BENTHIC MACROFAUNA INVENTORY OF TWO SHIPWRECKS FROM PERNAMBUCO COAST, NORTHEASTERN OF BRAZIL

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ABSTRACT

The fauna that inhabits artificial reef environments such as shipwrecks is part of a biological community that cannot be neglected. This study aimed to uncover the benthic animal biodiversity of the Servemar X and Vapor de Baixo shipwrecks, located on the coast of Pernambuco State, Brazil, to reveal the importance of these artificial environments for hard substrata benthic fauna. They are sunk about 8.8 km from each other and settled on the sandy bottom at an average depth of 23 m. During the period of December 2005 to February 2007, the shipwrecks were visited to collect biological data. Organisms were identified with the aid of relevant bibliography (at a specific level when possible) or sent for identification by specialists when necessary. A total of 57 taxa were identified, of which 41 were found on Vapor de Baixo and 29 on Servemar X. The benthic macrofauna included eight phyla: Porifera (Demospongiae), Cnidaria (Hydrozoa and Anthozoa), Mollusca (Bivalvia and Gastropoda), Annelida (Polychaeta), Arthropoda (Cirripedia), Bryozoa (Cheilostomata), Echinodermata (Asteroidea and Echinoidea), and Chordata (Ascidiacea). Only 34.6% of the species were common to both shipwrecks. Biodiversity was considered compatible when compared with other shipwrecks located from the Brazilian coast and other locations. Regarding the species distribution in Brazil, eight new occurrences were recorded for Pernambuco: two reports for northward distribution expansion (*Obelia dichotoma* and *Celleporaria atlantica*), two southward (*Spondylus erinaceus* and *Didemnum duplicatum*), and another four species that closed their distributional hiatus in the Northeast Region (*Aetea sica, Hippaliosina imperfecta*, *Stylopoma informata* and *Trididemnum orbiculatum*). The shipwrecks that serve as artificial reefs in shallow waters of Pernambuco may contribute to the success of larvae that were previously being lost due to the scarcity of appropriate substrates on which to settle

Keywords: Artificial reefs, benthic invertebrates, biofouling, fauna inventory.

RESUMO

A fauna que habita os ambientes recifais artificiais, como os naufrágios, é uma parte da comunidade biológica que não pode ser negligenciada. Este estudo objetivou inventariar a fauna de macro-invertebrados sésseis e sedentários dos naufrágios Servemar X e Vapor de Baixo, localizados no Estado de Pernambuco, Brasil, visando informar as preferências desses animais em termos de nichos e associações biológicas nesses ambientes. Os respectivos naufrágios distam 8,8 km um do outro e estão assentados em fundo arenoso a uma profundidade média de 23 m. Durante o período de dezembro de 2005 a fevereiro de 2007, foram executados mergulhos autônomos para coleta de material biológico. Os organismos não identificados *in locu* foram retirados com o auxílio de espátula e martelo e acondicionados em sacos plásticos. Associações biológicas e distribuição espacial dos invertebrados foram anotadas e fotografadas. A identificação dos organismos foi realizada com o apoio de bibliografia relevante para cada grupo taxonômico e em nível de espécie, quando possível, ou por especialista. O número total de taxa foi 57, sendo que 41 espécies foram encontradas no Naufrágio Vapor de Baixo e 29 no Servemar X. A macrofauna bêntica se distribuiu em oito filos: Porifera (Demospongiae), Cnidaria (Hydrozoa e Anthozoa), Mollusca (Bivalvia e Gastropoda), Annelida (Polychaeta), Arthropoda (Cirripedia), Bryozoa (Cheilostomata), Echinodermata (Asteroidea e Echinoidea) e Chordata (Ascidiacea). Apenas 34,6% das espécies foram comuns a ambos os naufrágios. A quantidade de taxa registrada por filos nos naufrágios foi considerada compatível quando comparada com a de outros naufrágios localizados no litoral brasileiro e em outras localidades. Em relação à distribuição das espécies no litoral brasileiro, foram registradas oito novas ocorrências para o Estado de Pernambuco. Foram dois registros de expansão em direção Norte (*Obelia dichotoma* e *Celleporaria atlantica*), dois em direção Sul (*Spondylus erinaceus* e *Didemnum duplicatum*) e outras quatro preenchendo um hiato de sua distribuição na Região Nordeste (*Aetea sica, Hippaliosina imperfecta, Stylopoma informata* e *Tridemnum orbiculatum*). A presença de recifes artificiais representados por naufrágios em águas rasas do Estado de Pernambuco pode contribuir para o sucesso no assentamento das larvas que eram previamente perdidas devido à escassez de substratos apropriados.

Palavras-chave: *Biofouling,* inventário de fauna, invertebrados bênticos, recifes artificiais.

INTRODUCTION

Artificial reef environments are formed by submerged structures that have been accidentally or deliberately sunk in aquatic environments – especially marine ecosystems. During long periods of time, these structures receive layers of biomass from the forms of life around them, and are used for commercial and scientific research (Bastos, 2005). According to Miller (2002), these environments have also helped in environmental restoration processes. Cairns (1991), in turn, has classified ecological restoration into five types: restoration, preemptive restoration, rehabilitation, natural recovery, and enhancement. According to Pratt (1994), initiatives that attempt to establish artificial reefs may be classified as rehabilitation initiatives; this means that some of the ecological features of the already disturbed reef ecosystem are replaced. Enhancement, on the other hand, implies in the establishment of alternative ecosystems. In this case, reefs are built on soft bottoms or open water sites for recreational or commercial fishing purposes.

Several different structures have been used as artificial reefs, such as concrete blocks (Bombace *et al*., 1994; Clark & Edwards, 1994), tires, oil platforms (Bull & Kendall, 1994), submarines, planes, and shipwrecks (Zintzen *et al*., 2006). Similarly to natural reef environments, they provide substrate, shelter from predation and tidal currents, growth and food areas, nursery space, and recruitment habitats for individuals of the benthic fauna. Moreover, artificial reefs n also facilitate fish recruitment (Woodhead & Jacobson, 1985; Hixon & Beets, 1989; Wendt *et al*., 1989; Conceição *et al*.; 1997; Pickering *et al*., 1998; Scheffer, 2001; Boaventura *et al*., 2006; Zalmon & Gomes, 2003; Azevedo *et al*., 2006; Brotto *et al.*, 2006; Krohling *et al*., 2006; Almeida, 2007).

Recife, the capital of the state of Pernambuco, Brazil is known as the "Brazilian Shipwreck Capital". This title has been attributed not only for the amount of sunken ships, but also due to the easy access to these wrecks and the area's clear waters (Carvalho, 2010). Taking these characteristics into account, the so-called "shipwreck park" was created with the goal of expanding the market for underwater tourism in that region (Santos & Passavante, 2007; Santos *et al*., 2008). However, few studies have aimed to survey the macrozoobenthic organisms found in these shipwrecks, and most have not been published in scientific journals (Macêdo, 2001; Barradas *et al*., 2003; Amaral *et al*., 2004; Lira *et al*., *in press*).

Massin *et al.* (2002) point out that technical issues are the main reasons why this community is not studied more frequently. Yet the fauna that inhabits structures such as shipwrecks is part of a biological community that cannot be neglected (Zintzen *et al.,* 2006). Thus, this study aimed to qualitatively survey benthic macrofauna species that occur in shipwrecks Servemar X and Vapor de Baixo shipwrecks and inform their preferences in terms of ecological niches and biological associations on these submerged structures.

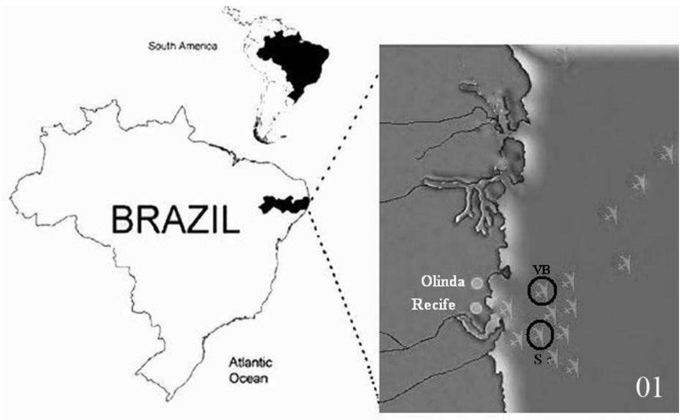
MATERIAL AND METHODS

The Servemar X shipwreck, sunk as scrap in January 2002, is located 7.5 miles (12.1 km) from the coast (08º07'19"S, 34º45'46"W), while the Vapor de Baixo (wrecked in 1850) is settled five miles (8.0 km) from the Port of Recife (08°03'28"S, 034°47'67"W) (Carvalho, 2010). They are distant about 8.8 km from each other (J. Calado, personal communication). The former has a 17.2 m long steel hull that it is in good shape regarding its integrity; the second, with an iron hull, is dismantled (Carvalho, 2010). Both of them are settled on the sandy bottom at an average depth of 23 m (Figure 1).

There are two seasons in the area: a dry season (September to February) and a rainy season (March to August). Average precipitation is high (approximately 2.500 mm/year). Water temperature varies from 25ºC to 32º, while salinity ranges from 36.4 to 37, respectively, in the rainy and dry months; water transparency reaches 23 m in depth (Gomes *et al.,* 1998).

During the period of December 2005 to February 2007, 29 incursions were undertaken to collect animals and carry out observations on ecological niches and biological associations, using scuba equipment. Species' spatial distribution and abundance in the different habitats (subjected to direct/indirect light, sedimentation and hydrodynamism) were considered. Initially, species were observed and photographed and, when possible, identified *in locu* (some corals and echinoderms). The remaining organisms were collected (taking only a few samples per morphospecies to minimize environmental impact) and stored in plastic bags. For each sampling two or three researchers dived for an average of 25 minutes.

In the lab, the organisms were fixed in 10% formaldehyde or 70% alcohol, following specifications for each taxonomic group. The material was later sorted and classified into functional groups. Organism identification was performed with the aid of relevant bibliography for each taxonomic group and at a specific level when possible, or sent for identification by specialists when necessary. Some biological associations were recorded while sorting and identifying species.



gure 1. Map of shipwreck locations on the coast of Pernambuco, Brazil, with indications for the Servemar X (S) and Vapor de Baixo (VB) shipwrecks. Source: Carvalho (2010).

Table I. Invertebrates found in the Servemar X (S) and Vapor de Baixo (VP) shipwrecks between December 2005 to February 2007 and their geographical distribution as reported in the literature. (#)= new occurrence to Pernambuco State.

TAXON	S	VB	DISTRIBUTION
Porifera			
Aplysina fulva (Pallas, 1766)		X	W Atlantic, Brazil: ASPSP, FN, AP to SC
Chondrilla nucula Schmidt, 1862		X	Cosmopolitan, Brazil: RO, FN, AP to SC
Cliona cf. *delitrix*		X	
Desmapsamma anchorata (Carter, 1882)	X	X	Widespread, Brazil: RN to RJ
Dysidea sp.		X	
Hyattella sp.		X	
Ircinia strobilina (Lamarck, 1816)		X	W Atlantic, Brazil: RO, FN, AP to ES
Monanchora arbuscula (Duchassaing & Michelotti, 1864)	X	X	W Atlantic, Brazil: FN, AP to SC
Mycale microsigmatosa (Arndt, 1927)		X	Widespread, Brazil: PE to SC
Cnidaria			
Carijoa riisei (Duchassaing & Michelotti, 1860)	X	X	Cosmopolitan, Brazil: ASPSP, MA to SC
Halopteris sp.		X	Cosmopolitan, Brazil: PE to SP
Macrorhynchia philippina Kirchenpauer, 1872		X	Cosmopolitan, Brazil: PE to SP
Obelia dichotoma (Linnaeus, 1758)	X	X	Cosmopolitan, Brazil: PE (#), BA to RS
Sertularella diaphana (Allman, 1885)		X	Cosmopolitan, Brazil: FN, PE to BA
Siderastrea stellata Verrill, 1868		X	Endemic to Brazil: RO, FN, MA to RJ
Sertularia rugosissima Thornely, 1904		X	Cosmopolitan, Brazil: PE to SC
Mollusca			
Acrosterigma magnum (Linnaeus, 1758)		X	W Atlantic, Brazil: RO, FN, PA to PE
Arca imbricata Bruguière, 1789		X	Cosmopolitan, Brazil: RO, FN, PA to SC
Chama macerophylla Gmelin, 1791	X	X	Cosmopolitan, Brazil: RO, FN, AP to SC

Chama sinuosa Broderip, 1835	X		W Atlantic, Brazil: RO, FN, PA to RJ
Codakia orbicularis (Linnaeus, 1758)		X	W Atlantic, Brazil: ASPSP, RO, FN, CE to SC
Macrocypraea zebra (Linnaeus, 1758)		X	W Atlantic, Brazil: RN to SC
Musculus lateralis (Say, 1822)	X		W Atlantic, Brazil: CE to SC
Spondylus erinaceus Reeve,1856	X	X	W Atlantic, Brazil: CE, PE (#)
Spondylus ictericus Reeve, 1856	X		W Atlantic, Brazil: FN, PE to SC
Strombus sp.		X	
Tellina sp.		X	
unidentified Gastropoda	X		
Polychaeta			
unidentified Eunicidae	X		
unidentified Maldanidae	X		
unidentified Nereidae	X		
unidentified Sabellidae	X	X	
unidentified Serpulidae	X	X	
unidentified Syllidae	X		
Spirobranchus sp.	X	X	
Cirripedia			
Balanus trigonus Darwin, 1854	X	X	Cosmopolitan, Brazil: AP to RS
Newmanella radiata (Bruguière, 1789)	X	X	W Atlantic, Brazil: PE to SC
Bryozoa			
Aetea sica (Couch, 1844)	X	X	Cosmopolitan, Brazil: FN, RN, PE (#), AL to SP
Bugula cf. *minima*	X		
Celleporaria atlantica (Busk, 1884)	X		Endemic to Brazil: PE (#), AL to ES
Hippaliosina imperfecta (Canu & Bassler, 1928)		X	Endemic to Brazil: RO, PE (#), BA to ES
Steginoporella magnilabris (Busk, 1854)	X		Cosmopolitan, Brazil: CE to RJ

Stylopoma informata (Lonsdale, 1845)		X	Cosmopolitan, Brazil: CE, PE (#); SP
Trypostega striatula (Smitt, 1873)		X	Cosmopolitan, Brazil: PE to PR
Echinodermata			
Astropecten sp.	X	X	
Diadema antillarum Philippi, 1845	X	X	Amphi-Atlantic, Brazil: PE to SP
Linckia sp.	X	X	
Lytechinus variegatus (Lamarck, 1816)	X		W Atlantic, Brazil: PE to SC
Ascidiacea			
Aplidium lobatum Savigny, 1816		X	W Atlantic, Indian, Brazil: CE to BA
Botryllus sp.	X		
Didemnum sp.	X	X	
Didemnum duplicatum Monniot, 1983	X	X	W Atlantic, Brazil: PB, PE (#)
Diplosoma listerianum (Milne-Edwards, 1841)	X	X	Cosmopolitan, Brazil: RN to SC
Eudistoma sp.	X		
Microcosmus exasperatus Heller, 1878	X	X	Cosmopolitan, Brazil: FN, RN to SC
Phallusia nigra Savigny, 1816		X	Cosmopolitan, Brazil: PE to SP
Polycarpa spongiabilis (Traustedt, 1883)	X		W Atlantic, Brazil: AP to SC
Symplegma brakenhielmi (Michaelsen, 1904)	X		Cosmopolitan, Brazil: PB to SC
Trididemnum orbiculatum (Van Name, 1902)	X	X	Cosmopolitan, Brazil: CE, PE (#), AL to SC

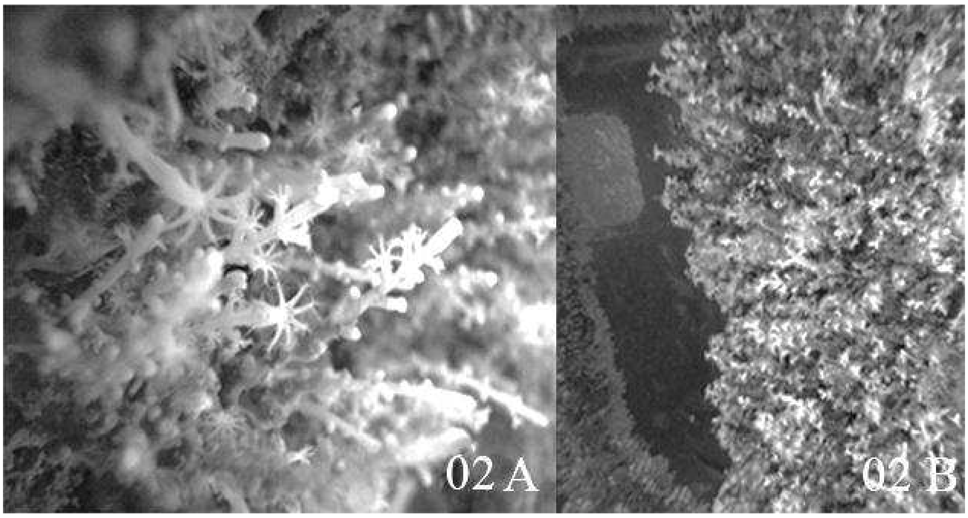


Figure 2. The octocoral *Carijoa riisei*. A) Close in its polyps in the Vapor de Baixo Shipwreck. B) Associated with encrusting sponge in the Servemar X Shipwreck. Photo by Simone Albuquerque Lira.

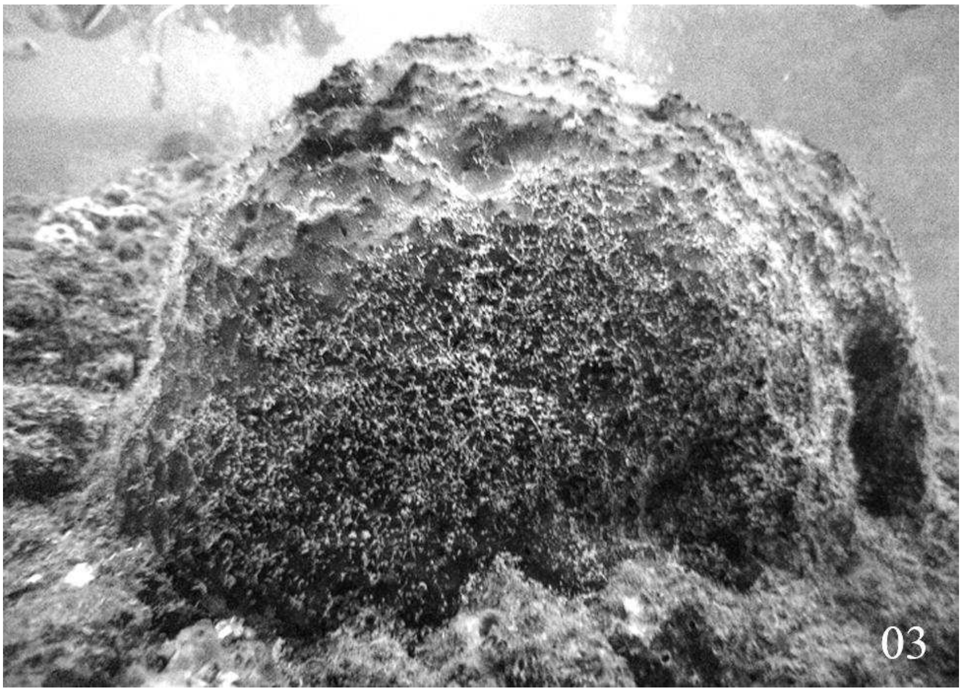


Figure 3. The sponge *Ircinia strobilina* on the Vapor de Baixo Shipwreck, in June 2009. Photo by Simone Albuquerque Lira.

RESULTS

A total of 57 taxa were identified, of which 41 species were found on the Vapor de Baixo and 29 on the Servemar X shipwrecks. Benthic macrofauna included eight phyla: Porifera (Demospongiae), Cnidaria (Hydrozoa and Anthozoa), Mollusca (Bivalvia and Gastropoda), Annelida (Polychaeta), Arthropoda (Cirripedia), Bryozoa (Cheilostomata), Echinodermata (Asteroidea and Echinoidea), and Chordata (Ascidiacea). Only 34.6% of the species were common to both shipwrecks (Table I).

Regarding the species found in both shipwrecks, the octocoral *Carijoa riisei* was the common feature of these two samples (Figure 2). For Servemar X, it was the main species in terms of surface cover (Figure 2B) and was found in several areas, especially on the propeller and areas less exposed to light and sedimentation; it was also found on the Vapor de Baixo paddlewheel. The erect colonies, which can reach 10–20 cm in length, create a third dimension on the shipwreck surface (Figure 2A). Frequently found associated with this octocoral species are two encrusting sponges – *Desmapsamma anchorata* and *Monanchora arbuscula* – observed as epibiont organisms. At the Vapor de Baixo shipwreck Porifera was the main group in terms of number of species and space occupation, and seven other species were found: *Aplysina fulva, Chondrilla nucula, Cliona* cf. *delitrix* (Figure 4), *Dysidea* sp., *Hyattella* sp., *Ircinia strobilina* (Figure 3), and *Mycale microsigmatosa.*

Another species common to both shipwrecks was the bushy wine-glass hydroid *Obelia dichotoma*, which was found settled on most surfaces. Additionally, four other hydroid species were found in the Vapor de Baixo shipwreck: *Halopteris* sp., *Macrorhynchia philippina, Sertularella diaphana*, and *Sertularia rugosissima*; all were widely distributed, often associated with other animals over the shipwreck's hull and preferably on the paddlewheel and near the sea floor.

The zooxanthellate massive coral *Siderastrea stellata* Verrill, 1868 was found in continuous extensions all over the Vapor de Baixo hull; some of its encrusting and hemispherical colonies were bleached. The perforating sponge *Cliona* cf. *delitrix* was observed living inside colonies of this coral species (Figure 4), as well as the Christmas tree worm *Spirobranchus* sp. This last species (Figure 5) and some other sessile polychaetes Sabellidae and Serpulidae were found on the hard substrata of both shipwrecks, but were not identified. Other polychaetes (Eunicidae, Maldanidae, Nereidae, and Syllidae) were also found on the Servemar X.

Apart from these species, oysters, barnacles, byozoans, and ascidians were also common as epifauna on these shipwrecks. Among the sessile bivalves found, the species *Spondylus erinaceus* was the post conspicuous on both wrecks. Specimens were usually set on the sides of the hull, supporting arborescent bryozoans and hydroids in their valves. *Chama macerophylla* was also common to both sites. Two other sessile/sedentary bivalve species were found in the Vapor de Baixo wreck: the leafy jewel box *Chama sinuosa* and the mossy ark *Arca imbricata,* settled by cementing the basis and bissus, respectively. Three endopsammic species were found solely on this shipwreck: *Codakia orbicularis*, *Tellina* sp., *Acrosterigma magnum*, commonly noted in crevices of the hull and amongst oyster and barnacle shells. *Musculus lateralis* and *Spondylus ictericus* were found only on Servemar X.

Two barnacle species were recorded for both sites: *Balanus trigonus* (the commonest species) and *Newmanella radiata*. Encrusting bryozoans were found over some bare areas of the wrecks and covering bivalve and barnacle shells. Three were identified at the Vapor de Baixo (*Hippaliosina imperfecta, Stylopoma informata*, and *Trypostega striatula*) and three on Servemar X (*Bugula* cf. *minima, Celleporaria atlantica* and *Steginoporella* magnilabris). Only the stonate bryozoan *Aetea sica* was identified on (a)biogenic substrata of both wrecks. Colonies of the ascidians *Didemnum duplicatum*, *Didemnum* sp., *Diplosoma listerianum, Trididemnum orbiculatum*, and the solitary species *Microcosmus exasperatus* were recorded for both shipwrecks. *Aplidium lobatum* and *Phallusia nigra* were unique to the Vapor de Baixo shipwreck and *Botryllus* sp., *Eudistoma* sp., *Polycarpa spongiabilis* and *Symplegma brakenhielmi* were unique to the Servemar X.

Regarding the sedentary fauna, two gastropods were identified from the Vapor de Baixo shipwreck: the measled cowrie *Macrocypraea zebra* and the large conch *Strombus* sp. Four echinoderm species were recorded on and under the nearest sediments: the starfish *Linckia* sp. and *Astropecten* sp. and the long-spined sea urchin *Diadema antillarum antillarum* were observed at both wrecks, while *Lytechinus variegatus* was unique to the Servemar X.

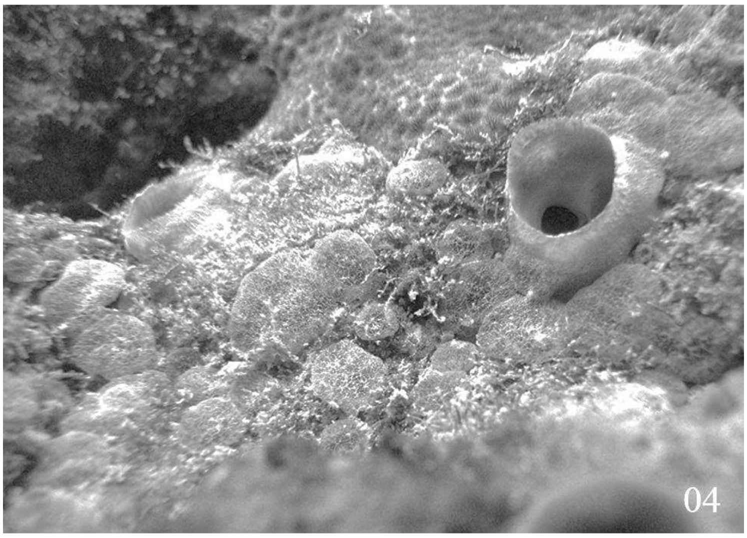


Figure 4. Sponge *Cliona* cf. *delitrix* and coral *Siderastrea stellata* on the Vapor de Baixo Shipwreck in June 2009. Photo by Simone Albuquerque Lira.

Figure 5. The polychaete *Spirobranchus* sp. on the hard substrate. Photo by Ralf Cordeiro.

DISCUSSION

The biodiversity of the investigated shipwrecks includes 57 taxa – a number compatible with what has been found for shipwrecks located on the Brazilian coast and other locations. For example, the Pirapama shipwreck (1.6 km from the Vapor de Baixo and about 8.3 km from the Servemar X, also 23 m deep, but sunk 120 years ago) presented 65 species (Lira *et al*., *in press*). Also in Brazil, Guaitolini & Ghisolfi (2007) found 50 species of invertebrates at the Victory 8B Shipwreck, sunk in 2003 in an average depth of 32 m, off the coast of Espírito Santo State (Southeast region). Regarding the fouling community of shipwrecks in temperate climates, Wendt *et al*. (1989) investigated five sunken ships in South Carolina and Georgia (USA) (22-31 m deep, 3.5 to 10 years old) and reported a total of 93 species for all of the wrecks. Genzano *et al.* (2007), however, only recorded 11 species of macrobenthic fauna for the James Clunies wreck in Mar del Plata, Argentina (10 m deep, 50 years old). Zintzen *et al.* (2006), in turn, identified 121 species on two shipwrecks off the Belgian coast, located 16 and 42 m deep and that had gone down 10 years earlier.

The habit of the commonest sessile species of both wrecks, the snowflake coral *Carijoa riisei*, which was found in areas less exposed to light and to sedimentation, is well documented in the literature (Laborel, 1969; Rees, 1972; DeFelice *et al.,* 2001; Kelmo *et al.,* 2003). Kahng & Grigg (2005) reported this species in Hawaii on shaded, hard substrata, subjected to moderate current flows, and less than 40 m deep. These authors suggested that this adaptation occurs because the species lacks zooxanthellae and is skiophilous (shade loving). According to Bayer (1961), in fouling communities it grows in dense clusters, in an arborescent colonial manner, and is thus an ideal structure for epibiont association; this fact has also been verified by Neves *et al.* (2007) in shallow natural reefs of Pernambuco.

The association observed among *C. riisei* and the sponges *Desmapsamma anchorata* and *Monanchora arbuscula* has also been observed by Mothes *et al.* (2003) and Cerrano *et al.* (2006). Calcinai *et al.* (2004) had considered this relationship as a symbiotic association, with the two partners supporting each other by giving rise to a more rigid structure: the sponge growing vertically, stressing its own growth strategies and therefore avoiding competition for space, and in return, its cover protecting the octocoral from predation.

The spatial occupation of shipwreck surfaces by sponges is a common fact in natural (Diaz & Rützler, 2001; Cedro *et al*., 2007) and artificial reefs (Perkol-Finkel & Benayahu, 2005; present study). Sponges are generally slow to recruit in new habitats because they have very specific requirements for substrate quality, food particles, light, and current regime (Carballo *et al*., 1996). They can be slow growing, long-living species, which appear more frequently during the later stages of community succession (Bailey-Brock 1989; Boaventura *et al*., 2006). However, once established, sponges can dominate both artificial and natural reefs (Walker *et al.*, 2007).

The fact that hydroids were the third most common type of benthic fauna in the spatial occupation of hard substrata was expected. Wendt *et al.* (1989), while studying five shipwrecks sunk 22-31 m deep in the South Atlantic Bight (South Carolina to Georgia) noted that hydroids comprised the greatest percentage of species. Zintzen *et al.* (2006) found that the hydrozoan *Tubularia indivisa* Linnaeus, 1758 constituted one of the two main communities of two shipwrecks off the Belgian Coast. In the examined shipwrecks *Obelia dichotoma* was found at both sites; it is an euribiotic species, which grows on man-made hard substrates, thalloid algae, seagrasses, sponges, crustaceans, swimming vertebrates, and seagrass (Cornelius, 1982; Galea *et al.,* 2007).

Regarding the fact that only one species of coral – *Siderastrea stellata* – was found (and in only one of the wrecks, the Vapor de Baixo) it is interesting to note that Lira *et al*. (*in press*) mentioned five coral species for the Pirapama shipwreck. Despite the similarity between these two sites (the same abiotic conditions and the same type of substrate, an iron hull) and the short distance between them, other information may be uncovered in future studies to explain the presence or absence of these coral species in such environments. A possible interfering variable may be the rate of sediment accumulation, which influences coral recruitment, development, and growth (Bachtiar, 2000; Dutra *et al.,* 2006). Although there is no quantitative abiotic data for the Vapor de Baixo, it might have higher rates of sedimentation due to its closeness to river mouths of Recife and Olinda, which flow into the Port of Recife.

A fact worth noting is that *S. stellata* is the toughest among all coral species of Pernambuco. According to Laborel (1969) and Mayal *et al*. (2002), it is extremely tolerant to adverse conditions, including excessive local sediment input. Corroborating this assertion, Farrapeira *et al.* (2009) found *S. stellata* in the mouth of a high salinity estuary in Pernambuco. The absence of some species of corals at the Servemar X can be explained by its age. According to Fitzhardinge & Bailey-Brock (1989), corals are inconspicuous on newly immersed substrata when compared to algae and other organisms. Moreover, newly settled corals are extremely vulnerable due to many factors, including grazing fish and urchins, overgrowth and shading by faster growing organisms, and sedimentation.

The presence of the boring sponge *Cliona* cf. *delitrix* (Pang, 1973) living in association with the massive starlet coral *Siderastrea stellata* deserves to be emphasized. Species of the genus *Cliona* are known for their ability to bore limestone and also the shells of living or dead oysters or other calcareous object. Clionid sponges excavate their galleries by chemically etching away tiny chips of shells (Ruppert & Fox, 1988). The species *C. delitrix*, for example, is considered responsible for the death of *Montastraea annularis* colonies in Cuba (Bruckner & Bruckner, 2006).

The association with common epifaunal organisms that colonize the wrecks may justify the occurrence of some taxa. An example is the presence of several *Spirobranchus* sp. in coral and other hard substrata crevices. The species of this genus are obligate associates of corals (Bailey-Brock, 1976; Kupriyanova *et al.,* 2001), but are also found associated to the blacklipped pearl oyster *Pinctada imbricata* Röding, 1798 (Díaz & Liñero-Arana, 2003). According to Glasby *et al*. (2000), *Siprobranchus* species is more of an associate to corals than a borer: after the larvae has settled on the coral, it secretes a fine calcareous tube and stimulates the coral to grow around it; as the coral grows, the worm continually secretes its tube to ensure the tube opening is kept clear of coral skeleton.

Commensalism also explains the presence of the mussel *Musculus lateralis* in the shipwrecks samples. This bivalve usually lives attached to ascidians, in the crevices of zooid colonies (Bertrand, 1971; Rios, 2009) and associated to sponges (Duarte & Nalesso, 1996). However, Culter & Truitt (1997), also found this species on artificial reef constructions (floating reef modules) in a soft-bottom region of Florida.

Several species found in shipwrecks have also been recorded for other artificial reef environments, following the definition of Perkol-Finkel & Benayahu (2004), which also includes structures like oil jetties and gas platforms. The sponges *Chondrilla nucula* encrusted artificial reefs in Florida (Cummings, 1994); *Desmapsamma anchorata* is common on pilings, rocks and on corals offshore (Hechtel, 1965), and *Ircinia strobilina* was from a sunken iron ship, 12.5 m in Atlantic Panama (Little Jr, 1963). All of them were mentioned by Lira *et al.* (*in press*) for the Pirapama shipwreck. Regarding the cnidarians, the hydroids *Macrorhynchia philippina* and *Sertularella diaphana* were found on the Pirapama shipwreck (Macêdo, 2001; Lira *et al.*, *in press*), and *Obelia dichotoma* is very common in dock areas and on pilings (Millard, 1975), jetties (Deevey Jr., 1950), oil platforms (Lewbel *et al*., 1987), and shipwrecks (Wendt *et al*., 1989). The snowflake octocoral *Carijoa riisei* is usually part of the fouling community of harbors, pier pilings and wrecks (DeFelice *et al*., 2001). In Brazil it has been found on the Pirapama wreck, 23 m deep (Lira *et al.*, *in press*), and on Victory 8B, off the coast of Espírito Santo, standing at an average depth of 32 m (Almeida, 2007). This species is also found abundantly on oil rigs and artificial reefs of the Gulf of Mexico (Bull & Kendall, 1994; Cummings, 1994).

Other common specimens of shallow artificial reefs are the bivalves and barnacles. From the reported fauna, two jewel box bivalves have also been mentioned on this kind of hard substrata: *Chama macerophylla*, common on rock, reefs, wrecks, and sea walls, from shallow waters to 525 m deep (Wendt *et al*., 1989; Campbell *et al.,* 2004); and *Chama sinuosa*, found on the Pirapama shipwreck (Macêdo, 2001; Lira *et al.* (*in press*). *Balanus trigonus* and *Newmanella radiata* can be highlighted among the barnacles. *B. trigonus* is a common fouling species that occupies a variety of biogenic and abiogenic substrates, including artificial reefs located 20 m deep in New Zealand (Russell, 1975), a stationary oil platform 38 m deep (Yan *et al.*, 2006), shipwrecks from the South Atlantic Bight 22-31 m deep (Wendt *et al*., 1989), the Adriatic Sea (10-34 m) (Ponti *et al*., 2002), and the Pernambuco coast (23 m deep) (Lira *et al.*, *in press*). *N. radiata* is commonest on concrete pilings, beachrocks, fences, and (rarely) on mangroves (Southward, 1975), but has also been found on the exposed hull of a wrecked ship 15 m below the surface, in the Gulf of Mexico (Ross, 1969), as well as on the Pirapama wreck Lira *et al.*, *in press*).

The bryozoans and ascidians are also important components of the fouling community of shipwrecks. Regarding the list of species found here, the bryozoans *Steginoporella magnilabris* deserves to be mentioned. It is common on piles, shells, sponges, and corals, in shallow waters up to 25 m deep (Orburn, 1914); yet, Lira *et al.* (*in press*) found numerous colonies of this species on the Pirapama shipwrecks. The same occurred for *Trypostega striatula*. In relation to the ascidians, four species have been recorded frequently on artificial reefs. *Diplosoma listerianum* colonizes multiple habitats including fouling and benthic communities in vertical and lower horizontal surfaces of natural and artificial substrata; it is frequently found filling the interstices between larger elements of the community (Relini *et al.*, 1998; Goodbody, 2003; Breves-Ramos *et al.*, 2005; Dijkstra *et al.,* 2007). *Microcosmus exasperatus* grows on piers, pilings and less often attached to shell fragments or other hard substrates on the sea floor (Goodbody, 2003), but has been recorded for two shipwrecks: in Pernambuco Lira *et al.* (*in press*) and in Brisbane, Australia (Walker *et al*., 2007). *Phallusia nigra* is abundant in harbor and lagoon areas, attached to mangrove roots, piers, pilings, buoys and ship bottoms from the surface to about 35 m deep (Goodbody, 1962).

Regarding the distributional status of the cited species, two had its distribution extended northward to Pernambuco: the bushy wine-glass hydroid *Obelia dichotoma*, with previous records from the states of Bahia (Kelmo & Attrill, 2003) and Rio Grande do Sul (Migotto *et al*., 2002); and the bryozoan *Celleporaria atlantica*, which has been described for Bahia by Busk (1884) and is endemic to Brazil, with distribution from the states of Alagoas to Espírito Santo (Vieira *et al*., 2008). The thorny oyster *Spondylus erinaceus* and the paintbrush tunicate *Didemnum duplicatum* had its distribution extended southward to Pernambuco. *S. erinaceus* had been previously recorded for the state of Ceará (Rios, 2009), and the *D. duplicatum* species to Paraíba (Gama *et al*., 2006). Lastly, the finding of four other species in Pernambuco closed their distributional hiatus for the Northeast region. It was also the case of the bryozoans *Aetea sica, Hippaliosina imperfecta*, and *Stylopoma informata* (Vieira *et al*., 2008), and the compound ascidian *Trididemnum orbiculatum* (Lotufo, 2002).

Three species deserve to be highlighted from the entire group in relation to dispersal processes, as their planktonic stages are inexistent or short. Of the hydroid species mentioned above, the most interesting case is that of *M. philippina*. It is a circumglobal hydroid of tropical and subtropical waters (Millard, 1975); nevertheless, it does not have free-swimming medusa stages, so its dispersal must have occurred in the form of hydroids settled on ship hulls (Morri *et al.,* 2009). This study reports another possible way that this species spread. In this case, it is using artificial reefs to expand its distribution in shallow waters, as it had been cited for first time in Pernambuco by Calder & Mayal (1998). A similar event was observed by Fenner (2001) regarding the expanded distribution of the Indo-Pacific orange sun coral *Tubastrea coccinea* Lesson, 1829 in Gulf of Mexico. This species was found on reefs, inside the fuselages of airplane wrecks, on shipwrecks and on pier pilings.

A similar process occurs for most ascidians, which benthic adults also use vessels as a passive means of transportation; they have lecithotrophic larvae (which feed on their own nutrient reserves and do not remain in the plankton for a long period of time) and limited dispersal ability (Lambert, 2005). Two species exemplifies this: *Diplosoma listerianum* and *Phallusia nigra.* In the case of *Diplosoma listerianum,* like other colonial ascidians, the larvae are brooded and released only when competent to settle (Lambert, 2002). The free-swimming periods of the larvae last 2-6 h (Van Duyl *et al.,* 1981). Although having the ability to attach tenaciously to substrates, the tunic is flaccid and tears easily. If even a small bit adheres to any organisms that are being transported, it can rapidly colonize a new substrate, even if it is already in reproductive mode. The period between fertilization and settlement for the black sea squirt *P. nigra*, for instance, is as short as twelve hours (Goodbody & Fischer, 1974).

The presence of artificial reefs – in this case, shipwrecks – in shallow waters of Pernambuco may contribute to the success of larvae settlement that were previously being lost due to the scarcity of appropriate substrates. These structures provide attachment sites and microhabitats for a range of species typically not found in the surrounding soft sediments. Similar observations have also been made by Zintzen *et al.* (2006) while studying the epifaunal community associated with two shipwrecks in the Belgian continental shelf. These preliminary results show possible spots of the species richness for the sessile and slow moving epifauna of Pernambuco. The two sites investigated show striking differences in terms of species assemblage, yet more intensive sampling is needed in order to discern ecological patterns.

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