

ISABELA BACALHAU DE OLIVEIRA

ESTUDO DA ESTRUTURA POPULACIONAL DO MARISCO  
*Anomalocardia brasiliiana* (GMELIN, 1791) NA PRAIA DE MANGUE SECO,  
LITORAL NORTE DE PERNAMBUCO-BRASIL

Recife, PE

Fevereiro, 2010

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Universidade Federal Rural de Pernambuco  
Departamento de Pesca e Aqüicultura  
Programa de Pós-Graduação em Recursos Pesqueiros e Aqüicultura

ESTUDO DA ESTRUTURA POPULACIONAL DO MARISCO  
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LITORAL NORTE DE PERNAMBUCO-BRASIL

ISABELA BACALHAU DE OLIVEIRA

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Orientador: Alfredo Olivera Gálvez  
Co-orientador: Silvio Ricardo Maurano Peixoto

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ISABELA BACALHAU DE OLIVEIRA

Esta dissertação foi julgada para a obtenção do título de **Mestre em Recursos Pesqueiros e Aqüicultura** e aprovada em 23 de fevereiro de 2010 pelo Programa de Pós-Graduação em Recursos Pesqueiros e Aqüicultura, em sua forma final.

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Dedico este trabalho as pessoas mais importantes de minha vida e que sempre estarão presentes em meu coração.

Minha mãe Maria das Graças Bacalhau;

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Meu irmão Márcio Bacalhau;

Minha irmã Fabiane Bacalhau;

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## RESUMO

O presente estudo objetivou analisar a distribuição espaço-temporal do marisco *Anomalocardia brasiliiana* e avaliar a recomposição do estoque desta espécie em relação ao número e ao tamanho dos mariscos capturados no verão e inverno na praia de Mangue Seco, Pernambuco. No primeiro estudo, a linha de praia (1.800 m) foi dividida em três trechos (T), sendo T1 de 0 a 600m, T2 de 600 a 1200m e T3 de 1200 a 1800m. Durante a pesquisa foram coletados um total de 1.016 espécimes nos meses de Janeiro (verão) e Agosto (inverno) de 2009. Desse total, 636 mariscos foram coletados no verão e 380 no inverno. Os valores máximos de densidade registrados no período de verão foram  $414,91 \pm 82,48$  ind.m<sup>2</sup> no T3 e  $323,49 \pm 90,11$  no T1, sendo ambos diferentes significativamente do T2 ( $156,12 \pm 28,72$  ind.m<sup>2</sup>). No inverno ocorreram os menores valores de densidade com  $102,67 \pm 5,07$  ind.m<sup>2</sup> e  $122,37 \pm 36,86$  ind.m<sup>2</sup> para T1 e T2, respectivamente, ambos diferindo significativamente do T3 ( $296,76 \pm 45,20$  ind.m<sup>2</sup>). No segundo estudo foram avaliados três tratamentos correspondendo a uma área de 18,75m<sup>2</sup> cada, onde: os mariscos foram retirados manualmente pelas pescadoras, coletados com auxílio de um apetrecho de pesca, e onde não houve a coleta de mariscos. A amostragem dos mariscos nestes tratamentos foi realizada em três momentos: antes das coletas pelas marisqueiras, após uma hora e 24 horas após estas coletas. Foram observados mariscos com tamanho menor ( $15,46 \pm 0,86$  mm), após a coleta manual, sem diferença significativa entre o tamanho dos animais encontrados após a coleta com o apetrecho ( $18,16 \pm 0,92$  mm). A quantidade de animais capturados com tamanho maior que 20 mm foi superior a 80% no inverno, e inferior a 20 % no verão, sem diferença entre os tipos de coleta para ambas as estações. Os indivíduos da espécie *A. brasiliiana* apresentaram uma distribuição espacial característica, com uma maior abundância de juvenis no período de verão enquanto que os adultos foram mais abundantes no período de inverno. O tipo de coleta avaliado e o momento da extração não influenciaram na quantidade de mariscos, visto que o estoque de *A. brasiliiana* da praia de Mangue Seco ainda é bem denso e tendo capacidade de se recompor após um período de 24h da atividade de coleta pelas marisqueiras. As estações de inverno e verão exercem influencia na abundância de *A. brasiliiana*, com maior quantidade de mariscos com tamanho recomendado para pesca (> 20 mm) no período do inverno.

**Palavras chaves:** Moluscos bentônicos, distribuição, densidade e métodos de pesca



## ABSTRACT

This study aimed to analyze the spatial and temporal distribution of the clam *Anomalocardia brasiliiana* and evaluate the stock recovery of this species in relation to the clam number and size after extraction in summer and winter in Mangue Seco, Pernambuco. In the first study, the beach (1800 m) was divided into three sections (S): S1 0 to 600m, S2 600 and 1200m and S3 1200 to 1800m. During this research a total of 1,016 specimens were collected in January (summer) and August (winter) of 2009, corresponding to 636 clams collected in the summer and 380 in the winter. The maximum density recorded in the summer period were  $414.91 \pm 82.48$  ind.m<sup>-2</sup> at S3 and  $323.49 \pm 90.11$  ind.m<sup>-2</sup> at S1, both were significantly different from S2 ( $156.12 \pm 28.72$  ind.m<sup>-2</sup>). In winter, the lowest densities were observed with  $102.67 \pm 5.07$  ind.m<sup>-2</sup> and  $122.37 \pm 36.86$  ind m<sup>-2</sup> for S1 and S2, respectively, both significantly different from S3 ( $296.76 \pm 45.20$  ind.m<sup>-2</sup>). The second study evaluated three treatments corresponding to an area of 18.75 m<sup>2</sup> each, where: the clams were removed manually by the fishers, collected using a fishing gear, and where there was no harvesting of clam. The sampling of the clams in these treatments was conducted in three moments: before extraction by fishers, after an hour and after 24 hours. Clams showed a smaller size ( $15.46 \pm 0.86$  mm) after manual collecting, but no significant difference in the size of the animals was found after the collection with the fishing gear ( $18.16 \pm 0.92$  mm). The number of the animals collected with size larger than 20 mm was greater than 80% in the winter and lower than 20% in the summer, without significant differences between the collection type tested for both seasons. The *A. brasiliiana* showed a characteristic spatial distribution, with a greater abundance of juveniles during the summer while the adults were more abundant during the winter. The collection type and the extraction period did not influence the clam amount, as the stock of *A. brasiliiana* in Mangue Seco is still quite dense and probably has the capacity to reconstitute itself after a period of 24 hours without clam extraction. The winter and summer seasons have a great influence on the abundance of *A. brasiliiana*, with the largest number of animals within the recommended fishing size (> 20 mm) during the winter.

**Keywords:** Benthic molluscs, distribution, density and fishing methods

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## 1. INTRODUÇÃO

No Brasil muitas espécies de bivalves presentes em áreas intermareais são comestíveis e têm sido amplamente coletados em várias regiões do país. Estudos sobre a reprodução e ecologia de bivalves marinhos são tidos como o alicerce para o estabelecimento de programas de manejo desses invertebrados, pois podem favorecer a manutenção de estoques naturais e, assim, contribuir para o desenvolvimento de atividades extrativistas e de maricultura (ARAÚJO, 2001).

Um considerado esforço tem sido colocado no desenvolvimento sustentável de técnicas para um cultivo efetivo e comercialização de uma variedade de animais aquáticos e espécies de vegetais, incluindo, por exemplo, varias espécies de algas, moluscos, camarões, e peixes (ROSENTHAL et al., 1995). Em contraste, pouco esforço tem sido colocado para ajudar no processo crucial de selecionar um local adequado para o crescimento em campo da espécie escolhida (KAPETSKY et al., 1987, 1988; MEADEN e KAPETSKY, 1991; ROSS et al., 1993; FRIDLEY, 1995; KAPETSKY e NATH, 1997; AGUILAR-MANJARREZ e NATH, 1998; PARKER et al., 1998; RUBEC et al., 1998).

O local onde há maior abundância de moluscos bentônicos como a espécie *Anomalocardia brasiliiana* é a região entre marés que é caracterizada pela interação de fatores ambientais de origem terrestre e os de origem marinha, sendo o mais importante dos fatores ambientais, sem dúvida, a maré (NIBBAKEN, 1994). Todos os fatores, interagindo entre si, propiciam um ecossistema com uma grande variedade de manchas de *micro-habitats*.

As comunidades de invertebrados intertidais apresentam padrões temporais e espaciais que são o resultado da habilidade da espécie de lidar com as mudanças nos fatores físicos e biológicos associados com as principais interações ambientais, tais como a influência maré, a taxa de exposição, e as características da água e do substrato (RODIL et al, 2008).

A distribuição espacial de organismos bentônicos em ambientes inconsolidados tem sido associada a diversos fatores biológicos, tais como comportamento reprodutivo e disponibilidade de alimento, e também a fatores físico-químicos como hidrodinamismo, granulometria, quantidade de matéria orgânica e umidade da área (MCLACHLAN, 1983), ou ainda a uma combinação dos mesmos.

No elo principal da cadeia produtiva de moluscos está o extrativismo de mariscos onde a coleta é geralmente feita por mulheres chamadas marisqueiras que extraem diferentes espécies de moluscos da região entre marés, trabalham em grupos, usam canoas para se deslocar, utensílios rudimentares para extrair os moluscos dos bancos naturais, utilizam mão de obra familiar e exploram ambientes ecológicos localizados dentro do estuário (MOREIRA, 2007). A mariscagem de bivalves está entre as atividades de subsistência mais comuns nos ecossistemas costeiros (PEDROZA-JÚNIOR, 2002).

Diversos estudos já foram realizados sobre a biologia de *A. brasiliana*, considerando-se os aspectos morfofuncionais adaptativos e ecológicos, os estudos de dinâmica populacional nos litorais baiano (PESO, 1980), paulista (NARCHI 1972, 1974 e 1976; HIROKI, 1977; SCHAEFFER-NOVELLI, 1976, 1980; ARRUDA-SOARES et al., 1982; LEONEL et al., 1983), catarinense (PEZZUTO e ECHTERNACHT, 1999; BOEHS e MAGALHÃES, 2004 e ROSA, 1989), paranaense (LANA et al., 1989; NETTO & LANA, 1994; BOEHS, 2000), paraibano (GROTTA e LUNETTA, 1980), norte rio grandense (CARNEIRO, 1994 e RODRIGUES, 2009), cearense (ARAÚJO e ROCHA-BARREIRA, 2004; BARREIRA e ARAÚJO, 2005) e as observações sobre distribuição demográfica, crescimento e repovoamento na região caribenha (MONTI et al., 1991).

O estado de Pernambuco, localizado na região do Nordeste do Brasil, a ostra nativa *Crassostrea rhizophorae*, o marisco *Anomalocardia brasiliana*, e o marisco redondo *Lucina pectinata* são naturalmente encontrados nos estuários e praias do estado, sendo a extração

desses moluscos uma fonte de alimento e renda para muitos pescadores, o que torna seus estoques já bastantes explorados.

A *A. brasiliiana* segue como principal recurso pesqueiro entre os bivalves no estado de Pernambuco, sendo a principal fonte de renda para as marisqueiras, e teve sua exploração quase que dobrada entre os anos de 2003 a 2005. Dentre as principais espécies de maior produção no estado, o marisco é a que mais se destaca, com uma produção de 2.479,2t responsável por 20% da produção total de moluscos (CEPENE, 2006).

A exploração desordenada deste recurso pode comprometer os estoques naturais, alterando o ambiente costeiro através do grande esforço de pesca exercido por centenas de pescadores presentes nesta região e pela escassez de pesquisas relacionadas a esta espécie voltada para o estado.

Segundo Nishida (2000), a exploração extrativista destes bivalves ao longo do ano, a degradação ambiental crescente e a falta de estudos que subsidiem sua regulamentação têm comprometido os estoques desse molusco em diversas regiões do litoral brasileiro. Devido à alta extração em muitos locais do litoral o marisco não é mais encontrado facilmente, e segundo relatos das marisqueiras da região estes organismos vêm apresentando um tamanho cada vez menor, mesmo nas áreas de grandes concentrações como no litoral norte do estado.

Apesar do grande consumo de mariscos no Brasil, não há cultivo do grupo dos venerídeos, o qual se enquadra a espécie nativa *A. brasiliiana* que é tradicionalmente explorada por diversas comunidades litorâneas (RIGHETTI, 2006). Sendo assim, novas alternativas que tenham como objetivo o manejo e a recomposição dos estoques naturais do marisco *A. brasiliiana* devem ser imediatamente pesquisadas. As medidas legais até então tomadas em relação a este tema não têm apresentado um resultado prático na preservação dos estoques naturais da espécie (RIGHETTI, 2006).

Sendo o litoral brasileiro, a base de vida para gerações de povos, catadores de caranguejos, ostras, mariscos e outros animais, essas pessoas, são uma parte integral dos ecossistemas costeiros. Tendo visualizado a importância dos recursos costeiros, iniciativas como o Projeto Gente da Maré, uma cooperação entre o governo brasileiro e o governo canadense, nas suas diversas parcerias vem buscando meios para reduzir a pobreza e auxiliar as comunidades que dependem destes recursos marinhos para sua sustentabilidade, por meio de diálogo equitável, gestão participativa e tecnologias apropriadas e inovadoras. Segundo Vinatea (2000), o manejo integrado poderá garantir a conservação dos recursos naturais costeiros e, simultaneamente, melhorar a qualidade de vida de todos os atores vinculados aos recursos em questão.

O presente trabalho se propõe a realizar o estudo da estrutura populacional do molusco bivalve *A. brasiliiana* no litoral norte do estado de Pernambuco. Este estudo servirá como base para a realização de futuros estudos sobre a dinâmica populacional desta espécie, representando uma importante ferramenta para o gerenciamento costeiro integrado e um melhor desempenho dos aspectos sócio-econômicos da população local.

## **2. OBJETIVOS**

### **2.1. Objetivo geral**

- Identificar a estrutura da população do bivalve *Anomalocardia brasiliiana* no município de Igarassu, litoral norte do Estado de Pernambuco.

### **2.2. Objetivos Específicos**



- Avaliar a estrutura quantitativa da população de *A. brasiliiana* na praia de Mangue Seco, Igarassu - PE;
- Estimar a densidade populacional de *A. brasiliiana* durante as estações verão e inverno.
- Avaliar a recomposição do estoque de *A. brasiliiana* após a coleta pela pesca extrativista do marisco na região;

### 3. REVISÃO DE LITERATURA

*A. brasiliiana* se enquadra dentro da família Veneridae (Mollusca, Bivalvia) que reúne aproximadamente 500 espécies viventes, pertencentes à aproximadamente cinquenta gêneros e doze subfamílias (CANAPA et al, 1996); essa diversidade está relacionada à grande variedade de habitats para os quais estão adaptados, como praias arenosas, areno-lodosas, manguezais e fundos arenosos em ambientes coralíneos (CANTERA, 1991). No Brasil foram registradas 35 espécies de venerídeos, pertencentes a quatorze gêneros e sete subfamílias (RIOS, 1994).

A espécie *A. brasiliiana* distribui-se desde a costa das Antilhas até o Uruguai (RIOS, 1994). Assim como os demais moluscos bivalves da família Veneridae, a espécie possui hábitos suspensívoros, habitam fundos areno-lodosos costeiros localizados em enseadas, baías e desembocadura de estuários e ficam confinados ao sublitoral ou a níveis intermareais baixos por não resistirem a temperaturas acima de 42°C (READ, 1964; NARCHI, 1972; RIOS, 1994; PEZZUTO & ECHTERNACHT, 1999). *A. brasiliiana* é um organismo eurihalino (SCHAEFFER-NOVELLI, 1976) e apresenta grande resistência a baixos níveis de oxigênio e condições de anoxia (HIROKI, 1971). A espécie é dióica, porém não apresenta dimorfismo sexual aparente e somente estudos histológicos permitem a sexagem dos indivíduos (GROTTA & LUNETTA, 1980).

Leonel et al. (1983) verificaram a capacidade de *A. brasiliiana* de tolerar o estresse hiposmótico e confirmaram a possibilidade de sua ocorrência em ambientes de água salobra sujeitos a variações de salinidade. Barreiras e Araújo (2005) observaram que a diminuição da salinidade, devido a um aumento na pluviosidade, aumentou o percentual de machos de *A. brasiliiana*. Carneiro (1994) verificou que as maiores densidades populacionais de *A. brasiliiana* na praia de Barra/Grossos/RN, ocorreram no período chuvoso e principalmente nos meses de menor salinidade. As populações de *A. brasiliiana* encontram-se em manchas com grandes densidades de indivíduos onde dificilmente co-ocorrem outras espécies (SCHAEFFER-NOVELLI, 1976).

Estudos sobre o ciclo reprodutivo da espécie foram realizados em vários estados brasileiros, incluindo regiões litorâneas de São Paulo (NARCHI, 1976), na Paraíba (GROTTA, 1979), na Bahia (PESO, 1980), no Paraná (BOEHS, 2000), em Santa Catarina (ARAÚJO, 2001) e no Ceará (BARREIRA e ARAÚJO, 2005). Entretanto ainda não foram realizados estudos em populações de *A. brasiliiana* no litoral de Pernambuco.

No Estado de São Paulo ocorrem dois picos reprodutivos ao ano com a liberação de gametas, que podem permanecer até quatro semanas no plâncton, na primavera e verão. No Estado da Paraíba, próximo a Linha do Equador, a espécie apresenta indivíduos produzindo gametas o ano todo, características atribuída às condições ambientais favoráveis (NARCHI, 1976; GROTTA & LUNETTA, 1980 e 1982). Em Florianópolis (SC), Araújo (2001) obteve como resultados que *A. brasiliiana* apresenta gametogênese, maturação e eliminação dos gametas simultaneamente entre primavera e outono. Além disso, obteve que a maturidade dos indivíduos ocorre quando alcançam 15 mm de largura com a diferenciação sexual iniciada quando os indivíduos alcançam 7 mm. Finalmente Barreiras e Araújo (2005) obteve como resultados no Fortim (CE), que *A. brasiliiana* possui ciclo reprodutivo contínuo, na qual as quatro fases de desenvolvimento das gônadas foram observadas quase que simultaneamente

em um ano de estudos, mas podendo observar com maior intensidade dois picos reprodutivos de julho a outubro e de fevereiro a abril.

Arruda-Soares et al. (1982) recomendaram a captura de espécimes de *A. brasiliiana* com comprimento acima de 20 mm, quando os indivíduos já têm alcançado um grau de desenvolvimento gonadal que possibilite a reprodução. Entretanto Martins e Souto (2006) encontraram que 6% dos indivíduos capturados de *A. brasiliiana* no manguezal de Acupe, Bahia, estavam abaixo de 20 mm. Estes autores relataram que as marisqueiras coletam os indivíduos menores para garantir, ao menos, uma pequena quantidade para comer. Neste caso, mesmo que haja a intencionalidade de conservar o recurso, a necessidade de sustentar a família é preponderante em relação à preocupação ecológica (MARTINS E SOUTO, 2006).

Dias et al. (2007) analisando aspectos socioeconômicos e perspectivas das mulheres marisqueiras na Reserva de Desenvolvimento Sustentável (RDS) Ponta do Tubarão no Rio Grande do Norte, verificaram que a partir dos dados de produção diária fornecida pelas entrevistadas, estimou-se uma produção diária média de 47,9kg/ dia de *A. brasiliiana*, resultando em 3,2kg/pessoa/dia. Considerando-se que as coletas ocorrem pelo menos durante 15 dias por mês, a produção mensal pode chegar a 670,6kg, com uma média mensal de 459,8kg.

Silva-Cavalcanti e Costa (2009) através da aplicação de questionários com os pescadores da praia de Mangue Seco contataram que as mulheres vão mais vezes a pesca de *A. brasiliiana* do que os homens e além de que elas passam mais tempo na pesca do que eles. No verão as mulheres extraem em média 15Kg/dia e no inverno 10Kg/dia em quanto os homens conseguem extrair 17,5 Kg/dia no verão e 13Kg/dia no inverno. Tradicionalmente mariscos entre 10 e 31 mm são coletados. Estes autores ao comparem a praia de Mangue Seco (área não protegida) com o estuário do rio Goiana (área protegida) em Pernambuco relataram haver

diferenças significativas entre as médias declaradas de kg de carne produzida no verão e no inverno, o rendimento familiar, semanalmente, no verão, o preço do verão, o tempo gasto no comércio e a frequência de colheita. A média da renda familiar, verão e inverno rendimentos semanais, produção da carne no verão e no inverno foram maiores na área não protegida. No entanto, os preços da carne independentemente da estação do ano, foram maiores na área protegida. A frequência da coleta e tempo gasto no comércio também foram superiores na área protegida.

Moreira (2007), avaliando os impactos do extrativismo de *A. brasiliiana* nos estuários dos rios Paciência e Cururuca em São Luís no Maranhão, constatou que no estuário do rio Paciência o comprimento dos indivíduos de *A. brasiliiana* coletados pelas pescadoras variou de 17 a 35 mm, enquanto que no estuário do rio Cururuca o tamanho variou de 20 e 23 mm. Em ambos os estuários as marisqueiras capturavam indivíduos de *A. brasiliiana* com mais frequência do que as demais espécies, provavelmente por serem mais abundantes na região, podendo ser capturados o ano todo.

Rodrigues e Henry-Silva (2008) constataram que nas praias próximas ao estuário do rio Apodi/Mossoró no estado do Rio Grande do Norte os indivíduos coletados pelas marisqueiras variaram entre 16 e 28 mm de comprimento com um valor médio de 20 mm. Esta preferência por indivíduos maiores provavelmente deve-se a possibilidade de obter maior lucro com a comercialização da matéria prima, bem como com a preocupação ambiental de permitir que indivíduos de *A. brasiliiana* atinjam um tamanho mínimo para a sua reprodução. De-Jesus et al. (2004) ao realizarem a análise biométrica de populações de *A. brasiliiana* na região estuarina de São Francisco do Conde, localizado na porção Nordeste da Baía de Todos os Santos, encontraram indivíduos com comprimento médios de 20.9 mm (período seco) e 19.72 mm (período chuvoso) e largura dos de 25.02 mm (período seco) e 22.93 mm (período chuvoso).

Os indicadores sociais para a área de estudo revelam a predominância de uma população de baixa renda familiar, com elevado percentual de analfabetos, sobretudo na zona rural; moradias de baixo padrão de construção e condições sanitárias precárias. Este quadro se tem agravado nas últimas décadas como resultado, entre outros fatores, do descompasso entre a dinâmica demográfica e a economia litorânea, decorrente de uma oferta insuficiente de bens e serviços básicos às comunidades urbanas e rurais (ALMEIDA e GÁLVEZ, 2007).

A concentração fundiária na região e as condições de trabalho somadas às poucas opções presentes geram o deslocamento da população rural para os núcleos urbanos, em busca de emprego e melhores condições de vida (CPRH, 2001).

Por isso, o desenvolvimento da maricultura deve ser planejado em consonância com os princípios de gestão integrada dos ambientes costeiros e marinhos, de forma a evitar os conflitos de uso entre as atividades que competem pela ocupação dos espaços e utilização dos recursos naturais costeiros e marinhos, tais como: extrativismo, pesca, turismo, tráfego aquaviário (TOVAR et al, 2000).

Conseguir unir a gestão deste recurso pesqueiro com novas tecnologias de maricultura, em busca do crescimento e do desenvolvimento sustentável desta espécie, contribuirá pra a melhoria da renda familiar dos principais atores desta atividade, as marisqueiras.

## **4. ARTIGOS CIENTÍFICOS**

### **4.1. Spatial and temporal distribution of shellfish *Anomalocardia brasiliiana* (Gmelin, 1791) in Mangue Seco beach, Pernambuco - Brazil**

Isabela Bacalhau\*, Antônio Amorim, Henrique Lavander, Leônidas Oliveira, Silvio Peixoto e Alfredo O. Gálvez

### **4.2. Evaluation of replenishment of stocks of shellfish *Anomalocardia brasiliiana* in fishing area in Mangue Seco beach, north coast of Pernambuco, Brazil**

Isabela Oliveira\*, Sérgio Silva-Neto, Roberta Soares, Silvio Peixoto e Alfredo Gálvez

1 Spatial and temporal distribution of shellfish *Anomalocardia brasiliiana* (Gmelin, 1791) in  
2 Mangue Seco beach, Pernambuco - Brazil

3 Isabela Bacalhau\*, Antônio Amorim, Henrique Lavander, Leônidas Oliveira, Silvio  
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## 20 Abstract

21 This study aims to analyze the spatial and temporal distribution of *Anomalocardia brasiliiana*  
22 along the Mangue Seco beach (Igarassu, PE, Brazil). The 1800 meters beach line, in the  
23 south-north, was divided into three sections (S) of 600 meters each, and S1 0 to 600, S2 600  
24 to 1200m and S3 1200 to 1800m. In all, 540 were samples taken in different parts, levels and  
25 seasons. Being collected a total of 1,016 specimens in January (summer) and August (winter)  
26 2009. Of this total, 636 clams were collected in summer, 55% juvenile size less than 15 mm,  
27 and 380 in winter 57% were adult size between 21 and 25 mm in length. The maximum  
28 density recorded in the summer period were  $414.91 \pm 82.48 \text{ ind.m}^{-2}$  at S3 and  $323.49 \pm 90.11$   
29  $\text{ind.m}^{-2}$  at S1, both being significantly different from S2 ( $156.12 \pm 28.72 \text{ ind.m}^{-2}$ ). In winter  
30 there were the lowest density with  $102.67 \pm 5.07 \text{ ind.m}^{-2}$  and  $122.37 \pm 36.86 \text{ ind m}^{-2}$  for S1  
31 and S2, respectively, both significantly different from S3 ( $296.76 \text{ ind.m}^{-2} \pm 45.20$ ). The  
32 relationship between the stations S3 obtained the highest rates of biomass with  $1,248.47 \pm$   
33  $305.82 \text{ g.m}^{-2}$  and  $1,136 \pm 191.14 \text{ g.m}^{-2}$  for the summer and winter, respectively, being  
34 significantly different from the other sections for the two stations. The rains exert an influence  
35 on the distribution of the bivalve *A. brasiliiana*, with lower density after this period, however  
36 the animals are larger ( $> 20\text{mm}$ ) increase in size due to food availability during rainy seasons.

37 Keywords: Seasons, Density, Biomass.

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## 43 1. Introduction

44 On all continents at least one clam from exposed beaches is extensively collected as part  
45 of a recreation, artisanal or commercial fishery (Mclachlan *et al.*, 1996). These same authors  
46 define a recreational fishery as collection for bait or food without sale or dependence on the  
47 resource; a artisanal fishery as collection for subsistence or sale by individuals or groups  
48 using traditional methods; and a commercial as collection for sale by corporate or collective  
49 organizations.

50 The mollusc *Anomalocardia brasiliiana* is a species well accepted for human  
51 consumption, easy to locate and arrest and is operated by hand in various regions of the  
52 country, both for subsistence and for sale (Pezzuto and Echternacht, 1999). On the Brazilian  
53 coast, several species of molluscs from the estuarine regions are explored in a rough manner  
54 by traditional communities, without the use of management measures to ensure sustainable  
55 use of resources (Araújo, 2001).

56 The Brazilian coast has widely spread and intense fisheries of *A. brasiliiana*, important for  
57 large groups of economic and socially disfavoured families. The meat is sold, and represents  
58 the main (often the only and irreplaceable) source of monetary income for entire small  
59 traditional communities (Silva-Cavalcanti and Costa, 2009). In Pernambuco state coast, the  
60 clam's fishery has a great socio-economic importance, being marketed at different scales,  
61 especially for coastal communities, who use it also in the family diet.

62 This species, *A. brasiliiana*, because they distribute in unconsolidated environments has  
63 been associated with several biological factors such as reproductive behavior and food  
64 availability, as well as physical and chemical factors such as hydrodynamics, particle size,  
65 amount of organic matter and moisture from the area or to a combination thereof (Mclachlan,  
66 1983). Soares-Gomes and Pires-Vanin (2003) when studying abundance and diversity

67 patterns of molluscs, reported that the fauna of bivalves can be safely employed in  
68 representing the benthic community structure in general.

69 Intertidal invertebrate communities show temporal and spatial patterns that are the result  
70 of the ability of species to cope with changes in physical and biological factors associated  
71 with major environmental gradients, such as tidal influence, exposure rate, and water and  
72 substrate characteristics (Rodil *et al.*, 2008).

73 Studies of biology and ecology of *A. brasiliiana* were carried out on the coast of the state  
74 of Sao Paulo (Pereira-Smith *et al.* 1982; Narchi, 1972 and 1974, and Schaeffer-Novelli,  
75 1976), Santa Catarina (Rosa, 1989) and Paraná (Boehs, 2000; Lana *et al.*, 1989; Netto and  
76 Lana, 1994). Also observations were made about their demographic distribution, growth and  
77 spawning in the Caribbean (Monti *et al.*, 1991).

78 This study aims to analyze the spatial and temporal distribution of *A. brasiliiana* along the  
79 Mangue Seco beach (Igarassu, PE, Brazil), this place is one of the main areas of the shellfish  
80 catch in the state.

81

## 82 **2. Material and Methods**

### 83 2.1. Study area

84 The Igarassu city locality on the north Pernambuco coast, doing part of the Recife  
85 metropolitan area, distant 28 km to capital, has an area of 302.9 km<sup>2</sup>, a population of 86,519  
86 inhabitants and a tropical climate type with rainy summer dry. In the city there are three  
87 conserved areas use sustainable: Environmental Protection Area (APA) of channel Santa Cruz  
88 estuary, APA Timbo river estuary and APA of Nova Cruz. The most famous beach of the  
89 city, the Captain's beach, also known as Mangue Seco, is located in Nova Cruz (S

90 07°49'44,19" e W 035°50'03,06" has approximately 2.000m of the beach line, shallow water  
91 with small wave and intensive tide, with a tide variation in the low-water mark above the  
92 500m (Figura 1). It covers a multitude of highly productive ecosystems and is considered the  
93 green region, where one can find segments of plains covered by coconut trees, with extensive  
94 mangrove estuaries, coral sands, crowns, islands and reefs, among other (<http://www.pe-az.com.br>).

96

97 Insert figure 1.

98

## 99 2.2. Sample methods

100 The 1800 meters beach line, in the south-north, was divided into three sections (S) of 600  
101 meters each, and S1 0 to 600, S2 600 to 1200m and S3 1200 to 1800m, the beach was divided  
102 by to present differences in the amount of fishermen present in each section. Parallel to the  
103 beach were delineated three levels sample (L) contained in the range of tidal variation and the  
104 levels distribution to distance 20m for each, L1 20m , L2 40m and the L3 60m from the  
105 beach line. Along the beach were built 90 transversal lines imaginary (transects), and each  
106 point of intersection between the transect and the level was a collection point. Sampling was  
107 carried out during low tide, during two time intervals: January 2009, representing the summer  
108 season (no rain), and August 2009, representing the winter (rain).

109 Specimens were collected using a cylindrical tube, 20cm long by 10 cm diameter (0.0079  
110 m<sup>2</sup>) excavating the sediment down to 10-cm-depth. The sediment was sieved using a 2-mm-  
111 mesh net. The collected material was analyzed at the Laboratory of Mariculture Sustainable,  
112 Universidade Federal Rural de Pernambuco, Brazil.

113 Maximum length of the anterior-posterior axis (Shell length, SL) of each individual was  
114 measured to the nearest 0.01 mm with digital vernier callipers and weighed in a analogue  
115 balance with accuracy of 0.25 g and distributed in five size classes: C1 ( $\leq 15$  mm), C2 (16 to  
116 20 mm), C3 (21 to 25 mm), C4 (26 to 30 mm) and C5 ( $> 30$  mm). Individuals caught in this  
117 study were classified as juveniles when their shell length to 20 mm and as adult with length  
118 greater than 20 mm, classification developed by Arruda-Soares *et al.* (1982).

119 Sea-surface temperature (SST) and salinity were recorded in situ at each sampling point.  
120 The water temperature was obtained with a mercury thermometer and salinity using a  
121 refractometer Model S10 - Atago. Were removed sediment samples of the collection sites for  
122 particle size analysis using a cylindrical tube with 5 cm in diameter, excavating the sediment  
123 down to 10-cm-depth and stored in plastic bags.

124

### 125 2.3. Data analysis

126 Data from distribution communities were analyzed in terms of number of *A. brasiliiana*,  
127 abundance (individuals per m<sup>2</sup>), and biomass (g.m<sup>-2</sup>). Data on number, abundance and  
128 biomass were analyzed by factorial analysis of variance (ANOVA), followed by Duncan's  
129 Multiple Range Test to determine differences among station, levels and seasons.

130

## 131 3. Results

132 The water temperature measured in the collection's days, for study area, during the  
133 summer recorded a minimum 27 ° C and a maximum of 32 ° C. In winter the minimum water  
134 temperature was 25 ° C and maximum 30 ° C. The salinity ranged between 38 and 40 in

135 January (summer) and between 26 and 35 in August (winter). There was significant difference  
136 between the mean values salinity for the study area (Table 1).

137 The rainfall (mm) observed for the city of Igarassu during the period January to December  
138 2009 is shown in Figure 2, these data were obtained from the Meteorological Laboratory of  
139 Pernambuco (LAMEPE), associated with the Technology Institute of Pernambuco (ITEP).

140

141 Insert figure 2

142

143 The mean grain size for each section, in Mangue Seco beach, with greater representation,  
144 were 70.15% of coarse sand and medium sand 16.74% average for the section 1. For section  
145 2, 85.80% and 6.29% of coarse sand and gravel, respectively, and the third section (S3)  
146 60.83%, 17.35% and 13.05% of coarse sand, medium sand and fine sand, respectively (Figure  
147 3).

148

149 Insert table 1

150 Insert figure 3

151

152 In all, 540 were samples taken in different parts, levels and seasons. Being collected a  
153 total of 1,016 specimens in January (summer) and August (winter) 2009. Of this total, 636  
154 clams in the summer representing a percentage of 63% and 380 individuals (equivalent to  
155 37%) in winter.

156 In the two seasons studied were collected from individuals with widely varying size. In  
157 summer, the class C1 ( $\leq 15$  mm) was the most abundant, with 347 specimens captured,  
158 representing about 55% of the total organisms collected and for classes C2, C3 and C4  
159 showed values of 96, 114 and 76 animals collected (Figure 4a, b, c).

160 In winter, the class C3 (21 to 25 mm) was more abundant with 218 individuals,  
161 representing 57% of animals captured and the classes C1, C2 and C4 presented 64, 48 and 47  
162 animals collected (Figure 4 d, e, f). However, in the two seasons, the class C5 ( $> 30$  mm) was  
163 the one with the least amount of clam with only three animals per season, a total of 0.5% and  
164 0.8% for the summer and winter, respectively (Figure 4).

165 For the tidal level studied (L1, L2 and L3) was not significant difference between the  
166 average values of biomass and density of clam caught (Table 2). For the summer, although  
167 there is no difference, we see a trend with higher biomass in intertidal levels (L2 $>$  L3 $>$  L1)  
168 and density (L2 $>$  L1 $>$  L3). In winter, the pattern of biomass between the levels was the same,  
169 differing only in density (L2 $>$  L3 $>$  L1). Figures 4 and 5 show the values of biomass and  
170 density of levels for each section.

171

172 Insert table 2

173 Insert figure 4 and 5

174

175 Comparing the periods of summer and winter there were no significant differences in  
176 population density of *A. brasiliiana* in the study area, with  $298.17 \pm 53.00$  ind.m<sup>-2</sup> and  $173.93$   
177  $\pm 35.17$  ind.m<sup>-2</sup>, respectively. However significant differences were found comparing the  
178 section S1, S2 and S3 and the interaction of it with the seasons (Table 3). The maximum

179 density recorded in the summer period were  $414.91 \pm 82.48 \text{ ind.m}^{-2}$  at S3 and  $323.49 \pm 90.11$   
180  $\text{ind.m}^{-2}$  at S1, both significantly different from S2 ( $156.12 \pm 28.72 \text{ ind.m}^{-2}$ ). In winter the  
181 lowest densities occurred with  $102.67 \pm 5.07 \text{ ind.m}^{-2}$  and  $122.37 \pm 36.86 \text{ ind.m}^{-2}$  for S1 and  
182 S2, respectively, both significantly different from S3 ( $296.76 \pm 45, 20 \text{ ind.m}^{-2}$ ). The density  
183 showed seasonal fluctuation, with higher values during summer and lower values during  
184 winter seasons (Figure 5).

185 With respect to biomass, there was no significant difference between the two studied  
186 periods, with of  $730.40 \text{ gm}^{-2}$  for the summer and  $729.13 \text{ gm}^{-2}$  for the winter (Figure 6). The  
187 results showed a significant difference between sections and between the interactions of the  
188 sections with the seasons (Table 3). The S3 was significantly different between the stations  
189 and between the section, S1 and S2, being the main section with the higher number of clam  
190 and consequently higher biomass.

191

192 Insert Table 3

193

#### 194 **4. Discussion**

195 Significant differences were observed in mean salinity over the sections in two seasons.  
196 The drop in salinity during winter is related to increased rainfall in the months prior to collect.  
197 Filho (2001) reported that in estuaries, drastic changes in salinity (daily, seasonal, interannual)  
198 influence markedly the distribution of benthic associations. Leonel *et al.* (1983) proved  
199 experimentally that, *A. brasiliiana* tolerate variations in salinity from 17 to 42‰. Monti *et al.*  
200 (1991), in Guadeloupe, verified the occurrence of *A. brasiliiana* in areas with salinity between  
201 17 and 38‰.

202 In the present study did not observe a difference in the standard grain size in the three  
203 stretches of beach. Magalhães *et al.* (1998) observed the absence of this species in locations  
204 with substrate composed of thicker sand and higher densities in substrates composed of fine-  
205 grained and with lots of organic matter. In the same way Boehs *et al.*, (2008) observed this  
206 pattern predominantly in the aggregate population of *A. brasiliiana* of intertidal non-vegetated  
207 estuarine complex of Paranaguá Bay, Paraná - Brazil.

208 The rainfall precipitation observed for the year 2009 influenced the pattern of distribution  
209 of *A. brasiliiana*, for the month of August, there was a greater number of clam larger than 20  
210 mm and in the collect in January, which typically follows a period of drought , the dominance  
211 was clam with size less than 20 mm. Terrestrial runoff, river discharge and resuspension of  
212 bottom sediments by tidal currents are the principal source of nutrients in tropical estuarine  
213 ecosystems (Von Prahll *et al.* 1990; Cantera and Blanco 2001; Medeiros *et al.* 2001). Thus, it  
214 can be assumed that highest primary productivity (and thus food availability) is associated to  
215 rainy seasons, as observed by Gocke *et al.* (2001) in a tropical estuary in Costa Rica and  
216 Hernández and Gocke (1990) in a coastal lagoon at the Caribbean coast of Colombia.  
217 Riascos (2006) related these studies to the reproductive cycle of the tropical bivalve *Donax*  
218 *dentifer* at the Colombian Pacific, where by this author, food availability during rainy seasons  
219 would play an important role within the chronology of reproductive events, and this  
220 conclusion can be too used for the *A. brasiliiana* specie.

221 The density and biomass of *A. brasiliiana* in relation to tidal level showed a distribution  
222 pattern more frequently at level 2 (L2>L1>L3). Corroborating the results of Rodil *et al.*  
223 (2008) to analyze the distribution pattern of macrobenthic community, noted a higher density  
224 of mollusks at the intertidal level (L2>L3>L1), differing only from level 1 to 3.



225 The density of *A. brasiliiana* was lower in winter, this reduction may be related to the  
226 fishing activity of this species, because the month of August precedes the summer period where  
227 there is more demand for this product in the region. Rodil *et al* (2008), in estuarine beach in  
228 Spain, reached the same conclusion that the bivalves were scarce in April, probably because  
229 of the local clam gathering activities during the previous months. These mollusks are used by  
230 fishing communities for subsistence consumption and sale to the consumer market (Pezzuto &  
231 Echternacht, 1999; Rosa, 1989;). Another factor that may have influenced the lower density is  
232 the increase in rainfall during the winter, which alters the salinity of the sea leading to  
233 increased mortality rates and consequently lower density of individuals collected during this  
234 period (Barreira and Araújo, 2005; Bezerra, 1998; Boehs *et al.*, 2008; Estrada, 2001; Monti,  
235 1991; Möueza *et. al.*, 1988; 1999). The value of density can also be reduced by natural self-  
236 limitation which is imposed, mainly for adult classes, which are present in high densities,  
237 cause reduction of space and food for small animals (Pezzuto e Echternacht, 1999).

238

## 239 **5. Conclusion**

240 The rains exert an influence on the distribution of the bivalve *A. brasiliiana*, with lower  
241 density after this period, however the animals are larger (> 20mm) increase in size due to food  
242 availability during rainy seasons. These results can serve as a basis for future management  
243 programs for the species, through the maintenance of natural stocks and fishing activity in the  
244 region.

245

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345 Table 1: Mean ( $\pm$  SD) water temperature ( $^{\circ}$  C) and salinity ( $\text{‰}$ ) in Mangue Seco (Pernambuco  
 346 - Brazil), during the summer and winter, the three sections (S1 to S3).

	Summer			Winter		
	Mean $\pm$ SD			Mean $\pm$ SD		
	S1	S2	S3	S1	S2	S3
Temperature	29.1 $\pm$ 1.38 <sup>a*</sup>	28.5 $\pm$ 1.07 <sup>a</sup>	28.9 $\pm$ 0.59 <sup>a</sup>	27.3 $\pm$ 1.2 <sup>a</sup>	28.3 $\pm$ 3.9 <sup>a</sup>	28.3 $\pm$ 1.0 <sup>a</sup>
Salinity	39.8 $\pm$ 0.36 <sup>a</sup>	38,3 $\pm$ 0.76 <sup>b</sup>	37.5 $\pm$ 0.51 <sup>b</sup>	30.4 $\pm$ 1.8 <sup>b</sup>	38.3 $\pm$ 0.76 <sup>a</sup>	34.0 $\pm$ 3.3 <sup>b</sup>

347 \* Different letters among lines indicate significant differences ( $p < 0,05$ )

348

349 Table 2: Mean ( $\pm$  SE) density ( $\text{ind.m}^{-2}$ ) and biomass ( $\text{g.m}^{-2}$ ) to levels (L1, L2 and L3) in  
 350 summer and winter.

Tidal Level	Summer		Winter	
	$\text{g.m}^{-2}$	$\text{ind.m}^{-2}$	$\text{g.m}^{-2}$	$\text{ind.m}^{-2}$
L1	430.37 $\pm$ 124.28 <sup>a*</sup>	289.73 $\pm$ 110.52 <sup>a</sup>	526.00 $\pm$ 197.49 <sup>a</sup>	132.21 $\pm$ 42.91 <sup>a</sup>
L2	995.70 $\pm$ 385.79 <sup>a</sup>	354.53 $\pm$ 98.98 <sup>a</sup>	864.63 $\pm$ 326.33 <sup>a</sup>	192.67 $\pm$ 89.31 <sup>a</sup>
L3	765.13 $\pm$ 288.67 <sup>a</sup>	250.35 $\pm$ 94.31 <sup>a</sup>	796.77 $\pm$ 119.36 <sup>a</sup>	196.91 $\pm$ 60.92 <sup>a</sup>

351 \* Different letters among columns indicate significant differences ( $p < 0,05$ )

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357 Table 3: Biomass and population density (Mean  $\pm$  SE) of *A. brasiliiana* one way S1 (0-600m),  
 358 S2 (600-1200) and S3 (1200-1800m), the season (S = Summer and W = Winter) and the  
 359 interaction between section and the seasons in the Beach Mangue Seco, Pernambuco - Brazil.

	Biomass	Density
Sections	g.m <sup>-2</sup>	ind.m <sup>-2</sup>
S1	462,71 $\pm$ 40,07 <sup>a</sup>	213,08 $\pm$ 64,92 <sup>ab*</sup>
S2	533,95 $\pm$ 105,01 <sup>a</sup>	139,24 $\pm$ 22,22 <sup>a</sup>
S3	1192,63 $\pm$ 163,21 <sup>b</sup>	355,84 $\pm$ 49,67 <sup>b</sup>
Seasons	g.m <sup>-2</sup>	ind.m <sup>-2</sup>
S	730,40 $\pm$ 165,43 <sup>a</sup>	298,17 $\pm$ 53,00 <sup>a</sup>
W	729,13 $\pm$ 126,44 <sup>a</sup>	173,93 $\pm$ 35,17 <sup>a</sup>
Sections x Seasons	g.m <sup>-2</sup>	ind.m <sup>-2</sup>
S1 S	412,10 $\pm$ 51,79 <sup>a</sup>	323,49 $\pm$ 90,11 <sup>c</sup>
S2 S	530,63 $\pm$ 165,53 <sup>a</sup>	156,12 $\pm$ 28,72 <sup>ab</sup>
S3 S	1248,47 $\pm$ 305,82 <sup>b</sup>	414,91 $\pm$ 82,48 <sup>c</sup>
S1 W	513,33 $\pm$ 52,76 <sup>a</sup>	102,67 $\pm$ 5,07 <sup>a</sup>
S2 W	537,27 $\pm$ 166,53 <sup>a</sup>	122,37 $\pm$ 36,86 <sup>a</sup>
S3 W	1136,80 $\pm$ 191,14 <sup>b</sup>	296,76 $\pm$ 45,20 <sup>bc</sup>

360 \* Different letters among columns indicate significant differences (p<0,05)

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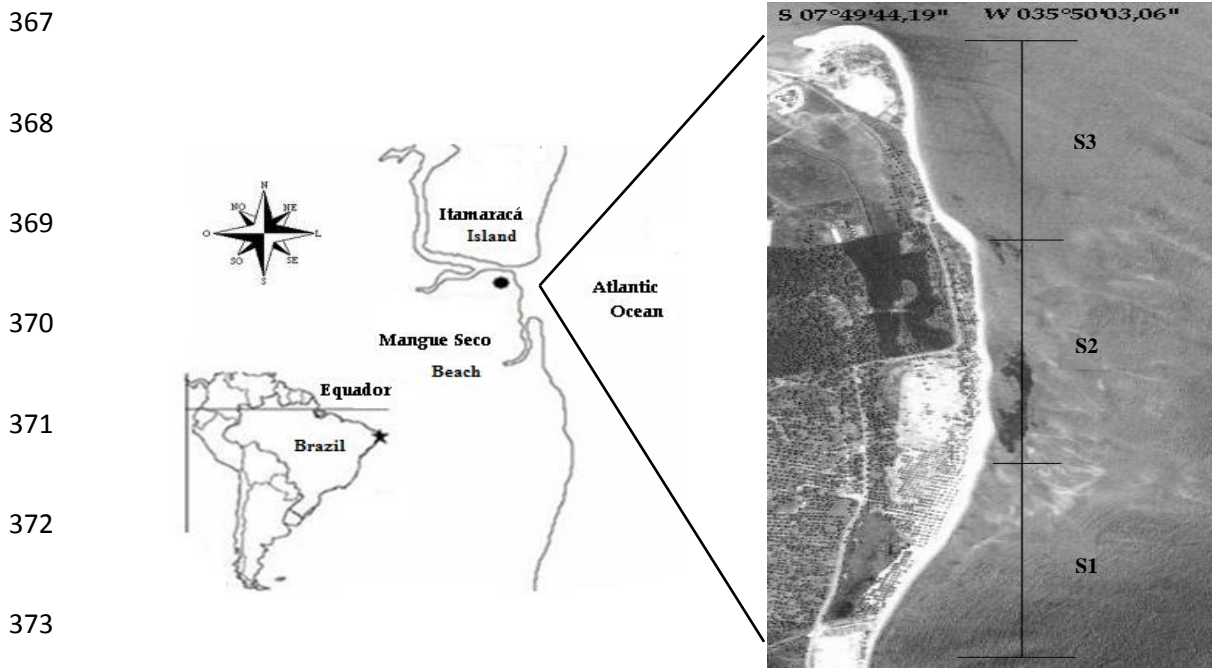
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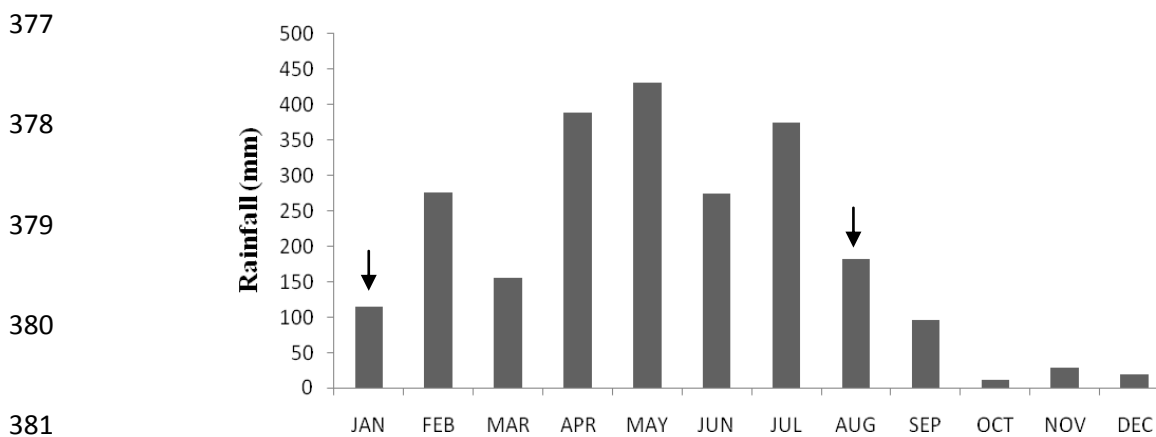
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374 Figure 1: Map showing location and satellite image of study area in Mangue Seco Beach  
 375 north coast of Pernambuco. The vertical line indicates the sections of 600 meters (S1, S2 and  
 376 S3) analyzed along the beach.



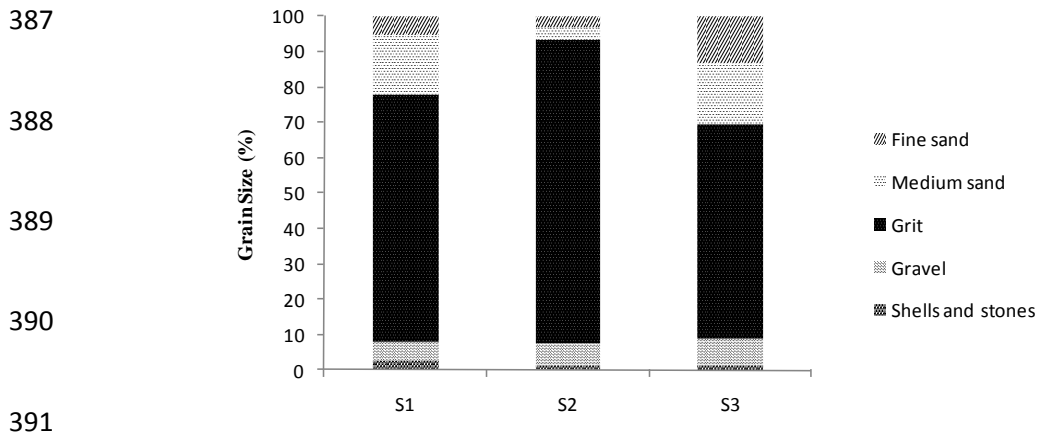
382 Figure 2: Rainfall (mm) recorded for the period January to December 2009. Arrows indicate  
 383 the months of collection. Source: LAMEPE.

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392 Figure 3: Particle size of the three areas studied (S1, S2 and S3) of Mangué Seco.

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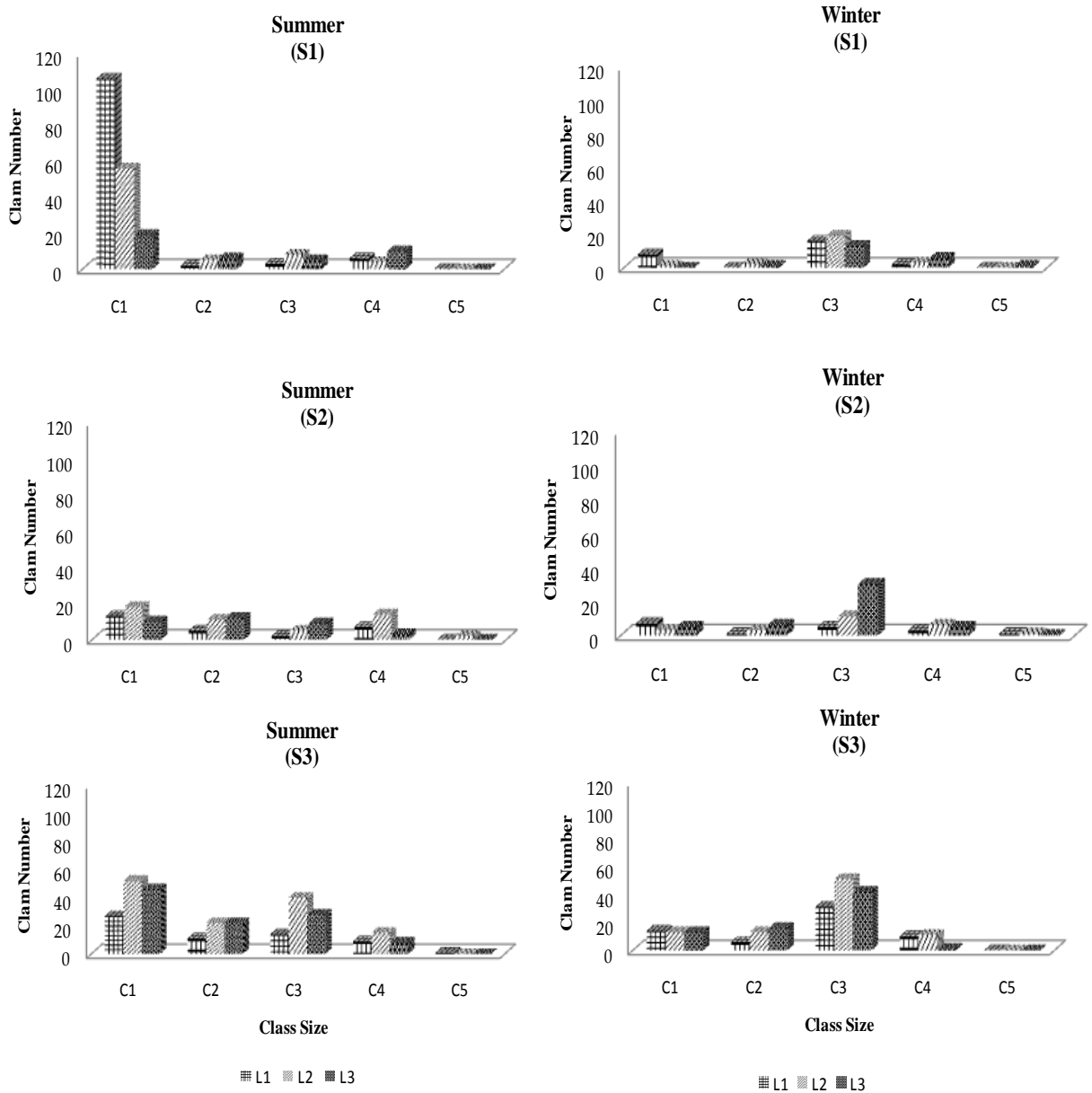
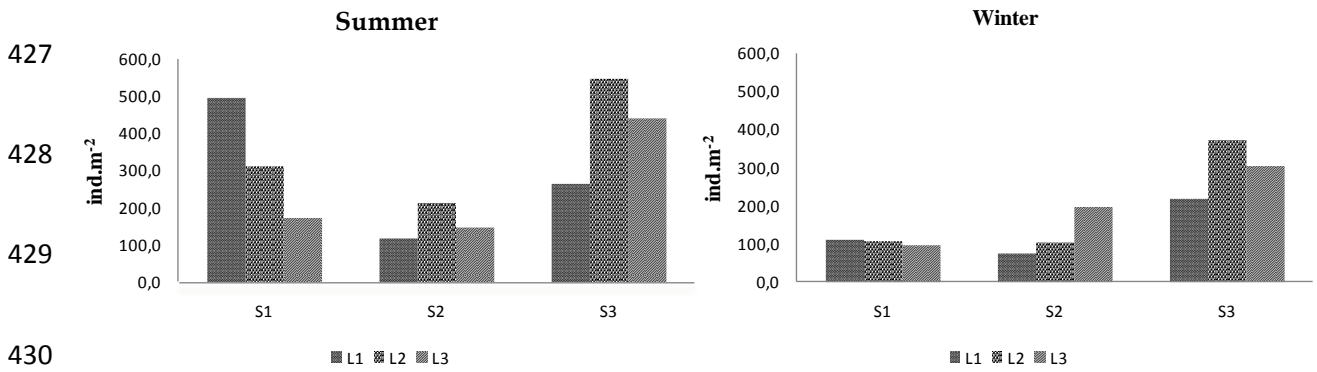


Figure 4: Clam Number, *A. brasiliiana*, collected during the months of January (summer) and August 2009 (winter), separated for class size in the sections S1 (0-600m), S2 (600-1200m) and S3 (1200-1800m) in Mangue Seco beach. L = sample levels. C1 (<15 mm), C2 (16-20 mm), C3 (21-25 mm), C4 (26-30 mm) and C5 (>30 mm).

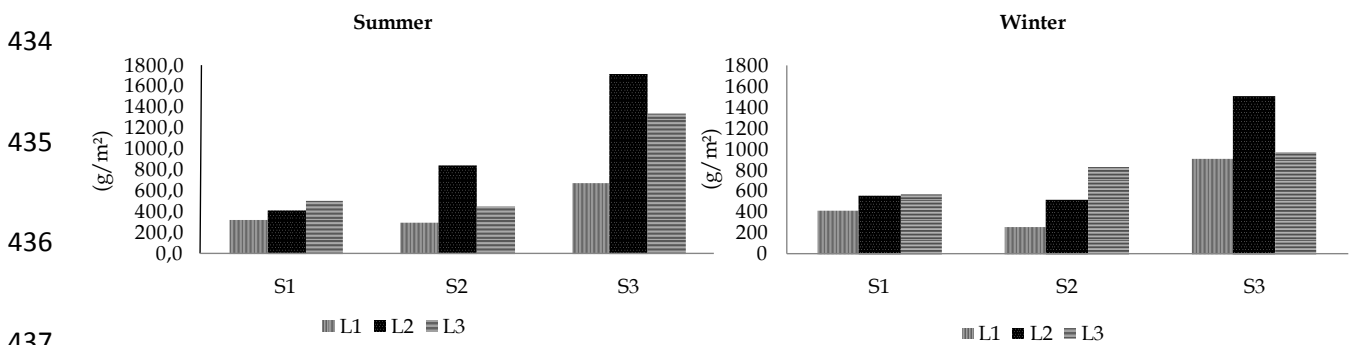
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431 Figure 5: Population density of *A. brasiliiana* by sections (S1, S2 and S3) levels (L1, L2 and  
 432 L3) of Mangue Seco beach, during the summer and winter.

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438 Figure 6: Biomass of *A. brasiliiana* by sections (S1, S2 and S3) and levels (L1, L2 and L3) of  
 439 Mangue Seco beach, during the summer and winter.

1 An evaluation of the replenishment of shellfish stocks *Anomalocardia brasiliiana* in fishing  
2 area in Mangue Seco beach, north coast of Pernambuco, Brazil

3  
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## 20 Abstract

21 The aim of the study was to evaluate the recovery of the *Anomalocardia brasiliiana* stock  
22 looking at the number and size of clams harvested in summer and winter, after extraction with  
23 different methods of capture. Three treatments were evaluated corresponding to an area of  
24 18.75 square meters each, representing where; the clams were removed manually by the  
25 fishermen, were collected by a gillnet fishery, and harvesting was not common. The samples  
26 were taken at three moments for each treatments: before the fishermen had harvested the  
27 clams, an hour after the harvest and finally after 24 hours. The clams were smaller after the  
28 manual extraction ( $15.46 \pm 0.86$  mm) however there was not a significant difference between  
29 the size of the animals found after the collection carried out with a gillnet ( $18.16 \pm 0.92$  mm).  
30 There were more captured animals with a size larger than 20 mm in winter (80% ), than in  
31 summer (20%) with no difference between the types of collect for both stations. The type of  
32 collect and the moment of extraction didn't influence the number of clams, since the *A.*  
33 *brasiliiana* stock found in the Mangue Seco is large and has the capacity to recover after a  
34 period of 24 hours of harvesting. The winter and summer exert influence on the abundance of  
35 *A. brasiliiana*, with greater amounts of clams with recommended size for fishing ( $> 20$  mm)  
36 found in winter.

37 Keywords: Shellfish benthic, density and fishing methods.

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## 42        **1. Introduction**

43        Clams are being extensively collected from exposed beaches throughout the world as part  
44 of recreation, artisanal activity or commercial fishery (McLachlan *et al.*, 1996). These same  
45 authors define recreational fishery as the collection of bait or food without sale or dependence  
46 on the resource; artisanal fishery as collection for subsistence or sale by individuals or groups  
47 using traditional methods; and commercial as collection for sale by corporate or collective  
48 organizations.

49        The mollusc, *Anomalocardia brasiliiana* is easy to locate and extract, and so is commonly  
50 consumed in Brazil. The harvesting is carried out in various regions of the country, both for  
51 subsistence and for sale (Pezzuto e Echternacht, 1999). On the Brazilian coast, several species  
52 of molluscs from the estuarine regions have been explored extensively, providing the  
53 livelihood for large groups of economically and socially disfavoured families however  
54 without the use of management measures needed to ensure the sustainable use of resources  
55 (Araújo, 2001; Silva-Cavalcanti and Costa, 2009).

56        The uncontrolled exploitation of this specie may compromise the remaining natural  
57 stocks, altering the coastal environment. This exploitation is carried out by hundreds of  
58 fishermen who live in this region and unfortunately there is a lack of research related to this  
59 species facing the state. Due to the amount of extraction that has taken place it is already  
60 harder to find the clam in many parts of the north coast of Pernambuco, and according to  
61 reports from the region's fisherwoman, even areas of large concentration are showing a  
62 reduction in size.

63        On the Mangue Seco Beach, north coast Pernambuco, the harvesting of the *A. brasiliiana*  
64 is done in two ways: manually, usually done by women, and the collect using a gillnet fishery,  
65 known as netting, usually held by men and requiring a more physical effort. In the period

66 before the summer there is an increase in fishing for clams on this beach, because in summer  
67 there is a greater demand for this product in bars and restaurants of the region.

68 Studies focused on the biology of marine bivalves are important for establishing  
69 management programs in order to ensure the maintenance of natural stocks, and thus  
70 contribute to the development of extractive activities and mariculture (Moreira, 2007). This  
71 study is aimed to evaluate the recomposition of stock *A. brasiliiana* regarding the number and  
72 size of clam harvested in winter and summer, after extraction with two different methods of  
73 fishing.

74

## 75 **2. Material and Methods**

### 76 2.1. Study area

77 Igarassu city on the north Pernambuco coast is part of the Recife metropolitan area  
78 being 28 km from the capital, and has an area of 302.9 km<sup>2</sup>, a population of 86,519  
79 inhabitants and a tropical climate type with rainy winters and dry summers. In the city  
80 there are three protected areas: Environmental Protection Area (APA) of channel Santa  
81 Cruz estuary, APA Timbo river estuary and APA of Nova Cruz. The most famous beach  
82 of the city, the Captain's beach, also known as Mangue Seco, is located in Nova Cruz (S  
83 07°49'44,19" e W 035°50'03,06". It has a beach length of approximately 2km, has shallow  
84 water with small waves and an intensive tide, with a tide variation in the low-water mark  
85 above the 500m (Figura 1). It consists of a multitude of highly productive ecosystems and  
86 is considered the green region, where one can find areas covered by coconut trees, with  
87 extensive mangrove estuaries, coral sands, crowns, islands and reefs, among other  
88 (<http://www.pe-az.com.br>).

89        Insert Figure 1

90

## 91        2.2.        Experimental Design

92        The study was conducted in August 2009 and January 2010, and represents both the summer and  
93 winter seasons. Each of these three treatments/methods (T) was carried out three times (6.25  
94 m<sup>2</sup>, 3 times ) , corresponding to an area of 18.75 m<sup>2</sup> per treatment. The three method a being;  
95 the clams removed manually by fisherwoman (T1) (Figura 2a), those collected with a gillnet  
96 fishery popularly known as netting (T2) (Figura 2b), and where no extraction of clam (T3).  
97 The clams were sampled at three specific moments for each method: before the clams were  
98 collected (M<sub>0</sub>), after one hour (M<sub>1h</sub>) and 24 h after the sampling (M<sub>24h</sub>).

99

100        Insert Figure 2

101

102        The samples of *A. brasiliiana* were taken randomly with a cylindrical collector, which  
103 had a 25 cm diameter and a depth of 10 cm (0.049 m<sup>2</sup>). Each treatment was performed 9  
104 times. The clams were measured with a caliper, precision 0.01 mm, using the maximum  
105 length of the shell on its anterior-posterior axis (Shell length, SL), and sorted into five size  
106 classes: C1 ( $\leq 15$  mm), C2 (16 to 20 mm), C3 (21 to 25 mm), C4 (26 to 30 mm) and C5 (> 30  
107 mm). Individuals caught in this study were classified as juveniles when their shell length was  
108 smaller than 20 mm and as adult when larger than 20 mm, classification developed by  
109 Arruda-Soares *et al.* (1982).

110



### 111 2.3. Data analysis

112 The stock data was analyzed in terms of amount, size and method of fishing. Data  
113 regarding the amount, size and method of fishing was analyzed by factorial analysis of  
114 variance (ANOVA), followed by Duncan's Multiple Range Test to determine differences  
115 between the treatments, moment of collection and seasons.

116

### 117 3. Results

118 458 clams were collected during winter, with; 112, 169 and 177 representing the  
119 treatments T1, T2 and T3, respectively. In the summer 904 clams were collected; 319, 241  
120 and 344 representing the T1, T2 and T3, respectively.

121 There was not a significant difference when comparing the number of clams caught  
122 between the treatments and between the time of collection. There was also no difference with  
123 the size of animals collected (Table 1). The collected data shows how the seasons impact the  
124 number of animals, with the largest amount collected in summer ( $11.16 \pm 0.63$ ) ( $5.63 \pm 0.55$   
125 in winter). However the average size of animals collected in summer were  $15.55 \pm 0.39$  and  
126  $19.78 \pm 0.82$  in winter, and so there is no significant difference (Table 1).

127

128 Insert Table 1

129

130 The interaction of treatments and moment of collect with the season, showed the effect of  
131 seasons on the number of clams present. There was a greater quantity in the summer with  
132  $11.81 \pm 1.15$  (T1),  $8.93 \pm 0.91$  (T2 ) and  $12.74 \pm 1.08$  (T3), which differed greatly from data

133 obtained for the same treatments in the winter. This same pattern was observed for moment of  
134 collection, with  $12.78 \pm 1.04$  ( $M_0$ ),  $9.44 \pm 1.07$  ( $M_{1h}$ ) and  $11.26 \pm 1.08$  ( $M_{24h}$ ) in the summer,  
135 differing significantly to the winter results (Table 2).

136 A significant change between T2 and T3 in winter and T2 in summer was observed when  
137 comparing the effect of seasons on the length of the clams, with average size of *A. brasiliiana*  
138 from  $20.83 \pm 1.48$  mm and  $22.59 \pm 0.57$  mm for the winter and  $15.48 \pm 0.85$  mm in summer  
139 (Table 2). However there was no great difference in the size of clams collected when looking  
140 at the time of collection.

141 The number of animals collected in winter 82 (n = 112) for the T1 treatment was larger  
142 than 20 mm, and represented approximately 82% of the clams caught. During the same period  
143 the amount of clams larger than 20mm for T2 and T3 were 158 (n = 168) and 162 (n = 177),  
144 representing approximately 94% and 91% of the clams collected (Figure 3). During the  
145 summer the number of clams collected that were larger than 20 mm, in T1, T2 and T3 was 28  
146 (n = 319), 41 (n = 241) and 63 (n = 344), representing approximately 8.8% , 17% and 18%  
147 respectively, with the number of adult animals collected far less than in winter. Neither station  
148 revealed animals larger than 30 mm.

149

150 Insert figure 3

151

#### 152 **4. Discussion**

153 The decrease in the density of *A. brasiliiana* during the winter may be related to the fishing  
154 activity of this species, as these areas are located in places accessible to humans and its catch  
155 requires a low capital investment. These molluscs are used by fishing communities for

156 consumption and sale to the consumer market (Pezzuto and Echternacht, 1999; Rosa, 1989).  
157 Silva-Cavalcanti and Costa (2009) reported that it is more common to find women fishing for  
158 clams than men, however the women's harvest on average is, 15.0 kg / day in summer and  
159 10.0 kg / day in winter, and men 17.5 kg / day in summer and 13.0 kg / day in winter. The  
160 highest catches in the summer are related to the greater abundance of *A. brasiliiana* in this  
161 period, which too can be related to the gillnet fishery utilized. Smaller quantities of clams  
162 were found  $7.59 \pm 0.69$  after this method of collection.

163 Studies conducted by Barrera and Araújo (2005) in Ceará, report that the species *A.*  
164 *brasiliiana* has two spawning peaks, one in spring and one in the fall. There are no studies  
165 about the reproductive biology of this species in Pernambuco. However when comparing  
166 these results from Ceará, we can see a similarity in the abundance of *A. brasiliiana* juveniles  
167 in the summer of 2010 due to a possible spawning peak of this species during the winter of  
168 2009, which may have influenced the variation in the size and number of animals found.

169 In general, during the winter of each year the juveniles are recorded at approximately 1  
170 mm shell length. They show a rapid growth reaching 6 to 8 mm even in spring, 20 mm in  
171 about eight to nine months in the summer / autumn of the following year (recruitment fishery)  
172 and 30 mm at 2 years, when their life expectancy drops dramatically, not exceeding 3 years of  
173 age (Pezzuto and Echternacht, 1999; Souza, 2003; Nandi, 2005).

174 The average size of the clams harvested at T1 was  $15.46 \pm 0.86$  and T2 was  $18.16 \pm 0.92$   
175 when they were collected by fishermen. This can be related to a possible reduction in the size of  
176 this species, even without significant difference between treatments. This data corresponds to  
177 that found by Silva-Costa and Cavalcanti (2009); the daily extraction of clam was indicated  
178 (63.4%) as responsible for the reduction in shell length and traditionally, and thus animals  
179 between 10 and 31 mm were collected.

180       Rodrigues (2009) evaluated the population of *A. brasiliiana* in Barra Beach in the state Rio  
181 Grande do Norte, and found that adult animals with a length of 23 to 28 mm prevailed in the  
182 months of September and October/07. In the period between October/07 to March/08 the  
183 largest entry of young individuals in the population was found. Between January to May/08 a  
184 greater abundance of individuals with size from 4 to 12 mm in length were found. The same  
185 can also be observed in this study, as there was a greater abundance of clams above 20 mm in  
186 August 2009, and in January 2010 with a greater frequency was noted (size between 5 and 16  
187 mm).

188       Barletta and Costa (2009) reported that molluscs (*A. brasiliiana*, *Tagelus plebeius*) in the  
189 Goiana river estuary in Pernambuco are extracted by hand during low tide (at least 4 hours per  
190 day), with primarily women and children carrying out the harvesting. In the same way one can  
191 see the same trend for the Mangue Seco beach, differing only with the entry of men in this  
192 activity, which mainly use the gillnet for their collection of clams. This is one of the most  
193 important fishing activities in the region, both for subsistence income and financial.

194       It was not possible to demonstrate a reduction in the density of stock *A. brasiliiana* due to  
195 time restraints, because the number of clams collected after 24 hours was the same as the  
196 baseline. This is mentioned by Silva-Costa and Cavalcanti (2009) who reported that the  
197 depletion of *A. brasiliiana* in Mangue Seco cannot be predicted, due to migration for banks  
198 within the same area. However, successful resource management involves social organization  
199 within protected territories, and there should be a better management of areas with a high  
200 presence of fishermen, or even diary ordering of local fisheries.

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## 204        **5. Conclusion**

205        The method of collection and the estimated time of extraction did not influence the  
206 amount of clams, since the *A. brasiliiana* stock of the Mangue Seco is still abundant and could  
207 be regenerate after a period of 24 hours. The winter and summer seasons have a great  
208 influence on the abundance of *A. brasiliiana*, with the largest number of animals with the  
209 recommended size for fishing found during the winter period. There is need for further studies  
210 to assess the carrying capacity of this resource at this beach.

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## 212        **Acknowledgments**

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217 Canada.

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275 Table 1: Mean ( $\pm$  SE) of the number and length of clams collected between treatments (T1,  
 276 T2 and T3) for two seasons (S = summer and W = winter) in different moments ( $M_0$  - samples  
 277 taken before collected by fisher,  $M_{1h}$  - samples taken after collect of fisher,  $M_{24h}$  - samples  
 278 removed after 24 hours).

Tratament	N <sup>o</sup> of Clams	Size (mm)
T1	7.98 $\pm$ 0.86 <sup>a*</sup>	15.46 $\pm$ 0.86 <sup>a</sup>
T2	7.59 $\pm$ 0.69 <sup>a</sup>	18.16 $\pm$ 0.92 <sup>a</sup>
T3	9.61 $\pm$ 0.86 <sup>a</sup>	19.38 $\pm$ 0.60 <sup>a</sup>
Seasons	N <sup>o</sup> of Clams	Size (mm)
W	5.63 $\pm$ 0.55 <sup>a</sup>	19.78 $\pm$ 0.82 <sup>a</sup>
S	11.16 $\pm$ 0.63 <sup>b</sup>	15.55 $\pm$ 0.39 <sup>a</sup>
Moment	N <sup>o</sup> of Clams	Size (mm)
$M_0$	9.02 $\pm$ 0.85 <sup>a</sup>	17.99 $\pm$ 0.82 <sup>a</sup>
$M_{1h}$	7.07 $\pm$ 0.71 <sup>a</sup>	17.17 $\pm$ 0.86 <sup>a</sup>
$M_{24h}$	9.09 $\pm$ 0.85 <sup>a</sup>	17.84 $\pm$ 0.83 <sup>a</sup>

279 \* Different letters among columns indicate significant differences ( $p < 0,05$ )

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288 Table 2: Mean ( $\pm$  SE) of the interaction between seasons, treatments and moments through of  
 289 the number and length of clams caught in Mangue Seco.

Tratament / Seasons	N <sup>o</sup> of Clams	Size (mm)
T1 W	4.15 $\pm$ 0.76 <sup>a*</sup>	15.93 $\pm$ 1.65 <sup>ab</sup>
T2 W	6.26 $\pm$ 0.98 <sup>a</sup>	20.83 $\pm$ 1.48 <sup>ac</sup>
T3 W	6.48 $\pm$ 1.05 <sup>a</sup>	22.59 $\pm$ 0.57 <sup>c</sup>
T1 S	11.81 $\pm$ 1.15 <sup>b</sup>	14.99 $\pm$ 0.55 <sup>ab</sup>
T2 S	8.93 $\pm$ 0.91 <sup>b</sup>	15.48 $\pm$ 0.85 <sup>b</sup>
T3 S	12.74 $\pm$ 1.08 <sup>b</sup>	16.17 $\pm$ 0.59 <sup>abc</sup>
Moment / Seasons	N <sup>o</sup> of Clams	Size (mm)
M <sub>0</sub> W	5.26 $\pm$ 0.88 <sup>a</sup>	20.05 $\pm$ 1.47 <sup>a</sup>
M <sub>1h</sub> W	4.77 $\pm$ 0.70 <sup>a</sup>	18.63 $\pm$ 1.47 <sup>a</sup>
M <sub>24h</sub> W	6.79 $\pm$ 1.17 <sup>a</sup>	20.60 $\pm$ 1.24 <sup>a</sup>
M <sub>0</sub> S	12.78 $\pm$ 1.04 <sup>b</sup>	15.93 $\pm$ 0.47 <sup>a</sup>
M <sub>1h</sub> S	9.44 $\pm$ 1.07 <sup>b</sup>	15.43 $\pm$ 0.70 <sup>a</sup>
M <sub>24h</sub> S	11.26 $\pm$ 1.08 <sup>b</sup>	15.28 $\pm$ 0.83 <sup>a</sup>

290 \* Different letters among columns indicate significant differences ( $p < 0,05$ )

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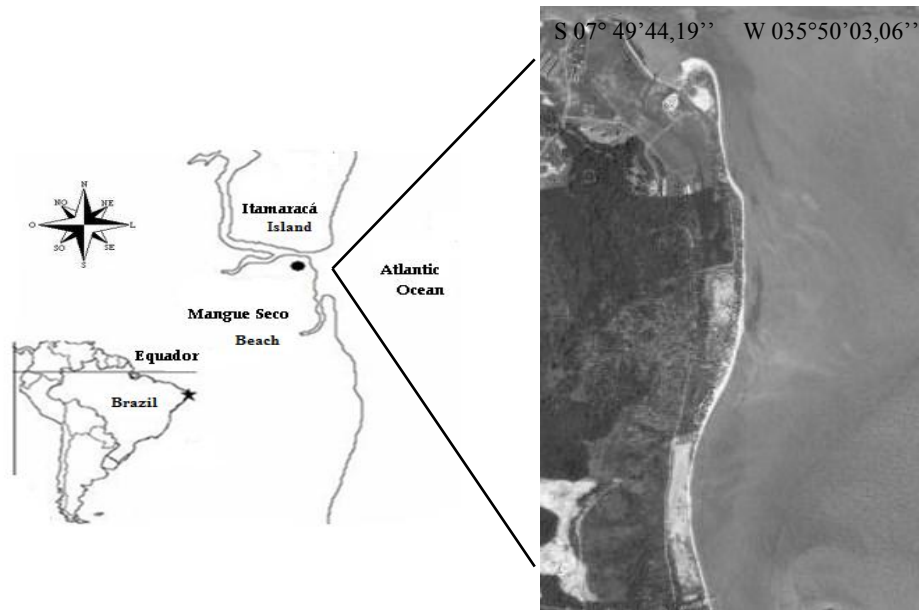
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Figure 1: Map showing location and satellite image of study area in Mangue Seco Beach

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north coast of Pernambuco.

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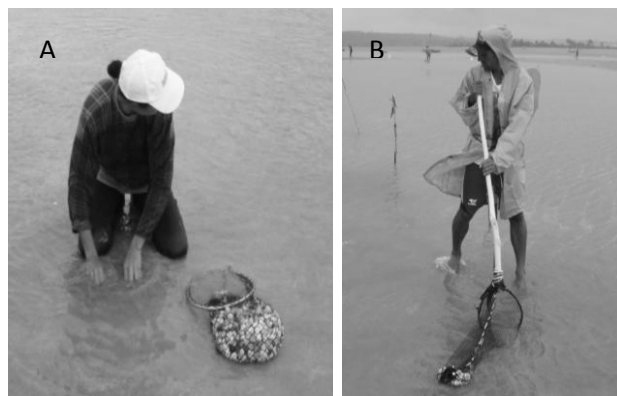
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Figure 2: Photo A - Fisherwoman making manual collection of clams (T1) and Photo B -

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Fisherman doing collecting shellfish using the gillnet (T2).

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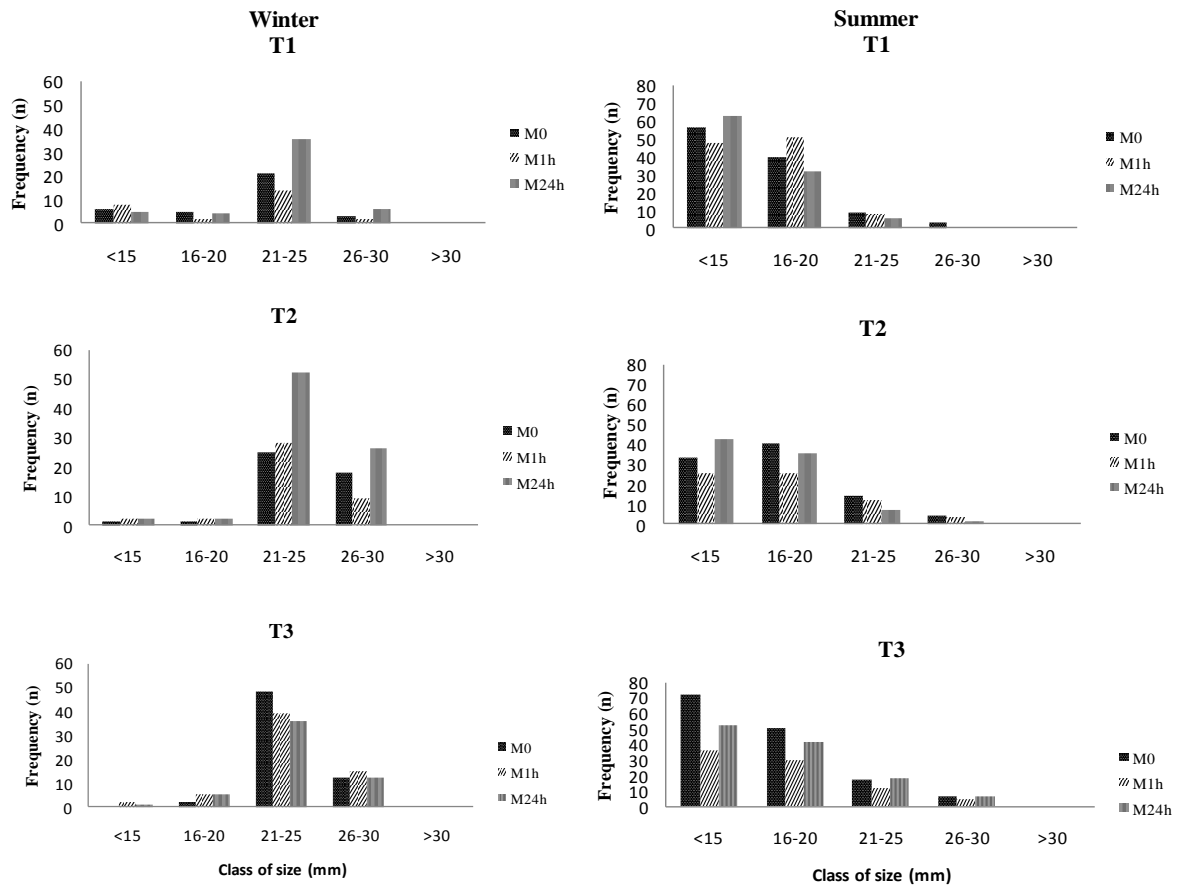
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328 Figure 3: Frequency of size classes (mm) observed for clams collected during the months of  
 329 August 2009 (winter) and January 2010 (summer). M<sub>0</sub> - samples taken before the collections  
 330 by fisher, M<sub>1h</sub> - samples taken after collection of fisher and M<sub>24h</sub> - samples removed after 24  
 331 hours.

## 6. CONSIDERAÇÕES FINAIS

Os indivíduos da espécie *A. brasiliiana* apresentam uma distribuição espacial característica, com uma maior abundância de juvenis no período de verão enquanto que os adultos são mais abundantes no período de inverno. As estações inverno e verão têm grande influência na abundância de *A. brasiliiana*, com maior quantidade de animais em tamanho recomendado para pesca ( $> 20$  mm) no período do inverno.

O tipo de coleta e o tempo estimado de extração não influenciaram na quantidade de moluscos, uma vez que o estoque *A. brasiliiana* da praia de Mangue Seco ainda é abundante e pôde se recompor após um período de 24 horas, sem extração.

Há necessidade de novos estudos para avaliação da capacidade de suporte deste recurso nesta praia. Os resultados encontrados podem servir como base para futuros programas de manejo da espécie, através da manutenção dos estoques naturais e atividades pesqueiras na região.

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## Revista Scientia Marina

O artigo científico 2 “An evaluation of the replenishment of shellfish stocks *Anomalocardia brasiliensis* in fishing area in Mangue Seco beach, north coast of Pernambuco, Brazil” foi submetido a revista Scientia Marina.

## NORMAS

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## INSTRUCTIONS TO AUTHORS

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- Please include the title, the complete name ( first name and family name) and postal address of the author(s), and the fax number and e-mail address of the corresponding author
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