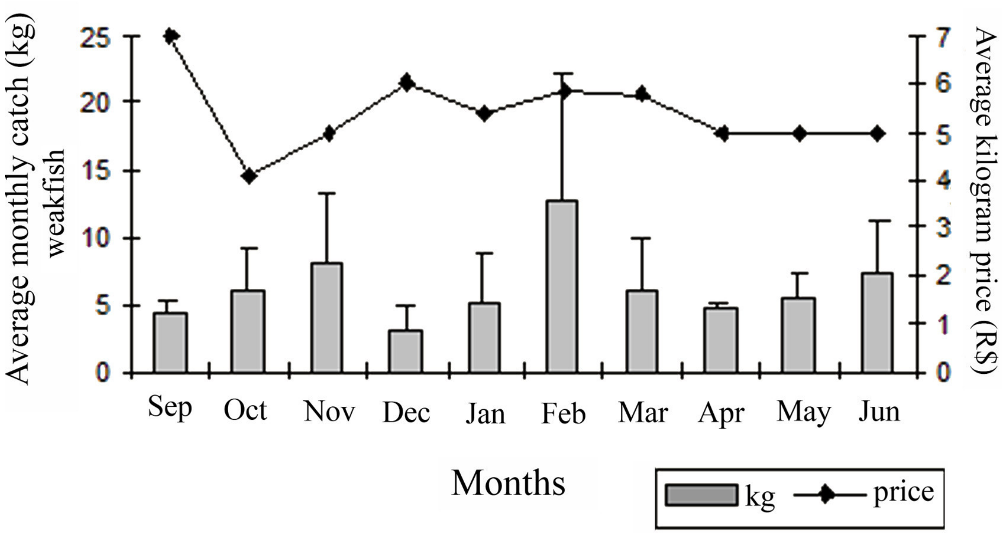


Figure 5 – a) Monthly variation in capture of the sea bob shrimp and price paid for the kilogram (R$). b) Monthly variation in the capture of weakfish and price paid for the kilogram (R$)

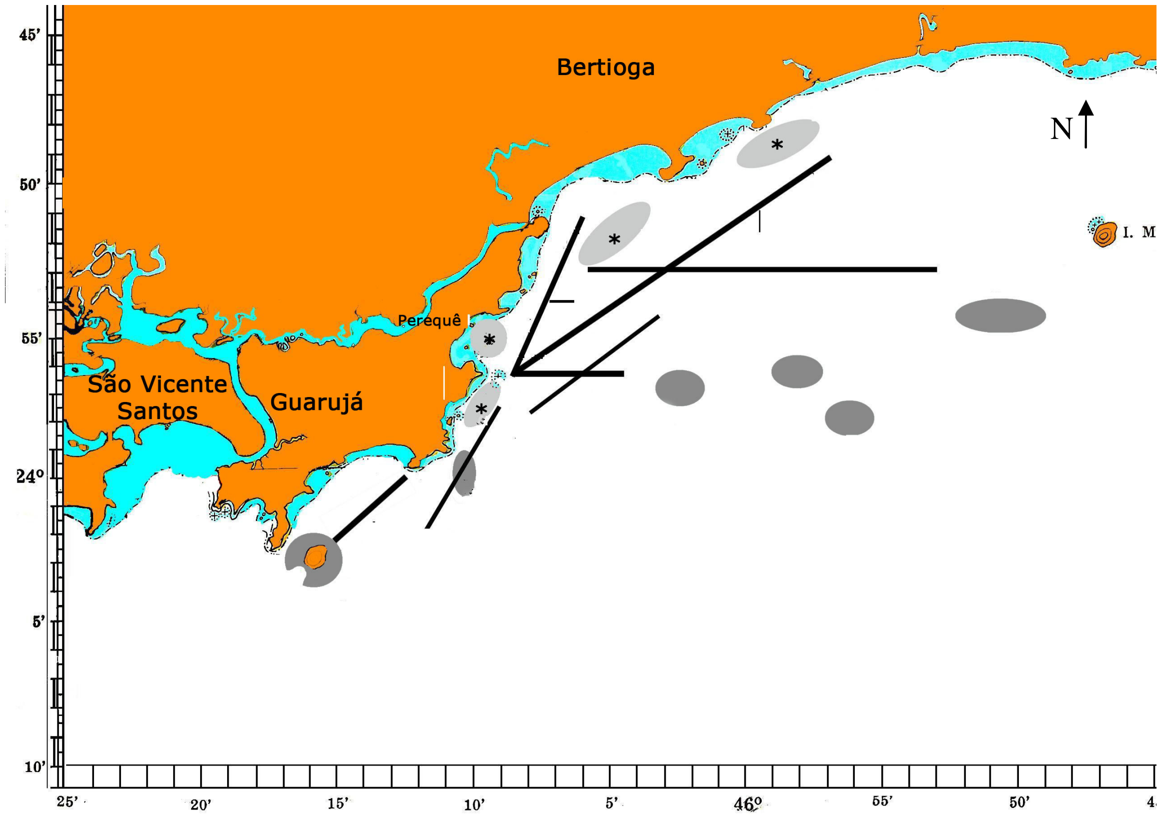


Figure 6 – Main fishing spots used by trawlers and gillnetters in Perequê. Lighter grey areas (*) represent the main spots used by both trawlers and gillnetters, while darker grey areas are just used by trawlers. Black lines represent the trajectories trawled by trawlers on their way to the main spots (they also trawl along the trajectories). Adapted from Nautical Letters 1711 (Brasil – Costa Sul: Proximidades do Porto de Santos) and 1700 (Brasil – Costa Sul: da ilha de São Sebastião à Ilha do Bom Abrigo), Marinha do Brasil, Hidrografia e Navegação).

CAPÍTULO III

Optimal foraging among Brazilian fishermen: environmental and economic factors as behavioral determinants

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Running title: Optimal foraging among Brazilian fishermen

Key words: Ecological models, seasonal behavior, small-scale fishery, decision making, Human Ecology, fisheries management

Abstract

This chapter explores Orians & Pearson (1979) Central Place Foraging Model with data on Perequê (São Paulo Coast, Brazil) trawl and gillnet small-scale fisheries, concerning the optimization of two currencies: calories and money made from fish /shrimp sales. We investigated through linear regressions if a fisherman would stay longer in a patch if he needed to travel to a more distant patch, bringing home more food, since the optimal load size increases with distance to the central place. Both fishermen group did not seem to optimize when the whole dataset was analyzed. As the weather plays an important role on fisheries success we decided to carry out the same analyses independently for each season. The results showed that gillnetters have a better success when fishing far away from the village (r^2>15% for all seasons, but summer), which, besides conforming to the model predictions, suggests some prey depletion as the fish species targeted are shallow-water species. Moreover, they also optimized their financial return more than their caloric return in the winter and the spring, which coincides with the arrival of economically important fish species. Trawlers, on the other hand, do not maximize either their caloric or financial return as much as gillnetters (although the results are significant for all the seasons; $p<0.05$), but they do fish longer in more productive seasons regardless of the distance traveled (r^2>30%). Both results for trawl and gillnet fisheries suggest non conservationist strategies by both groups and some evidence of fish overexploitation. We recommend zoning of the area between trawlers and gillnetters and no-take zones in addition to a better enforcement of the existent laws as a way of preventing general overfishing.

Key words: optimal foraging, artisanal fisheries, Brazilian coast

Introduction

The use of behavioral ecological models in situations where human foragers need to carry back the result of their foraging activity to a camp site or village only began to be exploited around the 1980s (Bettinger & Malhi 1997, Metcalfe & Barlow 1992, Winterhalder 1981). Some initial attempts to use these models were applied successfully in archaeological surveys (Bettinger & Malhi 1997, Zeanah 2002), while ethnological studies have shown that even current human groups can bring important insights to the understanding of human evolutionary patterns of resource collection (Bird & Bliege Bird 1997, Bunn *et al.* 1988).

Charnov (1976), with his well-known Marginal Value Theorem (MVT), was the first to consider the time that a forager (an animal in his example) would have to remain in a patch once the forager chose it in relation to other exploitable patches. A slight variation of the MVT, the Central Place Foraging Model add the component of transporting the food back to a camp site or village, the place where the food acquired will be shared and/or consumed (Orians & Pearson 1979). This is usually the observed situation among settled human groups, which often engage in foraging excursions aiming at bringing back home food for his/her family, relatives or friends (Beckerman 1983). Fishing activities perfectly illustrate this situation, given the greater difficulties in consuming the food in the fishing spot (patch), which probably explains why a greater deal of attention has been given to this subsistence activity (Aswani 1998, Begossi 1992, Bliege-Bird & Bird 1997, Beckerman 1983).

Patch profitability is one of the aspects that have been investigated along the last two decades (Kaplan & Hill 1992, Begossi 1992, Aswani 1998, Sosis 2002), as it is still rather unclear why foragers do not always exploit the most profitable spot, regardless any sign of depletion. Environmental conditions may play an important role in this decision-making process (Kaplan & Hill 1992), as they can affect the patch profitability along the day in a way that the best patch on average is not necessarily the best patch of the day. When these details are taken into account it is sometimes possible to demonstrate the response of foragers to short-term environmental variations.

Regardless the model used, it is always assumed that the forager is maximizing some fitness currency, which for practical reasons is usually defined as calories (Kaplan & Hill 1992, Smith 1979) however insufficient it may be in some cases (Hill 1988). Even though we have not been able to find out better ways of measuring fitness in human beings, we have an additional aspect to explore. Current human foragers groups may be also involved in the market trades (Seixas & Troutt 2003), exchanging part of their foraging returns for money. How this affects their foraging activities is not clear yet.

Most studies just ignore this aspect, although sometimes almost everything that is hunted, fished or collected may end up in the market and not in the foragers' own dishes. This does not necessarily mean that they are not optimizing their diet, since exchanging goods (food for money in this case) may be an alternative to reach such goal (Begossi & Richerson 1993, de Boer & Prins 1989, Smith 1991). However, most applications of patch models have not considered this possibility and it may be the case that we do not observe calorie optimization, but financial optimization (Aswani 1998, Nehrer & Begossi 2000). If, at first glance, one can suppose that food can be directly translated into money, it is necessary to state that market imposes different prices to products. Doing so, a forager may be not maximizing his/her return in kilogram, which would be translated into calories, but the monetary return, aiming at high-valued species. Needless to say that high-valued species are not necessarily the most profitable ones in terms of calories and vice-versa, although this may be usually true for fish. Some Brazilian fishermen for example use to fish valuable catfishes, which are not consume by them due to food taboos, but are still commercialized (Begossi *et al.* 2004b).

This chapter provides insight into foraging behaviors that can be constrained by market demands. We use here the Central Place Foraging Model under its conventional perspective, in which foragers (fishermen) are expected to optimize their time allocation according to the distance traveled, but we also consider the market price of their main fishing resources as one of the possible optimized variables. We focused our study on Guarujá municipality (Santo Amaro Island) in southeastern Brazilian coast, where we observed two different fishing strategies adopted not concomitantly by artisanal fishermen, gillnet fishing for fish and shrimp trawling. We believe that the inclusion of economic variables applied to a market inserted group using a well-established theoretical framework, such as Optimal Foraging Theory, can contribute and expand the use of behavioral ecological models, nowadays mainly restricted to the more and more scarce subsistence-oriented human groups (Bird 2007, Hames 1987, Hill 1988).

An overview of the Central Place Foraging Model

Behavioral models are based on assumptions about the decision makers and their environment. Here we are dealing with the Central Place Foraging Model (Orians & Pearson 1979), as our foragers are constrained by travel limitations, and they do need to return home to bring some food to their family or to exchange what they fished for money. This model assumes that a habitat has a number of homogeneous resource patches located at varying distances from a central place (the village in this case), asking the question: which of the patches will maximize the rate of energy delivery to the central place? Even though the decision variable is which patch to exploit, the solution depends both on time that it takes to travel to each patch and on the energetic gain provided by each of them. Such model is based on the following assumptions:

1 – Patches have negatively accelerating daily gain curves, which may be due to different factors: prey depletion, changing environmental conditions along the day (this can influence on prey and predator’s behavior), prey species’ behavior (different feeding activity along the day, daily movements, etc.), and decreasing efficiency of the forager as the load increases (Beckerman 1983).

2 – Here specifically, we also assume that decisions concerning which patch to exploit and which fishing method to use (here gillnet fishing and trawling fishing) are interdependent, once one method is chosen in a given day, the other is automatically eliminated. We believe that the opposite is not true (choosing the patch will not determine the fishing method), or, if it does, it is based on a long term decision. Fishermen may observe the profitable returns of their colleagues or their own decreasing return for a certain time before deciding to switch to another method. It is not a daily decision.

Predictions of the model

The patch residence time determines load size and the leaving rule for patches will be based on the long term average rate of energy delivery: the forager might switch patches when his return from foraging in a patch fall below the average rate of return from all the other patches in the area exploited. Direct tests of the model are not easy to perform and would require experimental conditions (Hawkes *et al.* 1991). However, Smith (1991) shows that it is possible to correlate patch residence time with patch profitability if: 1) the patch gain curves do not overlap within a habitat being exploited; 2) patchs experience a negatively accelerating gain curve and 3) that each patch can potentially be exploited on any given day.

These assumptions seem to hold or sound reasonable in the studied fishing community (Guarujá), although sometimes it is difficult to delimitate the physical limits of each patch and then assure that their rate of energy delivery curves do not overlap. Based on this, our first prediction is that a fisherman will stay longer in a patch if he needs to travel to a more distant patch, since the optimal load size increases with distance to the central place (de Boer & Prins 1989). Translating into statistical terms, we expect 1) a positive correlation between the distance traveled with the time spent fishing, and consequently 2) a positive correlation between the traveled distance and the final return on fish or shrimp biomass caught and money.

Material and Methods

The study site

Guarujá (23°59'S/46°15'W) and most of the Brazilian coast belong to the Atlantic Forest domain (from 4 to 32°S), which encompasses a different set of vegetation ranging from sand dune shrub vegetation and mangroves to lowland rainforest (<100m) and montane rainforest (100-600m). The Atlantic Forest is restricted nowadays to less than 8% of its original area of 1.100,000 Km^2 (Myers *et al.* 2000). The region climate is, according to Koeppen's classification, tropical wet (Af), with a slight decrease of rain during the winter time, with the temperature varying from 11 to 35ºC along the year. The local hydrography is marked by the presence of small rivers and abundant streams and creeks.

The ethnographic background of a commercial small scale fishing society

Fishermen of this island (Santo Amaro) are mainly placed in one beach, Perequê, in the north of the municipality of Guarujá. About 8000 people are estimated to live in Perequê, but only its central part constitutes a fishing village, where no more than 300 families dwell in a very limited area.

The fishing village was initially formed by “caiçaras” families (a local group descendant of the miscegenation between the native indigenous and Portuguese) (Adams 2000). Up to now, some “caiçaras” from other Brazilian regions based their subsistence and economy mainly on fish and secondarily on cassava (*Manihot sculenta*). However, the region where this island lies on is suitable for shrimp fishing, which is not intensively exploited by caiçaras in a commercial way. The high shrimp productivity of this region attracted professional small-scale fishermen from the south Brazilian coast, where this resource was depleted. Shrimp trawlers started to settle in Perequê in the middle 1970s and they can still be considered an important migrant group to the region. Nowadays migrants from the Brazilian northeast also constitute part of this population. Some of them found a profession in fishing while others have other jobs. The former inhabitants, the “caiçaras”, were displaced, adapted to the shrimp fishing or are still struggling to survive the competition and impacts caused by this new fishing method (trawling), while making a living off of the gillnet fishing.

Data collection

We followed fish landings of 30 main fishermen, chosen according to their age (older than 20 years old), fishing experience (more than 10 years), time living on the place (more than 10 years), willingness and availability to take part in the study. Out of these 30 fishermen, seven were gillnet fishermen (hereafter gillnetters) and worked with 11 fishing helpers and 23 were shrimp trawlers (hereafter just trawlers) who worked with five other fishing helpers. The sample period extended from July 2004 to July 2005. We did not sample shrimp landings between March and May 2005, due to the shrimp closed season.

Shrimp and fish catch (kg) was weighted in shrimp processing plants or in the fish market in front of the beach. “Mix” (*mistur*a) (small fishes with low commercial value) was weighted by the researchers or had its weight estimated by the fishermen, as the mix was usually donated on the beach or taken home for consumption. We interviewed the fishermen about the fishing spot visited, kind of nets used, number and duration of trawls (in the case of trawlers), price received by the kilogram of each species and expenses with oil, ice and boat repairs. We also followed 21 shrimp fishing trips to identify the fishing spots using a GPS, besides observing *in loci* how shrimp fisheries work (duration of each trawl, total catch, by-catch discharged behavior, etc.).

Statistical analysis

The central place foraging model analysis considered the fish and shrimp fishing strategies using the whole dataset and the data separated by seasons. Basically, the fisheries are done using gillnets and trawls to catch fish and shrimp respectively, which makes unnecessary the analysis for different techniques. The few events (six) using other techniques were not considered here. For each kind of fishery, we performed simple linear regressions (after data normalization through natural logarthm) having trip time to and from the fishing spot as the independent variable, which represents the distance traveled by the fishermen from his central place. Time spent fishing (in minutes, excluding traveling time), fish/shrimp weight (kg) and the gross financial gains from fish/shrimp sales were the dependent variables. The same analyses were carried out for each season. When the average value of the regression variables suggested some difference among the Seasons, we used One-Way ANOVA (Tukey test *a posteriori*) to confirm such average differences,

Results

The frequency that each prey type was exploited is as follow: they fished for shrimp in 100% of the observational days (40 days), while they fished using gillnets in 86.6% of the days (55 days, since there is no closed season). Sea bob shrimp (*Xyphopenaeus kroyeri*) was the main species target by trawlers, comprising 95% (32 ton) of their catch, followed by white shrimp (*Penaeus schimitti*), which represented 2% of the catch (0.4 ton). Gillnetters targeted mainly weakfish (*Cynoscion* spp), corresponding to 30% of their catch (0.5 ton), and other 16 species contributed to the remaining of the catch in a non-relevant way except for "mix", many small fish species with low economic value that corresponded to other 29% of the catch. They are the same species considered bycatch by trawlers.

Gillnet fishery

An optimal forager, according to the Central Place Foraging Model, is expected to stay longer in a fishing spot if he needs to travel further to that spot, since he needs to bring more food to compensate the distance traveled. However, although significant, the regression between the distance traveled and the time that gillnetters actually fish is low (r^2 = 7.3%) (Table 1). This is also valid for the correlations between "traveling time" and "financial" or "kilogram return". Higher returns (in kg or $) are assured if they travel longer distances to the fishing spot (r^2 > 12%), but even this regression also requires other variables to explain the remaining of the variation. Consequently, we cannot say that gillnetters are maximizing their short-term individual goals by harvesting resources as efficiently as possible.

However, some tendencies and patterns can be seen when the data are grouped for example in new categories, such as season or habitat. It was not possible to group our data in different habitats, because the environment is rather continuous, with no lagoons or reefs in this region. However, there is some variation in the weather conditions along the year, which is very likely to affect the presence/abundance of fish (Annex 8). In this case, part of their final return would be given by environmental factors, although this does not totally explain the amount of time they stay in a fishing spot – except for the few times when they need to return earlier due to rough sea conditions.

After carrying out some correlations between the financial return and environmental factors, we noticed that only wind is negatively correlated with the gross financial return (Spearman r = -0.41; p = 0.009). Considering that variables such as "gross financial return" and "gross kilogram return" are highly unpredictable along the year (Table 2), we decide to exploit if decisions about fishing further or staying longer would be influenced by general patterns given by environmental factors (probably wind or other not measured factor) related to the seasons of the year. These new analyses did bring different outcomes as we will see below.

The assumption about distance and time fishing just holds in the fall (r^2 = 62%). During this time it is true that going further makes fishermen stay longer to compensate the greater investment in time travelling. In the other seasons (except for the summer), the same general pattern showed in the first general regression still prevails: only the distance traveled explains the caloric (kg) and financial returns. Again, we found some evidence that fishermen's success is mostly dependant on going fishing far away from the coastal village (Table 1).

It is worth noticing that in winter and spring, the distance traveled explains the financial return better than the kilogram return, which is probably due to local economic value attributed to the fished species. We then checked which species were fished during these seasons and we observed that in the spring, weakfish (*Cynoscion* spp, Sciaenidae) represents 56% of their money made from fish selling, while it represents 30% of the amount of fish caught in this period. This pattern is even clearer in the winter, when white shrimp (*Pennaeus schmitt*, Penaeidae) caught on gillnets represents 29% of the fish sales, but just 6% of what is caught, and weakfish again has an important contribution to their profits (Table 3)[9]. No significant regressions between distance traveled and amount caught or financial return were observed in the summer.

Other results also reinforce the idea of a depletion or absence of fish resource close to the central place. For instance, during the winter the traveled distance explains about 54% of the

[9] This table was not made to shrimp fisheries, as sea bob shrimp represents pretty much (above 96%) the sole resource exploited and commercialized in all the seasons.

gross financial return, but a fisherman should travel for at least 57 min round-trip for not incurring in debts (see the equation and the negative intercept) (Table 1).

Shrimp Trawl Fishery

Not differently of the gillnetters' results, trawlers behavior do not follow what we would expect based on the model assumptions. The time that they fish in a spot is almost completely independent of the distance traveled ($r^2 < 5\%$) (Table 4). In this case and despite the much more intense fishing, we cannot say that they need to travel further to get some shrimp, which would suggest local resource depletion. We also do not have evidence to confirm the health shrimp fisheries condition, although the average kilogram return values suggest that they can still catch shrimp productively (Table 2).

When the same analyses were done to the three different seasons in which we could observe shrimp fishery (spring, summer and winter), the regressions were significant but travel time here explained much less of the financial and caloric return (Table 4). We then decided to investigate if success would be correlated to time spent trawling, as we noticed that fishermen intensify their effort in seasons they consider more productive. This correlation turned out real, time trawling explains most of their return in kilogram (Table 4). In this case, as it can be seen by the coefficient of variation, the variable that shows the trawling time ("time fishing") is the one that varies the least, also keeping a very stable average value (low standard deviation) (Table 2). We also observed no correlation between the three main measured weather-related variables (tide height, wind speed and daily average temperature) and the gross financial return (Pearson correlation, $p > 0.05$).

Our own observations (n=21) of the trawling fishing trips support the idea that the distance traveled does not imply in a longer or shorter time fishing or in the final return, since the distance traveled until the fishing spot is considerably restrict, always quite close to the coast (estimated by us in 57.85 km^2 through mapping of the spots). During spring, time trawling explains less than 35% of the gross kilogram return, while in winter and summer this value is above 60% (Table 4). Winter is also the season when fishermen tend to stay a longer time trawling, while in summer they spend the least time (ANOVA: $F_{time\ fishing}$ = 2,76; p =0,06) and have the lowest profits ($F_{gross\ return\ R\$}$ = 7,18; p = 0,001; Tukey winter and summer: Q = 3,89; p < 0,05; spring and summer: Q = 5,17; p < 0,01).

Discussion

Maximization of the short term return is the aim of an optimal forager (Stephens & Krebs, 1986). An optimal forager would not be concerned with resource depletion or with its future consequences, but just to forage as efficiently as possible (for example, due to high competition among them or between different groups, Begossi 1992), though such efficiency can sometimes result in non-intentional conservation of resources (Hames 1987, Aswani 1998). This is a statement difficult to accept by cultural ecologists (Sahlins 1968), who claim that different mechanisms such as food taboos evolved to deter overexploitation of resources (Coulding & Folke 1997, McDonald 1977) and explain the apparent population stability of current human groups nowadays.

Our first results showed that if we simply analyze the data as a whole we will conclude that we are not dealing with optimal foragers, they seem to not aim or not be able to maximize anything. Apparently this would be great news for management decision makers, fishermen could be behaving in a non-intentional conservationist way (Coulding & Folke 1997, Gadgil & Vartak 1974).

However, a closer look of this simple situation analyzed here could bring us two different aspects, they are either not maximizing because there is nothing left to pursue (gillnetters) or the resource is still abundant and is especially abundant closer to the village (trawlers) due to biological characteristics of the exploited species. Shrimp for instance reproduces in estuaries, and the main species exploited by these local fishermen (*Xyphopenaeus kroyeri* and *Penaeus schimitti*) occur predominantly in shallow waters (Castro *et al.* 2005). Begossi (1992) also suggested that non-maximization could be a competition outcome: fishermen would remain longer than the optimal time in a patch because the alternative ones were probably already depleted by competing fishermen. But a more detailed analysis by season brings up a different scenario: apparently we are indeed dealing with optimal foragers.

Beginning with gillnetters, we observed that in general they are partially behaving as expected by the model, as a better return is assured depending on how distant they go from the village. Here we seem to have some clear evidence of overexploitation. The fish species (*Cynoscion* spp., *Centropomus undecimalis, Micropogonias furnieri, Mugil platanus,* etc.- Table 3) they are catching are associated to shallow and estuarine water, such as Perequê bay (Van Os *et al.* 1981), but they cannot fish them close to the village anymore. However, how could we say that they are optimal foragers if the model may be just indicating an overfishing problem? This result would be valid in itself, but we can still suppose that they are optimizing as long as they are maximizing their return, doing whatever it takes for that, traveling to distant spots for example, although they do not stay there longer than they would stay in a closer one. We noticed that they intensify their time fishing when the resource is less abundant (summer, Table 2), which is exactly what is predicted by the model. Burger *et al.* (2005) demonstrates, for example, that Nunamiut Eskimos intensify their carcass-processing in bad times, using the resources that are typically ignored in good times. This is analogous to saying that they stay longer in a patch (fishing in our case) when the prey encounter rate decreases. The archaeological and ethnographic records abound with evidence suggesting resource depression by human predation, when other exogenous factors can be ruled out (Alvard 1993, Canon 2003, Thomas 2007).

The relevance of taking economic aspects into account is also clear, as we can see that the more distant they go the more money they make in winter and spring, which is probably due to higher priced species occurring at these periods (but that bring similar return in kilogram). However the usual low gillnetters' returns (in kg) suggest that the patches are all depleted. Marchal *et al.* (2007) showed, on the other hand, that fish prices provided only partial information on fishermen's behavior of North Sea Dutch and French region, suggesting the existence of other economic incentives (subsidies and operational and fixed costs) driving fishermen's decisions. The differences between the studies may be explained by a totally different ecological and socio-economic background, where different methods are used (gillnets x large beam trawlers and large otter-trawlers), different species are targeted (multi tropical species x plaice/ sole and saithe[10]) and different degrees of market insertion take place (small-scale x industrial).

According to the models, we would expect efficient foragers to decide to not pay the costs of searching an increasingly elusive prey in a specific patch (Thomas 2007). But apparently the prey is all used up in all the patches and they would do better switching their target, which could have been shrimp, if this resource were not taken over by the outsider shrimp trawlers. Regardless the reasons for them insisting on exploiting an exhausted resource, it is evident that they do not behave as conservationists at all, which is no news among foraging societies. Keegan (1986), for example, studied the Machiguenga, a horticulturalist indigenous group from Peru, and showed how useful the models could be to dismantle hypotheses suggesting soil use conservation practices. The complicate packaging of cultigens in their tropical gardens aimed just at getting the maximum total return for their investments: they would not include cultigens that protect the soil if they did not have potential diet benefits (Keegan 1986).

On the other hand, we observed shrimp trawlers apparently optimizing in all seasons, although travel time explains just a little of their caloric and financial return. But here we can just conclude that they catch more shrimp if they trawl longer, regardless the distance they travel, apparently demonstrating that the greater the effort the greater the success. Which is more likely to happen is that they do not change their trawling strategy regardless of the season or place. Probably the absence of patches with well defined boundaries is the main reason for that: they cannot really leave a patch if their return drops to a sub-optimal level. We followed 21 trips to confirm the inexistence of such patches, besides mapping some of the spots they trawled reported during the interviews. We observed that although there are some preferred spots for trawling according to the sea bottom (sand or mud), they trawl the whole area regardless. Under a conservationist perspective, this is a negative aspect. Fishermen exploit the region close to the coast over and over, leaving no abandoned patch behind where prey types would be able to rebound (Alvard 1993, Thomas 2007).

[10] Plaice: *Pleuronectes platessa*; sole: *Solea solea*; saither: *Pollachius virens* (Marchal *et al.* 2007).

So how can we explain that their return (either in calories (kg) or in monetized currency) is given by their time fishing in each season, while this does not hold when the whole dataset is analyzed? We can see some slight, but significant, differences in travel time according to the season. Fishermen can probably adjust to these small differences in each season, varying their traveling time within a narrow range for each period. This results in them fishing for different proportions of time in relation to their traveling time. For example, they travel shorter distances in summer and even though they also fish for a shorter (but the difference is non significant) period, the proportion fishing time/travel time is 2.1, while in winter it is 1.8 and in spring it is 1.2, representing a variation of 75% between summer and spring. Interestingly here it is not the financial return that is maximized, but only the amount caught, probably because there is hardly any variation in the price paid per kilogram to the fisherman (R$ 1,50 – 2,00 /kg) for the main species caught (*Xyphopenaeus kroyeri*).

A comparison between these fishermen and some more typical *caiçara* communities, where there are no or almost no migrants and less commercial shrimp fishery would be certainly add to the understanding of Perequê's situation. We chose for that two other islands located on Sepetiba Bay (Rio de Janeiro State) and Cananéia (São Paulo State). Both places rely on artisanal shrimp fishery as an important source of income (Begossi 1992, Begossi *et al.* 2006). In Sepetiba, Begossi (1992) observed that the longer the time spent in a spot, the larger the number of shrimp they catch ($Y = 0.61 - 24.05 X$; $r^2=0.52$; $p > 0.001$) and consequently the amount in kilogram ($Y = 0.02 - 0.2X$; $r^2=0.38$; $p > 0.001$), which roughly equals to our conclusion that the longer the trawling time the greater the return. Under an optimal foraging perspective, she shows that, differently of what we found, in Sepetiba the time that fishermen will remain in a spot does relate to the distance traveled ($Y = 1.53 + 49.26 X$; $r^2=0.22$; $p = 0.024$) The same is true for Cananéia, the number of shrimp caught increases with travel time ($Y = 1.20 + 0.77X$; $r^2=0.19$ $p > 0.001$) (there is no information available on time on each spot). This suggests that apparently, the model predictions work even better when applied to more resource-dependent and less market-oriented groups (Begossi *et al.* 2005).

In general, we cannot say that the model itself is a good descriptor of the situation observed among the Guarujá fishermen, unless we go deeper into details that only some ethnographic observations can reveal. This is both the case of different behaviors according to the season and different economic value of some targeted species. If we do not take into account economic variables, such as how much money they make when fishing in different ways, we would probably miss an important component of their optimization process. Our conclusion would have been similar, they optimize for their return in kilogram, but they do optimize even more their financial return. Obviously in most cases the two variables (kg and $) are correlated, but apparently money is what really matters, since they often do not consume what they fish. Fishing is a profession for both groups, they make a living off of it, it is just natural to expect such results. We were aware that some discrepancies between the theoretical optimal and practical decisions could happen due to some limitations of using a simple deterministic model, as for example the lack of perfect knowledge (de Boer & Prins 1989). Moreover, direct tests of patch models require detailed data on return rates and time budgets, which is hard to be done in real conditions and apparently have not happened yet in studies on human behavior (Thomas 2007).

Perspectives on resource extraction in Guarujá

As pointed out by Hawkes *et al.* (1982), optimal foraging theory does not necessarily explain and describe the whole diversity of subsistence economies. In some cases, some basic ethnographic knowledge helps understand the data in the context (Durrenberger & Pálsson 1986). We should ask how important environmental, social and/or economic factors are for the group studied before drawing up our conclusions.

Another important point is the relevance of what we found to decision makers. If any management measure is to be adopted, they might consider the poor fishing conditions of the region for fish. Was this fishery overexploited by gillnetters as we suggested in a simplistic way? Was trawling fishery being harmful to fish species? There is strong and well established evidence on the negative impacts of trawling on juveniles of fish species (Jones 1992, Prena *et al.* 1999)

There is also a common complaint among gillnetters saying that trawlers damage the sea floor and bring home or discharge considerable amounts of juvenile fishes (Futtemma & Seixas 2008, MacCord *in press*). Such processes are usually complex and both things may be happening there and deserve further investigation. Regardless of the causes, it stands out the fact that there is barely fish for consumption. On the other hand, based on the high and stable fishery returns, shrimp is apparently still abundant even close to the village, hence there is still time to avoid overexploitation. However, biological studies are necessary to confirm shrimp and fish population status.

However, the most important aspect showed here is that, regardless weight or profit maximization, both gillnetters and trawlers optimize their short-term goals and they do whatever it takes to harvest resources as efficiently as possible. In the case of gillnetters, this implies in an increasingly pressure over already scarce resources, while in case of trawlers we cannot assure that their foraging behavior is non-sustainable, as prey is still abundant. Glaser & Diele (2004) showed however, that even when biological sustainability criteria is met this does not imply in achieving social and economic sustainability. Compromising one of the aspects of sustainability threatens the success of relevant management initiatives, where centrally affected stakeholders would be taken into account (Glaser & Diele 2004). Future work on Perequê should look at possible evidence of economic and social erosion if appropriate sustainable schemes are to be developed.

Patch foraging models state that to keep some optimal behavior, foragers should move between patches when their return decreases, leaving the remaining prey and giving them a chance to rebound. However, the sea is one big patch in this area and except for the closing fishing period (3 months a year) there is no other time for prey to recover. Zoning of the area with specific gillnet fishery, shrimp trawl fishery and no-take areas, associated to a stronger enforcement of the closed period, would give the system a better chance of being sustainably exploited in the long run. Moreover, future work should also evaluate deeper and in details the local ecological status of fisheries, associating it with social and economic sustainability studies. Associating different investigations lines, such as behavioral ecology to ethnographic and socio-economic analysis, may provide the needed insights and answers to the design of conservation practices.

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Table 1 – Linear regressions carried out using the gillnet fish landings. Ns = non significant. *The equation is just shown when it is significant. Tr = Travel; Fis = Fishing; Ret = Return.

	Regression	r^2 (%)	p	Equation (Y = a + bX)*
Total	Tr.time x Fis.time	7,34	0,009	Y= 4,73 + 0,4X
	Tr.time x Ret. (kg)	14,82	0,001	Y = 0,66X
	Tr.time x Ret. ($)	12,56	0,001	Y = 0,9X
Winter	Tr.time x Fis.time	0,02	0,96	Ns
	Tr.time x Ret. (kg)	33,81	0,03	Y = 1,99X
	Tr.timex Ret. ($)	53,87	0,007	Y = -12,69 + 3,15X
Spring	Tr.time x Fis.time	4,16	0,28	Ns
	Tr.time x Ret. (kg)	17,28	0,02	Y = 0,4X
	Tr.time x Ret. ($)	27,01	0,003	Y = 0,86X
Summer	Tr.time x T.pesc.	1,01	0,65	Ns
	Tr.time x Ret. (kg)	3,68	0,38	Ns
	Tr.time x Ret. ($)	2,87	0,44	Ns
	Fis.time x Ret. (kg)	0,80	0,69	Ns
Fall	Tr.time x Fis.time	61,76	0,001	Y = 1,28X
	Tr.time x Ret. (kg)	42,78	0,001	Y = -2,34 + 1,09X
	Tr.time x Ret. ($)	17,38	0,03	Y = 0,93X

Table 2 – Average values and coefficient of variation (CV = Standard Deviation / Average) of the variables used in the regressions, after Log_n transformation.

	Travel time		Fishing Time		Gross return (kg)		Gross return (R$)	
Number of trips	Avg	CV	Avg	CV	Avg	CV	Avg	CV
Gillnet fishin								
Total (91)	5,48	0,08	6,92	0,10	2,75	0,28	3,78	0,31
Winter (12)	5,44	0,06	6,84	0,07	2,94	0,34	4,44	0,31
Spring (30)	5,36	0,10	6,92	0,11	2,83	0,19	3,77	0,24
Summer (23)	5,42	0,06	7,11	0,07	2,56	0,38	3,51	0,42
Fall (26)	5,69	0,08	6,80	0,11	2,76	0,27	3,72	0,27
Trawl fishing								
Total (320)	5,18	0,13	5,85	0,08	4,37	0,19	5,03	0,17
Winter (113)	5,28	0,10	5,90	0,06	4,44	0,22	5,09	0,16
Spring (106)	5,24	0,15	5,89	0,08	4,41	0,17	5,20	0,13
Summer (101)	5,01	0,12	5,76	0,10	4,25	0,19	4,77	0,22

Table 3 – Seasonal exploitation of fish resources by gillnet fishery. For each season is shown the amount caught (kg), its percentage in relation to the total, how much money was made from each product sale and how much this represents in percentage.

Common Name	Scientific Name	Spring (n=30)				Summer (n=23)				Fall (n=26)				Winter (n=12)			
		kg	%	$	%	kg	%	$	%	kg	%	$	%	kg	%	$	%
Atlantic tripletail	*Lobotes surinamensis*	5	1.05	5	0.31									60	1.86	10	1.23
Barracuda	*Sphyraena* spp.													10	0.31	5	0.61
Catfish	Pimelodidae	7	2.11	4.5	0.28	33	7.58	62.5	3.87							9.5	1.17
Cutlass fish	*Trichiurus lepturus*									6	13.82	11	7.80	60.5	1.88	47	5.78
Florida Pompano	*Trachinotus carolinus*													20	0.62	11	1.35
Leather Jacket	*Oligoplites saliens*	5	1.05	10	0.63	14.4	3.31	26.7	1.65					80	2.49	107	13.15
Mix	Small fish of different families	186.5	28.42	125.5	7.85	125	28.61	105	6.50	11	25.35	3	2.13	269	8.35	207	25.44
Mullet	*Mugil platanus*													40	1.24	10	1.23
Shark	*Carcharhinus* spp.; *Sphyrna* spp.	49.3	18.95	202.5	12.66	83	19.08	430	26.57	5.5	12.67	32	22.70	38	1.18		
Smooth Puffer	*Lagocephalus laevigatus*									2.5	5.76						
Snook	*Centropomus undecimalis*	21.1	6.32	155.5	9.73	13.5	3.10	125	7.73					80	2.49	9.6	1.18
Southern Kingcroaker	*Menticirrhus americanus*	0.5	1.05			3	0.69	15	0.93					10	0.31	5	0.61
Spanish Mackerel	*Scomberomus brasiliensis*	3.5	1.05	17.5	1.09					3	6.91			659	20.48	146	17.94
Weakfish	*Cynoscion* spp.	187.6	30.53	889.9	55.66	156	35.78	837	51.76	15.4	35.48	95	67.38	960	29.84	182	22.40
White Shrimp	*Penaeus schimitti*													905	28.11	51.4	6.32
Whitemouth croaker	*Micropogonias furnieri*	78	9.47	188.5	11.79	8	1.84	16	0.99					26.8	0.83	13	1.60
Total		543.6	100	1599	100	435	100	1616	100	43.4	100	141	100	3217	100	814	100

Table 4 – Linear regressions carried out using the shrimp landings. Ns = non significant. *The equation is just shown when it is significant. Tr = Travel; Fis = Fishing; Ret = Return.

	Regression	r^2 (%)	p	Equations (Y = a + bX)*
Total	Tr.time x Fis.time	1,45	0,03	Y = 5,4 + 0,09X
	Tr.time x Ret. (kg)	2,96	0,002	Y = 3,22 + 0,22X
	Tr.time x Ret. ($)	3,73	0,001	Y = 3,7 +0,26X
	Trawl. Time x Ret (kg)	2,38	0,006	Y = 2,72 + 0,28X
Winter	Tr.time x Fis.time	0,16	0,68	Ns
	Tr.time x Ret. (kg)	2,02	0,13	Ns
	Tr.time x Ret. ($)	3,58	0,04	Y = 3,64 + 0,27X
	Trawl. Time x Ret (kg)	60,29	0,001	Y = -7,06 + 1,95X
Spring	Tr.time x Fis.time	0,06	0,8	Ns
	Tr.time x Ret. (kg)	6,16	0,01	Y = 3,16 + 0,24X
	Tr.time x Ret. ($)	4,46	0,03	Y = 4,24 + 0,19X
	Trawl. Time x Ret (kg)	33,79	0,001	Y = 0.97X
Summer	Tr.time x Fis.time	8,20	0,004	Y = 4,45 + 0.26X
	Tr.time x Ret. (kg)	14,39	0,001	Y = 1,69 + 0,51
	Tr.time x Ret. ($)	10,04	0,001	Y = 1,95 + 0,56X
	Trawl. time x Ret (kg)	63,03	0,001	Y = -2,48 + 1,17X

Table 5 – Total amount caught, gross revenue, time allocated to traveling and fishing and productivity in each season.

Fishing method	Season	Total amount caught (kg)	Travel time (min)	Fishing (residence) time (min)	Per capita return rate (kg/min)	Total gross revenue (R$)	Per capita return rate (R$/min)
Net fishing	Winter	322.92	2875	5635	0.038	1913,25	0.23
	Spring	546.05	7130	35855	0.013	1615,90	0.04
	Summer	434.70	5460	19110	0.018	1524,70	0.06
	Fall	531.25	8475	16760	0.021	1438,00	0.06
Shrimp fishing	Winter	13346.39	24885	43655	0.19	24142.31	0.35
	Spring	11299.79	35038	41065	0.15	23822.88	0.31
	Summer	8870.32	17344	35758	0.17	15877.57	0.30
Total		35351.42	101207	197838		70334.61	

CONCLUSÕES GERAIS

A presente tese traz uma caracterização de uma das poucas, talvez única, comunidade estritamente pesqueira remanescente no Guarujá. Apesar das tendências turísticas do local, existe uma dependência destes recursos que vão além da Praia do Perequê. O camarão retirado de lá abastece parte do mercado do Estado de São Paulo, enquanto o peixe abastece os restaurantes locais que dependem do turismo. Desta forma, um olhar mais atento para os pescadores é uma necessidade tanto econômica quanto social e por "olhar" implica-se em adotar medidas de caráter ecológico e sócio-econômico que diminuam a pressão sobre o recurso sem prejudicar àqueles que dependem dele. Partiu-se de objetivos que visavam caracterizar os aspectos sócio-econômicos locais, a pesca e o processo de tomada de decisão. Entretanto, os resultados encontrados superaram as expectativas iniciais, trazendo aspectos sobre o processo migratório dos pescadores, conflitos a respeito do direito de acesso ao recurso e algumas evidências de sobre-exploração ou de exploração não controlada.

Trata-se de uma comunidade diferenciada em relação às demais comunidades caiçaras do litoral de São Paulo. A presença majoritária de migrantes do sul do país trouxe influências que abrangem os aspectos econômicos e sociais. Há um maior interesse comercial na pesca, com baixa relevância na subsistência. A pesca do camarão raramente ou nunca tem caráter de subsistência neste local. Embora seja possível afirmar que isto tenha influenciado a compra de barcos maiores, na medida em que pressionou mesmo os pescadores caiçaras nativos a se profissionalizarem, não é possível dizer quantitativamente o grau desta influência. Além disso, esta pesca criou uma economia local totalmente centrada em um único produto, o camarão, do qual grande parte das famílias depende direta e indiretamente. Os caiçaras locais ainda conseguem de certa forma manter um certo distanciamento desta economia.

Os conflitos entre os dois grupos de pescadores ainda são esporádicos, não reconhecidos abertamente por todos e pouco agressivos. Entretanto, a constatação de que camaroeiros não hesitam em danificar as redes dos outros pescadores e estes em retaliação também não hesitam em tomar satisfação ou ameaçar denunciá-los aos órgãos ambientais (nenhum denúncia de fato foi observada durante o período de campo) sugere que tais conflitos sejam reais. A evolução desta situação merece ser observada cuidadosamente.

A captura de camarão sete barbas ainda é abundante e, provavelmente explica porque muitos pescadores ainda se aventuram a tentar a vida neste ramo, migrando para a região. Entretanto, o esforço também é grande e preocupa em termos de sobre-exploração. Já a pesca de peixe é irrisória em termos financeiros, apesar do esforço considerável em números de horas pescando. Apesar disto, o retorno da pesca com redes é menos variável que o alto, mas mais imprevisível retorno do camarão. Pescadores convencionais já não vivem exclusivamente da pesca de peixe, enquanto camaroeiros correm o risco de estar na mesma situação se o esforço continuar intenso e se o número de novos pescadores aderindo a esta pescaria continuar crescendo.

O uso de modelos de forrageio também demonstrou que aparentemente não se tratavam de forrageadores ótimos quando os dados foram analisados conjuntamente. Entretanto, a análise por estações do ano mostrou que pescadores que utilizam rede de espera só atingem melhor retorno quando pescam longe da comunidade. Este resultado específico sugere uma sobre-exploração do recurso próximo à vila, visto que as espécies que eles almejam vivem próximas à costa. Também seguindo as previsões do modelo, estes pescadores intensificam a pesca quando o recurso se torna menos abundante (verão). Já os pescadores de camarão otimizam em todas as estações, já que quanto mais tempo arrastando, maior o retorno, independentemente da distância viajada. Isto sugere que contrariamente ao peixe, o camarão ainda é abundante próximo à costa. Sugere ainda a não existência de pontos de pesca claramente definidos para os pescadores de camarão. O processo de otimização de ambos os grupos sugere ainda uma estratégia que visa o retorno de curto prazo, sem nenhuma ação intencional ou não que leve à conservação dos recursos. A baixa relevância de ambas as pescarias para a subsistência também fica clara na medida em que ambos os grupos parecem maximizar mais o retorno financeiro do que o retorno calórico.

Apesar dos conflitos iniciais, ainda não há nenhuma forma de restrição local ou comunitária de acesso aos recursos. O período de defeso estabelecido pelos órgãos governamentais não é respeitado em função de deficiências na fiscalização associadas à ineficiência do pagamento do seguro desemprego, muitas vezes pago meses após o fim do defeso. As demais portarias que visam limitar ambas as pescas também não são efetivamente praticadas, em função da falta de pessoal, dinheiro e disposição para fiscalização. Desta forma, a área pescada por pescadores do Perequê é de acesso livre (*open access* – condição para a "Tragédia dos Comuns"), o que reforça ainda mais a necessidade de medidas urgentes e enérgicas, a fim de se evitar o colapso total do camarão e do que restou do peixe.

A partir destes pontos, fica clara a necessidade de adoção de medidas que possam reverter um quadro que apresenta perspectivas ainda positivas, visto que nem todos os recursos estão sobre-explorados. Alguns pontos são sugeridos abaixo, baseados no que foi observado no decorrer desta tese, e também levando em conta a praticidade e o custo de se tornar tais medidas efetivas. Por exemplo, hoje já se sabe que pescarias tropicais não são manejadas de modo eficaz quando se adotam as mesmas ações desenvolvidas para ambientes temperados, como a adoção de cotas. Desta forma, manejar "como", "onde" e "quando" pescar parece ser mais efetivo do que se manejar "quanto" pescar. Vale lembrar ainda que o quadro retratado nesta tese é comum a diversos pontos do mundo, conforme demonstrado a longo das discussões de cada capítulo, onde são comuns os exemplos de co-existência (pacífica ou não) entre grupos de pescadores com interesses distintos. Assim, as medidas de manejo abaixo, embora baseadas num quadro local tem aplicação global:

- a primeira e mais importante medida sugerida é o estabelecimento de áreas de pesca que não se sobreponham entre aqueles que utilizam redes de espera e aqueles que arrastam o camarão. A única razão clara identificada para os conflitos locais diz respeito ao uso concomitante de estratégias de pesca distintas no mesmo local. Não são necessárias grandes mudanças para que isto aconteça, basta fazer uso da lei existente ou contemplar tal ponto no Plano de Gerenciamento Costeiro para a Baixada Santista, o qual ainda se encontra em fase de desenvolvimento. O estabelecimento de isóbatas para a pesca, de acordo com a tecnologia empregada e tamanho do barco, certamente contribuiria para parte da resolução dos problemas.

Uma outra alternativa seria a definição de áreas onde o arrasto seria permitido, conforme já ocorrido no Plano de Gerenciamento Costeiro do Litoral Norte (Futtemma & Seixas 2008).

- estabelecimento de áreas onde a pesca fosse totalmente proibida a fim de contribuir para a recomposição do estoque pesqueiro. Tal medida deve ser tomada em conjunto com os pescadores para que áreas reconhecidas por eles como relevantes e as quais eles aceitam abdicar sejam escolhidas. Medidas desta natureza não implicam em alterar o comportamento do pescador no que diz respeito aos seus métodos de pesca, horários e épocas, o que certamente contribuiria para a sua maior aceitação. O estabelecimento de áreas de proteção favorece especialmente espécies sedentárias (Bohnsack 2000), algumas das quais de relevância para pesca local, tal como a garoupa.

- cumprimento das leis existentes, como as que dizem respeito ao tamanho mínimo exigido para a captura do camarão sete-barbas, branco e diferentes pescados, e ao período de defeso. Entretanto, fazer com que tal sugestão seja colocada em prática é extremamente difícil, uma vez que não há nenhuma forma de organização local efetiva que possa auxiliar neste processo. A fiscalização por órgãos governamentais mostra-se ineficaz e desacreditada pelos pescadores. Além disto, a falta de incentivo para o cumprimento da lei é considerável, como o já mencionado atraso do seguro desemprego.

- controle da frota de pesca de camarão e das quantidades desembarcadas: a entrada de novos pescadores leva ao aumento do esforço, mas isto não necessariamente é percebido pelo simples controle das quantidades desembarcadas. Até que se atinja um momento crítico, a produção de camarão pode se manter aparentemente estável ocultando um esforço maior, seja em número de horas pescadas ou em aumento no número de pescadores ativos. A adoção de um sistema de licenças de pesca local restringindo o acesso a área contribuiria para diminuição do esforço e também para valorização da área pelos pescadores locais. Isto ajudaria no reconhecimento do local como de uso comum e não de livre acesso. Não estamos falando aqui em se estabelecer cotas de captura ou individuais, as quais apresentam uma série de restrições (Berkes *et al.* 2006), mas sim em limitar a entrada de novos pescadores. Entretanto, a efetividade de tal medida requer o envolvimento de comunidades e grupos próximos, como os pescadores de Bertioga, pois a simples limitação do número de pescadores do Perequê não evitaria a pesca no local por pescadores vindos de outros locais.

- desvinculação do pescador local dos atravessadores. As salgas locais praticam basicamente os mesmos preços entre elas e "preferem" pescadores fiéis, que sempre comercializam com os mesmos atravessadores. Desta forma, a competição e o livre comércio local é comprometido, prejudicando o pescador, o qual deve se submeter às condições e preços oferecidos pelo comércio local. Já é fato aceito de que a existência de atravessadores nesta etapa inicial do comércio do pescado compromete o sucesso de iniciativas de manejo já em prática (Kalikoski *et al.* submetido). Entretanto, a independência comercial do pescador requer organizações locais fortes, levando à proposta seguinte.

- construição e/ou reforma das instituições formais (Colônia de Pescadores) e informais, caso elas existam, embora nenhuma forma de organização local informal tenha sido identificada[11]. Não é fácil estabelecer as diretrizes para que isto ocorra, mas o suporte governamental para que iniciativas partam da comunidade através do seu empoderamento certamente contribui (Kalikoski *et al.* submitted). Uma organização local forte auxiliaria no reconhecimento das medidas necessárias à manutenção da pesca local, redução de conflitos, institucionalização de tais medidas e, principalmente, adaptação das mesmas dentro de limites ecológicos possíveis às necessidades sócio-econômicas locais (Berkes *et al.* 2006: 63).

Desta forma, o manejo dos recursos locais depende de uma congruência de fatores de diferentes esferas, mas especialmente dos pescadores e de instituições governamentais. É essencial ainda pesquisas que complementem as informações existentes, por exemplo, sugerindo as taxas de exploração adequada e capacidade suporte do local. A falta de coesão comunitária certamente aumenta as dificuldades, já que não há um elo que possa sugerir mudanças e adaptações em medidas existentes ou que venham a ser propostas considerando as necessidades reais e urgentes dos pescadores locais. A adoção de medidas isoladas, como somente o defeso, também não favorece uma exploração adequada, visto que os pescadores tendem a buscar modos compensatórios, por exemplo, intensificando o esforço durante o

[11] É importante salientar que a análise institucional não foi um dos pontos abordados neste trabalho, portanto, não é possível afirmar a não existência de organizações locais, mas elas certamente não são evidentes ou claramente ativas.

período em que a pesca se encontra aberta. Entretanto, a pesca de pequena escala enfrenta uma crise sem precedentes ao redor do mundo, postergar iniciativas só levará ao agravamento de uma situação que ainda que seja local, reflete um quadro global.

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ANEXOS

Anexo 1 – Ficha utilizada para coleta de dados sócio-econômico

LOCAL: (   )Perequê   DATA: ____/____/____   FICHA Nº ________

A – DADOS PESSOAIS

1 – Nome do pescador ____

2 – Data de nascimento: ___/___/___   3 – Cidade/Estado de nascimento ______________

4 – Tempo de moradia no local (em anos): ______

5 – Por que se mudou para cá? ____

6 – Estado civil

(   ) solteiro   7 - Quantas pessoas na família ____

(   ) casado   8 – Quantas trabalham _____

(   ) separado

(   ) viúvo

7 – Possui conta em banco? ( ) N   (   )S   (   )C.Corrente   (   ) Poupança

B – PERFIL DOS MEMBROS DA FAMÍLIA DE CADA DOMICÍLIO

Nome	Parentesco	Sexo	Idade	Escolaridade	Ativ. Econômica	Renda	Ajud. Pesca

C – PESCA

1 - Tempo como pescador: ______   2- Horário de Pesca: (   ) manhã ( ) tarde (   ) noite

3 - Há quanto tempo pesca no local: ___________ 4 – Pesca em outros locais: ____ Onde ____

5 – Possui barco (   ) Sim   (   ) Não, trabalha como (   ) Meeiro   (   ) Outros ___________

6 – Tem ajudante de pesca ____ É: (   ) Parente   (   ) Amigo   (   ) Empregado

7 – Principais pescados capturados:

Espécie	Período (D/N)	Época + freqüente	Local de maior incidência	Kg na última pescaria

Época: 1. Verão; 2. Outono; 3. Inverno; 4. Primavera’

8 - Região onde pesca ____________________

9 – Existem locais de pesca pré determinados para cada pescador: (   ) Sim   (   ) Não

10 – A quem vende o pescado: (   ) Não vende

(   ) – peixarias   (   ) – salgas   (   ) – quiosques de praia   (   ) – varejo

(   ) – feira   (   ) – CEASA

11 – Conservação do Pescado	12 – Doação do pescado	13 - Ganho do pescado
1 – a fresco	1 – não doa	1 – não ganha
2 – a gelo	2 – parentes no bairro	2 – parentes no bairro
3 – congelador/freezer	3 – parentes de outros locais	3 – parentes de outros locais
4 – salgado	4 – vizinhos	4 – vizinhos
5 – outros ( )	5 – amigos de fora	5 – amigos de fora

14 – Equipamentos de pesca (embarcações, motores e redes)

Equipamento	Próprio	Emprestado	Outro	Características	Quanto duram?	Quanto custam?

15 – Outros: (   ) espinhel   (   ) linhadas   (   ) vara de pescar   (   ) outros __________

16 – Pesca o ano todo: (   ) Sim (   ) Não, época ________________

17 – Se não, o que faz neste período (fonte de renda) _________________________________

18 – Renda mensal bruta da pesca: R$ _______________

Anexo 2 – Ficha utilizada para acompanhamento de desembarque de camarão

LOCAL: Perequê/Guarujá DATA: ____/____/____ FICHA Nº ________

Nome do Pescador ___________________________________ Hora ida: ___:___ Hora volta: ___:___

Tripulação: N ________ Vínculo _______________/____________

Locais de pesca visitados: 1_______________________ 2______________________________

Malha _____________ Comprimento ______________________

Nº de arrastos: ________

Duração arrasto: 1)____:____ 2)____:____ 3)____:____ 4)____:____ 5)____:____ 6)____:____

7)____:____ 8)____:____ 9)____:____

Espécie	Peso	Quant.	Preço (kg)	Retirado		Parentesco
				Cons.	Doaç.	
Sete-barbas misturado						
Sete-barbas escolhido						
Camarão Branco						
Mistura						

Gastos da viagem

Custos fixos		Custos variáveis	
Descrição	Valor	Descrição	Valor
Óleo diesel (_____l)		Lanche	
Gelo (____ caixas)			
Óleo lubrificante			

Anexo 3 – Ficha utilizada para acompanhamento de desembarque de peixes

LOCAL: Perequê/Guarujá DATA: ____/____/____ FICHA Nº ________

Nome do Pescador ____________________________________

Tripulação: N ________ Vínculo ________________/________________

Locais de pesca visitados: 1 ____________________ 2 ________________________________

Rede espera:HI 1:___:____ HV 1: ___:_____ HI 2: ___:___ HV 2: ___:___

* Malha: _____Comprimento _______ Altura ______ Alt. de coloc. ____ Hora revista: ____:____

Instalação: Dia ____/____ Hora ____:____ Recolhimento: Dia ____/____ Hora ____:____

* Malha: _____Comprimento _______ Altura ______ Alt. de coloc. ____ Hora revista: ____:____

Instalação: Dia ____/____ Hora ____:____ Recolhimento: Dia ____/____ Hora ____:____

* Malha: _____Comprimento________ Altura ______ Alt. de coloc. ____ Hora revista: ____:____

Instalação: Dia ____/____ Hora ____:____ Recolhimento: Dia ____/____ Hora ____:____

Pescado

Espécie	Peso	Quant.	Preço (kg)	Retirado		Parentesco
				Cons.	Doaç.	

Gastos da viagem

Custos fixos		Custos variáveis	
Descrição	Valor	Descrição	Valor
Óleo diesel (__l)			
Gelo (__ caixas)			
Óleo lubrificante			

Anexo 4 – Ficha utilizada para acompanhamento das viagens de pesca de camarão

LOCAL: Perequê/Guarujá DATA: ____/____/____ FICHA Nº ________

Nome do Pescador ___________________________________ Barco ______________________

Tripulação: N ________ Vínculo _____________________

Hora de saída: ___:___ Hora de retorno: ___:___

Tecnologia: ( ) Arrasto de porta ( ) Outra _______________

Malha _________ Comprimento ____________

Pesqueiro	H. Chegada	H Saída	T. arrasto	Espécies	Kg	Nº	Coletado (nº etiq.)

Espécie	Kg vendidos	Preço (kg)	Retirado p/ consumo (kg)

Gastos da viagem

Custos fixos		Custos variáveis	
Descrição	Valor	Descrição	Valor

Annex 5 – Amount of each species (or group of species) captured in the trawl fisheries, number of times they were present in the fish landings and money made by fishermen after selling them.

Family	Common name	Species	Amount caught (kg)	Number of times present in fish landings (n = 325)	Total money made from sale (R$)
Peneaidae	Sea bob shrimp	*Xiphopenaeus kroyeri*	31864	317	56776.558
		Artemisia longinaris			
		Rimapenaeus constrictus			
Hippolytidae		*Exhippolysmata oplophoroides*			
Alpheidae		*Alpheus* spp.			
Solenoceridae		*Pleoticus muelleri*			
Peneaidae	White shrimp	*Penaeus schimitti*	368.68	142	6744.83
Palinuridae	Lobster	*Panulirus* spp.	1	1	
Different fish families	Mixing		1391.4	262	290
Dasyatidae	Stingray		6	2	
Sciaenidae	Weakfish	*Cynoscion* spp.	12.5	3	50
	Black margate	*Anisotremus surinamensis*	4	1	10
	Whitemouth croaker	*Micropogonias furnieri*	8.8	1	18
Serranidae	Dusky Grouper	*Epinephelus marginatus*	52.5	5	88
Tetraodontidae	Smooth puffer	*Lagocephalus laevigatus*	0.5	1	
Total			33709.38	735*	63977.39

*This value does not correspond to the number of sampled fish landings, but to the number of times the species was present in the fish landings

Annex 6 – Amount of each species (or group of species) captured in gillnet fisheries, number of times they were present in the fish landings and money made by fishermen after selling them.

Family	Common name	Species	Amount caught (kg)	Number of times present in fish landings (n = 92)	Total money made from sale (R$)
Carangidae	Florida pompano	*Trachinotus carolinus*	11	2	20
	Castin leatherjacket	*Oligoplites saliens*	122.4	8	117
Centropomomidae	Snook	*Centropomus undecimalis*	44.25	13	365.5
Lobotidae	Atlantic tripletail	*Lobotes surinamensis*	15	2	65
Mugilidae	Mullet	*Mugil platanus*	10	1	40
Pimelodidae	Catfish		40	3	67
Sciaenidae	Weakfish	*Cynoscion* spp.	540.6	83	2291.6
	Whitemouth croaker	*Micropogonias furnieri*	99	15	238.75
Scombridae	Mackerel	*Scomberomorus brasiliensis*	152.5	15	676.5
Sphyraenidae	Barracuda	*Sphyraena* spp.	5	1	10
Trichiuridae	Atlantic cutlass fish	*Trichiurus lepturus*	53	5	70.5
Carcharhinidae and Shyrnidae	Shark	*Carcharhinus* spp.; *Sphyrna* spp.	139.8	24	646.5
Different fish families	Mix**		524	75	509
Peneaidae	White shrimp	*Penaeus schimitti*	43.4	6	760.5
Total			1799.95	253*	5877.85

*This value does not correspond to the number of sampled fish landings, but to the number of times the species was present in the fish landings. ** Southern Kingcroaker and Smooth Puffer (presented in Chapter 3 – Table 3) were considered in Mix, as they were all sold together.

Annex 7 – Amount of each species (or group of species) captured with hand line fisheries, number of times they were present in the fish landings and money made by fishermen after selling them.

Family	Common name	Species	Amount caught (kg)	Number of times present in fish landings	Total money made from sale (R$)
Serranidae	Dusky Grouper	*Epinephelus marginatus*	49	4	707
Sciaenidae	Whitemouth croaker	*Micropogonias furnieri*	2	2	
Total			51	6*	707

*This value does not correspond to the number of sampled fish landings, but to the number of times the species was present in the fish landings

Annex 8 – Average values for the Environmental variables considered: tide, wave height, wind speed, average temperature, maximum temperature, minimum temperature and humidity.

Month	Tide	Wave height	Wind speed (m/s)	Avg. temperature (C)	Max. temperature (C)	Min. temperature (C)	Humidity (%)
Aug/04	0.77	2.0	3.63	16.8	22.8	15.0	75
Sep/04	0.73	1.8	7.37	22.0	23.8	17.5	78.7
Oct/04	0.72	1.5	6.14	23.2	24.2	19.2	73.8
Nov/04	0.68	1.5	4.40	21.3	26.3	17.7	83.0
Dec/04	0.72	0.5	2.78	25.6	27.8	22.2	76.8
Jan/05	0.82	1.3	5.78	24.8	26.6	21.8	78.2
Feb/05	0.84	1.0	3.60	23.2	31.6	19.8	74.0
Mar/05	0.92	0.2	3.58	28.5	29.8	23.4	75.8
Apr/05	0.90	2.1	3.24	22.2	23.6	19.2	60.0
May/05	0.92	0.5	4.18	27.2	30.2	19.6	60.0
Jun/05	0.88	0.4	2.24	24.4	27.2	18.2	66.4
Jul/05	0.83	2.3	5.64	19.2	22.0	17.4	81.4