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PEDRO BASTOS DE MACÊDO CARNEIRO

ESCALAS ESPACIAIS E BIODIVERSIDADE DE ORGANISMOS BENTÔNICOS NO ATLÂNTICO SUDOESTE

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Tese apresentada ao Curso de Doutorado em Ciências Marinhas Tropicais do Instituto de Ciências do Mar da Universidade Federal do Ceará, como parte dos requisitos para obtenção do título de Doutor em Ciências Marinhas Tropicais. Área de concentração: Utilização e Manejo de Ecossistemas Marinhos e Estuarinos.

Orientador: Prof. Dr. Tito Monteiro da Cruz Lotufo

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Aprovada em: _____/_____/_____

BANCA EXAMINADORA

Prof. Dr. Tito Monteiro da Cruz Lotufo (Orientador)
Universidade de São Paulo (USP)

Prof. Dr. Paulo Antunes Horta Junior
Universidade Federal de Santa Catarina (UFSC)

Prof. Dr. Sergio Rossi
Università del Salento (UNISALENTO)

Prof. Dr. Marcelo Freire Moro
Universidade Federal do Ceará (UFC)

Prof. Dr. Marcelo de Oliveira Soares
Universidade Federal do Ceará (UFC)

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RESUMO

O objetivo da presente tese foi detectar e discutir padrões de distribuição da diversidade biológica em ambientes rochosos localizados no entremarés ao longo da costa tropical e subtropical do Atlântico sulamericano. Para tanto, o assunto foi dividido em dois capítulos, o primeiro tratando de padrões em escalas locais em recifes de arenito, e o segundo tratando de escalas regionais, objetivando detectar gradientes latitudinais. No caso dos recifes de arenito, foram escolhidas formações no litoral do Ceará, e adotou-se uma metodologia de amostragem hierárquica: 180 quadrats distribuídos em 18 transectos, que cobriam 3 regiões (superior, média e inferior) de 6 recifes de arenito, que se agrupavam em duas praias, representando o trecho do litoral em questão. Essa abordagem hierárquica permitiu estudar dois padrões principais: a importância relativa da zonação vertical e a influência de diferentes escalas nos descritores da comunidade (riqueza de espécies e entropia da comunidade). Esses padrões foram então comparados com aqueles observados em recifes de coral e costões rochosos de clima temperado. Verificou-se que, diferentemente do apontado por trabalhos anteriores, os recifes de arenito podem abrigar uma biota rica, que se distribui de forma desigual no espaço, descrevendo padrões peculiares: (1) a zonação vertical, apesar de existente, é menos intensa que variações "horizontais" (i.e. ao longo da costa) em cada recife estudado; e (2) a riqueza de espécies é fortemente influenciada por fenômenos em escalas médias, porém a entropia das comunidades é mais fortemente determinada por fatores locais. Essa combinação específica de padrões os diferencia tanto de exemplares típicos de recifes de coral quanto de costões rochosos, colocando-as em uma posição mais ou menos intermediária em termos de riqueza. Portanto, esses ambientes necessitam de estudos focados e demandam estratégias de proteção mais abrangentes visando sua efetiva conservação. Já em relação aos padrões latitudinais, foram estudadas variações espaciais tanto entre praias quanto entre unidades políticas ao longo do litoral do Brasil e do Uruguai. Para isso, foram comparadas 26 listas de espécies de macroalgas marinhas, que complementaram os dados levantados anteriormente na presente tese. Os dados dessas listas foram compilados e comparados a modelos teóricos de distribuição de espécies, a saber: crescimento ou diminuição monotônica da diversidade com o aumento da latitude ou, alternativamente, variação unimodal no número de espécies, que prevê um pico de riqueza em latitudes intermediárias e uma diminuição tanto para norte quanto para sul desse pico. Além disso, foi analisada a possibilidade de tais padrões serem aleatórios ou serem influenciados por fatores e recursos ambientais como temperatura, salinidade, radiação fotossinteticamente ativa, razão nitrato:fosfato e velocidade do vento. Verificou-se que o modelo que melhor descreve a variação no número de espécies é o unimodal e, apesar da distribuição aleatória de espécies explicar parte do gradiente observado, a combinação dos fatores ambientais é capaz de prever com maior exatidão a diversidade de macroalgas. A coincidência do padrão unimodal em escala de praia e de unidade política sugere que tal padrão não é artificial. Esse gradiente também é similar ao observado para outros organismos na região. Além disso, esse padrão concorda com propostas recentes que indicam que a diversidade de organismos marinhos segue um padrão bimodal, com dois picos de riqueza localizados, respectivamente, em latitudes medianas tanto do hemisfério norte quanto do sul, ao invés do clássico padrão monotônico. Após essas análises, que abrangeram escalas que vão de centímetros a milhares de quilômetros, é prudente concluir que abordagens integrativas, que enfoquem múltiplas escalas, são absolutamente necessárias para se entender padrões de diversidade marinha, principalmente porque tais padrões são geralmente complexos e, ao menos em alguns casos, podem depender mais da escala de análise do que de fatores biológicos reais. Abordagens desse tipo são então fundamentais para a correta descrição dos fenômenos ecológicos, sem a qual é impossível estabelecer estratégias de conservação eficientes.

Palavras-chave: Padrões de diversidade. Riqueza de espécies. Ambientes recifais. Gradientes latitudinais.

ABSTRACT

The aim of this dissertation was to identify and discuss distribution patterns of biological diversity in intertidal rocky environments along the tropical and subtropical coast of the southwest Atlantic Ocean. The topic was discussed in two chapters, the first dealing with patterns in sandstone reefs at local scales, and a second one dealing with regional scales, aiming to detect latitudinal gradients. Regarding sandstone reefs, intertidal formations were chosen on the coast of Ceará state, and a hierarchical sampling methodology was used to detect patterns: 180 quadrats over 18 transects, covering three regions (upper, middle and lower) of 6 sandstone reefs, which were grouped in two sites, representing the stretch of coastline under study. This hierarchical approach has allowed the study of two main patterns: the relative importance of vertical zonation and the influence of different scales on community descriptors (species richness and community entropy). These patterns were then compared to the ones observed in coral reefs and temperate rocky shores. Our results show that, unlike indicated by previous studies, sandstone reefs may harbor a rich biota, which is distributed unevenly in space, describing peculiar patterns: (1) vertical zonation, despite present, is less intense than "horizontal" (i.e. along the coast) variations within each studied reef; and (2) species richness is strongly influenced by phenomena at medium scales, but the diversity is more strongly determined by local factors. This specific combination of patterns differentiates sandstone reefs from typical exemplars of both coral reefs and rocky shores, placing them in a somewhat intermediary position. Hence these environments require more focused studies, and demand more comprehensive protection strategies to ensure their effective conservation. In relation to latitudinal patterns, spatial variations were studied both among local beaches and among regional polities along the coasts of Brazil and Uruguay, by comparing 26 lists of species of marine macroalgae, which complemented the data collected previously in this thesis. The data from these lists were compiled and compared to theoretical models of distribution of species, namely: monotonic increase or decrease of diversity with increasing latitude or, alternatively, unimodal variation in the number of species, which predicts a richness peak in mid-latitudes and a decrease both northward and southward of this peak. Additionally, it was analyzed the possibility that such patterns were randomly generated, or else if they were influenced by climatic factors and resources such as temperature, salinity, photosynthetically active radiation, nitrate:phosphate ratio and wind speed. The model that best describes the variation in the number of species is the unimodal, and the combination of environmental features is able to predict with greater accuracy the diversity of macroalgae, although a random distribution of species could also explain part of the observed gradient. The coincidence of the unimodal pattern at both beach and political unity scales suggests that this pattern is not artificial. This gradient is also similar to that observed for other organisms in the same region. In addition, this pattern agrees with recent suggestions indicating that the diversity of marine organisms follows a bimodal pattern, with two richness peaks located respectively in the mid latitudes of both the northern and southern hemispheres, rather than the classic monotonic pattern. Considering these analyzes, which covered scales ranging from centimeters to thousands of kilometers, it is prudent to conclude that integrative approaches, which addresses multiple scales at the same time, are absolutely necessary to understand marine diversity patterns. Mainly because such patterns are usually complex and, at least in some cases, may depend more on the scale of analysis than on real biological features. Such approaches are thus fundamental to the correct description of ecological phenomena, and therefore essential to establish effective conservation strategies.

Keywords: Diversity patterns. Species richness. Reef environments. Latitudinal gradients.

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INTRODUÇÃO

1.1 BIODIVERSIDADE E A QUESTÃO DA ESCALA

Do ponto de vista humano, a imensa diversidade dos organismos vivos no planeta Terra não é apenas esteticamente deslumbrante, ela é fundamental para as nossas sociedades, nos seus mais diversos modos de funcionamento e sistemas de produção (CARDINALE *et al.*, 2012; MIDGLEY, 2012). Estimativas recentes apontam que cerca de 8 milhões de espécies de organismos eucariontes vivem atualmente no planeta, sendo que desse total menos de 20% são conhecidas pela ciência (COSTELLO; MAY; STORK, 2013; MORA *et al.*, 2011). Essa multidão de diferentes formas de vida existe em permanente interação umas com as outras, trocando matéria e energia em complexas redes ecológicas. Um aspecto importante dessas redes é que elas não são sistemas fechados, nem funcionam como jogos de soma-zero, então seus processos podem resultar em produtividade abundante e extrapolar suas fronteiras imediatas. Assim prestam "serviços" essenciais dos quais a humanidade se apropria (GÓMEZ-BAGGETHUN *et al.*, 2010). A título de contextualização, esses serviços possuem um valor anual estimado em pelo menos 125 trilhões de dólares (CONSTANZA *et al*., 2014).

Sendo parte integrante da biodiversidade, a humanidade sempre esteve intimamente relacionada com os demais organismos do planeta (MAYR, 1998). Um interesse legítimo em conhecê-los pode ser percebido já em vestígios pré-históricos (MARCINIAK, 2005), e estudos sistemáticos dessa variedade de espécies existem desde pelo menos o século III a.C (VOULTSIADOU; VAFIDIS, 2007). No entanto, a partir do século XIX, com o avanço da revolução industrial e do desenvolvimento do conhecimento científico, sobretudo através da formalização da teoria da evolução, a forma de se enxergar esses outros seres e suas relações com o *Homo sapiens* foi completamente modificada, o que redefiniu a maneira pela qual a biodiversidade deveria ser estudada (MAYR, 2005; ZIMMER, 2003). Desde então, passou a fazer sentido investigar não apenas quais os organismos que existem em uma certa localidade, mas também como esses organismos surgiram e por que alguns locais abrigam mais espécies que outros (ex. JOHNSON; BAARLI, 1999; POWELL; MOORE; SMITH, 2015). Passou a ser possível traçar, além das relações de semelhança e parentesco entre os organismos, suas histórias evolutivas, incluindo eventos de irradiação adaptativa (RAINEY; TRAVISANO, 1998; SCHLUTER, 1996) e extinção (BENTON, 2009; RAUP; SEPKOSKI, 1984), que são determinantes para a estruturação da biodiversidade do planeta (BENTON, 1995). A partir dessa mudança de paradigma, novos aspectos da diversidade biológica passaram a ser considerados, como a importância ecológica das diversidades intraespecíficas (VIOLLE *et al.*, 2012).

Esses avanços no estudo da biodiversidade, ao mesmo tempo em que trouxeram uma compreensão mais profunda da importância e da interdependência da biodiversidade, consolidaram a percepção de que a ação humana vem pondo em risco muitas das espécies do planeta, comprometendo redes de interação ecológica e a prestação de serviços ambientais (BALVANERA *et al.*, 2006; CARDINALE *et al.*, 2012; PECL *et al.,* 2017; WORM *et al.*, 2006). Essa crise na biodiversidade, que vem assumindo escala de catástrofe global (BELLWOOD *et al.*, 2004; BUTCHART *et al.*, 2010; DIRZO *et al.*, 2014), obrigou a criação e a reformulação de conceitos ecológicos, visando principalmente a tomada de decisão na busca da mitigação desses problemas (FRANCO, 2013). Em conjunto, esses desenvolvimentos resultaram numa percepção mais holística e abrangente da diversidade biológica que sugere que a quantidade e a variedade de espécies de um dado local são determinadas por uma combinação de múltiplos fatores, que vão de históricos a estocÁsticos, passando por físico-químicos e biológicos, todos interagindo de forma complexa para estruturar comunidades locais a partir do *pool* regional de espécies (ALLEN; GILLOOLY, 2006; BLANDIN, 2011; HUBBELL, 2001; RICKLEFS, 2004; TAYLOR, 2011).

Por essa visão, o número de espécies em um dado local seria resultado do aparecimento de organismos (por imigração ou especiação), menos o desaparecimento de organismos (por extinções locais), num processo dinâmico mediado pelas condições ambientais. No entanto, esses eventos são complexos e podem, por sua vez, ser influenciados por diversos fatores. No caso da especiação, além de causas diretamente ligadas às populações e aos indivíduos que às compõem, como mutações (BUTLIN *et al.*, 2012; GAVRILETS, 2014), determinantes externos, como variações ambientais, parecem influenciar decisivamente quantas e quão rapidamente novas espécies serão formadas (GOULD; ELDREDGE, 1977; HUNT; HOPKINS; LIDGARD, 2015), e portanto são úteis na compreensão dos padrões da biodiversidade. Em relação à extinção de espécies, a história evolutiva do planeta pode ser dividida em curtos períodos de extinção em massa e longos períodos nos quais o ritmo de extinções foi lento, porém constante (JABLONSKI, 1986). Em qualquer caso, extinções podem ser causadas por fatores biológicos, como uma corrida armamentista evolutiva (ideia que muitas vezes assume clara conotação gradualista e que tem sido chamada de hipótese da Rainha Vermelha), ou então pela influência de eventos abióticos e do acaso (nesse caso chamada de hipótese do Bobo da Corte), ou ainda por uma combinação de ambas as condições (BENTON, 2009).

Essa variedade de fatores determinantes corrobora a visão de que a biodiversidade é derivada de fenômenos e processos múltiplos e que, portanto, precisa ser analisado em múltiplas escalas espaciais e temporais, levando em conta desde eventos locais, como a competição interespecífica, até mudanças globais, como a deriva continental (LEVIN, 1992). Do ponto de vista ecológico, a questão das escalas é fundamental, porém noções mais sistematizadas da sua relevância só se desenvolveram nas últimas décadas do século XX (CHAVE, 2013; SCHNEIDER, 2001), não por coincidência em paralelo com as novas abordagens holísticas do estudo da biodiversidade. Desde então, esse aspecto tem sido considerado preponderante na resolução das novas questões ecológicas, precisamente por considerar de forma explícita a complexidade inerente dos ecossistemas (CHAVE, 2013; LEVIN, 1992; SCHNEIDER, 2001).

Por outro lado, uma abordagem multiescala (ex. FRASCHETTI; TERLIZZI; BENEDETTI-CECCHI, 2005) não deve ser vista apenas como uma questão de preferência metodológica. De um ponto de vista puramente holístico, que em ecologia costuma estar ligado à ideia de propriedades emergentes (BERGANDI, 2011), um dado sistema pode possuir propriedades particulares, diferentes daquelas do somatório das suas partes (BERTALANFFY, VON, 2015; TREPL; VOIGT, 2011). Assim, um aspecto nem sempre considerado é o de que abordagens de múltiplas escalas podem ir além de questões meramente ligadas ao nível de detalhamento e de resolução espacial/temporal. Elas podem mesmo ser obrigatórias na compreensão dos sistemas nos quais fenômenos em escalas amplas não podem ser totalmente reduzidos àqueles de escalas locais (BERGANDI, 2011; TREPL; VOIGT, 2011) e, portanto, uma definição precisa das escalas de trabalho deveria estar necessariamente presente na descrição de tais sistemas.

Especificamente no caso dos estudos da biodiversidade, essa questão poderia ser posta da seguinte maneira: além de fatores diversos influenciarem o surgimento e a extinção de espécies em um dado local, à medida em que ocorre uma agregação de diferentes táxons, surgem novos fenômenos relevantes, que vão além da simples interação direta entre os organismos (predação, competição, etc.), e que podem mesmo influenciar a coexistência dessas espécies e o funcionamento e evolução do sistema. Nesse caso, seria obrigatório considerar tanto as escalas dos indivíduos, quanto da própria comunidade para uma completa compreensão da estrutura das assembleias biológicas (BERTALANFFY, 2015).

A visão de que sistemas ecológicos, como por exemplo as comunidades biológicas, podem funcionar como um todo coeso, com propriedades particulares que transcendem aquelas das espécies que a compõe, é sem dúvida controversa (ex. GLEASON, 1926; MCINTOSH, 1998; NICOLSON; MCINTOSH, 2002) e não deve ser generalizada (LORTIE *et al.*, 2004). No entanto, algumas propriedades ecológicas parecem sim emergir apenas em escalas mais amplas, não sendo perceptíveis nos níveis mais basais de interação entre as espécies (LIU *et al.*, 2012; OLLINGER *et al.*, 2013; SCHINDLER; ARMSTRONG; REED, 2015; SUWEIS *et al.*, 2013). Esse parece ser o caso, por exemplo, da "estabilidade" das comunidades biológicas (IVES; CARPENTER, 2007; MCCANN, 2000). A ideia de que os organismos são capazes de constituir assembleias estáveis costuma se originar de uma visão harmônica da natureza, que por vezes parece estar mais ligada à questões políticas do que científicas (NIKISIANIS; STAMOU, 2016). Em todo o caso, esse possível vício de origem não parece tirar nem a validade nem a utilidade desse conceito, que continua a ser amplamente empregado na literatura especializada (por exemplo, uma busca pela palavra-chave "community stability" no banco de dados do ScienceDirect revela um aumento no número de publicações com essa temática ao longo do séc. XXI, tendo sido publicados 551 artigos sobre o tema entre os anos de 2008 e 2016, sendo que 184 desses trabalhos [33%] saíram apenas entre 2015 e 2016). Essa popularidade parece decorrer, em parte, da relação próxima que o conceito de estabilidade mantém com outras ideias caras à ecologia, como sucessão ecológica (CONNELL; SLATYER, 1977), comunidade clímax (WHITTAKER, 1974) e resiliência à distúrbios (PETERSON; ALLEN; HOLLING, 1998). Além disso, essa ideia tem sido fundamental no desenvolvimento de estratégias de conservação, recuperação de habitats, e previsão de impactos ambientais (FOLKE, 2006; FOLKE *et al.*, 2002).

A aplicabilidade da ideia de estabilidade decorre da relação aparentemente positiva que existe entre essa e a diversidade biológica (LOREAU; MEZANCOURT, 2013). Em outras palavras, ambientes que abrigam mais espécies parecem ser mais capazes de resistir à distúrbios do que ambientes menos diversos, sendo os primeiros portanto mais "estáveis". Os mecanismos exatos pelos quais a biodiversidade poderia aumentar a estabilidade dos ecossistemas ainda são motivo de debate (LOREAU; MEZANCOURT, 2013). Mas se por um lado essa relação positiva pode ser atribuída à interação direta entre as espécies (MOUGI; KONDOH, 2012; ROHR; SAAVEDRA; BASCOMPTE, 2014), por outro ela também parece ser influenciada por fatores que transcendem essas interações, como por exemplo a complementaridade entre os nichos e a redundância ecológica (DOWNING; BROWN; LEIBOLD, 2014; LOREAU; MAZANCOURT, 2013; MAZANCOURT *et al.*, 2013; MOUGI; KONDOH, 2012; PETERSON; ALLEN; HOLLING, 1998). Portanto, a "estabilidade" de uma comunidade parece ser uma propriedade que emerge apenas em níveis de organização mais elevados, que ultrapassam aqueles das espécies indivíduais, estando mais ligada à processos e funções gerais dos ecossistemas. Essa generalidade torna a questão das escalas essencial para a compreensão da estrutura e funcionamento dos sistemas biológicos (HALLETT *et al.*, 2014).

Apesar dos avanços teóricos na compreensão da importância das escalas nos estudos de biodiversidade, nem sempre esses são acompanhados por estudos empíricos. No caso do ambiente marinho, principalmente nas regiões tropicais, a adoção dessas abordagens ainda permanece incipiente. Por outro lado, essas regiões estão sendo fortemente ameaçadas pelas mudanças globais (CHEUNG *et al.*, 2009; HALPERN *et al.*, 2008). Dessa forma, novos estudos precisam urgentemente considerar a adoção de abordagens integrativas, a fim de gerar informações mais abrangentes e produzir uma compreensão mais completa dos seus ecossistemas. Sem esses dados básicos, estratégias de conservação podem ser seriamente prejudicadas (REGAN; COLYVAN; BURGMAN, 2002). No presente estudo serão abordados padrões da biodiversidade marinha em diferentes escalas, tendo como foco trechos tropicais e temperados quentes da costa atlântica da América do Sul.

1.2 BIODIVERSIDADE MARINHA NO BRASIL

Com cerca de 7500 km de extensão, a costa do Brasil possui uma enorme variedade de condições ambientais (MUEHE, 2010). Se estendendo principalmente na direção norte-sul, esse litoral atravessa climas que vão de semi-áridos a sub-tropicais (GARREAUD *et al.*, 2009). Tendo sido formada pela separação dos continentes americano e africano (MOHRIAK; TAIWANI, 2000), e sendo moldada por variações tanto no nível do mar quanto do continente adjacente (ANGULO; LESSA, 1997; DOBSON; DICKENS; REA, 2001), a costa brasileira é margeada por uma extensa e complexa plataforma continental, mais larga nos seus extremos norte e sul do que no trecho intermediário do litoral, e que abrange tanto áreas de ressurgência quanto regiões predominantemente oligotróficas (NAGAI; SOUSA; MAHIQUES, 2014; VITAL, 2014). Na região de interface continente-oceano, são observadas praias arenosas, bancos de dunas, estuários diversos, lagoas, recifes de coral, costões rochosos, bancos de algas calcárias, recifes de arenito, etc. (MUEHE, 2010).

Essa grande variedade de habitats abriga uma também rica diversidade biológica. Estudos recentes (MILOSLAVICH *et al.*, 2011) registraram 9.103 espécies de organismos marinhos na Zona Econômica Exclusiva do Brasil (definida pelas Nações Unidas como a área marinha que dista até 200 milhas náuticas do continente adjacente), o que equivale a cerca de 4% do total de espécies marinhas atualmente conhecidas no mundo (APPELTANS *et al.*, 2012), colocando a costa do país em 13º lugar em número de espécies, entre 26 eco-regiões marinhas globais (COSTELLO *et al.*, 2010). Dentre os macrorganismos, os grupos taxonômicos mais diversos no Brasil são os crustáceos, moluscos, peixes, anelídeos, algas e cnidários (LONGO; AMADO-FILHO, 2014). Para muitos desses grupos, a costa brasileira parece constituir uma região biogeográfica particular (BARROSO; LOTUFO; MATTHEWS-CASCON, 2016; BRIGGS; BOWEN, 2012). Esta particularidade costuma ser atribuída ao efeito de barreiras oceanográficas que impedem a livre dispersão de organismos, como o oceano atlântico para leste, o rio da Prata ao sul e o rio Amazonas ao norte (MCLACHLAN; BIRD, 1984; ROCHA, 2003). Sabe-se que essas barreiras não são de fato absolutas, (LAURENZANO; FARÍAS; SCHUBART, 2012; ROCHA, 2003). A ação das correntes oceânicas, ao transportar larvas, organismos pelágicos e estruturas flutuantes, pode permitir a conexão entre populações brasileiras e áreas adjascentes (FLOETER *et al.*, 2008). Além disso há um extenso sistema recifal ao largo do rio Amazonas (MOURA *et al.*, 2016), que se estende da costa nordeste do Brasil à Guiana Francesa, constituindo uma ponte de ligação entre o Brasil e o Caribe para um grande número de espécies. Mesmo assim, as eventuais permeabilidades das barreiras biogeográficas não parecem anular o caráter particular para a biota marinha nesse trecho do Atântico Sul.

Apesar desse caráter singular, nem sempre a elevada diversidade da biota marinha brasileira foi reconhecida por pesquisadores, que muitas vezes preferiram focar nas imensas e megadiversas florestas do interior do continente (RATHBUN, 1879). Apesar dessa realidade vir mudando nas últimas décadas (LONGO; AMADO-FILHO, 2014), mudança essa que ocorre em sintonia com os crescentes desenvolvimentos da taxonomia em escala mundial

(APPELTANS *et al.*, 2012; MORA *et al.*, 2011), o país ainda permanece atrás de outras nações em termos de conhecimento da biota marinha bentônica, tanto do ponto de vista taxonômico quanto ecológico (TURRA *et al.*, 2016). Em uma época de fortes mudanças ambientais, essa falta de conhecimento, sempre associada à falta de reconhecimento da sua importância ou da sua capacidade de suportar alterações, se constitui num risco sério aos ecossistemas marinhos.

Recentemente, a partir da junção dos esforços de mais de uma centena de pesquisadores, oriundos de 50 instituições de pesquisa do Brasil, criou-se a Rede de Monitoramento de Habitats Bentônicos Costeiros (ReBentos). Essa rede visa gerar dados de longo prazo sobre a biodiversidade bentônica brasileira, com o intuito de gerar dados padronizados e em larga escala sobre a mesma, possibilitando assim a previsão dos impactos das mudanças climáticas sobre essa biota. Essa união de esforços tem sido produtiva e vem chegando a resultados importantes, como aqueles publicados em recente número especial do *Brazilian Journal of Oceanography* (2016). No entanto, mesmo sendo bastante ampla, a ReBentos ainda não consegue abranger todos os ambientes bentônicos do país. Por exemplo, o enfoque em recifes não-coralíneos, extremamente comuns no litoral da região Nordeste, ainda tem sido insuficiente. Além disso, para se entender processos em ecologia, além de dados de qualidade, é preciso um esforço na detecção de padrões (UNDERWOOD; CHAPMAN; CONNELL, 2000). Para isso é preciso abordagens que integrem os dados, principalmente nas suas diferentes escalas.

1.3 COMUNIDADES MARINHAS EM SUBSTRATOS ROCHOSOS

Grande parte da biodiversidade marinha é encontrada em associação a substratos sólidos, em comunidades bentônicas e demersais (WAHL, 2009). Esses fundos maciços ocorrem desde a região entremarés até o oceano profundo, provendo um substrato relativamente estável, favorável a fixação e estabelecimento de organismos. Essa estabilidade relativa tem servido de base para o surgimento e desenvolvimento de interações ecológicas, que resultaram em alguns dos ecossistemas mais produtivos e diversos do mundo (WAHL, 2009).

Ao longo da costa brasileira, existem, inegavelmente, grandes extensões de substrato rochoso (MUEHE, 2010). De um ponto de vista geológico, essas formações rochosas podem ter composições diversas, mas de maneira geral pode-se falar em rochas biogênicas, sedimentares e cristalinas, a depender de se elas se originam de processos biológicos, sedimentares ou magmáticos/metamórficos (MUEHE, 2010). As primeiras formam os recifes biogênicos, formações de história geológica peculiar dado seu caráter biológico, que são comuns em trechos da região Nordeste, como no Cabo do Calcanhar (RN) e no Banco dos Abrolhos (BA) (LEÃO; KIKUCHI; TESTA, 2003). As últimas aparecem como afloramentos antigos próximos às linhas de praia, muitas vezes formando escarpas íngremes que são comumente chamadas de costões rochosos, sendo abundantes no Sudeste brasileiro (COUTINHO *et al.*, 2016). Já as rochas sedimentares, cuja ocorrência coincide com a dos recifes de coral no Nordeste, tem uma origem mais recente, por vezes contemporânea, sendo formadas pela cimentação da areia da praia ou dos sedimentos subjacentes (BAPTISTA, 2010; FERREIRA JR *et al.*, 2011). Elas costumam aflorar pela ação erosiva do mar (VOUSDOUKAS; VELEGRAKIS; PLOMARITIS, 2007), e por conta do relevo baixo, estão mais expostas à ação deste, por vezes aparecendo separadas da praia por um braço de mar (RATHBUN, 1879). Também podem estar parcialmente cobertas por sedimento, caracterizando por vezes um substrato misto (PORTUGAL *et al.*, 2016).

Devido às características peculiares das formações sedimentares, normalmente aceita-se que essas não constituam costões rochosos verdadeiros (COUTINHO *et al.*, 2016), já que esse termo costuma trazer implícito um sentido de costas elevadas. Isso por vezes tem causado certa confusão terminológica, já que o termo equivalente em inglês (*rocky shores*) tem um sentido bem mais amplo, englobando qualquer extensão rochosa encontrada no mesolitoral (SCHWARTZ, 2005), sendo também aplicável às formações sedimentares brasileiras. Uma saída comum para evitar confusões tem sido denominar essas formações de recifes de arenito, termo que se justifica por motivos históricos, etimológicos, e pela tradição náutica que denomina como recife os obstáculos à navegação (BAPTISTA, 2010), mas que também não é consensual, por ter assumido um sentido mais biológico na literatura anglófona (ALLABY, 2008). Independente do termo utilizado, as formações sedimentares são as menos estudadas do país.

Em relação aos padrões de diversidade, esses são, de forma geral, ainda pouco conhecidos nos habitats de substrato rochoso da costa brasileira. Padrões em escalas locais são relativamente bem compreendidos em costões rochosos e recifes de coral, a partir tanto de trabalhos locais quanto de estudos em ecossistemas análogos de outras regiões (FRANCINI-FILHO *et al.*, 2013; ZAMPROGNO; FERNANDES; FERNANDES, 2012).

Porém, padrões em escalas regionais ainda permanecem pouco conhecidos, mesmo nesses habitats mais estudados. No caso das plataformas de arenito, devido à baixa quantidade de estudos, esses ambientes têm sido excluídos de análises mais abrangentes, e quase nada se sabe sobre sua diversidade para além de escalas muito locais, o que pode prejudicar ações de conservação. A intenção da presente tese é preencher algumas dessas lacunas, pela inclusão, numa abordagem integrada, tanto de recifes de arenito quanto de escalas mais amplas nas análises de padrão da diversidade biológica da costa tropical e temperada quente do Atlântico sudoeste.

Em outras palavras, o objetivo da presente tese é discutir como algumas comunidades bentônicas representativas se organizam em diferentes escalas espaciais ao longo das costas tropical e temperada quente do Atlântico sudoeste. Para isso o assunto será dividido em dois capítulos[1]: um primeiro tratará de fenômenos em escalas locais, enfocando as formações de arenito brasileiras. O segundo tratará de escalas regionais, analisando gradientes latitudinais de diversidade de espécies de macroalgas. Esses últimos padrões serão discutidos no âmbito de propostas recentes que sugerem que a diversidade de organismos marinhos pode não se comportar como previsto pelas teorias clássicas. Assim, pretende-se ampliar o entendimento dos processos que estruturam a biodiversidade marinha brasileira, permitindo uma melhor identificação de fatores que porventura possam vir a por em risco esta biota. Assim espera-se que as informações aqui apresentadas contribuam para tomadas de decisão mais bem informadas, no sentido de ampliar os esforços de conservação da nossa biodiversidade.

1.4 OBJETIVOS E HIPÓTESES

1.4.1 Objetivo geral

Detectar e discutir padrões de diversidade de organismos marinhos bentônicos no entremarés rochoso ao longo da costa tropical e subtropical do oceano Atlântico sudoeste (Brasil e Uruguai).

1.4.2 Objetivos específicos

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[1] Ambos os manuscritos foram elaborados visando atingir um público internacional, e por isso foram redigidos em língua inglesa em formato sucinto.

- Detectar padrões em escalas locais em recifes de arenito da costa brasileira.
- Quantificar a influência de diferentes escalas na estruturação e composição da diversidade de recifes de arenito.
- Descrever a relação latitude – riqueza de espécies de macroalgas ao longo de trecho tropical e subtropical da costa Atlântica Sul-Americana.
- Testar a possível influência da distribuição aleatoria de organismos sobre gradiente latitudinal de riqueza de macroalgas em trecho tropical e subtropical da costa Atlântica Sul-Americana.
- Avaliar a importância de fatores ambientais no gradiente latitudinal de riqueza de macroalgas em trecho tropical e subtropical da costa Atlântica Sul-Americana.

1.4.3 Hipóteses

1. Abordagens multi-escala geram descrições mais robustas de comunidades marinhas bentônicas de regiões entremarés.
2. Recifes de arenito, devido ao relevo predominantemente plano, exibem zonação vertical pouco intensa.
3. Escalas mais amplas afetam mais a riqueza de espécies em ambientes de recifes de arenito.
4. Os recifes de arenito ocupam uma posição intermediária entre recifes de coral e os costões rochosos de ambientes temperados em termos de padrões de diversidade.
5. A diversidade de macroalgas descreve uma relação parabólica (unimodal) com a latitude ao longo da costa leste tropical da América do Sul, como previsto por modelos recentes (i.e. CHAUDHARY; SAEEDI; COSTELLO, 2016).
6. Fatores climáticos influenciam mais do que o esperado por modelos aleatórios na formação de gradientes latitudinais ao longo da costa leste tropical da América do Sul.

2 BIODIVERSITY PATTERNS IN MARINE HARD-BOTTOM ENVIRONMENTS: WHERE DO TROPICAL SANDSTONE BANKS FIT?[2]

2.1 INTRODUCTION

Marine hard-bottom environments are one of the most productive and biodiverse ecosystems of the world (WAHL, 2009), nonetheless they are also among the most threatened by anthropogenic impacts (HALPERN *et al.*, 2007). These habitats constitute an heterogeneous group of environments, with diverse geological origins and different environmental settings, among which temperate rocky shores and tropical coral reefs are arguably the most well studied (BENSON, 2002; SPONSEL, 2009). These two ecosystems may share some general ecological features, such as high levels of benthic production and spatial heterogeneity (BARRY; DAYTON, 1991; HATCHER, 1990; PAINE, 2002). Nevertheless, specific characteristics set them apart: while typical rocky shore communities result from the action of tides and waves over stretches of stony coastlines, reefs are formed by the growth of corals and other calcareous organisms receiving only a marginal influence of tidal fluctuations (SCHWARTZ, 2005).

Such ecological differences apparently result in contrasting patterns of biodiversity across spatial scales. In any ecosystem, species diversity is structured by a complex interplay of phenomena, from local circumstances to global events, such as a site-specific competition for space and worldwide latitudinal gradients (LEVIN, 1992; WIENS, 1989). However, the prevalent scales of variation may be different among these discrepant marine hard-bottom environments, depending on the intensity of the influence of specific biotic and abiotic factors. For example, considering patterns of species composition (as measured, for example, by the Bray-Curtis index), typical temperate rocky shores, due to the predominant influence of tidal fluctuations, seem to be largely affected by relatively broad-scale phenomena (BURROWS; HARVEY; ROBB, 2009; CHAPMAN, 2002; COLEMAN, 2002; UNDERWOOD; CHAPMAN, 1998; VIEJO; ÅBERG, 2003, but see FRASCHETTI; TERLIZZI; BENEDETTI-CECCHI, 2005 for evidence on the prevalence of local-scale factors for abundance and richness patterns, particularly within specific intertidal zones). These factors result in a regular vertical zonation of organisms, which is usually the most relevant pattern in

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[2] Este capítulo foi redigido em inglês com o intuito de ser acessível ao público internacional.

this environment from local to medium scales, being surpassed only at the broadest levels, following changes in species composition among regions (ARAÚJO, et al., 2005; BENEDETTI-CECCHI, L., 2001; CHAPPUIS; TERRADAS; CEFALÌ, 2014; VALDIVIA et al., 2011). On the other hand, the composition on coral reefs seems to be more affected by a confluence of local-scale factors, such as competition and predation (HARRIS; LEWIS; SMITH,, 2015; WILLIAMS et al., 2015), which affect primordially the reef biota, even in the presence of clearly definable depth- and exposure-related zones (HUSTON, M. A., 1985). This is reflected, for example, in the larger sensibility of coralline formations to phenomena which alter the relative competitive ability of benthic organisms, such as the removal of top predators or an increase in nutrient availability (DUDGEON *et al.*, 2010; HUGHES *et al.*, 2007; MCMANUS; POLSENBERG, 2004; NORSTRÖM *et al.*, 2009).

Understand these ecological differences is necessary to the evaluation of the generality of biological patterns in these ecosystems (HUSTON, M. A, 1999; UNDERWOOD; CHAPMAN; CONNELL, 2000). Consequently, it can be useful to the establishment of efficient conservation efforts, which are particularly needed in times of global environmental changes (HENLE *et al.*, 2014). However, the discrepancies may be complex and have various reasons, thus it is not always easy to determine its origins (UNDERWOOD; CHAPMAN, 1996; 1998). Specifically for coral reefs and rocky shores, besides their constituent nature (biotic vs abiotic), the climatic zone in which these formations were mostly studied (tropical vs temperate) may be a major cause for their apparently contrasting behaviours (DAVIS, 2009; MENGE, B A; LUBCHENCO, J, 1981; VERGÉS *et al.*, 2014). Moreover, even considering that tidal fluctuations exert an intense influence on rocky shores, the resulting vertical pattern is not independent from biological interactions (RAFFAELLI; HAWKINS, 1999), thus the mentioned differences in substrate composition and environmental setting may play a major role in the prevalence of the zonation. Therefore, due to these multiple sources of variation, a direct comparison between temperate rocky shores and tropical coral reefs may not be enough to clarify why these ecosystems seem to function differently. Hence, the inclusion of other ecosystems may be useful in this context.

Besides coral reefs, tropical coasts worldwide may house extensive stretches of sandstone outcrops (VOUSDOUKAS; VELEGRAKIS; PLOMARITIS, 2007). These may appear as subtidal platforms (e.g. SOARES et al., 2016), forming rocky “barrier reefs” (e.g. MABESOONE, 1964), or as stone beds within intertidal zones (e.g. PORTUGAL et al., 2016).

In the latter case, they seem to constitute a type of tropical rocky shore, according to the general definition of Coutinhos et al. (2016). These formations, despite their inorganic nature, may also sustain a diverse biota and provide relevant ecosystem services, such as coastal protection, being important elements of many shorelines (e.g. REY et al., 2004; SEMENIUK; SEARLE, 1987; SPURGEON; DAVIS JR.; SHINNU, 2003). In fact, coralline and sandstone formations are often related, and many geographical areas share large expanses of both (see BURKE et al., 2011 and DANJO; KAWASAKI, 2014 for a comparison of global coral reef and beachrock distribution). This relationship may go beyond spatial proximity, and some significant coral coverage may develop atop sandstone banks (e.g. CASTRO; PIRES, 2001). Nevertheless, similarly to temperate rocky shores, the absence of a coralline facies on sandstone environments suggest that their ecology is markedly different from the ecology of biological coral reefs. Therefore, they seem to be adequate candidates to the assessment of the ecological differences between marine hard-bottom ecosystems.

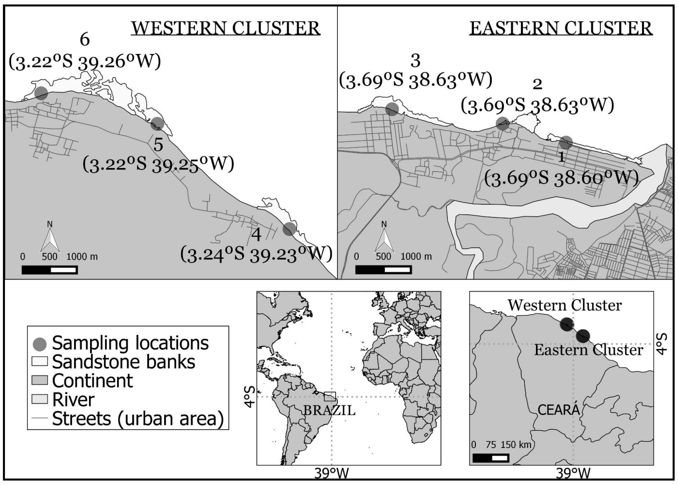
The present study describes and discusses patterns of species composition in South Atlantic sandstone formations in the context of multiscale approaches (CHAVE, 2013; LEVIN, 1992; SCHNEIDER, 2001; WIENS, 1989). We aim to (1) compare the relevance of vertical zonation of species composition with local scale horizontal variations along the coast, and (2) quantify the contribution of each scale to the regional diversity via additive partition of its α and β components. In other words, our objective is to verify in which ecological aspects these sandstone banks are similar to temperate rocky shores (as expected by their inorganic nature), and in which they are closer to coral reefs (as expected by their tropical position) in order to investigate the generality of biological patterns in these hard-bottom ecosystems. This paper will focus on scales from tens of centimeters to tens of kilometers, covering a region with uniform climate and oceanographic conditions, seeking to analyze mesoscale structuring patterns, hence excluding broad-scale changes due to differences among biogeographical areas.

2.2 METHODS

2.2.1 Study area

The study was conducted on intertidal sandstone outcrops on the equatorial coast of South America, along the northern Brazilian shoreline (FIGURE 1). The formations under study comprise two clusters located within the same geographical area (~90km apart), and thus sharing similar environmental conditions such as temperature, rainfall, exposure to waves, and water turbidity. Next to the easternmost group there is a protected environmental area guarding the estuary of a temporary river. This river crosses a dense urban area and hence, despite the conservation effort, may be a source of pollution to the adjacent coastal waters (NILIN *et al.*, 2013).

Figure 1 – Map showing the location of six sandstone banks (1 to 6) divided into two areas (east and west) on the equatorial coast of South America.



Source: prepared by the author. Obs. Western and eastern clusters are located, respectively, at the municipalities of Trairi and Caucaia, both in Ceará state, Brazil. Note the larger urban area and the presence of a river next to the eastern banks

The climate of the region is tropical wet and dry (Aw in Köppen classification), and both climatic and oceanographic conditions are largely determined by broad-scale phenomena (KNOPPERS; EKAU; FIGUEIREDO, 1999; PHILANDER; PACANOWSKI, 1986; POLZIN; HASTENRATH, 2014). This section of the Brazilian coast is also under direct influence of the trade winds, with currents running almost exclusively from east to west. The tidal regime is semidiurnal, with a mean spring tidal range of 3.3 m and a mean neap tidal range of 1.2 m.

This area is within the distribution range of Brazilian coral reefs (LEÃO *et al.*, 2016), and possesses the warm and oligotrophic waters necessary for coral growth (KNOPPERS; EKAU; FIGUEIREDO, 1999). However, a wind-driven resuspension of marine sediments usually raises the turbidity along the coast, hindering the establishment of extensive coralline formations (KNOPPERS; EKAU; FIGUEIREDO, 1999; SOARES et al., 2016). Nevertheless, due to their spatial proximity and ecological similarity, these arenitic structures have been historically called sandstone reefs in the literature on South American hard-bottom environments (e.g. MABESOONE, 1964; MARTINEZ; MENDES; LEITE, 2012; RATHBUN, 1879; SOARES et al., 2016). On the other hand, by being located within intertidal zones, these formations could fall into general definitions of rocky shores (e.g. COUTINHO et al., 2016). Therefore, to discriminate them from true coral reefs and temperate rocky coasts, these formations will be referred to as sandstone banks in the remainder of the present paper.

These sandstone banks were either formed by the consolidation of beach sand and have a quaternary origin (beachrocks) or are sedimentary stones of tertiary age exposed by coastal erosion (MORAIS, 1969). They also show varying degrees of $CaCO_3$ and Fe_2O_3 cements, what may result in different levels of porosity (MORAIS, 1969). Due to these differences, substrate rugosity differed among the studied sandstone formations, the western banks being flatter than the eastern ones (mean rugosity of 0.90 ± 0.09 and 0.98 ± 0.01 in the eastern and western clusters, respectively). Nevertheless, all studied banks had a very gentle slope (around 2º) and were restricted to the intertidal and shallow subtidal zones between the ocean and a sand-dominated supralittoral, being completely covered by seawater during high tides.

2.2.2 Data sampling

Data were collected following a modified version of the NaGISA protocol (RIGBY; IKEN, K; SHIRAYAMA, Y, 2007), excluding subtidal areas. Three sandstone banks were selected from each cluster. The intertidal region of each bank was divided into three zones parallel to the shoreline, representing the upper, middle, and lower strata of the mid-littoral. The upper zone was roughly the area immediately before the transition from rocky substrate to adjacent onshore sand deposits; the middle zone was the flat plateau comprising most of the bank area; and the lower zone was the transition from mid- to infralittoral, where the biota is permanently under the action of tides or waves but not necessarily submerged. Visually, these three zones represent significant vertical variations in the biota of sandstone banks, marking clear changes in the composition of assemblages.

In each sandstone bank, three 30x5m belt transects were positioned, one at each zone. The exact distance between transects varied depending on the size of the bank, but was always in the scale of tens of meters (from 15m to 90m). In each transect, ten 50 x 50 cm^2 quadrats were distributed randomly, avoiding obvious changes in environmental conditions, such as tide pools in upper zones.

Both the species richness of sessile organisms and the primary cover (organisms growing directly on the substrate) were assessed by the point intercept method, using 100 systematically distributed points in each quadrat as a reference. This approach was used to standardize the sampling effort, decreasing the risk of observation errors due to the presence of small and ephemeral epibionts among highly branched seaweeds. Nevertheless, it may have underestimated the coverage of epiphytic organisms and of organism growing mostly outside the reef flat, among which are important reef engineers, such as corals and zoantids. Regardless of these limitations, the efficiency of this methodology in detecting biodiversity was evaluated by species accumulation curves, which were constructed using mean richness per sample in 1000 random permutations of the data.

2.2.3 Prevalence of vertical zonation

Vertical zonation in intertidal environments can be defined as the changes in community composition following a tide-generated gradient. Due to the gentle slope of the studied sandstone banks, we first assessed if these formations really display such a pattern by performing a distance based redundancy analysis (db-RDA) (LEGENDRE; ANDERSON, 1999) using both the Bray-Curtis and the Sørensen dissimilarity matrices of the samples (i.e. the quadrats). Hence, we tested whether the benthic community changed among the previously established vertical zones (a factor with three levels: upper, middle, and lower) both in terms of species occurrence (Sørensen) and abundance (Bray-Curtis). Considering that zones are not independent within each sandstone formation (i.e. the composition of the upper zone is related to the composition of the middle and lower zones), the analysis was conditioned by removing the influence attributable to the differences among banks.

The magnitude of vertical and horizontal changes in species composition was then compared following the approach of Benedetti-Cecchi (2001) and Valdivia et al. (2011). But unlike these authors, we avoided testing multiple spatial scales. We did so to simplify data collection and analysis, and also to address specifically whether vertical changes were more intense than horizontal ones even at local level, a feature that would allow a more direct comparison of sandstone banks to coral reefs and rocky shores.

Per this approach, differences in species composition among samples were summarized, again using both Bray–Curtis and Sørensen dissimilarities, for each sandstone bank independently. A one-way permutational multivariate analysis of variance (perMANOVA), with zones as the single factor, was then used to estimate vertical and horizontal variations in each bank for each dissimilarity measure. According to the properties of the perMANOVA, residual mean squares ($MS_{residual}$) represent the variation within zones (i.e., horizontal change), whereas variation among zones (i.e. the vertical changes, MS_{zones}) was equated to the expected mean squares of the treatment by the formula $(MS_{zones} - MS_{residual})/n$, where n was the number of replicate quadrats within each zone ($n = 10$). This process resulted in six independent measures of vertical and horizontal variability for each dissimilarity measure, one for each bank. Finally, a paired t-test was used to analyze whether the horizontal and vertical variability, in both abundance and occurrence of species, were significantly different across banks. Data normality was analyzed using the Shapiro–Wilk test while the homogeneity of variances was analyzed with the Levene test.

2.2.4 Additive partition of diversity

To directly assess how the structure of benthic assemblages changes across spatial scales, we used an additive partition of the sandstone banks biodiversity (VEECH *et al.*, 2002). Two diversity measures were used in this analysis: species richness and the community entropy (i.e. the Shannon index, which was originally developed to express information content, and thus should be regarded as a measure of a system's entropy) (MAGURRAN, 2004). In this method, local diversity (α diversity) and the variation of local diversity (β diversity) are expressed in the same unit, and regional diversity (γ diversity) is the sum of both ($\gamma = \alpha + \beta$). By expressing α-diversity and β-diversity in the same unit, this approach allows a more direct interpretation of this second measurement. For example, if richness-α is the mean number of species in a sample, richness-β is the mean number of species absent from a sample. Similarly, if entropy-α (i.e. mean local Shannon index) is the average degree of uncertainty in predicting the identity of a species randomly chosen from a sample with known composition, entropy-β (i.e. the variation in mean local Shannon index) is the increase in uncertainty brought by the knowledge of the meta-community composition (see MARCON et al., 2014 for a thorough discussion on the definition of Shannon β).

Besides permitting a more direct interpretation of β diversity, this method allows the partition of the overall diversity among different scales, thus allowing the quantification of their individual contributions (VEECH *et al.*, 2002). In the present study, we have considered five hierarchical scales, according to the sampling scheme: quadrat, transect, bank, cluster and region. We are aware that the vertical zones are not fully nested across sandstone formations, but we have included the individual transects as one of the scales in this analysis to represent the mean difference between a quadrat's and a zone's diversity, thus further refining the partition. Furthermore, even if it is not possible to discuss differences at regional scale, due to the lack of replicate at this level, it was included to allow an estimate of gamma diversity. Hence, the benthic partitions were divided as follows: α-diversity was the average diversity among quadrats, β1-diversity was the difference between α and the mean diversity among transects, β2 as the difference between β1 and the mean diversity among sandstone banks, and so on until all five scales were covered.

Finally, this method can provide hypotheses tests by comparing the results of the partition to those of null models (VEECH *et al.*, 2002). In the present study, these models were generated by 1000 random permutations of the data, to test weather a random assemblage of species could generate the observed pattern, or alternatively, if there are rules of assembly structuring the communities.

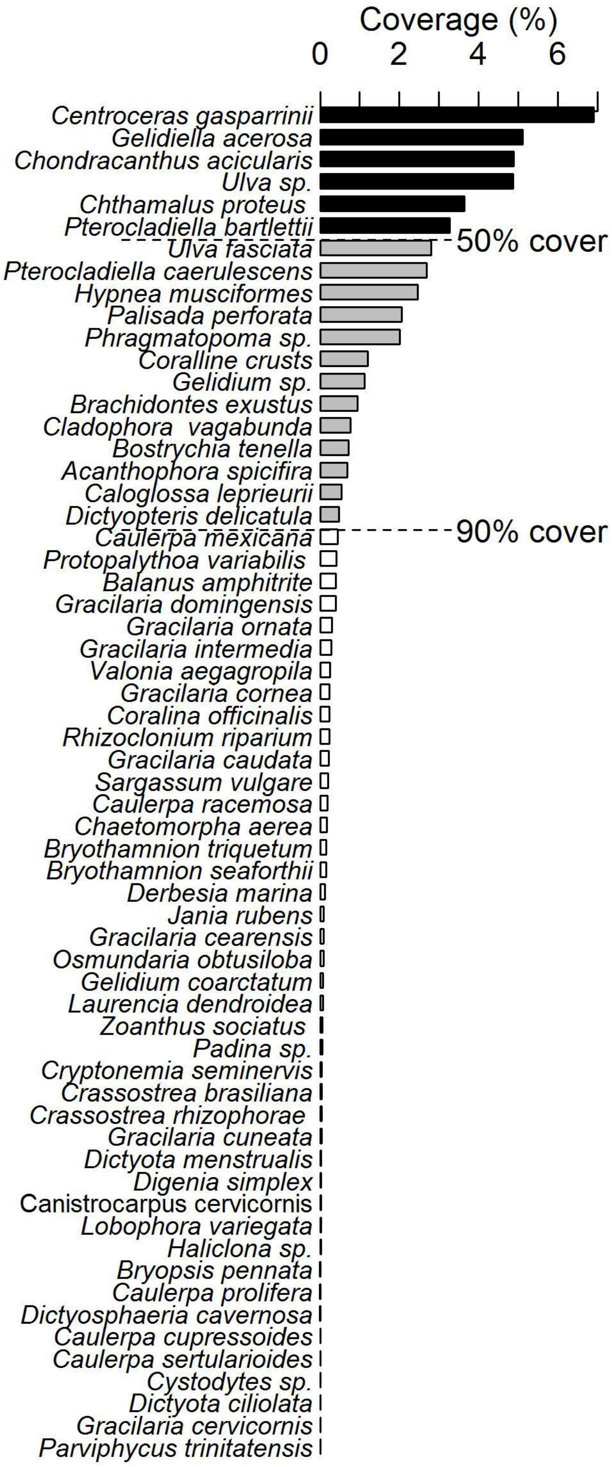
All the statistical analyses, for both the assessment of vertical zonation and the additive partition of diversity, were performed in R 3.3.2 using the VEGAN package (OKSANEN et al., 2017).

2.3 RESULTS

2.3.1 Sandstone bank vertical zonation

Sixty-one species were found on the studied sandstone banks: 9 animals and 52 seaweeds (APPENDIX A). Depending on the sample, organisms covered 0% to 100% of the substrate, with a mean value of 52% ± 23% (mean±SD). Only one species was found in more than 50% of the quadrats (the green alga *Ulva fasciata* Delile), and six species were responsible for half of the biological cover: the red algae *Centroceras gasparrini* (Meneghini) Kützing, *Gelidiella acerosa* (Forsskål) Feldmann and G. Hamel, *Chondracanthus acicularis* (Roth) Fredericq, and *Pterocladiella bartlettii* (W.R. Taylor) Santelices; the green alga *Ulva* sp.; and the barnacle *Chthamalus proteus* Dando and Southward 1980 (FIGURE 2).

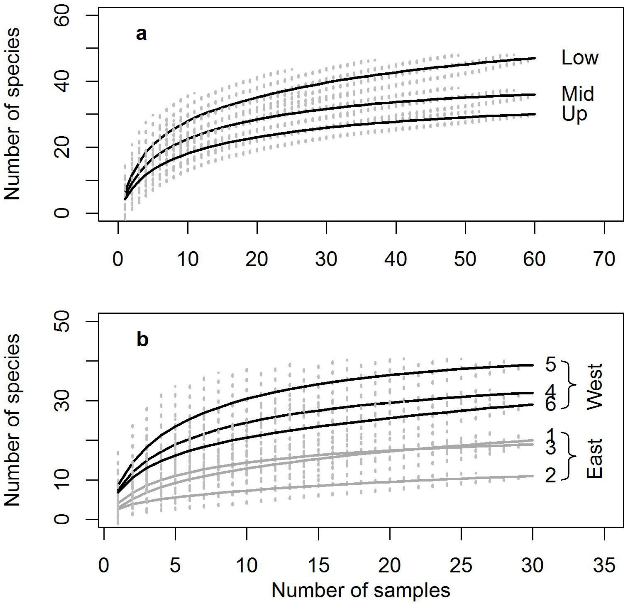
Figure 2 – Mean coverage of 61 species of benthic organisms on South American sandstone banks.



Source: prepared by the author. Obs. black bars are the species whose cumulative coverage accounts for 50% of the biological cover. Grey and black bars sum 90% of the biological cover. Biological cover is approximately 52% of total coverage

The species accumulation curves indicate that the sampling effort was sufficient, with all curves approaching stabilization. These curves also suggest differences in species richness among bank strata (FIGURE 3a) and differences along the coast, among banks and bank clusters (FIGURE 3b).

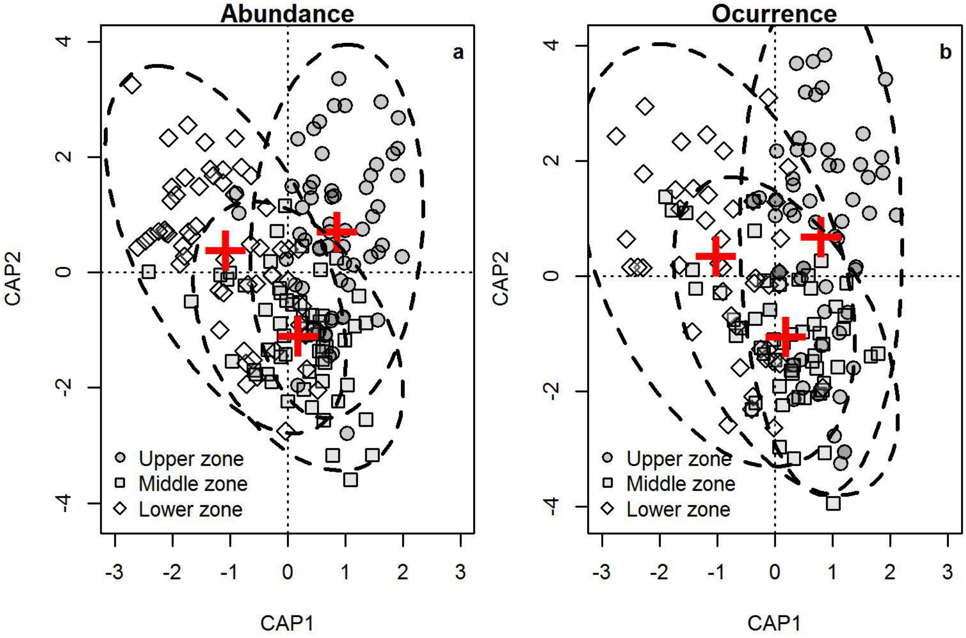
Figure 3 – Species accumulation curves in sandstone banks.



Source: prepared by the author. Obs. dashed vertical lines cover 2x standard deviation. **a**: species accumulation in three intertidal zones (upper, middle, and lower), suggesting differences in richness among intertidal strata. **b**: species accumulation in six sandstone banks (1 to 6) from two clusters (East and West), also suggesting differences in the number of species along the coastline

The composition of benthic assemblages differed significantly among zones, both in terms of species occurrence ($F_{2,170} = 11.2$, $p = 0.001$) and abundance ($F_{2,170} = 6.3$, $p = 0.001$), particularly between the upper and lower strata. In general, richness increased and the species composition changed following a clear vertical gradient (FIGURE 4a-b): higher levels, when totally exposed, were dominated by barnacles (*Amphibalanus amphitrite* and *Chthamalus proteus*), mussels (*Brachidontes exustus*), and oysters (*Crassostrea brasiliana*), but these animals were replaced by foliose green algae (*Ulva* spp.) if there were tide pools or sand present; the intermediate sections were dominated by filamentous (*Centroceras gasparrini*) and fleshy (*Gelidiella acerosa* and *Palisada perforata*) red algae, which are resistant to desiccation and burial; and the lower regions were dominated by fleshy (*Hypnea pseudomusciformis*), foliose (*Ulva* spp. and *Pterocladiella* spp.), and larger articulate and crustose calcareous algae. However, the ordination analyses also suggest that such a pattern may not be totally consistent throughout the studied formations, since there was often a superposition of upper, middle and lower quadrats in terms of dissimilarity measures (e.g. points located below the abscissa in both graphics of FIGURE 4).

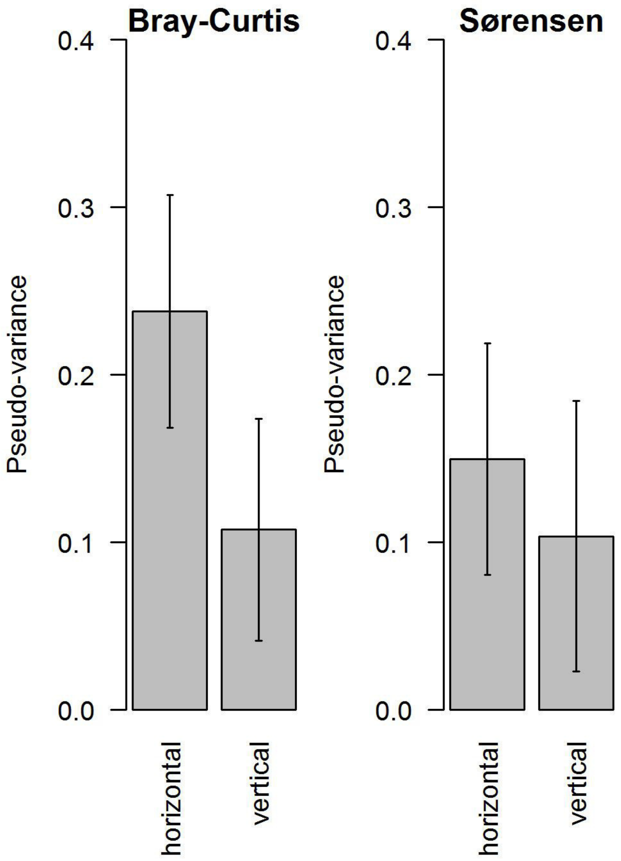
Figure 4 – Distance-based Redundancy Analysis depicting the differences in species composition among three intertidal zones in six sandstone banks from the equatorial coast of South America



Source: prepared by the author. Obs. **a**: differences in species composition measured by the Bray-Curtis dissimilarity. **b**: differences in species composition measured by the Sørensen dissimilarity. In both cases the differences were significant (p = 0.001). Black crosses mark the centroid of each group. Ellipses are the 95% confidence interval of the standard deviations of each group.

Despite the existence of this significant (albeit probably non-ubiquitous) vertical gradient, the comparison between vertical and horizontal variations revealed that along-shore changes were always stronger than the modifications perpendicular to the coastline (FIGURE 5). However, only in the case of abundance-based dissimilarity measures (i.e. Bray-Curtis) such a difference was significant (Paired t test: t_6 = 3.15, P = 0.025). In other words, species composition changes due to tide-generated gradients were less intense than the variations attributable to other factors — such as substrate heterogeneity, sedimentation, predation or competition — particularly regarding the relative abundance of the organisms.

Figure 5 – Comparison of vertical and horizontal variations in community structure within sandstone banks.



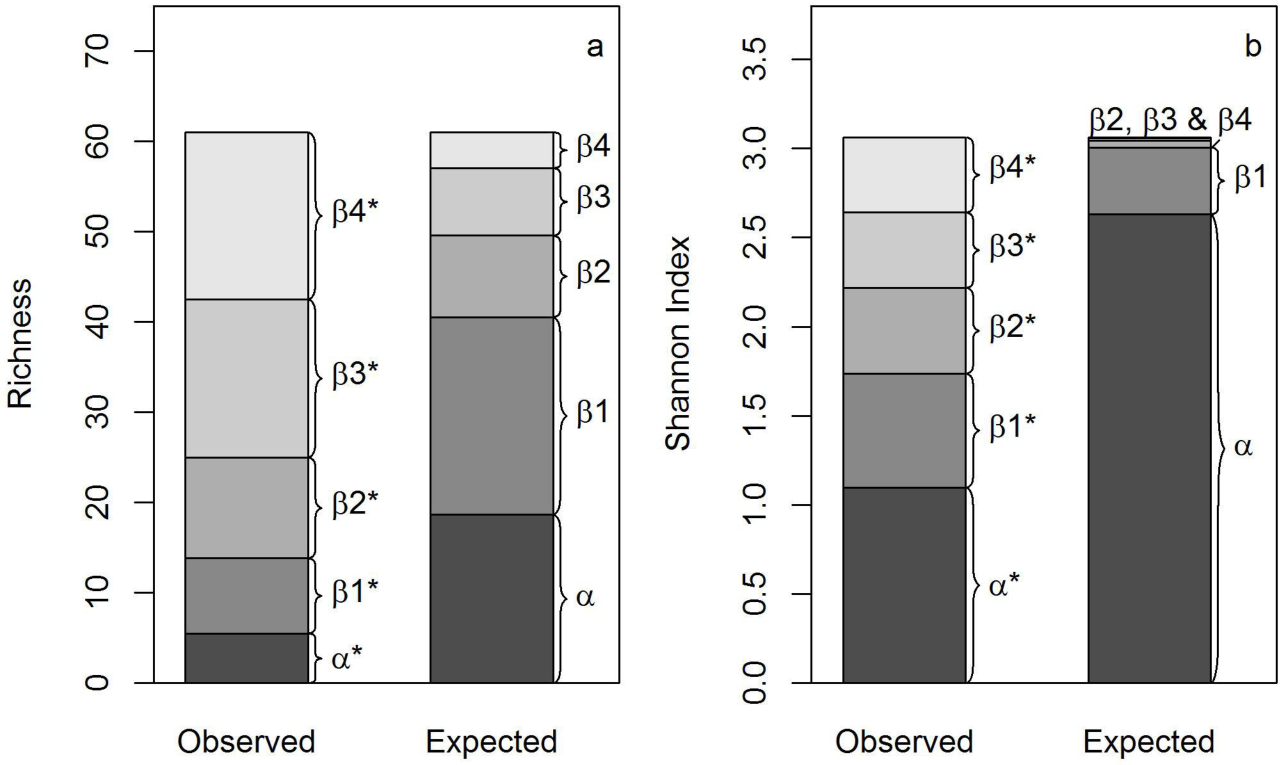
Source: prepared by the author. Obs. **a:** differences in community structure measured by Bray–Curtis index, which includes abundance data. **b**: differences in community structure measured by Sørensen–Dice index, which uses occurrence data only. Despite the larger horizontal variation in both indexes, the difference was only significant in the case of Bray–Curtis. Data are represented by the mean ± standard deviations of the pseudo-variances calculated by PERMANOVA

2.3.2 Additive partitioning of diversity

The partitioning of diversity revealed that, while the species richness on sandstone banks received a larger contribution from broader spatial scales, entropy patterns (i.e. the Shannon index) were more influenced at the square and transect levels (FIGURE 6).

The observed patterns of richness and entropy were not random. At every level, both diversity measures, in their α and β components, were significantly lower than expected (FIGURE 6). This suggests some limitation to the establishment of diversity by small-scale factors, such as a saturation in the number of species within each quadrat.

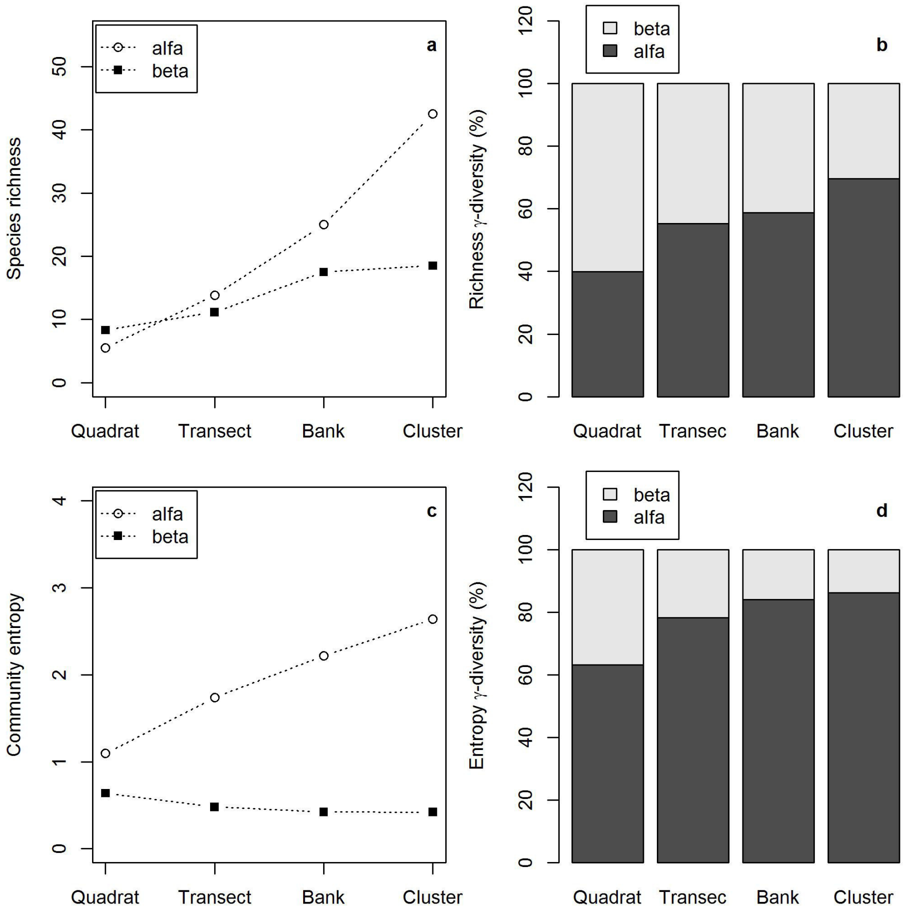
Figure 6 – Additive partition of benthic diversity in sandstone banks.



Source: prepared by the author. Obs. **a**: diversity measured as species richness. **b**: diversity measured as community entropy (Shannon index). α: sample diversity (quadrat), β1: mean difference between samples, β2: mean difference between transects, β3: mean difference between sandstone banks, β4: mean difference between clusters of banks. γ=α+β1+β2+β3+β4. *Significantly different from expected. Notice the large contribution of broader scales (β3 and β4) to the observed γ richness (**a**), while observed γ-diversity was more influenced at narrower scales (α and β1) (**b**)

Finally, all diversity measures had an absolute increase with scale (FIGURE 7a,c), with the exception of entropy-β (FIGURE 7c). This indicates that each successive increase in scale contributed less to the system entropy, even if the number of species was actively growing. In other words, increments in richness seemed to be caused by the appearance of increasingly rarer species, which were not able to affect overall patterns of dominance and evenness. On the other hand, comparing the contribution of the α and β components to the overall γ-diversity, there was a clear and consistent decrease in the relative importance of the β across spatial levels (FIGURE 7b,d). This suggests that the differences among benthic assemblages contribute successively less to the regional γ-diversity following each increase in scale.

Figure 7 – Absolute (**a**-**c**) and relative (**b**-**d**) growth of α and β diversities at increasingly broader scales.



Source: prepared by the author. Obs. **a-b** diversity measured as richness. **c-d** diversity measured as community entropy (Shannon index).

2.4 DISCUSSION

2.4.1 Biodiversity in sandstone banks

Biodiversity in tropical non-coral hard-bottom habitats is generally regarded as poor. This type of ecosystem is sometimes described as barren, devoid of fleshy organisms, with the sessile benthos largely dominated by crusts, probably as a consequence of intense herbivory (KAEHLER; WILLIAMS, 1996, 1998; LUBCHENCO et al., 1984; MACUSI; DEEPANANDA, 2013). In the present study, the biotic primary cover on each cluster of sandstone banks varied from 31 to 53 species. Although different methodologies hinder direct comparisons, these numbers were not much different than those found on intertidal reef flats of Atlantic coral reefs, which are largely dominated by macroalgae. For example, studies of two of the largest South Atlantic coraline formations, the Abrolhos reefs and the Rocas atoll, found 34 and 20 species on their plateaus, respectively, and at least the latter was described as having a monotone physiognomy (FONSECA; VILLAÇA; KNOPPERS, 2012; VILLAÇA; PITOMBO, 1997). Considering that only primary cover was investigated in the present study and that some species-rich microhabitats, such as tide pools and cracks, were purposely excluded from the analysis, a relatively large biodiversity is evident in the sandstone habitats.

On the other hand, the species composition on sandstone banks seems to differ considerably from that on coral reefs, particularly regarding the abundance of corals and sponges (SOARES et al., 2016). Despite the extensive coverage of barnacles, polychaetes, mussels, oysters, zoanthids, sponges, and ascidians, there were more seaweeds than animals on the rocky outcrops. Furthermore, calcium carbonate producers seem to be relatively less important in sandstone habitats. The most abundant $CaCO_3$ producers, coralline red algae, were found mostly as encrusting forms on the lower intertidal zones. Scleractinian corals, particularly *Siderastrea stellata*, are common in the present study's area (SOARES; RABELO; MATHEWS-CASCON, 2011), but they did not cover a large enough area to be detected by our protocol, and they were observed mostly inside tidepools. Other important carbonate producers, such as the calcareous green alga *Halimeda*, were completely absent, despite their abundance on reef habitats at higher latitudes (BANDEIRA-PEDROSA; PEREIRA; OLIVEIRA, 2004). New studies are necessary to quantify $CaCO_3$ production in sandstone banks and to assess its role in the ecology of these habitats.

Although less prevalent in sandstone formations, the presence of reef-building organisms, such as corals and crustose algae, should not be disregarded. These organisms actually structured three-dimensional concretions over the area, which were discontinuously distributed but could reach considerable sizes (see LABOREL; KEMPF, 1966 for examples in other locations). Thus, they could act as real ecosystem engineers (*sensu* JONES; LAWTON; SHACHAK, 1997), affecting local environmental conditions and structuring habitats. The resulting landscape is often a mosaic, with loose sand (visually both calcareous and siliceous in composition), sandstone, calcareous algae, corals, and other biological constructions, such as *Phragmatopoma* colonies, composing the substrate. Hence, due to this relevant component of biological frame-builders, the sandstone formations seem to be different from many typical temperate rocky shores (e.g. BALLANTINE, 1961), and the use of the traditional "sandstone reef" terminology seems justified.

2.4.2 Spatial variability

Despite present and noticeable, vertical zonation does not seem to be the major source of variation on sandstone banks. Horizontal changes in species composition were stronger than vertical ones, even at the narrow spatial scales considered in the present study. This is at odds with the expected for temperate rocky shores, in which vertical zonation is the main distribution pattern, at least until scales of at least hundreds of meters are reached (ARAÚJO, R. *et al.*, 2005; BENEDETTI-CECCHI, L., 2001; CHAPPUIS; TERRADAS; CEFALÌ, 2014; VALDIVIA *et al.*, 2011). On the other hand, a relatively low prevalence of vertical patterns seems to be common in rocky coasts from tropical regions (ESTON *et al.*, 1986; RAFFAELLI; HAWKINS, 1999).

The present study did not aim to investigate the causes of such a difference. Nevertheless, it may be partly attributable to the very gentle slope of the studied sandstone banks (around 2º), which permits the complete submersion of the substrate, creating numerous microhabitats even in the highest intertidal areas. However, mounting evidence suggest that vertical zonation rarely can be explained solely by direct physical gradients, and it seems clear that the ecological relationships among organisms may be crucial to the origin of such a pattern (RAFFAELLI; HAWKINS, 1999). For example, tropical environments usually house an abundant and diverse assemblage of herbivores, and may experience high temperatures and low nutrient regimes that change little among seasons (MACUSI; DEEPANANDA, 2013; VERGÉS *et al.*, 2014). When combined, these factors often result high levels of chronic predation on these ecosystems (MACUSI; DEEPANANDA, 2013; VERGÉS *et al.*, 2014). Other authors have noticed that such a herbivory pressure may affect markedly rocky shores within the tropics, including a considerable smoothing of the vertical gradients in these ecosystems (MENGE, B A; LUBCHENCO, J, 1981; RAFFAELLI; HAWKINS, 1999). In the present study we did not measure predation levels, but due to the high abundance of herbivorous fish usually found in low latitude formations along the Brazilian coast (FERREIRA et al., 2004; FLOETER et al., 2004), it seems a possible explanation of why vertical gradients produced less variation in the studied sandstone banks than the horizontal changes.

Additionaly, biological communities may change due to variations in species composition or in their relative abundances (BASELGA, 2010). In the present study, we have detected strong vertical and horizontal variations in both parameters. However, horizontal changes of relative species abundance were the most intense among all considered variations, being the only significantly different from vertical ones (as shown in FIGURE 5). On one hand, this suggest that the significant changes in taxonomic composition are relatively homogeneous over the sandstone banks, at least within the considered scales. On the other hand, a high level of variation in local abundance may be the result of an intense predation (ADLER; RAFF; LAUENROTH, 2001; MENGE; LUBCHENCO, J, 1981), thus corroborating the above-mentioned hypothesis on the causes of the relatively weak vertical gradient on these formations.

2.4.3 Partition of diversity

Our results suggest that while broad scale variations contributed mostly to the regional species richness of tropical sandstone banks, the community entropy was mostly driven at the smallest levels. This indicates that richness in the studied banks followed the traditional species-area relationship (LOMOLINO, 2000), but with patterns of species dominance and evenness being largely determined by local factors.

Due to the lack of studies, it is not yet possible to draw definitive patterns related to the additive partition of diversity in either coral reefs or rocky shores. Nevertheless, available evidence suggests that most of the variation in the number of coral species in biological reefs is driven by factors acting at local scales; and that this high local β-diversity should contribute markedly to the regional species richness (ATEWEBERHAN; MCCLANAHAN, 2016; BELMAKER *et al.*, 2008; ZVULONI; WOESIK, VAN; LOYA, 2010). Such a pattern is in accordance with the observations by authors working with species composition instead of richness, who have also pointed that variations among sites within a reef can be stronger than variations among reefs or even among groups of reefs (HARRIS; LEWIS, L. S.; SMITH, J. E., 2015; WILLIAMS, S. M. *et al.*, 2015), to the point of describing some coralline faunas as homogeneous at broad spatial scales (PAWLIK; LOH, 2016).

Contrariwise, most changes in the species richness of temperate rocky shores seem to follow phenomena occurring at medium to broader levels (ARCHAMBAULT; BOURGET, 1996; BURROWS; HARVEY; ROBB, 2009; HULL, 1999; OKUDA *et al.*, 2004, 2009). The composition of the biological communities on these environments apparently is also under a strong influence of regional features (BENEDETTI-CECCHI *et al.*, 2003; CHAPMAN, 2002;

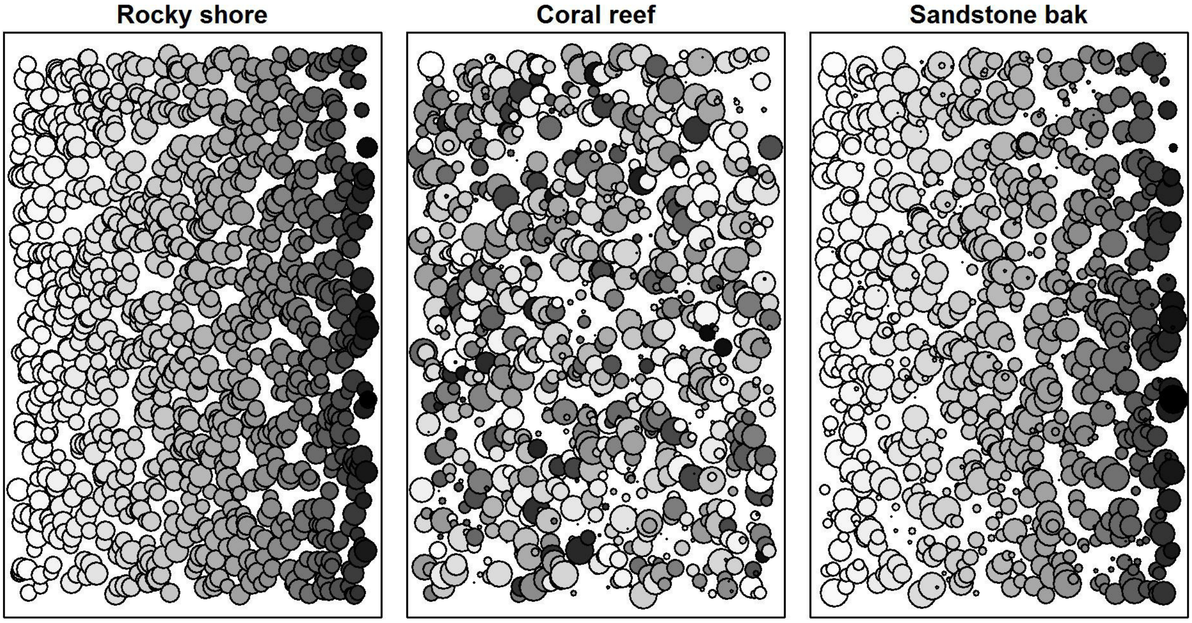
COLEMAN, 2002; JOHNSON *et al.*, 2001; UNDERWOOD; CHAPMAN, 1998; VIEJO; ÅBERG, 2003), which is probably due to the pervasive effects of tidal fluctuations (ARAÚJO *et al.*, 2005; BENEDETTI-CECCHI, 2001; CHAPPUIS; TERRADAS; CEFALÌ, 2014; VALDIVIA *et al.*, 2011). However, these ecosystems should not be regarded as homogeneous at local spatial scales (FRASCHETTI; TERLIZZI; BENEDETTI-CECCHI, 2005), but differently from coral reefs, their inorganic nature — which is not limited by specific environmental settings, and hence can sustain a biota without keystone species (like corals in coral reefs) (MACUSI; DEEPANANDA, 2013) — may favour a more balanced distribution of the variance across scales. Such explanation, despite speculative, agrees with our results on sandstone banks, whose richness also receives a large contribution of process at broad scales.

Regarding entropy patterns, the literature is very scarce, but the available evidence suggest that it is determined at local scales in both coral reefs and rocky shores (ATEWEBERHAN; MCCLANAHAN, 2016; OKUDA *et al.*, 2004). This indicates that dominance and evenness in benthic assemblages will not change drastically among locations, at least less than the observed among sites within locations. However, while the evidence at hand indicates a reduction in the relative contribution of successively broader scales in the case of coralline ecosystems (ATEWEBERHAN; MCCLANAHAN, 2016); it points to an increase, or at least a relative stability, in rock formations (OKUDA *et al.*, 2004). This divergent pattern may also result from the differences in local and regional levels of heterogeneity observed in these ecosystems.

If the proposed differences between rocky shores and coral reefs represent at least a general trend, it would imply that the analyzed sandstone banks were more similar to temperate rocky shores regarding the structure of species richness across scales; but would be closer to coral reefs regarding the factors affecting trends of community entropy (a schematic depiction of these similarities can be seen in FIGURE 8).

This mixed nature may be the result of a combination of the abiotic character of sandstone banks, and the tropical environmental conditions wherein they are found. In other words, whereas the lack of a coralline cover permits intense changes in community composition at broader spatial scales, a complex interplay of predation, recruitment, competition and disturbance affect the communities at narrow scales. The non-randomness of richness and diversity patterns also supports this view. All estimates of α and β components of diversity, as measured either by species richness or by the Shannon index, were significantly different from the expected in random communities. Particularly at narrow scales, the estimated values were consistently lower than predicted, but in the case of richness, the whole pattern completely reversed. This indicates that the studied benthic communities are not a random subset of the regional species pool. But more specifically, it suggests that the factors influencing the assembly of these communities may act by limiting the number of species within a given quadrat, whereas allowing a higher-than-expected level of change at the scales of individual and clusters of sandstone banks.

Figure 8 – Schematic depiction of the different patterns of variation in benthic community composition in temperate rocky shores, tropical coral reefs, and tropical sandstone banks.



Source: prepared by the author. Obs. Both circle sizes and colours represent different aspects of community variation. Notice how rocky shores change mostly at broader scales, coral reefs at very local scales, and sandstone banks at both.

2.4.4 Concluding remarks

Our results indicate that tropical sandstone banks may be diverse ecosystems with high spatial heterogeneity, which contradicts some earlier studies (KAEHLER; WILLIAMS, 1996, 1998; LUBCHENCO *et al.*, 1984; MACUSI; DEEPANANDA, 2013). On one hand, they may share the same regional species pool with coral reefs, but their benthic communities seem to be assembled according to different rules. On the other hand, some key ecological aspects, such as the less intense vertical zonation, and a higher influence of local scale processes, seem to contrast with more typical temperate rocky shores. New studies are needed to evaluate if such differences are also present in other tropical marine hard-bottom environments, such as crystalline rock cliffs and boulder beds (COUTINHO *et al*., 2016).

As expected, factors at multiple scales affect this habitat, changing community entropy, composition and species richness. However, since along-shore variations seem to be strong – sometimes stronger than vertical zonation – future studies must address this aspect when comparing different sites. Furthermore, new studies are needed to evaluate the identity and the relative importance of the local-scale factors structuring these communities. In the present paper, based on previous studies, we hypothesized that predation may exert a major influence on this benthic assemblages. However, we expect that other features, such as competition, spatial heterogeneity and sedimentary dynamics, may also be relevant.

The differences between tropical sandstone banks and both coral reefs and rocky shores may indicate future scenarios for these ecosystems in times of global environmental changes. The rising sea temperatures apparently may have a homogenizing effect on some of these ecosystems: whereas temperate rocky shore may face a “tropicalization” of their biota (VERGÉS *et al.*, 2014); the worldwide degradation of coral reefs, with the consequent reduction of their living coverage, may result in landscapes which are not essentially different from inorganic banks (ROGERS *et al.*, 2015). In both cases, the emerging ecological setting may be somewhat similar to sandstone banks. Therefore, assessments of patterns and processes within and among their communities may be useful to the establishment of efforts aiming to mitigate the predicted losses of biodiversity and ecosystem services.

Since our data suggest that this ecosystem is relatively different from that of both coral reefs and rocky shores, with a somewhat intermediate condition regarding patterns of diversity, more focused investigations would be beneficial for their conservation. Human impacts seem to be already affecting Brazilian sandstone banks (PORTUGAL *et al.*, 2016; SCHERNER *et al.*, 2013), and considering our results, particularly the ones related to strong along-coast variations in species composition, broader protection strategies should be preferred, covering at least entire shores rather than isolated formations, to ensure the maintenance of regional biodiversity.

3 GRADIENTS OF SEAWEED DIVERSITY ALONG TROPICAL AND WARM TEMPERATE SOUTH-WEST ATLANTIC OCEAN: TESTING FOR NON-LINEAR AND NON-RANDOM PATTERNS[3]

3.1 INTRODUCTION

Latitudinal gradients of species diversity are a widely noticed pattern in ecology (HILLEBRAND, 2004; MITTELBACH *et al.*, 2007; PIANKA, 1966; ROHDE, 1992; WILLIG; KAUFMAN; STEVENS, 2003). For many ecosystems and taxonomic groups, the number of species decreases poleward. However, despite centuries of research and many alternative hypotheses, the causes of such a widespread arrangement are still debated (BOLTOVSKOY; CORREA, 2017; CHAUDHARY; SAEEDI; COSTELLO, 2016; LAMANNA *et al.*, 2014; QIAN *et al.*, 2013; RODRIGUES *et al.*, 2017; ROMDAL; ARAÚJO; RAHBEK, 2013). Moreover, despite common, this pattern is not universal: for some groups it actually seems to be the inverse, the highest richness being found in mid to high latitudes (KINDLMANN; SCHÖDELBAUEROVÁ; DIXON, 2007; WILLIG; KAUFMAN; STEVENS, 2003).

Recently, a paper by Chaudhary, Saeedi and Costello (2016) proposed that, for most marine organisms, instead of a single Equatorial diversity peak, there are actually two peaks, on north and south mid-latitudes. Therefore, latitudinal gradients of marine biodiversity could be better described by two hump-shaped curves, one in each hemisphere, in what can be described as a bimodal pattern. In tropical and warm temperate south-west (SW) Atlantic Ocean, some authors apparently have detected such mid-latitude diversity peaks for different taxa (e.g. FLOETER et al., 2001; LEVINTON; MACKIE, 2013; MACPHERSON, 2002). However, few studies have recognized it (e.g. BARROSO; LOTUFO; MATTHEWS-CASCON, 2016). A more direct assessment is therefore needed to clarify the issue, particularly one focusing on groups with different evolutionary histories and ecological affinities.

Along the South American coastline, macroalgae assume important roles as ecosystem engineers, structuring biogenic reefs, rhodolith beds and canopy, being one of the richest and most abundant organisms in hard-bottom habitats (FIGUEIREDO, *et al.*, 2009;

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[3] Este capítulo foi redigido em inglês com o intuito de ser acessível ao público internacional.

FRANCINI-FILHO *et al.*, 2013; HORTA *et al.*, 2016; LIUZZI; GAPPA; PIRIZ, 2011; MARTINS *et al.*, 2012; MASI.; ZALMON, 2012; PORTUGAL *et al.*, 2016; SOARES *et al.*, 2016; SOARES; MEIRELLES; LEMOS, 2011; ZAMPROGNO; FERNANDES; FERNANDES, 2012). Remarkably, seaweeds are among the organisms that usually display unusual, often inverse, latitudinal gradients of diversity (BOLTON, 1994; KEITH; KERSWELL; CONNOLLY, 2014; KERSWELL, 2006) and some authors have already pointed the complex and bimodal nature of this pattern (ETTI; SCHILS, 2016). In the South American continent, for example, an inverse pattern has been observed in both Pacific and Atlantic coasts, for cold temperate and polar floras (LIUZZI; GAPPA; PIRIZ, 2011; SANTELICES; MARQUET, 1998). Therefore, this group of organisms seem an adequate choice to test the existence of atypical latitudinal gradients.

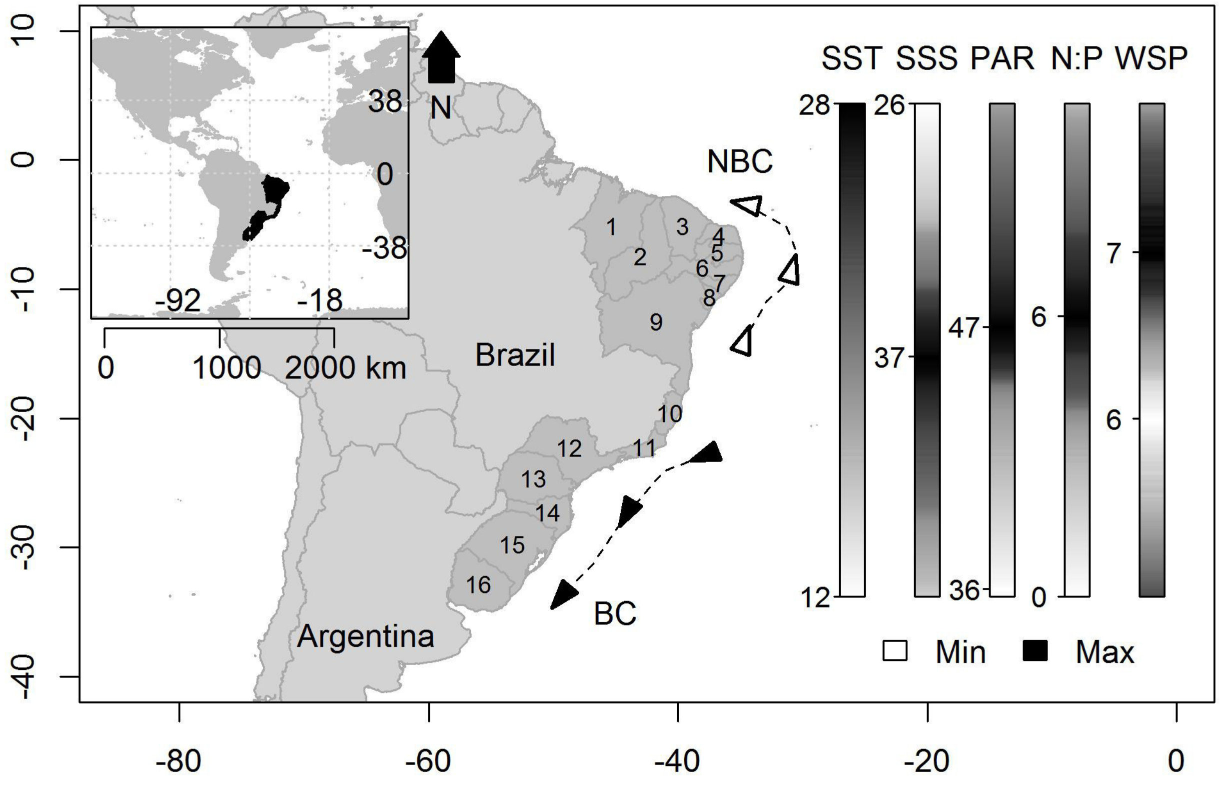
Similarly to more traditional latitudinal gradients, the possible causes of unusual patterns have also been vividly debated (KEITH; KERSWELL; CONNOLLY, 2014; KERSWELL, 2006; KIEL; NIELSEN, 2010; MATEO *et al.*, 2016; PYRON; BURBRINK, 2009; RIVADENEIRA *et al.*, 2011). Some authors have attributed at least some deviations to scale effects (e.g. WILLIG; KAUFMAN; STEVENS, 2003). Therefore, a correspondence between regional and local patterns could give support to the existence of atypical trends (CHAVE, 2013; LEVIN, 1992; SCHNEIDER, 2001; WIENS, 1989). Herein, we use such a multi-scale approach to analyse latitudinal patterns of seaweed diversity along tropical and subtropical SW Atlantic Ocean (Brazilian and Uruguayan coasts). More specifically, we test whether these organisms follow a monotonic pattern (either classic or inverse) consistently across scales, as observed in nearby floras (LIUZZI; GAPPA; PIRIZ, 2011; SANTELICES; MARQUET, P., 1998); or else if it follows a consistent hump-shaped pattern, thus agreeing with the global scheme proposed by Chaudhary *et al.* (2016). Furthermore, we investigate if this pattern could be attributed to random statistical effects (i.e. mid-domain effects) or if true environmental gradients are the main cause. Finally, we discuss how this pattern relates to the limits of floristic biogeographical regions on the SW Atlantic coast (*sensu* HORTA et al., 2001).

3.2 METHODS

3.2.1 Data collection

Macroalgae occurrence databases were constructed with data from tropical and sub-tropical South American coast, from around 2ºS to 35ºS. Along this coast, the climate ranges from hot semi-arid to temperate maritime, and the oceanographic conditions follow clear environmental gradients (FIGURE 9).

Figure 9 – Tropical and subtropical coastal states of east South America, along with gradients of oceanographic and climatic features.



Source: prepared by the author. Obs. The colour ramps of the vertical bars were constructed from a second degree Loess curves of the original environmental variables (retrieved from BioORACLE and NREL) across latitudes (α=0.75) in order to smooth the patterns (original data can be found in APPENDIX B). Black and white arrowheads depict the major flow direction of the Brazil Current and of the North Brazil Current, respectively. SST = mean minimum sea surface temperature (ºC); SSS = sea surface salinity (PSS); PAR = mean photosynthetically active radiation (Einstein/m²/day); N:P = nitrate to phosphate ration; and WSP = mean wind speed at 10m (m/s).

To quantify local richness (i.e. richness on a particular site), species lists were constructed with data from 93 locations along the South American coast (APPENDIX C). Six of these sites were surveyed in the present study by means of transects (n=3) placed on the intertidal zone of sandstone banks in the N/NE coast of Brazil (CHAPTER 4). The remaining data was based on 23 published papers or academic thesis (given that they are available online) in which authors performed punctual surveys of seaweed species (a list of the data sources is found in APPENDIX D).

During data acquisition, we avoided sites clearly within estuaries, due to their very particular floras (HORTA *et al.*, 2001). Additionally, if data on more than one survey was available in a study, one of them was randomly chosen to represent the community. Therefore, we have disregarded seasonal variations, which despite possibly important in some sites (particularly in the southern locations), were not consistently assessed in all studies. In all included surveys, authors have used either guided (along transects) or unguided (by random walking) sampling strategies, but all focused on intertidal assemblages, during limited periods of low spring tides. Thus, despite methodological differences, that sampling effort was similar among studies.

To quantify regional richness, we have considered species lists for 16 Uruguayan and Brazilian coastal states (APPENDIX E) based on Menezes et al. (2015) and Guiry and Guiry (2016). The northernmost and southernmost states wherein a given species was recorded were considered the limits to its distribution. We assumed that species distribution was continuous between recorded latitudinal limits (LIUZZI; GAPPA; PIRIZ, 2011). We acknowledge that political boundaries are artificial and not necessarily ecologically meaningful, however data on distribution of South American seaweed species is often inexact, with taxa frequently appearing as globally distributed. Therefore, we have used political limits as a proxy for species distributions, and used the coordinates of each state coastline mid-point in calculations. It is also noteworthy that many species can extend its distribution range beyond tropical and warm temperate SW Atlantic. Nevertheless, we have assumed that the Amazon and Plata rivers constitute ecophysiological barriers for dispersion (HORTA *et al.*, 2001), and treated the studied assemblages as a sufficiently independent flora (HOEK, 1984).

Local and regional databases listed, respectively, 379 and 711 species, and were carefully checked for consistency in nomenclature, and updated following Guiry and Guiry (2016). Groups that are known to be poorly sampled along SW Atlantic, such as the non-articulated calcareous algae, were excluded from the analyses. The final lists (APPENDICES C and E) included classes Phaeophyceae, Ulvophyceae, Bangiophyceae and Florideophyceae except for encrusting red algae species (subclass Corallinophycidae). These classes are the richest among brown, green and red macroalgae.

3.2.2 Patterns of diversity

Linear models relating species richness and latitude were constructed with both local and regional datasets. These models tested either a monotonic variation in species richness with latitude, or, based on the possibility of mid-latitude diversity peaks, a parabolic unimodal pattern (i.e. a polynomial quadratic model). These models were evaluated based on explanatory power (R^2) and p-value. Additionally, the relationship between local and regional richness was evaluated through a simple regression analysis by ordinary least squares (JANKE; TINSLEY, 2005).

3.2.3 Causes of gradients

Diversity gradients may be a product of random mid-domain effects, without real ecological causes (COLWELL; HURTT, 1994). In the present study, these aleatory effects were treated as expected outcomes of random models of species distribution (COLWELL; RAHBEK; GOTELLI, 2005; COLWELL; LEES, 2000; ZAPATA; GASTON; CHOWN, 2003). Hence, we tested whether our observations deviate from the predictions of these models, following the approach of Currie and Kerr (2008). Considering the high level of variation among sites at local scale, the adequacy of mid-domain explanations was assessed only among coastal states (i.e. at regional scale).

The expected species richness under the mid-domain effect was estimated via ‘rangemodelR’ package (MARATHE, 2016), in R 3.3.2. Observed and expected values were compared following Currie & Kerr (2008). Differences in the slope of expected and observed regression lines were compared via t-test. The variance explained by random and linear models were compared by their coefficients of determination. A D’Agostino test was used to analyse if the distribution of the observed data is symmetrical (i.e. skewness = 0). And an Anderson-Darling test to investigate if the distribution of the observed and expected values are identical. Therefore, we tested predictions 1, 2, 4 and 5 of the mid-domain hypothesis, as presented by Currie & Kerr (2008).

Alternatively, we tested whether environmental features could explain the observed pattern through linear models. First, to test the proposition by Chaudhary, Saeedi and Costello (2016) that extreme temperatures are a possible cause for the latitudinal gradient, we analysed if minimum sea surface temperature (SST) is related to seaweed species richness via ordinary least squares (OLS) regression. Then, we assessed the combined of effects of temperature and four other environmental parameters: sea surface salinity (SSS), mean photosynthetically active radiation (PAR), nitrate:phosphate ratio (N:P) and wind speed at 10 m. Additionally, both models were also run including a measure of coastline length, in order to adjust for the species-area relationship (LOMOLINO, 2000).

These environmental variables were chosen to represent eco-evolutionary drivers traditionally important to seaweed development, reproduction and distribution (KIRST, 1990). With the exception of wind speed, all were acquired directly or derived from the Bio-ORACLE database (TYBERGHEIN *et al.*, 2012). Wind data was retrieved from global ocean wind speed maps produced by the National Renewable Energy Laboratory (NREL) (available at www.nrel.gov). Coastline length for each coastal state was measured by the authors on vector files retrieved from GADM database of global administrative areas version 2.8 (available at www.gadm.org).

Considering that these variables may be strongly correlated to each other (FIGURE 9), their association to seaweed diversity was assessed by principal component (PCA) regression (JOLLIFFE, 2002). In this analysis, instead of the original environmental variables, we use the values of their principal components (PCs), calculated for each site (i.e. political unit) from the standardized environmental data, to explain the variations in seaweed richness via ordinary least squares multiple regression (JOLLIFFE, 2002). However, to ensure a reduction in multicollinearity, the full set of components should not be included in the analysis (JOLLIFFE, 2002). Hence, in the present study we have selected the subset of components which produced the best possible model of seaweed richness according to the Akaike Information Criterion (AIC). This optimal subset was selected by stepwise simulations of the data, hence we avoided using only the components with the highest eigenvalues, which, despite being the most important aspects of the explanatory variables, may not be related to the response variable (JOLLIFFE, 2002).

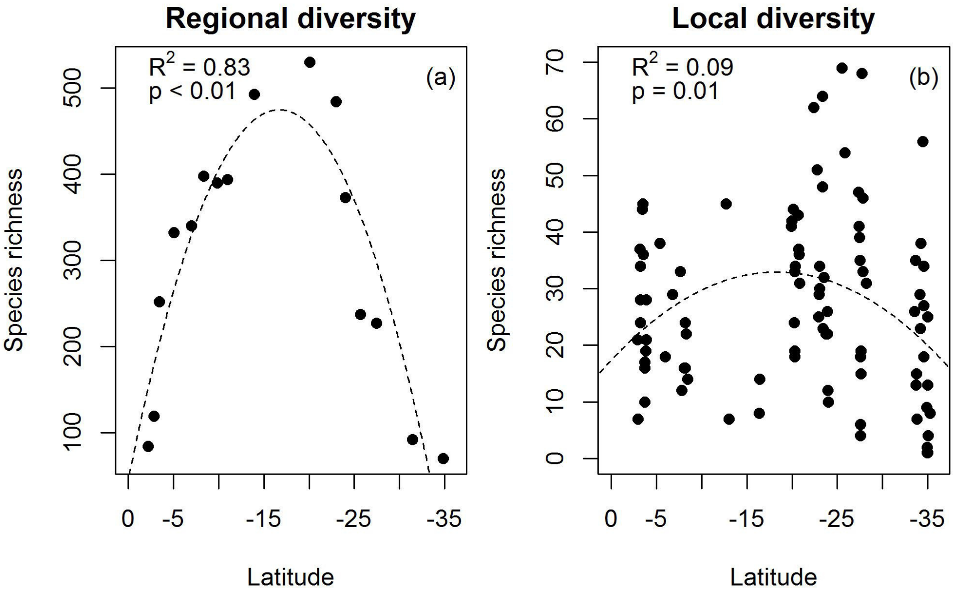
Both the OLS and the PCA models were constructed assuming that the correlations between species richness and environmental parameters were linear, except in the case of temperature, which was considered unimodal after a visual inspection of the data and following the results of previous studies (KEITH; KERSWELL; CONNOLLY, 2014). Therefore, instead of the original variable, a second-order orthogonal polynomial of the temperature was included in both the OLS model and when extracting the principal components, to allow the assessment of its non-linear effects.

Finally, the explanatory power of the environmental features was compared to both the random model and the baseline latitudinal variation. The adequacy of all these models was assessed by checking its residuals homoscedasticity (Breusch-Pagan test) and normality (Shapiro-Wilk test).

3.3 RESULTS

Both regional and local diversities showed a clear unimodal pattern along the SW Atlantic coast, with richness increasing from the extremes to the middle of the considered latitudinal gradient (FIGURE 10).

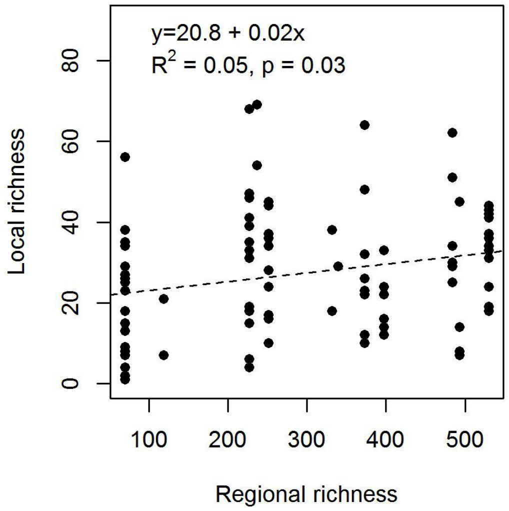
Figure 10 – Seaweed species richness vs. latitude in tropical and subtropical SW Atlantic ocean.



Source: prepared by the author. Obs. Local (a) and regional (b) scales are shown. At both scales a polynomial quadratic model could be fitted to the data.

At the regional scale, richness was higher around 16.8ºS. The data could be fitted to a quadratic polynomial model ($F_{2,13} = 32.2$, $p < 0.0001$), explaining 83% of the observed variance (FIGURE 10a). A similar model could also be applied at local scale ($F_{2,90} = 4.6$, $p = 0.01$), explaining 9.3% of the observed variance, and predicting a richness peak around 17.5ºS (FIGURE 10b). This pattern remained even after the removal of two apparent outlier sites (i.e. with 68 and 69 species) from the analysis. Finally, there was a significant positive relationship between regional and local richness (linear regression $r = 0.23$, $F_{1,88} = 4.8$, $p = 0.03$). The regional number of species explained around 5% of the variance in local number of species (FIGURE 11).

Figure 11 –Significant positive relationship between regional and local seaweed species richness in tropical and subtropical SW Atlantic Ocean.

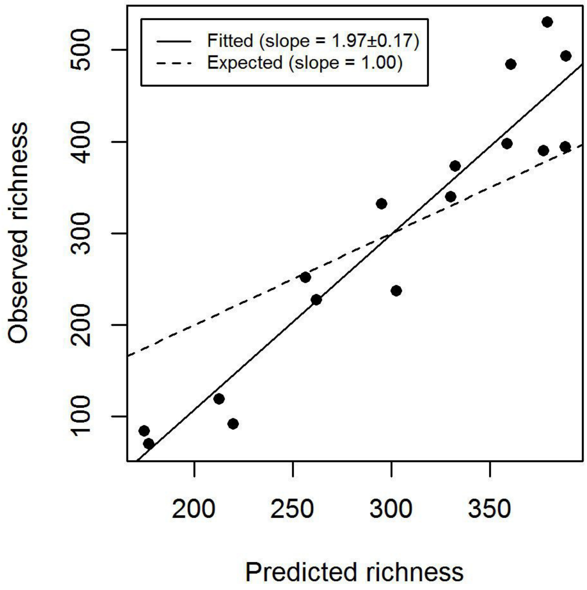


Source: prepared by the author.

The observed pattern at regional scale showed important deviations from the expected by random mid-domain models. Despite a significant relationship between observed and predicted richness (linear regression $R^2 = 0.90$, $F_{1,14} = 130.4$, $p < 0.001$), and a similar probability distribution between these two parameters (standardized Anderson-Darling = 0.99, $p = 0.13$), which was also symmetric in shape (D'Agostino $Z = -0.32$, $p = 0.75$), the slope of the regression line between observed and predicted values was steeper than expected (i.e. significantly larger than 1, $t_{14} = 5.56$, $p < 0.001$) (FIGURE 12). Furthermore, the random model could explain only 69% of the observed variance, considerably less than the fitted quadratic polynomial model, which explained 83% of the variation among latitudes (FIGURE 13a-b).

Regarding environmental features, seaweed richness was not related to coastline length, neither alone, nor combined with the other variables ($p \geq 0.19$ in all cases). Minimum sea surface temperature was a better predictor, exhibiting a significant ($F_{2,13} = 8.919$, $p = 0.004$) non-linear (unimodal) relationship with species richness (that could be described by the quadratic polynomial function $Y = -399.15X^2 + 201.55X + 300.94$). Nevertheless, despite significant, the link between temperature and seaweed richness was relatively weak when compared to the random model (i.e. $R^2 = 0.58$) (FIGURE 13c).

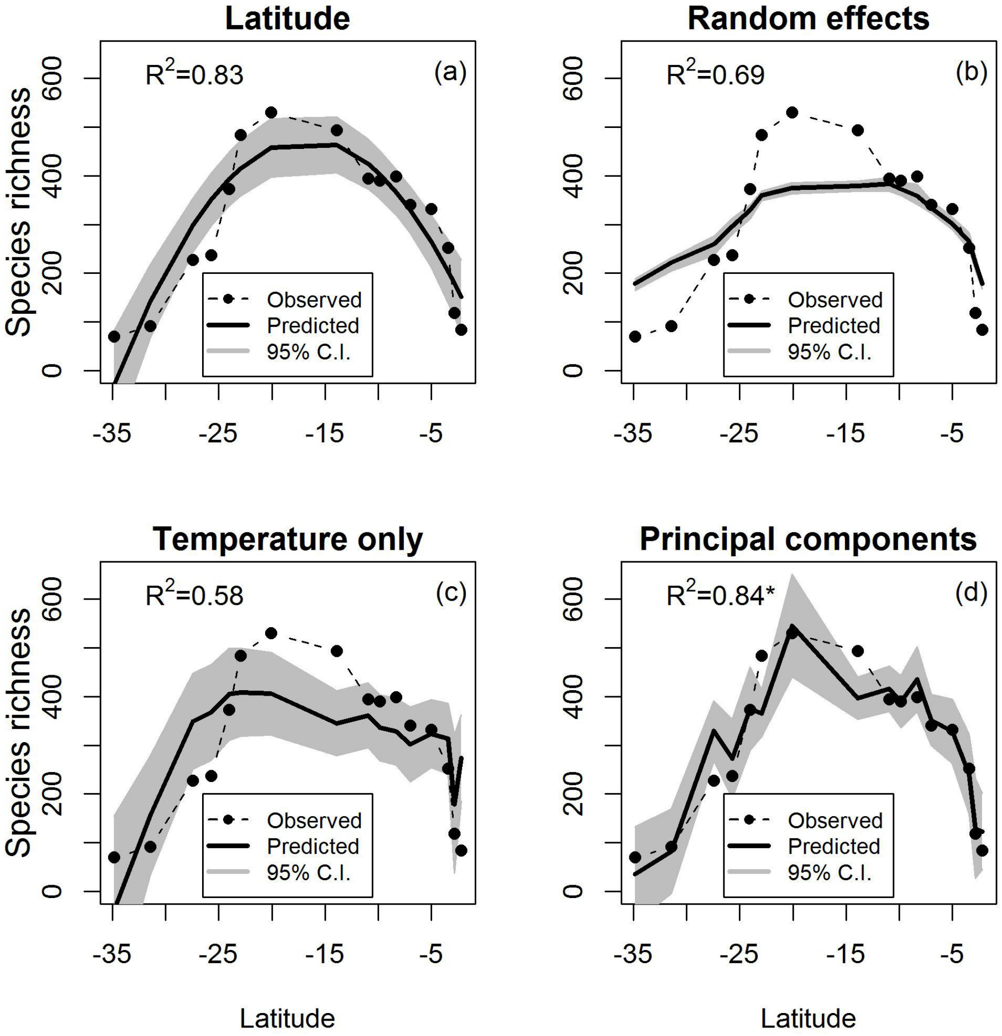
Figure 12 – Significant positive relationship between regional seaweed species richness, and the values predicted by a mid-domain effect model.



Source: prepared by the author. Obs. Despite the significant relationship ($R^2 = 0.90$, $F_{1,14} = 130.4$, $p < 0.001$), the fitted slope line is steeper than expected ($t_{14} = 5.56$, $p < 0.001$), suggesting relevant departures from random.

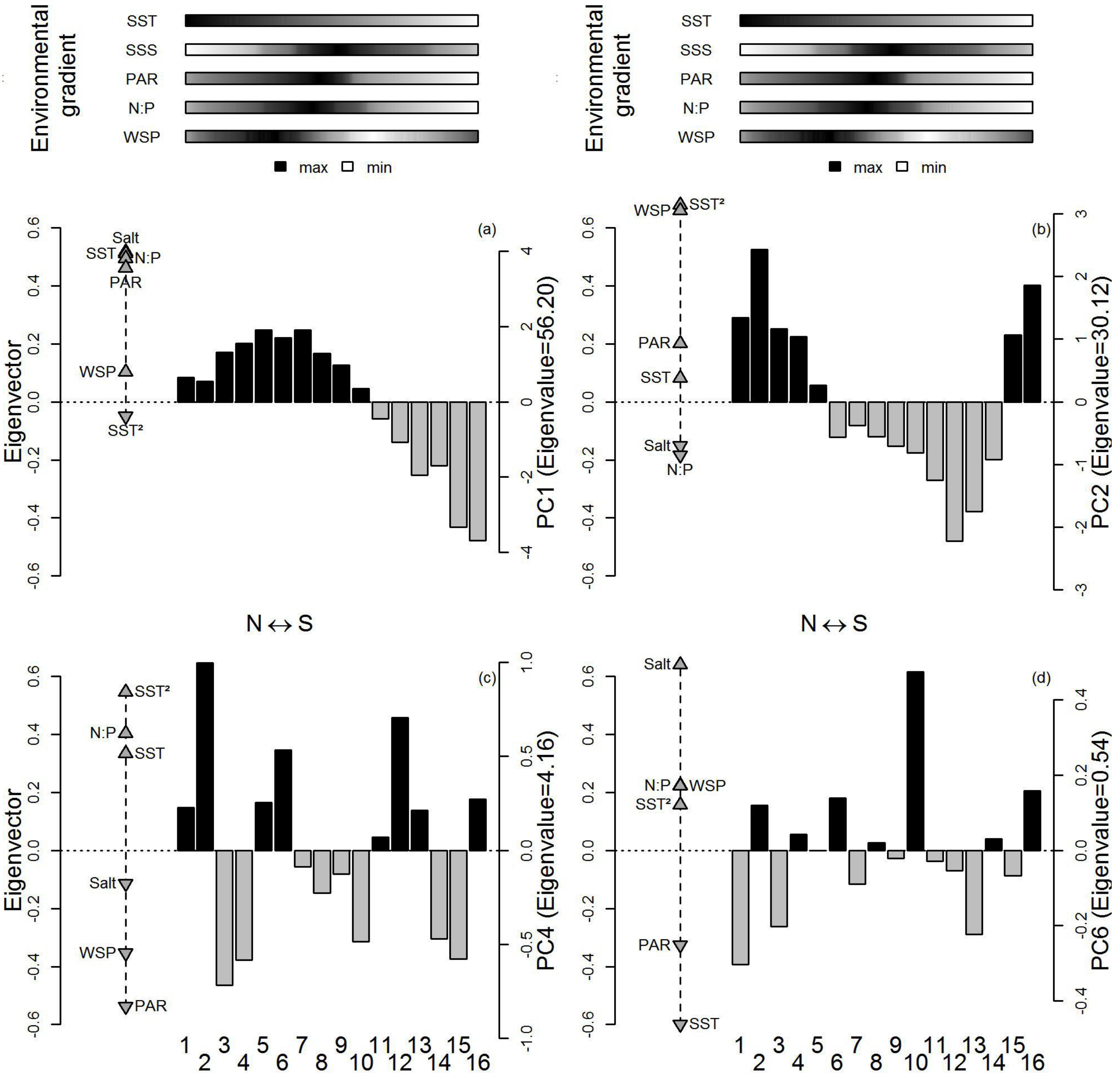
The combined effect of all five environmental variables (SST, SSS, PAR, N:P and wind speed), as assessed via PCA regression, was a better option (FIGURE 13d), resulting in a model that could explain most changes in seaweed diversity (adjusted $R^2 = 0.84$), without relevant problems of residuals distribution (which were normally distributed and homoscedastic according to the Shapiro-Wilk and the Breusch-Pagan test, respectively). The stepwise simulations showed that the subset of environmental principal components which resulted in the model with the lowest AIC, and therefore with the largest predictive power, included only PCs 2, 1, 6 and 4 (graphically depicted in FIGURE 14). When combined, these components had the strongest association with seaweed richness, irrespective of their individual relationships with algal diversity (summarized in Table 1), or even their contribution to the overall environmental variation (Table 2). In terms of the original variables, the final model can be expressed as: $S_{algae} = 300.9 - 31.6\,SST^2 - 181.7SST + 233.5SSS + 84.6N{:}P - 69.5PAR + 38.0WIND$.

Figure 13 – Four explanatory models to seaweed species richness along tropical and subtropical SW Atlantic ocean.



Source: prepared by the author. Obs. (a) baseline latitudinal variation, (b) random mid-domain effect, (c) temperature as the only explanatory variable, and (d) linear combinations of five environmental features (temperature, salinity, PAR, nitrate:phosphate and wind speed), as derived via Principal Component (PCA) regression, used as explanatory variables. * adjusted R^2.

Figure 14 – Barplots of components 1 (a), 2 (b), 4 (c) and 6 (d), as generated via Principal Component Analysis of five environmental features (temperature, salinity, PAR, nitrate:phosphate and wind speed) along tropical and subtropical SW Atlantic Ocean.



Source: prepared by the author. Obs. The arrowheads represent the eigenvectors showing the magnitude and direction of the influence of each environmental feature. Numbers represent the coastal states depicted in Figure 9: 1 = Maranhão, 2 = Piauí, 3 = Ceará, 4 = Rio Grande do Norte, 5 = Paraíba, 6 = Pernambuco, 7 = Alagoas, 8 = Sergipe, 9 = Bahia, 10 = Espírito Santo, 11 = Rio de Janeiro, 12 = São Paulo, 13 = Paraná, 14 = Santa Catarina, 15 = Rio Grande do Sul, 16 = Uruguay. SST = mean sea surface temperature (ºC); SSS = sea surface salinity (PSS); PAR = mean photosynthetically active radiation (Einstein/m²/day); N:P = nitrate to phosphate ration; and WSP = mean wind speed at 10m (m/s).

Table 1 – Regression of the seaweed diversity along tropical and subtropical SW Atlantic Ocean versus linear combinations (PCs) of environmental features (SST, SSS, PAR, N:P and wind speed), constructed via Principal Component Analysis.

Variable	**Estimated coefficient (standard error)**
Intercept	300.94 (15.17)*
PC1	43.10 (8.53)*
PC2	-76.40 (11.66)*
PC4	-46.54 (31.38)
PC6	303.51 (86.98)*
R^2 / Adjusted R^2 / $F_{4,11}$	0.88 / 0.84 / 20.71*

Source: prepared by the author. Obs. The model shown, including only PC1, PC2, PC4 and PC6, has the best explanatory power according to the Akaike Information Criterion (AIC). * Significant at P = 0.05

Table 2 – Principal Component Analysis of environmental features along tropical and subtropical SW Atlantic Ocean.

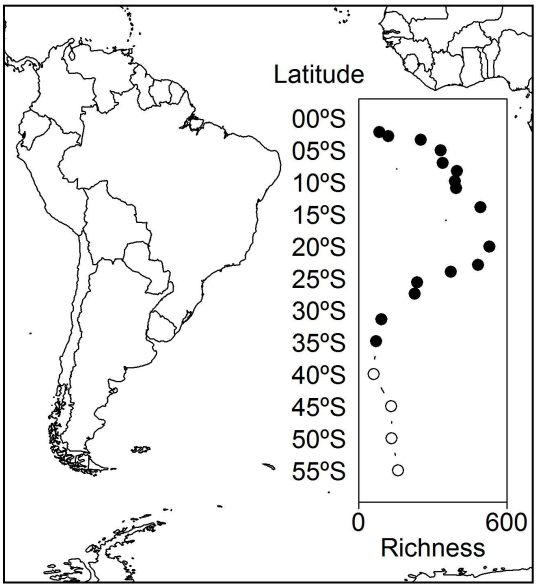
Variable	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**
SSS	0.52	-0.15	0.08	-0.11	-0.53	0.64
SST	0.51	0.08	-035	0.33	-0.37	-0.60
SST^2	-0.05	0.68	0.45	0.55	-0.10	0.16
N:P	0.49	-0.18	-0.08	0.40	0.71	0.22
PAR	0.46	0.20	0.56	-0.54	0.20	-0.33
WSP	0.10	0.66	-0.59	-0.35	0.17	0.22
% of environmental variance	56.20	30.12	6.72	4.16	2.26	0.54
% of algae diversity variance*	27.18	45.78	0.32	2.35	0.15	12.97

Source: prepared by the author. Obs. Both the eigenvectors of each Principal Component (PC) and their proportional contribution to the total environmental variance are shown. It is also depicted their contribution to the variance of seaweed diversity along this coastline, as estimated by Principal Component Regression. SST = mean sea surface temperature; SSS = sea surface salinity; PAR = mean photosynthetically active radiation; N:P = nitrate to phosphate ration; and WSP = mean wind speed at 10m. *Estimated by Principal Component Regression

3.4 DISCUSSION

Our results support the existence of a hemispherical unimodal pattern for seaweed diversity, since it has been consistently observed in the SW Atlantic Ocean (FIGURE 15). They also support a global bimodal pattern of diversity, as proposed by Chaudhary, Saeedi and Costello *et al*. (2016) for marine organisms. Robust local and regional patterns indicate that this is not an artificial trend, caused by differences in sampling effort along the South American coast. Furthermore, previous studies have reported mid-latitude diversity peaks for other SW Atlantic marine organisms — such as corals (LEÃO; KIKUCHI; TESTA, 2003), fishes (FLOETER *et al*., 2001), cephalopods (MACPHERSON, 2002), crabs (LEVINTON; MACKIE, 2013) and prosobranch snails (BARROSO; LOTUFO; MATTHEWS-CASCON, 2016). This coincidence suggests the existence of a more general diversity trend. Given the large ecological and phylogenetic particularities of these organisms, unimodal patterns do not seem to be the result of a single factor, especially of local environmental conditions around the diversity peak, as have been previously proposed (BARROSO; LOTUFO; MATTHEWS-CASCON, 2016).

Figure 15 – Latitudinal gradient of seaweed diversity along the Southwest Atlantic Ocean.



Source: prepared by the author. Obs. Black dots are the richness values observed in the present study. White dots represent the richness values observed by Liuzzi *et al*. (2011) for colder southern floras.

Since our results corroborate the hemispheric unimodality of marine diversity distributional patterns, usual explanations for latitudinal gradients may have to be revised when dealing with Atlantic seaweeds. Classical mid-domain effects cannot explain either a global bimodal pattern or the observed regional trend. Some authors have proposed that, besides geographic spaces, mid-domain effects could also apply to other environmental features, such as temperature (LETTEN; LYONS; MOLES, 2013). Per this idea, a random distribution of species ranges within a given temperature interval would have its highest diversity around the middle point. Considering the climatic gradients in our planet, this could actually result in a bimodal pattern (LETTEN; LYONS; MOLES, 2013). However, our results suggest a complex relationship among environmental variables and seaweed richness, and also that seaweed species distribution cannot be adequately described by random models. Therefore, other approaches should be investigated.

The observed significant albeit non-linear relationship of temperature and seaweed diversity may be due to the removal of sensible species in extreme environments. Such unimodal pattern have already been observed for tropical seaweeds (KEITH; KERSWELL; CONNOLLY, 2014), and it contradicts a common view that higher temperatures lead to faster evolutionary rates, resulting in more diverse assemblages near the Equator (BROWN., 2014). However, as reinforced by our evidences, temperature alone explains relatively little of seaweed diversity variations, despite its importance. Other studies, working with both mean SST and SST range (as opposed to minimum SST adopted in the present paper) have also detected such a small correlation between temperature and seaweed richness (KEITH; KERSWELL; CONNOLLY, 2014), nevertheless the effects of other variables on this relationship have not yet been assessed.

In the present study, we used a principal component analysis to assess the joint relationship of five environmental variables on the SW Atlantic seaweed richness, including temperature, salinity, PAR, N:P ratio and wind speed. The results pointed that components 2, 1, 6 and 4, in this order, were the most important to this relation, explaining 84% of the variation. These PCs can be interpreted as follows: component 2 was largely influenced by wind speed and extremes of temperature (both high and low, as represented by SST^2), and clearly separated the species-rich central states from the impoverished peripheral ones (as have been shown in Fig 14a), thus representing a gradient of extreme conditions. Component 1 received a large contribution of minimum SST, PAR, salinity and nutrients, and separated northern from southern states (Figure 14b), hence it represented a latitudinal gradient of the environmental conditions. Component 6, as the least contributor to environmental variance, resulted in a complex pattern of coastal states, probably changing in accordance with local environmental features, but consistently separating neighbour localities according to a conflicting influence of temperature and salinity (FIGURE 14c). And finally, component 4, despite also displaying an apparently complex but consistent pattern (FIGURE 14d), is significantly associated to annual cumulative rainfall along the studied coastline (APPENDIX F). Together, these four components explained as much of the algae richness variance as the baseline latitudinal gradient (84% and 83%, respectively).

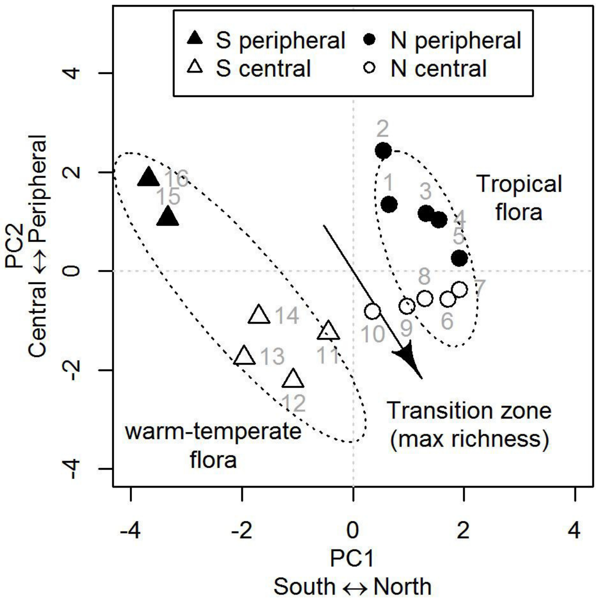
The final model (expressed by the original environmental data) suggest that the seaweed species richness was negatively related to temperature and PAR, but positively related to salinity, N:P ration and wind speed. Therefore, it suggests an important influence of environmental features to the establishment of seaweed diversity along the SW tropical and subtropical Atlantic Ocean. However, considering the complexity of the possible combinations of these factors and resources (ETTI; SCHILS, 2016), it may be more useful to interpret the patterns of the macroalgae diversity as related to the individual PCs. Hence, the highest seaweed species richness was observed in less extreme environments in terms of wind speed and temperature (PC2). Within the same environmental settings, northern states were richer than their southern counterparts (PC1), maybe due to the northward transport of cold-water species by oceanic currents (discussed below). Then the influence of local conditions became stronger, and sites with combining moderate temperatures with high salinities had the highest richness (PC6). Finally, there was a variation in richness that may be attributed to the heterogeneous distribution of rain along the coastline (PC4), with rainier sites being generally poorer in terms of diversity. Hence, the combination of a mild climate, a somewhat northern (and sometimes downstream) position, and a set of local environmental conditions that include low rainfall and high salinity characterize the area sustaining the richest seaweed flora on the SW Atlantic Ocean. It is noteworthy that, in this ocean basin, the Intertropical Convergence Zone is one of the single most important phenomena influencing this particular combination of environmental features (SCHNEIDER; BISCHOFF; HAUG, 2014).

It is noteworthy that the large importance of component 2 suggests that wind speed is a relevant driver of seaweed diversity. This variable is rarely included in studies of latitudinal gradients, despite its worldwide large scale patterns (YOUNG *et al*. 2011). On coastal areas, wind drives currents and wave energy, considerably affecting oceanographic conditions (PIANCA; MAZZINI; SIEGLE, 2010; SIMPSON; SHARPLES, 2012; TALLEY *et al.*, 2011). Previous research reported detrimental effects of the wind speed on populations of SW Atlantic marine primary producers, including seagrass and seaweeds (e.g. BARROS; ROCHA-BARREIRA, 2014; CARNEIRO; PEREIRA; MATTHEWS-CASCON, 2016; NETO et al., 2015). In the present study, we have detected an apparently positive relationship of wind speed and seaweed richness (according to our final model expressed in terms of raw environmental variables), that would contradict the previous data. Nevertheless, wind seems to be a complex factor, and among all the environmental features considered herein, it was the only one displaying both its maximum and minimum values around the middle point of the coastline (FIGURE 9), thus without exhibiting a strong gradient across latitudes. In any case, between these two extremes, the observed diversity peak appeared dislocated toward the area with slower winds. Therefore, irrespective of model coefficients, the high number of macroalgae species in this region apparently benefited from a calmer environment, as discussed above.

The Principal component analysis of the environmental variables, particularly the first 2 explicative axes, resulted in an arrangement of coastal states very similar to the one obtained by Horta *et al.* (2001), who worked with the composition of seaweed species and genera (FIGURE 16). In their work, these authors found a northern tropical flora, a southern warm temperate flora, and a transition zone in between (HORTA *et al.*, 2001). The same pattern can be observed in the PCA analysis, with the transition zone in the mid-latitude states of Bahia and Espírito Santo (points 9 and 10 in FIGURE 16, respectively), which is also the region with the highest diversity. Furthermore, the characterization of central and peripheral coastal states, used in the interpretation of component 2, may not be totally artificial. The distinction between these groups occurs approximately 1300 km to both north and south of the transition zone. This suggests that the observed unimodal pattern may also reflect the seaweed biogeography, with the transitional area congregating representatives of both north and south provinces.

In terms of individual species, biodiversity hotspots, such as the richness peak observed in the present study, may be regarded as 1) centres of accumulation; 2) centres of distribution overlap; or 3) centres of origination (BOWEN, Brian W *et al.*, 2013). The overlap hypothesis has been used to explain the singular composition of the seaweed flora in the SW Atlantic transition zone (HORTA *et al.*, 2001). Notwithstanding, our results suggest a decrease in seaweed diversity in harsher environments, thus they apparently favour a centre of origination model. It is important to note, however, that both roles are not mutually exclusive. In fact, they often act together structuring patterns of biodiversity, in what has been called biodiversity feedback (BOWEN *et al.*, 2013).

Figure 16 – Scatterplot of Principal Components 1 and 2, derived from a Principal Component Analysis of environmental features (temperature, salinity, PAR, nitrate:phosphate and wind speed) along tropical and subtropical SW Atlantic Ocean.



Source: prepared by the author. Obs. The components separated the political states along this coastline into a tropical and a warm temperate group, with a transition zone in between. A similar pattern was observed by Horta *et a*l. (2001) working with seaweed species composition. The political units are numbered sequentially form northernmost (1) to southernmost (16)

One of the main features in the transition zone is the Abrolhos bank (LOPES; CASTRO, 2013). It has a large influence on regional oceanography, is the home of the richest coral fauna in the whole South Atlantic Ocean, and sustains the largest known rhodolith bed in the world (LOPES; CASTRO, 2013). In the case of corals, it has been proposed that Abrolhos volcanic mounts acted as refuges against the low sea level during the Last Glacial Maximum (LGM) (LEÃO et al., 2010; LEÃO; KIKUCHI; TESTA, 2003). The LGM exerted a strong influence on many marine floras around the world (HOARAU *et al.*, 2007; LI; HU; DUAN, 2016; PROVAN; WATTIER; MAGGS, 2005). It also caused marked changes in the South American continent, and the low sea levels during this period probably exposed its entire continental shelf (CLAPPERTON, 1993; LEITE *et al.*, 2016). If the refuge hypothesis proves to be true for corals, it may also have influenced the origin of SW Atlantic macroalgae.

Oceanic currents can influence the dispersion of organisms and the species composition of seaweed floras (WERNBERG *et al.*, 2013). The eastern South American coast is mainly influenced by two surface currents: the primarily northward flowing North Brazil Current (NBC), and the primarily southward flowing Brazil Current (BC) (PETERSON, R. G.; STRAMMA, 1991). These currents diverge into different directions around 14ºS (RODRIGUES; ROTHSTEIN; WIMBUSH, 2007) – also near the diversity peak and the Abrolhos bank. Therefore, in the current interglacial period, the NBC and the BC may have been carrying species from the Abrolhos towards the north and the south, respectively. In this process, the seaweeds encounter fast winds and extremely hot or cold waters, which remove the less tolerant species, and thus creates the observed latitudinal pattern. This proposal, although speculative, seems to be in accordance with our results. On the other hand, the possibility of a biodiversity feedback still holds, with the transition zone also possibly acting as an overlap centre (as suggested by HORTA *et al.* 2001) if one considers that the NBC may suffer from episodic changes of direction (KNOPPERS; EKAU; FIGUEIREDO, A. G., 1999; MATANO; PALMA; PIOLA, 2010; PETERSON, R. G.; STRAMMA, 1991). Thus, this current may possibly carry cold-water species into the north, and hence contribute to the observed richness peak. Such a possibility, though, needs further studies to be properly verified.

The consistent multiscale hemispheric unimodal pattern of diversity observed in the present work for tropical and warm temperate SW Atlantic seaweeds is different from those usually reported for other phycoflora around the world, which was frequently interpreted as inverse across latitudes (BOLTON, 1994; KERSWELL, 2006; KONAR *et al.*, 2010; LIUZZI; GAPPA; PIRIZ, 2011; SANTELICES; MARQUET, 1998). However, this apparently inverse pattern may also have a unimodal aspect. Their inverted appearance may be due to the southern position of their richness peaks: whereas in tropical and warm temperate south-west Atlantic Ocean (present study) this peak was around latitude 17ºS, in these other previous studies it was always below 30ºS (Table 3). Further south, there was often a consistent decrease in species richness, hence a unimodal pattern apparently could also characterize their diversity gradients. In any case, our results are more closely related to the idea proposed by Chaudhary, Saeedi and Costello (2016), corroborating a bimodal global pattern for marine organisms. Such a pattern, irrespective of shape, seems to be the result of a complex interaction of environmental and evolutionary drivers (ETTI; SCHILS, 2016). Therefore, instead of a single explanation, future studies should include phenomena at multiple spatial and temporal scales to uncover the role of distinct processes that result in the bimodal diversity pattern.

Table 3 – Studies on the latitudinal gradient of marine macroalgae diversity, with the approximate location of their respective richness peaks. In most cases there was a consistent decrease in the number of species south of the peak, thus suggesting a unimodal pattern.

Location	**Richness peak latitude**	**Southward decrease**	**Reference**
Global	From 30º to 50º N and 30º to 50º S	YES	BOLTON, 1994
Global	35º N and 35º S	YES	KERSWELL, 2006
Global	35º N and 35º S	YES	ETTI; SCHILS, 2016
Northern hemisphere	From 45º to 60º N	YES	KONAR e*t al*., 2010
Atlantic coast of Europe	30º N	YES	SANTELICES; MARQUET, 1998
Pacific coast of South America	60º S	NO	SANTELICES; MARQUET, 1998
Argentina	47º S	NO	LIUZZI e*t al*., 2011
Atlantic coast of South America	17ºS	YES	Present study

Source: prepared by the author.

4 CONCLUSÃO

Na presente tese buscou-se testar as seguintes seis hipóteses:

1. Abordagens multi-escala geram descrições mais robustas de comunidades marinhas bentônicas de regiões entremarés.
2. Recifes de arenito, devido ao relevo predominantemente plano, exibem zonação vertical pouco intensa.
3. Escalas mais amplas afetam mais a riqueza de espécies em ambientes de recifes de arenito.
4. Os recifes de arenito ocupam uma posição intermediária entre recifes de coral e os costões rochosos de ambientes temperados em termos de padrões de diversidade.
5. A diversidade de macroalgas descreve uma relação parabólica (unimodal) com a latitude ao longo da costa leste tropical da América do Sul, como previsto por modelos recentes (i.e. CHAUDHARY; SAEEDI; COSTELLO, 2016).
6. Fatores climáticos influenciam mais do que o esperado por modelos aleatórios na formação de gradientes latitudinais ao longo da costa leste tropical da América do Sul.

Os resultados da pesquisa sustentaram total ou parcialmente todas as seis, porém algumas precisam ser reformuladas. No caso da hipótese dois, a zonação vertical não foi pouco intensa, pelo contrário. Mas ela de fato provocou menos variações que as modificações horizontais nos recifes de arenito. A hipótese três foi corroborada, porém ao mesmo tempo que escalas mais amplas afetam a riqueza de espécies em recifes de arenito, escalas mais locais parecem estruturar seus padrões de diversidade. Por fim, em relação à hipótese quatro, apesar de ser possível enxergar uma posição intermediária dos recifes de arenito em termos das regras de montagem das comunidades marinhas de fundo consolidado, é preciso ter em mente que foram analisados apenas alguns dos diferentes aspectos da diversidade nesses ecossistemas, e não há razões para esperar que o mesmo padrão seja mantido para a totalidade da sua biodiversidade (por exemplo, no caso da diversidade taxonômica ou genética).

A partir dos resultados ora apresentados, novos estudos poderão refinar o conhecimento sobre os ambientes marinhos de fundo consolidado do Brasil, inclusive do ponto de vista prático. Por exemplo, os recifes de arenito da costa equatorial brasileira aparentemente possuem uma composição de espécies menos estável em escalas mais amplas do que os recifes de coral; porém a combinação dessas espécies na formação de comunidades individuais está mais sujeita à influência de fatores biológicos típicos de escalas locais (e uma menor influência de gradientes físicos diretos) do que em costões rochosos temperados. Como esses ambientes vêm sendo modificados pela ação humana, já tendo ocorrido uma diminuição significativa na riqueza de alguns pontos (Portugal et al., 2016), são necessárias estratégias de conservação para a manutenção dos serviços ambientais por eles prestados. Nossos resultados sugerem então que, para serem efetivas, essas estratégias devem considerar tanto as características específicas de cada localidade (que estruturam os padrões de entropia), quanto dinâmica de trocas entre elas (que influenciam a riqueza de espécies). Portanto, ações restritas, como a criação de unidades de conservação isoladas, não deverão ser capazes de evitar novas perdas de diversidade. Devido às semelhanças entre os padrões locais de diversidade, sugere-se que os recifes de coral, inclusive por serem muito mais estudados, podem fornecer modelos adequados para a elaboração de estratégias eficientes de conservação dos recifes de arenito brasileiras.

Por outro lado, a combinação de escalas locais e regionais permitiu a detecção e confirmação de um padrão unimodal para a riqueza de espécies de macroalgas ao longo da costa do oceano atlântico sudoeste. Esse padrão hemisférico concorda com o padrão global bimodal que vem sendo detectado para organismos marinhos. Porém, mais especificamente, ele sugere a existência de gradientes de diversidade biológica claros ao longo da costa brasileira, o que tem implicações para a manutenção da diversidade marinha brasileira. Como foi detectada uma relação significativa entre a riqueza local e o banco regional de espécies, esses gradientes também precisam ser considerados na elaboração de estratégias de conservação da biodiversidade do país. Com isso, o fluxo de organismos e genes entre *hotspots* de diversidade ao longo da costa brasileira (como o Abrolhos, por exemplo) e as regiões mais periféricas precisa ser urgentemente avaliado, principalmente considerando-se o contexto atual de mudanças climáticas, que poderão ter consequências em escalas globais

Por fim, no presente estudo foram consideradas apenas variações em escalas espaciais. No Brasil, abundam estudos de curto prazo, porém ainda são incipientes os esforços de coleta permanente de dados biológicos. Isso impede a avaliação da importância relativa das múltiplas escalas temporais, o que, de acordo com nossos resultados, é essencial para a compreensão do funcionamento dos ecossistemas. Portanto, apesar das dificuldades logísticas e operacionais de se fazer um estudo longo, é imperativo que se ampliem os prazos de aquisição de informações. Inclusive para que também seja possível comparar variações espacias e temporais nas comunidades biológicas, o que permitirá um compreensão ainda mais adequada do funcionamento das mesmas, com consequências extremamente benéficas para a sua conservação e, portanto, para as sociedades humanas que delas dependem.

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APENDICE A – COMUNIDADES BENTÔNICAS EM RECIFES DE ARENITO[4]

Tabela 4 – Cobertura média em três estratos (superior, médio e inferior) de seis recifes de arenito na costa do estado do ceará. Continua.

Municipio	CAUCAIA									TRAIRI									Média	%
Recife	1			2			**3**			4			5			6				
Estrato	S	M	I	S	M	I	S	M	I	S	M	I	S	M	I	S	M	I		
Acanthophora spicifira	0	0	0	0	0	0	0	0	0	0	0,4	0	0	4,1	1,2	0	0,6	6	0,68	1,32
Amansia multifida	0	0	0,5	0	0	0	0	0	0	0	0	1,6	0	0	3,1	0	0	0	0,29	0,56
Balanus amphitrite	0	0	0	0	0	0	0	0	0	0	0	0	7,1	0	0	0	0	0	0,39	0,76
Bostrychia tenella	0	0	0	0	0	0	0	12,7	0	0	0	0	0	0	0	0	0	0	0,71	1,36
Brachidontes exustus	16,7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,93	1,79
Bryopsis pennata	0	0	0	0,1	0	0	0	0	0	0	0	0	0	0	0,1	0	0	0	0,01	0,02
Bryothamnion seaforthii	0	0	2,5	0	0	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0,14	0,28
Bryothamnion triquetum	0	0	0	0	0	0	0	0	0	0	0	1,4	0	0	1,3	0	0	0	0,15	0,29
Caloglossa leprieurii	0	0	0	0	0	0	0	9,5	0	0	0	0	0	0	0	0	0	0	0,53	1,02
Canistrocarpus cervicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,4	0	0	0	0,02	0,04
Caulerpa cupressoides	0	0	0	0	0	0	0	0	0	0	0,1	0	0	0	0	0	0	0	0,01	0,01
Caulerpa mexicana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,8	0	0	0	0,43	0,84
Caulerpa prolifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,2	0	0	0	0,01	0,02
Caulerpa racemosa	0	0	0	0	0	0	0	0	0	2,3	0,4	0	0,5	0	0	0	0	0	0,18	0,34
Caulerpa sertularioides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1	0,01	0,01
Centrocera clavulatum	3,2	12,6	3,6	10,7	36,8	34,5	1,4	11,8	3,6	0	0	0	0	0	0	2,7	1,8	0	6,82	13,17
Chaetomorpha aerea	0	2,7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,4	0,17	0,33
Chondracanthus acicularis	0	3,3	30,9	0	0	0	0	1,4	19	4,9	6	0,2	0	4,7	0,1	14,8	1,6	0	4,83	9,33
Chthamalus proteus	15,5	9,6	0	1,1	0	0	21	2,7	0	0	0	0	12,4	0	0	0,6	1,7	0	3,59	6,93
Cladophora vagabunda	0	10,1	2,5	0	0	0	0,4	0	0,2	0	0	0	0	0,2	0,1	0,1	0	0	0,76	1,46
Coralina officinalis	0	0	0,3	0	0	0	0	0	0	0	0	1,8	0	0,1	1,9	0	0	0	0,23	0,44
Crassostrea rhizophorae	0	0	0	0	0	0	0,2	0	0	0	0	0	0	0	0	0,5	0	0	0,04	0,08
Cryptonemia seminervis	0	0	0	0	0	0	0	0	0	0	0	0,4	0	0	0,4	0	0	0	0,04	0,09
Cystodytes sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1	0,01	0,01
Derbesia marina	0	0	0	0,7	0,7	0	0	0,4	0,4	0	0	0	0	0	0	0	0	0	0,12	0,24
Dictyopteris delicatula	0	0	0,1	0	0	0	0	0	0	0	1,5	4,9	0	0	1,9	0	0	0	0,47	0,90
Dictyosphaeria cavernosa	0	0	0	0	0	0	0	0	0	0,2	0	0	0	0	0	0	0	0	0,01	0,02

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[4] O conteúdo deste apêndice pode ser encontrado em formato digital em http://dx.doi.org/10.6084/m9.figshare.5270689

Tabela 4 – Cobertura média em três estratos (superior, médio e inferior) de seis recifes de arenito na costa do estado do ceará. Continuação.

Municipio	CAUCAIA									TRAIRI										
Recife	1			2			**3**			4			5			6			Média	%
Estrato	S	M	I	S	M	I	S	M	I	S	M	I	S	M	I	S	M	I		
Dictyota ciliolata	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1	0	0	0	0	0,01	0,01
Dictyota menstrualis	0	0	0	0	0	0	0	0	0	0,3	0	0,2	0	0	0	0	0	0	0,03	0,05
Digenia simplex	0	0	0	0	0	0	0	0	0	0	0	0	0	0,2	0,1	0	0	0,2	0,03	0,05
Gelidiella acerosa	0	0	0,5	0	0	0	0	0	0	28,7	9,7	4,4	0	17,5	18,3	2,3	8,8	0,8	5,06	9,77
Gelidium coarctatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,4	0	0,08	0,15
Gelidium sp.	0	0,8	0,4	0	0	0,6	0,1	0,1	5,9	3,3	8,7	0	0	0	0	0	0	0	1,11	2,14
Gracilaria caudata	0	0	0	0	0	0	0	0	1,6	0	0	0,7	0	0,9	0	0	0,7	0,1	0,22	0,43
Gracilaria cearensis	0	0	1,2	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0,08	0,16
Gracilaria cervicornis	0	0	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,01	0,01
Gracilaria cornea	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2,4	0	0	0,9	0,24	0,46
Gracilaria cuneata	0	0	0	0	0	0	0	0	0	0	0	0,6	0	0	0	0	0	0	0,03	0,06
Gracilaria domingensis	0	0	0,5	0	0	0,4	0	0	0	0	0	1,2	0	0,3	1	0	1,4	2,1	0,38	0,74
Gracilaria intermedia	0	0	0	0	0	0,1	0	0	0	0	0	4	0	0,2	0,3	0	0,1	0,2	0,27	0,53
Haliclona sp.	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0,02	0,03
Hypnea musciformes	0	0,3	4	0	0	0	0	0	1,6	2,2	2,2	2,4	0	2,5	2	1,3	6,6	18,8	2,44	4,71
Hypnea spinella	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0,2	0	0	0	0	0,04	0,09
Jania rubens	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0,3	0,6	0,3	0,09	0,18
Laurencia dendroidea	0	0	0	0	0	0	0,1	0	0	0	0	0	0	0	1	0	0	0,1	0,07	0,13
Lobophora variegata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,4	0	0	0	0,02	0,04
Osmundaria obtusiloba	0	0	0	0	0	0	0	0	0	0	0	0,4	0	0	1,1	0	0	0	0,08	0,16
Padina sp.	0	0	0	0	0	0	0	0	0	0	0	0,2	0	0,4	0	0	0,2	0,2	0,06	0,11
Palisada perforata	0	0	0	0	0	0	0	0	0	7,2	1,2	1	1,6	6	4,3	2,8	8,6	3,8	2,03	3,92
Parviphycus trinitatensis	0	0	0	0	0	0	0	0	0,1	0	0	0	0	0	0	0	0	0	0,01	0,01
Phragmatopoma sp.	0	11,2	15,4	0	0	0	0	0	0	0	0	0	0	0	0	2,4	6,8	0	1,99	3,84
Protopalythoa variabilis	0	0	0	0	0	0	0	0	0	2,5	0	0,1	0	4,2	0,6	0	0	0	0,41	0,79
Pterocladiella bartlettii	0	0	0	0	0	0	0	0	1,7	0	0	0	30,6	4,5	1,4	2,9	14,3	2,8	3,23	6,25
Pterocladiella caerulescens	0	0,1	0,4	0	0	0	0	0,4	1,2	8,9	7,1	12,9	0,2	2,9	6,7	2,4	3,6	1,1	2,66	5,14
Rhizoclonium riparium	0	0	0	0	0	1,8	0,6	1,7	0	0	0	0	0	0	0	0	0	0	0,23	0,44
Rhodophyta calcaria	0	0	0	0	0	0	0	0,1	0	0	0,1	6,9	0	0,4	10,7	0,6	0,1	2,4	1,18	2,29

Tabela 4 – Cobertura média em três estratos (superior, médio e inferior) de seis recifes de arenito na costa do estado do ceará. Conclusão.

Municipio	CAUCAIA									TRAIRI									Média	%
Recife	1			2			**3**			4			5			6				
Estrato	S	M	I	S	M	I	S	M	I	S	M	I	S	M	I	S	M	I		
Sargassum vulgare	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1	3,5	0	0	0,1	0,21	0,40
Ulva fasciata	0,7	3,3	11,8	0,7	2	6	1	4,1	8,5	3,2	2,1	0,8	0	1,3	1	1,1	2,2	0	2,77	5,34
Ulva sp.	32,4	6,6	4,6	8,6	1,5	4,4	7,3	2,5	2,2	0,1	0	0	0	2,6	0	11,8	0	2,1	4,82	9,30
Valonia aegagropila	0	0	0	0	0	0	0	0	0	1,6	0,7	0,3	0	1,7	0	0,2	0	0	0,25	0,48
Zoanthus sociatus	0	0	0	0	0	0	0	0	0	0,8	0	0	0,3	0	0	0	0	0	0,06	0,12
COBERTURA TOTAL	68,5	60,6	79,3	21,9	41	47,9	32,1	47,4	46	66,8	40,5	47,7	52,7	55,6	73,3	46,8	61,1	42,6	51,77	100

Fonte: elaborada pelo autor. S = Superior, M = Médio, I = Inferior. Recifes de 1 a 6 são respectivamente: Dois Coqueiros, Iparana, Pacheco, Guajiru, Manguinhos e Flecheiras, e correspondem aos recifes descritos no capítulo 1.

APENDICE B – VARIÁVEIS GEOGRÁFICAS E CLIMÁTICAS DAS UNIDADES POLÍTICAS[5]

Tabela 5 – Riqueza de espécies, coordenadas, tamanho do litoral e variáveis climáticas em 16 unidades políticas ao longo da costa tropical e subtropical do oceano Atlântico sudoeste.

Estado	**Nome**	**Spp**	**Long**	**Lat**	**RFA (Einstein/m^2/day)**	**SSM (PSS)**	**TSM (°C)**	**Vento (m/s)**	**N:P**	**Costa (km)**
1	Maranhão	84	-44,54	-2,21	43,40	35,65	27,79	8,01	5,76	5336
2	Piauí	119	-44,13	-2,88	40,01	35,82	29,42	8,58	5,56	106
3	Ceará	252	-38,88	-3,46	48,16	36,29	26,93	8,07	5,71	878
4	Rio Grande do Norte	332	-36,71	-5,04	47,55	36,38	26,69	8,18	6,65	687
5	Paraíba	340	-34,88	-7,04	47,79	36,59	27,20	7,16	7,85	289
6	Pernambuco	398	-34,96	-8,38	45,62	36,78	26,57	6,58	7,98	624
7	Alagoas	390	-35,88	-9,88	49,14	36,85	26,37	6,66	7,41	382
8	Sergipe	394	-37,13	-11,04	46,15	36,78	25,61	6,75	6,49	266
9	Bahia	493	-39,04	-14,04	45,11	37,14	26,12	6,31	5,07	3212
10	Espírito Santo	530	-40,13	-20,13	40,80	36,53	23,21	7,21	5,90	800
11	Rio de Janeiro	484	-44,04	-22,96	38,38	35,39	22,46	6,75	6,27	2369
12	São Paulo	373	-46,46	-24,04	35,13	35,35	21,58	5,73	5,95	2125
13	Paraná	237	-48,54	-25,79	35,29	34,86	19,52	5,93	4,25	1296
14	Santa Catarina	227	-48,54	-27,46	37,57	35,08	18,92	6,76	3,92	1887
15	Rio Grande do Sul	92	-51,29	-31,46	37,08	33,74	15,18	7,58	1,73	2732
16	Uruguai	70	-53,38	-33,79	38,37	33,46	12,75	7,15	1,95	1038

Fonte: elaborado pelo autor. Obs. Spp = riqueza de espécies, Long = longitude, Lat = latitude, RFA = radiação fotossinteticamente ativa, SSM = salinidade da superficie do mar, TSM = temperatura da superficie do mar, N:P = razão nitrato:fosfato. Todas as variáveis foram obtidas no banco de dados do BioOracle (TYBERGHEIN *et al.*, 2012), com exceção do comprimento da costa que foi medido pelo autor em arquivos vetorizados obtidos no GADM (disponível em www.gadm.org).

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[5] O conteúdo deste apêndice pode ser encontrado em formato digital em http://dx.doi.org/10.6084/m9.figshare.5270689

APÊNDICE C – ESPÉCIES DE MACROALGAS EM 93 LOCALIDADES AO LONGO DO ATLÂNTICO SUDOESTE[6]

Tabela 6 – Espécies de macroalgas e respectiovos locais de ocorrência ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continua.

Espécie	Localidade
Acanthophora muscoides	9, 26.
Acanthophora spicifera	1, 2, 3, 4, 5, 6, 7, 8, 9, 17, 18, 19, 24, 25, 26, 41, 43, 47, 49, 50, 51, 59, 60, 61, 63, 70, 71.
Acetabularia calyculus	1, 2, 49.
Acetabularia crenulata	1.
Acinetospora crinita	71.
Acrochaetium cadicola	70.
Acrochaetium sp.	16, 22, 48, 51, 53.
Acrosorium ciliolatum	42.
Aghardhiella subulata	61, 63, 70.
Aglaothamnion cordatum	42, 48.
Aglaothamnion felipponei	74, 79, 81, 82, 85.
Aglaothamnion felliponei	43, 49, 52, 59, 60, 61, 63, 70, 72.
Aglaothamnion uruguayense	30, 42, 43, 57, 59, 60, 61, 62, 64, 70, 71, 72, 73, 81, 82, 84, 85, 88, 90, 92, 93.
Ahnfeltia plicata	82, 85.
Amansia multifida	3, 5, 6, 7, 8, 9, 12, 19, 31, 32, 35.
Amphiroa anastomosans	16, 26, 30, 37, 40, 41, 52.
Amphiroa beauvoisii	13, 14, 15, 16, 31, 38, 42, 43, 44, 45, 46, 53, 55, 56, 59, 61, 62, 72, 79, 80, 81, 82, 83, 85, 86, 89.
Amphiroa fragilissima	7, 22, 23, 30, 31, 43, 46, 47, 48, 49, 51, 61, 62, 71, 72.
Amphiroa rigida	39, 48, 49.
Amphiroa sp.	19, 24, 28, 29, 51, 54.
Anadyomene stellata	8, 24, 26, 30, 31, 32, 38, 39, 40.
Antithamnionella atlantica	30.
Antithamnionella breviramosa	48, 49.
Antithamnionella graeffei	16.
Arthrocardia flabellata	32, 33, 45, 48, 61, 62, 72, 73.
Arthrocardia gardneri	72, 73.
Arthrocardia variabilis	30, 32, 33, 35, 36, 37, 38, 39, 45, 48.
Asparagopsis taxiformis	16, 34, 37, 38, 39, 41, 42, 46, 48, 49, 56, 59, 61, 63, 64, 70.
Asteronema breviarticulatum	18, 43, 46, 53, 56, 62.
Bachelotia antillarum	38, 46, 47, 56, 59, 62, 63, 64, 68, 70, 71.
Bachelotia fulvescens	51.
Bangia artropurpurea	50.

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[6] O conteúdo deste apêndice pode ser encontrado em formato digital em http://dx.doi.org/10.6084/m9.figshare.5270689

Tabela 6 – Espécies de macroalgas e respectiovos locais de ocorrência ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

Espécie	**Localidade**
Bangia atropurpurea	81, 85.
Blidingia marginata	26, 68, 70.
Boodleopsis pusilla	53, 59, 60.
Bostrychia calliptera	51, 53, 59.
Bostrychia montagnei	59, 60.
Bostrychia moritziana	59.
Bostrychia radicans	59, 60, 65, 66, 67, 68, 69, 70, 71, 90, 93.
Bostrychia tenella	47, 48, 49, 59, 63, 70.
Botryocladia occidentalis	3, 7, 8, 9, 19, 25, 26.
Botryocladia pyriformis	30.
Bryocladia cuspidata	48, 49, 52, 55.
Bryocladia sp.	58.
Bryocladia thyrsigera	22, 42, 50, 55, 60, 62, 63, 70.
Bryopsis corymbosa	43.
Bryopsis hypnoides	58, 75, 83, 84, 85, 89.
Bryopsis pennata	5, 11, 14, 18, 21, 22, 26, 36, 42, 46, 47, 49, 50, 56, 59, 60, 75, 81, 82, 83, 89.
Bryopsis plumosa	19, 35, 36, 38, 74, 75, 81, 82, 83, 85, 89.
Bryopsis sp.	20, 23, 37, 40, 41, 54, 55, 57, 71.
Bryothamnion seaforthii	7, 8, 9, 11, 12, 17, 19, 31, 32, 55, 59, 60, 61, 63, 70.
Bryothamnion triquetrum	5, 6, 7, 14, 16.
Callithamnion corymbosum	42, 73.
Caloglossa leprieurii	59, 60.
Canistrocarpus cervicornis	3, 5, 7, 15, 16, 29, 30, 40, 41, 43, 48, 49, 62, 63, 64, 70.
Catenella caespitosa	59.
Caulacanthus ustulatus	42.
Caulerpa ambigua	48.
Caulerpa cupressoides	3, 6, 7, 8, 14, 16, 19, 26, 28, 29, 31, 32, 33, 38, 39, 40, 49.
Caulerpa fastigiata	30, 34, 43, 44, 49, 50, 54, 57, 58, 59, 60.
Caulerpa lanuginosa	31.
Caulerpa mexicana	1, 2, 3, 5, 7, 9, 21, 26, 32.
Caulerpa prolifera	3, 5, 7, 9, 19, 21, 32, 40.
Caulerpa racemosa	3, 5, 6, 7, 8, 9, 14, 15, 16, 17, 21, 23, 24, 25, 26, 27, 28, 30, 31, 34, 36, 37, 38, 39, 40, 41, 43, 49, 54, 55, 56.
Caulerpa scalpelliformis	36.
Caulerpa serrulata	29.
Caulerpa sertularioides	3, 4, 7, 8, 21, 23, 24, 26, 27, 31, 41, 45, 49.
Caulerpa sp.	59, 60.

Tabela 6 – Espécies de macroalgas e respectiovos locais de ocorrência ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

Espécie	**Localidade**
Caulerpa verticillata	14, 15, 38, 41.
Caulerpa webbiana	38, 39.
Centroceras clavulatum	4, 8, 10, 11, 12, 14, 18, 22, 27, 30, 31, 32, 33, 34, 35, 36, 37, 38, 42, 44, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 66, 67, 68,
Centroceras gasparrinii	45.
Ceramium brasiliense	3, 26, 42, 43, 44, 60, 61, 62, 63, 66, 69, 70, 71, 85.
Ceramium brevizonatum	33, 42, 44, 46, 48, 59.
Ceramium codii	47.
Ceramium comptum	48, 49, 63, 70.
Ceramium corniculatum	82, 83.
Ceramium dawsonii	26, 33, 34, 47, 52, 59, 60.
Ceramium deslongchampsii	32.
Ceramium diaphanum	46, 47, 59, 82, 85.
Ceramium leutzelburgii	46, 69, 70.
Ceramium sp.	13, 14, 15, 51, 54, 55, 59, 60, 64, 70.
Ceramium tenerrimum	34, 61, 64, 70.
Ceramium uruguayense	79, 81, 82, 83, 84, 85, 89, 90.
Ceramium vagans	16.
Ceratodictyon planicaule	14, 15, 16, 20, 21, 22, 23, 24, 47.
Ceratodictyon sp.	13.
Ceratodictyon tenue	43.
Ceratodictyon variabile	13, 15, 16, 42, 49, 51, 55, 62, 63, 64, 70.
Ceratodictyon volubilis	50, 54.
Chaetomorpha aerea	4, 12, 18, 20, 21, 42, 59, 71, 75.
Chaetomorpha antennina	18, 32, 35, 36, 38, 42, 44, 45, 46, 47, 49, 52, 53, 54, 57, 59, 60, 61, 72, 75.
Chaetomorpha brachygona	42, 44, 59, 75.
Chaetomorpha gracilis	65, 67, 68, 69, 70.
Chaetomorpha sp.	14, 53, 55, 58.
Chamaedoris penicillum	24.
Champia compressa	45.
Champia parvula	33, 34, 45, 49, 61, 63, 70, 72.
Champia salicornioides	44.
Champia vieillardii	42, 49.
Chnoospora minima	33, 43, 48, 53, 60.
Chondracanthus acicularis	4, 5, 6, 10, 12, 16, 18, 20, 21, 22, 23, 25, 26, 31, 32, 37, 38, 39, 42, 46, 48, 49, 50, 60, 61, 62, 64, 6, 69, 70, 71, 75, 77, 82, 83, 89.

Tabela 6 – Espécies de macroalgas e respectiovos locais de ocorrência ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

Espécie	**Localidade**
Chondracanthus elegans	31, 37, 60, 73.
Chondracanthus saudersii	51.
Chondracanthus sp.	54, 55.
Chondracanthus teedei	42, 44, 50, 51, 52, 54, 55, 57, 61, 64, 70, 71, 73.
Chondracantus teedei	74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 89, 90.
Chondria atropurpurea	42, 44, 54, 55, 77, 82, 83, 84, 85, 89, 90.
Chondria dangeardii	16.
Chondria decipiens	43.
Chondria polyrhiza	43, 61, 62, 63, 64, 68, 70, 71.
Chrysymenia enteromorpha	41.
Cladophora albida	59, 69, 70, 82, 83, 89, 93.
Cladophora coelothrix	71.
Cladophora conferta	81.
Cladophora corallicola	42, 46, 47.
Cladophora dalmatica	71.
Cladophora liebetruthii	80, 81, 82.
Cladophora montagneana	32, 42, 46, 49, 71.
Cladophora ordinata	18, 32, 62, 67, 68, 69, 70, 71, 73.
Cladophora prolifera	26, 30, 31, 38, 42, 44, 48, 49, 53, 61, 62, 63, 64, 68, 70, 71, 72, 73.
Cladophora rupestris	36, 42, 44.
Cladophora sp.	22, 50, 51, 53, 55, 58, 61, 63, 65, 66, 68, 69, 70, 71, 72, 73.
Cladophora utrulosa	55.
Cladophora vagabunda	4, 5, 10, 12, 31, 32, 35, 36, 42, 43, 44, 45, 48, 49, 59, 60, 61, 62, 63, 64, 66, 68, 70, 72, 73, 82.
Cladophoropsis membranacea	1, 18, 22, 23, 31, 38, 39, 46, 48, 49, 55, 64, 66, 69, 70, 71.
Codium decorticatum	23, 40, 42, 44, 59, 60, 64, 70, 71, 73, 74, 75, 79, 80, 81, 82, 83, 85, 89.
Codium intertextum	31, 34, 37, 38, 39, 40, 41, 42, 48, 49.
Codium isthmocladum	3, 7, 19, 30, 31, 37, 39, 40, 41.
Codium sp.	15.
Codium taylorii	3, 9, 37, 38, 39, 45, 59, 60, 64, 70, 75, 76, 79, 80, 81, 82, 89.
Colaconema hallandicum	82.
Colpomenia sinuosa	7, 13, 14, 15, 19, 24, 28, 30, 31, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 46, 47, 48, 49, 56, 59, 61, 62, 72, 82.
Corallina officinalis	5, 6, 8, 12, 31, 32, 37, 38, 39, 42, 43, 45, 52, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 89.
Corallina panizzoi	31, 32, 35, 36, 37, 39.
Corallina sp.	21.
Corynomorpha clavata	18.

Tabela 6 – Espécies de macroalgas e respectiovos locais de ocorrência ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

Espécie	**Localidade**
Cottoniella filamentosa	61, 71.
Craspedocarpus jolyi	59.
Cryptonemia bengryi	30.
Cryptonemia crenulata	3, 7, 8, 9, 16, 18, 19, 24, 26.
Cryptonemia seminervis	3, 5, 6, 8, 9, 26, 32, 33, 36, 37, 39, 40.
Cryptopleura ramosa	45, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 89.
Dasya baillouviana	41.
Dasya brasiliensis	43, 48.
Dasya corymbifera	43.
Dasya hutchinsiae	38.
Dasya ocellata	36, 37, 38.
Dasya sp.	51.
Derbesia marina	10, 11, 45, 64, 70.
Derbesia tenuissima	46, 49.
Dermocorynus dichotomus	60.
Dichotomaria frutescens	51.
Dichotomaria marginata	26, 30, 31, 39, 40, 49, 61.
Dichotomaria obtusata	30, 40, 49.
Dictyopteris delicatula	1, 3, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 24, 25, 26, 31, 32, 33, 35, 36, 38, 39, 40, 41, 42, 43, 46, 48, 49, 61, 62, 63, 70.
Dictyopteris justii	15, 16, 19.
Dictyopteris plagiogramma	14, 15, 29, 49.
Dictyopteris polypodioides	16.
Dictyopteris sp.	14.
Dictyosphaeria cavernosa	3, 6, 7.
Dictyosphaeria versluysii	13, 14, 15, 17, 19, 24, 26, 28, 40.
Dictyota bartayresiana	19.
Dictyota ciliolata	3, 5, 9, 42, 45, 49.
Dictyota crenulata	3, 30, 31, 38, 40, 41.
Dictyota dichotoma	43, 53.
Dictyota divaricata	3.
Dictyota jamaiscensis	26.
Dictyota menstrualis	1, 3, 6, 8, 9, 13, 16, 17, 26, 56, 59, 63, 64, 70, 71.
Dictyota mertensii	3, 7, 14, 16, 17, 29, 33.
Dictyota pulchella	13.
Dictyota sp.	15, 24, 51, 54, 55, 62, 72.
Digenea simplex	3, 4, 5, 7, 8, 24.

Tabela 6 – Espécies de macroalgas e respectiovos locais de ocorrência ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

Espécie	Localidade
Enantiocladia duperreyi	19, 23.
Erythrotrichia carnea	22, 25, 49, 53, 68, 70, 73, 82.
Erythrotrichia vexillaris	82.
Feldmannia indica	45, 46, 47.
Feldmannia irregularis	33, 37, 38, 41, 42, 43, 44, 46, 47, 48, 49, 52, 56, 61, 62, 63, 70, 71, 73.
Feldmannia mitchelliae	37, 41, 42, 43, 46, 47, 48, 49, 51, 52, 56, 61, 74.
Fosliella chamaedoris	48, 49.
Galaxaura frutescens	50.
Galaxaura oblongata	7, 26.
Galaxaura rugosa	13, 14, 15, 31, 40.
Gastroclonium parvum	42.
Gayliella flaccida	16, 18, 22, 42, 43, 59.
Gayralia brasiliensis	59, 60.
Gayralia oxysperma	49, 59.
Gelidiella acerosa	1, 4, 5, 6, 7, 12, 13, 14, 15, 16, 17, 19, 20, 22, 23, 24, 25, 26.
Gelidiella ligulata	16.
Gelidium americanum	17, 18.
Gelidium coarctatum	4, 17, 18, 26.
Gelidium crinale	6, 8, 9, 10, 11, 12, 17, 18, 22, 32, 38, 44, 45, 46, 47, 52, 56, 59, 61, 63, 66, 70, 71
Gelidium floridanum	30, 31, 32, 33, 36, 45, 59, 73.
Gelidium pusillum	50, 54, 55, 57, 58, 59, 60, 62, 64, 70, 71, 74, 75, 79, 81.
Gelidium sp.	50, 51, 53, 55, 59, 60.
Gelidium torulosum	17.
Gigartina acicularis	8.
Gonimophyllum africanum	74, 81, 82, 83, 89.
Gracilaria birdiae	1, 2, 18.
Gracilaria caudata	4, 5, 6, 7, 8, 10, 26, 30, 32, 51, 60.
Gracilaria cearensis	6, 8, 12.
Gracilaria cervicornis	3, 7, 8, 9, 12, 17, 18, 19, 26, 30, 32, 38, 39, 49, 59.
Gracilaria cornea	3, 4, 5, 6, 7, 8, 19, 21, 23, 24, 26.
Gracilaria cuneata	6, 7, 8, 9, 30, 32, 39, 40.
Gracilaria curtissiae	8, 9.
Gracilaria domingensis	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 18, 22, 26, 30, 32, 40, 50, 59, 60, 62, 63, 64, 66, 68, 70, 71, 72.
Gracilaria foliifera	74, 75, 82.
Gracilaria lemaneiformis	3, 7, 8, 9.
Gracilaria mammilaris	23, 25.

Tabela 6 – Espécies de macroalgas e respectiovos locais de ocorrência ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

Espécie	**Localidade**
Gracilaria ornata	3, 4, 5, 6, 8, 9, 11.
Gracilaria sp.	18, 19, 21, 23, 24, 25, 30, 32, 35, 41.
Gracilaria yoneshigueana	42.
Gracilariopsis sp.	32.
Gracilariopsis tenuifrons	50.
Grateloupia cuneifolia	61, 63, 64, 66, 70.
Grateloupia doryphora	42, 44, 59, 60, 74, 75, 76, 77, 79, 81, 85.
Grateloupia filicina	36, 42, 52, 75, 79, 80, 81, 82, 83, 84, 85.
Grateloupia filiformis	71, 73.
Grateloupia sp.	54, 57.
Griffithsia globulifera	73.
Griffithsia schousboei	48.
Gymnogongrus griffithsiae	32, 34, 42, 44, 50, 51, 52, 57, 58, 59, 60, 61, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 89, 90.
Gymnothamnion elegans	43.
Halimeda cuneata	30, 31, 32, 33, 35, 36, 37, 38, 39, 40, 41.
Halimeda discoidea	26.
Halimeda opuntia	19, 26.
Halimeda sp.	22.
Halimeda tuna	29.
Haliptilon subulatum	16.
Haloplegma duperreyi	1, 7, 8, 9, 30.
Halymenia brasiliana	19.
Halymenia duchassaingii	31, 35, 36.
Halymenia floresii	9, 19.
Halymenia pseudofloresii	36.
Herposiphonia bipinnata	43.
Herposiphonia secunda	30, 34, 42, 43, 46, 47, 48, 49, 56, 59, 60, 62, 66, 68, 70, 71, 72, 73.
Herposiphonia tenella	22, 33, 55.
Heterosiphonia crispella	41, 49, 62, 63, 67, 70, 71, 72.
Heterosiphonia gibbesii	37, 54.
Heterosiphonia wudermanii	51.
Hildenbrandia prototypus	50, 51, 53, 54, 55, 57, 58.
Hildenbrandia rubra	44, 60, 79, 80, 81, 82, 83, 85.
Hincksia conifera	42, 46.
Hincksia onslowensis	41.
Hypnea cervicornis	9, 26, 36, 41, 43.

Tabela 6 – Espécies de macroalgas e respectiovos locais de ocorrência ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

Espécie	**Localidade**
Hypnea cornuta	22.
Hypnea crespa	54.
Hypnea musciformis	1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 19, 21, 22, 23, 24, 25, 26, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 42, 43, 45, 48, 49, 50, 51, 52, 53, 59, 60, 61, 62, 71, 72, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 89, 90.
Hypnea sp.	51, 54.
Hypnea spinella	1, 2, 5, 6, 9, 13, 16, 17, 18, 21, 24, 26, 34, 41, 42, 45, 46, 47, 48, 49, 50, 51, 52, 56, 59, 60, 61, 62, 63, 64, 66, 70, 71, 72, 73.
Jania adhaerens	7, 16, 19, 21, 30, 34, 37, 39, 40, 42, 43, 44, 45, 47, 48, 49, 56, 61, 62, 63, 64, 66, 68, 70, 71, 72, 73.
Jania capillacea	15, 31, 36, 38, 39, 40, 43, 45, 46, 47, 61, 62.
Jania cubensis	8, 9, 31, 42.
Jania pumila	16, 48, 49.
Jania rosea	42.
Jania rubens	4, 5, 17, 32, 36, 37, 38, 39, 40, 43, 59, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 89.
Jania sagittata	38.
Jania sp.	13, 14, 16, 51, 54, 55.
Jania subulata	1, 7, 8, 9, 45.
Jania verrucosa	33, 42, 62.
Laurencia clavata	18.
Laurencia decomposita	51.
Laurencia dendroidea	1, 4, 5, 8, 10, 15, 19, 25, 38.
Laurencia filiformis	8, 16, 33, 49, 52, 56.
Laurencia furcata	8.
Laurencia intricata	16.
Laurencia microcladia	3, 8.
Laurencia obtusa	8, 30, 39, 43, 72.
Laurencia sp.	17, 32, 35, 37, 41, 62.
Laurencia tepida	31.
Levringia brasiliensis	43, 59, 63, 70, 74, 75, 76.
Lobophora variegata	3, 5, 7, 8, 9, 16, 17, 19, 20, 26, 30, 43, 60, 61, 72, 73.
Lomentaria corallicola	16, 59.
Macrocystis pyrifera	80, 82.
Meristotheca gelidium	30.
Myrionema strangulans	46.
Nemalion helminthoides	38, 75, 79, 82, 85.
Neomeris annulata	29.
Neosiphonia ferulacea	44, 56, 72.

Tabela 6 – Espécies de macroalgas e respectiovos locais de ocorrência ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

Espécie	**Localidade**
Neosiphonia gorgoniae	16, 37.
Neosiphonia sertularioides	43.
Neosiphonia sphaerocarpa	62, 64, 69, 70.
Ochtodes secundiramea	29, 30, 36, 38, 39, 41.
Osmundaria obtusiloba	3, 5, 6, 7, 8, 9, 22, 26, 32, 37, 41.
Padina antillarum	21, 24, 60.
Padina boegersenii	19.
Padina gymnospora	1, 3, 4, 5, 6, 7, 8, 9, 13, 14, 20, 22, 26, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 47, 48, 49, 51, 56, 59, 60, 61, 63, 70.
Padina sp.	50, 53, 54, 55.
Palisada flagellifera	26, 43, 52, 61, 63, 64, 70.
Palisada perforata	1, 4, 5, 6, 7, 13, 14, 15, 18, 19, 20, 21, 22, 23, 24, 25, 26, 28, 30, 31, 36, 38, 39, 40, 41, 46, 47, 49, 60.
Parviphycus trinitatensis	9, 10, 32, 47, 69, 70, 71.
Petalonia fascia	59, 74, 75, 79, 80, 81, 82.
Peyssonelia sp.	32, 38, 48, 49.
Pleonosporium polystichum	62, 64, 70, 72, 73.
Plocamium brasiliense	32, 33, 34, 37, 38, 39, 42, 49, 59, 61.
Polisyhonia atlantica	42.
Polysiphonia decussata	73.
Polysiphonia denudata	62.
Polysiphonia foetidissima	35, 74, 75, 76, 77, 79, 81, 83, 84.
Polysiphonia fucoides	74, 75, 79, 82.
Polysiphonia howeii	13, 14, 15, 30, 40, 43, 44, 48, 68, 70.
Polysiphonia schneideri	30.
Polysiphonia scopulorum	43, 46, 47.
Polysiphonia sp.	10, 60.
Polysiphonia subtilissima	18, 47, 48, 49, 72, 77, 81, 82, 83, 84, 85.
Polysiphonia virgata	75, 77, 81, 82, 83, 84, 85, 89, 90.
Porphyra pujalsiae	75, 76, 79, 81, 82.
Porphyra rizzinii	82.
Pterocladiella bartlettii	3, 4, 5, 7, 8, 9, 10, 27, 45.
Pterocladiella beachiae	3, 4, 5, 6, 7, 8, 10, 12, 16, 26, 27.
Pterocladiella capillacea	31, 32, 36, 37, 38, 39, 42, 45, 48, 49, 59, 60, 63, 64, 66, 68, 69, 70, 71.
Pterocladiella capillaceae	74, 77, 79, 80, 81, 82, 83, 84, 85, 86, 89.

Tabela 6 – Espécies de macroalgas e respectiovos locais de ocorrência ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

Espécie	**Localidade**
Pterocladiella sp.	32, 45.
Pterosiphonia parasitica	42, 43, 73.
Pterosiphonia pennata	42, 43, 48, 52, 55, 59, 60, 61, 62, 63, 64, 70, 72, 73.
Pterosiphonia spinifera	43.
Ptilothamnion speluncarum	43.
Punctaria latifolia	79, 82.
Pyropia acanthophora	45, 49, 59, 60.
Pyropia leucosticta	74, 75, 79, 81, 82, 85.
Pyropia sp.	36.
Pyropia suborbiculata	59, 60.
Ralfsia expansa	42, 43, 46, 47, 52, 53, 56.
Rhizoclonium africanum	48, 49.
Rhizoclonium riparium	10, 11, 18, 48, 59, 60, 61, 62, 63, 64, 70, 82.
Rhizoclonium sp.	59.
Rhizoclonium tortuosum	53, 59.
Rhodymenia divaricata	31.
Rhodymenia pseudopalmata	51, 59.
Rhodymenia pseudopamata	61, 62, 63, 66, 70, 72, 73.
Rhodymenia sp.	55.
Rodymenia obtusa	82.
Rodymenia pseudopalmata	74, 75, 81, 82, 83.
Sahlingia subintegra	63, 70, 71, 79, 80, 81, 82.
Sargassum cymosum	7, 13, 15, 35, 36, 59, 60, 61, 62, 64, 70, 72.
Sargassum filipendula	7, 8, 16, 33, 60, 73.
Sargassum furcatum	31, 40, 43, 56.
Sargassum hytrix	7, 14, 16.
Sargassum polyceratium	38.
Sargassum sp.	13, 14, 19, 28, 29, 47, 51, 53.
Sargassum stenophyllum	30, 31, 32, 37, 39, 52, 61, 63, 64, 70.
Sargassum vulgare	3, 4, 5, 7, 13, 14, 17, 20, 24, 25, 36, 39, 42, 45, 48, 49, 59, 60, 61, 62, 71.
Scinaia furcellata	31.
Scytosiphn lomentaria	75, 79, 80, 81, 82.
Solieria filiformis	8, 30, 51.
Spatoglossum schroederi	3, 7, 8, 9, 16, 19, 26, 64, 70.
Spermothamnion nonatoi	50, 53.
Spermothamnion sp.	54, 57.

Tabela 6 – Espécies de macroalgas e respectiovos locais de ocorrência ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Conclusão.

Espécie	**Localidade**
Sphacelaria brachygona	42, 56, 60, 61, 64, 70.
Sphacelaria novae-hollandiae	43.
Sphacelaria rigidula	46, 47.
Sphacelaria sp.	61, 62, 71, 72.
Sphacelaria tribuloides	40, 41, 46, 48, 49, 61, 62, 71, 72.
Spyridia filamentosa	32, 43, 61, 63, 64, 70, 71, 73.
Spyridia hypnoides	18, 32, 38, 39, 43, 59, 63, 64, 66, 69, 70, 71.
Stylonema alsidii	48, 85.
Stypopodium zonale	31.
Tricleocarpa cylindrica	40, 49, 59.
Tricleocarpa fragilis	29.
Udotea flabellum	19, 29, 40.
Udotea occidentalis	3, 7.
Ulva bubosa	81, 82.
Ulva clathrata	1, 60, 65, 71.
Ulva compressa	32, 44, 48, 49, 71, 74, 75, 80, 82, 89, 90, 93.
Ulva fasciata	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 19, 20, 22, 24, 26, 31, 32, 33, 35, 36, 37, 38, 39, 42, 43, 44, 45, 48, 49, 50, 59, 60, 71, 74, 75, 76, 77, 80, 81, 82, 83, 84, 85,
Ulva flexuosa	18, 26, 27, 37, 39, 40, 42, 49, 59, 60, 63, 67, 68, 69, 70, 71, 74, 82, 84, 85, 88, 92, 93
Ulva intestinalis	75, 82, 85, 90, 92.
Ulva lactuca	1, 8, 9, 14, 18, 26, 27, 28, 29, 30, 31, 34, 35, 36, 37, 38, 39, 40, 41, 42, 45, 46, 47, 48, 49, 59, 60, 66, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 89, 90, 92, 93.
Ulva lingulata	42, 50, 62, 66, 68, 70, 75, 79, 80, 81, 82, 85, 89, 90, 93.
Ulva linza	42, 49, 68, 70, 72, 74, 75, 80, 82, 85, 87, 89, 91, 93.
Ulva prolifera	79, 81, 82, 83, 85, 89, 90.
Ulva rigida	22, 36, 37, 44, 52.
Ulva sp.	4, 5, 6, 10, 11, 12, 20, 23, 25, 51, 53, 54, 55, 57, 58, 72.
Ulvella viridis	79, 80, 81, 82.
Valonia aegagropila	1, 4, 5, 6, 26, 40.
Valonia macrophysa	14.
Wrangelia argus	33, 34, 46, 48, 49, 51, 52, 56, 59, 60.
Wurdemannia miniata	42.
Zonaria tournefortii	30, 31, 40, 41.

Fonte: elaborado pelo autor. 1 = Coqueiro, 2 = Barra Grande, 3 = Mundaú, 4 = Flecheiras, 5 = Manguinhos, 6 = Guajiru, 7 = Paracuru, 8 = Taíba, 9 = Pecém, 10 = Pacheco, 11 = Iparana, 12 = Dois Coqueiros, 13 = Porto, 14 = Caieira, 15 = Leão, 16 = Maracajau, 17 = Pirangi, 18 = Mamanguape, 19 = Ponta de Pedras, 20 = Itamaracá, 21 = Pina, 22 = Boa Viagem 1, 23 = Piedade, 24 = Itapoama, 25 = Muro Alto, 26 = Itacimirim, 27 = Pituba, 28 = Coroa Vermelha, 29 = Recife de Fora, 30 = Coqueiral, 31 = Enseada das Garcas, 32 = Jacaraípe, 33 = Carapebus, 34 = Camburi, 35 = Ilha do Frade, 36 = Ilha do Boi, 37 = da Costa, 38 = Castanheiras, 39 = Bacutia, 40 = Parati, 41 = Castelhanos, 42 = Cavaleiros, 43 = Rasa, 44 = Boa Viagem 2, 45 = Itacoatiara, 46 = Enseada, 47 = Foca, 48 = Canto da Paciencia, 49 = Vila da Picinguaba, 50 = Pereque Açu, 51 = do Costa, 52 = Cigarras, 53 = Jureia, 54 = Branca, 55 = Preta, 56 = Ponta da Sela, 57 = Ilha Porchat, 58 = Prainha, 59 = Ilha do Mel, 60 = Ilha do Farol, 61 = Palmas, 62 = Ponta das Canas, 63 = Antenor, 64 = Sambaqui, 65 = Ponta Baixo, 66 = Ponta do Coral, 67 = Barreiros, 68 = Coqueiros, 69 = Saco dos Limões, 70 = Ribeirão da Ilha, 71 = Caieira da Barra do Sul, 72 = Ponta do Papagaio, 73 = Ribanceira, 74 = Coronilla, 75 = Santa Teresa, 76 = Coronilla del Mar, 77 = Santa Tereza da Coronilla, 78 = Arroyo Valizas, 79 = Punta del Diablo, 80 = Cabo Polonio, 81 = Pedrera, 82 = Paloma, 83 = Jose Ignacio, 84 = Barra de Maldonado, 85 = Punta del Leste, 86 = Isla de Lobos, 87 = Ramirez, 88 = del Cerro, 89 = Piriapolis, 90 = Atlantida, 91 = Pocitos, 92 = Buceo, 93 = Santa Ana.

APENDICE D – REFERÊNCIAS UTILIZADAS NO CÁLCULO DA RIQUEZA LOCAL DE ESPÉCIES E LISTA DESSAS LOCALIDADES

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Tabela 7 – Sítios usadas no cálculo da riqueza local de macroalgas ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continua.

REGIÃO	ESTADO	LOCALIDADE	LONGITUDE	LATITUDE	REF.
Tropical	PI	Coqueiro	-41.53	-2.91	1
Tropical	PI	Barra Grande	-41.41	-2.93	1
Tropical	CE	Mundaú	-39.37	-3.17	2
Tropical	CE	Flecheiras	-39.26	-3.22	3
Tropical	CE	Manguinhos	-39.25	-3.22	3
Tropical	CE	Guajiru	-39.23	-3.24	3
Tropical	CE	Paracuru	-39.03	-3.42	2
Tropical	CE	Taíba	-38.88	-3.50	2
Tropical	CE	Pecém	-38.83	-3.55	2
Tropical	CE	Pacheco	-38.63	-3.69	3
Tropical	CE	Iparana	-38.63	-3.69	3
Tropical	CE	Dois Coqueiros	-38.60	-3.69	3
Tropical	FN	Porto	-32.40	-3.84	4
Tropical	FN	Caieira	-32.40	-3.84	4
Tropical	FN	Leão	-32.44	-3.87	4
Tropical	RN	Maracajau	-35.25	-5.39	5
Tropical	RN	Pirangi	-35.11	-5.98	6
Tropical	PB	Mamanguape	-34.92	-6.78	7
Tropical	PE	Ponta de Pedras	-34.81	-7.62	4
Tropical	PE	Itamaracá	-34.84	-7.78	4
Tropical	PE	Pina	-34.88	-8.09	4
Tropical	PE	Boa Viagem 1	-34.90	-8.15	8
Tropical	PE	Piedade	-34.92	-8.18	4
Tropical	PE	Itapoama	-34.95	-8.30	4
Tropical	PE	Muro Alto	-34.98	-8.44	4
Tropical	BA	Itacimirim	-38.33	-12.70	9
Tropical	BA	Pituba	-38.46	-13.01	10
Transição	BA	Coroa Vermelha	-39.00	-16.34	11
Transição	BA	Recife de Fora	-38.98	-16.41	11
Transição	ES	Coqueiral	-40.13	-19.93	4
Transição	ES	Enseada das Garcas	-40.13	-19.98	4
Transição	ES	Jacaraípe	-40.18	-20.13	12
Transição	ES	Carapebus	-40.22	-20.25	13
Transição	ES	Camburi	-40.25	-20.27	13
Transição	ES	Ilha do Frade	-40.28	-20.30	4
Transição	ES	Ilha do Boi	-40.28	-20.31	4
Transição	ES	da Costa	-40.27	-20.32	4
Transição	ES	Castanheiras	-40.48	-20.67	4
Transição	ES	Bacutia	-40.52	-20.73	4
Transição	ES	Parati	-40.58	-20.80	4
Transição	ES	Castelhanos	-40.63	-20.84	4
Temperada quente	RJ	Cavaleiros	-41.80	-22.41	14
Temperada quente	RJ	Rasa	-41.94	-22.76	15
Temperada quente	RJ	Boa Viagem 2	-43.13	-22.91	16
Temperada quente	RJ	Itacoatiara	-43.04	-22.97	17
Temperada quente	RJ	Enseada	-44.23	-23.05	18
Temperada quente	RJ	Foca	-44.24	-23.05	18
Temperada quente	SP	Canto da Paciencia	-44.87	-23.36	19
Temperada quente	SP	Vila da Picinguaba	-44.84	-23.38	19
Temperada quente	SP	Pereque Açu	-45.07	-23.43	4
Temperada quente	SP	do Costa	-45.17	-23.52	4
Temperada quente	SP	Cigarras	-45.35	-23.73	20
Temperada quente	SP	Jureia	-45.79	-23.77	4

Tabela 7 – Sítios usadas no cálculo da riqueza local de macroalgas ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Conclusão.

REGIÃO	ESTADO	LOCALIDADE	LONGITUDE	LATITUDE	REF.
Temperada quente	SP	Branca	-46.14	-23.87	4
Temperada quente	SP	Preta	-46.14	-23.88	4
Temperada quente	SP	Ponta da Sela	-45.45	-23.88	20
Temperada quente	SP	Ilha Porchat	-46.37	-23.98	4
Temperada quente	SP	Prainha	-46.39	-23.98	4
Temperada quente	PR	Ilha do Mel	-48.33	-25.54	21
Temperada quente	PR	Ilha do Farol	-48.54	-25.85	21
Temperada quente	SC	Palmas	-48.53	-27.33	22
Temperada quente	SC	Ponta das Canas	-48.43	-27.39	22
Temperada quente	SC	Antenor	-48.57	-27.43	22
Temperada quente	SC	Sambaqui	-48.54	-27.49	22
Temperada quente	SC	Ponta Baixo	-48.61	-27.55	22
Temperada quente	SC	Ponta do Coral	-48.54	-27.57	22
Temperada quente	SC	Barreiros	-48.63	-27.58	22
Temperada quente	SC	Coqueiros	-48.57	-27.60	22
Temperada quente	SC	Saco dos Limões	-48.55	-27.61	22
Temperada quente	SC	Ribeirão da Ilha	-48.57	-27.73	22
Temperada quente	SC	Caieira da Barra do Sul	-48.56	-27.82	22
Temperada quente	SC	Ponta do Papagaio	-48.58	-27.85	22
Temperada quente	SC	Ribanceira	-48.65	-28.18	23
Uruguai	UR	Coronilla	-53.26	-33.53	24
Uruguai	UR	Santa Teresa	-53.28	-33.67	24
Uruguai	UR	Coronilla del Mar	-53.28	-33.69	24
Uruguai	UR	Santa Tereza da Coronilla	-53.28	-33.74	24
Uruguai	UR	Arroyo Valizas	-53.35	-33.80	24
Uruguai	UR	Punta del Diablo	-53.62	-34.14	24
Uruguai	UR	Cabo Polonio	-53.59	-34.20	24
Uruguai	UR	Pedrera	-53.61	-34.25	24
Uruguai	UR	Paloma	-54.02	-34.45	24
Uruguai	UR	Jose Ignacio	-54.05	-34.54	24
Uruguai	UR	Barra de Maldonado	-54.05	-34.55	24
Uruguai	UR	Punta del Leste	-54.05	-34.58	24
Uruguai	UR	Isla de Lobos	-54.67	-34.86	24
Uruguai	UR	Ramirez	-55.39	-34.95	24
Uruguai	UR	del Cerro	-55.42	-34.96	24
Uruguai	UR	Piriapolis	-54.89	-34.97	24
Uruguai	UR	Atlantida	-54.95	-34.99	24
Uruguai	UR	Pocitos	-55.08	-34.99	24
Uruguai	UR	Buceo	-55.02	-35.03	24
Uruguai	UR	Santa Ana	-54.98	-35.24	24

Fonte: elaborado pelo autor. 1 = VOLTOLINI et al., 2012; 2 = MATTHEWS-CASCON; LOTUFO, 2006; 3 = Presente estudo; 4 = SCHERNER et al., 2013; 5 = SILVA, 2006; 6 = AZEVEDO et al., 2011; 7 = ARAÚJO; MIRANDA; KANAGAWA, 2008; 8 = RIBEIRO et al., 2008; 9 = ALTAMIRO; NUNES, 1997; 10 = MACEDO et al., 2009; 11 = COSTA JR. et al., 2002; 12 = BARBOSA; FIGUEIREDO; TESTA, 2008; 13 = SÁ, 2011; 14 = LOIVOS, 2006; 15 = GUIMARÃES; COUTINHO, 1996; 16 = TAOUIL; YONESHIGUE-VALENTIN, 2002; 17 = JESUS; MACHADO; MUNIZ, 2013; 18 = BRITO; SZÉCHY; CASSANO, 2002; 19 = MACHADO; SILVA; NASSAR, 2007; 20 = LAQUILA, 2006; 21 = PELLIZARI et al., 2014; 22 = BOUZON et al., 2006; 23 = FAVERI et al., 2010; 24 = COLL; OLIVEIRA 1999.

APENDICE E – ESPÉCIES DE MACROALGAS EM 16 ESTADOS AO LONGO DO ATLÂNTICO SUDOESTE[7]

Tabela 8 – Algas por unidade política na costa tropical e subtropical do oceano Atlântico sudoeste. Continua.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Acanthophora muscoides	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Acanthophora spicifera	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Acetabularia caliculus	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Acetabularia crenulata	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Acetabularia schenckii	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
Acinetospora crinita	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Acrochaetium agardhiellae	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Acrochaetium avrainvilleae	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Acrochaetium corymbiferum	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Acrochaetium densum	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Acrochaetium elegans	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Acrochaetium epispiculum	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Acrochaetium flexuosum	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Acrochaetium globosum	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0
Acrochaetium liagorae	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Acrochaetium microscopicum	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Acrochaetium phacelorhizum	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Acrochaetium sancti-thomae	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Acrochaetium savianum	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Acrochaetium unipes	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0
Acrosorium ciliolatum	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
Acrothamnion butleriae	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0
Agardhiella floridana	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Agardhiella ramosissima	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Agardhiella subulata	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Aglaothamnion borgesenii	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Aglaothamnion cordatum	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Aglaothamnion diaphanum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Aglaothamnion felipponei	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	1
Aglaothamnion halliae	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0
Aglaothamnion hervey	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Aglaothamnion tenuissimum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Aglaothamnion uruguayense	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
Ahnfeltia plicata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Amansia multifida	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Amphiroa anastomosans	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Amphiroa anceps	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Amphiroa beauvoisii	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1

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[7] O conteúdo deste apêndice pode ser encontrado em formato digital em http://dx.doi.org/10.6084/m9.figshare.5270689

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Amphiroa exilis	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
Amphiroa fragilissima	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Amphiroa rigida	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Amphiroa vanbosseae	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Anadyomene lacerata	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0
Anadyomene linkiana	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Anadyomene pavonina	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Anadyomene rhizoidifera	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
Anadyomene saldanhae	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Anadyomene stellata	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Anotrichium tenue	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Anotrichium yagii	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
Antithamnion antillanum	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Antithamnion cruciatum	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
Antithamnion villosum	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Antithamnionella atlantica	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
Antithamnionella boergesenii	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Antithamnionella breviramosa	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Antithamnionella graeffei	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Apoglossum gregarium	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Archestenogramma brasiliense	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0
Arthrocardia variabilis	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
Ascocyclus hypneae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Asparagopsis taxiformis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Asterocladon rhodochortonoides	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Asteromenia peltata	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Asteronema breviarticulatum	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Avrainvillea elliottii	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Avrainvillea levis	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Avrainvillea longicaulis	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Avrainvillea nigricans	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Bachelotia antillarum	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Blastophysa rhizopus	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Blidingia marginata	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0
Blidingia minima	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1
Bolbocoleon jolyi	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Bolbocoleon piliferum	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Boodlea composita	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Boodleopsis pusilla	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Boodleopsis vaucherioidea	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Bostrychia calliptera	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Bostrychia kelanensis	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Bostrychia montagnei	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Bostrychia moritziana	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Bostrychia pilulifera	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bostrychia radicans	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bostrychia tenella	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Botryocladia bahamensis	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Botryocladia occidentalis	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Botryocladia pyriformis	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Botryocladia wynnei	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
Branchioglossum minutum	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Bryocladia cuspidata	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Bryocladia thyrsigera	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Bryopsis corymbosa	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0
Bryopsis hypnoides	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1
Bryopsis pennata	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bryopsis plumosa	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bryothamnion seaforthii	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Bryothamnion triquetrum	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Calliblepharis occidentalis	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Callithamniella flexilis	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Callithamniella tingitana	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0
Callithamnion callithamnioides	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Callithamnion corymbosum	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
Callithamnion tetragonum	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
Callophyllis microdonta	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Caloglossa leprieurii	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Caloglossa ogasawaraensis	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
Canistrocarpus cervicornis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Canistrocarpus crispatus	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Carpomitra costata	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Catenella impudica	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Caulerpa ambigua	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Caulerpa ashmeadii	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0
Caulerpa brachypus	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Caulerpa chemnitzia	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Caulerpa cupressoides	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Caulerpa denticulata	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Caulerpa fastigiata	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Caulerpa floridana	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Caulerpa kempfii	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Caulerpa lanuginosa	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Caulerpa macrophysa	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
Caulerpa mexicana	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Caulerpa microphysa	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0
Caulerpa murrayi	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Caulerpa prolifera	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Caulerpa pusilla	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Caulerpa racemosa	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Caulerpa serrulata	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Caulerpa sertularioides	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Caulerpa taxifolia	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Caulerpa verticillata	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Caulerpa webbiana	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Centroceras gasparrinii	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Centroceras micracanthum	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Centrocerocolax ubatubensis	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0
Ceramium affine	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ceramium brasiliense	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ceramium brevizonatum	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Ceramium cimbricum	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0
Ceramium clarionense	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Ceramium codii	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Ceramium comptum	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Ceramium corniculatum	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	1
Ceramium dawsonii	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Ceramium deslongchampsii	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Ceramium diaphanum	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
Ceramium filicula	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ceramium flaccidum	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Ceramium fujianum	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Ceramium luetzelburgii	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Ceramium nitens	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Ceramium siliquosum	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1
Ceramium tenerrimum	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Ceramium tenuicorne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ceramium uruguayense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ceramium vagans	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Ceratodictyon intricatum	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Ceratodictyon planicaule	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Ceratodictyon repens	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ceratodictyon variabile	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Chaetomorpha aerea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Chaetomorpha antennina	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Chaetomorpha brachygona	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Chaetomorpha clavata	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0
Chaetomorpha ligustica	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
Chaetomorpha minima	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Chaetomorpha nodosa	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Chaetomorpha pachynema	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Chaetomorpha vieillardii	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Chamaedoris peniculum	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Champia compressa	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Champia feldmannii	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Champia minuscula	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
Champia parvula	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Champia salicornioides	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
Champia vieillardii	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Chnoospora minima	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Chondracanthus acicularis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Chondracanthus elegans	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1
Chondracanthus saundersii	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Chondracanthus teedei	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Chondria arcuata	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Chondria atropurpurea	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1
Chondria capillaris	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Chondria collinsiana	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Chondria curvilineata	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Chondria dangeardii	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Chondria dasyphylla	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	1
Chondria decipiens	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0
Chondria floridana	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Chondria leptacremon	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Chondria littoralis	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Chondria platyramea	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Chondria polyrhiza	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Chondria sedifolia	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Chrysymenia dickieana	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Chrysymenia enteromorpha	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Chrysymenia ventricosa	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Cladophora albida	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1
Cladophora aokii	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
Cladophora brasiliana	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Cladophora catenata	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Cladophora coelothrix	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Cladophora conferta	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Cladophora corallicola	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Cladophora crispula	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0
Cladophora dalmatica	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Cladophora flexuosa	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Cladophora fracta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cladophora laetevirens	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Cladophora lehmanniana	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1
Cladophora liebetruthii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cladophora montagneana	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Cladophora ordinata	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Cladophora pellucidoidea	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
Cladophora prolifera	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Cladophora pseudorupestris	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Cladophora rupestris	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Cladophora sericea	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Cladophora socialis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Cladophora vagabunda	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cladophoropsis macromeres	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Cladophoropsis membranacea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Cladosiphon occidentalis	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Claudea elegans	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0
Codium decorticatum	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Codium intertextum	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Codium isthmocladum	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Codium pernambucensis	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Codium profundum	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Codium repens	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Codium spongiosum	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Codium taylorii	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Coelarthrum cliftonii	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Coelothrix irregularis	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Colaconema codicola	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Colaconema hallandicum	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1
Colaconema infestans	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
Colpomenia sinuosa	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Compsothamnion thuyoides	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Corallina officinalis	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1
Corallina panizzoi	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Corallophila atlantica	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Corynecladia clavata	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Corynomorpha clavata	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Cottoniella filamentosa	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
Cottoniella fusiformis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Craspedocarpus jolyi	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0
Crouania attenuata	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Crouania elisiae	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cryptonemia bengryi	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Cryptonemia crenulata	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Cryptonemia delicatula	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Cryptonemia flabellifolia	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Cryptonemia limensis	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Cryptonemia seminervis	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Cryptopleura calophylloides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cryptopleura crispa	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Cryptopleura hayamensis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Cryptopleura peltata	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Cryptopleura ramosa	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Dasya baillouviana	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Dasya brasiliensis	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Dasya caraibica	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Dasya corymbifera	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0
Dasya elongata	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Dasya hutchinsiae	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Dasya ocellata	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Dasya rigidula	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Dasycladus vermicularis	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Dawsoniocolax bostrychiae	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Derbesia marina	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Derbesia tenuissima	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
Derbesia vaucheriaeformis	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Dichotomaria marginata	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Dichotomaria obtusata	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Dictyopteris crassinervia	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Dictyopteris delicatula	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Dictyopteris jamaicensis	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Dictyopteris jolyana	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Dictyopteris justii	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Dictyopteris plagiogramma	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Dictyopteris polypodioides	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0
Dictyosphaeria cavernosa	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Dictyosphaeria ocellata	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Dictyosphaeria versluysii	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Dictyota bartayresiana	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Dictyota caribaea	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Dictyota ciliolata	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Dictyota dolabellana	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Dictyota friabilis	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Dictyota guineensis	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
Dictyota implexa	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0
Dictyota jamaicensis	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Dictyota menstrualis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Dictyota mertensii	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Dictyota pinnatifida	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Dictyota pulchella	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
Dictyurus occidentalis	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Digenea simplex	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Diplothamnion tetrastichum	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Dipterosiphonia dendritica	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Dipterosiphonia reversa	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Dipterosiphonia rigens	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Dohrniella antillara	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Dotyophycus pacificum	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ectocarpus fasciculatus	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Ectocarpus rallsiae	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ectocarpus siliculosus	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0
Ectocarpus variabilis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Elachista minutissima	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Elachistiella leptonematoides	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Enantiocladia duperreyi	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Endarachne binghamiae	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ernodesmis verticillata	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Feldmannia caespitula	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Feldmannia indica	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Feldmannia irregularis	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0
Feldmannia mitchelliae	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Feldmannia simplex	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Frikkiella searlesii	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Galaxaura comans	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Galaxaura rugosa	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Ganonema farinosum	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Ganonema pinnatum	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Gastroclonium parvum	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0
Gayralia brasiliensis	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0
Gayralia oxysperma	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Gelidiella acerosa	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Gelidiella hancockii	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Gelidiella ligulata	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Gelidiocolax pustulata	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Gelidium americanum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Gelidium coarctatum	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Gelidium corneum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Gelidium crinale	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gelidium floridanum	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Gelidium microdonticum	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Gelidium spinosum	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Gelidium torulosum	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0
Gloiocallis dendroidea	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Gloiocladia hassleri	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Gloiocladia iyoensis	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Gomontia lignicola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Gonimophyllum africanum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Gracilaria abyssalis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Gracilaria armata	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Gracilaria birdiae	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Gracilaria brasiliensis	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Gracilaria caudata	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Gracilaria cearensis	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Gracilaria cervicornis	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Gracilaria cornea	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Gracilaria cuneata	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Gracilaria curtissiae	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Gracilaria cylindrica	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Gracilaria domingensis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Gracilaria flabelliformis	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Gracilaria foliifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Gracilaria galetensis	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Gracilaria gracilis	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Gracilaria hayi	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0
Gracilaria intermedia	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Gracilaria isabellana	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Gracilaria mammillaris	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Gracilaria oliveirarum	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Gracilaria ornata	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Gracilaria pauciramosa	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Gracilaria rangifera	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Gracilaria tepocensis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Gracilariopsis silvana	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Gracilariopsis tenuifrons	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Grallatoria reptans	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Grateloupia cuneifolia	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1
Grateloupia dichotoma	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Grateloupia doryphora	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Grateloupia filicina	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Grateloupia filiformis	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Grateloupia subpectinata	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Grateloupia turuturu	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
Griffithsia caribaea	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Griffithsia globulifera	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0
Griffithsia radicans	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Griffithsia schousboei	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Grinnellia americana	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Gymnogongrus griffithsiae	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Gymnothamnion elegans	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Halimeda cuneata	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Halimeda discoidea	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Halimeda gracilis	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Halimeda incrassata	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Halimeda opuntia	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Halimeda simulans	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0
Halimeda tuna	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Halopithys schottii	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Haloplegma duperreyi	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Halopteris filicina	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Halydictyon mirabile	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Halymenia brasiliana	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Halymenia clathrata	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Halymenia duchassaingii	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0
Halymenia elongata	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Halymenia floresii	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Halymenia floridana	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Halymenia integra	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Halymenia pseudofloresii	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Halymenia vinacea	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Hapalospongidion macrocarpum	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Haraldia tenuis	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Hecatonema floridanum	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Hecatonema terminale	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Helminthocladia calvadosii	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Herponema tortugense	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
Herposiphonia bipinnata	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Herposiphonia delicatula	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Herposiphonia nuda	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Herposiphonia parca	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Herposiphonia secunda	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Herposiphonia tenella	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Heterodasya mucronata	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Heterosiphonia crassipes	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Heterosiphonia crispella	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Heterosiphonia gibbesii	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Hildenbrandia rubra	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Hincksia conifera	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Hincksia onslowensis	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Hydroclathrus clathratus	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Hypnea aspera	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Hypnea cenomyce	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Hypnea cervicornis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Hypnea cornuta	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Hypnea edeniana	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Hypnea flava	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Hypnea musciformis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hypnea nigrescens	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Hypnea platyclada	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Hypnea pseudomusciformis	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Hypnea spinella	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Hypnea stellulifera	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Hypnea valentiae	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Hypoglossum anomalum	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Hypoglossum hypoglossoides	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Hypoglossum tenuifolium	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Janczewskia moriformis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Jania adhaerens	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Jania capillacea	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Jania crassa	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
Jania cubensis	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Jania cultrata	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Jania prolifera	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0
Jania pumila	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Jania rubens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Jania sagittata	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
Jania subulata	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Jania ungulata	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Jolyna laminarioides	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Kallymenia limminghei	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Kallymenia westii	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Kappaphycus alvarezii	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
Kuckuckia spinosa	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Kuetzingiella battersii	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Kuetzingiella elachistaeformis	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Laminaria abyssalis	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Laurencia aldingensis	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Laurencia caduciramulosa	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Laurencia caraibica	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Laurencia catarinensis	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Laurencia decumbens	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Laurencia dendroidea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Laurencia oliveirana	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Laurencia translucida	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Laurencia venusta	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Laurenciella marilzae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Lejolisia mediterranea	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Leptofauchea pacifica	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Leptofauchea rhodymenioides	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Levringia brasiliensis	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Liagora albicans	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Liagora ceranoides	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Liagoropsis schrammii	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
Lithoporella atlantica	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Lobophora variegata	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Lomentaria corallicola	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Lomentaria rawitscheri	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Lophocladia trichoclados	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Lophosiphonia cristata	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Lophosiphonia obscura	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Macrocystis pyrifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Meridiocolax polysiphoniae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Meristotheca echinocarpa	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Meristotheca gelidium	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Microdictyon boergesenii	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Microdictyon calodictyon	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Microdictyon japonicum	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microdictyon marinum	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Microdictyon pseudohapteron	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Microdictyon tenuius	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Microdictyon umbilicatum	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Microdictyon vanbosseae	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Murrayella periclados	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Myriactula minor	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Myriogramme prostrata	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Myrionema strangulans	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Nemacystus howei	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Nemalion helminthoides	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
Neomeris annulata	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Neoralfsia expansa	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Neosiphonia ferulacea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Neosiphonia gorgoniae	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Neosiphonia harveyi	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Neosiphonia saccorhiza	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Neosiphonia sertularioides	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Neosiphonia sphaerocarpa	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Neosiphonia tepida	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Neosiphonia tongatensis	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Neostromatella monostromatica	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Nereia tropica	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Neuroglossum binderianum	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
Nitophyllum adhaerens	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Nitophyllum punctatum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Nitophyllum wilkinsoniae	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Ochtodes secundiramea	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Ophidocladus simpliciusculus	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Osmundaria melvillii	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Osmundaria obtusiloba	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Osmundaria volubilis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Osmundea lata	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Osmundea pinnatifida	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Osmundea sanctarum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Padina antillarum	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
Padina boergesenii	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Padina gymnospora	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Padina pavonica	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Padina profunda	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Padina sanctae-crucis	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Palisada corallopsis	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Palisada flagellifera	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Palisada furcata	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Palisada perforata	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Parviphycus setaceous	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0
Parviphycus trinitatensis	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Parvocaulis myriosporus	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Parvocaulis parvulus	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Parvocaulis pusillus	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0
Paulsilvella huveorum	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Pedobesia ryukyuensis	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Penicillus capitatus	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Penicillus pyriformis	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Periphykon delesserioides	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Petalonia fascia	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Petroglossum undulatum	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Petrosiphon adhaerens	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Peyssonnelia armorica	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Peyssonnelia boergesenii	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
Peyssonnelia boudouresquei	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0
Peyssonnelia inamoena	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Peyssonnelia polymorpha	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Peyssonnelia rosenvingei	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Peyssonnelia simulans	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Peyssonnelia valentinii	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Phaeophila dendroides	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Phyllodictyon anastomosans	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Phyllodictyon pulcherrimum	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Platoma cyclocolpum	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Platysiphonia delicata	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Pleonosporium boergesenii	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Pleonosporium borreri	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Pleonosporium mexicanum	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Plocamium brasiliense	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0
Polysiphonia atlantica	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Polysiphonia decussata	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
Polysiphonia denudata	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Polysiphonia exilis	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Polysiphonia foetidissima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Polysiphonia fucoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Polysiphonia havanensis	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Polysiphonia howei	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Polysiphonia incompta	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Polysiphonia scopulorum	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Polysiphonia subtilissima	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Polysiphonia virgata	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Predaea feldmannii	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Predaea tenuis	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Protectocarpus speciosus	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Pseudendoclonium marinum	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Pseudendoclonium submarinum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Pseudocodium floridanum	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Pseudolithoderma moreirae	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Pseudolithoderma subextensum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Pterocladiella australafricanensis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Pterocladiella bartlettii	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Pterocladiella beachiae	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Pterocladiella caerulescens	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Pterocladiella capillacea	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pterocladiella sanctarum	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0
Pterocladiella taylorii	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Pterosiphonia parasitica	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
Pterosiphonia pennata	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Pterosiphonia spinifera	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Pterothamnion heteromorphum	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ptilothamnion speluncarum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Punctaria latifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Reticulocaulis mucosissimus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Rhipidosiphon floridensis	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Rhipilia crassa	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Rhipilia diaphana	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Rhipilia fungiformis	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0
Rhipilia orientalis	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
Rhipilia penicilloides	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Rhipilia tomentosa	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Rhipiliopsis peltata	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Rhipiliopsis stri	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
Rhizoclonium africanum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Rhizoclonium hieroglyphicum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Rhizoclonium riparium	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Rhodophyllis gracilarioides	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Rhodymenia delicatula	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0
Rhodymenia divaricata	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Rhodymenia obtusa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Rhodymenia pseudopalmata	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1
Rosenvingea intricata	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0
Rosenvingea orientalis	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0
Sargassum acinarium	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Sargassum buxifolium	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Sargassum cymosum	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Sargassum filipendula	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Sargassum furcatum	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
Sargassum hystrix	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Sargassum lendigerum	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Sargassum liebmannii	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
Sargassum platycarpum	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Sargassum polyceratium	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0
Sargassum ramifolium	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Sargassum stenophyllum	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Sargassum vulgare	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Scinaia aborealis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Scinaia complanata	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Scinaia furcellata	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Scinaia halliae	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
Scytosiphon lomentaria	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Sebdenia flabellata	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Siphonocladus rigidus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Siphonocladus tropicus	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Solieria filiformis	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Sonderophycus capensis	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Spatoglossum schroederi	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Spermothamnion investiens	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Spermothamnion nonatoi	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0
Sphacelaria brachygona	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Sphacelaria novae-hollandiae	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Sphacelaria rigidula	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Sphacelaria tribuloides	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Spongoclonium caribaeum	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Sporochnus bolleanus	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0
Sporochnus pedunculatus	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Spyridia clavata	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Spyridia filamentosa	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Spyridia hypnoides	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Spyridiocolax capixaba	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Stenogramme interrupta	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Streblocladia corymbifera	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
Streblonema parasiticum	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Stromatella monostromatica	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Struvea elegans	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Stypopodium zonale	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Syringoderma abyssicola	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Taenioma nanum	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Taenioma perpusillum	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
Thuretia bornetii	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Tiffaniella gorgonea	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Titanophora incrustans	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Tolypiocladia glomerulata	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Trichogloea requienii	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Tricleocarpa cylindrica	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Tricleocarpa fragilis	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Turbinaria turbinata	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

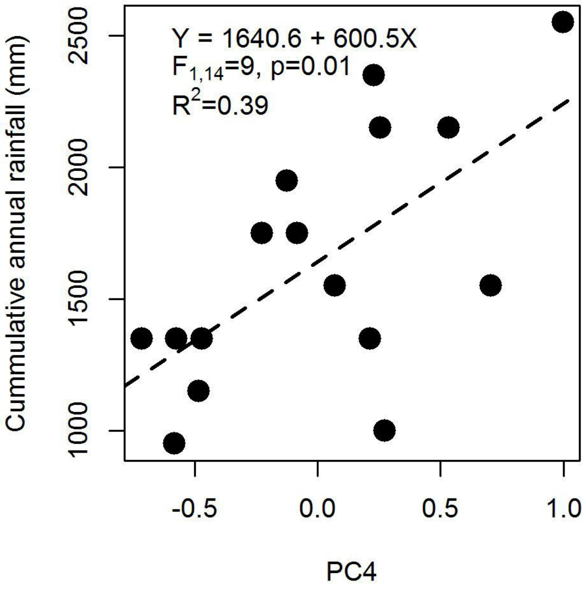
Tabela 8 – Algas por unidade política ao longo da costa tropical e subtropical do oceano Atlântico sudoeste. Continuação.

	MA	PI	CE	RN	PB	PE	AL	SE	BA	ES	RJ	SP	PR	SC	RS	UR
Udotea abbottiorum	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Udotea caribaea	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Udotea cyathiformis	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Udotea dixonii	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Udotea flabellum	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Udotea occidentalis	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Udotea uniestratea	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ulothrix flacca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ulva chaetomorphoides	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Ulva clathrata	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Ulva compressa	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ulva fasciata	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ulva flexuosa	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ulva hookeriana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ulva intestinalis	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ulva lactuca	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ulva linza	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ulva multiramosa	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ulva prolifera	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	1
Ulva rigida	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0
Ulvella lens	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Ulvella scutata	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Ulvella viridis	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Urospora penicilliformis	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Valonia aegagropila	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Valonia macrophysa	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Valonia utricularis	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Valonia ventricosa	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Wrangelia argus	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Wrangelia penicillata	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Wrightiella tumanowiczii	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Wurdemannia miniata	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Yuzurua poiteaui	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Zonaria tournefortii	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
TOTAL	84	119	253	332	340	398	390	394	493	530	484	373	237	227	92	70

Fonte: elaborado pelo autor. MA = Maranhão, PI = Piauí, CE = Ceará, RN = Rio Grande do Norte, PB = Paraíba, PE = Pernambuco, AL = Alagoas, SE = Sergipe, BA = Bahia, ES = Espírito Santo, RJ = Rio de Janeiro, SP = São Paulo, PR = Paraná, SC = Santa Catarina, RS = Rio Grande do Sul, UR = Uruguai.

APENDICE F – RELAÇÃO ENTRE PLUVIOSIDADE E O COMPONENTE PRINCIPAL 4 DAS VARIÁVEIS AMBIENTAIS

Figura 17 – Relação positiva entre pluviosidade e o componente principa nº4 das variáveis ambientais.



Fonte: elaborado pelo autor.