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LIFE BELOW WATER

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Chapter 5

Sustainable development of fisheries

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Introduction

Marine and estuarine fishery in Brazil is performed by millions of fishermen and produces almost 500 thousand tons of fish per year (FAO, 2017), thus being an important source of food, employment and income for people and the country (Haimovici et al., 2014). However, since the 1990s, it remained stagnant and its stocks are overexploited. For this reason, Embrapa, in partnership with several institutions, has been carrying out projects and intervention actions to increase scientific knowledge, improve ocean health and enhance the contribution of marine biodiversity to Brazil's socioeconomic development, according to the target already described in Chapter 4 (14a). The Company has also developed projects to provide access for small-scale artisanal fishermen to marine resources and markets (Figure 1) (target 14.b).

Among the actions already carried out, many aim to meet target 14.7: by 2030, increase the economic benefits to Small Island developing States and least developed countries, from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism (United Nations, 2017).

Crustacean fisheries

Studies on estuarine fishery began with projects related to mangrove crab (*Ucides cordatus*) because of its important role both in nutrient recycling on trophic structure of mangroves (Christofoletti et al., 2013; Santos et al., 2016a) and in securing the livelihoods of thousands of people in Brazilian coastal areas (Alves; Nishida, 2002, 2003; Nascimento et al., 2012, 2017). In the Parnaíba River

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Figure 1. Detail of artisanal estuary fishing in the state of Piauí, Brazil.

Delta, mangrove crab catching represents 30% of fish landed in the state of Piauí (Fogaça et al., 2015).

Therefore, in 2003, Embrapa Mid-North addressed crab catching in the region, funded by Banco do Nordeste. The work involved production chain diagnosis, identifying fisheries sites, fishing gears, loading and unloading places, transportation methods, and marketing price. A socioeconomic diagnosis of crab catchers, by identifying family composition and income, age group, schooling status and living conditions, was also made (Legat; Puchnick, 2011). Results allowed to identify the sector reality and served to rank priority research actions of Embrapa Mid-North, priority training actions of the Brazilian Micro and Small Business Support Service (Sebrae), and social actions of the Piauí and Maranhão governments for this production chain. The project also estimated the Capture per Effort Unit (CPUE), which is the amount of collected crabs per person per day; it ranged between 14.6 and 22.6. It was verified that only crab males were caught and that their average size was higher than that of crab females.

Between 2009 and 2010, the team assessed the population composition and density (individuals per square meter), the reproductive and ecdysis periods. This information was presented to environmental authorities and was input for drafting the mangrove crab management plan in 2017, prepared by the Instituto Chico Mendes de Conservação da Biodiversidade (Chico Mendes Institute for Biodiversity Conservation – ICMBio). In 2014, the Embrapa Unit – in partnership with the Comissão Ilha Ativa (Active Ilha Commission), State University of Piauí (Uespi), Federal University of Piauí (UFPI), ICMBio and City Hall of Ilha Grande, with funding from the Fundo Brasileiro para a Biodiversidade (Brazilian Biodiversity Fund – Funbio) – monitored the mangrove crab unloading in the ports of Ilha Grande, the largest island of the Parnaíba River Delta. The study concluded that 12,000 crab ropes are unloaded monthly (each rope contains four individuals), totaling 576,000 crabs unloaded between 2014 and 2015 (Fogaça et al., 2015).

Actions focused on the production chain of mangrove crab were also carried out by Embrapa Amapá. Between 2009 and 2010, information on the catch size and its compliance with the law (which requires a carapace width of more than 60 mm in order to guarantee crab reproduction, fishing sites and sales), as well as crab price in the market, were collected. It was found that animals were collected all over Amapá, except in the closed season (during which capture is forbidden), when crab from the state of Pará was sold. Carapace size was within the allowed limit and sale price depended on product demand and supply. In 2014, the same team carried out a study on the mangrove crab bio-ecology in the state of Amapá. Findings included higher crab densities per burrow, a greater number of individuals per square meter during summer, higher male/female ratio (1: 38/1), larger catch size compared to those found in other studies, higher frequency of females with eggs and mature females with carapace width between 59.8 mm and 67.5 mm, and highest reproductive peak in May to August (Amaral et al., 2014). This information was (and is) important for establishing regional management programs for crab.

All these studies aim to increase technical-scientific knowledge on fishing resources and their uses, thus characterizing artisanal fishing. Therefore, in 2010, the Embrapa Amapá team conducted a study to characterize artisanal fishing in the state in order to learn about its reality and propose solutions for its improvement (Silva; Dias, 2010). The region's privileged geographic location makes its fisheries to be under the influence of both the Amazon River and the Atlantic Ocean. The study concluded that the traditional fishing activity is basically artisanal and not very competitive compared to fishing activities by industrial vessels from other Brazilian states and even from other countries in the region. Problems related to the land issue, social organization of fishermen, fishing industries and state fishery production were presented. It was suggested that the sector's development depends on infrastructure improvements, such as: investments in fishing fleets, modernization and construction of modern and adequate unloading ports, reliable knowledge of the statistics of fish unloading, and improvement in methods for processing fish, which is in general sold *in natura* or salted. Therefore, based on this information, appropriate policies for artisanal fisheries in the region could be designed.

Shellfish harvesting

Another fishing activity investigated by Embrapa Mid-North was shellfish harvesting. In 2010, by interviewing fishermen and monitoring fisheries, Embrapa assessed the main shellfish species collected in the Cardoso and Camurupim rivers estuaries (Legat et al., 2010). Seven species of bivalve shellfish and three harvesting sites along the coast of Piauí were identified, in which 165 fishermen worked throughout the year. Native oyster species (*C. rhizophorae* and *C. gasar*) were harvested in January, February, July and December, when there were more tourists in the region. Occasionally *Mytella charruana* was harvested, depending on its presence in the estuary; it is more abundant from October to December. The *Mytella guyanensis* harvesting occurred throughout the year. The *Anomalocardia brasiliana* stood out as the main harvested species, and was the only one used for both consumption and sale. The species *Iphigenia brasiliana* and *Tagelus plebeius* were characterized as *A. brasiliana* harvest bycatches.

Since 2007, Embrapa Mid-North has been carrying out actions related to seafood processing by supporting the Luís Correia Fishermen Association, the Ilha Grande Shellfish Harvesters Association and shellfish harvester groups in Barra Grande, all located in the state of Piauí. In 2010, the composition and yield (8%) of *A. brasiliana* flesh were determined (Freitas et al., 2010). In 2012, an investigation on the traditional knowledge of shellfish harvesters was performed; conclusions were that they manage the resource guided by harvesting larger animals and alternating harvesting sites, which shows that shellfish harvesting is a traditional local family activity (Freitas et al., 2012). In 2014, in order to improve the microbiological and sensorial quality of shellfish, depuration tests were carried out in partnership with the Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba (São Francisco and Parnaíba Valleys Development Company – Codevasf) and the Active Ilha Commission; results were that a 24-hour-long depuration in potable water in a static system is efficient for eliminating sand and 99% of the microbial content in the product (Santos et al., 2016b).

Artisanal fisheries

With regard to fishing estuarine, marine and elasmobranch fish, Embrapa Mid-North monitored fish-weir fisheries off the coast of Piauí (Mai et al., 2012). Three fish-weirs were monitored during daytime and nighttime operations between December 2008 and November 2009. A total of 117 fish species belonging to 41 families were recorded. There was no significant difference in average catch weight between rainy and dry seasons, between the daytime and nighttime shifts, and between full moon and new moon phases. The annual catch per fish-weir was estimated at 1.2 ton of fish, of which 79.0% were made up of commercially important fish species for the state of Piauí. In the same vein, the Projeto Sociobiodiversidade da Ilha (Ilha Socio-biodiversity Project, already mentioned above) monitored marine fishery in Pedra do Sal, Parnaíba, state of Piauí. Observations totaled 40 fishing vessels per month, 79 species belonging to 37 families, of which the following were of major commercial importance: *Lutjanus jocu*, *Megalops atlanticus*, *Scomberomorus cavalla*, *Centropomus undecimalis* and *Cynoscion acoupa*, as well as 14 non-commercial species including bycatches of endangered species, such as nurse shark (*Ginglymostoma cirratum*), goliath grouper (*Epinephelus itajara*) and hammerhead (*Sphyrna* sp.). With regard to fishing gears used, nine kinds were observed: hand line, gillnet, casting net, longline and launch, among which gillnet and line represented 74.45% of equipment used in total production.

More recently, in 2015, sponsored by Petrobras through its Petrobras Socioambiental Program, a study was carried out on fishing in the Timonha and Ubatuba rivers estuary (Pereira; Rocha, 2015). It was led by the non-governmental organization (ONG) Active Ilha Commission, in partnership between Embrapa Mid-North, UFPI, Uespi, Federal Institute of Ceará (IFCE), Associação de Pesquisa e Preservação de Ecossistemas Aquáticos (Association for Research and Conservation of Aquatic Ecosystems – Aquasis) and ICMBio. The main project result was drafting and publicly releasing the *Carta-Proposta dos Encontros de Pesca dos rios Timonha e Ubatuba (Timonha and Ubatuba rivers Fishing Meetings Letter-Proposal)*, whose proposals include planning and zoning estuary fishing, increasing the income and enhancing the life quality of community fisherman families located in that region (Pereira; Rocha, 2015). Also, results indicated: a) lower fishing effort in sites closer to coastal zones; b) white mullet (*Mugil curema*) was almost exclusively caught in nets and represented 50% of the amount of species harvested by this system; and c) in terms of environmental diversity, 127 species were identified. Studies have also been carried out on reproduction: catfish (*Sciades herzbergii* and *Aspistor luniscutis*) were able to spawn throughout the whole sampling period (August 2014 to June 2015) and to offer parental care (egg incubation in the mouth), requiring longer closed season time; for white mullets, there are indications that their average size on first maturation is from 23 cm for both males and females. In addition to these fisheries-related studies, physical-chemical and biological parameters of estuarine water were also monitored. This information may contribute to drafting the management plan for the Environmental Protection Area (APA) of the Parnaíba River Delta, where the estuary is located.

Institutional actions

Despite all these actions carried out since 2003, it was only in 2009, after Law No. 11,958, of June 26 was signed, which created Embrapa Fisheries and Aquaculture, that Embrapa officially joined other Brazilian institutions to directly contribute to the sustainable development of fisheries. This Unit evolved from the Aquapesquisa Project, funded by the former Ministry of Fisheries and Aquaculture (MPA), which was intended to build a significant database containing information from public, private and non-governmental institutions working in scientific research and development, rural education and extension, fisheries and aquaculture. Aquapesquisa final product was a document titled *Diagnóstico Estratégico de Instituições Demandantes e Ofertantes de Tecnologia em Pesca e Aquicultura* (*Strategic Diagnosis of Fisheries and Aquaculture Technology Demanding and Granting Institutions)* (Rebelatto Junior et al., 2013), which identified 3,479 Brazilian institutions working in the area. To better manage the existing socio-technical network, a record of professionals ranked according to their respective areas of activity was organized. The project is intended to be periodically updated, thus allowing its future expansion as the sector evolves. The diagnosis also identified bottlenecks in the fish production chain, which allows better guidance for sector institutions focused on creating (especially sustainable) technologies and proposing interventions, especially on less consolidated areas (Rebelatto Junior et al., 2014).

In this context, in order to better organize information on the Brazilian fishing sector, *Prospesque* was held in June 2012, in Palmas, state of Tocantins, in order to strategically plan the decision making on generating and transferring technologies for the sustainable development of fisheries (Lima et al., 2012).

Fifty experts joined representing proportionally Brazil's regions and four areas of the fishing sector, namely: inland artisanal fishing, marine artisanal fishing, sport fishing and industrial fishing. With such a plural group of specialists, a balanced debate on the main research and technological development demands of the sector was possible. From this technical meeting, the *Relatório técnico do Seminário Nacional de Prospecção de Demandas da Cadeia Produtiva da Pesca PROPESQUE* (*Technical report of the National Seminar on Prospecting Demands of the Fishing Production Chain PROSPESQUE)* (Lima et al., 2012) was released, which, among analytic perspectives, pointed to the main research barriers for the sustainable development of artisanal marine fisheries: a) lack of monitoring and updated production of fisheries statistics to support public policies; b) lack of implementation of a national fisheries monitoring plan and need for developing sustainable management plans; c) need for social, biological, economic, environmental and technological studies on fishing activity (economic analyses and cost-benefit studies on the activity, studies on the socio-environmental aspects and their relation with the concept of sustainability); d) need for obtaining information in regularly predetermined frequency on the production chain for monitoring and input for public policies; e) development of ecosystem approaches to assess the sustainability of exploited stocks; f) need for creating collaborative research and development networks on fishing in the whole country in order to jointly design projects to deeply change the national fisheries context towards a sustainable scenario.

Including fish in school feeding

Another project that produced a solution for artisanal fishermen to access alternative markets was the one on Technology transfer for including family farmed fish in school feeding. It combined developing a marketing strategy for local fishermen based on acknowledging the value of institutional competences for fostering local development; joining public and private institutions and beneficiaries at all levels to plan and be involved; training parties to adopt technologies, manage cooperative enterprises and assure food security. These actions allowed fishermen to be included in governmental procurement policies, and provided quality food (fish) to beneficiary audiences, such as public schools, nursing homes, rehabilitation centers and other institutions that work with vulnerable populations (Sousa et al., 2016).

Fisheries management

Still in order to address the demands of artisanal fishing, Embrapa Fisheries and Aquaculture conducted a study in the South of the state of Bahia, in the region of Valença, to assess the fishing dynamics, productivity and harvested species from the five main fishing methods adopted by the region's motorized fleet, according to the fishermen's perception. This survey served as input for actions to broaden the fishing communities knowledge on their reality and to empower them, so that they could play the main role in defining their aspirations and capacities and take part in different stages of designing sector policies (Silva, 2014).

Fish quality

In order to promote fishermen's access to markets, the product must also be qualified. Therefore, Embrapa Mid-North joined a project for industrializing mangrove crab, thus assuring higher income to catchers and better microbiological quality to the product, which is processed in an industry accredited with the Federal Inspection Service (SIF) seal in the state of Piauí. Still on crab quality, the Unit conducted an assessment of the nutritional composition and sensorial acceptance of crustacean collected in different locations of the APA of the Parnaíba River Delta; conclusions were that crab from sites with higher salinity (> 32) were tastier due to higher mineral content (Silva et al., 2014). The characteristics of crab breaking were evaluated in different places of Parnaíba and Ilha Grande, showing that it is a family activity, performed by both males and females, who earn less than the minimum wage on average; however, the products hygienic-sanitary conditions were within the standards required by Brazilian regulations (Silva et al., 2017).

Another important cause of reduced food quality is the presence of contaminants. Thus, in 2009, Embrapa Coastal Tablelands assessed the presence of methylmercury in zooplankton and phytoplankton and mercury in marine fish from the region of Cabo Frio, in the state of Rio de Janeiro. The highest Hg content was found in tuna muscle and the lowest in sardine. Methyl Hg levels increased according to the trophic levels studied (planktivorous to carnivores), while inorganic mercury (Hg) level was higher at the base of the trophic chain (phytoplankton) (Silva et al., 2009).

The same Embrapa Unit assessed the risk of consuming marine fish traded in Aracaju, Salvador and Maceió focusing on metal contents. Lead and cadmium levels found in the species investigated did not pose risks to consumers of the three cities based on estimates of the risk index used in this study. Zinc contents in all species were below the Tolerable Maximum Limit (TML) by Brazilian regulations. However, in amberjack, tuna, catfish, shark and *dourado*, the highest levels of arsenic were found, thus posing consumers at potential risk (Santos; Silva, 2015; Leite Junior; Silva, 2016).

In 2017, Embrapa Food Technology, in partnership with the Fundação Instituto de Pesca do Estado do Rio de Janeiro (Rio de Janeiro State Fisheries Foundation – Fiperj), assessed chemical contamination levels in fish from Sepetiba Bay, located in the state of Rio de Janeiro; it was focused on residues of organochlorine pesticides (OP), which have great impact because of its environmental persistence, bioaccumulation and high toxicity, and of inorganic contaminants that can occur at high concentrations in aquatic environment and have a high cumulative power in the biota due to intake of food already contaminated with metals or to minerals absorbed from water. Different species were assessed, such as sardines (*Cetengraulis edentulus*), cutlass fish (*Trichiurus lepturus*), mullet (*Mugil liza*), catfish (*Genidens genidens*), bluefish (*Pomatomus saltatrix*), leatherjacket fish (*Oligoplites saurus*) and shrimp (*Farfantepenaeus paulensis* and *Litopenaeus* sp.). Residues of the following were detected: delta-BHC in 77.74% of samples, heptachlor in 56.52% of samples and organochlorine in 71.7% of samples; dichloro-diphenyl-trichloro-ethane (DDT) and its metabolites (dichloro-diphenyl-ethene – DDD and dichloro-diphenyl-dichloro-ethane – DDE) were also found (Castro et al., 2017). Among inorganic contaminants monitored in this study, values for arsenic, lead and cadmium were above those permitted by Brazilian regulations. The following significant values were observed: 1209.04 mg/kg of iron, 2040.02 mg/kg of zinc and 989.95 mg/kg of aluminum and also 9233.58 ng/kg of nickel. This study revealed that the bay is already environmentally degraded due to the presence of contaminants in fish (Freitas et al., 2017).

Final considerations

These experiences reveal the importance of initiatives of Embrapa and other research, innovation, extension and education institutions to support and enhance the sustainable development of fisheries; they provided solutions that can be replicated in Brazil and abroad to promote the organization of the activity, management of harvesting areas, control of overfishing and improvement of product quality so that fishermen can access the consumer market, thus contributing to Brazil's social and economic development.

References

ALVES, R. R. N.; NISHIDA, A. K. A ecdise do caranguejo-uçá, *Ucides cordatus* L. (Decapoda, Brachyura) na visão dos caranguejeiros. **Interciência**, v. 27, n. 3, p. 110-117, 2002.

ALVES, R. R. N.; NISHIDA, A. K. Aspectos socioeconômicos e percepção ambiental dos catadores de caranguejo-uçá, *Ucides cordatus* (L. 1763) (Decapoda, Brachyura), no estuário do Rio Mamanguape, Nordeste do Brasil. **Interciência**, v. 28, n. 1, p. 36-43, 2003.

AMARAL, K. D. S.; VIEIRA, I. M.; OSÓRIO, F. M.; ROCHA, J. D. M.; LIMA, J. F. Bioecology of the crab *Ucides cordatus* (Crustacea, Decapoda) in mangroves influenced by the Amazon River, Brazil. **Acta Amazonica**, v. 44, n. 2, p. 213-222, 2014.

CASTRO, I. M.; ANJOS, M. R.; CALIXTO, F. A. A.; MACHADO, E. S.; CRUZ FILHO, A. G.; FREITAS, S. C. Determinação multirresíduo de agrotóxicos organoclorados em pescado de captura por CG-DCE. In: ENCONTRO NACIONAL, 20.; CONGRESSO LATINO AMERICANO DE ANALISTAS DE ALIMENTOS, 6., 2017, Belém, PA. **Segurança e qualidade de alimentos**. Belém, PA: LACEN: UFPA, 2017. 1 CD-ROM.

CHRISTOFOLETTI, R. A.; HATTORI, G. Y.; PINHEIRO, M. A. A. Food selection by a mangrove crab: temporal changes in fasted animals. **Hydrobiologia**, v. 702, n. 1, p. 63-72, 2013.

FAO. Fisheries and Aquaculture Department. **Fishery statistical collections**: global production. Available at: <http://www.fao.org/fishery/statistics/global-production/en>. Accessed on: Nov 11, 2017.

FOGAÇA, F. H. dos S.; ROCHA, F. M. R. da; SOUZA, L. I. de. (Org.). **Saberes para a proteção do extrativismo da Ilha Grande de Santa Isabel**. Parnaíba: SIEART, 2015. 48 p.

FREITAS, S. C. de; CONTE, C.; SILVA, T. dos S.; SIMAS, E. S.; CRUZ FILHO, A. G. da; CALIXTO, F. A. A. Avaliação de metais pesados em pescado da Baía de Sepetiba, Rio de Janeiro. In: ENCONTRO NACIONAL, 20.; CONGRESSO LATINO AMERICANO DE ANALISTAS DE ALIMENTOS, 6., 2017, Belém, PA. **Segurança e qualidade de alimentos**. Belém, PA: LACEN: UFPA, 2017. 1 CD-ROM.

FREITAS, S. T.; BARROS, R. F. M.; FOGAÇA, F. H. S.; LEGAT, J. F. A.; PAMPLIN, P. A. Z. Conhecimento tradicional das marisqueiras de Barra Grande, área de proteção ambiental do delta do Rio Parnaíba, Piauí, Brasil. **Ambiente & Sociedade**, v. 15, n. 2, p. 91-112, 2012. Available at: <http://www.scielo.br/pdf/asoc/v15n2/06.pdf>. Accessed on: Nov 12, 2017.

FREITAS, S. T.; FOGAÇA, F. H. S.; LEGAT, J. F. A.; BARROS, R. F. M.; PAMPLIN, P. A. Z. Análise morfométrica das conchas e rendimento da carne de *Anomalocardia brasiliana* no estuário adjacente da Praia de Barra Grande, Cajueiro da Praia, PI. In: CONGRESSO BRASILEIRO DE OCEANOGRAFIA, 3., 2010, Rio Grande. **Anais**... Rio Grande: Associação Brasileira de Oceanografia, 2010. p. 02404-02406.

HAIMOVICI, M. (Org.). **Sistemas pesqueiros marinhos e estuarinos do Brasil**: caracterização e análise da sustentabilidade. Rio Grande: Ed. FURG, 2011. 104 p.

HAIMOVICI, M.; LEITE, T. S.; MARINHO, R. A.; BATISTA, B.; MADRID, R. M.; OLIVEIRA, J. E. L.; LIMA, F. D.; CANDICE, L. As pescarias de polvos do Nordeste do Brasil. In: HAIMOVICI, M.; ANDRIGUETTO FILHO, J. M.; SUNYE, P. S. (Org.). **A pesca marinha e estuarina no Brasil**: estudos de caso multidisciplinares. Rio Grande: Ed. FURG, 2014. p. 147-159.

LEGAT, J. F. A.; LEGAT, A. P.; PEREIRA, A. M. L.; FOGACA, F. H. dos S.; COLIN, F. N. Levantamento das principais espécies de moluscos bivalves capturadas no Estado do Piauí. In: CONGRESSO BRASILEIRO DE OCEANOGRAFIA, 3., 2010, Rio Grande. **Anais**... Rio Grande: Associação Brasileira de Oceanografia, 2010. p. 00876-00878.

LEGAT, J. F. A.; PUCHNICK, A. L. Sustentabilidade da pesca do caranguejo-uça, *Ucides cordatus* na área de proteção ambiental do Delta do Rio Parnaíba. In: XIMENES, L. J. F. (Org.). **Ciência e tecnologia para aquicultura e pesca no Nordeste**. Fortaleza: Banco do Nordeste do Brasil, 2011. v. 8, p. 167-192.

LEITE JUNIOR, F. de S.; SILVA, C. A. Avaliação do risco de consumo de peixes marinhos comercializados em Aracaju, Salvador e Maceió com foco nos teores de metais pesados. In: SEMINÁRIO DE INICIAÇÃO CIENTÍFICA E PÓS-GRADUAÇÃO DA EMBRAPA TABULEIROS COSTEIROS, 6., 2016, Aracaju. **Anais**... Aracaju: Embrapa Tabuleiros Costeiros, 2016. p. 51. Available at: <http://ainfo.cnptia.embrapa.br/digital/bitstream/item/147695/1/Avaliacao-do-risco.pdf>. Accessed on: Dec 11, 2017.

LIMA, A.; PRYSTHON, A.; ROSA, D. K.; LUIZ, D. de B.; SOUSA, D.; ROUTLEDGE, E. A. B.; MATAVELI, M.; UMMUS, M.; CRUVINEL, P.; BARROSO, R.; MATTOS, S. M. G. de; SOARES, S. **Relatório técnico do Seminário Nacional de Prospecção de Demandas da Cadeia Produtiva da Pesca PROSPESQUE**. Brasília, DF: Embrapa, 2012. 88 p. Available at: <http://ainfo.cnptia.embrapa.br/digital/bitstream/item/122526/1/CNPASA-2012.pdf>. Accessed on: Nov 11, 2017.

MAI, A. C. G.; SILVA, T. F. A.; LEGAT, J. F. A. Assessment of the Fish-weir fishery of the coast of Piauí State, Brazil. **Arquivos de Ciências do Mar**, v. 45, n. 2, p. 40-48, 2012.

NASCIMENTO, D. M.; ALVES, R. R. N.; BARBOZA, R. R. D.; SCHMIDT, A. J.; DIELE, K.; MOURÃO, J. S. Commercial relationships between intermediaries and harvesters of the mangrove crab *Ucides cordatus* (Linnaeus, 1763) in the Mamanguape River estuary, Brazil, and their socio-ecological implications. **Ecological Economics**, v. 131, p. 44-51, Jan 2017.

NASCIMENTO, D. M.; FERREIRA, E. M.; BEZERRA, D. M. M. S. Q.; ROCHA, P. D.; ALVES, R. R. N.; MOURÃO, J. S. Capture techniques' use of *caranguejo-uçá* crabs (*Ucides cordatus*) in Paraíba state (northeastern Brazil) and its socio-environmental implications. **Anais da Academia Brasileira de Ciências**, v. 84, n. 4, p. 1051-1064, 2012. Available at: <http://www.scielo.br/pdf/aabc/v84n4/aop8112.pdf>. Accessed on: Nov 12, 2017.

PEREIRA, A. M. L.; ROCHA, F. M. R. (Org.). **A pesca no estuário do Timonha e Ubatuba**. Parnaíba: Sieart, 2015. 100 p.

REBELATTO JUNIOR, I. A.; FLORES, R. M. V.; LIMA, A. F.; PRYSTHON, A.; ROSA, D. K.; PINHO, M. S. de; SOARES, S. S. Diagnóstico estratégico de instituições ofertantes e demandantes de tecnologias em pesca e aquicultura – Projeto Aquapesquisa. In: CONGRESSO BRASILEIRO DE ENGENHARIA DE PESCA, 18., 2013, Paulo Afonso. [**Anais**...]. Paulo Afonso: Ed. Uneb, 2013. Available at: <http://ainfo.cnptia.embrapa.br/digital/bitstream/item/166683/1/CNPASA-2013-conbep.pdf>. Accessed on: Oct 5, 2017.

REBELATTO JUNIOR, I. A.; FLORES, R. M. V.; LIMA, A. F.; SILVA, A. P.; ROSA, D. K.; PINHO, M. S.; SOARES, S. S. Strategic diagnosis of institutions suppliers and demanders of technology in fisheries and aquaculture. **Brazilian Journal of Aquatic Science and Technology**, v. 18, n. 2, p. NB5-NB8, 2014. Available at: <http://ainfo.cnptia.embrapa.br/digital/bitstream/item/120413/1/cnpasa-2014-bjast.pdf>. Accessed on: Dec 11, 2017.

SANTOS, L. C. M.; PINHEIRO, M. A. A.; DAHDOUH-GUEBAS, F.; BITENCOURT, M. D. Population status and fishery potential of the mangrove crab, *Ucides cordatus* (Linnaeus, 1763) in North-eastern Brazil. **Journal of the Marine Biological Association of the United Kingdom**, p. 1-11, Sept. 2016a. DOI: 10.1017/S0025315416001259.

SANTOS, R. V. dos; FOGAÇA, F. H. S.; PEREIRA, A. M. L.; MIZAEL, F. H.; RODRIGUES, L. A.; MAGALHÃES, J. A. Depuration of *Anomalocardia brasiliana* to increase the value of shellfish collected on the Piaui Coast, Brazil. In: IUFOST 2016: WORLD CONGRESS OF FOOD SCIENCE AND TECHNOLOGY, 18., 2016, Dublin. **Greening the global food supply chain**: through innovation in food science and technology: congress proceedings. [Dublin]: IFSTI, 2016b.

SANTOS, S. O.; SILVA, C. A. da. Determinação dos metais ferro e zinco em peixes marinhos comercializados em Aracaju, SE, Salvador, BA e Maceió, AL. In: SEMINÁRIO DE INICIAÇÃO CIENTÍFICA E PÓS-GRADUAÇÃO DA EMBRAPA TABULEIROS COSTEIROS, 5., 2015, Aracaju. **Anais**... Brasília, DF: Embrapa, 2015. p. 102-109. Available at: <http://ainfo.cnptia.embrapa.br/digital/bitstream/item/131750/1/Determinacao-dos-metais.pdf>. Accessed on: Nov 11, 2017.

SILVA, A. P. Pesca artesanal e empresas de petróleo: a abordagem participativa como proposta de desenvolvimento no Baixo-Sul da Bahia, Brasil. **Cadernos Gestão Social**, v. 5, n. 1, p. 13-29, 2014.

SILVA, C. A.; TESSIER, E.; SILVA-FILHO, E. V.; WASSERMAN, J. C. F. A. Biomagnificación del mercurio em la cadena pelágica marina de la región de surgencia de Cabo Frío, RJ, Brasil. In: SIMPÓSIO INTERNACIONAL DE CIÊNCIAS DEL MAR, 2., 2009, Vigo. **Resúmenes**... Vigo: Faculdade de Ciencias del Mar, 2009. p. 163-164.

SILVA, L. M. A.; DIAS, M. T. A pesca artesanal no Estado do Amapá: estado atual e desafios. **Boletim Técnico Científico do Cepnor**, v. 10, n. 1, p. 43-53, 2010.

SILVA, R. S.; MENDES, W.; MAI, M. G.; FOGAÇA, F. H. S.; PEREIRA, A. M. L.; MAGALHÃES, J. A.; COSTA, N. L. Caracterização do processamento artesanal da carne de caranguejo-uçá *Ucides cordatus* e perfil socioeconômico dos quebradores. **Pubvet**, v. 11, n. 6, p. 566-574, 2017.

SILVA, T. F. A.; FOGAÇA, F. H. S.; VIEIRA, S. G. A.; FERREIRA, I. A.; SANTOS FILHO, L. G. A.; MAGALHÃES, J. A.; LEGAT, J. F. A. Physicochemical and sensory quality attributes of the mangrove crab, *Ucides cordatus*, from the Parnaíba River's Delta Environmental Protection Area. **Arquivos de Ciências do Mar**, v. 47, n. 1, p. 102-109, 2014.

SOUSA, D. N.; ALMEIDA, H. C. G.; MILAGRES, C. S. F.; NIEDERLE, P. A. Transferência de tecnologia e estratégias de comercialização do pescado da agricultura familiar para a alimentação escolar: a experiência da Embrapa no Estado do Tocantins. In: CONGRESSO DA SOCIEDADE BRASILEIRA DE ECONOMIA, ADMINISTRAÇÃO E SOCIOLOGIA RURAL, 54., 2016, Maceió. **Desenvolvimento território e biodiversidade**. Maceió: Ed. UFAL, 2016.

UNITED NATIONS. **Goal 14**: Conserve and sustainably use the oceans, seas and marine resources. Available at: <http://www.un.org/sustainabledevelopment/oceans/>. Accessed on: Nov 20, 2017.