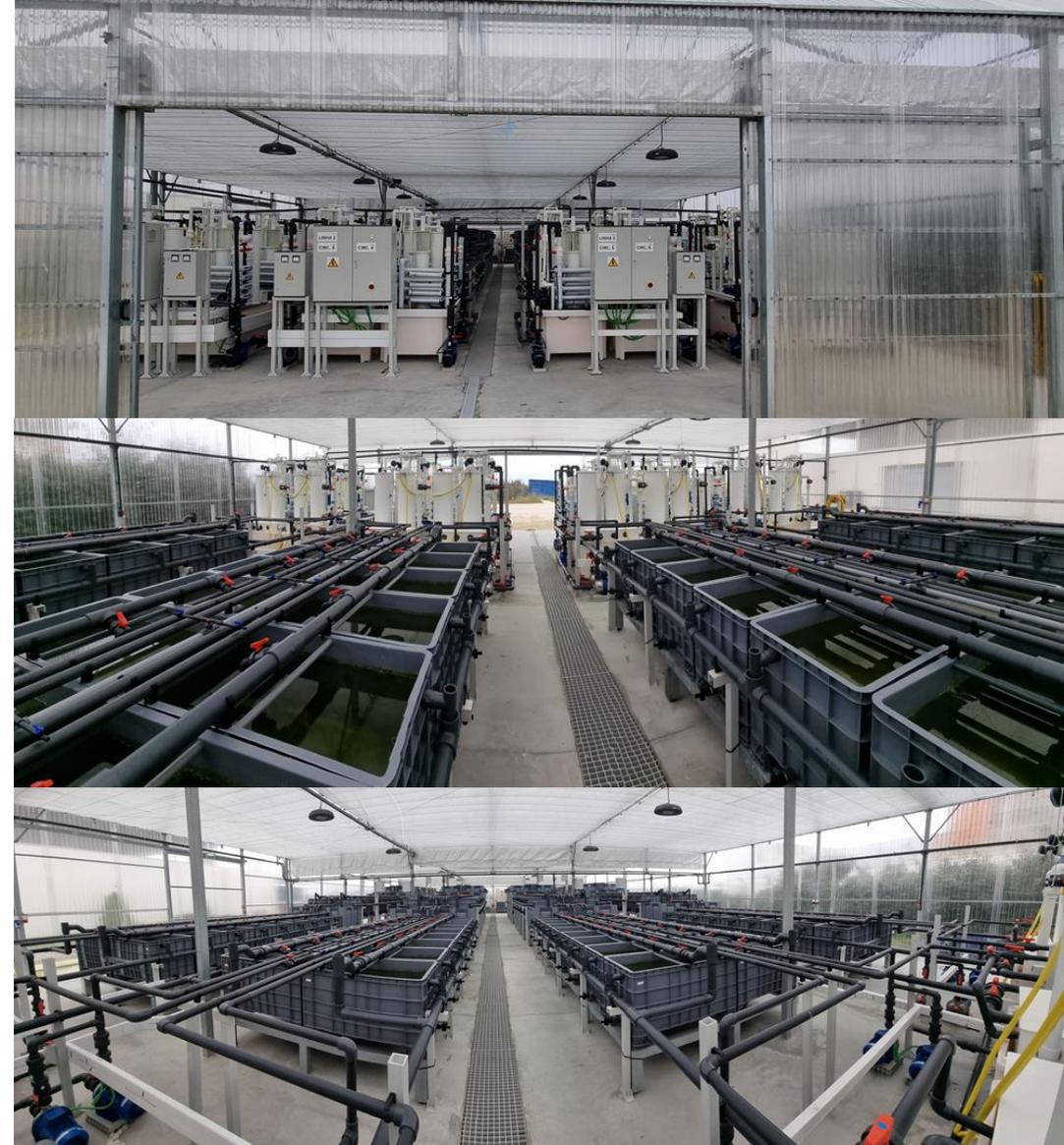


# Uso de macrófitas e invertebrados na aquicultura multitrófica integrada

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de aveiro



MARINE BIOTECHNOLOGY  
& AQUACULTURE



## Ricardo Calado

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### graus académicos

2020 Habilitation in Biology, University of Aveiro

2005 PhD in Biology, Specialization in Animal Biotechnology by the Faculty of Sciences of the University of Lisbon

1999 5 years degree (Licenciatura) in Biology Applied to Animal Resources – Marine Branch by the Faculty of Sciences of the University of Lisbon with the final classification of 16 (out of 20).

### interesses de investigação

Blue BioEconomy

Sustainable Aquaculture

Traceability of Seafood and Live Marine Organisms

Bioprospecting of Marine Natural Products

Marine Lipidomics

### publicações

Artigos WoS (208)

Outros Artigos (5)

Livros (4)

Teses (17)



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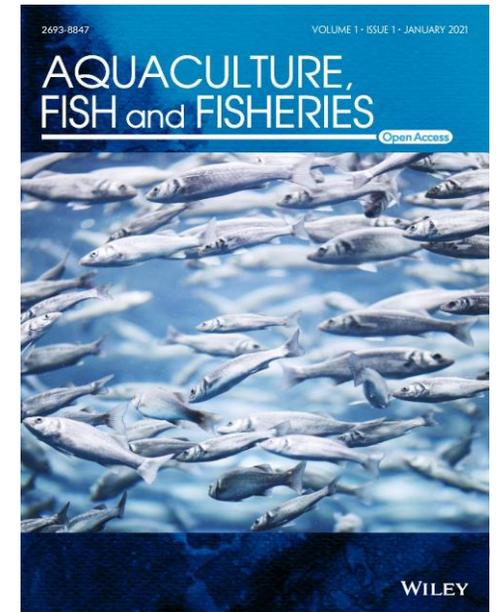
## Calado, Ricardo

📍 Universidade de Aveiro, Aveiro, Portugal 📄 6701738529 🌐 <https://orcid.org/0000-0002-1670-9335> [View more](#)

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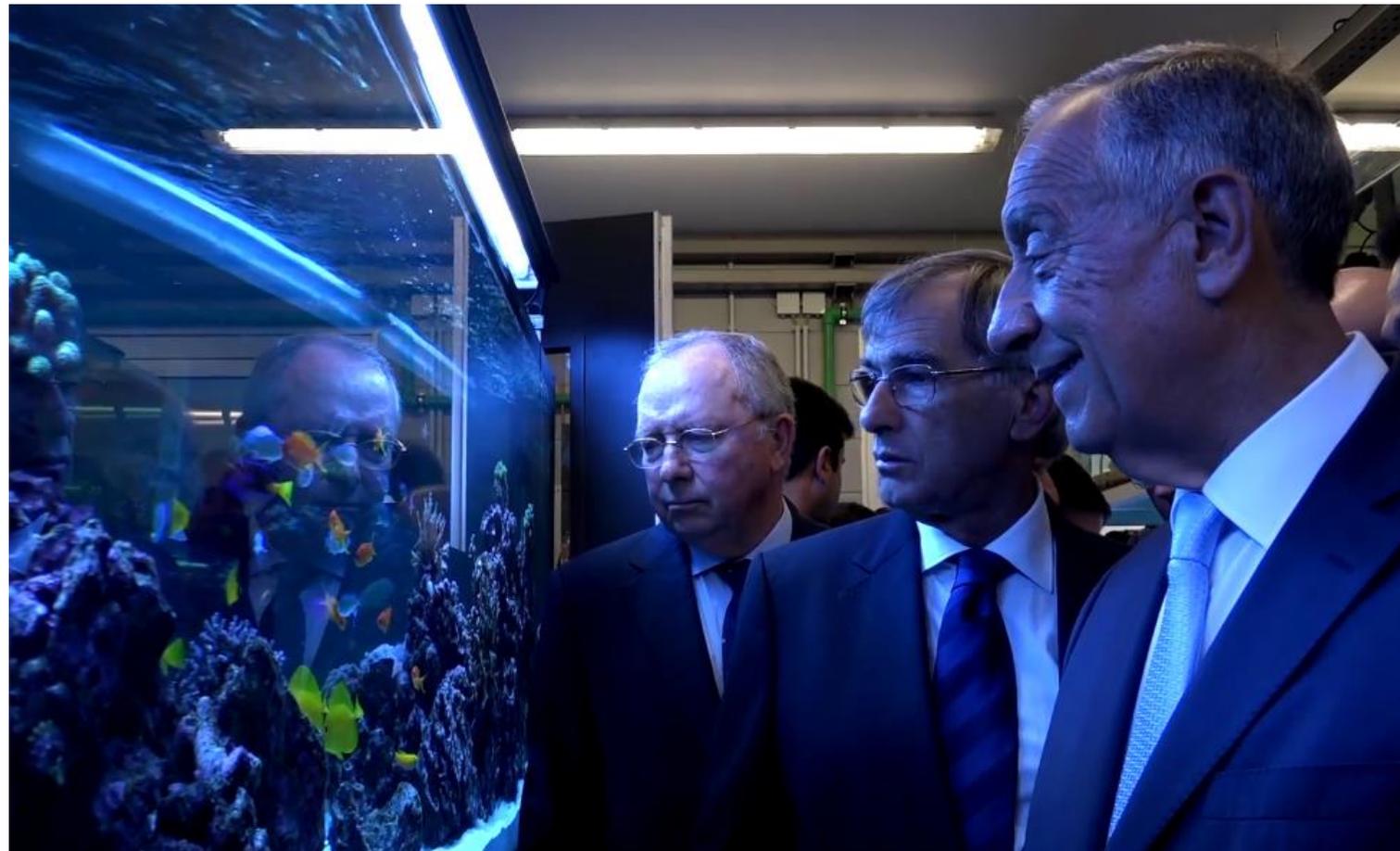
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**Marcelo Rebelo de Sousa**

Ílhavo, 15 de junho de 2017

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**“Just another day  
at the office...”**

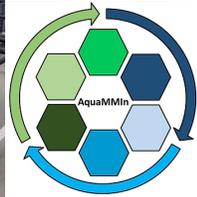
# Centro de Pesquisa e Reabilitação de Animais Marinhos (CPRAM-ECOMARE)



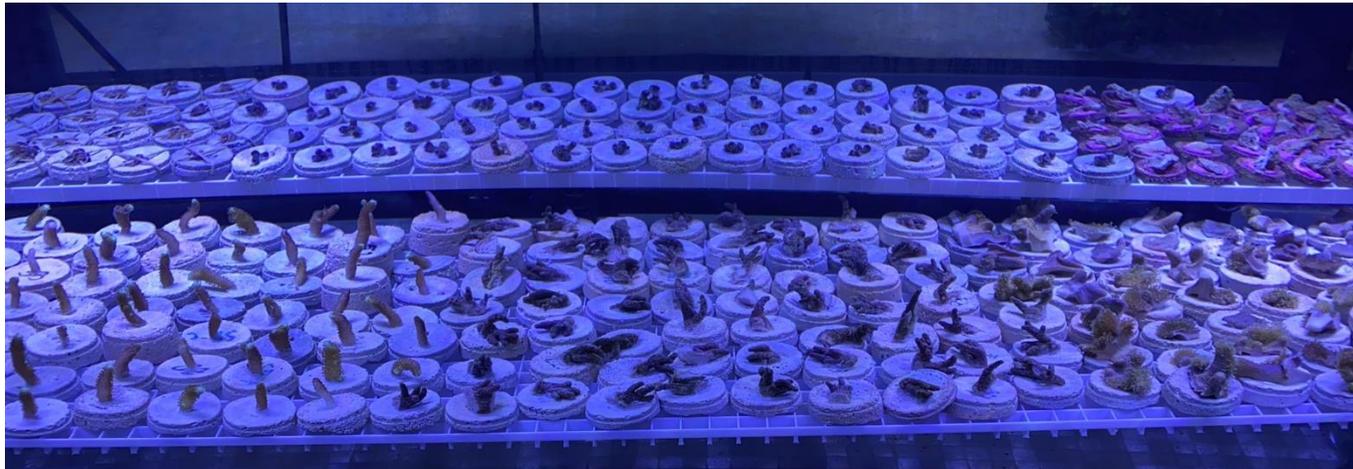
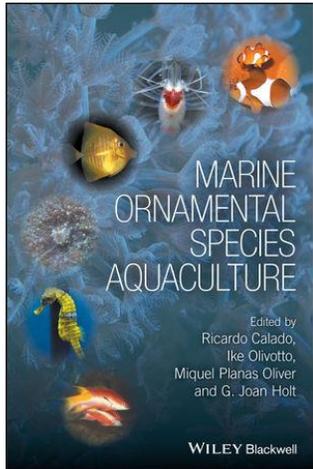
# Centro de Extensão e de Pesquisa em Aquacultura e Mar (CEPAM-ECOMARE)

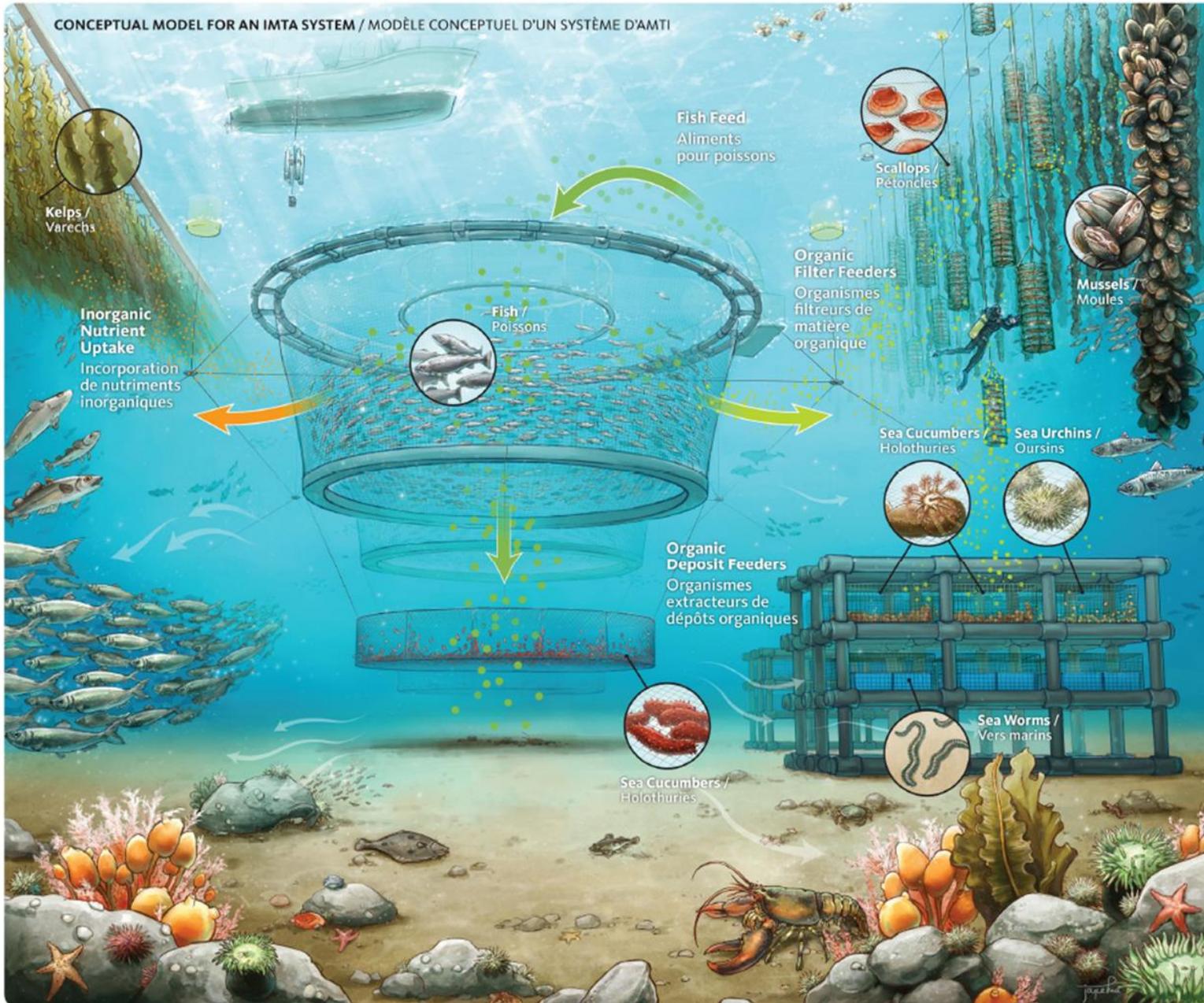


# Centro de Extensão e de Pesquisa em Aquacultura e Mar (CEPAM-ECOMARE)



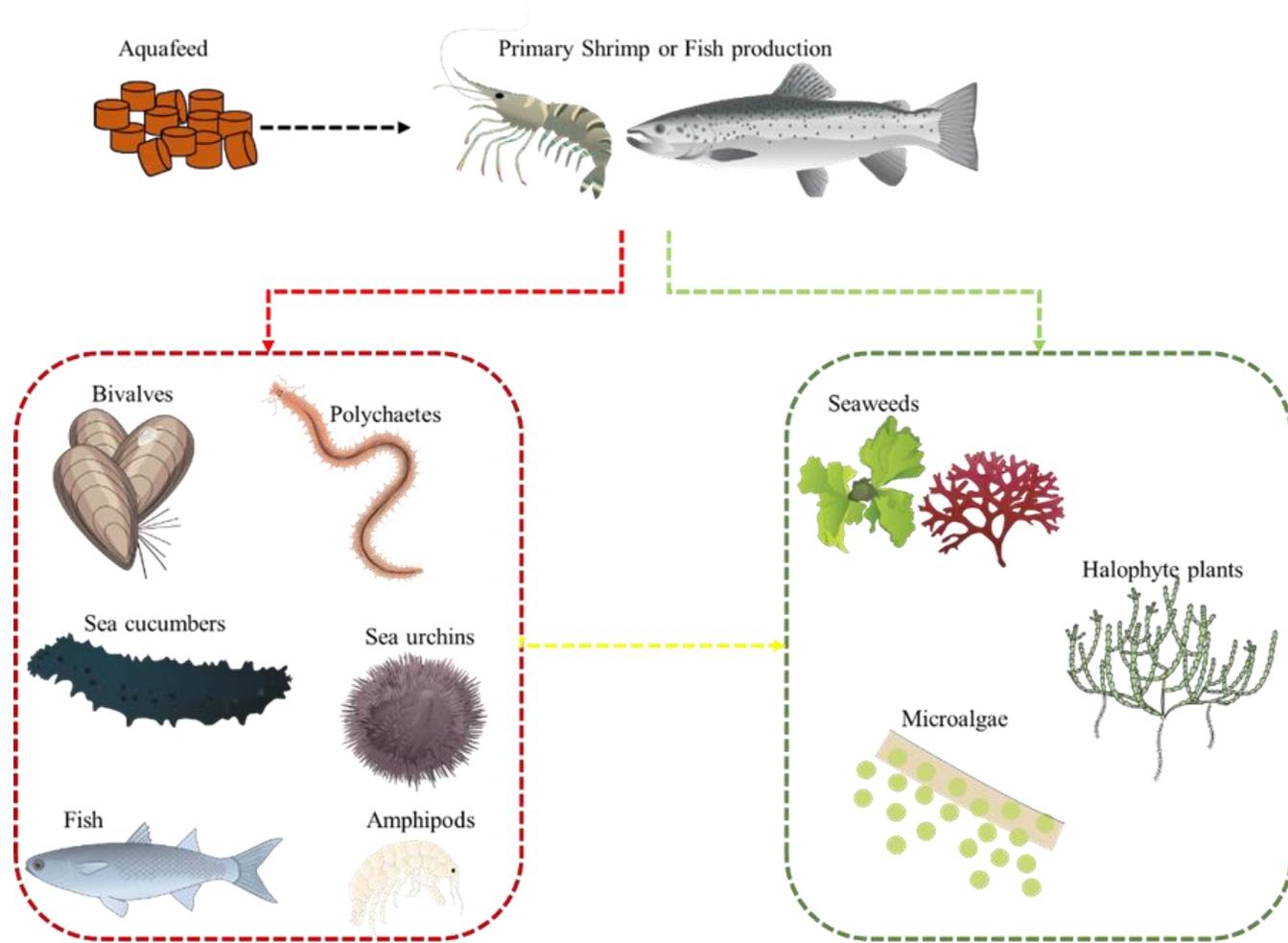
# Centro de Extensão e de Pesquisa em Aquacultura e Mar (CEPAM-ECOMARE)





## Aquicultura Multitrófica Integrada AMTI

A solução “milagrosa”  
para uma aquicultura sustentável...



Num sistema de AMTI espécies aquáticas de diferentes níveis tróficos são cultivadas de forma integrada, de modo a melhorar a eficiência produtiva, reduzir o desperdício de nutrientes e promover serviços de ecossistema, como a biorremediação.



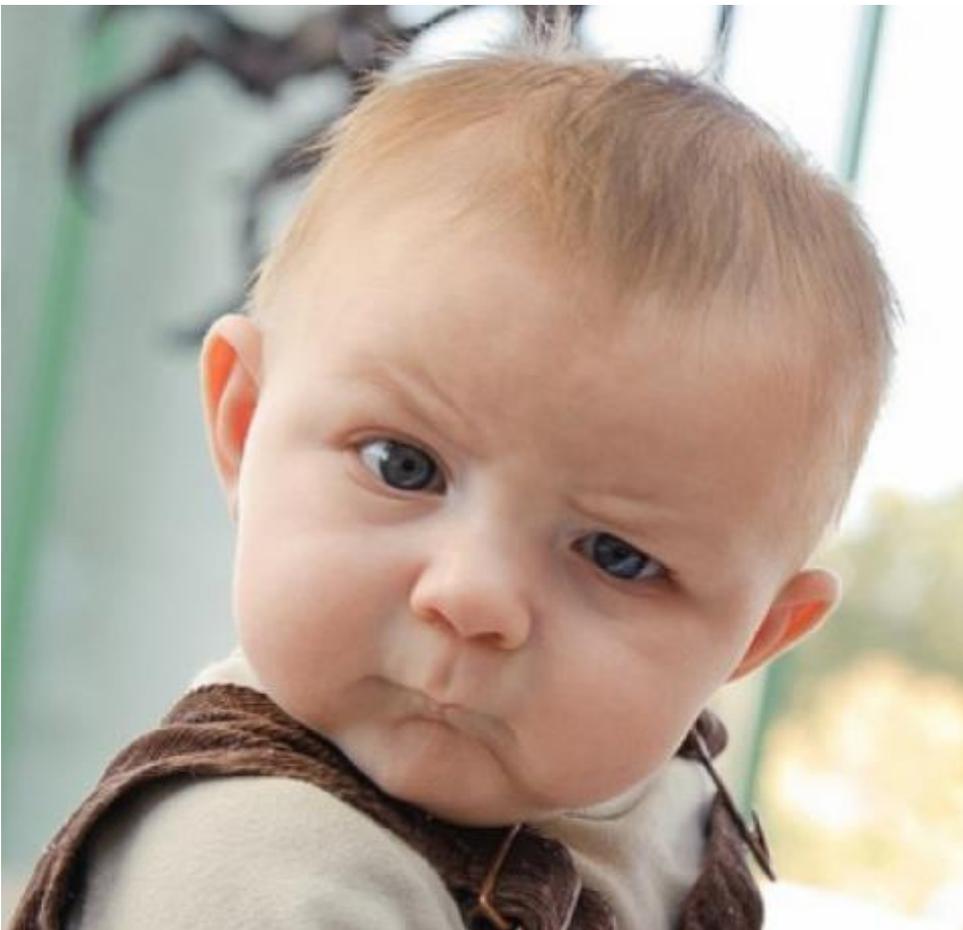
**Concetualmente, a AMTI faz todo o sentido, pois a produção de peixe e crustáceos em tanques e jaulas é ainda pouco eficiente no uso integral dos nutrientes fornecidos em rações aquícolas.**

**No entanto, a AMTI é um modelo de produção complexo cujo desempenho depende de um equilíbrio de interações tróficas difícil de alcançar entre as espécies cultivadas. É improvável que um piscicultor possua o conhecimento necessário para cultivar todas as espécies integradas num modelo de AMTI funcional e rentável.**





Por outras palavras, a AMTI pode tornar uma tarefa difícil, como a criação de peixes ou camarões, ainda mais desafiadora ao adicionar camadas de complexidade a sistemas de produção de monocultura já de si complexos...



**As “pequenas coisas” sobre AMTI de que ninguém fala:**

**Os sistemas AMTI são menos flexíveis do que os sistemas de monocultura na resposta ao mercado, pois se ocorrer um aumento na procura (e conseqüentemente do preço) das espécies extrativas (ex., bivalves e/ou algas), não é possível aumentar o fornecimento de nutrientes sem perturbar o equilíbrio necessário para manter um sistema AMTI.**

**As cadeias de valor das diferentes espécies cultivadas em AMTI são quase sempre distintas e desconexas, o que constitui um desafio para o produtor.**

**Muitas vezes os sistemas de AMTI  
combinam a Teoria e a Prática:**

**Teoria**

**Alguém sabe tudo, mas nada funciona...**

**Prática**

**Tudo funciona, mas ninguém sabe porquê...**

**Sistemas de AMTI**

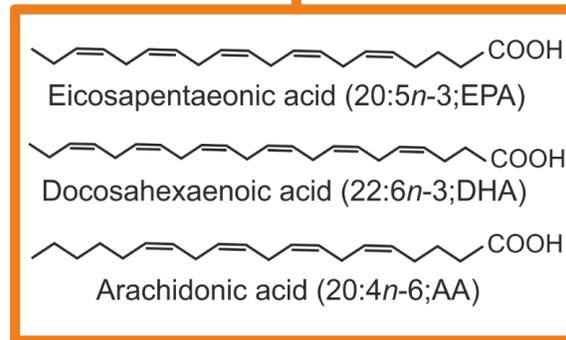
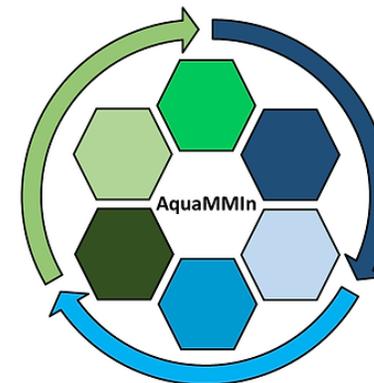
**Nada funciona e ninguém sabe porquê...**

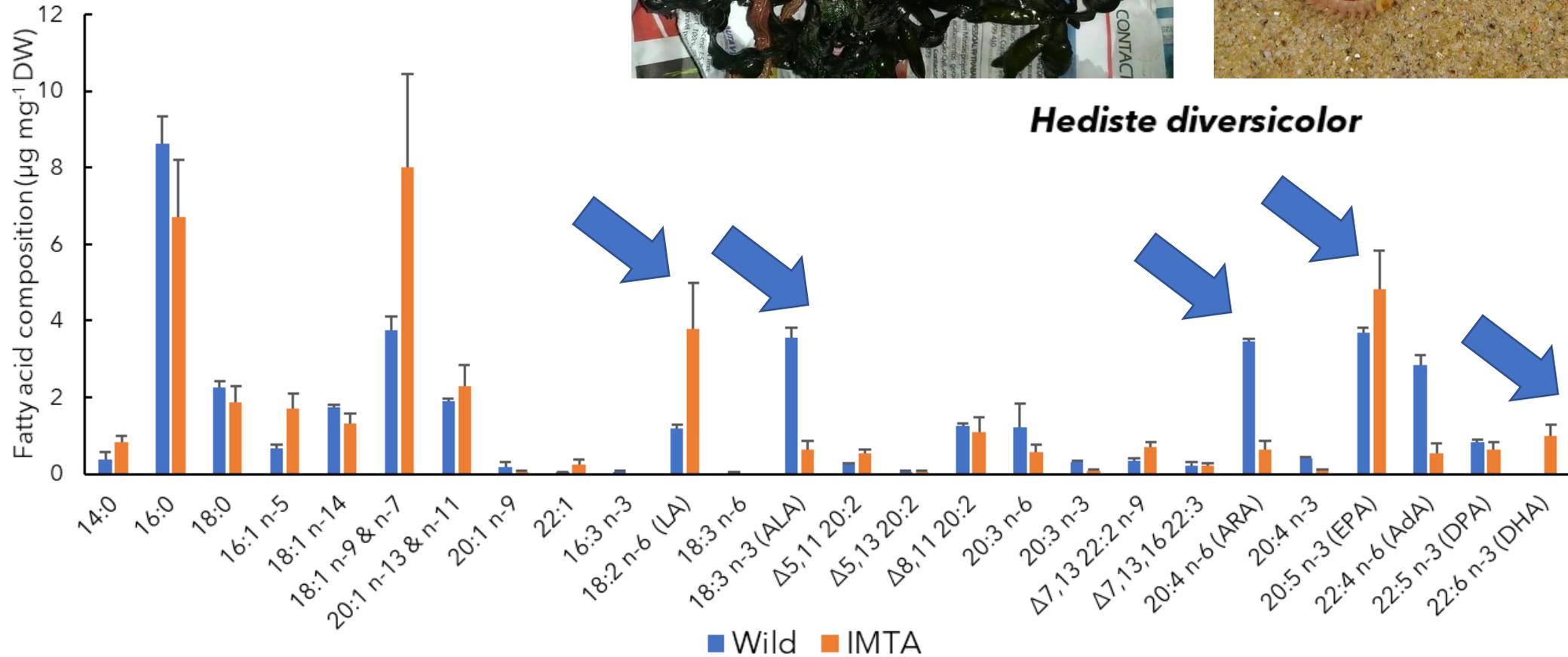


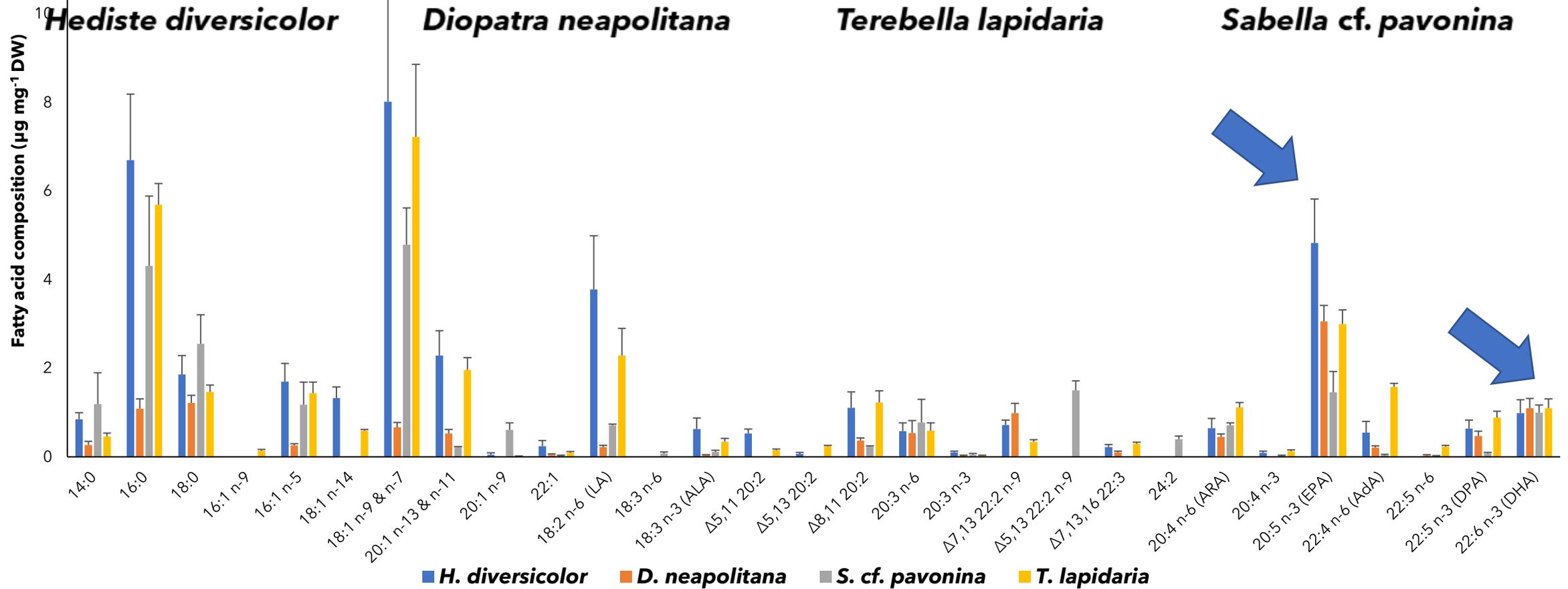


**Apesar de todos os desafios, se um produtor ainda assim quiser avançar com a instalação de um sistema de AMTI, o primeiro passo é reutilizar a matéria orgânica particulada existente na água...**

# Filtros de areia fluidizados por poliquetas (*Hediste diversicolor*)









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## Aquaculture

journal homepage: [www.elsevier.com/locate/aquaculture](http://www.elsevier.com/locate/aquaculture)



### Salinity shapes the stress responses and energy reserves of marine polychaetes exposed to warming: From molecular to functional phenotypes



Diana Madeira<sup>a,b,c,\*</sup>, Joana Filipa Fernandes<sup>a</sup>, Daniel Jerónimo<sup>a</sup>, Patrícia Martins<sup>a</sup>, Fernando Ricardo<sup>a</sup>, Andreia Santos<sup>a</sup>, Maria Rosário Domingues<sup>d,e</sup>, Mário Sousa Diniz<sup>b</sup>, Ricardo Calado<sup>a,\*\*</sup>



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## Environmental Research

journal homepage: [www.elsevier.com/locate/envres](http://www.elsevier.com/locate/envres)



### Calcium homeostasis and stable fatty acid composition underpin heatwave tolerance of the keystone polychaete *Hediste diversicolor*



Diana Madeira<sup>a,b,c,\*</sup>, Joana Filipa Fernandes<sup>a</sup>, Daniel Jerónimo<sup>a</sup>, Fernando Ricardo<sup>a</sup>, Andreia Santos<sup>a</sup>, Maria Rosário Domingues<sup>d,e</sup>, Ricardo Calado<sup>a,\*\*</sup>

## scientific reports

### OPEN Performance of polychaete assisted sand filters under contrasting nutrient loads in an integrated multi-trophic aquaculture (IMTA) system



Daniel Jerónimo<sup>1,2,3</sup>, Ana Isabel Lillebo<sup>1</sup>, Andreia Santos<sup>1</sup>, Javier Cremades<sup>2</sup> & Ricardo Calado<sup>1,2,3</sup>

### Modulation of fatty acid profiles by global and local ocean change drivers in the ragworm *Hediste diversicolor*: implications for aquaculture production



Joana Filipa Fernandes<sup>a,\*</sup>, Fernando Ricardo<sup>a</sup>, Daniel Jerónimo<sup>a</sup>, Andreia Santos<sup>a</sup>, Maria Rosário Domingues<sup>b,c</sup>, Ricardo Calado<sup>a</sup>, Diana Madeira<sup>a,d,\*</sup>

frontiers  
in Marine Science

ORIGINAL RESEARCH  
published: 11 May 2021  
doi: 10.3389/fmars.2021.671545

### Optimizing the Timeframe to Produce Polychaetes (*Hediste diversicolor*) Enriched With Essential Fatty Acids Under Different Combinations of Temperature and Salinity

OPEN ACCESS

Edited by: Daniel Jerónimo<sup>1\*</sup>, Ana Isabel Lillebo<sup>1</sup>, Felisa Rey<sup>2,3</sup>, Henrique Koga Ili<sup>1</sup>, M. Rosário M. Domingues<sup>2,3</sup> and Ricardo Calado<sup>1\*</sup>

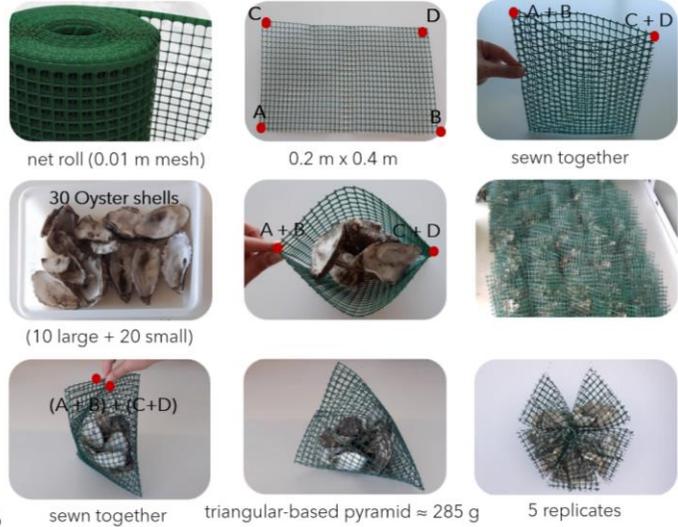
## scientific reports

### OPEN Unravelling the fatty acid profiles of different polychaete species cultured under integrated multi-trophic aquaculture (IMTA)

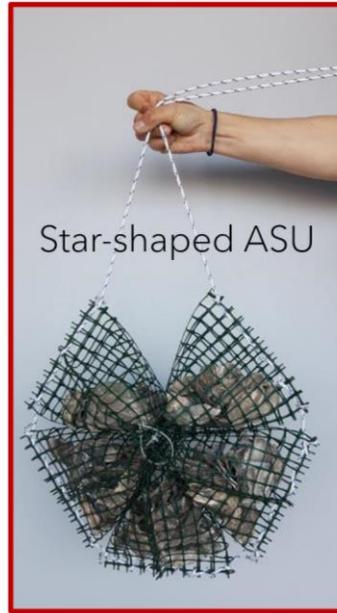


Daniel Jerónimo<sup>1,2,3</sup>, Ana Isabel Lillebo<sup>1</sup>, Elisabete Maciel<sup>1,3</sup>, M. Rosário M. Domingues<sup>2,3</sup>, Javier Cremades<sup>4</sup> & Ricardo Calado<sup>1,2,3</sup>

## Metodologia - Artificial Substrate Unit (ASU)



6



*Ascidiella aspersa*



*Ciona intestinalis*



*Microcosmus* sp.



*Molgula* sp.1



*Molgula* sp.2



*Styela* sp.



*Styela plicata*



*Botryllus schlosseri*



*Botrylloides violaceus*



*Clavelina lepadiformis*

**As ascídias (tunicados) conseguem filtrar matéria orgânica dissolvida presente na água e a sua biomassa apresenta elevado potencial biotecnológico.**



## Using Oyster Shells for Customized 3-D Structures for Monitoring Ecosystem Shifts on Ascidians Diversity

Luisa Marques<sup>\*</sup>, Guilherme Teixeira, Ricardo Calado and Ana Isabel Lillebo<sup>\*</sup>

## Potential of Ascidians as Extractive Species and Their Added Value in Marine Integrated Multitrophic Aquaculture Systems—From Pests to Valuable Blue Bioresources

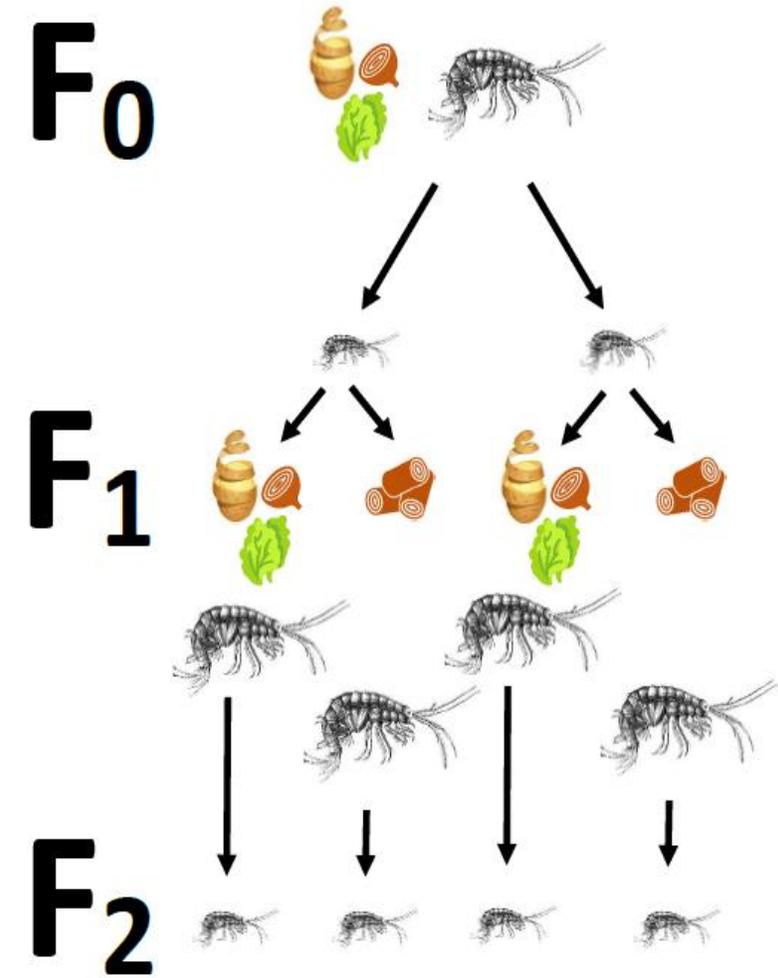
Luisa Marques<sup>\*</sup>, Ricardo Calado and Ana Isabel Lillebo<sup>\*</sup>



Article

## Screening for Health-Promoting Fatty Acids in Ascidians and Seaweeds Grown under the Influence of Fish Farming Activities

Luísa Marques<sup>1,\*</sup> , Maria Rosário Domingues<sup>2,3</sup> , Elisabete da Costa<sup>2,3</sup> , Maria Helena Abreu<sup>4</sup>, Ana Isabel Lillebo<sup>1</sup>  and Ricardo Calado<sup>1,\*</sup> 



Os anfípodes gamarídeos (ex. *Gammarus locusta*) realizam um “upgrade” trófico, sintetizando LC-PUFA a partir de alimento sem estas biomoléculas.



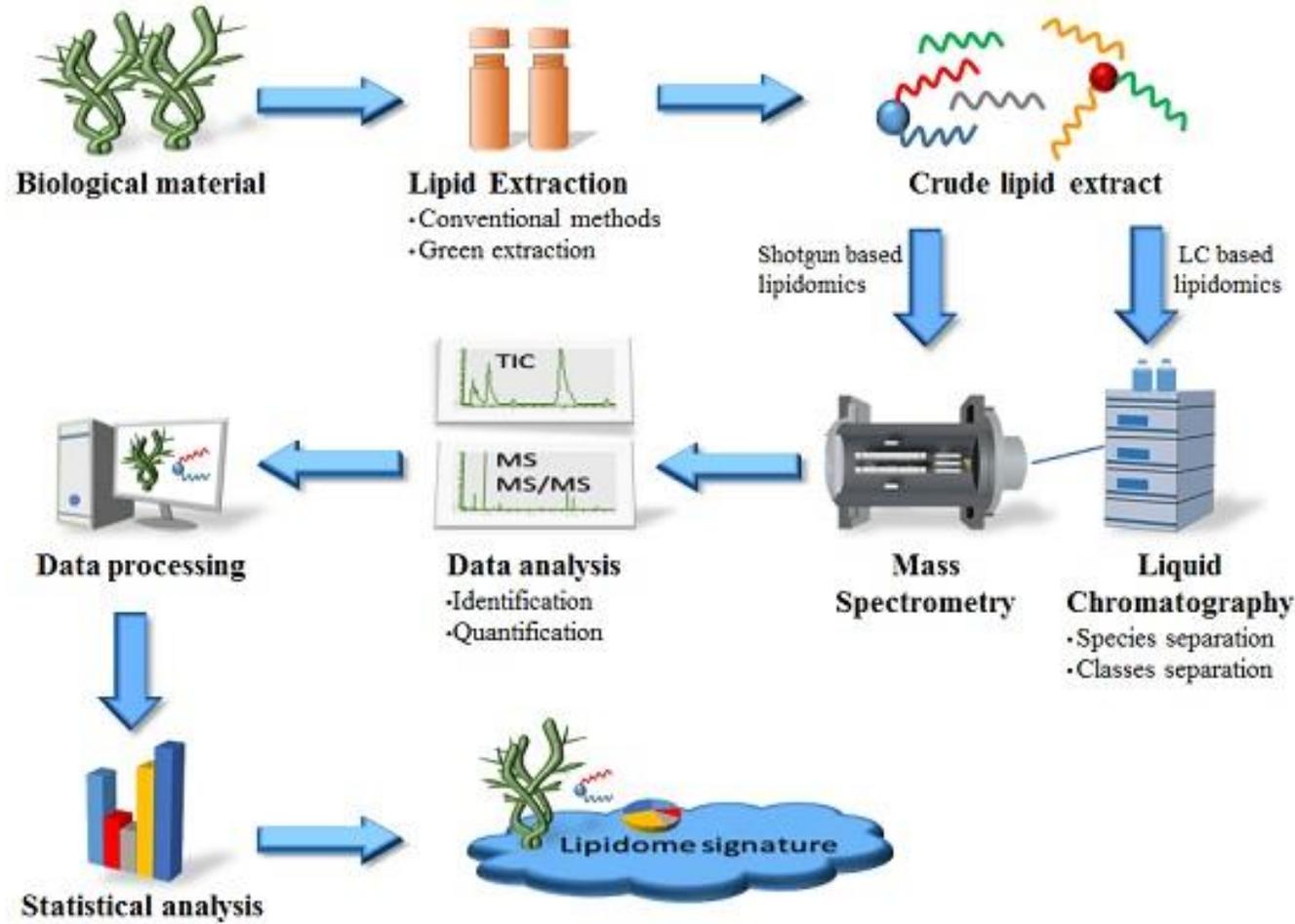
Depois de reutilizar a matéria orgânica particulada existente na água é necessário proceder à reutilização dos nutrientes inorgânicos dissolvidos na água...



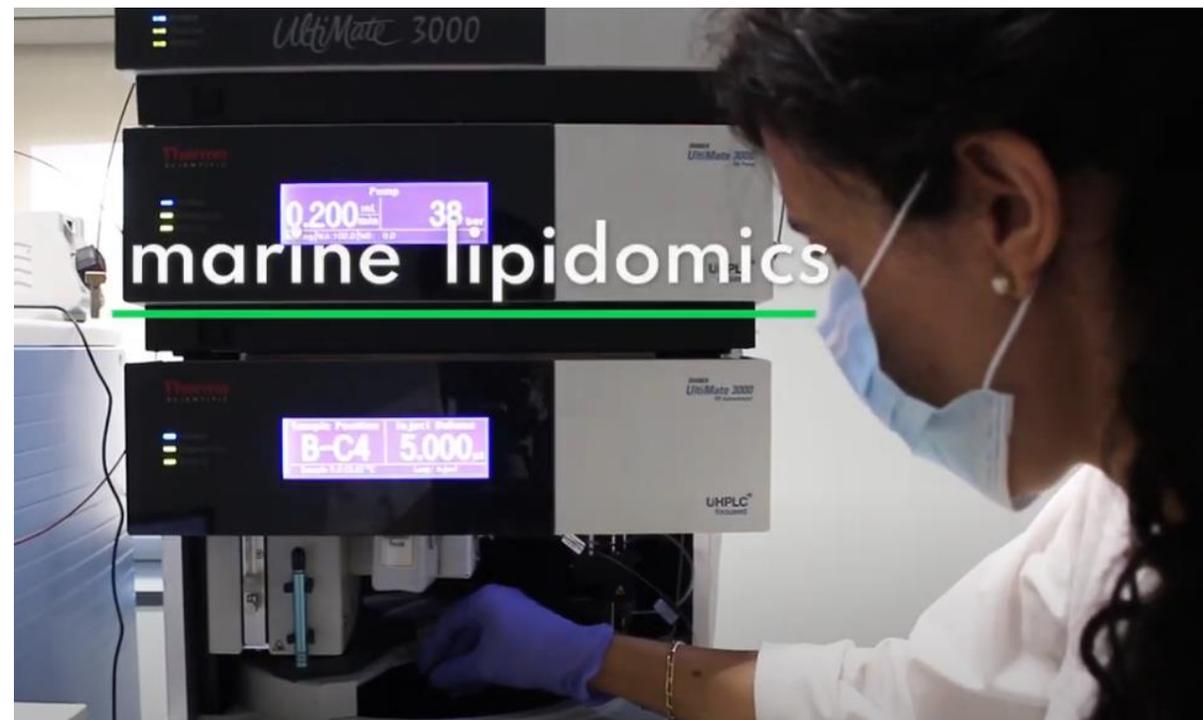


## Bioprospecting of Marine Macrophytes Using MS-Based Lipidomics as a New Approach

Elisabete Maciel <sup>1,2,\*</sup>, Miguel Costa Leal <sup>3</sup>, Ana Isabel Lillebø <sup>2</sup>, Pedro Domingues <sup>1</sup>, Maria Rosário Domingues <sup>1</sup> and Ricardo Calado <sup>2,\*</sup>



fatty acid profile

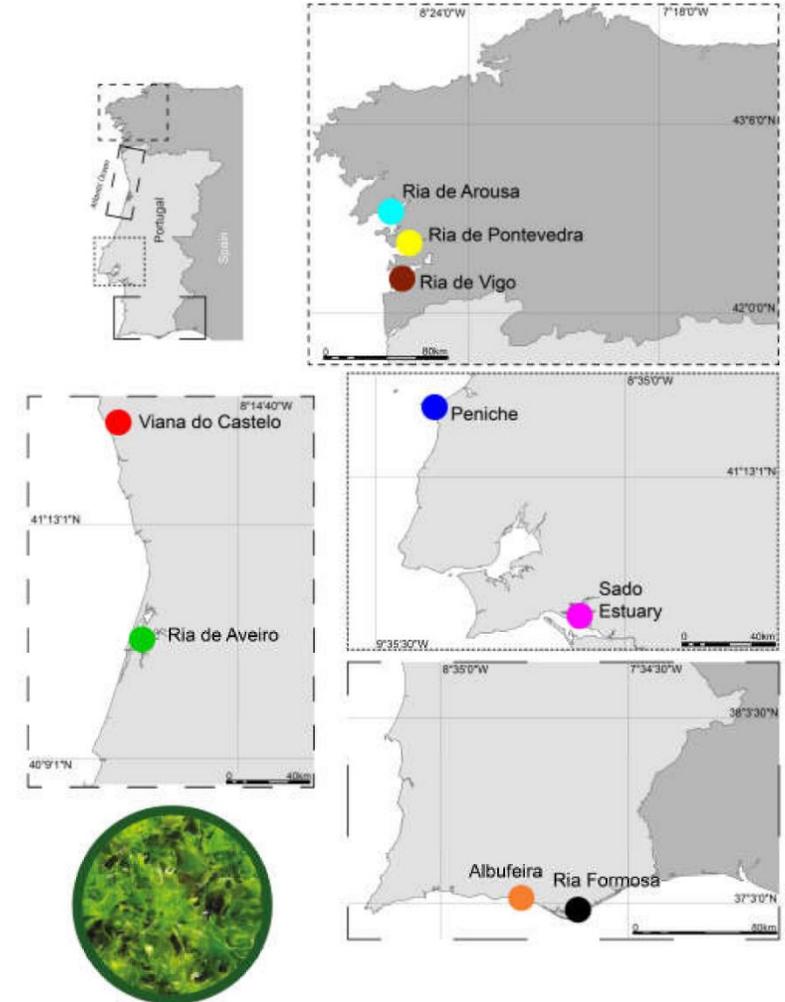
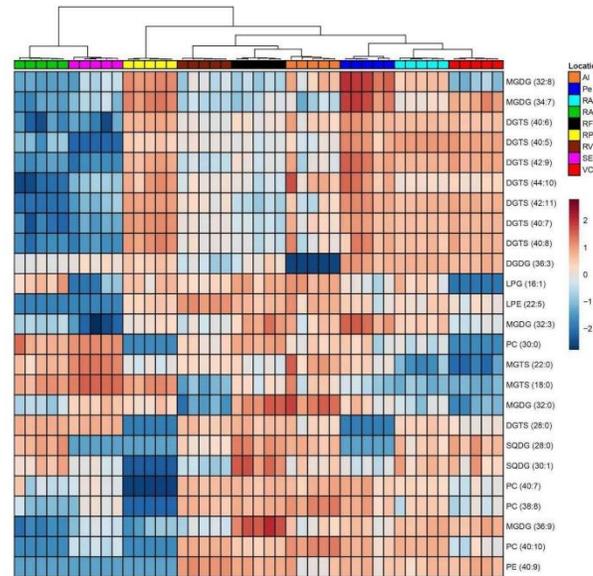
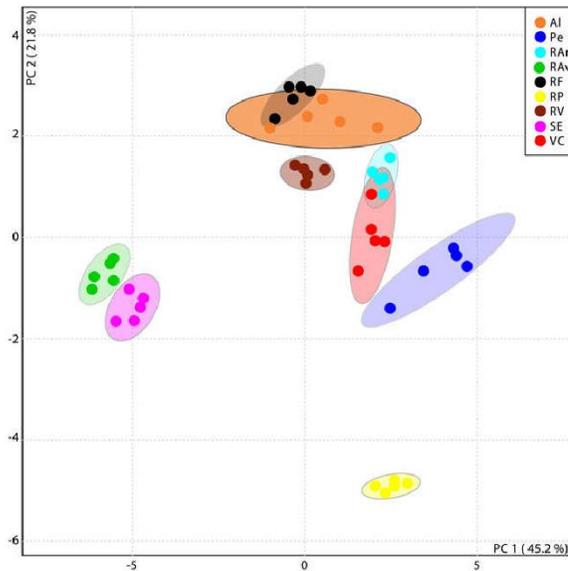


**Laboratório de Lipidómica Marinha @Departamento de Química  
Universidade de Aveiro**

Article

# Site-Specific Lipidomic Signatures of Sea Lettuce (*Ulva* spp., Chlorophyta) Hold the Potential to Trace Their Geographic Origin

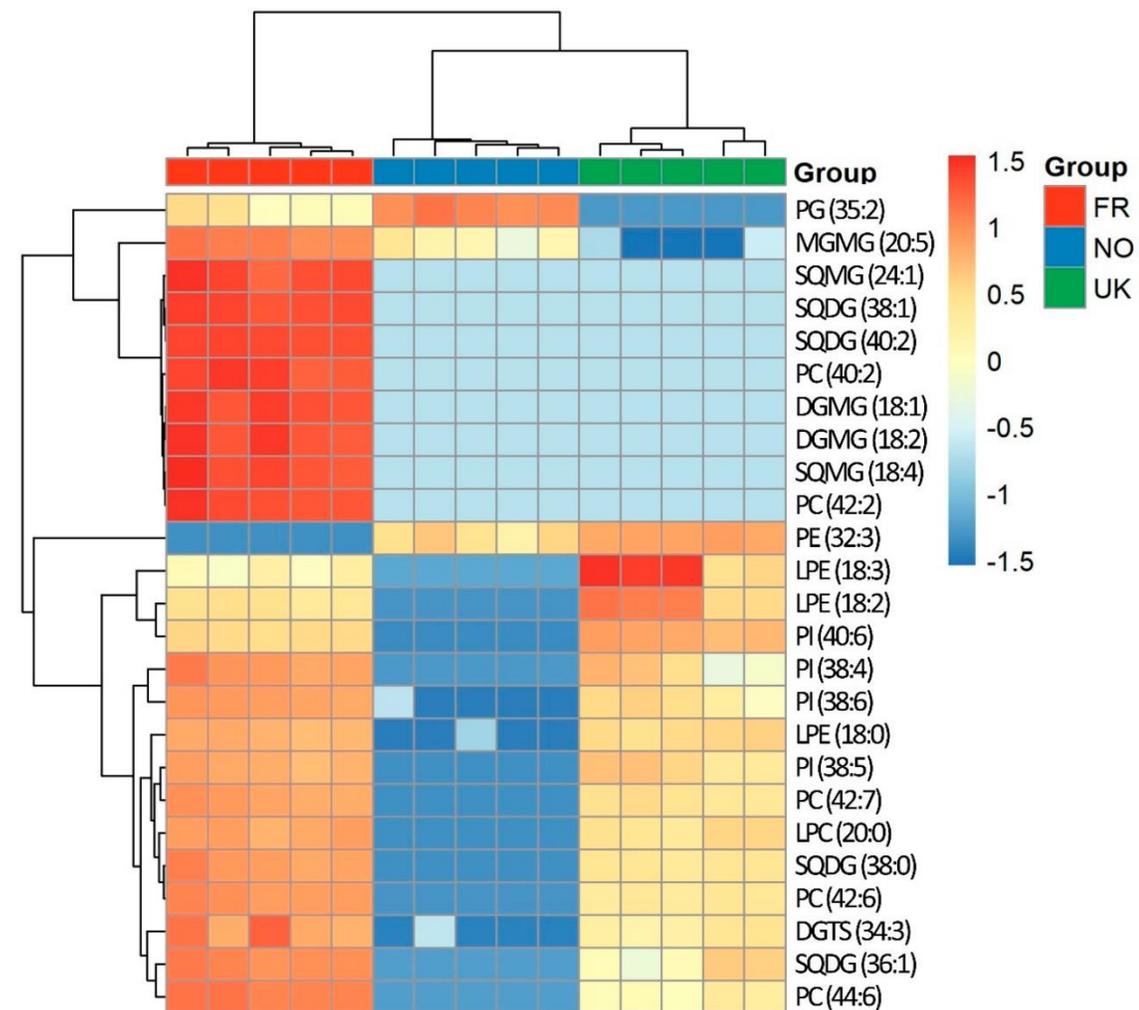
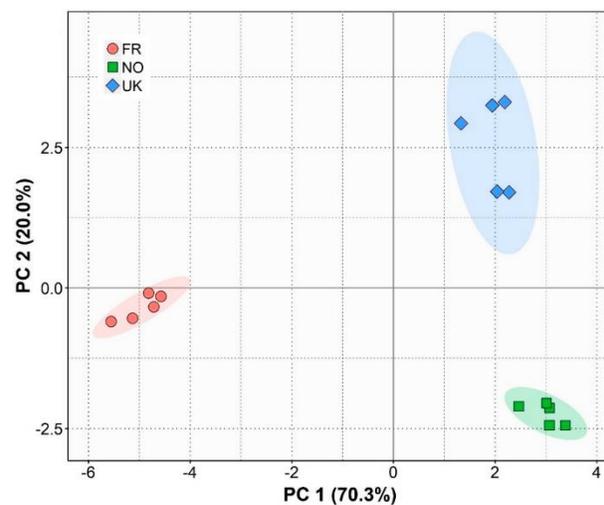
Elisabete da Costa <sup>1,2</sup>, Fernando Ricardo <sup>1,3</sup>, Tânia Melo <sup>1,2</sup>, Renato Mamede <sup>3</sup>, Maria H. Abreu <sup>4</sup>, Pedro Domingues <sup>1,2</sup>, M. Rosário Domingues <sup>1,2</sup> and Ricardo Calado <sup>3,\*</sup>



Article

# The Unique Lipidomic Signatures of *Saccharina latissima* Can Be Used to Pinpoint Their Geographic Origin

João P. Monteiro <sup>1,2,\*</sup>, Felisa Rey <sup>1,3</sup> , Tânia Melo <sup>1,2</sup>, Ana S. P. Moreira <sup>1,2</sup>, Jean-François Arbona <sup>4</sup>, Jorunn Skjermo <sup>5</sup> , Silje Forbord <sup>5</sup>, Jon Funderud <sup>6</sup>, Diogo Raposo <sup>6</sup>, Philip D. Kerrison <sup>7</sup>, Marie-Mathilde Perrineau <sup>7</sup>, Claire Gachon <sup>7</sup>, Pedro Domingues <sup>1</sup> , Ricardo Calado <sup>3</sup>  and M. Rosário Domingues <sup>1,2</sup> 





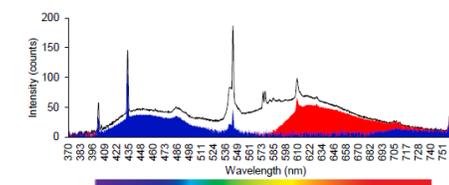
Intensidade



Espectro

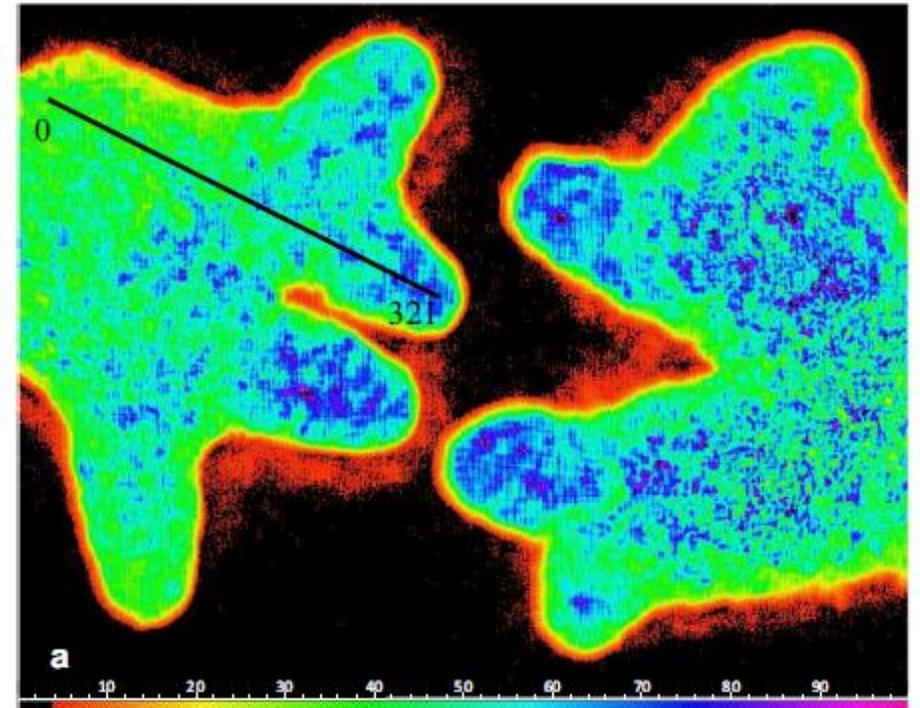
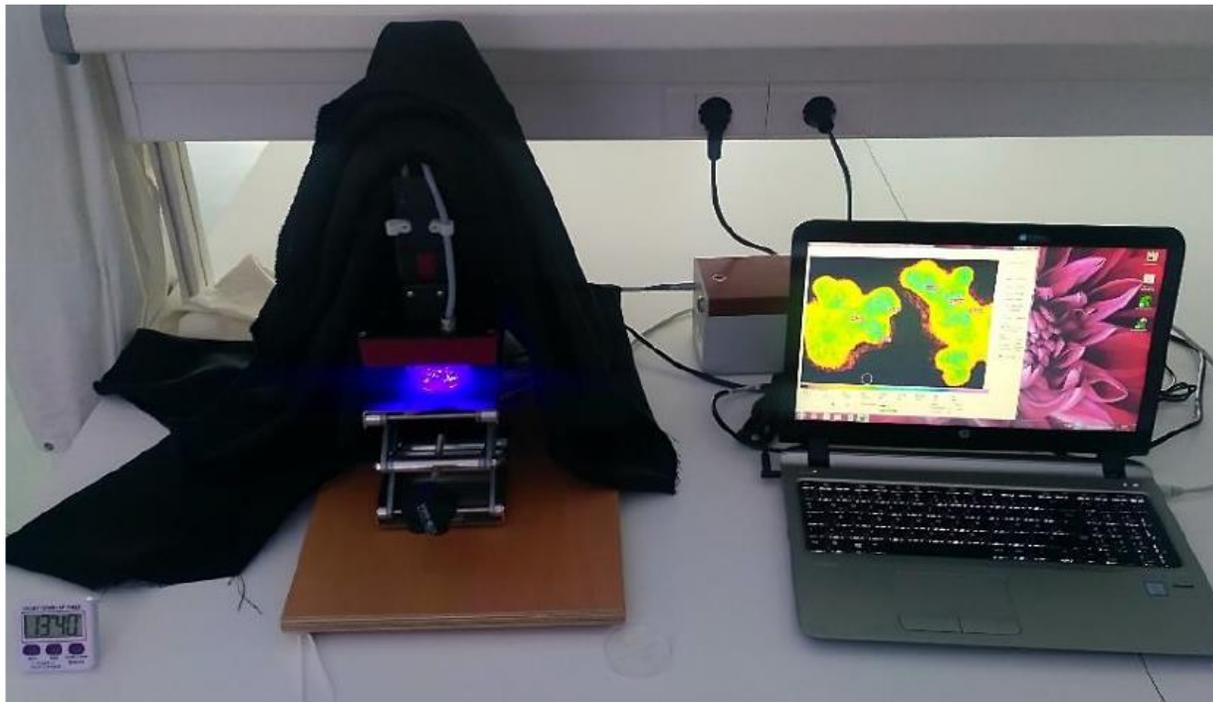


(ainda é grátis)



**Manipulando a intensidade e o espectro da luz do sol para otimizar o crescimento/qualidade das algas**

## Fluorescência da Clorofila a – Metodologias para avaliação da atividade fotossintética, fotoproteção e fotoinibição





# Controlling Light to Optimize Growth and Added Value of the Green Macroalga *Codium tomentosum*

Rúben Marques<sup>†</sup>, Anthony Moreira, Sónia Cruz, Ricardo Calado and Paulo Cartaxana<sup>\*</sup>



Communication

## Photosynthetic Pigment and Carbohydrate Profiling of *Fucus vesiculosus* from an Iberian Coastal Lagoon

Ana C. R. Resende<sup>1</sup> , Rui Pereira<sup>2</sup> , Cláudia Nunes<sup>3</sup> , Sónia Cruz<sup>4</sup> , Ricardo Calado<sup>4</sup>   
and Paulo Cartaxana<sup>4,\*</sup> 



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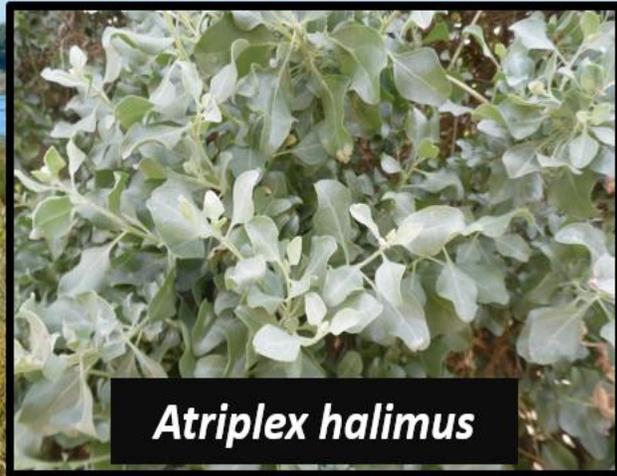


Spatial variability of elemental fingerprints of sea lettuce (*Ulva* spp.) and its potential use to trace geographic origin

Renato Mamede<sup>a,\*</sup>, Fernando Ricardo<sup>a</sup>, Maria Helena Abreu<sup>b</sup>, Eduardo Ferreira da Silva<sup>c</sup>,  
Carla Patinha<sup>c</sup>, Ricardo Calado<sup>a,\*</sup>



*Sarcocornia* spp.



*Atriplex halimus*



*Sesuvium portulacastrum*



*Halimione portulacoides*



*Salicornia* spp.



*Aster tripolium*



Grafts



Week 1



Week 5

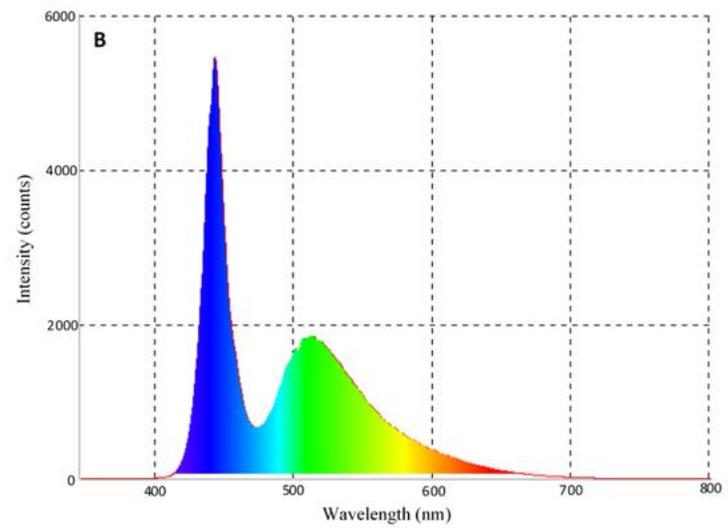
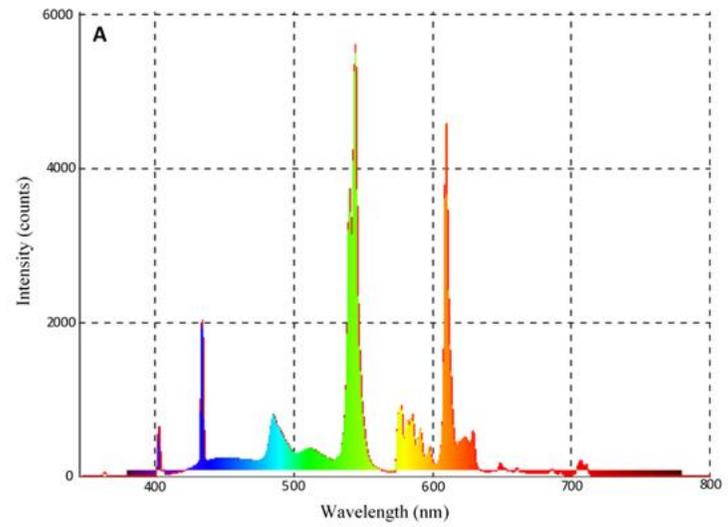


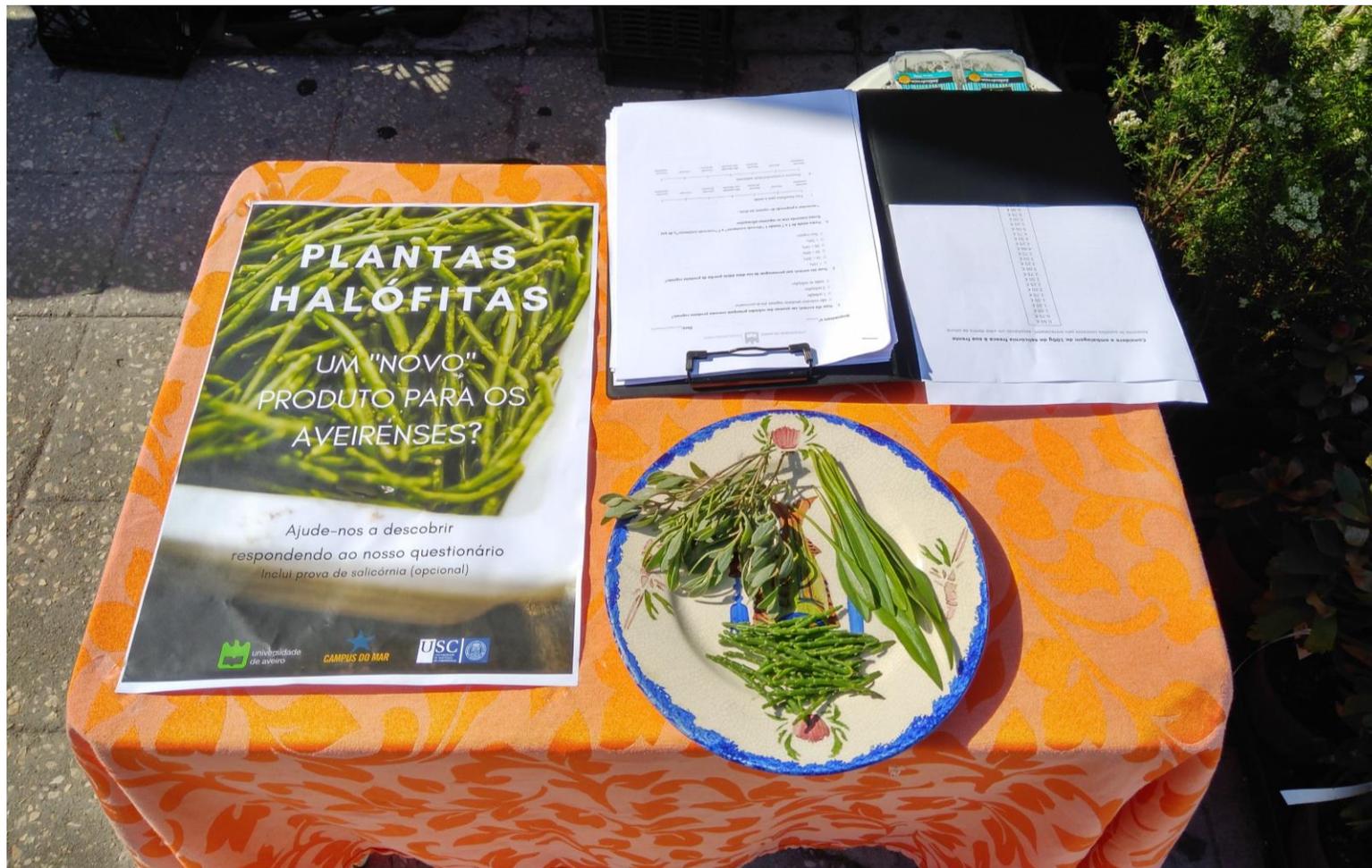
Week 10

	Nitrogen (mg L <sup>-1</sup> )	Phosphorous (mg L <sup>-1</sup> )
[N,P] <sub>low</sub>	6	0.8
[N,P] <sub>med</sub>	20	3.0
[N,P] <sub>high</sub>	100	6.0
Control	56	15.5

		[N,P] <sub>low</sub>	[N,P] <sub>med</sub>	[N,P] <sub>high</sub>	Control	
Final biomass	Initial biomass	g unit <sup>-1</sup>	44.6 ± 6.0	47.4 ± 6.3	49.3 ± 6.2	48.6 ± 2.1
	Total	g unit <sup>-1</sup>	195.9 ± 28.7 <sup>a</sup>	245.5 ± 39.7 <sup>ab</sup>	257.6 ± 40.8 <sup>ab</sup>	279.4 ± 44.7 <sup>b</sup>
		Aboveground	g unit <sup>-1</sup>	155.2 ± 16.7 <sup>a</sup>	216.3 ± 36.5 <sup>b</sup>	228.6 ± 35.4 <sup>b</sup>
	Belowground	g unit <sup>-1</sup>	40.3 ± 12.9	28.9 ± 4.5	29.0 ± 5.5	32.0 ± 6.7
	Total productivity	g m <sup>-2</sup> day <sup>-1</sup>	48.0 ± 7.9 <sup>a</sup>	62.9 ± 13.7 <sup>ab</sup>	66.1 ± 11.2 <sup>ab</sup>	73.3 ± 14.5 <sup>b</sup>
	Root: shoot ratio	-	0.26 ± 0.06 <sup>a</sup>	0.13 ± 0.02 <sup>b</sup>	0.13 ± 0.01 <sup>b</sup>	0.13 ± 0.02 <sup>b</sup>
	Leaves count	n unit <sup>-1</sup>	1658 ± 167	1879 ± 103	2008 ± 190	1958 ± 277
	Stems length	m unit <sup>-1</sup>	1.83 ± 0.12 <sup>a</sup>	2.29 ± 0.26 <sup>b</sup>	2.39 ± 0.22 <sup>b</sup>	2.51 ± 0.32 <sup>b</sup>





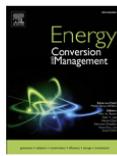




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## Energy Conversion and Management

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*Halimione portulacoides* biomass - a sustainable feedstock for bioenergy production from an integrated water-energy-food system

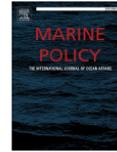
Ricardo N. Coimbra<sup>a</sup>, Marco Custódio<sup>b</sup>, Eduardo M. Cuerda-Correa<sup>c</sup>, Moonis Ali Khan<sup>d</sup>, Ricardo Calado<sup>b</sup>, Ana I. Lillebø<sup>b</sup>, Marta Otero<sup>a,e,\*</sup>



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## Marine Policy

journal homepage: [www.elsevier.com/locate/marpol](http://www.elsevier.com/locate/marpol)



Full length article

Halophytes as novel marine products – A consumers' perspective in Portugal and policy implications

Marco Custódio<sup>a,b,\*</sup>, Ana I. Lillebø<sup>a</sup>, Ricardo Calado<sup>a</sup>, Sebastián Villasante<sup>c,d,\*\*</sup>



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## Science of the Total Environment

journal homepage: [www.elsevier.com/locate/scitotenv](http://www.elsevier.com/locate/scitotenv)



Testing the hydroponic performance of the edible halophyte *Halimione portulacoides*, a potential extractive species for coastal Integrated Multi-Trophic Aquaculture

Marco Custódio<sup>a,\*</sup>, Sebastián Villasante<sup>b</sup>, Ricardo Calado<sup>a</sup>, Ana I. Lillebø<sup>a,\*</sup>

## REVIEWS IN Aquaculture

*Reviews in Aquaculture* (2020) 12, 392–405

doi: 10.1111/raq.12324

## Valuation of Ecosystem Services to promote sustainable aquaculture practices

Marco Custódio<sup>1,2</sup> , Sebastián Villasante<sup>2,3</sup> , Ricardo Calado<sup>1</sup> and Ana Isabel Lillebø<sup>1</sup>



Article

## LED Lighting and High-Density Planting Enhance the Cost-Efficiency of *Halimione portulacoides* Extraction Units for Integrated Aquaculture

Marco Custódio<sup>1,2,\*</sup>, Paulo Cartaxana<sup>1</sup> , Sebastián Villasante<sup>3,4,5</sup>, Ricardo Calado<sup>1</sup> and Ana Isabel Lillebø<sup>1,\*</sup>

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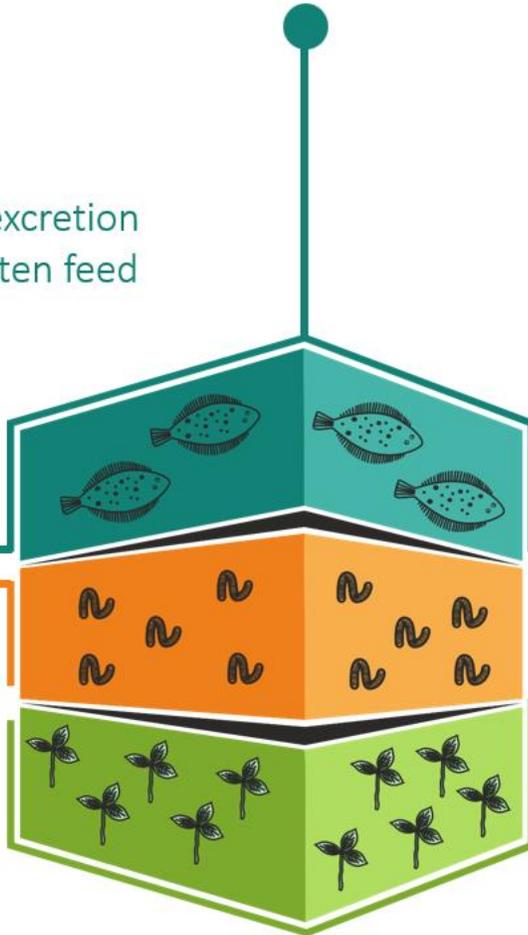
## Nutrient availability affects the polar lipidome of *Halimione portulacoides* leaves cultured in hydroponics

Marco Custódio<sup>1\*</sup> , Elisabete Maciel<sup>1,2,3</sup>, Maria Rosário Domingues<sup>2,3</sup>, Ana Isabel Lillebø<sup>1</sup> & Ricardo Calado<sup>1\*</sup>

Fish Feed

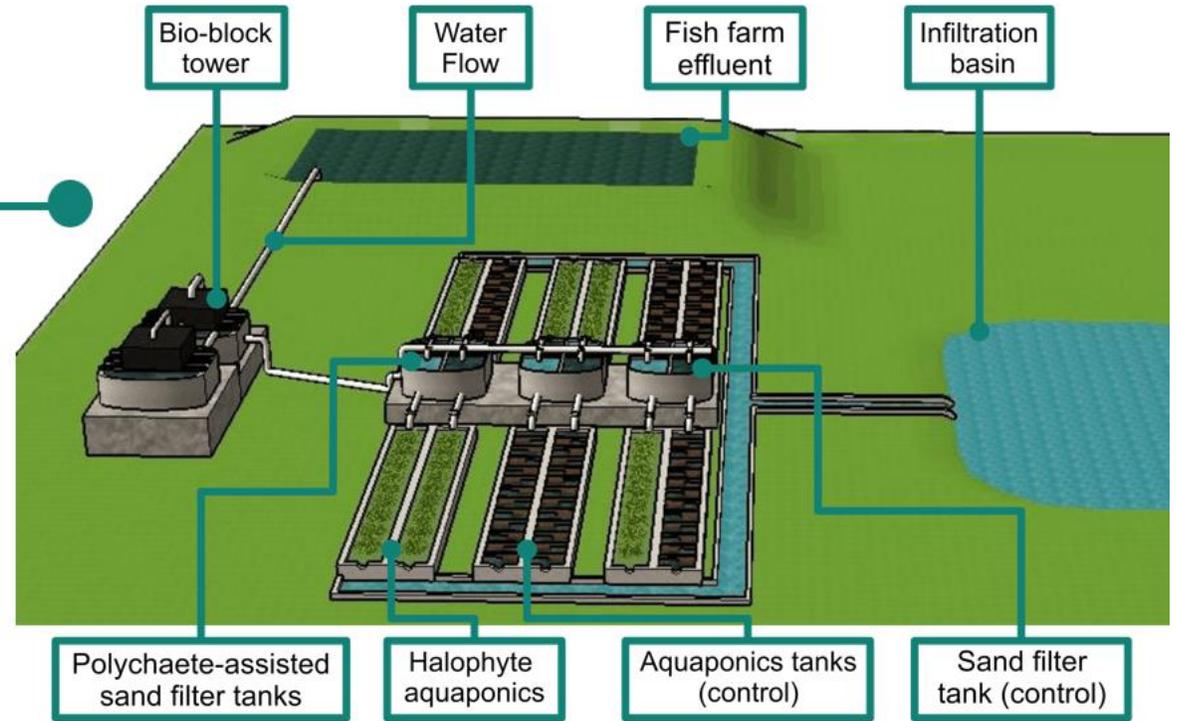
Effluent

- fish excretion
- uneaten feed



*Hediste diversicolor*

*Halimione portulacoides*



**Project STEP was designed to remove as much particulate organic matter and dissolved nutrients from fish farm effluent water as possible.**





New species for the biomitigation of a super-intensive marine fish farm effluent: Combined use of polychaete-assisted sand filters and halophyte aquaponics



Bruna Marques, Ricardo Calado \*, Ana I. Lillebø \*

FEATURE ARTICLE



## Adding value to ragworms (*Hediste diversicolor*) through the bioremediation of a super-intensive marine fish farm

Bruna Marques<sup>1</sup>, Ana Isabel Lillebø<sup>1</sup>, Fernando Ricardo<sup>1</sup>, Cláudia Nunes<sup>2,3</sup>, Manuel A. Coimbra<sup>3</sup>, Ricardo Calado<sup>1,\*</sup>

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## Aquaponics using a fish farm effluent shifts bacterial communities profile in halophytes rhizosphere and endosphere

Vanessa Oliveira<sup>3</sup>, Patrícia Martins<sup>2</sup>, Brunna Marques<sup>2</sup>, Daniel F. R. Cleary<sup>3</sup>, Ana I. Lillebø<sup>2</sup> & Ricardo Calado<sup>2</sup>



REVIEW

## Unravelling the potential of halophytes for marine integrated multi-trophic aquaculture (IMTA)—a perspective on performance, opportunities and challenges

Marco Custódio<sup>1,\*</sup>, Sebastian Villasante<sup>2</sup>, Javier Cremades<sup>3</sup>, Ricardo Calado<sup>1</sup>, Ana I. Lillebø<sup>1</sup>



molecules



Article

## Effect of High-Pressure Processing (HPP) on the Fatty Acid Profile of Different Sized Ragworms (*Hediste diversicolor*) Cultured in an Integrated Multi-Trophic Aquaculture (IMTA) System

Bruna Marques<sup>1</sup>, Ana Isabel Lillebø<sup>1,\*</sup>, Maria do Rosário M. Domingues<sup>2</sup>, Jorge A. Saraiva<sup>3</sup> and Ricardo Calado<sup>1,\*</sup>



applied  
sciences



Article

## Halophyte Plants Cultured in Aquaponics Hold the Same Potential for Valorization as Wild Conspecifics from Donor Sites

Bruna Marques<sup>1,\*</sup>, Elisabete Maciel<sup>2</sup>, Maria Rosário Domingues<sup>2,3</sup>, Ricardo Calado<sup>1</sup> and Ana Isabel Lillebø<sup>1</sup>

## A inspiração para novos modelos de AMTI



Os ecossistemas de recifes de coral são altamente produtivos e biodiversos, embora existam em ambientes oceânicos pobres em nutrientes (oligotróficos); este fenômeno é conhecido como o paradoxo de Darwin.



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MARINE BIOTECHNOLOGY  
& AQUACULTURE



**KEEP  
CALM  
AND  
DO YOUR  
RESEARCH**





**Obrigado!**  
**Gracias!**  
**Thank you!**  
**Merci!**  
**Grazie!**  
**Danke!**  
**Xièxiè!**