



# Tracing the geographic origin of bivalves – for value, safety, and conservation

**WSC2023 & ICMSS2023**

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Peniche, Portugal



**Ricardo Calado et al.**

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CENTRO DE ESTUDOS  
DO AMBIENTE E  
DO MAR



universidade  
de aveiro



**Portugal's best!!!**

**Ameijoas (clams) à Bulhão Pato**

(you only start living after you have tasted them...)



**When we look at this delicacy,  
what is the first thing that  
comes to mind?**



**Exactly!!!**

**Where did this seafood  
come from?**

**Was it sourced locally?**

**Was it legally harvested?**

**Is it safe to eat?**

**...**



Manila clam  
*Venerupis philippinarum*



**Illegal harvesting of clams in the Tagus estuary, Lisbon!  
More than 150 slave Thai fishermen identified!**

<https://expresso.pt/sociedade/2017-12-31-Escravos-do-rio-1>



Manila clam  
*Venerupis philippinarum*



**Over a 1000 people exploited (several are illegal/slave immigrants) on the illegal harvesting of clams in the Tagus estuary near Lisbon...  
Nearly 18M Euros net value (no taxes being paid...) with ≈6K Tones collected per year!**

[Ajoelham-se no lodo do Tejo, fazem duas marés, vivem em condições indignas: mais de mil pessoas exploradas na apanha ilegal da amêijoa \(expresso.pt\)](https://www.expresso.pt/pt/actualidade/1000-pessoas-exploadas-na-apanha-ilegal-da-amêijo-a-no-tejo)



**Ohhh...!!!**

**OK, I didn't know that...**

**Now, I really want to know!!!**



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**Can we tell apart seafood  
originating from different  
geographic locations?**





**Bivalves incorporate geochemical and biochemical cues from the environment during their lifetime that fingerprint them in unique ways!**

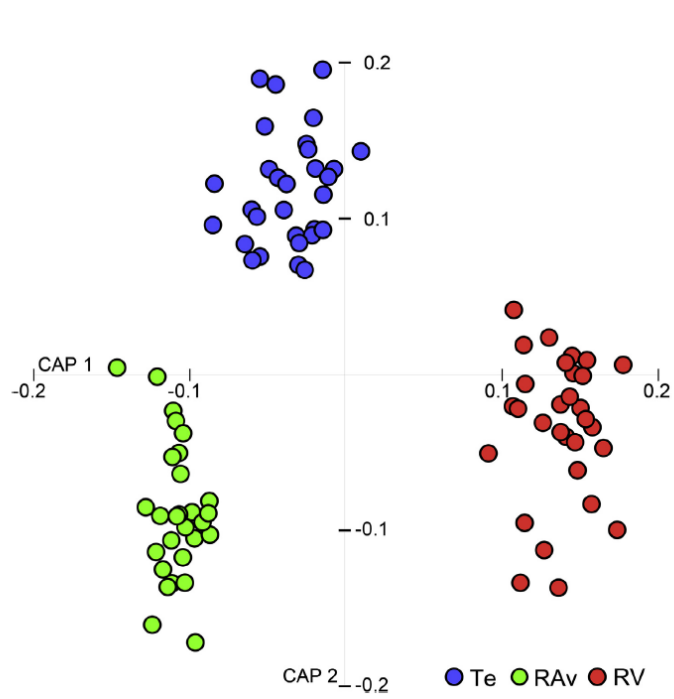




**Tracing the  
geographic origin  
of bivalves**

**Elemental analysis  
of the shell  
using ICP-MS**

**Fatty acid analysis  
of the adductor muscle  
using GC-MS**



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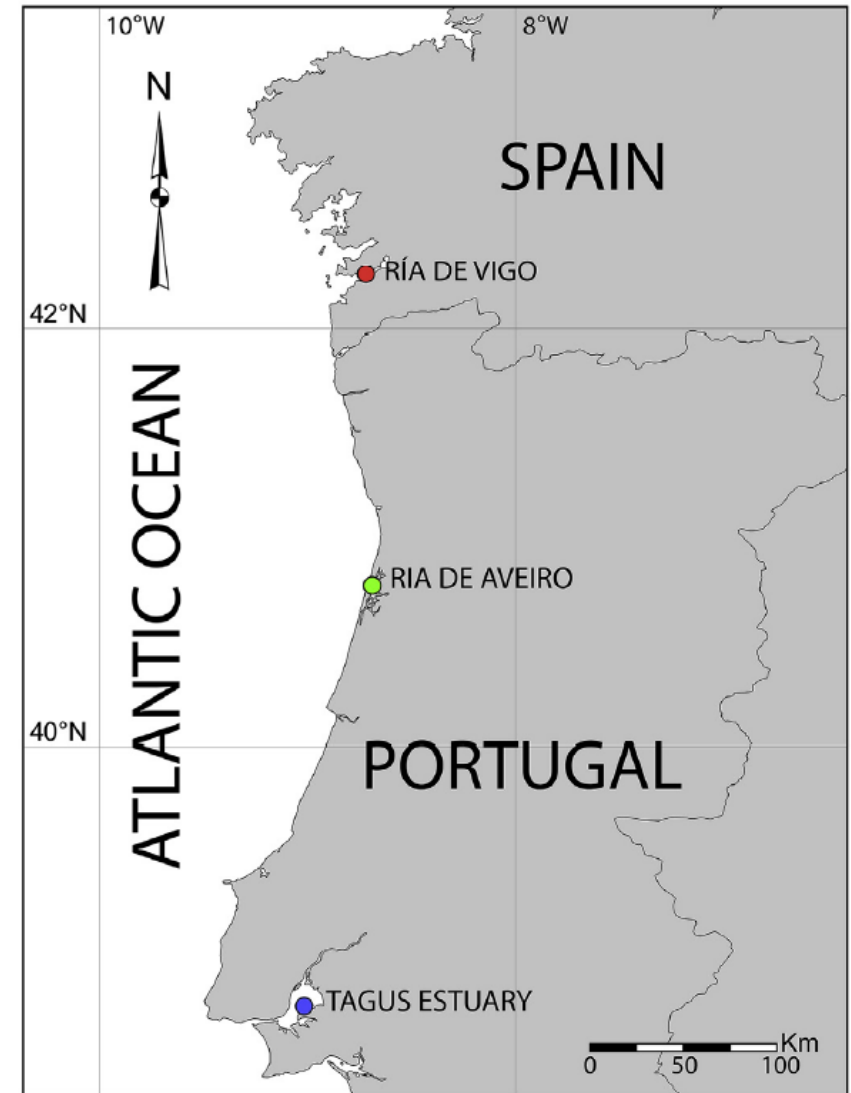
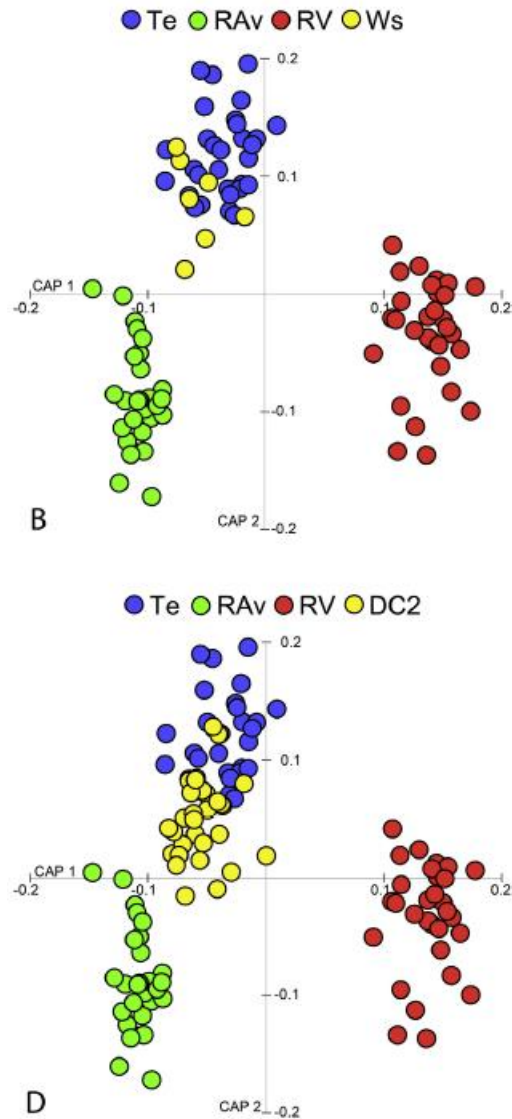
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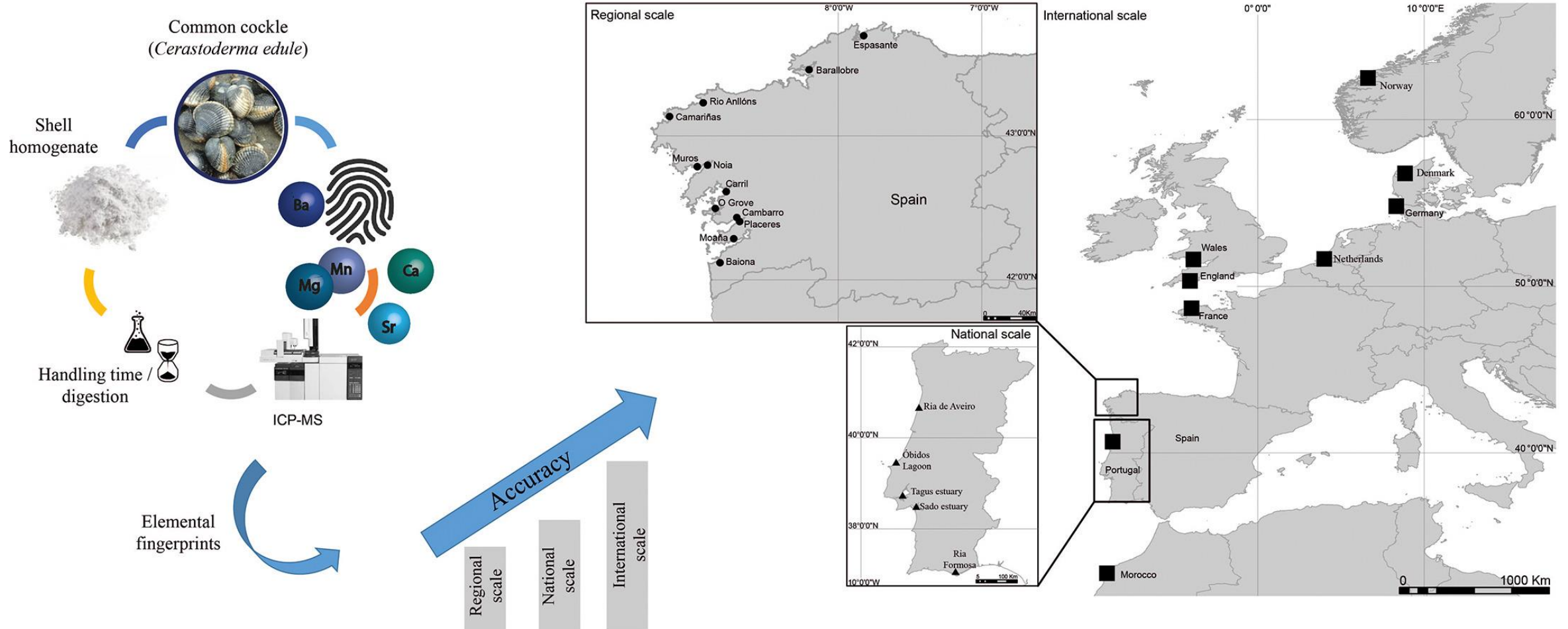


Revealing the illegal harvesting of Manila clams (*Ruditapes philippinarum*) using fatty acid profiles of the adductor muscle

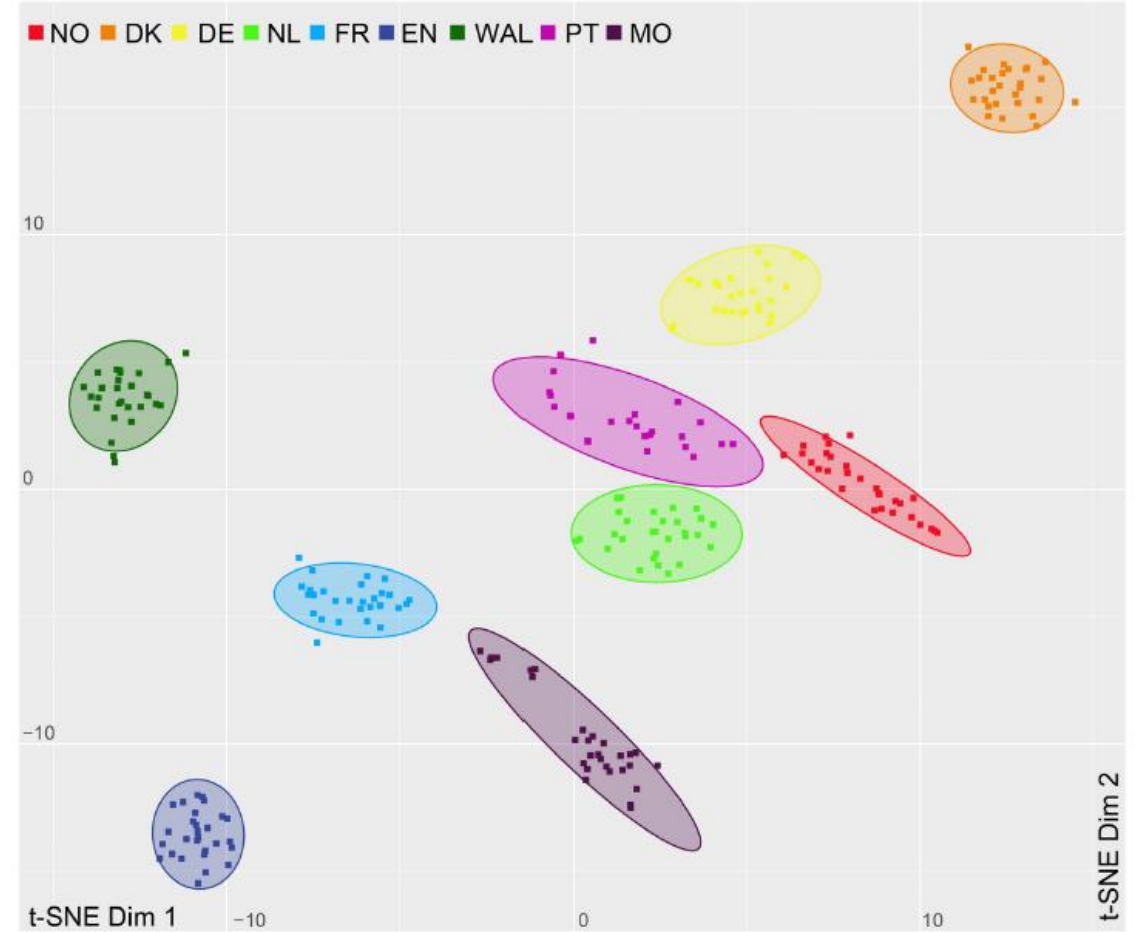
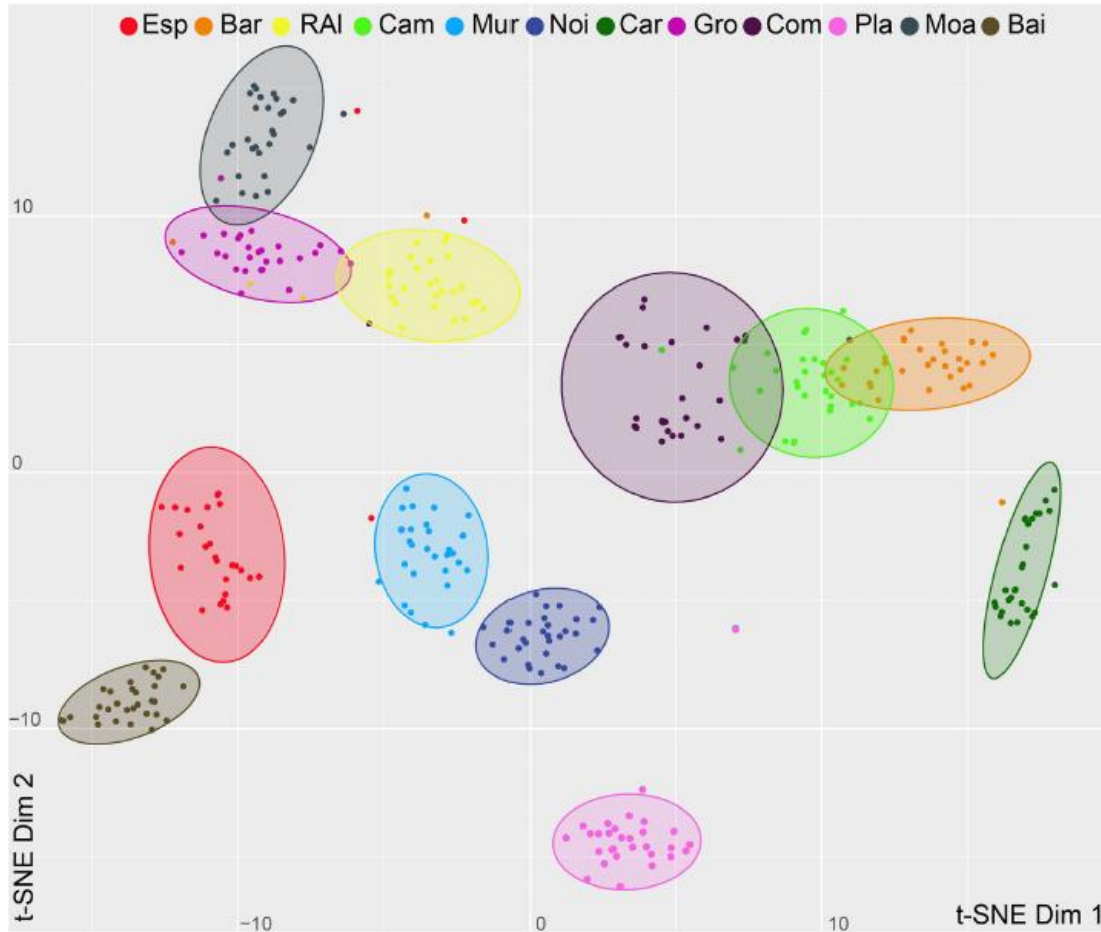
Renato Mamede<sup>a,\*</sup>, Fernando Ricardo<sup>a</sup>, Andreia Santos<sup>a</sup>, Seila Díaz<sup>b,c</sup>, Sónia A.O. Santos<sup>d</sup>, Regina Bispo<sup>e,f</sup>, M. Rosário M. Domingues<sup>b,h</sup>, Ricardo Calado<sup>a,i,\*</sup>



**At a large spatial scale, the geographic origin of bivalves can be confirmed with an accuracy up to 95% or more!**



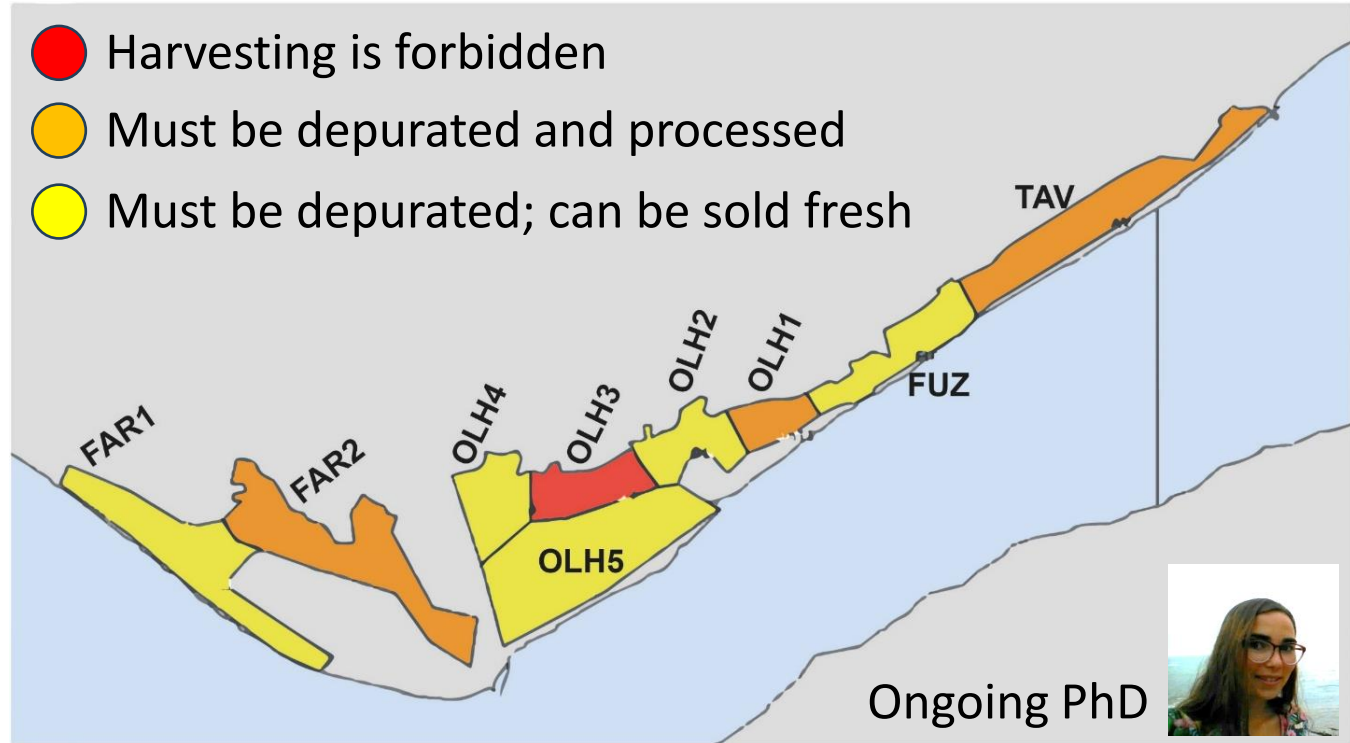
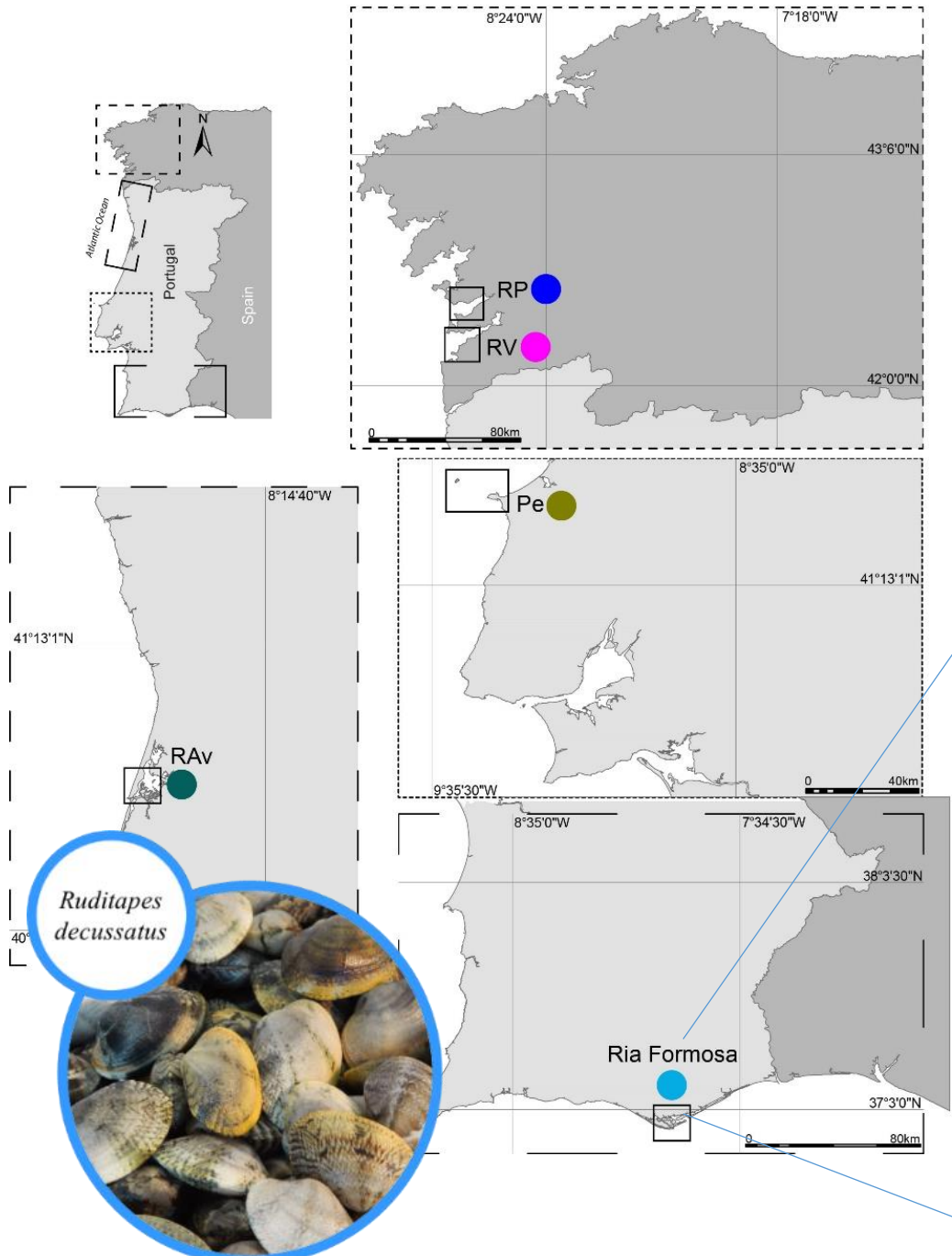
**The larger the spatial scale, the more accurately one can confirm the geographic origin of bivalves.**



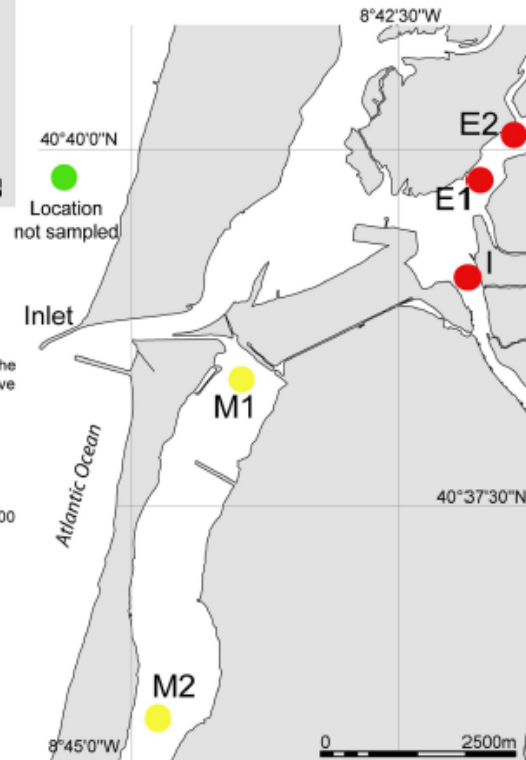
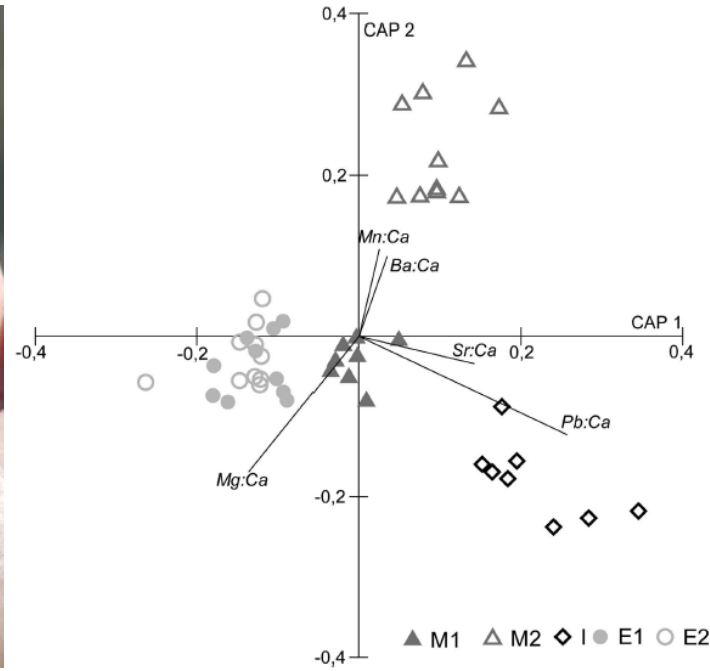
**The larger the spatial scale, the more accurately one can confirm the geographic origin of bivalves.**



**At smaller spatial scales confirming the geographic origin of clams can be more challenging, but it is paramount for food safety and product valorization...  
But it can still be achieved!**



# Indeed, it can still be achieved!



## SCIENTIFIC REPORTS

OPEN

Trace element fingerprinting of cockle (*Cerastoderma edule*) shells can reveal harvesting location in adjacent areas

Received: 22 December 2014  
Accepted: 27 May 2015  
Published: 07 July 2015

Fernando Ricardo<sup>1</sup>, Luciana Génio<sup>2</sup>, Miguel Costa Leal<sup>3</sup>, Rui Albuquerque<sup>4</sup>, Henrique Queiroga<sup>5</sup>, Rui Rosa<sup>2</sup> & Ricardo Calado<sup>4</sup>

Fishing/production areas for bivalves in the EU are ranked according to the levels of *Escherichia coli* present in the flesh and intra-valvular liquid of live specimens.

A areas ● : bivalves may not display more than 230 most probable number (MPN) *E. coli* per 100 g of flesh and intra-valvular liquid; no post-harvest treatment required.

B areas ● : 90% of bivalves must not exceed 4.600 MPN *E. coli* per 100 g of flesh and intra-valvular liquid, with the remaining 10% not exceeding 46.000 MPN *E. coli* per 100 g of flesh and intra-valvular liquid; must be depurated, relayed or cooked by an approved method.

C areas ● : bivalves must not exceed the limits of a five-tube, three dilution MPN test of 46.000 *E. coli* per 100 g of flesh and intravalvular liquid; must be relayed or cooked by an approved method.

SCIENTIFIC REPORTS

OPEN Potential use of fatty acid profiles of the adductor muscle of cockles (*Cerastoderma edule*) for traceability of collection site

Fernando Ricardo, Tânia Figueiredo, Ana S. Moreira, Felisa Rey, Manuel A. Coimbra, M. Rosário Domingues, Tânia Domingues, Miguel Costa Leal & Ricardo Calado

Geographic traceability of seafood is key to controlling its quality and safeguarding consumer interests. The present study assessed the fatty acid profile of the adductor muscle (AM) of fresh cockles (*Cerastoderma edule*) collected in the origin of aquaculture facilities in different bivalve aquaculture systems located within a coastal region. Results suggest that this biochemical approach holds the potential to trace sampling locations with a spatial resolution of 1 km<sup>2</sup>, even for areas with identical climatic and marine conditions. Cockles further away from the AM, i.e. in areas exposed to a higher wave intensity, exhibited lower levels of unsaturated fatty acids, which may be related to the higher structure of cell membranes, and a higher presence of polyunsaturated fatty acids, which enhance bivalve quality. Results suggest that the use of the fatty acid profile of the AM provides a reliable and applicable tool that is potential for tracing the origin of bivalves to their aquaculture areas.

SCIENTIFIC REPORTS

OPEN Spatio-temporal variability of trace elements fingerprints in cockle (*Cerastoderma edule*) shells and its relevance for tracing geographic origin

Fernando Ricardo, Tânia Figueiredo, Lucrecia Gómez & Ricardo Calado

Understanding spatio-temporal variability of trace elements (REs) in bivalve shells is fundamental to determine the discrimination power of this analytical approach and assess traceability along coastal regions. Spatial and temporal variability of REs in shells of cockles (*Cerastoderma edule*) was assessed in a coastal region of Galicia (NW Spain). REs (As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Se, Sr, Zn) were analyzed from the shells of cockles from eight different aquaculture systems (AS) and from the wild. REs were analyzed from the shells of cockles from eight different aquaculture systems (AS) and from the wild.

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SCIENTIFIC REPORTS

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

Rosario Mamede, Fernando Ricardo, María Helena Abreu, Kharlo Perreira da Silva, Gilda Patrício, Ricardo Calado

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SCIENTIFIC REPORTS

OPEN Successful Use of Geochemical Tools to Trace the Geographic Origin of Long-Snouted Seahorse *Hippocampus guttulatus* Raised in Captivity

Ana Elisa Galvão, Fernando Ricardo, Gilda Patrício, Edvaldo Pereira da Silva, Miguel Costa Leal, João Paulo, Miguel Pinais, and Ricardo Calado

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SCIENTIFIC REPORTS

OPEN Assessing the Use of Surrogate Species for a More Cost-Effective Traceability of Geographic Origin Using Elemental Fingerprints of Bivalve Shells

Rosario Mamede, Fernando Ricardo, Diana Gonçalves, Kharlo Perreira da Silva, Gilda Patrício, Ricardo Calado

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SCIENTIFIC REPORTS

OPEN Bacterial communities 16S rDNA fingerprinting as a potential tracing tool for cultured seabass *Dicentrarchus labrax*

Tânia Pimentel, Inês Mamede, Fernando Ricardo, Alexandre M. S. Soares & Ricardo Calado

Bacterial communities 16S rDNA fingerprinting as a potential tracing tool for cultured seabass *Dicentrarchus labrax*. The study was conducted in a coastal region of Galicia (NW Spain). REs (As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Se, Sr, Zn) were analyzed from the shells of cockles from eight different aquaculture systems (AS) and from the wild. REs were analyzed from the shells of cockles from eight different aquaculture systems (AS) and from the wild.

SCIENTIFIC REPORTS

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OPEN Trace element fingerprinting of cockle (*Cerastoderma edule*) shells can reveal harvesting location in adjacent areas

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SCIENTIFIC REPORTS

OPEN Seafood traceability: current needs, available tools, and biotechnological challenges for origin certification

Miguel Costa Leal, Tânia Pimentel, Fernando Ricardo, Rui Rosa, and Ricardo Calado

Seafood traceability: current needs, available tools, and biotechnological challenges for origin certification. The study was conducted in a coastal region of Galicia (NW Spain). REs (As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Se, Sr, Zn) were analyzed from the shells of cockles from eight different aquaculture systems (AS) and from the wild. REs were analyzed from the shells of cockles from eight different aquaculture systems (AS) and from the wild.

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SCIENTIFIC REPORTS

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

Felisa Rey, Tânia Pimentel, Ana S. Moreira, Ana S. Moreira, Diana Raposo, Rui Rosa, and Ricardo Calado

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SCIENTIFIC REPORTS

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# We have already screened several different types of seafood, with emphasis on multiple bivalve species.







We have been collaborating on a regular basis with authorities...



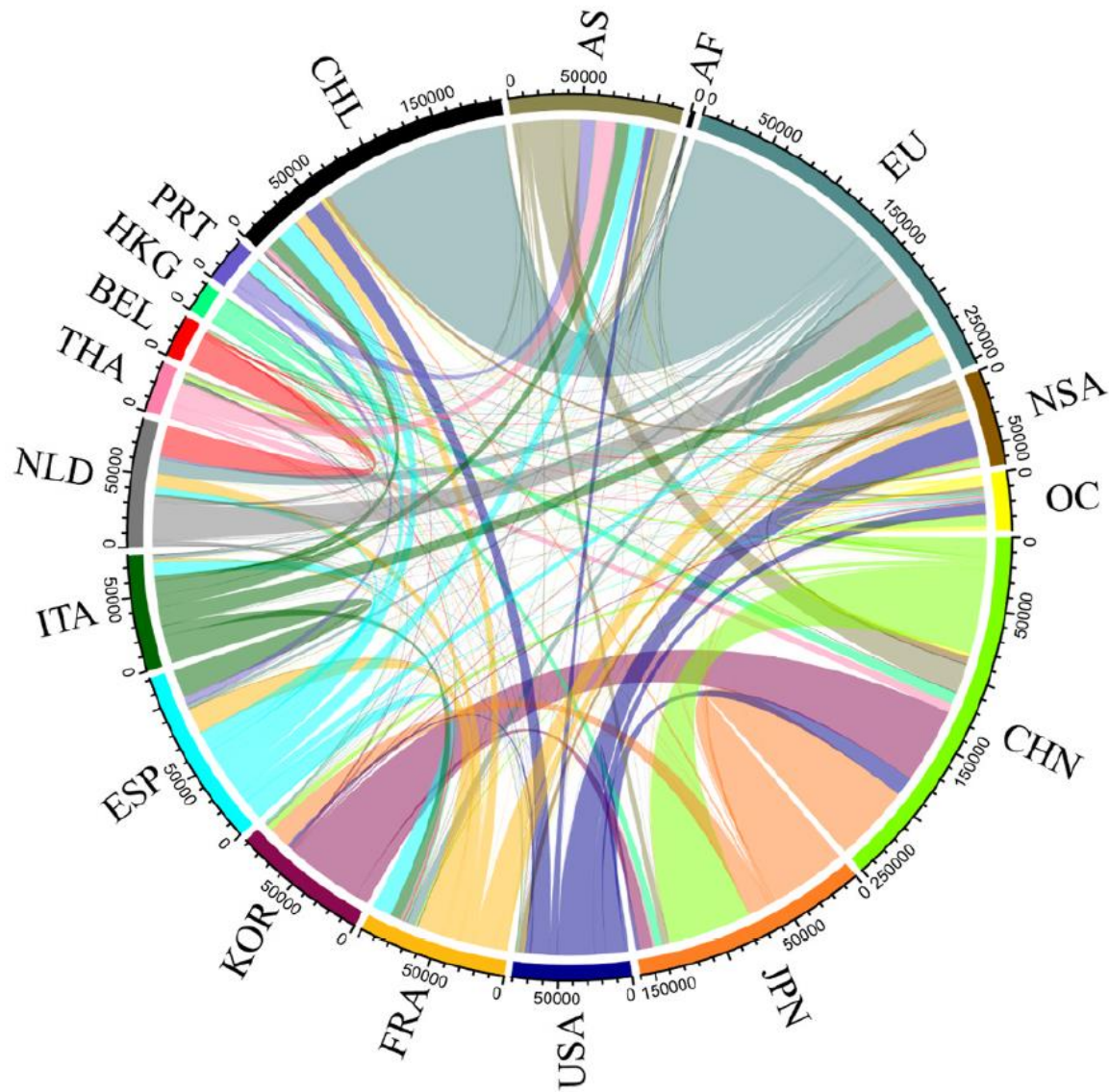
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**RASTREMAR**

**TraSeafood**

# The new National Laboratory for Traceability of Fisheries and Aquaculture Products



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Food Control

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Current trends in the traceability of geographic origin and detection of species-mislabeling in marine bivalves

Andrea Santos<sup>a,\*</sup>, Fernando Ricardo<sup>a</sup>, M. Rosário M. Domingues<sup>b,c</sup>, Carla Patinha<sup>d</sup>, Ricardo Calado<sup>a,\*</sup>





**Sou a ria de Aveiro, o sal do mundo!**  
*I am Ria de Aveiro, the salt of the world!*



ecomare

universidade de aveiro  
research centre for innovation and sustainability  
of the economy of the sea



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de aveiro





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laboratório para a inovação e sustentabilidade  
dos recursos marinhos



Grey-Green-Blue Infrastructure



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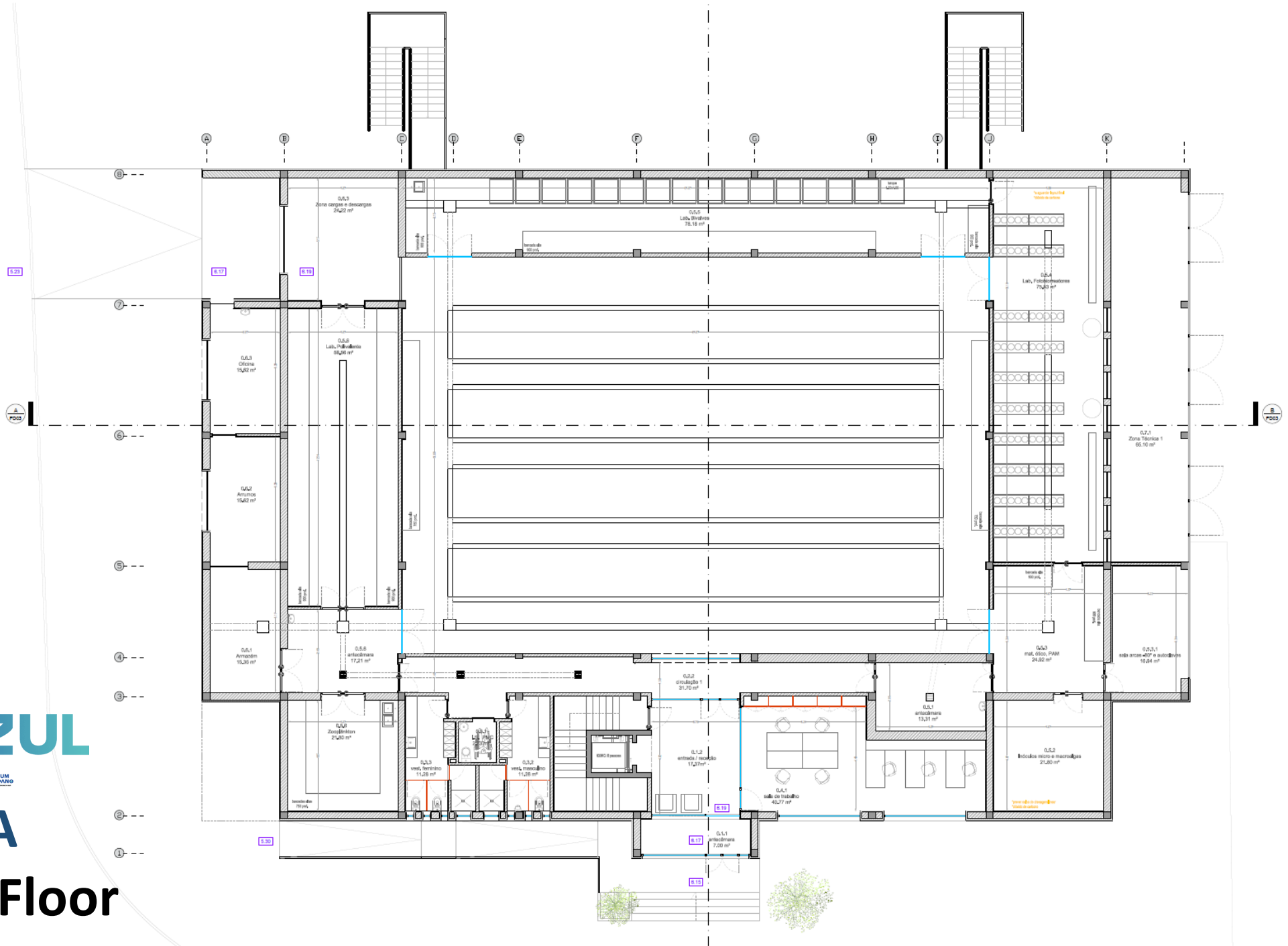
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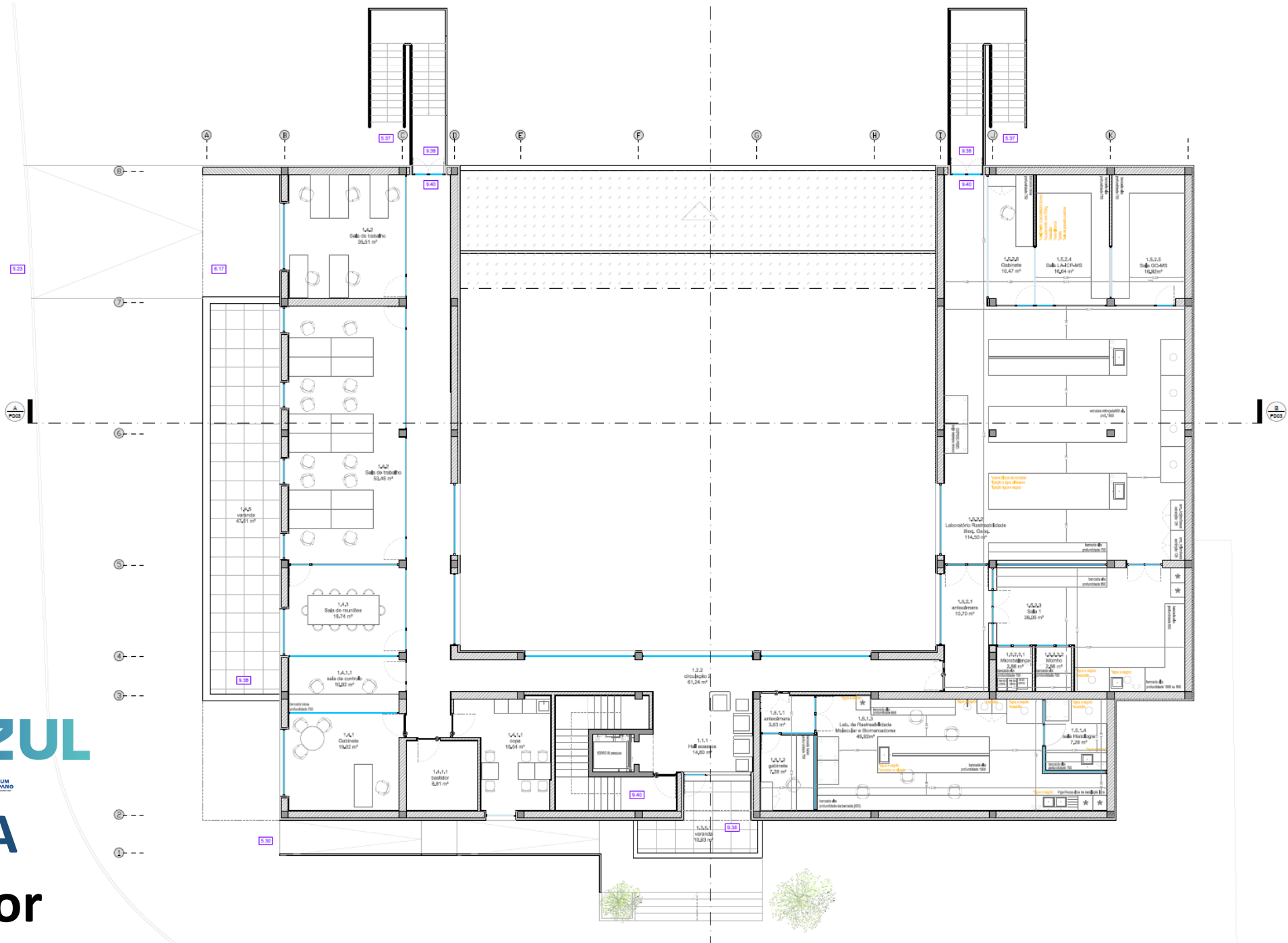
**CITAQUA**

**Ground Floor**



**HUBAZUL**  
PORTUGAL Ignited by FORUM  
OCIOVIVO

**CITAQUA**  
First Floor







**Portugal pioneered the creation of origin certification as early as the 18<sup>th</sup> century with Port Wine (*Vinho do Porto*).**



**One can use the same rationale and certify the geographic origin of bivalves.**

**This can add value to bivalves and enhance food safety!**





**We look forward for new challenges and collaborations!**

**We ambition to create an [open global database](#) of elemental and biochemical fingerprints.**

**Know your seafood!**

**It matters!**



**Thank you for your attention!**  
**Obrigado pela vossa atenção!**



**HUBAZUL**

**PORTUGAL**

Ignited by



**CESAM**

CENTRO DE ESTUDOS  
DO AMBIENTE E  
DO MAR



universidade  
de aveiro



**PRR**  
Plano de Recuperação  
e Resiliência



**REPÚBLICA  
PORTUGUESA**



Financiado pela  
União Europeia  
NextGenerationEU



**fundoazul**