Macroalgae Cultivation

Along the Romanian Black Sea Coast



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EXCELLENCE AND COMPETITIVENESS IN MARINE ALGAE AQUACULTURE FOR A SUSTAINABLE BLACK SEA

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Science for the Black Sea. Restoring today, protecting tomorrow.

Ecological reconstruction begins with small, patient steps in the laboratory, where researchers study a sensitive species, long affected by human pressures and climate change, so it can grow and eventually become a renewed source of life for the sea. Each year, this work provides a continuous supply of healthy algal juveniles, carefully cultivated under controlled conditions. Once the young algae become strong and resilient, they can be returned to the sea, though releasing them into the wild is always a carefully controlled step. It requires numerous tests and pilot trials, from assessing habitat suitability and monitoring early survival, to carefully choosing the right moment for release so the young algae avoid periods of environmental stress. Through repeated experiments and adaptive monitoring, scientists refine their methods, protect remaining natural populations, and ensure that every outplanted individual has the best chance to develop and help rebuild these underwater forests.

Ecological restoration accelerates recovery where natural regeneration is too slow or blocked by persistent stressors, delivering faster biodiversity gains, improved ecosystem services, and tangible benefits for people. At NIMRD "Grigore Antipa", we cultivate the brown macroalgae *Gongolaria barbata* under controlled laboratory conditions, giving us the tools needed to restore degraded habitats without disturbing the remaining natural populations. Protecting this species means far more than safeguarding a single seaweed species, it strengthens the very foundation of a healthy Black Sea ecosystem and ensures long-lasting benefits for future generations. The cultivation efforts carried out in the laboratory, the technologies developed, and the ecological restoration programs represent more than scientific interventions. They are direct investments in the future of Romania's coastline, in biodiversity, and in our society's ability to use marine resources responsibly and sustainably.

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Researcher at the National Institute for Marine Research and Development “Grigore Antipa” in Constanța, focused on promoting and developing macroalgae cultivation technologies for sustainable valorization, while supporting marine ecosystem restoration along the Romanian Black Sea coast.



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BEHIND THE SCIENCE:
a journey into growing underwater forests in the laboratory


Aerial view of *Gongolaria barbata*
underwater forest

FROM LAB TO SEA:

A VISION FOR RESTORATION

This brochure shares the essential steps, ideas, and hope behind macroalgae cultivation, offering a hopeful perspective on the future of marine restoration!

The purpose of this brochure is to communicate the scientific and ecological value of cultivating macroalgae, with a particular focus on the brown macroalgae ***Gongolaria barbata****.*

This habitat-forming species is essential for maintaining biodiversity, stabilizing substrates, and supporting the ecological balance of the Black Sea.

Gongolaria barbata once formed extensive underwater forests along the Romanian Black Sea coast, providing shelter, food, and structural stability for countless marine organisms, but today this species is severely affected. Its dramatic decline makes active restoration not only relevant but also necessary.

By detailing cultivation methods and ecological importance of this species, the brochure aims to connect science with the public and inspire support for long-term conservation efforts. Presenting our cultivation techniques serves a dual purpose: proving that environmental restoration is possible while highlighting the Black Sea's macroalgae in general as a valuable, sustainable resource.

Every laboratory-produced algal specimen that achieves stable attachment to the substrate represents a small but meaningful step toward what we call ecological restoration.



HELPING THE BLACK SEA

WHY CULTIVATING MACROALGAE MATTERS TODAY?



Established the scientific foundations necessary for developing marine algae aquaculture in Romania Black Sea sector.

Discover more!

A 3-year Horizon-Europe funded project supporting the National Institute for Marine Research and Development "Grigore Antipa" in establishing excellence in marine algae aquaculture within Romania Black Sea sector.

Algae aquaculture presents a sustainable solution for producing healthy marine products, contributing to carbon sequestration, and mitigating climate change impacts in the region.

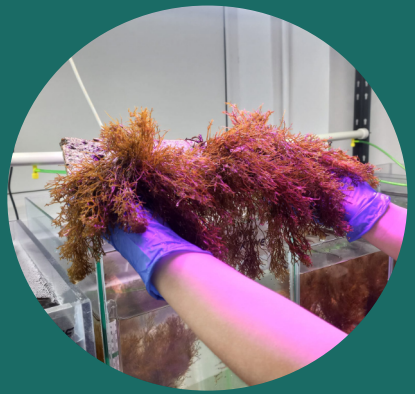
The initiative focuses on developing the local value chain for marine living resource exploitation, creating new jobs and market opportunities while supporting sustainable growth in the blue economy.

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UNDERWATER
FORESTS?

Beneath the surface of the Romanian coastal waters of the Black Sea, there once thrived a remarkable species that used to form rich, waving underwater forests built not of trees, but of macroalgae.

Dense submerged canopies, dominated by brown macroalgae of the genus *Cystoseira*, constituted highly productive ecosystems with significant structural complexity. Once dominant along the Romanian Black Sea coast, *Cystoseira* suffered a striking decline.





The harsh winter of 1971-1972 and intense human activities devastated the infralittoral ecosystems, leading to major losses.

Currently, its distribution is restricted to only certain areas of the coastal zone, where it persists in fragmented populations. Is significantly impacted by anthropogenic pressures, including coastal pollution and the effects of climate change.

When *Cystoseira* forests disappear, the whole ecosystem shifts: diverse underwater habitats turn into barren zones or become overrun by fast-growing algae, the same kind we often see washed up on beaches in summer.

So, let's explore...

Photosynthetic activity increases oxygen levels, improving ecosystem health. Macroalgae are among the most productive primary producers in coastal waters.

OXYGEN PRODUCTION

Rich in alginate, fucoidans, phenolic compounds, carotenoids, vitamins, and minerals. These compounds have pharmaceutical, cosmetic, and nutritional applications.

BIOACTIVE COMPOUNDS

Provides food, shelter, and settlement surfaces for rich fauna. *Cystoseira* forests support high biodiversity by creating complex three-dimensional habitats.

HABITAT

Biodiversity, nutrient cycling, climate regulation, bioremediation. These habitats contribute to carbon sequestration and water quality improvement.

ECOSYSTEM SERVICES

ARE THESE SPECIES IMPORTANT?

In one word: yes!



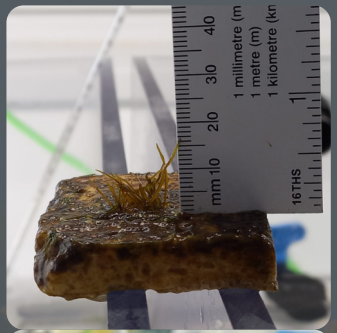
Introducing our key-habitat forming species

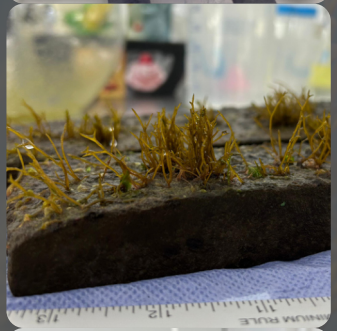
Gongolaria barbata

Gongolaria barbata, formerly known as *Cystoseira barbata*, anchors firmly to rocky substrates and grows into dense, branching canopies that form true underwater forests, providing shelter for fish, invertebrates, and numerous juvenile species.

This canopy-forming species plays a crucial role in stabilizing the seabed, enhancing water quality, and maintaining biodiversity.

Despite its importance, the species has experienced a long-term decline in the past decades, primarily as a result of eutrophication, coastal development, and various environmental stressors.







ESSENTIAL BUILDERS OF COASTAL STRUCTURE AND BIODIVERSITY

Given its high ecological value and its pronounced vulnerability to human-induced pressures, targeted ecological restoration interventions are being explored to facilitate its recovery along various sectors of the Romanian Black Sea coastline.

Cultivating Gongolaria barbata in the laboratory gives us a powerful tool to support future restoration activities of this species!

In this context, laboratory cultivation represents a key approach for producing healthy juveniles that can be used to enhance natural populations and facilitate the re-establishment of *Gongolaria barbata* in different areas.





THE IDEA:

WHAT ARE THE SCIENTIFIC MOTIVATIONS BEHIND THE LABORATORY CULTIVATION OF *GONGOLARIA BARBATA*?

What is the primary aim of the experiment?

Our goal is well-defined: to understand, protect, and restore the most ecologically valuable macroalgal species of the Romanian Black Sea coast, currently classified as **Critically Endangered in the national List of Endangered Marine Species**.

Cultivating this species under controlled laboratory conditions **allows us to examine its fundamental biology**, from reproductive process and attachment mechanisms to growth patterns and physiological responses, while also revealing its adaptability to environmental change.

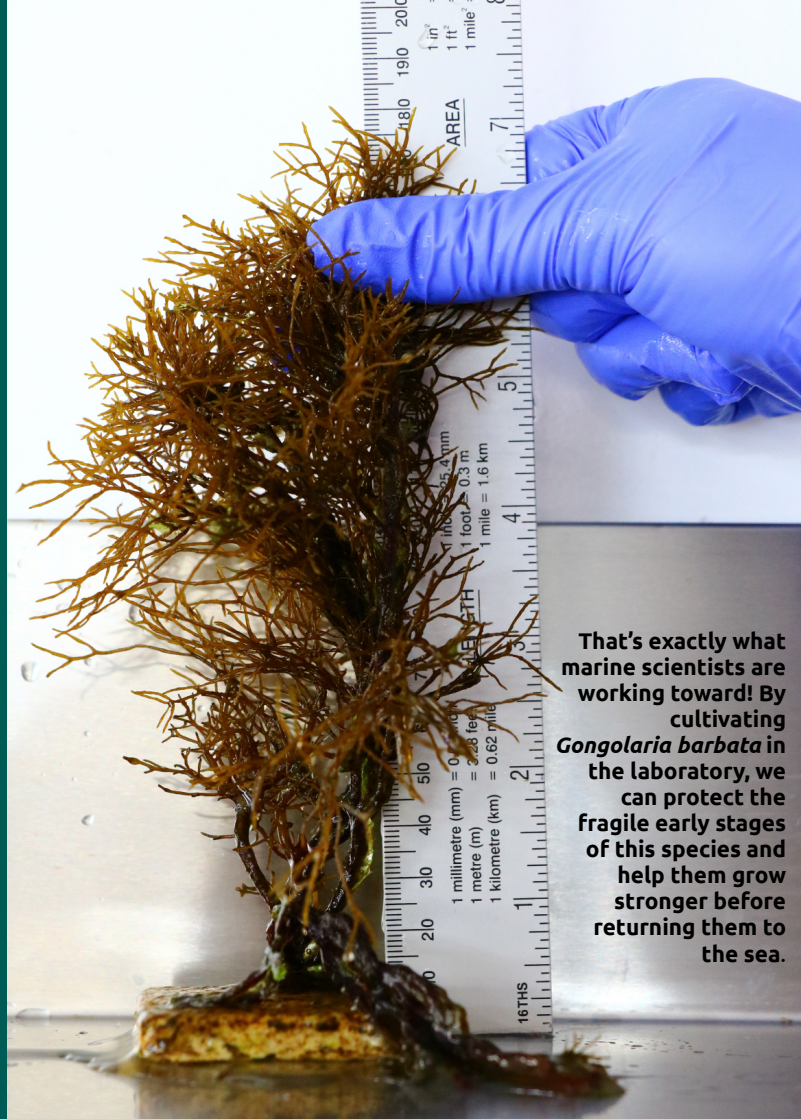
KEY QUESTION:

CAN WE GROW MARINE FORESTS … IN A LABORATORY?

Once they reach a healthy size, these lab-grown juveniles become the foundation for restoring damaged marine forests, helping us rebuild ecosystems that have been lost along many parts of the Romanian Black Sea coast.

This approach prevents the species from disappearing and brings us one step closer to restoring the underwater forests that provide so many benefits to marine life and to us.

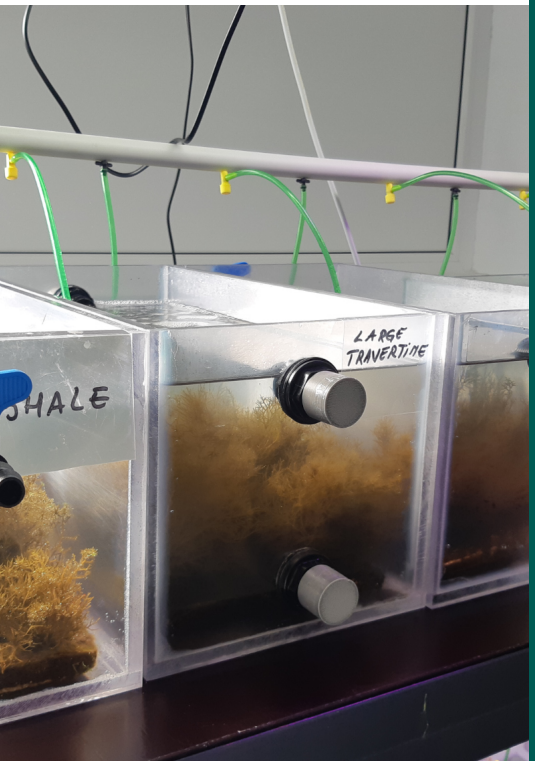
So yes, we can grow the beginnings of marine forests in a laboratory. Once the young algae become strong we move them into clean areas of the sea, where they have the best chance to thrive, and we monitor them closely to make sure they survive and continue to grow.



That's exactly what marine scientists are working toward! By cultivating *Gongolaria barbata* in the laboratory, we can protect the fragile early stages of this species and help them grow stronger before returning them to the sea.

Before starting any culture, it is essential to understand the ecological preferences of the species - in other words, the environmental conditions it needs in order to thrive.

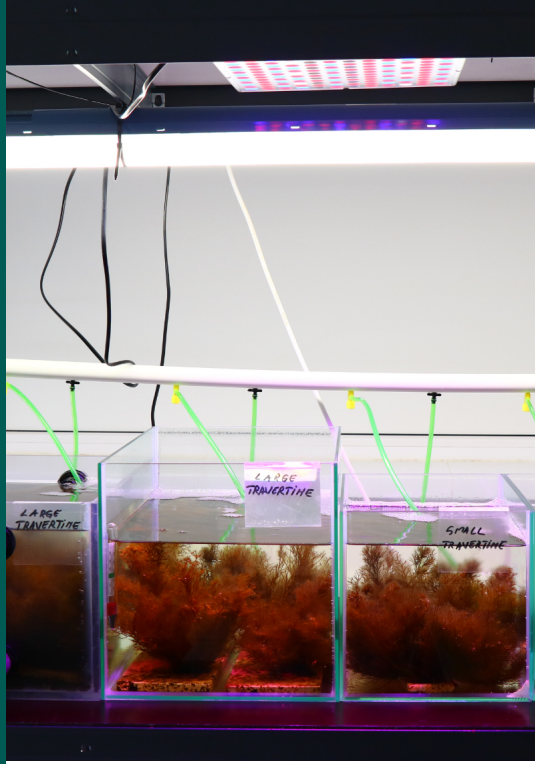
These are the conditions we recreate in the laboratory to give young algae the strongest possible start!



THIS IS WHERE OUR JOURNEY BEGINS

Everything we do in the lab is designed to mimic the condition of the Black Sea, only under ideal, carefully controlled environment. This gives our fragile algae the support they need to settle, grow, and prepare for life back in the sea!

WELCOME TO OUR LAB!



Through our work, we create the right conditions for new life to settle and thrive. We set up clean aquariums with filtered seawater and choose the best substrate to help the young algae attach and grow. In the lab, we make sure they get the right light and stay at the perfect temperature, giving them the perfect conditions to develop safely.

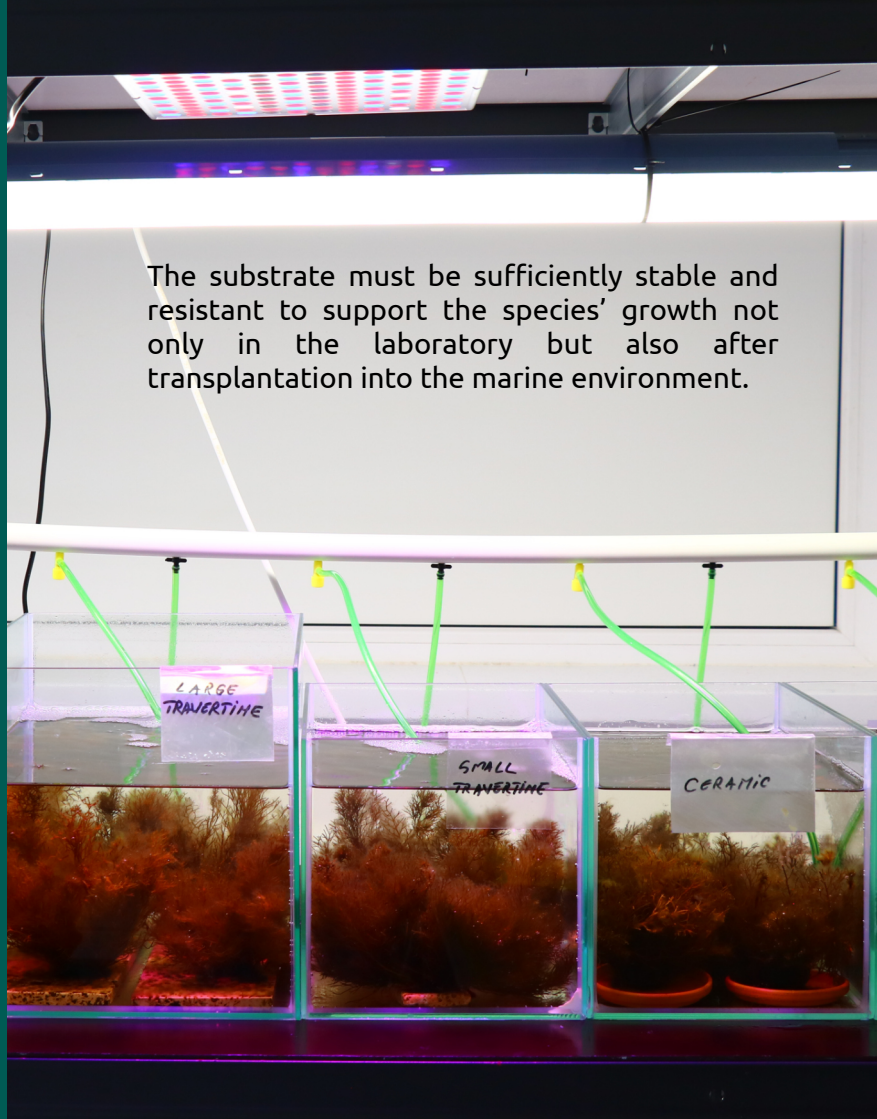

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In our laboratory, we use multiple glass aquaria with hard substrates on the bottom, giving the young algae a place to settle and grow. *Gongolaria barbata* needs a solid substrate to develop properly, and we as researchers rely on these substrates because they can later be transferred to the sea.

This helps us support the ecological restoration of this endangered species.

To achieve this, we experimented with different rocky substrates to identify the optimal surface for algal fixation and early development.

THE AQUARIA





Of course, we use Black Sea seawater in our experiments! But it's not used as-is. Before reaching the aquaria, the seawater is carefully filtered through several types of filters, each with different pore sizes.

This step removes suspended particles from the seawater, leaving us with clean, safe water for cultivating the young algae.

Every week, we replace the water in the aquaria. Before doing so, we check key seawater parameters like pH, salinity, temperature, and oxygen levels, to make sure everything is stable and that the seawater has the proper temperature.

These measurements help us detect any changes in the seawater that might affect the growth and health of the young *Gongolaria barbata* plants.

SEAWATER

And just like any growing organism, our young algae also need "*food*." We don't rely on plain seawater alone. In each aquarium, we add a special culture medium - a carefully prepared mix of vitamins and minerals that supports healthy, rapid growth of the algae.

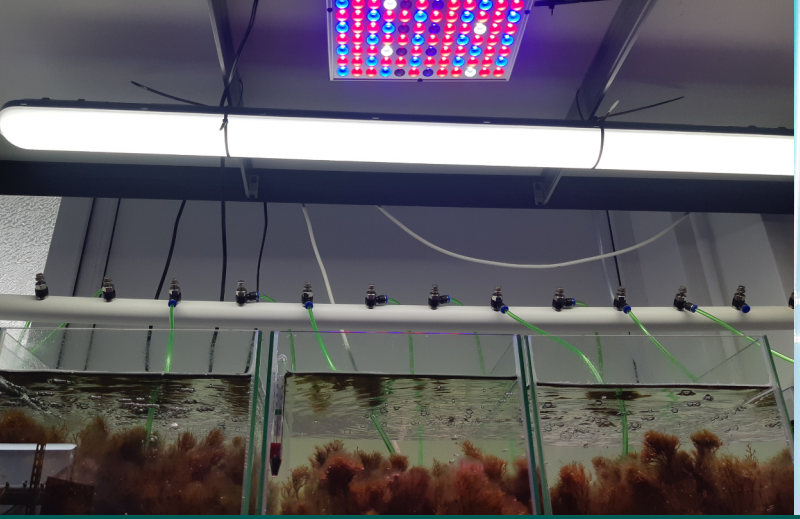
Gongolaria barbata is a perennial species, meaning it lives for several years in the sea and grows very slowly in the lab. But with the help of this enriched medium, we can gently stimulate its development.

After just a few months, our young algae reached more than 20 centimeters in height.

It may not seem like much, but once they are returned to the sea, these small algae become valuable habitat. **Tiny marine organisms will soon find shelter, food, and breeding spaces among their branches** - the first steps toward rebuilding an underwater forest.

NUTRIENTS





Inside the lab, we recreate the rhythm of day and night using special lamps that turn on and off just like sunlight, giving the small algae the energy they need to photosynthesize and grow.

We use a photoperiod of 16 hours of light and 8 hours of darkness.

Gongolaria barbata enjoys long “summer days”. Everything is carefully controlled so the algae can grow strong and healthy.

LIGHTING



An essential parameter is temperature - both the ambient temperature and the temperature of the seawater we use.

The laboratory temperature is maintained at a constant 20°C, whereas the seawater in the aquaria stays between 18 and 19°C.

TEMPERATURE

HOW DO WE GROW

Gongolaria barbata?

This booklet takes you behind the scenes of how we cultivate *Gongolaria barbata*, starting from its earliest microscopic life stages (tiny single-celled called zygotes), all the way to young, healthy algae ready to return to the sea. Through our story, you'll discover how we encourage new life to settle and grow the next generation of underwater forests.

Main steps:

- **Sampling**
- **Preparation**
- **Cultivation**







Our journey begins in the sea. We carefully identify and collect *Gongolaria barbata* fertile branches bearing mature structures called receptacles. Sampling is done with minimal impact: only a small part of the population is sampled. Then, these fertile fragments are transported to the lab in cool, dark conditions to preserve their viability.

Timing is critical!

The process requires sampling fertile material at its reproductive peak, in strict alignment with seawater temperature and other ecological factors.

SAMPLING





Back in the lab, the fertile material is gently cleaned and sorted. Small fragments from the tips of the algae are placed in several aquaria, on different types of hard substrates, and grown under controlled conditions.

We adjust light, temperature, and water quality to mimic their natural environment.

This preparation stage sets the foundation for successful gametes release and early development!

PREPARATION & CULTIVATION

Watching the magic happen!

Under the right conditions, the fertile receptacles begin releasing their gametes in just a few hours. This moment marks the beginning of a new generation of algae! Fertilization takes place in the water column, forming countless tiny zygotes that immediately start searching for a surface to settle on. That's why we must prepare the best possible substrate for them.

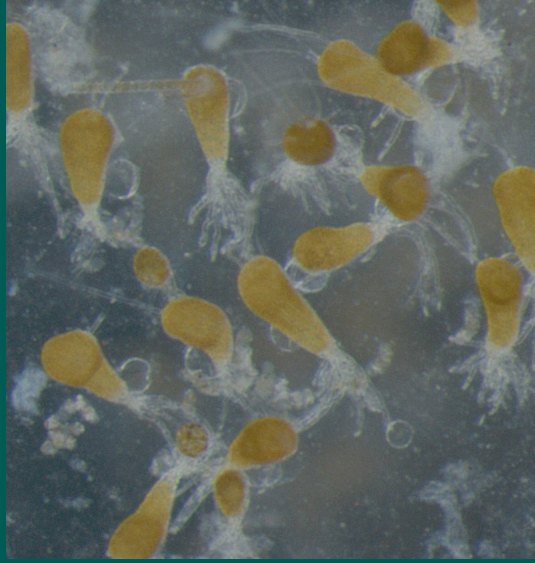


Each culture becomes a small forest in miniature!

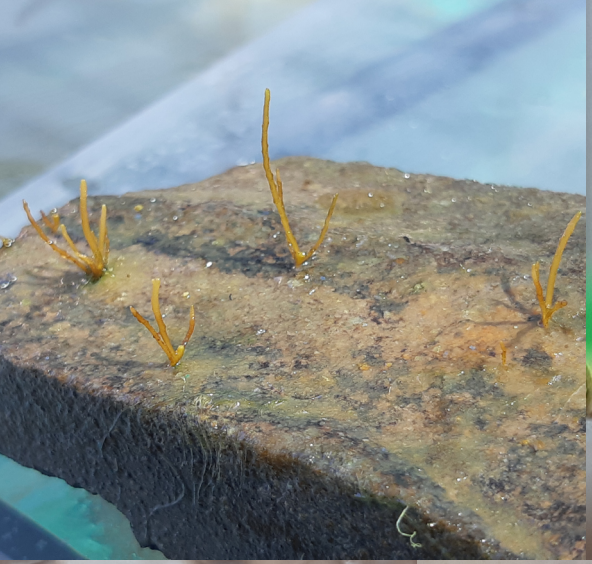
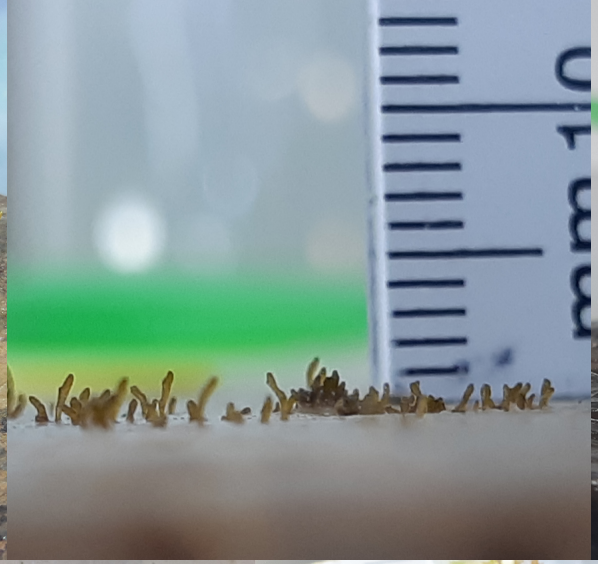
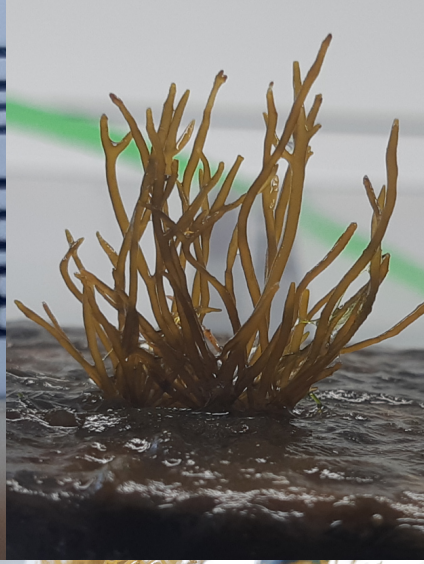
Healthy algae grow thicker and stronger, preparing for life in the sea!

Within days, the first recruits appear: microscopic, golden-brown dots that will eventually grow into juvenile algae. Following the initial branching phase, the species exhibits significant growth potential, capable of reaching a total length of almost two meters under natural sea condition.

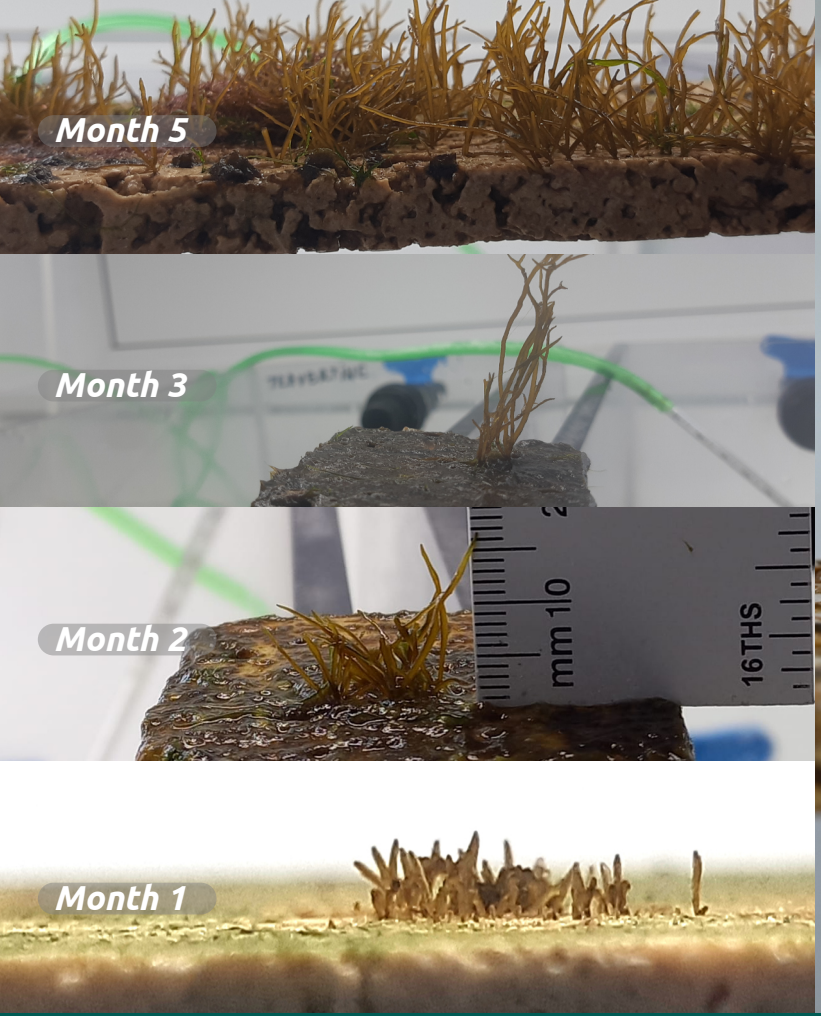
HOW DO WE MEASURE SUCCESS?



On a weekly basis, scientists monitor the species' development by measuring length and branching patterns, while observing color changes and monitoring overall health. As the recruits grow, they develop holdfasts, branches, and the characteristic structure of a young *Gongolaria barbata*.



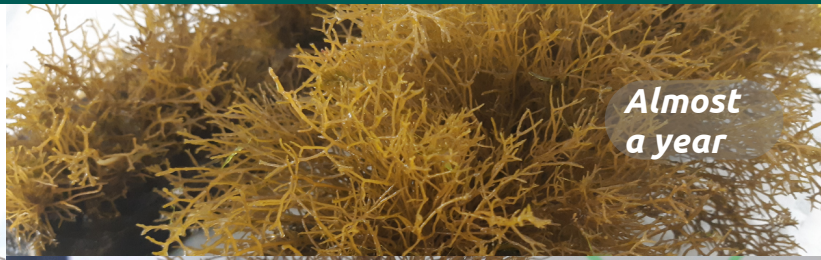



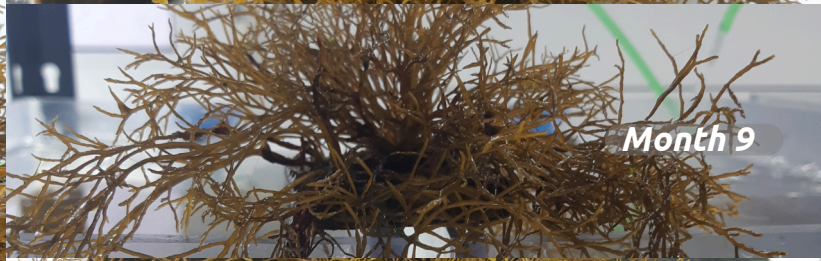


Early-Stage Versus

Long-Term Laboratory Cultivation











Results

This isn't just one algae, it's a small group growing together. By staying clustered, they can better resist waves, the even strong storms. A single specimen would be too exposed and could be torn off the substrate.

Where many grow together, strength increases!

Goal

In the lab, the algae have grown in compact clumps and are now prepared to withstand natural conditions, including strong waves and fluctuations in water temperature.



Impact

This approach facilitates the re-establishment of *Gongolaria barbata* populations in previously depleted areas, contributing to the formation of structurally complex habitats for associated marine fauna.

Findings

In other words, we obtained a high density of juvenile thalli per surface unit, which, once outplanted, can further propagate and establish new individuals.

Strategy

It must be collected at exactly the right time - not earlier, not later - to ensure healthy development.

Method

Everything starts with helping the zygotes attach and grow into new algae, but the most important factor is the quality of the reproductive material.

WHY CULTIVATING GONGOLARIA BARBATA MATTERS TO US ?

These underwater forests are more than just algae, they create shelter for marine life, improve water quality, and help protect coastlines from waves.

Gongolaria barbata is a unique species with a vital ecological role for the Romanian Black Sea coast. If it recovers, the entire marine environment benefits: better oxygenation, richer biodiversity, and even more beautiful underwater landscapes for divers to explore.



At the same time, this species is important for us as well, as it contains a wealth of remarkable compounds with antiviral, antibacterial, antioxidant, anti-inflammatory, and antifungal properties. If we manage to bring back these underwater forests, their value goes beyond ecology.

Gongolaria barbata can be used responsibly to create natural cosmetics, dietary supplements, bioplastics, and environmentally friendly fertilizers.

In other words, restoring the species not only heals the sea but also opens the door to sustainable, nature-respecting products.

When these forests will return into the sea, so does a rich marine life! Healthy marine forests enhance coastal resilience and generate sustainable benefits for local communities.

Gongolaria barbata is known as an underwater "architect."

This canopy-forming species acts as a nursery area, providing guidance and shelter for fish, with juveniles using the forests as hiding places and feeding grounds during their most vulnerable stages.

They're part of a much older lineage than most land plants - brown algae like Gongolaria barbata evolved long before flowering plants, so they're ancient "engineers" of the sea.

A single specimen can host an entire community: crabs, snails, juvenile fish, worms, and microalgae all live on or inside its branches, sometimes hundreds of individuals on one plant.

A single fertile branch can give rise to thousands of new individuals in the laboratory.



INTERESTING



FACTS

Gongolaria barbata forests can host hundreds of species in only a single square meter.

The fertile material can be manipulated to regenerate into new algal specimens following a predefined spatial arrangement, enabling us to optimize settlement patterns and increase post-transfer survival in the marine environment.

In its first week of development, Gongolaria barbata is so tiny that the young recruits can only be seen under a microscope — yet, once returned to the sea, they can grow into plants nearly 2 meters tall.

Gongolaria barbata helps improve coastal water quality by absorbing excess nutrients, reducing eutrophication, and acting as a natural coastal "filter".

Their so-called "root," the holdfast, works like a powerful natural anchor. It grips the rocks so firmly that during strong storms, the waves can uproot boulders before they manage to detach the algae.

IF MACROALGAE ALREADY GROW IN THE SEA, WHY DO WE NEED TO CULTIVATE THEM?

Although algae naturally grow in the sea, some species now need our help to survive. *Gongolaria barbata* has declined dramatically along the Romanian coast that it struggles to recover on its own, making laboratory cultivation essential to protect its most fragile early stages. After reaching sufficient strength, the juvenile algae are transplanted back into the Black Sea, contributing to habitat restoration and improved ecosystem health.



When algae are used for high-value products, quality matters. Growing them under carefully controlled laboratory conditions ensures a clean and reliable raw material, ideal for sensitive applications such as pharmaceuticals and cosmetics. In contrast, algae washed ashore are a mixed and often degraded blend of different species. They also can contain sand, shell fragments, and other impurities, making them unsuitable for high-quality uses.

Just as importantly, harvesting algae directly from the sea can put additional pressure on already fragile marine habitats. By cultivating macroalgae in the lab, we can produce the biomass we need while protecting the marine ecosystems we depend on.

Macroalgae cultivation is still in its early stages along the Romanian coast of the Black Sea, but it is already taking its first steps in this direction. Like any emerging field, it faces challenges and difficulties. However, it also brings significant promise and opportunities for the future. This type of aquaculture addresses two key challenges relevant to the Romanian Black Sea sector: the sustainable valorisation of algal biomass in a way that respects the marine environment, and the support of ecological restoration efforts, including helping to prevent the loss of certain macroalgal species.

IS THERE POTENTIAL FOR MACROALGAE AQUACULTURE IN ROMANIA?

At the same time, there is a growing interest in sustainable marine resources, as certain macroalgae species are rich in bioactive compounds that can be sustainably used in biotechnological and industrial applications. As a result, macroalgae aquaculture holds strong future potential. The main limitations are still related to infrastructure, expertise, and regulatory development, but macroalgae aquaculture is relevant for environmental and economic sustainability in the Black Sea region.



WHAT ECOSYSTEM SERVICES DO THRIVING GONGOLARIA BARBATA UNDERWATER FORESTS PROVIDE FOR US ALL?

In case of marine environment, ecosystem services can be simply understood as the benefits people gain from the sea, so, in other words, what we receive from a clean and healthy marine environment to support our well-being and quality of life. There are four categories of ecosystem services, and healthy *Gongolaria barbata* underwater forests provide all of them.

Provisioning – provide compounds with bioactive potential that form the basis for medicines, dietary supplements, cosmetic products, fertilizers and bioplastics. *Gongolaria barbata* is an important source of diverse bioactive compounds, such as antioxidants, polysaccharides, phenolics, and antimicrobial metabolites, that underpin multiple high-value applications. These compounds form the biochemical basis for pharmaceuticals, nutraceuticals, dietary supplements, cosmetic formulations, agricultural fertilizers, biostimulants, and emerging bioplastic materials. Through this biochemical richness, the species contributes directly to sustainable blue-bioeconomy development while supporting innovation across health, cosmetic, and biomaterial sectors.

Regulating – *Gongolaria barbata* plays a crucial role in coastal stability by anchoring and consolidating the rocky substrates it grows on, thereby reducing erosion and buffering wave action. Its dense canopies improve water quality through sustained oxygen production and efficient nutrient uptake and maintaining ecological balance. In addition, its complex three-dimensional structure provides essential habitat, shelter, and nursery areas for a wide range of marine organisms, supporting biodiversity and ecosystem resilience.



Cultural – *Gongolaria barbata* enhances coastal tourism and recreational activities, offering divers and swimmers access to underwater landscapes shaped by its dense marine forests. These vibrant habitats provide aesthetic value, inspiration, and opportunities for nature-based recreation, contributing to mental well-being by reducing stress and fostering a sense of connection with the marine environment. Swimming through these underwater forests offers a unique, enjoyable experience, like visiting an underwater museum, rich in marine life and natural beauty!

Supporting – These are indirect ecosystem services, yet they provide essential benefits for the marine environment and for human well-being. As an example, through photosynthesis, *Gongolaria barbata* generates oxygen that sustain higher trophic levels. Its role in nutrient cycling is equally essential: by absorbing, transforming, and re-mobilizing dissolved nutrients, this species supports its own growth while maintaining balanced nutrient dynamics in the surrounding waters. It is also considered an important bio-indicator of water quality.

Together, these processes form the ecological foundation upon which resilient, functioning coastal ecosystems depend!

MACROALGAE… A RESOURCE FOR THE FUTURE?

Yes, for the future of the Black Sea and for us all!

- *Habitat recovery – The brown alga Gongolaria barbata rebuilds structurally complex marine habitats, enhances nutrient regulation, and supports ecological balance in the Black Sea.*
- *Renewable value – Macroalgae offer a versatile resource for food, health, cosmetics, and biotechnology, enabling sustainable production and stimulating innovation.*
- *Community impact – Coastal communities benefit directly, gaining new market opportunities and pathways into future green industries.*

Macroalgae combine environmental benefits with economic potential!




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The marine life in the Black Sea is full of mysteries!

This is just one of them — and there are many more to explore.