



UNIVERSIDADE FEDERAL RURAL DE PERNAMBUCO
DEPARTAMENTO DE BIOLOGIA
CURSO DE BACHARELADO EM CIÊNCIAS BIOLÓGICAS

JOEL FRANCOLINO DA SILVA JÚNIOR

**INFLUÊNCIA DA SAZONALIDADE SOBRE AS ANGIOSPERMAS
MARINHAS EM UM REFÚGIO TROPICAL DE PEIXES-BOI: ÁREA
DE PROTEÇÃO AMBIENTAL BARRA DO RIO MAMANGUAPE,
BRASIL**

RECIFE

2023



UNIVERSIDADE FEDERAL RURAL DE PERNAMBUCO
DEPARTAMENTO DE BIOLOGIA
CURSO DE BACHARELADO EM CIÊNCIAS BIOLÓGICAS

**INFLUÊNCIA DA SAZONALIDADE SOBRE AS ANGIOSPERMAS
MARINHAS EM UM REFÚGIO TROPICAL DE PEIXES-BOI: ÁREA
DE PROTEÇÃO AMBIENTAL BARRA DO RIO MAMANGUAPE,
BRASIL**

ALUNO: JOEL FRANCOLINO DA SILVA JÚNIOR

Monografia apresentada à coordenação do curso de Bacharelado em Ciências Biológicas, da Universidade Federal Rural de Pernambuco, sob orientação e supervisão da professora Karine Matos Magalhães (professora adjunta da UFRPE), como requisito obrigatório para obtenção do título de Bacharel em Ciências Biológicas.

ORIENTADORA: KARINE MATOS MAGALHÃES

RECIFE
2023

Dados Internacionais de Catalogação na Publicação
Universidade Federal Rural de Pernambuco
Sistema Integrado de Bibliotecas
Gerada automaticamente, mediante os dados fornecidos pelo(a) autor(a)

- S586i Francolino da Silva Júnior, Joel
 INFLUÊNCIA DA SAZONALIDADE SOBRE AS ANGIOSPERMAS MARINHAS EM UM REFÚGIO
 TROPICAL DE PEIXES-BOI: ÁREA DE PROTEÇÃO AMBIENTAL
 BARRA DO RIO MAMANGUAPE, BRASIL / Joel Francolino da Silva Júnior. - 2023.
 25 f. : il.
- Orientadora: Karine Matos Magalhaes.
 Inclui referências e anexo(s).
- Trabalho de Conclusão de Curso (Graduação) - Universidade Federal Rural de Pernambuco,
 Bacharelado em Ciências Biológicas, Recife, 2023.
1. Peixe-boi. 2. alimento. 3. sazonalidade. 4. APA Barra do Rio Mamanguape. I. Magalhaes, Karine
 Matos, orient. II. Título

CDD 574

JOEL FRANCOLINO DA SILVA JÚNIOR

**INFLUÊNCIA DA SAZONALIDADE SOBRE AS ANGIOSPERMAS
MARINHAS EM UM REFÚGIO TROPICAL DE PEIXES-BOI: ÁREA
DE PROTEÇÃO AMBIENTAL BARRA DO RIO MAMANGUAPE,
BRASIL**

Monografia apresentada à coordenação do curso de Bacharelado em Ciências Biológicas, da Universidade Federal Rural de Pernambuco, sob orientação e supervisão da professora Karine Matos Magalhães (professora adjunta da UFRPE), como requisito obrigatório para obtenção do título de Bacharel em Ciências Biológicas.

BANCA EXAMINADORA

Prof^ª. Dr^ª. Karine Matos Magalhães
(Professora adjunta UFRPE)

Me. Ana Maria da Costa de Souza
(Doutoranda PPGBio - UFRPE - Membro Interno)

Dr. Yasmim Alline de Araujo Castro
(UPE - Membro Externo)

Prof. Dr. Alfredo Matos Moura Junior
(CAP - UFPE - Membro Externo)

RECIFE, 2023

AGRADECIMENTOS

Gostaria de agradecer primeiramente ao apoio da PETROBRÁS e do Projeto Viva o Peixe-boi Marinho por terem financiado as atividades que envolveram essa pesquisa. A própria Universidade Federal Rural de Pernambuco (UFRPE), Programa de Educação Tutorial em Ecologia da UFRPE e Laboratórios de Ecossistemas Aquáticos da UFRPE por terem me fornecido uma formação de excelência, assim como me apoiado através dos programas de bolsas estudantis durante essa jornada.

Aos meus familiares, em especial à minha mãe Margarete Maria Bernardo da Silva, que sempre me apoiaram me fornecendo as condições que permitiram que eu seguisse essa trajetória. A meus amigos, em especial Débora Maria Soares Ramos, que sempre me forneceram o apoio emocional quando necessitei além de me ajudarem a lidar com adversidades do dia a dia e observar em mim coisas que nem eu observava muitas vezes. A todos os meus colegas do Laboratório de Ecossistemas Aquáticos (LEAqua) da UFRPE, em especial à minha orientadora Karine Matos Magalhães, que não só me ajudou a progredir em minha carreira, constantemente me incentivando, treinando minhas habilidades profissionais e estimulando à evolução tanto dos meus pontos fortes quanto negativos, como também, se tornou uma ótima amiga com o qual poderia contar.

Esse trabalho também não seria possível sem o auxílio do professor Rodrigo Felipe Rodrigues do Carmo e de seu aluno de doutorado Gabriel Xavier Boldorini Ariero que forneceram toda a atenção e ajuda necessária para a realização das análises estatísticas aqui presentes.

RESUMO

Entre os requisitos de habitat para o peixe-boi marinho estão a disponibilidade de água doce, abrigo e alimentação. No litoral brasileiro os animais se alimentam, preferencialmente, de angiospermas marinhas, assim, saber seu estoque pode auxiliar nos esforços de conservação deste ameaçado animal. Diante disso, o presente trabalho teve como objetivo estimar o estoque alimentar de angiospermas marinhas para o peixe-boi marinho em um refúgio tropical de reintrodução, a APA Barra do Rio Mamanguape. No local, entre outubro de 2013 e junho de 2014, foram realizadas quatro coletas, sendo duas no período seco e duas no chuvoso, para testar a influência dos períodos sazonais do ano na densidade de hastes e nas biomassas das espécies. Foram realizados testes de diferenças de médias (Teste T) com auxílio do software R. Na região, foram localizados seis prados compostos por até 3 espécies. O efeito da sazonalidade foi registrado com o aumento da densidade de hastes de *Halodule wrightii* e biomassa aérea da *Halophila decipiens* durante o período chuvoso. Por outro lado, a biomassa aérea de *H. wrightii* foi significativamente maior no período seco. *Halophila baillonii*, a biomassa subterrânea de todas as espécies não apresentaram variações sazonais assim como não foram verificadas diferenças mas entre as biomassas entre prados mono e multiespecíficos. Foi calculado estoque total de angiospermas marinhas variando entre 950.540kg.dw a 1.738476kg.dw para os peixes-bois na área. De forma geral, o estoque de biomassa aérea da região apresentou produção maior durante os períodos secos do ano, indicando que há alimentação disponível para os animais, contudo, ainda são necessários cálculos de capacidade de suporte da área para fins de reintrodução de animais.

PALAVRAS-CHAVE: Peixe-boi, alimento, *Halodule*, *Halophila*, sazonalidade, APA Barra do Rio Mamanguape.

ABSTRACT

Among the habitat requirements for the marine manatee are the availability of fresh water, shelter and food. On the Brazilian coast, animals preferentially feed on marine angiosperms, so knowing their stock can help conservation efforts for this endangered animal. In view of this, the present work aimed to estimate the food stock of marine angiosperms for the marine manatee in a tropical reintroduction refuge, the APA Barra do Rio Mamanguape. On site, between October 2013 and June 2014, four collections were carried out, two in the dry season and two in the rainy season, to test the influence of the seasonal periods of the year on the density of stems and on the biomass of the species. Tests of differences in means (T Test) were carried out with the aid of the R software. In the region, six meadows composed of up to 3 species were located. The effect of seasonality was registered with the increase in stem density of *Halodule wrightii* and aerial biomass of *Halophila decipiens* during the rainy season. On the other hand, the aboveground biomass of *H. wrightii* was significantly higher in the dry period. *Halophila baillonii*, the belowground biomass of all species did not show seasonal variations, as well as differences between the biomass between mono and multispecific grasslands were not verified. Total marine angiosperm stocks ranging from 950,540kg.dw to 1,738,476kg.dw for manatees in the area were calculated. In general, the stock of aboveground biomass in the region showed higher production during the dry periods of the year, indicating that there is food available for the animals, however, calculations of the carrying capacity of the area are still necessary for the purpose of reintroducing animals.

KEYWORDS: Manatee, food, Halodule, Halophila, seasonality, APA Barra do Rio Mamanguape.

SUMÁRIO

AGRADECIMENTOS	2
RESUMO	3
ABSTRACT	4
1. INTRODUÇÃO	6
1.1. OBJETIVO	8
1.1.1. Objetivo Geral	8
1.1.2. Objetivos específicos	8
2. MATERIAIS E MÉTODOS	8
2.1. ÁREA DE ESTUDO	8
2.2. AMOSTRAGEM	9
2.3. ANÁLISES DE DADOS	9
3. RESULTADOS E DISCUSSÃO	10
3.1. CARACTERIZAÇÃO DOS PRADOS	10
3.2. PARÂMETROS POPULACIONAL	11
3.3. ESTOQUE ALIMENTAR	15
4. CONCLUSÃO	17
5. REFERÊNCIAS	18

1. INTRODUÇÃO

Ecosistemas costeiros como marismas, recifes de corais, manguezais e prados de angiospermas marinhas compõem ambientes de suma importância tanto para a biodiversidade quanto para a economia mundial (HEMMINGA e DUARTE, 2000; BURKE *et al.*, 2001; WAYCOTT *et al.*, 2004; ORTH *et al.*, 2006). Dentre esses sistemas, as angiospermas marinhas compõem um grupo de espécies evolutivamente recentes, quando comparadas às angiospermas terrestres, que se adaptaram para viver no ambiente aquático marinho (HEMMINGA e DUARTE, 2000) desde estuários até zonas de grande profundidades (aproximadamente 80 metros) (DUARTE, 1991; WAYCOTT *et al.*, 2004). Mesmo apresentando uma baixa diversidade se comparada as angiospermas terrestres (72 espécies), essas plantas se distribuem por todos os oceanos do mundo, com exceção do Antártico (HEMMINGA e DUARTE, 2000 ; SHORT *et al.*, 2007; HORT *et al.*, 2011).

Entre os serviços ecossistêmicos fornecidos pelos prados de angiospermas marinhas está o alto valor econômico atrelado a eles (HEMMINGA e DUARTE, 2000; NORDLUND, *et al.* 2016; NORDLUND *et al.*, 2018; CUNHA-LIGNON *et al.*, 2022) sendo estes considerados entre os ecossistemas mais valiosos do mundo (COSTANZA *et al.*, 2014). Além do valor econômico, essas plantas são vitais para a manutenção da vida marinha, podendo destacar a presença dessas mesma na cadeia trófica de muitas espécies marinhas e terrestres (HEMMINGA e DUARTE, 2000; HECK JR e VALENTINE, 2006; NORDLUND *et al.*, 2018; UNSWORTH *et al.* , 2019; LYAKURWA, 2020; VALENTINE e HECK, 2021), alta produtividade primária, estabilização de sedimentos e captação de carbono oceânico (DUARTE e CHISCANO, 1999; HEMMINGA e DUARTE, 2000; CUNHA-LIGNON *et al.*, 2022).

Como alimento direto, as diversas espécies de angiospermas marinhas são consumidas tanto por invertebrados quanto por vertebrados (HEMMINGA e DUARTE, 2000; HECK JR e VALENTINE, 2006; VALENTINE e HECK, 2021; ATTADEMO *et al.*, 2022), por conta de sua alta taxa proteica (MELO *et al.*, 2022). Conforme revisado por Cunha-Lignon (2022), essas plantas também

fazem parte da dieta humana, podendo ser consumidas diretamente em saladas, ou usadas de formas alternativas, como a utilização das sementes para a produção de farinha para biscoito. Entre os principais consumidores, os sirênios se destacam podendo consumir tanto suas folhas como suas raízes e rizomas (ATTADEMO *et al.*, 2022).

No território brasileiro, o Peixe-boi marinho (*Trichechus manatus manatus* Lineu, 1758) é descrito como um dos maiores consumidores das angiospermas marinhas diante do seu consumo diário, que vai de 8 a 13% de seu peso em alimento, priorizando as angiospermas marinhas (FAVERO *et al.*, 2020; MELO *et al.*, 2022). No Brasil, os mesmos são alvos de esforços de conservação desde a década de 1980 (NORMANDE *et al.*, 2015), o que reflete em seu atual status na lista nacional de espécies ameaçadas, enquadrando-o na categoria Em Perigo (EN) (MMA, 2022), mas que outrora figurava como criticamente ameaçado (CR) (NORMANDE *et al.*, 2015). Ainda que no cenário mundial tais animais sejam considerados Vulneráveis (VU) (IUCN, 2022), as perspectivas futuras para os mesmos apontam prováveis declínios populacionais, uma vez que as principais ameaças que afligem essa espécie tendem a aumentar nos próximos anos (MEIRELLES *et al.*, 2022).

Sabendo-se que entre os requisitos de habitats para o *T. manatus manatus* estão a alimentação e fontes de água doce (FAVERO *et al.*, 2020; MELO *et al.*, 2022), e que, atualmente, seu principal alimento (as angiospermas marinhas) passam por um acentuado declínio populacional por todo mundo (ORTH *et al.*, 2006; SHORT *et al.*, 2006; WAYCOTT *et al.*, 2009; SHORT *et al.*, 2011), o entendimento das dinâmicas populacionais, assim como o mapeamento e a conservação das angiospermas marinhas se fazem essenciais para garantir a conservação do Peixe-boi marinho. Um dos exemplos de esforços para conservação destes mamíferos está na Área de Proteção Ambiental (APA) Barra do Rio Mamanguape, onde o projeto Peixe-boi marinho já vem monitorando e reintroduzindo animais de desde 1994 (NORMANDE *et al.*, 2015). Até o momento, cerca de cinquenta animais já foram soltos na área (DOS SANTOS *et al.*, 2022). Deste modo, o presente trabalho visa quantificar a disponibilidade de alimento para o Peixe-boi marinho na APA Barra do Rio Mamanguape. Com os resultados obtidos, esperamos

contribuir nas tomadas de decisões voltadas às estratégias de conservação e manejo dessa espécie.

1.1. OBJETIVO

1.1.1. Objetivo Geral

Avaliar o estoque alimentar de angiospermas marinhas para o Peixe-boi marinho (*Trichechus manatus manatus*) na Área de Proteção Ambiental Barra do Rio Mamanguape, Paraíba.

1.1.2. Objetivos específicos

- Localizar os prados de angiospermas marinhas presentes na região;
- Identificar as espécies de angiospermas marinhas encontradas nos prados;
- Quantificar os parâmetros populacionais (densidade, biomassa aérea e subterrânea) das espécies identificadas;
- Analisar a variação do estoque alimentar (biomassas aéreas total) de angiospermas marinhas disponível para o Peixe-boi marinho.

2. MATERIAIS E MÉTODOS

2.1. ÁREA DE ESTUDO

A Área de Proteção Ambiental (APA) Barra do Rio Mamanguape, está localizada no estado da Paraíba, nordeste brasileiro (6°47'41" S; 35°03'15" W) (MAGALHÃES *et al.*, 2015). A área protegida de 14.640 ha foi criada pelo Decreto Federal nº. 924 de 10 de setembro de 1993 e envolve os estuários de dois rios (Mamanguape e Miriri) que incluem manguezais, ilhas, ilhotas, recifes (ICMbio, 2014) e prados de angiospermas marinhas (MAGALHÃES *et al.*, 2015). Apresenta um clima tropical e chuvoso com médias de pluviosidade anual acima de 1000 mm, com o período chuvoso que vai de fevereiro a agosto

e o seco de setembro a janeiro, com temperaturas médias que variam de 24°C a 27°C (ICMbio, 2014).

2.2. AMOSTRAGEM

O estudo foi realizado entre outubro de 2013 e junho de 2014 onde a identificação dos prados a serem monitorados se deu por meio de uma busca ativa seguida de mergulho para confirmação dos prados ao longo de 3,2km do estuário do rio Mamanguape. Após a localização dos prados, as áreas foram amostradas para determinação do efeito da variação dos parâmetros populacionais, em quatro coletas, sendo duas no período seco (outubro/2013 e janeiro/2014) e duas no período chuvoso (abril/2014 e junho/2014).

Em cada ponto amostral foram coletadas 10 amostras com auxílio de um coletor com área de 73,86 cm². Cada amostra foi devidamente marcada, armazenada e transportada até o momento das análises. Em laboratório, foram identificadas as espécies presentes em cada prado e calculadas a densidade de hastes e as biomassas aéreas e subterrâneas. A densidade foi determinada a partir da contagem de hastes de cada amostra e, após a contagem das hastes foi realizada a separação das partes aéreas e subterrâneas das plantas, e submetidas a secagem por um período de 48h sobre uma temperatura de 60°C, até peso seco constante (MAGALHÃES e AMARAL, 2021). Após a pesagem os valores obtidos foram convertidos para metro quadrado e para quilogramas, sendo expressos em hastes.m² (para densidade), g.dw.m⁻² (para as biomassas aéreas e subterrâneas de cada espécie) e kg.dw (para biomassa aérea total que corresponde ao estoque alimentar da região).

2.3. ANÁLISES DE DADOS

As análises estatísticas foram realizadas por meio de testes de diferenças de médias (Teste T) por meio do software R. Portanto, para aferir o estoque de angiospermas marinhas disponíveis para a alimentação do Peixe-boi marinho, foi testado a influência da sazonalidade e dos diferentes

tipos de prados para a construção do estoque alimentar (biomassa aérea total da região). Além disso, através dos mesmos testes, foi identificada a influência da sazonalidade nos parâmetros populacionais (biomassa aérea, biomassa subterrânea e densidade de hastes) das espécies de angiospermas marinhas encontradas. Para os dados de distribuição normal foram usados os testes de Levene, enquanto que, para os dados com distribuições anormais foram usados os testes de Kruskal.

Pelo fato de todas as espécies encontradas na área participarem da dieta do Peixe-boi marinho (MAGALHÃES *et al.*, 2022), o estoque alimentar de angiospermas marinhas situadas na APA Barra do Rio Mamanguape foi representado pelo quantitativo valor total da biomassa aérea da área de estudo. Diante disso, duas análises de diferenças de médias (Teste T) foram realizadas no software R, a fim de identificar a influência da sazonalidade no estoque alimentar disponível para o Peixe-boi marinho da região.

3. RESULTADOS E DISCUSSÃO

3.1. CARACTERIZAÇÃO DOS PRADOS

Na APA Barra de Mamanguape foram localizados seis prados de angiospermas marinhas, compostos pelas espécies *Halodule wrightii* Ascherson 1868, *Halophila baillonii* Ascherson 1874 e *Halophila decipiens* Ostenf 1902. A área total calculada de angiospermas marinhas no estuário foi de cerca de 30 ha. Entre os seis prados monitorados, dois eram monoespecíficos, compostos exclusivamente pela espécie *H. wrightii*, e quatro multiespecíficos, onde três apresentavam uma associação de duas espécies, *H. wrightii* e *H. decipiens*, e apenas um apresentava a associação de todas as três espécies. Os prados brasileiros pertencem à bioregião tropical e seis espécies são descritas para o litoral brasileiro, distribuídas entre os gêneros *Halophila*, *Halodule* e *Ruppia* (SHORT *et al.* 2007; SHORT *et al.*, 2011). Ou seja, a área da APA apresenta um dos prados mais diversos do Brasil, perdendo apenas para um prado do Piauí que tem cinco espécies (BARROS *et al.*, 2014; DA SILVA *et al.*, 2018).

Entre as espécies estudadas, a *Halodule wrightii* se mostra dominante por toda a costa da América do Sul (CREED, 1999; SHORT *et al.* 2007; SHORT *et al.*, 2011; MELO *et al.*, 2022), podendo ser encontrada em prados tanto mono quanto multiespecíficos (CREED, 1999; DUARTE e CHISCANO 1999; HEMMINGA e DUARTE, 2000; SHORT *et al.* 2007; SHORT *et al.*, 2011; MAGALHÃES *et al.*, 2021; MAGALHÃES *et al.*, 2022) o que foi confirmado no presente estudo. Essa confirmação já era esperada uma vez que Magalhães *et al.* (2015) já tinham descrito tanto a presença dessas três espécies quanto a conformação de prados multi e mono específicos na área estudada.

Entre as espécies ocorrentes na área duas pertencem ao gênero *Halophila* que é conhecido por ser o com maior número de espécies representantes e o mais distribuído no mundo (HEMMINGA e DUARTE, 2000; SHORT *et al.* 2007; SHORT *et al.*, 2011;). Entre as espécies deste gênero encontradas a *H. baillonii* é a mais rara no litoral brasileiro, tendo sido registrado pela primeira vez na APA após pouco mais de 80 anos desde seu último registro no litoral brasileiro (MAGALHÃES *et al.*, 2015). No momento apenas duas outras populações ocorrem no Brasil (MAGALHÃES *et al.*, 2022).

3.2. PARÂMETROS POPULACIONAIS

As espécies estudadas variaram em densidade de hastes entre 133 (mínima) e 7163 (máxima) hastes.m² no período seco para 113 (mínima) e 7295 (máxima) hastes.m² no chuvoso para *H. wrightii* (fig. 1a), apresentando médias mais elevadas durante os períodos secos e menores durante os chuvosos (p<0.05). Para as espécies do gênero *Halophila*, a *H. baillonii* apresentava variação entre 796 - 2520 hastes.m² no período seco para 133 (mínima) e 5040 (máxima) hastes.m² no período chuvoso (fig. 1b), enquanto que a *H. decipiens* apresentou variação de 796 (mínima) a 1724 (máxima) hastes.m² durante o período seco e 113 (mínima) a 10081 (máxima) hastes.m² no período chuvoso (fig. 1c), não sendo verificadas variações significativas entre os períodos estudados para nenhuma das duas espécies (p>0.05).

Estudos anteriores sobre a relação da densidade de *H. wrightii* já indicam que esta variável está relacionada ao comprimento de suas hastes e

tipos de praia que se encontram, e não com a variação sazonal (CREED, 1999; SHORT *et al.*, 2006; BARROS *et al.*, 2013). Quando comparados com outras populações do Brasil, independente da sazonalidade, nossos valores se mostram menores (MAGALHÃES *et al.*, 1997; DUARTE e CHISCANO, 1999; CREED, 1999; BARROS *et al.*, 2016; BERTELLI *et al.*, 2020; MAGALHÃES e AMARAL, 2021) sendo observado valores maiores apenas em locais que sofreram por algum impacto recente (BERTELLI *et al.*, 2020).

Entre as espécies diagnosticadas do gênero *Halophila*, ambas sofrem por escassez de estudos acerca de sua biologia no Brasil (BARROS *et al.*, 2013; BARROS *et al.*, 2016), dentre as espécies estudadas, a *H. baillonii* é a que menos conhecemos no que diz respeito à sua dinâmica ecológica (MAGALHÃES *et al.*, 2015). Muito por conta da sua baixa dispersão e seu alto número de populações em declínio (SHORT *et al.*, 2011). Levando em consideração ao pouco que sabemos sobre a dinâmica dessa espécie no Brasil, nossos dados mostram que a densidade de hastes é maior do que a das populações anteriormente encontradas pela costa brasileira (BARROS *et al.*, 2014; BARROS *et al.*, 2016), não variando muito desde sua primeira descrição no local (MAGALHÃES *et al.*, 2015). Entretanto, essa população é relativamente menor quando comparadas às registradas em países próximos, como exemplo de prado há o da Costa Rica (SAMPER-VILLARREAL *et al.* 2014).

No Brasil, a *H. decipiens* é conhecida por comumente estar associada a *H. wrightii*, formando prados multiespecíficos em regiões sempre submersas (LABOREL-DEGUEN, 1963). A densidade de suas hastes comumente é afetada e reduzida pelos efeitos das marés (LABOREL-DEGUEN, 1963), aumentando sua densidade de hastes durante o período seco (LABOREL-DEGUEN, 1963; BARROS *et al.*, 2016). Ainda que estudos na mesma região tenham indicado valores significativamente maiores no período seco (BARROS *et al.*, 2016), nossos dados não demonstraram variações significativas nos períodos estudados.

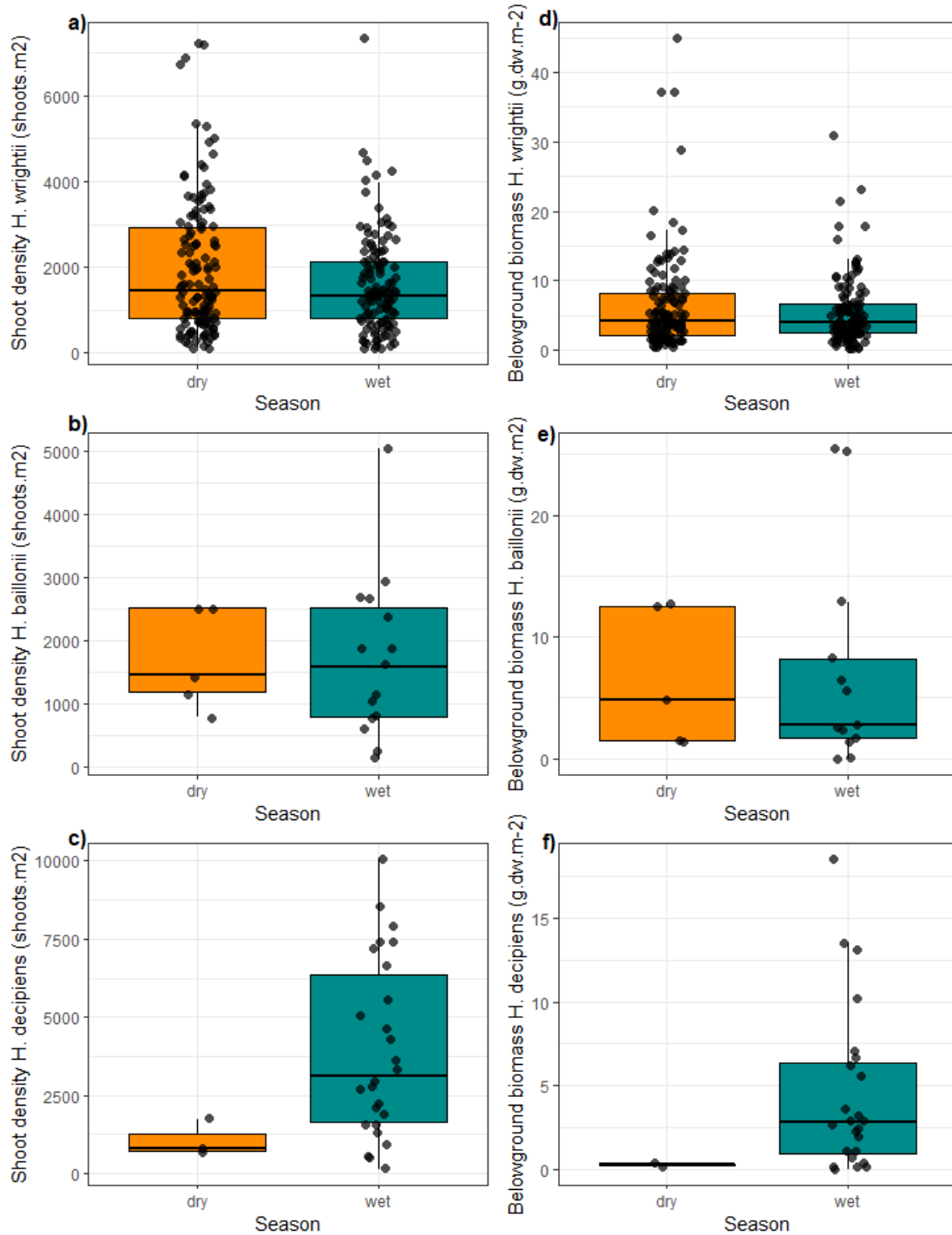


Fig. 01. Parâmetros populacionais das angiospermas marinhas situadas na APA Barra do Rio Mamanguape não vinculados à alimentação do Peixe-boi marinho. a) Densidade de hastes de *H.wrightii*; b) Densidade de hastes de *H. baillonii*; c) Densidade de hastes de *H. decipiens*; d) Biomassa subterrânea de *H.wrightii*; e) Biomassa subterrânea de *H. baillonii*; f) Biomassa subterrânea de *H. decipiens*.

As biomassas subterrâneas, independente da espécie, não apresentaram variações significativas entre os períodos climáticos do ano ($p > 0.05$). Para a *H. wrightii* o peso seco de sua biomassa subterrânea variou entre 0.40 (mínima) e 30.91 (máxima) g.dw.m⁻² no período seco para 0.13 (mínima) e 44.97 (máxima) g.dw.m⁻² no chuvoso (fig. 1d); a *H. baillonii* apresentou variação entre 1.33 (mínima) e 25.47 (máxima) g.dw.m⁻² no período seco para 0.00 (mínima) e 12.47 (máxima) g.dw.m⁻² no período chuvoso (fig. 1e); enquanto que a *H. decipiens* apresentou variação entre 0.13 (mínima) e 0.40 (máxima) g.dw.m⁻² no período seco para 0.00 (mínima) e 18.57 (máxima) g.dw.m⁻² no período chuvoso (fig. 1f). As baixas taxas de biomassa subterrâneas já eram esperadas, pois os gêneros diagnosticados são conhecidos por apresentarem maiores taxas de biomassa aéreas (DUARTE e CHISCANO, 1999).

A biomassa abaixo do solo da *H. wrightii*, em alguns locais da costa brasileira, é documentada como um parâmetro influenciado pelos padrões sazonais do ano (CREED 1999; SHORT *et al.*, 2006; BARROS *et al.*, 2016; MAGALHÃES e AMARAL, 2021). De forma geral, nossos dados foram inferiores a outros já documentados pelo Brasil, principalmente na região nordeste (SHORT *et al.*, 2006; MAGALHÃES e AMARAL, 2021), se assemelhando mais às biomassas subterrâneas dos prados localizados na região sudeste do país (SHORT *et al.*, 2006).

Diferente de nossas análises, estudos anteriores realizados na mesma população de *H. baillonii* situada na APA da Barra do Rio Mamanguape já indicavam que sua biomassa subterrânea não é influenciada períodos sazonais do ano (MAGALHÃES *et al.*, 2015). Os altos níveis de biomassa subterrâneas aqui identificados se mostram muito superiores à descrição anterior feita por Magalhães *et al* (2015); além disso, a biomassa subterrânea encontrada se mostrou maior que a dos demais prados de *H. baillonii* diagnosticados no Brasil (BARROS *et al.*, 2014) e também maior que o prado mais próximo fora da América do Sul (SAMPER-VILLARREAL *et al.* 2014), sendo esse um prado bem estabelecido na região.

Assim como as demais, a biomassa subterrânea da *H. decipiens* não apresentou diferenças significativas entre os períodos estudados, o que

coincide com estudos anteriores para essa espécie no Brasil (LABOREL-DEGUEN, 1963; BARROS *et al.*, 2016), o que pode indicar uma maior estabilidade da espécie na região. Nossos dados de biomassa subterrânea seca se mostram levemente superiores aos descritos anteriormente por Barros *et al.* (2016) e também aos de outras populações fora do Brasil, como o de uma população do Golfo da Califórnia (SANTAMARIA-GALLEGOS *et al.*, 2006).

Entre as espécies que compõem o estoque, *H. wrightii* apresentou dados de biomassa aérea significativamente maiores no período seco ($p < 0.05$), variando de 0.13 (mínima) e 35.28 (máxima) g.dw.m⁻² no período seco, para 0.13 (mínima) e 14.86 (máxima) g.dw.m⁻² no chuvoso (fig. 2a). Entretanto, as demais espécies demonstraram comportamentos diferentes quanto à dinâmica de suas biomassas aéreas. A *H. baillonii* não apresentou sofrer influência em nenhum dos períodos estudados ($P > 0.05$), variando sua biomassa aérea entre 2.12 (mínima) e 4.64 (máxima) g.dw.m⁻² no período seco para 0.53 (mínima) e 16.58 (máxima) g.dw.m⁻² no período chuvoso (fig. 2b). A *H. decipiens*, por sua vez, mostrou um comportamento inverso à *H. wrightii*, apresentando valores maiores nos períodos chuvosos ($p < 0.05$), com variações que iam de 0.53 (mínima) e 0.93 (máxima) g.dw.m⁻² no período seco para 0.13 (mínima) e 10.08 (máxima) g.dw.m⁻² no período chuvoso (fig. 2c).

Estudos anteriores com a *H. wrightii* já indicam a dinâmica dessa espécie em aumentar sua produção de biomassa aérea durante os períodos secos do ano, e reduzi-las nos períodos chuvosos (MAGALHÃES *et al.*, 1997; CREED, 1999; SHORT *et al.*, 2006; BARROS *et al.*, 2016; MAGALHÃES e AMARAL, 2021), mostrando que as adversidades causadas pelos períodos prolongados das chuvas afetam negativamente a produção de biomassa acima do solo da espécie. Em relação à *H. baillonii*, nossa descrição discorda do que relatado por Magalhães *et al.* (2015), que descreve que essa espécie, na APA Barra do Rio Mamanguape, varia sazonalmente sua biomassa aérea. Por outro lado, no presente estudo, a *H. decipiens* se favorece do período de chuvas para seu desenvolvimento, quase sumindo durante os períodos secos. Esse comportamento difere de estudos anteriores, que apresentaram o comportamento inverso ao descrito para a influência da sazonalidade na

biomassa aérea (LABOREL-DEGUEN, 1963; SANTAMARIA-GALLEGOS *et al.*, 2006; BARROS *et al.*, 2016).

3.3. ESTOQUE ALIMENTAR

O estoque alimentar, representado pela biomassa aérea total das angiospermas marinhas da área, apresentou uma maior produção durante os períodos secos do ano ($p < 0.005$) (fig. 2d); contudo não variou entre prados mono e multespecíficas ($p > 0.05$) (fig. 2e). Isso indica que a biomassa aérea total das angiospermas marinhas disponível para alimento do peixe-boi marinho sofre influência apenas pela sazonalidade, indo de encontro com informações da literatura (CREED, 1999; DUARTE e CHISCANO, 1999); portanto, as adversidades ambientais causadas pelos extensos períodos de chuva reduzem à disponibilidade de alimento para o Peixe-boi marinho.

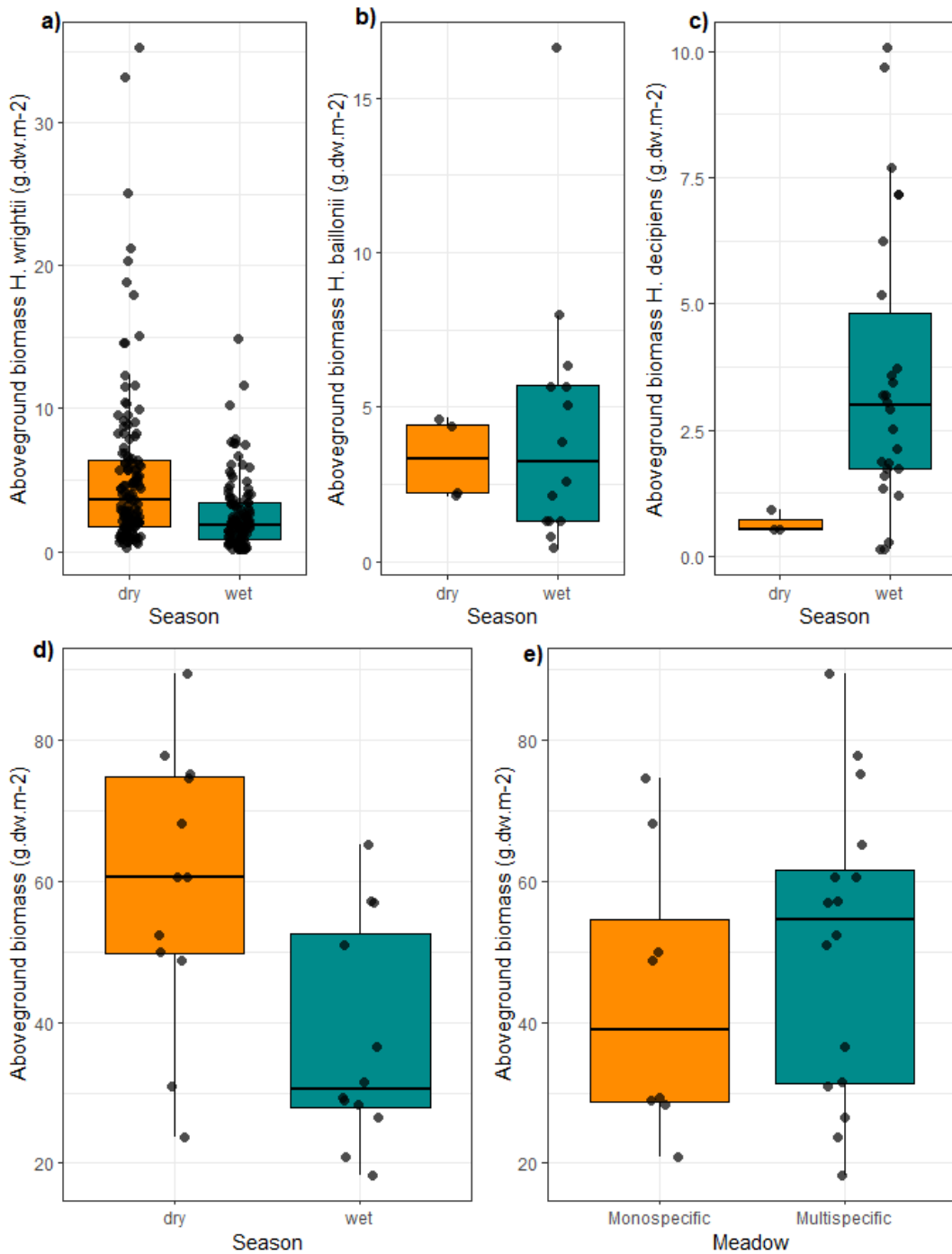


Fig. 02. Biomassa aérea das angiospermas marinha na APA Barra do Rio Mamanguape. a) Biomassa de *H.wrightii*; b) Biomassa aérea de *H. baillonii*; c) Biomassa de *H. decipiens*; d) Estoque alimentar para o Peixe-boi marinho presente na APA Barra do Rio Mamanguape nos períodos seco e chuvoso do ano. e) Estoque alimentar para o Peixe-boi marinho presente na APA Barra do Rio Mamanguape por composição do prado.

Assim, numa área de 30ha o estoque disponível de angiosperma marinha disponível para alimentação do peixe-boi variou entre mínimas de

950.540 kg.dw a máximas de 1.738476kg.dw, se mostrando maior quando comparado com modelagens anteriores feitas no nordeste brasileiro (FREIRE *et al.*, 2008) e em outros estudos de modelos tróficos feitos nas américas e que foram revisados por Castelblanco-Martínez *et al.* (2012).

Os dados levantados podem ser utilizados para estratégia de soltura dos animais em futuros cálculos de capacidade de suporte. Para isso, deve-se levar em consideração o crescimento rápido das espécies com taxa de renovação entre 4 e 7 dias (HEMMINGA e DUARTE, 2000); a dieta dos animais, visto que os Peixes-bois são herbívoros generalistas e oportunistas (CASTELBLANCO-MARTÍNEZ *et al.*, 2012; ATTADEMO *et al.*, 2022), que consomem de 8 e 13% do seu peso em alimento (ATTADEMO *et al.*, 2022; MELO *et al.*, 2022); para o Brasil, estima-se uma média de 400 kg por animal adulto (FREIRE *et al.*, 2008), tendo como principal alimento a *H. wrightii* (mas também se alimentando das outras espécies diagnosticadas) (ATTADEMO *et al.*, 2022; MELO *et al.*, 2022). Assim, com essas informações e as de produção de estoque na área, pode ser feito, no futuro, o cálculo de quantos animais podem ser mantidos em condições saudáveis para as plantas e peixes-boi.

4. CONCLUSÃO

Sendo a presença das angiospermas marinhas um dos três principais fatores que definem distribuição e uso de habitat pelo Peixe-boi marinho, e pelo fato da região estudada apresentar as condições ideais para esse animais(fontes de água doce, locais para descanso e alta concentração de angiospermas marinhas), a região vem sendo utilizada a mais de duas décadas como um ponto de reintrodução e reabilitação do Peixe-boi marinho. Desta forma, o presente estudo confirma a disponibilidade de angiospermas marinhas, elucidando o efeito das sazonalidade e das diferentes composições dos prados sobre a dinâmica das populações de angiospermas marinhas da região, sendo essas informações de suma importância para o entendimento da biologia comportamental do Peixe-boi marinho.

Sendo assim, esse trabalho se mostra importante pois as informações aqui apresentadas podem fundamentar novas discussões que auxiliem os gestores da unidade de conservação para uma melhor implementação do plano de manejo da região. Ademais, incentiva outras unidades que possuam projetos de reintrodução do Peixe-boi marinho a aderirem a projetos que façam o levantamento desse recurso vital para o animal.

Entretanto, por mais que pesquisas que realizam o levantamento do estoque alimentar sejam importantes, ainda há a necessidade de entender se a região possui capacidade de regeneração desse recurso. Diante disso, estudos que avaliam a capacidade de suporte da região são essenciais, a fim de garantir a continuidade da APA Barra do Rio Mamanguape como um importante ponto de reintrodução do Peixe-boi marinho.

5. REFERÊNCIAS

ATTADEMO, F.L.N., LUNA, F.O., ATHIÊ-SOUZA, S.M., SILVA-JUNIOR, J.F., VASCONCELOS, E.R.T.P.P., VASCONCELOS, J.B., AMARAL, A.B., MAGALHÃES, K.M (Orgs). **Guia de Itens Alimentares de Peixe-Boi-Marinho**. Brasília: ICMBio. 68 p., 2022.

BARROS, K., COSTA, F., ROCHA-ARREIRA, C. A. *Halophila baillonis* Ascherson bed on the semiarid coast of Brazil. **Feddes Repertorium**, v. 125, n. 3-4, p. 93-97, 2014.

BARROS, K. V. S., ROCHA-ARREIRA, C. A., MAGALHÃES, K. M. Ecology of Brazilian seagrasses: Is our current knowledge sufficient to make sound decisions about mitigating the effects of climate change?. **Iheringia, Série Botânica.**, v. 68, n. 1, p. 163-178, 2013.

BARROS, K. V. S., ROCHA-BARREIRA, C. A., MAGALHÃES, K. M. Seagrass meadows on the northeast coast of Brazil: habitat influence on the spatial and seasonal variations. Aquatic ecosystems: influences, interactions and impact on the environment. **Nova Science Publishers**, New Jersey, p. 1-29, 2016.

BARROS, K. V. D. S., XIMENES, C. F., CARNEIRO, P. B. M., ROCHA-BARREIRA, C. D. A., MAGALHÃES, K. M. Influence of the shoot density of *Halodule wrightii* Ascherson from rocky and sandy habitats on associated macroalgal communities. **Brazilian Journal of Oceanography**, v. 61, p. 205-214, 2013.

- BERTELLI, C. M., CREED, J. C., NUUTTILA, H. K., & UNSWORTH, R. K. The response of the seagrass *Halodule wrightii* Ascherson to environmental stressors. **Estuarine, Coastal and Shelf Science**, v. 238, p. 106693, 2020.
- BURKE, L., KURA, Y., KASSEM, K., REVENGA, C., SPALDING, M., MCALLISTER, D., CADDY, J. **Coastal ecosystems** (p. 77). Washington, DC: World Resources Institute, 2001.
- COLLIER, C. J., LANGLOIS, L. M., MCMAHON, K. M., UDY, J., RASHEED, M., LAWRENCE, E., CARTER, A. B., FRASER, M.W., MCKENZIE, L. J. What lies beneath: Predicting seagrass below-ground biomass from above-ground biomass, environmental conditions and seagrass community composition. **Ecological Indicators**, v. 121, p. 107156, 2021.
- COSTANZA, R., DE GROOT, R., SUTTON, P., VAN DER PLOEG, S., ANDERSON, S. J., KUBISZEWSKI, I., FARBER, S., TURNER, R. K. Changes in the global value of ecosystem services. **Global environmental change**, v. 26, p. 152-158, 2014.
- CREED, J. C. Distribution, seasonal abundance and shoot size of the seagrass *Halodule wrightii* near its southern limit at Rio de Janeiro state, Brazil. **Aquatic Botany**, v. 65, n. 1-4, p. 47-58, 1999.
- CUNHA-LIGNON, M., MENDONÇA, J. T., CONTI, L. A., BARROS, K. V. S., MAGALHÃES, K. M. Mangroves and Seagrasses. in: URBAN JR, E. R., ITTEKKOT, V.. **Blue Economy: An Ocean Science Perspective**. Springer Nature Singapore. 2022.
- DAHL, M., ASPLUND, M. E., DEYANOVA, D., FRANCO, J. N., KOLIJI, A., INFANTES, E., PERRY, D., BJORK, M., GULLSTROM, M. High seasonal variability in sediment carbon stocks of cold-temperate seagrass meadows. **Journal of Geophysical Research: Biogeosciences**, v. 125, n. 1, p. e2019JG005430, 2020.
- DA SILVA, N. P., COSTA, F. D. N., SILVA, M. F. S., MAYO, S. J., ANDRADE, I. M. Seagrasses of Piauí, Brazil: A floristic treatment. **Feddes Repertorium**, v. 129, n. 1, p. 43-50, 2018.
- DOS SANTOS, S. S., MEDEIROS, I. S., REBELO, V. A., CARVALHO, A. O. B., DUBUT, J. P., MANTOVALI, J. E., CÍRIACO, R. D., SANTOS, R. E. G., MARMONTEL, M., NORMANDE, I. C., VELÔSO, T. M. G., BORGES, J. C. G. Home ranges of released West Indian manatees *Trichechus manatus* in Brazil. **Oryx**, v. 56, n. 6, p. 939-946, 2022.
- MELO, L.I.S., OLIVEIRA, R.E.M., OLIVEIRA, M.F., SILVA-JUNIOR, J.F; AMARAL, C. B., LUNA, F.O., ATTADEMO, F.L.N., MAGALHÃES, K.M. Dieta e adaptações morfológicas para alimentação do peixe-boi-marinho (*Trichechus manatus manatus*). In: ATTADEMO, F.L.N., LUNA, F.O., ATHIÊ-SOUZA, S.M., SILVA-JUNIOR, J.F., VASCONCELOS, E.R.T.P.P., VASCONCELOS, J.B., AMARAL, A.B., MAGALHÃES, K.M. **Guia de itens alimentares de peixe-boi-marinho**. Brasília: ICMBio, 2022.p.10-11.
- DUARTE, C. M., CHISCANO, C. L. Seagrass biomass and production: a reassessment. **Aquatic botany**, v. 65, n. 1-4, p. 159-174, 1999.

- DUARTE, C. M. Seagrass depth limits. **Aquatic botany**, v. 40, n. 4, p. 363-377, 1991.
- FAVERO, I. T., FAVERO, G. E., CHOI-LIMA, K. F., DOS SANTOS, H. F., SOUZA-ALVES, J. P., DE SOUZA E SILVA, J., FEITOSA, J. L. L. Effects of freshwater limitation on distribution patterns and habitat use of the West Indian manatee, *Trichechus manatus*, in the northern Brazilian coast. **Aquatic Conservation: Marine and Freshwater Ecosystems**, v. 30, n. 8, p. 1665-1673, 2020.
- FREIRE, K. M., CHRISTENSEN, V., PAULY, D. Description of the East Brazil Large Marine Ecosystem using a trophic model. **Scientia Marina**, v. 72, n. 3, p. 477-491, 2008.
- HECK JR, K. L., VALENTINE, J. F. Plant–herbivore interactions in seagrass meadows. **Journal of Experimental Marine Biology and Ecology**, v. 330, n. 1, p. 420-436, 2006.
- HEMMINGA, M. A., DUARTE, C. M. Seagrass ecology. **Cambridge University Press**, 2000.
- ICMBio - Instituto Chico Mendes de Biodiversidade da Conservação. **Plano de Manejo da APA Barra do Rio Mamanguape**. 2014.
https://documentacao.socioambiental.org/ato_normativo/UC/1557_20140806_143616.pdf.
Acesso em: 08/12/2022.
- IUCN (2022) **The IUCN Red List of Threatened Species** v. 2022.2.
<https://www.iucnredlist.org/species/22103/9356917>. Acesso em:14/02/2023.
- LABOREL-DEGUEN, F. Nota preliminar sobre a ecologia das pradarias de fanerógamas marinhas nas costas dos estados de Pernambuco e da Paraíba. **Trabalhos do Instituto de Biologia Marítima e Oceanografia**, v. 3, n. 4, p. 39-50, 1963.
- LYAKURWA, J. V. First observation of vervet monkeys *Chlorocebus pygerythrus* feeding on seagrass *Thalassodendron ciliatum* along the Tanzanian coast. **Journal of East African Natural History**, v. 109, n. 1, p. 43-47, 2020.
- MAGALHÃES, K. M., AMARAL, C. B. First description of seagrass meadows from Fernando de Noronha archipelago in the tropical Southwestern Atlantic. **Aquatic Botany**, v. 168, p. 103305, 2021.
- MAGALHÃES, K. M., ATHIÊ-SOUZA, S. M., VASCONCELOS, J. B., VASCONCELOS, E. R. T. P. P., SILVA-JÚNIOR, J. F., AMARAL, C. B., LUNA, F. O., ATTADEMO, F. L.N., Fichas das espécies de algas, “pteridófitas” e angiospermas consumidos pelo Peixe-Boi-marinho no litoral brasileiro. In: ATTADEMO, F.L.N., LUNA, F.O., ATHIÊ-SOUZA, S.M., SILVA-JUNIOR, J.F., VASCONCELOS, E.R.T.P.P., VASCONCELOS, J.B., AMARAL, A.B., MAGALHÃES, K.M. **Guia de itens alimentares de peixe-boi-marinho**. Brasília: ICMBio, 2022.p.23-52.
- MAGALHÃES, K. M., BORGES, J. C., PITANGA, M. E. *Halophila baillonis* Ascherson: first population dynamics data for the Southern Hemisphere. **Anais da Academia Brasileira de Ciências**, v. 87, p. 861-865, 2015.

MAGALHÃES, K. M., BARROS, K. V. D. S., LIMA, M. C. S., ROCHA-BARREIRA, C. A., ROSA FILHO, J. S., SOARES, M. O. Oil spill+ COVID-19: a disastrous year for Brazilian seagrass conservation. **Science of the total environment**, v. 764, p. 142872, 2021.

MAGALHÃES, K.M., ESKINAZI-LECA, E. MOURA Jr., A.M. Morphometry and biomass of the seagrass *Halodule wrightii* Ascherson in North Littoral of Pernambuco. **Trab. Oceanogr. Univ. Fed. Pernambuco**, v. 25, p. 83-92, 1997.

MEIRELLES, A. C. O., DOS SANTOS LIMA, D., DE OLIVEIRA ALVES, M. D., BORGES, J. C. G., MARMONTEL, M., CARVALHO, V. L., DOS SANTOS, F. R. Don't let me down: West Indian manatee, *Trichechus manatus*, is still critically endangered in Brazil. **Journal for Nature Conservation**, v. 67, p. 126169, 2022.

MMA – Ministério do Meio Ambiente. (2022). Portaria No. 148, de 07 de Junho de 2022. **Lista Nacional Oficial de espécies da fauna ameaçadas de extinção**.

NORDLUND, L. M., KOCH, E. W., BARBIER, E. B., CREED, J. C. Seagrass ecosystem services and their variability across genera and geographical regions. **PLoS one**, v. 11, n. 10, p. e0163091, 2016.

NORDLUND, L. M., UNSWORTH, R. K., GULLSTROM, M., CULLEN-UNSWORTH, L. C. Global significance of seagrass fishery activity. **Fish and Fisheries**, v. 19, n. 3, p. 399-412, 2018.

NORMANDE, I. C., LUNA, F. D. O., MALHADO, A. C. M., BORGES, J. C. G., JUNIOR, P. C. V., ATTADEMO, F. L. N., LADLE, R. J. Eighteen years of Antillean manatee *Trichechus manatus manatus* releases in Brazil: lessons learnt. **Oryx**, v. 49, n. 2, p. 338-344, 2015.

ORTH, R. J., CARRUTHERS, T. J., DENNISON, W. C., DUARTE, C. M., FOURQUIREAN, J. W., HECK, K. L., HUGHES, A.R., KENDRICK, G.A., KENWORTHY, W.J., OLVANIK, S., SHORT, F.T., WAYCOTT, M., WILLIAMS, S. L. A global crisis for seagrass ecosystems. **Bioscience**, v. 56, n. 12, p. 987-996, 2006.

SAMPER-VILLARREAL, J., BOURG, A., SIBAJA-CORDERO, J. A., CORTÉS, J. Presence of a *Halophila baillonii* Asch.(Hydrocharitaceae) Seagrass Meadow and Associated Macrofauna on the Pacific Coast of Costa Rica. **Pacific Science**, v. 68, n. 3, p. 435-444, 2014.

SANTAMARIA-GALLEGOS, N. A., RIOSMENA-RODRIGUEZ, R., SÁNCHEZ-LIZASO, J. L. Occurrence and seasonality of *Halophila decipiens* Ostenfeld in the Gulf of California. **Aquat Bot**, v. 84, p. 363-366, 2006.

SHORT, F., CARRUTHERS, T., DENNISON, W., WAYCOTT, M. Global seagrass distribution and diversity: a bioregional model. **Journal of experimental marine biology and ecology**, v. 350, n. 1-2, p. 3-20, 2007.

SHORT, F. T., KOCH, E. W., CREED, J. C., MAGALHÃES, K. M., FERNANDEZ, E., GAECKLE, J. L. SeagrassNet monitoring across the Americas: case studies of seagrass decline. **Marine Ecology**, v. 27, n. 4, p. 277-289, 2006.

SHORT, F. T., POLIDORO, B., LIVINGSTONE, S. R., CARPENTER, K. E., BANDEIRA, S., BUJANG, J. S., CALUMPONG, H. P., CARRUTHERS, T. J. B., COLES R. G., DENNISON, W. C., ERFTEMEIJER, P. L. A., FORTES, M. D., FREEMAN, A. S., JAGTAP, T. G., KAMAL, A. H. M., KENDRICK, G. A., KENWORTHY, W. J., LA NAFIE, Y. A., NASUTION, I. M., ORTH, R. J., PRATHEP, A., SANCIANGCO, J. C., TUSSENBROEK, B. V., VERGARA, S. G., WAYCOTT, M., ZIEMAN, J. C. Extinction risk assessment of the world's seagrass species. *Biological Conservation*, v. 144, n. 7, p. 1961-1971, 2011.

UNSWORTH, R. K., NORDLUND, L. M., CULLEN-UNSWORTH, L. C. Seagrass meadows support global fisheries production. **Conservation Letters**, v. 12, n. 1, p. e12566, 2019.

VALENTINE, J. F., HECK, K. L. Herbivory in seagrass meadows: an evolving paradigm. **Estuaries and Coasts**, v. 44, n. 2, p. 491-505, 2021.

WAYCOTT, M., DUARTE, C. M., CARRUTHERS, T. J., ORTH, R. J., DENNISON, W. C., OLYARNIK, S., CALLADINE, A., FOURGUREAN, J. W., HECK JR, K. L., HUGHES, A. R., KENDRICK, G. A., KENWORTHY, W. J., SHORT, F. T., WILLIAMS, S. L. Accelerating loss of seagrasses across the globe threatens coastal ecosystems. **Proceedings of the national academy of sciences**, v. 106, n. 30, p. 12377-12381, 2009.

WAYCOTT, M., MCMAHON, K., MELLORS, J., CALLADINE, A., KLEINE, D. A guide to tropical seagrasses of the Indo-West Pacific. 2004.



AQUATIC BOTANY

An International Scientific Journal dealing with Applied and Fundamental Research on Macroscopic Submerged, Floating and Emergent Plants in Marine and Freshwater Ecosystems

AUTHOR INFORMATION PACK

TABLE OF CONTENTS

●	Description	p.1
●	Audience	p.1
●	Impact Factor	p.2
●	Abstracting and Indexing	p.2
●	Editorial Board	p.2
●	Guide for Authors	p.4



ISSN: 0304-3770

DESCRIPTION

Aquatic Botany offers a platform for papers relevant to a broad international readership on **fundamental and applied aspects of marine and freshwater macroscopic plants in a context of ecology or environmental biology**. This includes molecular, biochemical and physiological aspects of macroscopic aquatic plants as well as the classification, structure, function, dynamics and ecological interactions in plant-dominated aquatic communities and ecosystems. It is an outlet for papers dealing with research on the **consequences of disturbance and stressors** (e.g. environmental fluctuations and climate change, pollution, grazing and pathogens), **use and management of aquatic plants** (plant production and decomposition, commercial harvest, plant control) and the **conservation of aquatic plant communities** (breeding, transplantation and restoration). Specialized publications on certain rare taxa or papers on aquatic macroscopic plants from under-represented regions in the world can also find their place, subject to editor evaluation. Studies on fungi or microalgae will remain outside the scope of *Aquatic Botany*.

Interesting for further reading:

Editorial: [What is a plant? and what is aquatic botany?](#)

Elisabeth M. Gross, Thomas Wernberg, Jorge Terrados [http://dx.doi.org/10.1016/S0304-3770\(16\)30052-3](http://dx.doi.org/10.1016/S0304-3770(16)30052-3)

Editorial: [Aquatic botany since 1975: Have our views changed?](#)

Jan E. Vermaat, Elisabeth M. Gross <http://dx.doi.org/10.1016/j.aquabot.2016.07.001>

Benefits to authors

We also provide many author benefits, such as free PDFs, a liberal copyright policy, special discounts on Elsevier publications and much more. Please click here for more information on our [author services](#).

Please see our [Guide for Authors](#) for information on article submission. If you require any further information or help, please visit our [Support Center](#)

AUDIENCE

Aquatic Botanists, Marine and Freshwater Ecologists.

IMPACT FACTOR

2021: 1.968 © Clarivate Analytics Journal Citation Reports 2022

ABSTRACTING AND INDEXING

BIOSIS Citation Index
Ecology Abstracts
EMBiology
Aquatic Sciences and Fisheries Abstracts
Current Contents - Agriculture, Biology & Environmental Sciences
Ecological Abstracts
Fisheries Review
Freshwater and Aquaculture Contents Tables
Marine Science Contents Tables
Scopus

EDITORIAL BOARD

Editors-in-Chief

Thomas Wernberg, University of Western Australia, UWA Oceans Institute & School of Biological Sciences, Crawley, Western Australia, Australia

Brigitta I. van Tussenbroek, National Autonomous University of Mexico Institute for Marine Sciences and Limnology, Ciudad de México, Mexico

Francisca C. Aguiar, University of Lisbon Forest Research Centre, Lisbon, Portugal
Freshwater macrophytes, Ecological water quality, Invasive plant species, Riparian ecology, Ecohydrology, Rivers and streams, Climate change, Functional ecology, Ecosystem services

Honorary Editor

George Bowes, Gainesville, Florida, United States of America

Founding Editor

Cornelis den Hartog[†], Radboud University, Nijmegen, Netherlands

Editorial Advisory Board

Lars Anderson, University of California Davis, Davis, California, United States of America

Jean Armstrong, University of Hull, Hull, United Kingdom

Sven Beer, Tel Aviv University, Tel Aviv, Israel

Irmgard Blindow, University Greifswald Hiddensee Biology Research Station, Kloster, Germany

Rossano Bolpagni, University of Parma, Department of Chemistry Life Sciences and Environmental Sustainability, Parma, Italy

Freshwater macrophytes, Ecology, Functional traits, Remote Sensing, Biological invasions

Melinda Coleman, Southern Cross University National Marine Science Centre, Coffs Harbour, New South Wales, Australia

Joanna Freeland, Trent University, Peterborough, Ontario, Canada

Elisabeth M. Gross, Interdisciplinary Laboratory for Continental Environments, Vandoeuvre Les Nancy, France

Sabine Hilt, Leibniz-Institute of Freshwater Ecology and Inland Fisheries in the Forschungsverbund Berlin eV, Berlin, Germany

Andreas Hussner, Support Association Feldberg - Uckermärkische Seenlandschaft e V, Templin, Germany

Arunothai Jampeetong, Chiang Mai University, Chiang Mai, Thailand

Jae Geun Kim, Seoul National University, Department of Biology Education, Seoul, South Korea

Sarian Kosten, Radboud University, Nijmegen, Netherlands

Elizabeth LaRue, Purdue University, West Lafayette, Indiana, United States of America

Kun-Seop Lee, Pusan National University, Department of Biological Sciences, Busan, South Korea

Seagrass ecology, Impacts of climate change, Seagrass growth dynamics, Seagrass reproduction, Habitat restoration

Wei Li, Chinese Academy of Sciences Key Laboratory of Aquatic Botany and Watershed Ecology, Wuhan, China

Tatiana Lobato de Magalhães, Autonomous University of Queretaro, Faculty of Natural Science, Queretaro, Mexico

Aquatic plants, Wetland ecology, Landscape genetics, Spatial patterns

Paola Lombardo, Limno Consulting, Rome, Italy

Erik-Jan Malta, Foundation Aquaculture Technology Centre of Andalusia, Cadiz, Spain

Kathryn McMahon, Edith Cowan University, Joondalup, Australia

Mariusz Pelechaty, Adam Mickiewicz University, Poznan, Poland
Sara Puijalon, Laboratory of Biometry and Evolutionary Biology, Villeurbanne, France
Tenna Riis, Aarhus University, Aarhus, Denmark
Jennifer Ruesink, University of Washington, Seattle, Washington, United States of America
Susanne Claudia Schneider, Norwegian Institute for Water Research, Oslo, Norway
Fred Short, University of New Hampshire, Durham, New Hampshire, United States of America
Albertus J. Smit, University of the Western Cape, Bellville, South Africa
Jorge Miguel Terrados Muñoz, Mediterranean Institute for Advanced Studies, Esporles, Spain
Mads Solgaard Thomsen, University of Canterbury, Christchurch, New Zealand
Fernando Tuya, University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain
Jan Vermaat, Norwegian University of Life Sciences, Ås, Norway
Jan Vymazal, Czech University of Life Sciences Prague, Praha, Czechia
Kevin Wood, Wildfowl and Wetlands Trust, Gloucester, United Kingdom

GUIDE FOR AUTHORS

INTRODUCTION

Aquatic Botany is concerned with fundamental studies on structure, function, dynamics and classification of plant-dominated aquatic communities and ecosystems, as well as molecular, biochemical and physiological aspects of aquatic plants. It is also an outlet for papers dealing with applied research on plant-dominated aquatic systems, including the consequences of disturbance (e.g. transplantation, influence of herbicides and other chemicals, thermal pollution, biological control, grazing and disease), the use of aquatic plants, conservation of resources, and all aspects of aquatic plant production and decomposition.

Types of paper

1. Original research papers (Regular Papers)
2. Review articles
3. Short Communications
4. Letters to the Editor

Regular papers should report the results of original research. The material should not have been previously published elsewhere, except in a preliminary form. Number of references should not exceed 50 and number of displayed items (figures, plates, tables) should be limited to 6 to 8.

Review articles should cover subjects falling within the scope of the journal which are of active current interest. Authors should preferably contact editors with a short description of the review before submitting.

For Short Communication results and discussion can be combined in a short communication, while they should be separate sections in regular papers. Short Communications should be as completely documented, both by reference to the literature and description of the experimental procedures employed, as a regular paper. They should not occupy more than 3500 words including references, 2 figures or 2 tables or one of each. Number of references should not exceed 25.

Letters to the Editor offering comment or appropriate critique on material published in the journal are welcomed. The decision to publish submitted letters rests purely with the Editor-in-Chief.

Authors are encouraged to place all species distribution records in a publicly accessible database such as the national Global Biodiversity Information Facility (GBIF) nodes (<http://www.gbif.org>) or data centers endorsed by GBIF, including BioFresh (<http://www.freshwaterbiodiversity.eu>)"

Submission checklist

You can use this list to carry out a final check of your submission before you send it to the journal for review. Please check the relevant section in this Guide for Authors for more details.

Ensure that the following items are present:

One author has been designated as the corresponding author with contact details:

- E-mail address
- Full postal address

All necessary files have been uploaded:

Manuscript:

- Include keywords
- All figures (include relevant captions)
- All tables (including titles, description, footnotes)
- Ensure all figure and table citations in the text match the files provided
- Indicate clearly if color should be used for any figures in print

Graphical Abstracts / Highlights files (where applicable)

Supplemental files (where applicable)

Further considerations

- Manuscript has been 'spell checked' and 'grammar checked'
- All references mentioned in the Reference List are cited in the text, and vice versa
- Permission has been obtained for use of copyrighted material from other sources (including the Internet)
- A competing interests statement is provided, even if the authors have no competing interests to declare
- Journal policies detailed in this guide have been reviewed
- Referee suggestions and contact details provided, based on journal requirements

For further information, visit our [Support Center](#).

BEFORE YOU BEGIN

Ethics in publishing

Please see our information on [Ethics in publishing](#).

Declaration of competing interest

Corresponding authors, on behalf of all the authors of a submission, must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential conflicts of interest include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. All authors, including those *without* competing interests to declare, should provide the relevant information to the corresponding author (which, where relevant, may specify they have nothing to declare). Corresponding authors should then use [this tool](#) to create a shared statement and upload to the submission system at the Attach Files step. **Please do not convert the .docx template to another file type. Author signatures are not required.**

Submission declaration and verification

Submission of an article implies that the work described has not been published previously (except in the form of an abstract, a published lecture or academic thesis, see '[Multiple, redundant or concurrent publication](#)' for more information), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. To verify compliance, your article may be checked by [Crossref Similarity Check](#) and other originality or duplicate checking software.

Preprints

Please note that [preprints](#) can be shared anywhere at any time, in line with Elsevier's [sharing policy](#). Sharing your preprints e.g. on a preprint server will not count as prior publication (see '[Multiple, redundant or concurrent publication](#)' for more information).

Preprint posting on SSRN

In support of [Open Science](#), this journal offers its authors a free preprint posting service. Preprints provide early registration and dissemination of your research, which facilitates early citations and collaboration.

During submission to Editorial Manager, you can choose to release your manuscript publicly as a preprint on the preprint server [SSRN](#). Your choice will have no effect on the editorial process or outcome with the journal. Please note that the corresponding author is expected to seek approval from all co-authors before agreeing to release the manuscript publicly on SSRN.

You will be notified via email when your preprint is posted online and a Digital Object Identifier (DOI) is assigned. Your preprint will remain globally available free to read whether the journal accepts or rejects your manuscript.

For more information about posting to [SSRN](#), please consult the [SSRN Terms of Use](#) and [FAQs](#).

Use of inclusive language

Inclusive language acknowledges diversity, conveys respect to all people, is sensitive to differences, and promotes equal opportunities. Content should make no assumptions about the beliefs or commitments of any reader; contain nothing which might imply that one individual is superior to another on the grounds of age, gender, race, ethnicity, culture, sexual orientation, disability or health

condition; and use inclusive language throughout. Authors should ensure that writing is free from bias, stereotypes, slang, reference to dominant culture and/or cultural assumptions. We advise to seek gender neutrality by using plural nouns ("clinicians, patients/clients") as default/wherever possible to avoid using "he, she," or "he/she." We recommend avoiding the use of descriptors that refer to personal attributes such as age, gender, race, ethnicity, culture, sexual orientation, disability or health condition unless they are relevant and valid. When coding terminology is used, we recommend to avoid offensive or exclusionary terms such as "master", "slave", "blacklist" and "whitelist". We suggest using alternatives that are more appropriate and (self-) explanatory such as "primary", "secondary", "blocklist" and "allowlist". These guidelines are meant as a point of reference to help identify appropriate language but are by no means exhaustive or definitive.

Reporting sex- and gender-based analyses

Reporting guidance

For research involving or pertaining to humans, animals or eukaryotic cells, investigators should integrate sex and gender-based analyses (SGBA) into their research design according to funder/sponsor requirements and best practices within a field. Authors should address the sex and/or gender dimensions of their research in their article. In cases where they cannot, they should discuss this as a limitation to their research's generalizability. Importantly, authors should explicitly state what definitions of sex and/or gender they are applying to enhance the precision, rigor and reproducibility of their research and to avoid ambiguity or conflation of terms and the constructs to which they refer (see Definitions section below). Authors can refer to the [Sex and Gender Equity in Research \(SAGER\) guidelines](#) and the [SAGER guidelines checklist](#). These offer systematic approaches to the use and editorial review of sex and gender information in study design, data analysis, outcome reporting and research interpretation - however, please note there is no single, universally agreed-upon set of guidelines for defining sex and gender.

Definitions

Sex generally refers to a set of biological attributes that are associated with physical and physiological features (e.g., chromosomal genotype, hormonal levels, internal and external anatomy). A binary sex categorization (male/female) is usually designated at birth ("sex assigned at birth"), most often based solely on the visible external anatomy of a newborn. Gender generally refers to socially constructed roles, behaviors, and identities of women, men and gender-diverse people that occur in a historical and cultural context and may vary across societies and over time. Gender influences how people view themselves and each other, how they behave and interact and how power is distributed in society. Sex and gender are often incorrectly portrayed as binary (female/male or woman/man) and unchanging whereas these constructs actually exist along a spectrum and include additional sex categorizations and gender identities such as people who are intersex/have differences of sex development (DSD) or identify as non-binary. Moreover, the terms "sex" and "gender" can be ambiguous—thus it is important for authors to define the manner in which they are used. In addition to this definition guidance and the SAGER guidelines, the [resources on this page](#) offer further insight around sex and gender in research studies.

Author contributions

For transparency, we encourage authors to submit an author statement file outlining their individual contributions to the paper using the relevant CRediT roles: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing - original draft; Writing - review & editing. Authorship statements should be formatted with the names of authors first and CRediT role(s) following. [More details and an example](#).

Changes to authorship

Authors are expected to consider carefully the list and order of authors **before** submitting their manuscript and provide the definitive list of authors at the time of the original submission. Any addition, deletion or rearrangement of author names in the authorship list should be made only **before** the manuscript has been accepted and only if approved by the journal Editor. To request such a change, the Editor must receive the following from the **corresponding author**: (a) the reason for the change in author list and (b) written confirmation (e-mail, letter) from all authors that they agree with the addition, removal or rearrangement. In the case of addition or removal of authors, this includes confirmation from the author being added or removed.

Only in exceptional circumstances will the Editor consider the addition, deletion or rearrangement of authors **after** the manuscript has been accepted. While the Editor considers the request, publication of the manuscript will be suspended. If the manuscript has already been published in an online issue, any requests approved by the Editor will result in a corrigendum.

Article transfer service

This journal uses the Elsevier Article Transfer Service to find the best home for your manuscript. This means that if an editor feels your manuscript is more suitable for an alternative journal, you might be asked to consider transferring the manuscript to such a journal. The recommendation might be provided by a Journal Editor, a dedicated [Scientific Managing Editor](#), a tool assisted recommendation, or a combination. If you agree, your manuscript will be transferred, though you will have the opportunity to make changes to the manuscript before the submission is complete. Please note that your manuscript will be independently reviewed by the new journal. [More information](#).

Copyright

Upon acceptance of an article, authors will be asked to complete a 'Journal Publishing Agreement' (see [more information](#) on this). An e-mail will be sent to the corresponding author confirming receipt of the manuscript together with a 'Journal Publishing Agreement' form or a link to the online version of this agreement.

Subscribers may reproduce tables of contents or prepare lists of articles including abstracts for internal circulation within their institutions. [Permission](#) of the Publisher is required for resale or distribution outside the institution and for all other derivative works, including compilations and translations. If excerpts from other copyrighted works are included, the author(s) must obtain written permission from the copyright owners and credit the source(s) in the article. Elsevier has [preprinted forms](#) for use by authors in these cases.

For gold open access articles: Upon acceptance of an article, authors will be asked to complete a 'License Agreement' ([more information](#)). Permitted third party reuse of gold open access articles is determined by the author's choice of [user license](#).

Author rights

As an author you (or your employer or institution) have certain rights to reuse your work. [More information](#).

Elsevier supports responsible sharing

Find out how you can [share your research](#) published in Elsevier journals.

Role of the funding source

You are requested to identify who provided financial support for the conduct of the research and/or preparation of the article and to briefly describe the role of the sponsor(s), if any, in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication. If the funding source(s) had no such involvement, it is recommended to state this.

Open access

Please visit our [Open Access page](#) for more information.

Elsevier Researcher Academy

[Researcher Academy](#) is a free e-learning platform designed to support early and mid-career researchers throughout their research journey. The "Learn" environment at Researcher Academy offers several interactive modules, webinars, downloadable guides and resources to guide you through the process of writing for research and going through peer review. Feel free to use these free resources to improve your submission and navigate the publication process with ease.

Language services

Manuscripts should be written in English. Authors who are unsure of correct English usage should have their manuscript checked by someone proficient in the language. Manuscripts in which the English is difficult to understand may be returned to the author for revision before scientific review.

Authors who require information about language editing and copyediting services pre- and post-submission please visit <https://www.elsevier.com/languagepolishing> or our customer support site at <https://service.elsevier.com> for more information. Please note Elsevier neither endorses nor

takes responsibility for any products, goods or services offered by outside vendors through our services or in any advertising. For more information please refer to our Terms & Conditions: <https://www.elsevier.com/termsandconditions>.

Submission

Our online submission system guides you stepwise through the process of entering your article details and uploading your files. The system converts your article files to a single PDF file used in the peer-review process. Editable files (e.g., Word, LaTeX) are required to typeset your article for final publication. All correspondence, including notification of the Editor's decision and requests for revision, is sent by e-mail.

Please submit your article via <https://www.editorialmanager.com/aqbot/default.aspx>

Referees

Please submit, with the manuscript, the names and e-mail addresses of 4 potential referees.

Page charges

Aquatic Botany has no page charges.

PREPARATION

Queries

For questions about the editorial process (including the status of manuscripts under review) or for technical support on submissions, please visit our [Support Center](#).

Peer review

This journal operates a single anonymized review process. All contributions will be initially assessed by the editor for suitability for the journal. Papers deemed suitable are then typically sent to a minimum of two independent expert reviewers to assess the scientific quality of the paper. The Editor is responsible for the final decision regarding acceptance or rejection of articles. The Editor's decision is final. Editors are not involved in decisions about papers which they have written themselves or have been written by family members or colleagues or which relate to products or services in which the editor has an interest. Any such submission is subject to all of the journal's usual procedures, with peer review handled independently of the relevant editor and their research groups. [More information on types of peer review](#).

Use of wordprocessing software

It is important that the file be saved in the native format of the wordprocessor used. The text should be in single-column format. The document must have line numbers inserted. Keep the layout of the text as simple as possible. Most formatting codes will be removed and replaced on processing the article. In particular, do not use the wordprocessor's options to justify text or to hyphenate words. However, do use bold face, italics, subscripts, superscripts etc. When preparing tables, if you are using a table grid, use only one grid for each individual table and not a grid for each row. If no grid is used, use tabs, not spaces, to align columns. The electronic text should be prepared in a way very similar to that of conventional manuscripts (see also the Guide to Publishing with Elsevier: <https://www.elsevier.com/guidepublication>). Note that source files of figures, tables and text graphics will be required whether or not you embed your figures in the text. See also the section on Electronic artwork.

To avoid unnecessary errors you are strongly advised to use the 'spell-check' and 'grammar-check' functions of your wordprocessor.

Article structure

Subdivision - numbered sections

Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract is not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to 'the text'. Any subsection may be given a brief heading. Each heading should appear on its own separate line.

Introduction

State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Experimental

Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described.

Results

Results should be clear and concise.

Discussion

This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is appropriate for short communications or when results cannot easily be presented without direct interpretation. Avoid extensive citations and discussion of published literature. The main conclusions of the study should be presented in a short concluding paragraph at the end of the discussion.

Appendices

If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

Essential title page information

- **Title.** Concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.
- **Author names and affiliations.** Please clearly indicate the given name(s) and family name(s) of each author and check that all names are accurately spelled. You can add your name between parentheses in your own script behind the English transliteration. Present the authors' affiliation addresses (where the actual work was done) below the names. Indicate all affiliations with a lower-case superscript letter immediately after the author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address of each author.
- **Corresponding author.** Clearly indicate who will handle correspondence at all stages of refereeing and publication, also post-publication. This responsibility includes answering any future queries about Methodology and Materials. **Ensure that the e-mail address is given and that contact details are kept up to date by the corresponding author.**
- **Present/permanent address.** If an author has moved since the work described in the article was done, or was visiting at the time, a 'Present address' (or 'Permanent address') may be indicated as a footnote to that author's name. The address at which the author actually did the work must be retained as the main, affiliation address. Superscript Arabic numerals are used for such footnotes.

Highlights

Highlights are mandatory for this journal as they help increase the discoverability of your article via search engines. They consist of a short collection of bullet points that capture the novel results of your research as well as new methods that were used during the study (if any). Please have a look at the examples here: [example Highlights](#).

Highlights should be submitted in a separate editable file in the online submission system. Please use 'Highlights' in the file name and include 3 to 5 bullet points (maximum 85 characters, including spaces, per bullet point).

Abstract

A concise and factual abstract is required, no longer than 250 words. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separate from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, they must be cited in full, without reference to the reference list. Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

Graphical abstract

Although a graphical abstract is optional, its use is encouraged as it draws more attention to the online article. The graphical abstract should summarize the contents of the article in a concise, pictorial form designed to capture the attention of a wide readership. Graphical abstracts should be submitted as a separate file in the online submission system. Image size: Please provide an image with a minimum of 531 × 1328 pixels (h × w) or proportionally more. The image should be readable at a size of 5 × 13 cm using a regular screen resolution of 96 dpi. Preferred file types: TIFF, EPS, PDF or MS Office files. You can view [Example Graphical Abstracts](#) on our information site.

Keywords

Immediately after the abstract, provide keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, "and", "of"). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

Abbreviations

Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention there, as well as in the footnote. Ensure consistency of abbreviations throughout the article.

Acknowledgements

Collate acknowledgements in a separate section at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

Formatting of funding sources

List funding sources in this standard way to facilitate compliance to funder's requirements:

Funding: This work was supported by the National Institutes of Health [grant numbers xxxx, yyyy]; the Bill & Melinda Gates Foundation, Seattle, WA [grant number zzzz]; and the United States Institutes of Peace [grant number aaaa].

It is not necessary to include detailed descriptions on the program or type of grants and awards. When funding is from a block grant or other resources available to a university, college, or other research institution, submit the name of the institute or organization that provided the funding.

If no funding has been provided for the research, it is recommended to include the following sentence:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Nomenclature and units

Follow internationally accepted rules and conventions: use the international system of units (SI). If other quantities are mentioned, give their equivalent in SI.

Footnotes

Footnotes should be used sparingly. Number them consecutively throughout the article. Many word processors can build footnotes into the text, and this feature may be used. Otherwise, please indicate the position of footnotes in the text and list the footnotes themselves separately at the end of the article. Do not include footnotes in the Reference list.

Artwork

Electronic artwork

General points

- Make sure you use uniform lettering and sizing of your original artwork.
- Embed the used fonts if the application provides that option.
- Aim to use the following fonts in your illustrations: Arial, Courier, Times New Roman, Symbol, or use fonts that look similar.
- Number the illustrations according to their sequence in the text.
- Use a logical naming convention for your artwork files.
- Provide captions to illustrations separately.
- Size the illustrations close to the desired dimensions of the published version.
- Submit each illustration as a separate file.
- Ensure that color images are accessible to all, including those with impaired color vision.

A detailed [guide on electronic artwork](#) is available.

You are urged to visit this site; some excerpts from the detailed information are given here.

Formats

If your electronic artwork is created in a Microsoft Office application (Word, PowerPoint, Excel) then please supply 'as is' in the native document format.

Regardless of the application used other than Microsoft Office, when your electronic artwork is finalized, please 'Save as' or convert the images to one of the following formats (note the resolution requirements for line drawings, halftones, and line/halftone combinations given below):

EPS (or PDF): Vector drawings, embed all used fonts.

TIFF (or JPEG): Color or grayscale photographs (halftones), keep to a minimum of 300 dpi.

TIFF (or JPEG): Bitmapped (pure black & white pixels) line drawings, keep to a minimum of 1000 dpi.

TIFF (or JPEG): Combinations bitmapped line/half-tone (color or grayscale), keep to a minimum of 500 dpi.

Please do not:

- Supply files that are optimized for screen use (e.g., GIF, BMP, PICT, WPG); these typically have a low number of pixels and limited set of colors;
- Supply files that are too low in resolution;
- Submit graphics that are disproportionately large for the content.

Color artwork

Please make sure that artwork files are in an acceptable format (TIFF (or JPEG), EPS (or PDF), or MS Office files) and with the correct resolution. If, together with your accepted article, you submit usable color figures then Elsevier will ensure, at no additional charge, that these figures will appear in color online (e.g., ScienceDirect and other sites) regardless of whether or not these illustrations are reproduced in color in the printed version. **For color reproduction in print, you will receive information regarding the costs from Elsevier after receipt of your accepted article.** Please indicate your preference for color: in print or online only. [Further information on the preparation of electronic artwork.](#)

Figure captions

Ensure that each illustration has a caption. Supply captions separately, not attached to the figure. A caption should comprise a brief title (**not** on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

Tables

Please submit tables as editable text and not as images. Tables can be placed either next to the relevant text in the article, or on separate page(s) at the end. Number tables consecutively in accordance with their appearance in the text and place any table notes below the table body. Be sparing in the use of tables and ensure that the data presented in them do not duplicate results described elsewhere in the article. Please avoid using vertical rules and shading in table cells.

References

Citation in text

Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If these references are included in the reference list they should follow the standard reference style of the journal and should include a substitution of the publication date with either 'Unpublished results' or 'Personal communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

Reference links

Increased discoverability of research and high quality peer review are ensured by online links to the sources cited. In order to allow us to create links to abstracting and indexing services, such as Scopus, Crossref and PubMed, please ensure that data provided in the references are correct. Please note that incorrect surnames, journal/book titles, publication year and pagination may prevent link creation. When copying references, please be careful as they may already contain errors. Use of the DOI is highly encouraged.

A DOI is guaranteed never to change, so you can use it as a permanent link to any electronic article. An example of a citation using DOI for an article not yet in an issue is: VanDecar J.C., Russo R.M., James D.E., Ambeh W.B., Franke M. (2003). Aseismic continuation of the Lesser Antilles slab beneath northeastern Venezuela. *Journal of Geophysical Research*, <https://doi.org/10.1029/2001JB000884>. Please note the format of such citations should be in the same style as all other references in the paper.

Web references

As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list.

Data references

This journal encourages you to cite underlying or relevant datasets in your manuscript by citing them in your text and including a data reference in your Reference List. Data references should include the following elements: author name(s), dataset title, data repository, version (where available), year, and global persistent identifier. Add [dataset] immediately before the reference so we can properly identify it as a data reference. The [dataset] identifier will not appear in your published article.

Preprint references

Where a preprint has subsequently become available as a peer-reviewed publication, the formal publication should be used as the reference. If there are preprints that are central to your work or that cover crucial developments in the topic, but are not yet formally published, these may be referenced. Preprints should be clearly marked as such, for example by including the word preprint, or the name of the preprint server, as part of the reference. The preprint DOI should also be provided.

References in a special issue

Please ensure that the words 'this issue' are added to any references in the list (and any citations in the text) to other articles in the same Special Issue.

Reference management software

Most Elsevier journals have their reference template available in many of the most popular reference management software products. These include all products that support [Citation Style Language styles](#), such as [Mendeley](#). Using citation plug-ins from these products, authors only need to select the appropriate journal template when preparing their article, after which citations and bibliographies will be automatically formatted in the journal's style. If no template is yet available for this journal, please follow the format of the sample references and citations as shown in this Guide. If you use reference management software, please ensure that you remove all field codes before submitting the electronic manuscript. [More information on how to remove field codes from different reference management software](#).

Free Reference Style

There are no strict requirements on reference formatting at submission. References can be in any style or format as long as the style is consistent. Where applicable, author(s) name(s), journal title/book title, chapter title/article title, year of publication, volume number/book chapter and the pagination must be present. Use of DOI is highly encouraged. The reference style used by the journal will be applied to the accepted article by Elsevier at the proof stage. Note that missing data will be highlighted at proof stage for the author to correct. If you do wish to format the references yourself they should be arranged according to the following example:

[dataset] Oguro, M., Imahiro, S., Saito, S., Nakashizuka, T., 2015. Mortality data for Japanese oak wilt disease and surrounding forest compositions. Mendeley Data, v1. <http://dx.doi.org/10.17632/xwj98nb39r.1>.

Reference style

Text:

All citations in the text should refer to:

1. *Single author:* the author's name (without initials, unless there is ambiguity) and the year of publication;
 2. *Two authors:* both authors' names and the year of publication;
 3. *Three or more authors:* first author's name followed by "et al." and the year of publication.
- Citations may be made directly (or parenthetically). Groups of references should be listed chronologically.

List: References should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters "a", "b", "c", etc., placed after the year of publication.

Use the following system for arranging your references:

- a. For periodicals

Stewart, D.A., Agnew, D., Boyd, R., Briggs, R., Toland, P., 1993. The derivation of changes in Nephrops per unit effort values for the Northern Ireland fishing fleet. *Fish. Res.* 17, 273-292.

b. For edited symposia, special issues, etc. published in a periodical

Roberts, R.J., 1993. Ulcerative dermal necrosis (UDN) in wild salmonids. In: Bruno, D.W. (Ed.), *Pathological conditions of wild salmonids*. *Fish. Res.* 17, 3 14.

c. For books

Gaugh, Jr., H.G., 1992. *Statistical Analysis of Regional Yield Trials*. Elsevier, Amsterdam.

d. For multi-author books

Bucke, D., 1989. Histology. In: Austin, B., Austin, D.A. (Eds.), *Methods for the Microbiological Examination of Fish and Shellfish*. Wiley, New York, pp. 69-97.

In the case of publications in any language other than English, the original title is to be retained. However, the titles of publications in non-Latin alphabets should be transliterated, and a notation such as "(in Russian)" or "(in Greek, with English abstract)" should be added.

Work accepted for publication but not yet published should be referred to as "in press".

References concerning unpublished data and "personal communications" should not be cited in the reference list but may be mentioned in the text.

Journal abbreviations source

Journal names should be abbreviated according to the [List of Title Word Abbreviations](#).

Video

Elsevier accepts video material and animation sequences to support and enhance your scientific research. Authors who have video or animation files that they wish to submit with their article are strongly encouraged to include links to these within the body of the article. This can be done in the same way as a figure or table by referring to the video or animation content and noting in the body text where it should be placed. All submitted files should be properly labeled so that they directly relate to the video file's content. In order to ensure that your video or animation material is directly usable, please provide the file in one of our recommended file formats with a preferred maximum size of 150 MB per file, 1 GB in total. Video and animation files supplied will be published online in the electronic version of your article in Elsevier Web products, including [ScienceDirect](#). Please supply 'stills' with your files: you can choose any frame from the video or animation or make a separate image. These will be used instead of standard icons and will personalize the link to your video data. For more detailed instructions please visit our [video instruction pages](#). Note: since video and animation cannot be embedded in the print version of the journal, please provide text for both the electronic and the print version for the portions of the article that refer to this content.

Data visualization

Include interactive data visualizations in your publication and let your readers interact and engage more closely with your research. Follow the instructions [here](#) to find out about available data visualization options and how to include them with your article.

Supplementary material

Supplementary material such as applications, images and sound clips, can be published with your article to enhance it. Submitted supplementary items are published exactly as they are received (Excel or PowerPoint files will appear as such online). Please submit your material together with the article and supply a concise, descriptive caption for each supplementary file. If you wish to make changes to supplementary material during any stage of the process, please make sure to provide an updated file. Do not annotate any corrections on a previous version. Please switch off the 'Track Changes' option in Microsoft Office files as these will appear in the published version.

Research data

This journal requires and enables you to share data that supports your research publication where appropriate, and enables you to interlink the data with your published articles. Research data refers to the results of observations or experimentation that validate research findings. To facilitate reproducibility and data reuse, this journal also encourages you to share your software, code, models, algorithms, protocols, methods and other useful materials related to the project.

Below are a number of ways in which you can associate data with your article or make a statement about the availability of your data when submitting your manuscript. When sharing data in one of these ways, you are expected to cite the data in your manuscript and reference list. Please refer to the "References" section for more information about data citation. For more information on depositing, sharing and using research data and other relevant research materials, visit the [research data page](#).

Data linking

If you have made your research data available in a data repository, you can link your article directly to the dataset. Elsevier collaborates with a number of repositories to link articles on ScienceDirect with relevant repositories, giving readers access to underlying data that gives them a better understanding of the research described.

There are different ways to link your datasets to your article. When available, you can directly link your dataset to your article by providing the relevant information in the submission system. For more information, visit the [database linking page](#).

For [supported data repositories](#) a repository banner will automatically appear next to your published article on ScienceDirect.

In addition, you can link to relevant data or entities through identifiers within the text of your manuscript, using the following format: Database: xxxx (e.g., TAIR: AT1G01020; CCDC: 734053; PDB: 1XFN).

Research Elements

This journal enables you to publish research objects related to your original research – such as data, methods, protocols, software and hardware – as an additional paper in Research Elements.

Research Elements is a suite of peer-reviewed, open access journals which make your research objects findable, accessible and reusable. Articles place research objects into context by providing detailed descriptions of objects and their application, and linking to the associated original research articles. Research Elements articles can be prepared by you, or by one of your collaborators.

During submission, you will be alerted to the opportunity to prepare and submit a Research Elements article.

More information can be found on the [Research Elements page](#).

Data statement

To foster transparency, we require you to state the availability of your data in your submission if your data is unavailable to access or unsuitable to post. This may also be a requirement of your funding body or institution. You will have the opportunity to provide a data statement during the submission process. The statement will appear with your published article on ScienceDirect. For more information, visit the [Data Statement page](#).

AFTER ACCEPTANCE

Online proof correction

To ensure a fast publication process of the article, we kindly ask authors to provide us with their proof corrections within two days. Corresponding authors will receive an e-mail with a link to our online proofing system, allowing annotation and correction of proofs online. The environment is similar to MS Word: in addition to editing text, you can also comment on figures/tables and answer questions from the Copy Editor. Web-based proofing provides a faster and less error-prone process by allowing you to directly type your corrections, eliminating the potential introduction of errors.

If preferred, you can still choose to annotate and upload your edits on the PDF version. All instructions for proofing will be given in the e-mail we send to authors, including alternative methods to the online version and PDF.

We will do everything possible to get your article published quickly and accurately. Please use this proof only for checking the typesetting, editing, completeness and correctness of the text, tables and figures. Significant changes to the article as accepted for publication will only be considered at this stage with permission from the Editor. It is important to ensure that all corrections are sent back to us in one communication. Please check carefully before replying, as inclusion of any subsequent corrections cannot be guaranteed. Proofreading is solely your responsibility.

Offprints

The corresponding author will, at no cost, receive a customized [Share Link](#) providing 50 days free access to the final published version of the article on [ScienceDirect](#). The Share Link can be used for sharing the article via any communication channel, including email and social media. For an extra charge, paper offprints can be ordered via the offprint order form which is sent once the article is

accepted for publication. Corresponding authors who have published their article gold open access do not receive a Share Link as their final published version of the article is available open access on ScienceDirect and can be shared through the article DOI link.

Author's discount

Contributors to Elsevier journals are entitled to a 30% discount on most Elsevier books, if ordered directly from Elsevier.

AUTHOR INQUIRIES

Visit the [Elsevier Support Center](#) to find the answers you need. Here you will find everything from Frequently Asked Questions to ways to get in touch.

You can also [check the status of your submitted article](#) or find out [when your accepted article will be published](#).

© Copyright 2018 Elsevier | <https://www.elsevier.com>