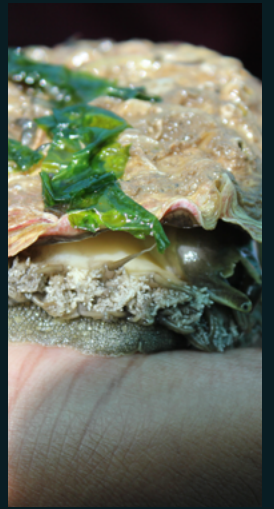
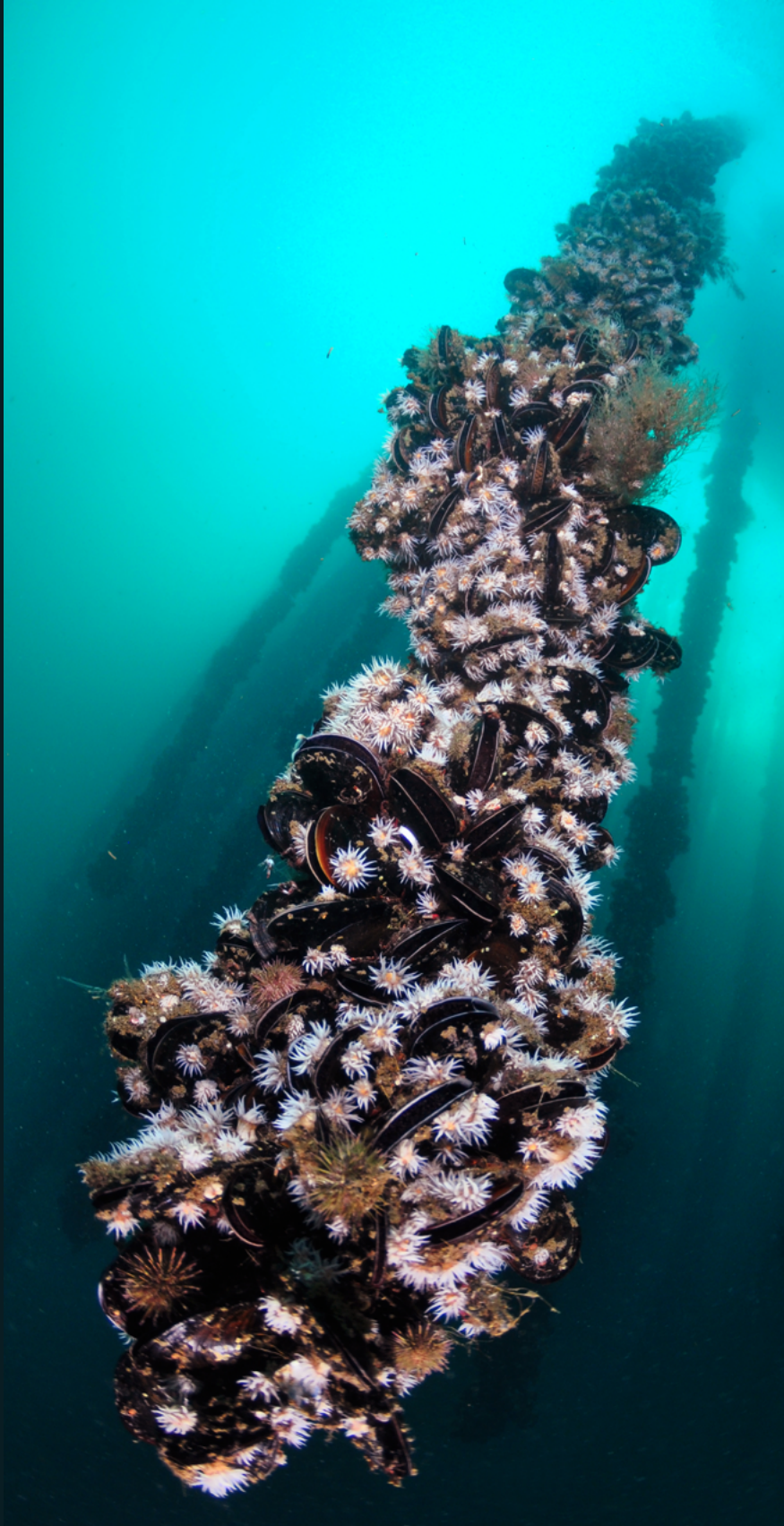


# AquaVitae

Unlocking the potential of sustainable aquaculture

## THE LEGACY



This booklet was made under the framework of the AquaVitae project.



The AquaVitae project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 818173.

The AquaVitae Legacy booklet reflects only the Consortium ´s view and that the European Commission is not responsible for any use that may be made of the information it contains.

The 35 partners of the project have contributed to the content.

Special thanks to Philip James, Céline Boechat, Marte Olsen, Rosa Chapela, Yolanda Irawan, Sofia Franco and Colin Hannon.

Cover pictures credits:

- Batea or mussel raft in Galicia. Picture by David Villegas.
- Oysters. Picture by Åsa Strand.
- Abalone. Picture by Pietro di Modica.
- Sea cucumber. Picture by Adobe Stock.
- Sea urchins. Picture by Lars Åke Andersen.

Designed by  
Guillotina Estudio, Spain.

Printed in November 2023 in  
GARPE, Vigo, Spain.



AquaVitae's coordinator, Phil James, holding the brown kelp *Saccharina latissima*. Picture by Emil Bremnes.

### Coordinator ´s letter

The world is facing unprecedented challenges in terms of climate change and achieving food supply and security. In the AquaVitae project, our aim was to increase the sustainable production of food and products from low trophic aquaculture systems and value chains, in order to achieve long lasting benefits for both people and the planet. Over the course of four and half years the project partners and a combined AquaVitae stakeholder group have had a significant impact across the Atlantic. The achievements and outputs from the AquaVitae project are many and varied. These include the creation and increased production of a wide range of products and production processes from both new and existing aquaculture species. In addition, outputs from the five value chains addressed in AquaVitae have had a meaningful and measurable impact.

The long-lasting international cooperation and research advances have contributed to the All-Atlantic Ocean Community and its ability to unlock sustainable food production now and into the future. The links and synergies created within the project will continue long after AquaVitae has been completed and is a major outcome from the project. The project outputs also include the benefits delivered to producers, supply chains, and retailers as well as the development of early

career professionals that will form a new generation of experts working in the field of sustainable aquaculture. The project also addressed new and growing markets, policy makers and societal citizens. This document highlights these advances, successes, and outputs.

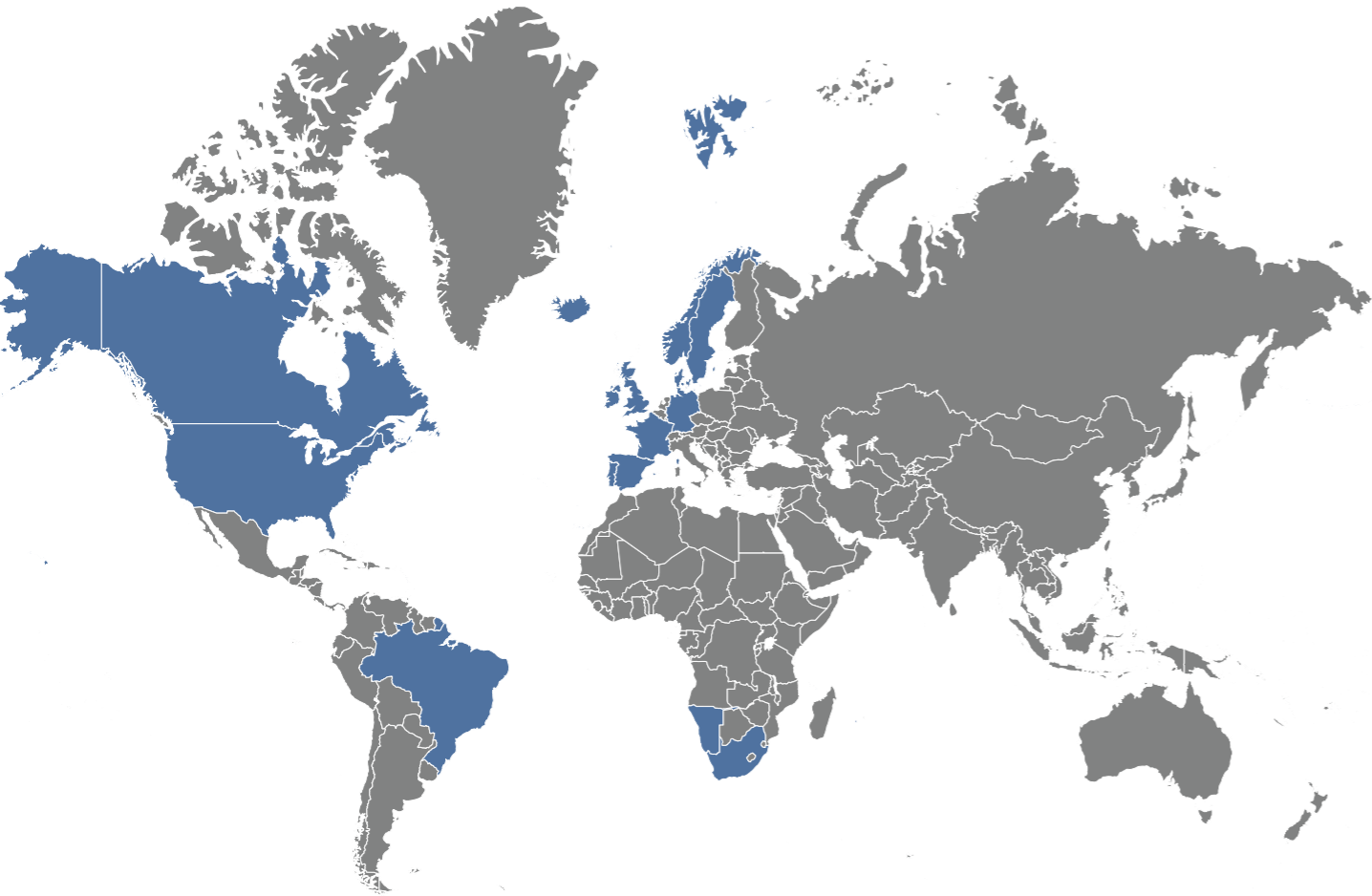
So, we hope you enjoy reading this legacy document and support us in our quest to unlock the sustainable production of low trophic aquaculture across the Atlantic now and into the future.

On a personal note, I would like to thank all the partners from around the Atlantic who have worked so tirelessly, as well as all the AquaVitae stakeholders who have engaged so readily to implement the outcomes of the project. A special mention should go to our colleagues outside the EU, in Brazil, South Africa, Namibia and North America, who have joined us with a tremendous amount of enthusiasm, expertise and goodwill. Together, we have made an outstanding contribution to the development of low trophic aquaculture across the Atlantic.

Phil James

AquaVitae Project Coordinator

# INDEX



## CONSUMERS

Eat food that also restores the ocean	6
Discover new food from the ocean	8
Inspiring new recipes	10
Cooking event in Brest: tasting the low trophic world	12
Integrated Multitrophic	
Aquaculture (IMTA) and circularity	14
Seaweed	17

## BUSINESS

Consumer attitudes towards low trophic species	18
Business economic analysis – Investors, industry perspectives and opportunities	19
Spiny business	21
Business case: sea urchin roe enhancement	22
What is the impact of low trophic aquaculture?	25
Technology to overcome industry challenges	26
All in the shell	28
Fresh fish from the Amazon	32
A tool to reduce in-breeding and increase profitability in tambaqui production in Brazil	32
Circular feeds	33

## POLICY MAKERS & SOCIETY

LTA and Agenda 2030	34
Which governance challenges are holding back - LTA in the Atlantic region?	35
Policy recommendations	36
All-Atlantic cooperation	38

## FIND OUT MORE ABOUT AQUAVITAE AND LTA

Educational resources	40
Having fun with low trophic aquaculture	41

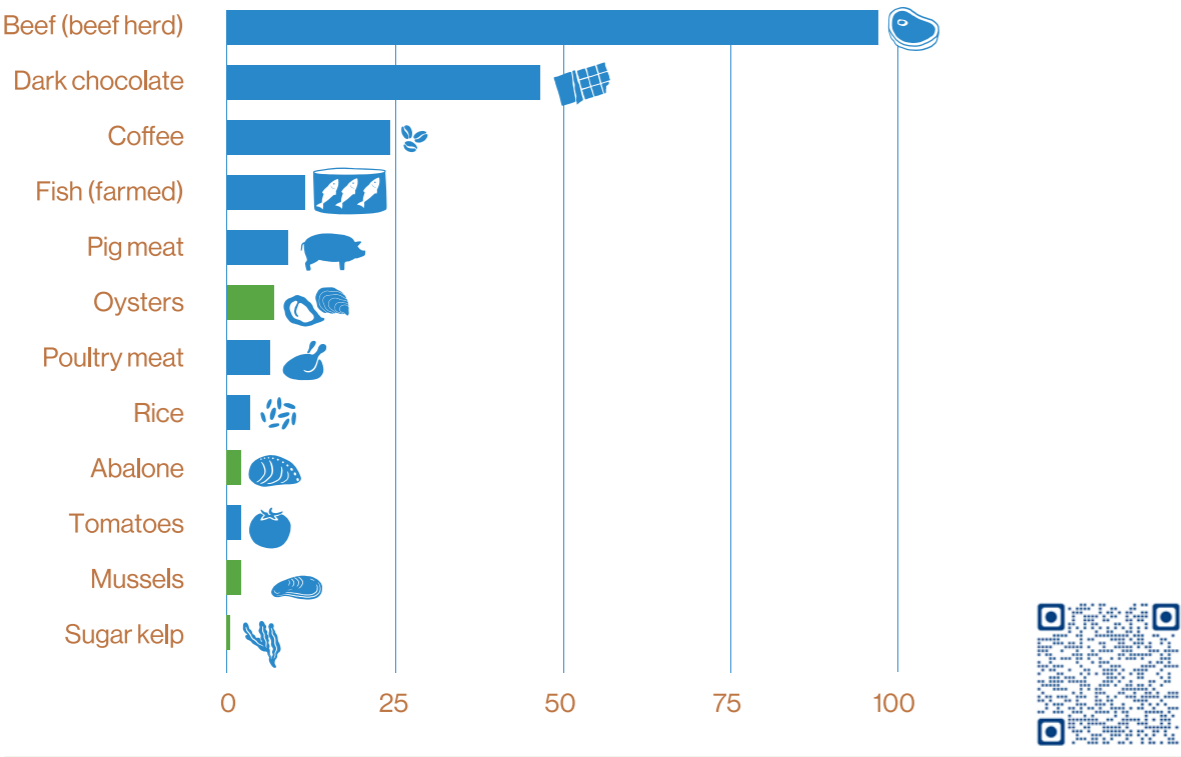
# CONSUMERS

## Eat food that also restores the ocean

By 2050, it is estimated that the Earth will be home to 10 billion people. Feeding the world is already a challenge today, and this raises an important question: How can we sustainably supply food to the increasing population now and in the years to come? One alternative is to expand the aquaculture production of familiar and novel food, particularly the production of low trophic species (LTS). Eating LTS can help reduce the carbon footprint of food production and preserve ecosystems. This means that whilst feeding the population, we are also making a positive contribution to the fight against climate change and biodiversity loss, ultimately contributing to improved ocean health.

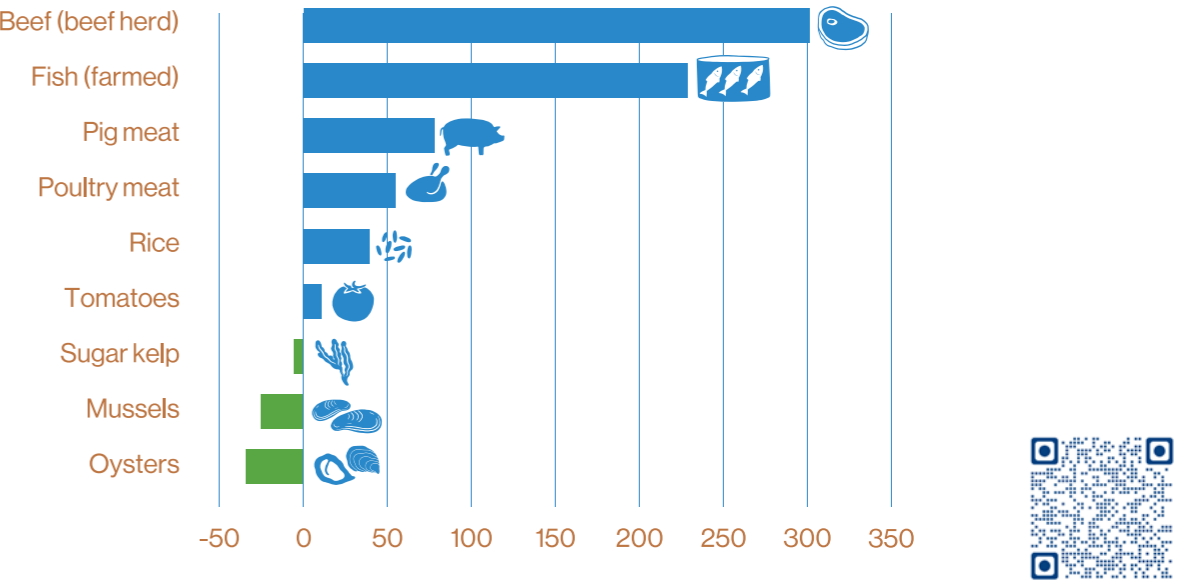
Low trophic species (LTS) have a low environmental impact and can even provide environmental benefits. Low trophic species include seaweeds, filter feeding shellfish such as mussels and oysters, grazers such as sea urchins and sea cucumbers, as well as some species of freshwater finfish. These species can be farmed in the sea or on land in tanks or ponds.

The AquaVitae project has compared the climate impact of LTS to other food products. We have found that low trophic aquaculture (LTA) can provide food with a smaller carbon footprint than other land based meat production systems. In fact, mussels, sugar kelp and abalone have a much smaller carbon footprint than most of the other food products investigated, while mussels have a smaller carbon footprint than all other meat products (see figure below).



The cradle-to-farm carbon footprint (t CO<sub>2</sub>/t food) of the production of LTS compared to other food types. Adapted from D6.2 Quantification of ecosystem services [scan the QR code to access Deliverables].

Low trophic species utilise nutrients and organic matter found in the water to grow, meaning that LTS extract nutrients instead of releasing them. Low trophic species can therefore compensate for the nutrient emissions of other food systems. For example, the production of one kilogram of sugar kelp seaweed can mitigate the emissions generated during the production of one kilogram of some vegetables and fruits, while the production of mussels and oysters is even more efficient.



Eutrophication index (PO<sub>4</sub>-eq/kg edible food fresh weight) of LTS compared to other food types. Adapted from D6.2 Quantification of ecosystem services [scan the QR code to access Deliverables].

Eating LTS and substituting foods with a higher carbon footprint means that you, as a consumer, can reduce your contribution to climate change by choosing a more environmentally friendly alternatives.



Oysters with lemon. Picture by Y. Irawan.

# Discover new food from the ocean

The AquaVitae project has identified tasty low trophic species (LTS) as promising candidates to supply nutritious and protein-rich sources as future sustainable food options. To ensure the quality of LTS as food ingredients, we have evaluated the food safety and nutritional aspects of their potential products (see figure below). This work was based on the human health risk-benefit assessment developed by the UN's Food and Agriculture Organisation.

## Which nutritional benefits do we get from low trophic species?



**SEAWEED**  
Vitamin B12, omega-3 and -6, selenium, proteins, and dietary fiber.



**ABALONE**  
High protein nutritional value, significant levels of macro- and micro-minerals.



**ROE FROM SEA URCHINS**  
Nutritious and rich in omega-3 and -6, minerals and vitamins.



**OYSTERS & MUSSELS**  
Low in fat but high in protein and provide adequate amounts of omega-3 as well as trace minerals and vitamins.



**WHITE FINFISH TAMBAQUI AND PIRARUCU**  
Excellent nutritional values, with space for nutrient improvement in farmed fish compared to wild fish.



Table adapted from D5.1. Report on health risk-benefit assessment of aquaculture products of the selected case studies [scan the QR code to access Deliverables].



Abalone with sake & kombu by chef Xavier Pensec. Picture by Philippe Emanuelli & Thierry Valentin.

# Inspiring new recipes



**Sea lettuce pesto using dried sea lettuce flakes by *France Haliotis***

### Ingredients

- 60 grams fresh basil
- 20 grams dried sea lettuce flakes
- 100 grams fresh cheese (Brousse or Faisselle)
- 100 grams toasted pine nuts
- 100 grams grated parmesan cheese
- 4 tablespoons olive oil
- 2 cloves of garlic
- Salt

### Instructions

1. Mix the dried sea lettuce flakes with the fresh cheese in a bowl. Leave to stand for an hour in the fridge.
2. Chop the basil and garlic cloves after peeling and removing the stalks.
3. Blend the sea lettuce and fresh cheese mixture, basil, toasted pine nuts, Parmesan, garlic and salt. Start blending.
4. When the ingredients begin to grind well, gently pour in the olive oil.
5. Blend until you obtain a purée.

More recipes by France Haliotis on [www.francehaliotis.com/recipes](http://www.francehaliotis.com/recipes)



**Mussels in vinaigrette by *CETMAR***

### Ingredients

- 12 mussels
- 1 bay leaf
- ½ red pepper
- ½ Italian green pepper
- ½ spring onion or onion
- Salt
- 2 tablespoons vinegar
- 4 tablespoons olive oil

### Instructions

1. Clean the mussels.
2. Pour water that covers the bottom of a low casserole dish.
3. Put the bay leaf into the water.
4. Bring to a boil and steam mussels for 5-10 min.
5. After steaming, take the mussel meat out of its shell and wait for the meat to cool.
6. Make the vinaigrette. Finely chop the peppers and spring onions. Mix everything together in a bowl and season to taste with a little salt, vinegar and extra virgin olive oil.
7. Cover the mussels with the vegetable vinaigrette and serve immediately or refrigerate for a while. You can add a chopped boiled egg.

More info and recipes by CETMAR on [www.bit.ly/recipescetmar](http://www.bit.ly/recipescetmar)



**Shucked oysters with pickled blackberries and buttermilk by chef Sarah Browne, *Oysome***

### Ingredients

- 200 grams washed blackberries
- 90 grams apple cider vinegar
- 60 grams water
- 30 grams sugar
- 100 ml buttermilk
- 2 tablespoons honey

### Instructions

1. One day in advance: Heat the vinegar, water and sugar in a pot until boiling. Pour this over your washed blackberries and allow to infuse. When cool, transfer to a sterilized jar and seal until ready to use. The flavour will be nice and strong after about 2 weeks, but the infused vinegar can be used after a day.
2. Stir the honey and buttermilk together in a small bowl.
3. Shuck the oysters. Top with a teaspoon of the buttermilk and a few drops of the blackberry vinegar. Serve immediately.

More recipes by Oysome on [www.oysome.com/recipes](http://www.oysome.com/recipes)



**Scrambled eggs with sea urchins by *Portomuiños***

### Ingredients

- 5 eggs
- 3 tablespoons of cream
- 100g of sea urchin roe (fresh or canned: 1 tin of Porto-Muiños)
- Salt
- Pepper

### Instructions

1. Beat 5 eggs.
2. Mix in 3 tablespoons of cream and the sea urchin roe.
3. Beat again and season with salt and pepper.
4. Heat a drizzle of olive oil in a frying pan and add the mixture. Stir until the egg sets.
5. Serve hot with toasted bread.

More recipes by Portomuiños on [auladecocinaportomuiños-recetas.blogspot.com](http://auladecocinaportomuiños-recetas.blogspot.com)

# Cooking event in Brest: tasting the low trophic world

AquaVitae hosted the *Masterclass: Cooking & tasting the low trophic world* in October 2022 at France Haliotis farm in Plouguerneau, a village in the North of Brest, France.

The event brought together various partners from the AquaVitae and InEVal projects, chefs and restaurant owners involved in the environmental organisation Ethic Ocean, members of the Équipage de la Mer and students from the IFAC of Brest Catering School.

During the workshop, chefs presented flavourful recipes using low trophic species (LTS) from the Atlantic area, such seaweeds, sea urchins, oysters, mussels, sea cucumbers and abalones. The participants had the opportunity to taste several dishes made with these species.

*“Last year I didn’t know the meaning of low trophic aquaculture. As one of BIM’s Young Chef Ambassadors I was invited to attend the workshop. The impact of the knowledge shared there is immeasurable. I have started my own business focused on celebrating Irish oysters – the ultimate aim of which is to educate and support consumers in the adoption of LTS into their diets”,* says chef Sarah Browne, Oysome Founder.



Seaweed decoration for the workshop. Picture by Björn Suckow.



Oyster plate with floral vinaigrette by chef Manon Fouchard. Picture by Y. Irawan.

Additionally, the attendees could also taste sea urchins coming from Norway. *“They are sweeter than the ones in the Mediterranean sea”,* ensures the French chef Léa Combelonge. Indeed, the flavor varies depending on the waters they grow in. Algae dishes were also a success, as were the different recipes created with abalone, a species that was a nice surprise for everybody.

*“Attending the workshop empowered me with the information and knowledge I needed in order to be able to speak confidently on the subject to others. I feel very strongly that these farming methods should be a key strategy in our future food systems as they not only offer a sustainable protein solution but also offer future sustainability in terms of protecting our rural communities”,* says chef Sarah Browne.

The chefs at the event regularly use some LTS in their menus, and state that they love the flavour of the species and their versatility in the kitchen. The event highlighted the environmental benefits of using LTS: the production of food from lower trophic levels uses less energy, has a lower carbon footprint and makes delicious food.



Abalone in brittany seaweed soup by Sylvain Huchette, France Haliotis CEO. Picture by Y. Irawan.

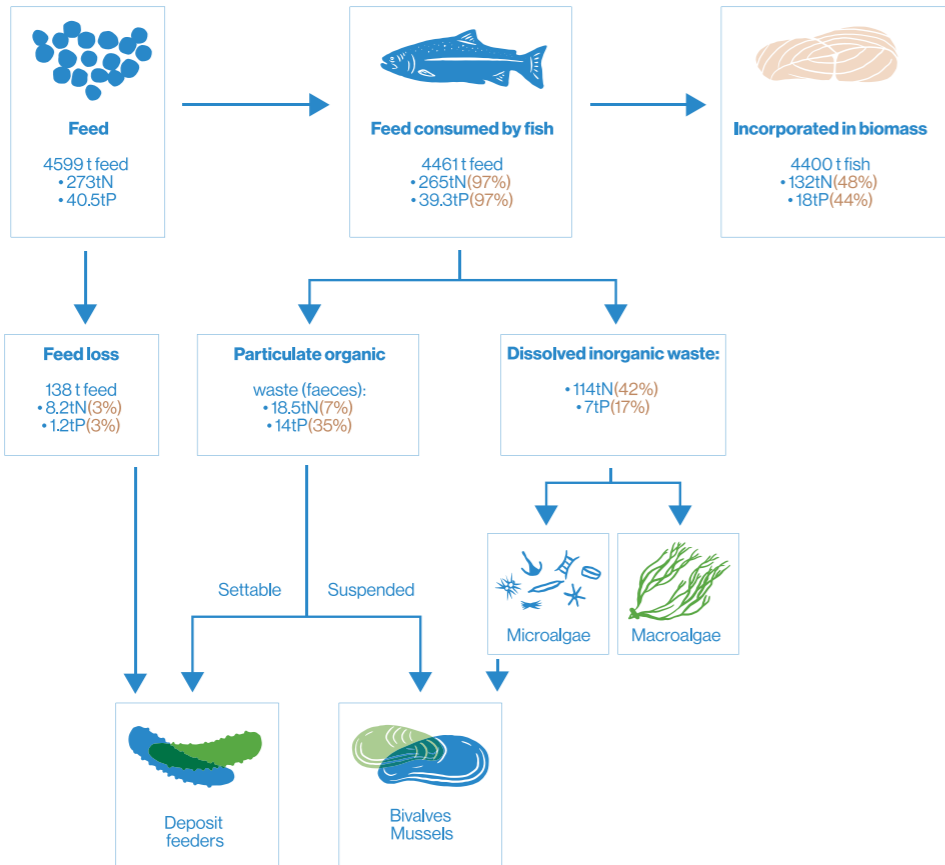
# Integrated Multitrophic Aquaculture (IMTA) and circularity

## Sea based IMTA

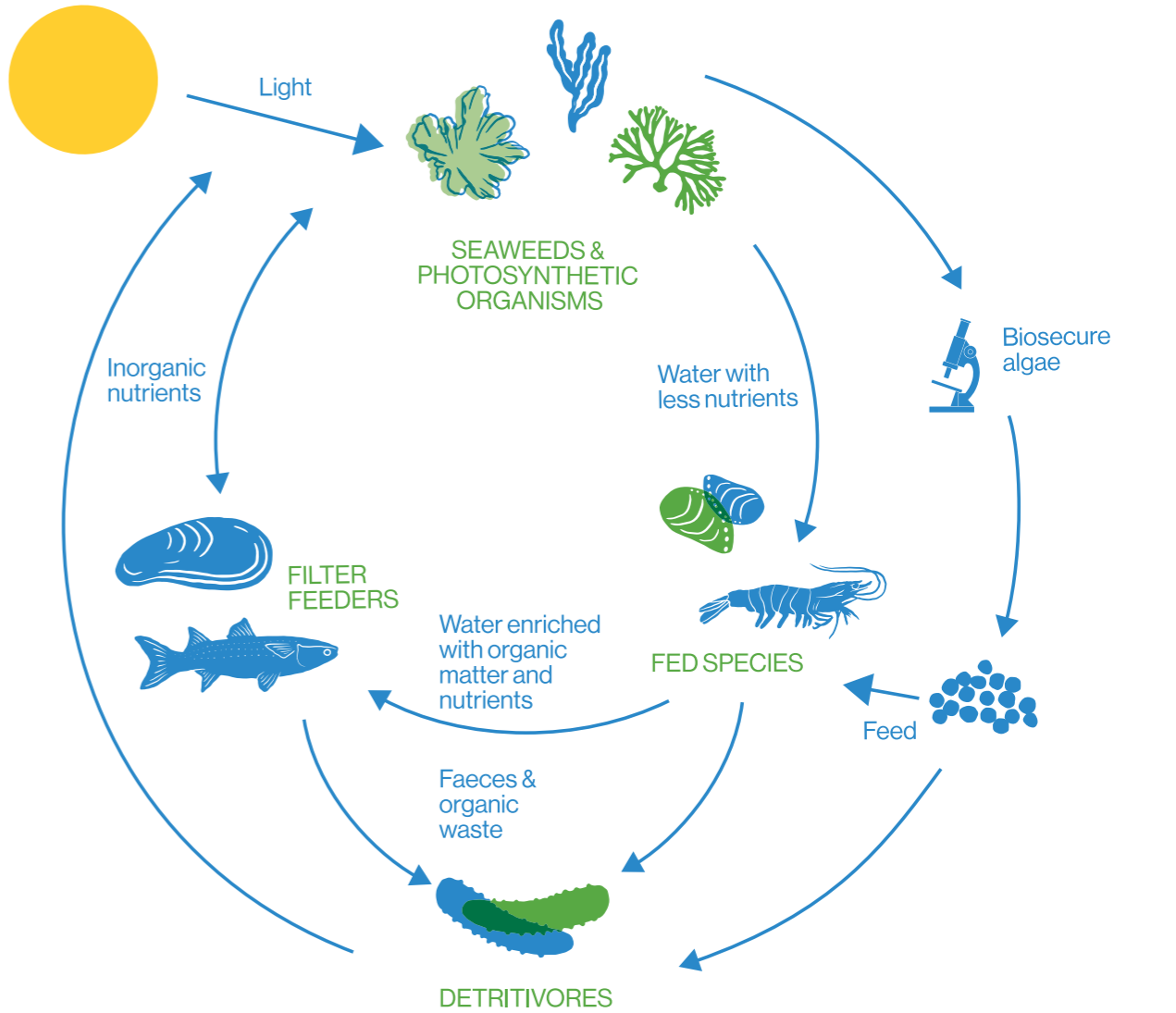
Integrated multi-trophic aquaculture (IMTA) is a sustainable approach to aquaculture in which species from different trophic levels are cultured together. This creates a circular system that can be more cost- efficient and reduce the environmental impact compared to the culture of each species alone. The concept can be applied to different species produced around the globe and adapted and designed according to their requirements. When implemented in the ocean, these are called sea based IMTA systems. The AquaVitae project focused on developing sea based IMTA systems for new species.

### IMPORTANT OUTCOMES INCLUDE:

1. A newly developed process to produce the seaweed Gracilaria spp. together with mussels.
2. Developed bio-secure IMTA-produced seaweed, safe for inclusion in aquafeeds.
3. Modelling the ecosystem services within a fjord system for the aquaculture of salmon, blue mussel and seaweed.
4. Long-line production of seaweed species sugar kelp, dulse, and wakame with abalone. The seaweed is then used to feed abalone and has potential as a human food resource.



IMTA diagram with percentages of feed that end up in the different compartments. Adapted from: Á Norðl, G., Lund, I., Andreassen, B., Taylor, D., Johannesen, T. T., Jacobsen, B., & Hughes, A. D. (2023). Modeling particulate waste assimilation by blue mussels within the spatial constraints of a commercial fish farm: implications for multitrophic aquaculture. Front. Mar. Sci. 10:1236294. Doi: 10.3389/fmars.2023.1236294



IMTA systems approach within the AquaVitae project. During the research different species of seaweeds, mussel and mullet were used as filter feeders; sea cucumber as a detritivore species; and abalone and shrimp were used as fed species.

## Land based and biofloc IMTA

Integrated multi-trophic aquaculture can also be conducted on land, in what is called land based IMTA. The AquaVitae project introduced new species to both land based IMTA and the inclusion of novel biofloc technology.

### IMPORTANT OUTCOMES INCLUDE:

1. Optimisation of hatchery and nursery processes applicable to different geographical areas.
2. IMTA concepts are applicable from nursery stages in abalone production, allowing integrated production of multiple species from early stages.
3. Successful integration of IMTA produced seaweed in novel bio-secure feed, which offers good growth performance.
4. Successful integration of sea cucumber to integrated production of abalone and seaweeds, demonstrating their bioremediation potential and provision of additional produce in IMTA systems.
5. IMTA concepts increased the efficiency of shrimp production in biofloc systems.
6. Biofloc systems can produce high quality seafood with low environmental impact.
7. Native estuarine seaweed can be integrated with shrimp and oyster production in a land based IMTA system.
8. Food products from different IMTA production systems are of high quality and are acceptable to consumers.



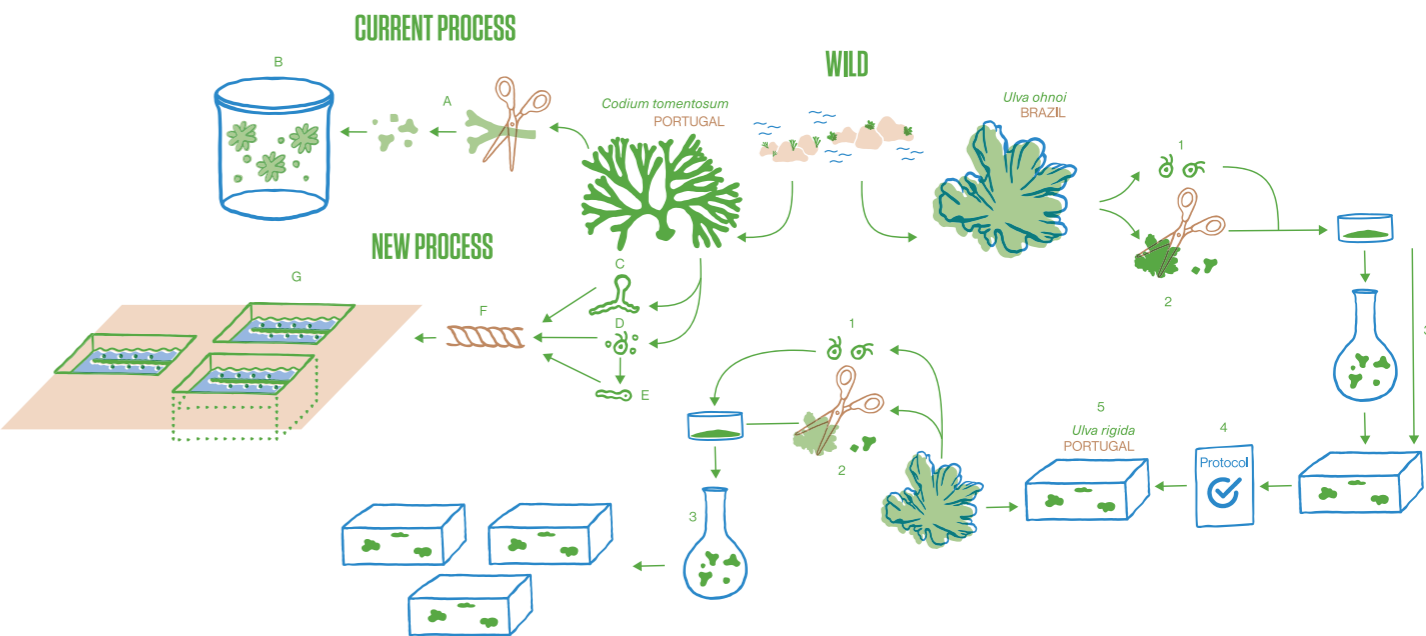
Seaweed *Ulva rigida* . Picture by Ecoaqua Spain.

# Seaweed

Seaweed is an underutilised marine resource in many countries. The AquaVitae project developed hatchery and cultivation protocols for the upscaling of new and novel species of seaweed. The feasibility of large-scale offshore seaweed production in the Faroe Islands was demonstrated and the value of seaweed as a food and feed ingredient was also assessed.

## IMPORTANT OUTCOMES INCLUDE:

1. New propagation methods were developed for local seaweed species in Portugal and Brazil.
2. Upscaled production capacity of seaweed to 500 tonnes wet weight in the Faroe Islands.
2. Utilisation of used equipment can reduce the capital costs by 41% and the carbon footprint by 46%.
3. Implementing mechanised seeding and harvesting equipment to minimise manual work in offshore seaweed production.
4. Models for identifying areas for cultivating seaweed in the Gulf of Maine and in the Faroe Islands were developed.
5. A novel feed formulation for abalone with powdered seaweed was manufactured and tested under IMTA conditions in Spain.



Development of novel propagation and cultivation methods for new species of seaweed.

- A - Fragmentation - asexual reproduction.
- B - Tumble culture (plastic tanks).
- C - Utricles - Micropropagation (asexual reproduction).
- D - Gametes
- E - Germlings
- F - Seeding in culture lines.
- G - Grow out in lines (earthen ponds).

- 1 - Gametes - sexual reproduction.
- 2 - Fragmentation - asexual reproduction.
- 3 - Up scale in laboratory.
- 4 - Verified protocol.
- 5 - Knowledge transfer to *U.rigida* (Portugal).

# BUSINESS

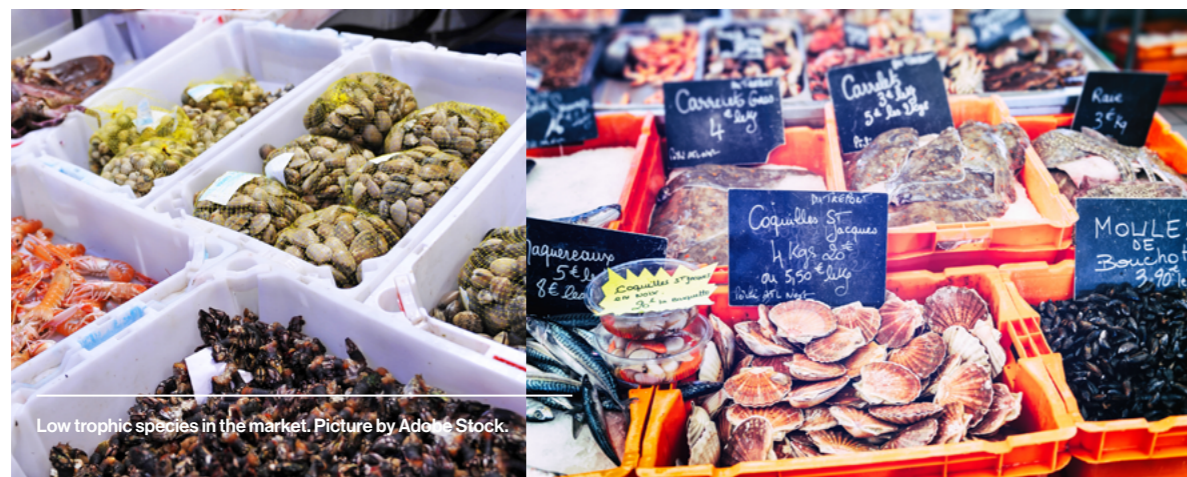
## Consumer attitudes towards low trophic species

Products from low trophic aquaculture (LTA) are healthy and sustainable and can be part of the future of sustainable food systems. However, LTA products are often unknown to consumers, and we need to understand more about what factors motivate consumers to purchase LTA products. The AquaVitae project, as a result, distributed a survey to consumers in Spain, South Africa, Brazil and the USA to investigate consumers' openness toward LTA products and their willingness to pay for them.

Overall, our survey results show that customers in Brazil were open to consume LTA products, while customers in the other countries were more reluctant to engage with LTA products. The consumers were also concerned about the potential environmental impact of the production. To promote LTA products, communication campaigns must be designed specifically for each individual country, and campaigns that highlight the sustainability of marine food production can influence consumers' perceptions of LTA products positively. Communication campaigns should be transparent and balanced and should incorporate information that triggers personal and emotional reactions. This transparency can lead to a greater feeling of trust among consumers.

### Willingness to pay for LTA products

Consumers were also willing to pay up to 50% more for seafood products based on the high nutritional quality of the products and up to 40% more for products that are certified as environmentally friendly. This is because seafood is a very important part of the diet and they want it to be safe, healthy and sustainable. However, as consumers are reluctant to pay more for socially responsible products, communications campaigns should emphasise health benefits instead of social responsibility.

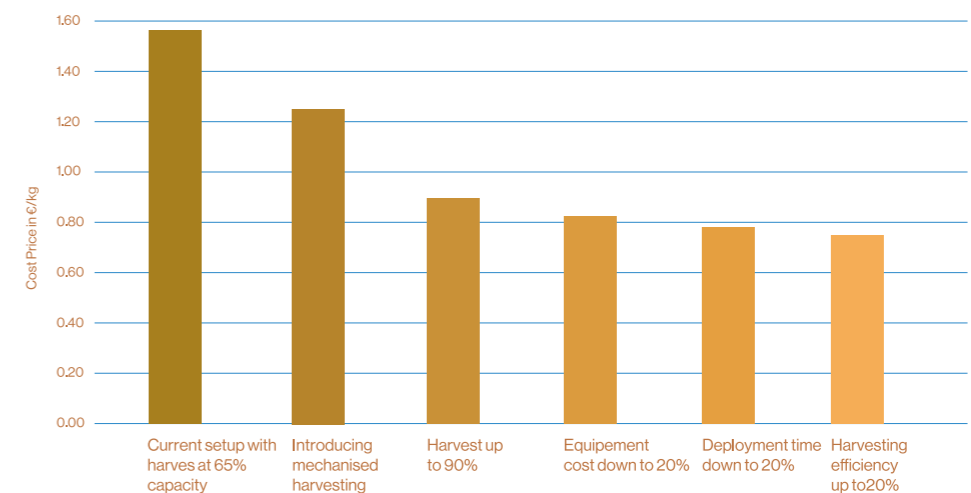


## Business economic analysis – Investors, industry perspectives and opportunities

The improvements in biological performance and innovative technologies advanced by the AquaVitae project have direct implications for the economic profitability of low trophic aquaculture (LTA). AquaVitae has focused on analysing the resulting change in cost structures from innovative practices, and its effect on revenue.

### Reducing the production costs of seaweed cultivation in the Faroe Islands

Production costs can be reduced, and profitability can be increased in seaweed cultivation in the Faroe Islands by optimising the yield in production and by increasing the efficiency through technological advancements. To illustrate how unit prices of seaweed are influenced by efficiency improvements and industrial knowledge, the AquaVitae project has developed 6 different scenarios as we can see in the figure below.



Optimization scenarios for seaweed production with Macroalgal Cultivation Rig – Exposed (MACR-E). Figure adapted from D7.3. Profitability analysis of new LTS in CSs [scan the QR code to access Deliverables].

In this summary, the different scenarios are presented. In the first one, harvest only reaches 65% of capacity due to technical challenges, entanglement, loss of harvest and other potential mishaps. In this case, the cost price will amount to €1.57/kg. However, if mechanised harvesting is implemented (second scenario), the cost price is reduced substantially and even further if shifting harvest is reduced to 90%, which occurs in the third case. There is therefore large potential for reducing costs and increasing profitability in seaweed cultivation considering different factors, such as reducing equipment cost by 20%, decreasing deployment time by 20% or increasing harvesting efficiency by 20% - (scenarios four, five and six, respectively).

# Spiny business

Sea cucumbers are a valuable seafood, which eat detritus matter and contribute to the recycling of organic matter in the sea. They can help restore seabed habitats and are a suitable species for integrated multitrophic aquaculture (IMTA) integration. In the AquaVitae project, three new species of sea cucumbers suitable for farming were identified. These species are the warty sea cucumber in South Africa, the grey sea cucumber in Brazil, and the aureolated sea cucumber in Spain.

Sea urchins are often present in very large numbers in areas known as sea urchin barrens. Barrens are caused by sea urchins grazing on seaweed until there is none left. In the AquaVitae project, we harvested sea urchins from these barrens and enhanced them into a valuable seafood product. This also creates the opportunity to reforest the areas with seaweed once the sea urchin barrens have been removed.

## IMPORTANT OUTCOMES INCLUDE:











1. Opening of three new commercial facilities for sea urchin enhancement in Norway and Spain.
2. Enhanced sea urchin roe introduced into European seafood markets.
3. Successful breeding of sea cucumbers in Brazil.
4. Reduced need for tank cleaning and improved growth of abalone when co-cultured with sea cucumber.


Sea cucumber in the sea bottom. Picture by Adobe Stock.

Sea urchins ready to eat. Picture by Björn Suckow.

# Business case: sea urchin roe enhancement

Sea urchins with low gonad content can be turned into a valuable product through roe enhancement. Wild sea urchins with low gonad content are harvested, held in a holding system and fed to increase the size and quality of the gonad. They are then transported live to market or value-added processing. The business plan below shows how enhancing sea urchin roe content can lead to increased value, and also outlines the socio-ecological costs and benefits.

 KEY PARTNERS	 KEY ACTIVITIES	 VALUE PROPOSITIONS	 CUSTOMER RELATIONSHIPS	 CUSTOMER SEGMENTS
<p>Research:</p> <ul style="list-style-type: none"><li>- Control the enhancement process</li><li>- Urchin health</li><li>- Feed development</li><li>- Document the effect of seabed restoration</li></ul>	<p>Sea urchin value chain:</p> <ul style="list-style-type: none"><li>- Harvesting</li><li>- Enhancement</li><li>- Processing</li><li>- Distribution</li></ul> <p>To process or not is an important decision.</p>	<p>Enhancement of wild-caught sea urchins will provide:</p> <ul style="list-style-type: none"><li>• High quality sea urchins:<ul style="list-style-type: none"><li>- High gonad content</li><li>- Improved taste</li><li>- Stable supply</li></ul></li><li>• Improved ocean health/ocean forest restoration</li><li>• Cleaning the seabed for sea urchins will contribute to help restoration and increased (or regained) biodiversity in coastal areas.</li></ul>	<p>Two main alternatives:</p> <ul style="list-style-type: none"><li>- Alliance with distributors</li><li>- Direct distribution to restaurants</li></ul>	<p>High-end restaurants</p> <p>Quality-conscious consumers</p> <p>Environmentally conscious consumers</p>
	 <b>KEY RESOURCES</b>		 <b>CUSTOMER CHANNELS</b>	
	<p>Access to wild sea urchins</p> <p>Access to specialized feed</p>		<p>Traditional/existing value chains and distribution channels for seafood</p>	
 <b>ECO-SOCIAL COSTS</b> <p>Emissions</p>		 <b>ECO-SOCIAL BENEFITS</b> <p>Seabed: ocean forest restoration</p> <p>Net carbon binding</p> <p>Employment</p>		
 <b>MAIN BOTTLENECKS AND AREAS OF IMPROVEMENT</b> <p>Feed development</p> <p>Methods for catching sea urchins</p> <p>Control of the enhancement process</p> <p>Market development</p> <p>Distribution</p>				



Sea urchin business example. Figure adapted from D7.6 Business plans for CSs of new LTS aquaculture [scan the QR code to access Deliverables].



Basket full of sea urchins. Picture by Lars Åke Andersen.

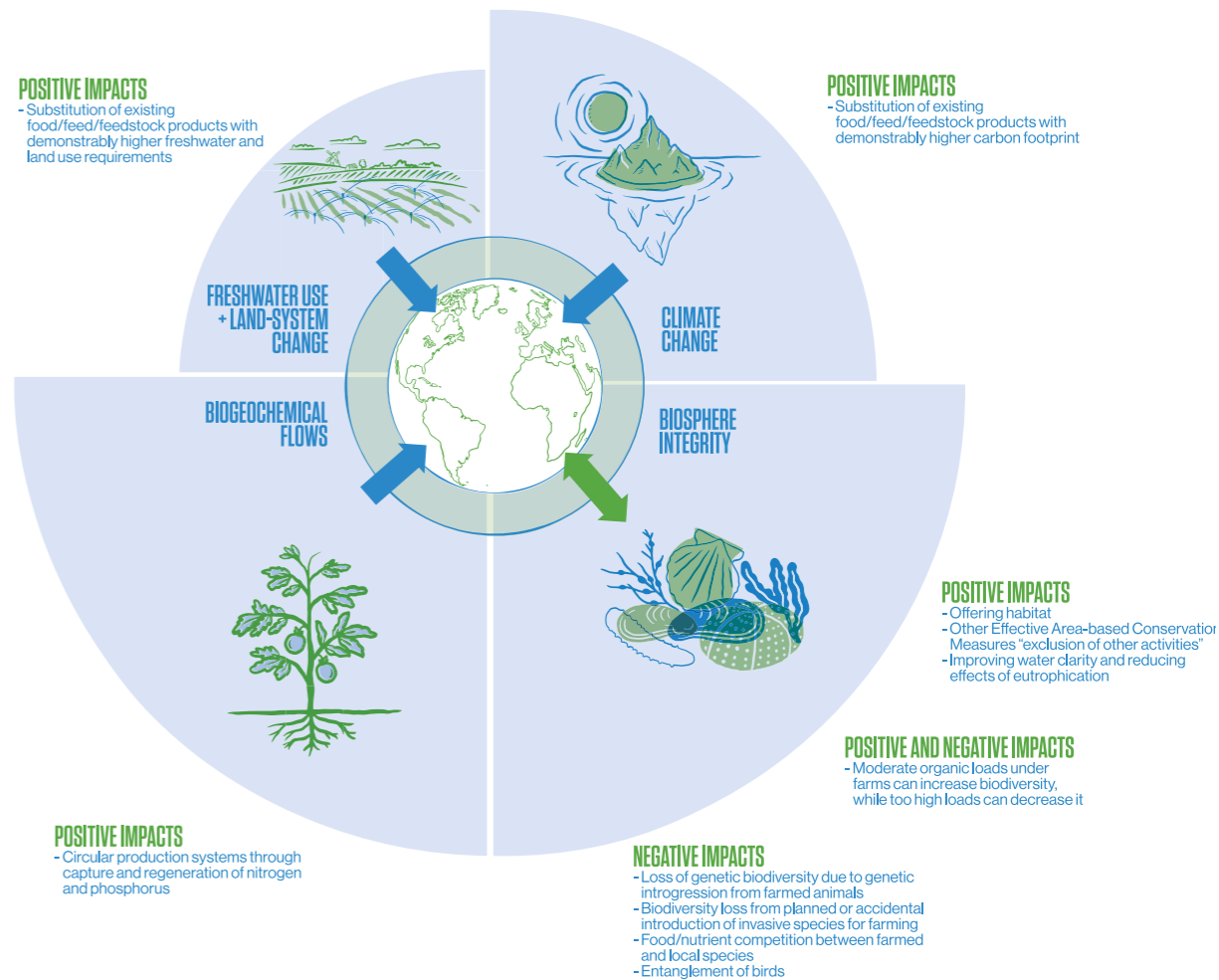


Mussels can increase biodiversity by providing habitat for a range of species, in this case a rock gunnel. Picture by Åsa Strand.

# What is the impact of low trophic aquaculture?

As with all food production systems, low trophic aquaculture (LTA) is highly interconnected to the ecosystem in which it occurs. Its impact on the environment can be either positive or negative, depending on factors such as the farmed species, the scale of the production, and local conditions.

The AquaVitae project has assessed LTA's strengths, weaknesses, opportunities, and threats. This has shown that there are several positive impacts of LTA, but there are also challenges. Proper management of LTA sites as well as site selection is important to mitigate the negative impacts of LTA and optimise its benefits. It is also important to strengthen the risk management within the LTA industry to make commercial enterprises more resilient to future threats. New technology and better use of monitoring data can support these efforts, ensuring a sustainable future for LTA.



LTA can move the global food sector closer towards a safe operating space.

# Technology to overcome industry challenges

## MONITOR YOUR BIOMASS

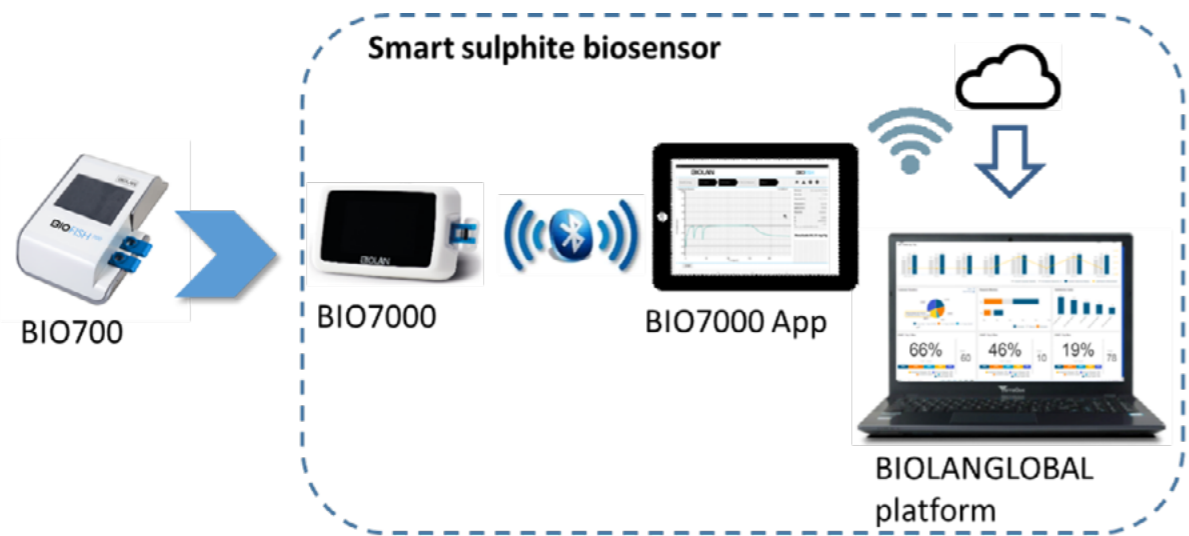
- An innovative camera system that simplifies underwater biomass monitoring in aquaculture, making it affordable and user-friendly.
- The solution integrates with underwater drones and can enable aquaculture businesses to quickly scan and measure their production in 3D.
- The technology which scans along mussel lines can be applied to other existing aquaculture systems.

## KEEP TRACK OF YOUR SULPHITE LEVEL

- AquaVitae has developed a portable, pocket-sized biosensor that uses screen-printed electrodes to quantify sulphite in shrimp culture water.
- It is user-friendly with the sensor capable of measuring sulphite concentrations in shrimp culture water in approximately 1 minute. A pipette is used to inject a sample into the biosensor.
- The sulphite sensor has been tested by stakeholders within the shrimp aquaculture industry.



Novel sensor integration platform on a seaweed rig at Kraknes outside Tromsø. Picture by Lars K. Vognild.

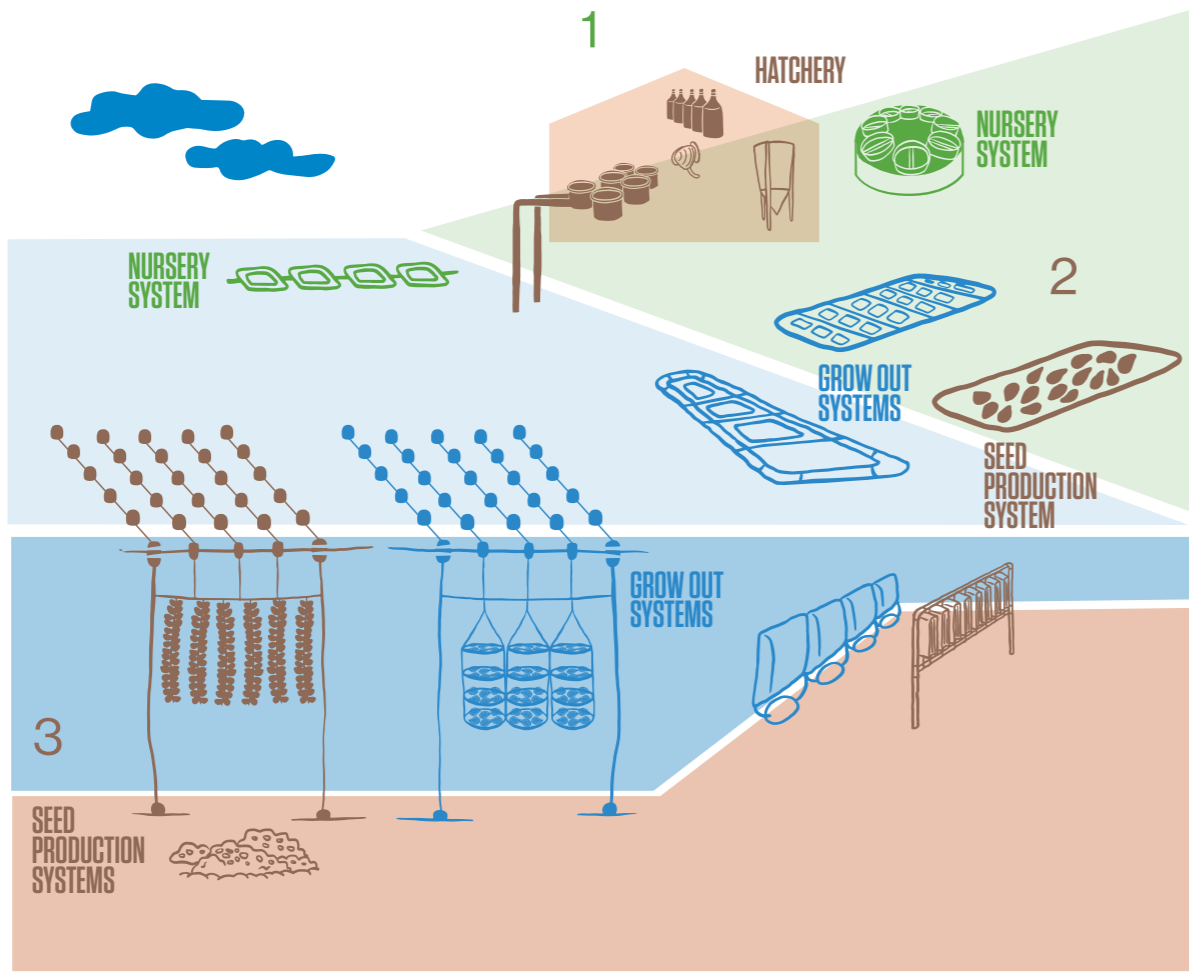


## INTEGRATE ALL YOUR SENSORS

- The AquaVitae project has developed a novel sensor integration platform to be used in productive aquaculture environments. Various data types are managed, and automatic storage and transfer of data is applicable.
- The platform has been tested in a seaweed aquaculture facility and could be integrated into larger aquaculture sites, or into smaller aquaculture operations where low-cost readily available sensors can give valuable production information.
- The platform supports wireless transmission, making this an attractive and affordable option for aquaculture management that may not otherwise consider this technological advancement.

# All in the shell

Species of bivalves, such as oysters and blue mussels, are popular low-trophic species for consumption. However, there is a need for improved protocols and techniques for both seed production and grow-out. In the AquaVitae project, optimised protocols for hatchery and sea-based production of oyster spat was developed. In addition, hatchery protocols for production of blue mussel seeds, and new grow-out systems were implemented.



The colors indicate the culture phase in the oyster production: brown -> seed production; green -> nursery; blue -> grow-out. Seed production can be done using three techniques: 1) in hatcheries, in which case a nursery system may be needed in the transition between seed and grow-out systems, 2) in land based spatting ponds and 3) using sea-based collectors.

Mussels and oysters are also amongst the most sustainable food production systems globally. However, there is still potential to further boost sustainability by transforming side streams into valued by-products. Investigating the potential of shellfish aquaculture side streams, the AquaVitae project focused on the alternative use of bivalve shells which are composed of calcium carbonate ( $\text{CaCO}_3$ ), also known for  $\text{CO}_2$  immobilization. Additionally, the project used protein hydrolysates derived from fisheries and aquaculture side streams as ingredients in the production of aquafeeds for juvenile fish.



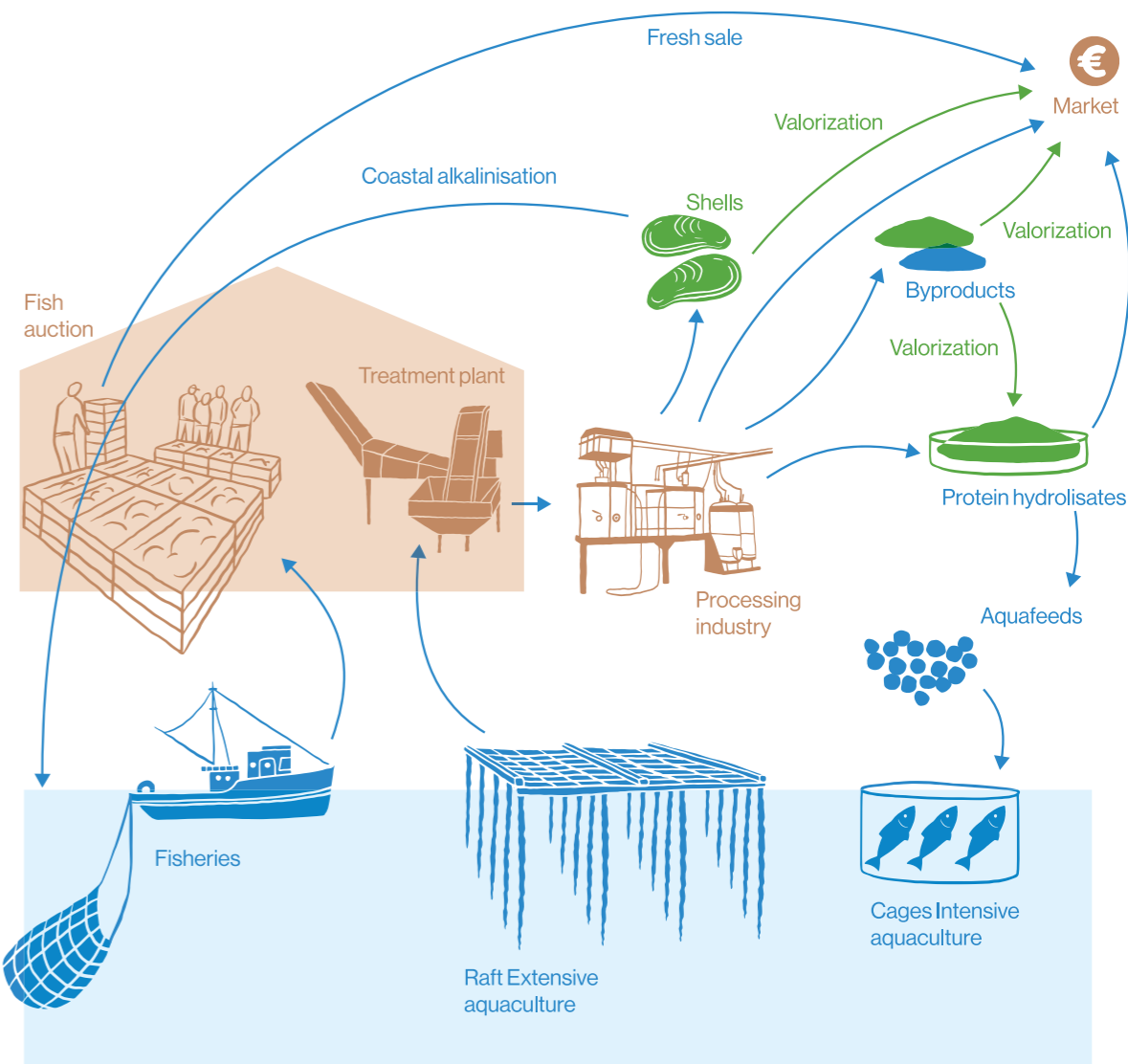
Oysters in the market. Picture by Åsa Strand.



Galician raft (batea). Picture by David Villegas.

#### IMPORTANT OUTCOMES INCLUDE:

1. Improved hatchery protocols and nursery systems for the production of native oyster species in Brazil and mussels in Europe.
2. Good practice recommendations for hatchery production of mussels, oysters and other LTA species in Europe.
3. Improved techniques and protocols for sea based oyster seed collection.
4. Development and evaluation of novel culture techniques for grow-out of mussels and oysters.
5. Development of an anti-fouling treatment protocol for mussels and oysters.
6. Successful testing of shell  $\text{CaCO}_3$  as a bulking aggregate in paints to immobilise carbon for extended periods.
7. AquaVitae has proposed practices to potentially mitigate coastal acidification by returning bivalve shells back to sea.
8. Novel low trophic proteins have been successfully implemented as functional additives in environmentally sustainable diets for juvenile gilthead seabream.



Green lines represent valorization processes of the different side streams. Blue lines represent the different stages of the mussel and fisheries value chains and direct uses of processing industry byproducts.

# Fresh fish from the Amazon

A number of valuable freshwater finfish are found in Brazil, two of which include the Amazonian round fish tambaqui and the giant air-breather pirarucu. However, knowledge gaps exist which negatively influence their aquacultural potential. AquaVitae has addressed issues related to the intermuscular bones of tambaqui, as well as with escapes of farmed tambaqui.

Novel species of marine finfish such as the Southern black drum are also found in Brazil, which is considered as an aquaculture species. The AquaVitae project has developed technology to successfully produce Southern black drum in an aquaculture setting.

**IMPORTANT OUTCOMES INCLUDE:**

- 1. Protocol for *in vivo* identification of intermuscular bones in tambaqui.
- 2. Protocol for production of 100% triploid tambaqui.
- 3. Method to collect semen in live broodstock of pirarucu.
- 4. Introduction of Southern black drum for marine finfish culture in the Atlantic Ocean, including early weaning off brine shrimp.
- 5. Successful juvenile Southern black drum production was increased by optimising temperature and salinity.



## A tool to reduce in-breeding and increase profitability in tambaqui production in Brazil

The profitability analysis focused on the use of genetic selection tools to contribute to increasing the genetic quality of tambaqui fingerlings by using better farming management to reduce inbreeding mating on Tambaqui production. Implementation of the tool should reduce production costs while at the same increase the supply of juveniles – which would bring significant gains to the entire production chain.

The added benefits were also illustrated when calculating revenue per hectare of water surface with the two scenarios, where the gross revenue was increased by 11 % with the use of selective breeding. It was concluded that the widespread adoption of the tool for pedigree control, breeding genetic management, and mating guidance will bring long-term benefits, in addition to immediate benefits for the producer using the technology, bringing additional productivity gains, enhancing profitability and increased production and supply of tambaqui to the consumer market.



## Circular feeds

An existing challenge experienced by the aquaculture industry is the availability of sustainable ingredients that can be flexibly used in the formulation of nutritious aquafeeds. The AquaVitae project focused on identification of potential resources resulting from low trophic species (LTS) side streams.

**IMPORTANT OUTCOMES INCLUDE:**

- 1. Increased aquafeed sustainability through the inclusion of underutilised or new low trophic ingredients (seaweed, mussel meal).
- 2. Development of new feeds for gilthead seabream, whiteleg shrimp, black drum, tambaqui, pirarucu, European and South African abalone.
- 3. Increased aquaculture resilience through self-sustaining, circular food chains. For example, seaweed produced in aquaculture waste-streams (i.e., in integrated multitrophic aquaculture, IMTA) was included in aquafeed.
- 4. Measures were developed to reduce the biosecurity-risk associated with circulating seaweed that was produced in aquaculture waste-streams back into aquafeeds.

# POLICY MAKERS & SOCIETY

## LTA and Agenda 2030

Low trophic aquaculture is a sustainable food production system, but it is still important to focus on how production can be improved to ensure a net positive impact on sustainability in the Atlantic Region. To achieve this, we first needed to know what we are striving for, and what our desired state of sustainability is. In the AquaVitae project, we highlighted how LTA aligns with the sustainable development goals in Agenda 2030.

Low trophic aquaculture can contribute to the fulfilment of Agenda 2030 in many ways. Traditionally sustainability is described as the union of the environmental, social and economic domains. However, as governance is increasingly recognised as an important part to support decision making and development of aquaculture, we acknowledge it in our definition of sustainable aquaculture.

### A desired state for LTS aquaculture in the Atlantic region

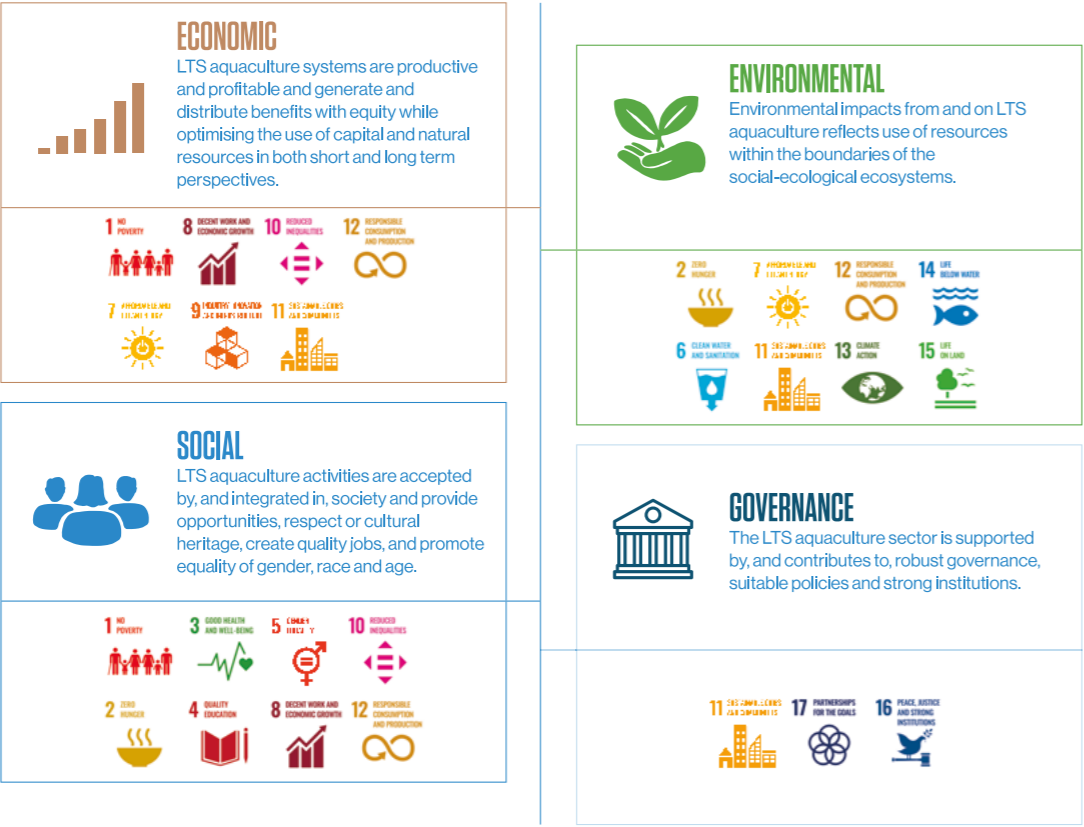


Figure adapted from Mayara Fabris design included in D6.1 Recommendations of indicators [scan the QR code to access Deliverables].

During AquaVitae, we have furthered the development of widely recognised aquaculture sustainability indicators, to include the governance dimension of sustainability. These indicators have been extensively tested in Brazil and recognised by the European Commission as one of the top sustainability frameworks, having a vast potential for application to Europe and across the Atlantic.



AquaVitae Policy round table in Brussels in March 2023.

## Which governance challenges are holding back LTA in the Atlantic region?

AquaVitae has conducted a number of workshops with stakeholders from different low trophic aquaculture (LTA) value chains and countries, reviewed governance frameworks across the Atlantic and analysed the adaptiveness of policies. This highlighted the diverse range of governance challenges experienced by the sector.

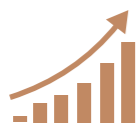
These challenges, synthesised in AquaVitae's *Policy Brief*, are noted below:

- Long and complicated licensing procedures.
- Lack of clear policy framework for emerging Atlantic LTA sectors.
- Limited industry recognition and representation.
- Value chains, market, and trade hurdles.
- Insufficient consideration of LTA in planning.
- Legal or regulatory deficiencies hinder IMTA.
- Public support is critical for LTA development.
- Start-ups lack financial support and advice.
- Co-location and integration with other activities remain difficult in practice.
- Offshore aquaculture is undermined by regulatory uncertainty.
- Insufficient or inadequate support to R&D and innovation.
- Food safety regulations and procedures are not always fit-for-purpose.

# Policy recommendations

## How to unlock the potential of LTA in the Atlantic region?

Following consultation with a wide range of stakeholders on governance challenges, AquaVitae has produced a Policy Brief that outlines a set of 15 actionable policy recommendations, to support the development of a diverse low trophic aquaculture (LTA) in the Atlantic region, in a way that is consistent with the environmental, economic and social pillars of sustainability:



1. Provide legal certainty to developers with streamlined licensing.
2. Diversify LTA through updated legal frameworks.
3. Ensure sustainability with area-based management.
4. Acknowledge LTA's value to restoration and remediation.
5. Shift to LTA to reduce food production's impact.
6. Implement sustainable growth strategies for LTA.
7. Support LTA's access to financial services.
8. Economically reward LTA's ecosystem services.
9. Encourage optimisation and innovation in LTA.
10. Enhance LTA's resilience to environmental and socio-economic change.
11. Raise awareness and social acceptance of LTA.
12. Improve LTA producers' participation.
13. Support transparency and accountability (T&A).
14. Develop systems for food safety and quality.
15. Build capacity in LTA in public and private sectors.



Want to read the full *Policy Brief*? Scan the QR code.



Oyster shells. Picture by Seafish.

# All-Atlantic cooperation

Networking and clustering activities are critical in large complex projects such as AquaVitae. They not only facilitate collaboration but also grant access to crucial resources and expertise. They also promote synergies, increase impact and visibility, and support innovation development. By leveraging these practices, researchers in AquaVitae have enhanced the quality and relevance of their work, addressed complex challenges, and contributed to scientific and societal advancements.

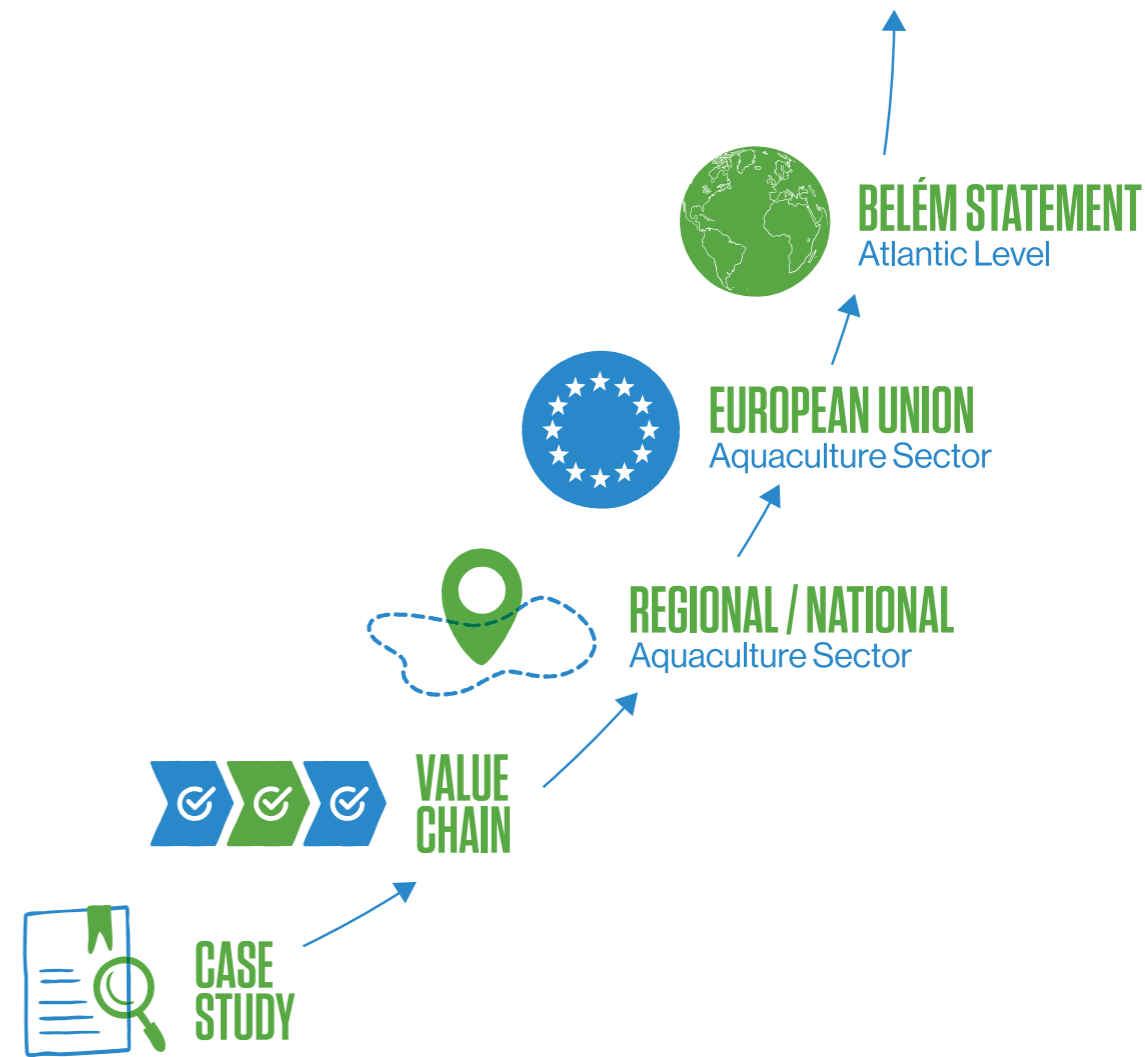
The AquaVitae consortium included partners from Europe, Brazil, South Africa, Namibia and North America. This diverse composition has given us the opportunity to build new and strong trans-Atlantic connections that will last well beyond the AquaVitae project.

Furthermore, the project has worked closely with our sister EU projects that address similar issues around the Atlantic, in particular the ASTRAL project. It has also been instrumental in contributing to the All-Atlantic Ocean Community.

Finally, several networks, such as the Altanet network (<https://altanet.info/>), have been established to disseminate results from the project and to encourage and promote low trophic aquaculture across the Atlantic.

***"It is not only about the results, but about the collaboration"***

Collaboration across the Atlantic has been based on the project's multi-actor platform, which includes policymakers, industry representatives, NGOs, and consumers. Stakeholders have played a key role in shaping the project's outcomes and benefiting from its findings. They form the cornerstone of AquaVitae, enabling seamless collaboration, knowledge exchange, and effective transfer of results to address real-world challenges. This continued engagement will also ensure that AquaVitae's impact extends far beyond the project.



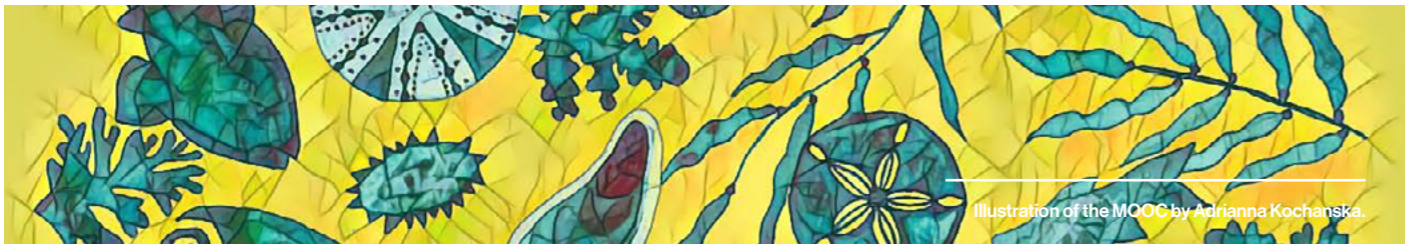
The low trophic species considered in AquaVitae were spread across Case Studies and Value Chains across the Atlantic.



Some partners from the AquaVitae project representing the three continents looking at the Atlantic.

# FIND OUT MORE ABOUT AQUAVITAE AND LTA

## Educational resources



- 1

LOW TROPIC AQUACULTURE AND SUSTAINABILITY
- 2

CULTURE SYSTEMS
- 3

MOLLUSCS
- 4

ECHINODERMS
- 5

MACROALGAE
- 6

FRESHWATER FISH
- 7

INTEGRATED MULTITROPIC AQUACULTURE
- 8

SEAFOOD SAFETY, CONSUMERS AND PRODUCTS
- 9

BUSINESS ECONOMICS AND BUSINESS PLANS
- 10

GOVERNANCE
- 11

FUTURE OF LOW TROPIC AQUACULTURE

AquaVitae has created a Massive Open Online Course (MOOC) on low trophic aquaculture (LTA). In the first months since its launch, over 420 learners have enrolled from different countries across the globe.

The MOOC is a free and open educational resource offering an interdisciplinary perspective into low trophic aquaculture (LTA), featuring case studies from across the Atlantic - including Europe, Brazil, and South Africa. Participants can navigate the material at their own pace and select topics that interest them. To earn the Open edX certificate, you'll need to achieve at least a 60% pass rate on assessments. In addition to the online certificate, participants can also register at UiT The Arctic University of Norway to receive 5 ECTS credits, which can count towards a master's degree.

The course received positive feedback from a group of reviewers who found it to be a comprehensive master-level course which provides a deep understanding of LTA and its role in addressing global challenges such as food security, sustainability, and climate change.

### Would you like to know more about LTA?

Various webinars were presented under the Low Trophic Life Series framework. Watch them on our Youtube channel!

Scan the QR code to watch the Low Trophic Life Webinars.

Enroll now!



## Having fun with low trophic aquaculture

Join us in discovering the world of low trophic species! Fill your plate and expand your palate with these new and nutritious delicacies that are good for both your health and the planet.



Elements of the AquaVitae Game. Picture by Y. Irawan.

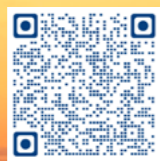
# WANT TO KNOW MORE ABOUT THE PROJECT? FIND US!

[www.aquavitaeproject.eu](http://www.aquavitaeproject.eu)

35 partners, 15 countries,  
5 value chains, 1 purpose:

## SUSTAINABLE SOLUTIONS FOR AQUACULTURE.

Scan the QR code to  
watch the AquaVitae final  
movie in English



Scan the QR code to watch  
the AquaVitae final movie in  
Portuguese





AquaVitae



This project has received funding from the European Union's Horizon 2020  
Research and Innovation Programme under Grant Agreement No 818173