# Combining active and passive restoration for biodiversity

## Native European flat oyster (*Ostrea edulis*) restoration in Northern Adriatic Sea

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RESTORE OUR OCEAN & WATERS

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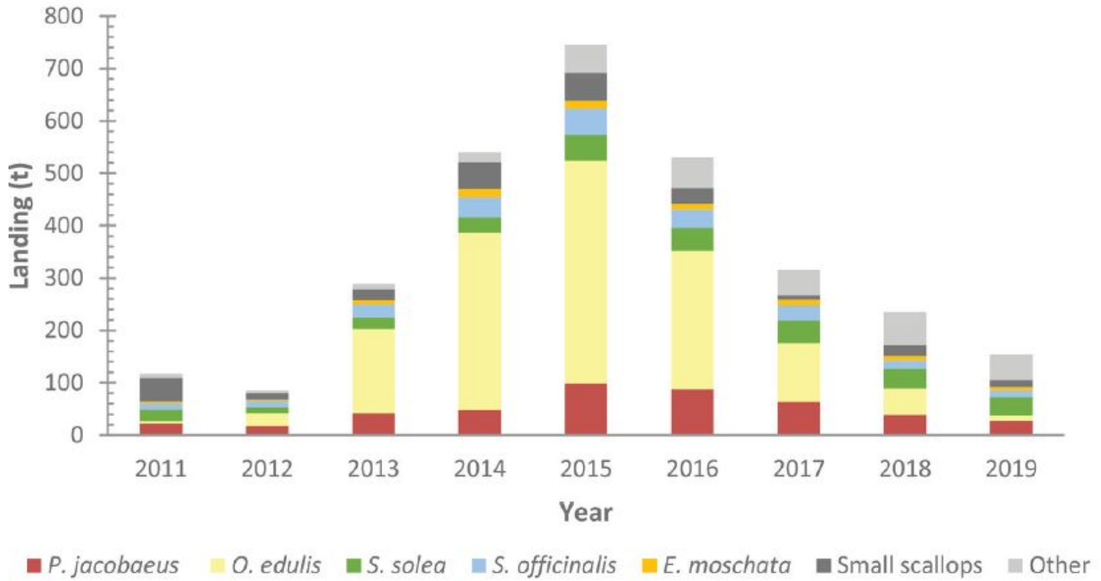
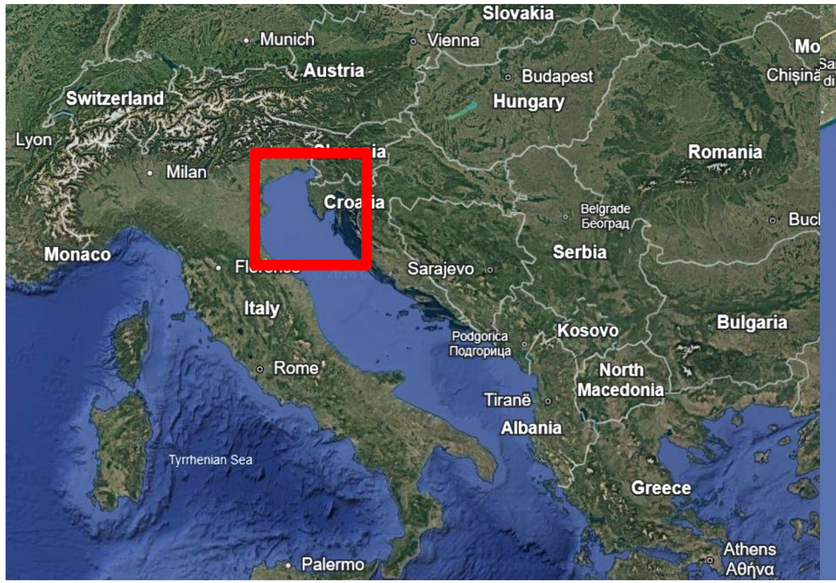
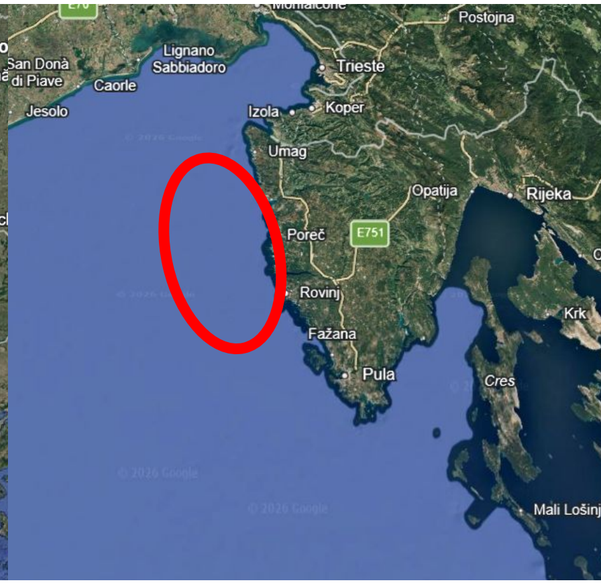
# The place & problem

- Croatia has a long history in farming native oysters - satisfy the needs of the Croatian market.
- Croatia's joining the EU in 2013 - New market opening.
- In last years abundance of *Ostrea edulis* has decreased significantly.

- ⬇ Biodiversity
- ⬇ Fisheries
- ⬇ Aquaculture
- ⬆ Costal erosion



# Why NbS?

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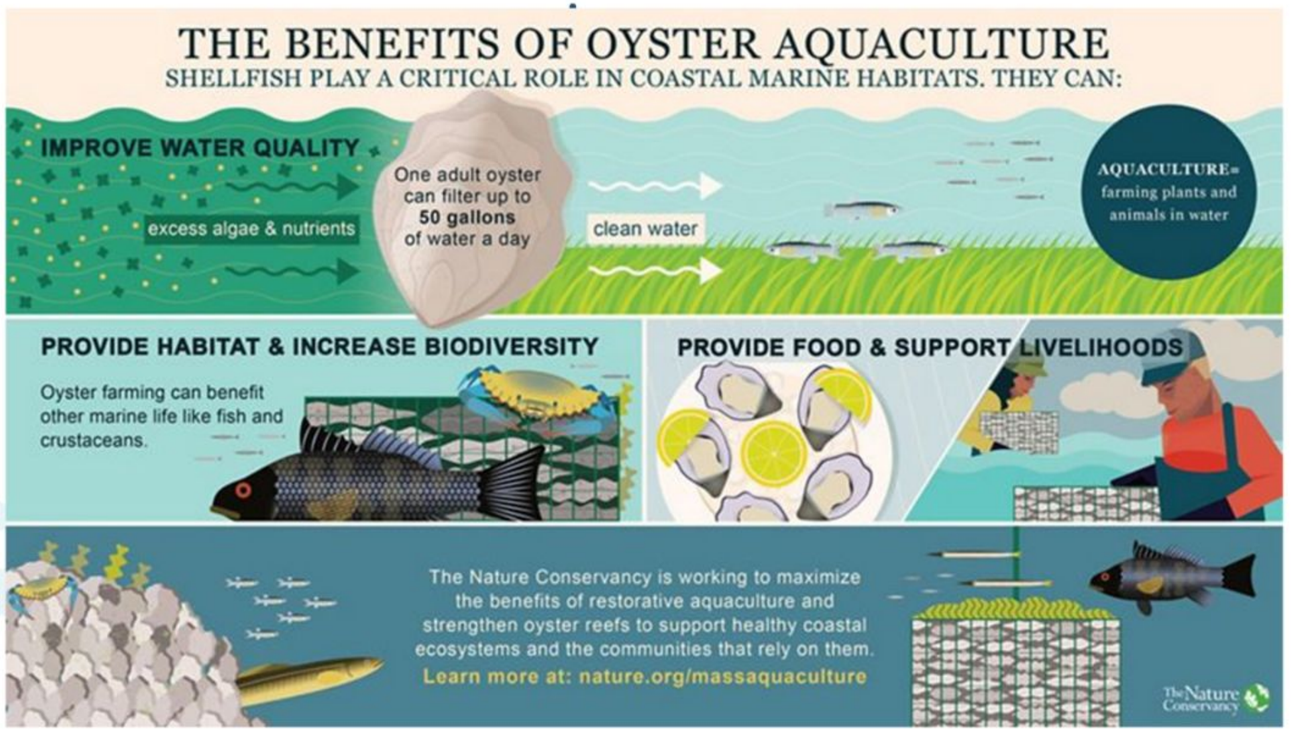
## One Investment, Triple Impact

Delivering ecological, social, and economic returns.

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## Passive restoration

(removing pressures so natural recovery can happen)
These should directly reduce disturbance and allow oysters to recover on their own.

- Fishing regulation
– Seasonal closures & rotational harvesting
– Reduces extraction pressure and allows recovery cycles

- No-take zones / MPAs
– Full protection areas where oyster populations can rebuild naturally

- Change in fishing equipment
– Shift away from bottom trawling or dredging to less destructive methods
– Reduces physical damage to seabed and remaining reefs

## Active restoration

(direct intervention to rebuild reefs)
These physically reintroduce structure or organisms.

- Deploy substrate (e.g. broken oyster shells)
– Provides settlement surface for larvae

- Artificial oyster reefs
– Built structures to recreate reef habitat and complexity

- Farming oysters on artificial reefs (removable structures)
– Hybrid approach: restoration + aquaculture
– Can act as broodstock and seed surrounding areas

## Enabling / indirect measures

(support passive restoration but are not restoration themselves)
These influence behavior, markets, or incentives.

- Changing demand
– Awareness campaigns to avoid dredged oysters
– Towards a systemic shift in consumption patterns and fostering shared values

- Ecotourism
– Creates alternative income streams
– Can reduce reliance on extractive activities, but only works if well managed

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# Benefits and Challenges

## BENEFITS

**Improved water quality**
Removed pollutants, reduced eutrophication, algal regulation

**Habitat regeneration**
Nursery, shelter, food

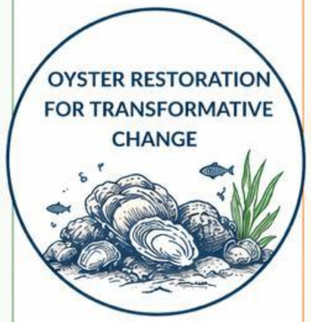
**Climate regulation**
Carbon storage

**Erosion protection**

**Biodiversity increase and enhanced ecosystem resilience**

**Support commercial and recreational fisheries & aquaculture**

**Biogeochemical cycling**
Supports nutrient (N, P) and carbon (C) cycling, improving ecosystem function




## CHALLENGES

**Livelihood disruption for fishers**
Loss of economic opportunity and identity

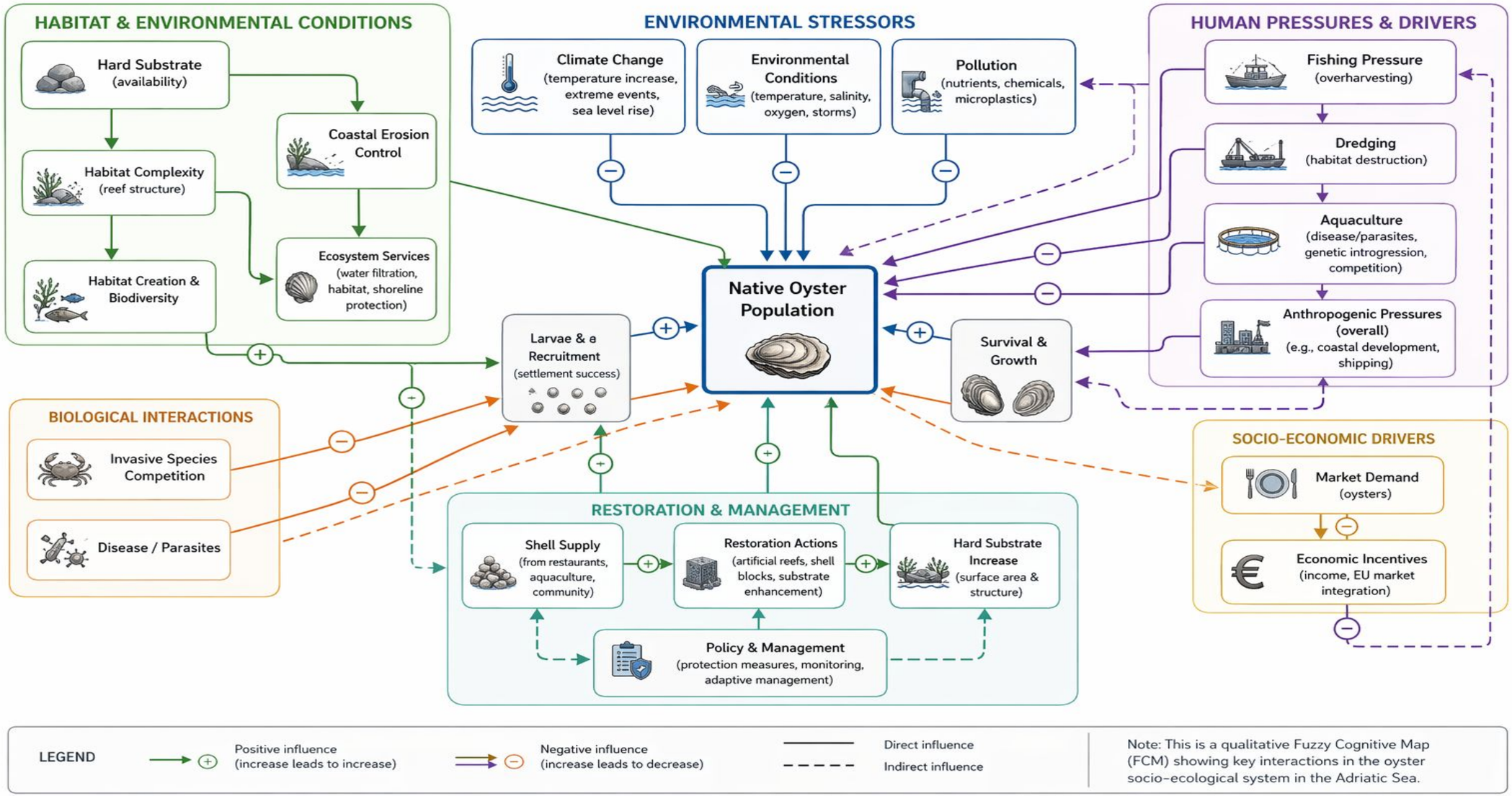
**Governance and ownership conflicts**
Competing interests, responsibilities, scaling

**Scientific uncertainty in system**
Limited time series, strong outcome dependence on location, changes due to climate change

**Disrupts existing benthic community**
Potential impacts on current ecosystem structure and species

**Short-term vs long-term value mismatch**
Benefits realized in the long term, costs felt in the short term

# The Socio-Ecological System



# WHO IS IN OUR LIVING LAB?

A multi-stakeholder partnership working together for native oyster restoration in the Adriatic Sea.


**TOGETHER FOR A COMMON GOAL:**
Restore native oyster reefs, improve ecosystem health, and secure sustainable benefits for people and nature.

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# HOW DID WE CO-DESIGN THE SOLUTION WITH THEM?

A living lab approach for native oyster reef restoration in the Adriatic Sea

We **co-create**, **test** and **adapt** solutions together in the real world.

## WHO IS INVOLVED?

**FISHERMEN**
Local knowledge, site insights, practical experience

**AQUACULTURE OPERATORS**
Shell supply, technical advice, operational collaboration

**RESTAURANTS & MARKETS**
Shell collection, market knowledge, consumer connection

**GOVERNMENT AGENCIES (Local, National, EU)**
Regulation, permits, policy alignment, enforcement

**RESEARCH & ACADEMIA**
Science, monitoring, data analysis, modelling

**NGOs**
Conservation expertise, facilitation, network and coordination

**LOCAL COMMUNITIES & CITIZEN SCIENTISTS / DIVERS**
Local support, monitoring, data collection, feedback

**RESTORATION PRACTITIONERS / LIVING LAB (PILOT)**
Design, build and implement restoration actions

## 1 CO-EXPLORE & UNDERSTAND

Define the problem together

- Share local knowledge
- Map historical oyster beds
- Identify key pressures and opportunities

## 2 CO-DESIGN SOLUTIONS

Generate and refine options together

- Co-design workshops and scenario building
- Explore restoration techniques and sites
- Assess feasibility, benefits and risks

## 3 CO-EVALUATE & DECIDE

Evaluate and agree on the best approach

- Multi-criteria assessment
- Discuss trade-offs
- Agree on priorities and actions

## 4 TEST TOGETHER IN THE REAL WORLD

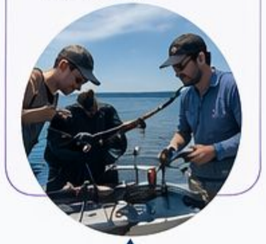
Implement and test solutions in the pilot

- Build and deploy oyster reef structures
- Establish shell recycling system
- Apply management measures

## 5 MONITOR, LEARN & ADAPT

Learn together and improve

- Monitor ecological and social outcomes
- Share results and experiences
- Adapt and scale what works



**Continuous feedback and iteration**

## TOOLS & ENABLERS

**Mapping & ROV surveys**
Identify suitable sites and monitor habitats

**Participatory workshops**
Co-design, build trust and align perspectives

**Shell recycling network**
From restaurants and aquaculture to restoration

**Data platform**
Share data, results and lessons transparently

**Open communication**
Regular updates, feedback and co-learning

## HOW DECISIONS ARE MADE

- Decisions are made collaboratively through open dialogue and consensus-building.
- We use transparent criteria (ecological, social, economic, feasibility).
- All voices are heard.
- Government partners provide final regulatory approval.

## WHAT WE CO-CREATE

**Restoration designs**
Reef structures, materials and methods

**Site selection and zoning**
Prioritized areas for restoration and protection

**Management measures**
Fishing restrictions, monitoring plans, enforcement ideas

**Resource networks**
Shell supply chains, partners and logistics

**Knowledge & capacity**
Shared learning, training and citizen science

## OUR SHARED GOAL

Restore native oyster reefs, improve ecosystem health and water quality, support local livelihoods and secure long-term benefits for people and nature in the Adriatic Sea.

This is a living lab: real people, real places, real impact.

Together we co-create a resilient future for the Adriatic Sea.

Local knowledge + Science + Collaboration = Lasting change

# SUSTAINABLE BUSINESS MODEL: EUROPEAN OYSTER RESTORATION

## 1. PARTNERS / STAKEHOLDERS

### A. Leading team

- Scientific partners (main managers / coordinators)
- Local municipality (funding, public sector negotiation, community engagement)
- Private sector investors
- Environmental foundations / Philanthropic orgs

### B. Full list of stakeholders

**Scientific partners:** Research companies, research institutes, university research groups

**Public sector partners:** Ministry of the environment (department of marine), schools

**Private sector partners:** Fishermen, aquaculture companies, restaurants

**Local community:** Municipality, citizens (independent), organised groups, NGOs

## 2. KEY ACTIVITIES

### Conservation measures

- Implement a coherent MSP plan

### Scientific research

1. Habitat Mapping (sonar, ground truthing with ROVs)
2. Data scoping (literature, public databases, questioning relevant people)
3. Identify priority areas
4. Monitoring activities (underwater surveys, divers, ROVs etc)
5. Evaluation of recruitment and settlement

### Stakeholder engagement

1. Substrate creation
2. Create concrete blocks from shells
3. Deployment
4. Workshops (continuous)
5. Citizen science initiatives

## 3. VALUE PROPOSITION

### ENVIRONMENTAL

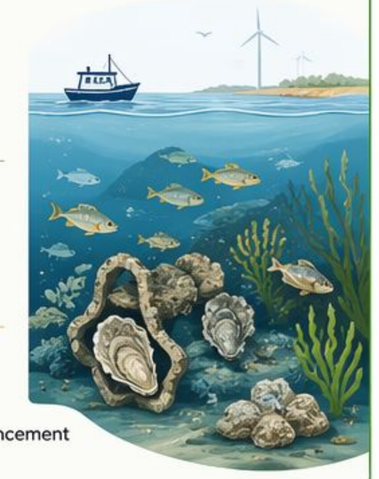
- Artificial reef
- Biodiversity

### ECONOMIC

- Fisheries
- Aquaculture
- Ecotourism

### SOCIAL

- Food security
- Technological advancement



## 4. RESOURCES

### Human capital

- Labour
- Volunteering

### Physical capital

- Equipment
- Boats
- Machines
- etc.

## 5. PRODUCTS / SERVICES

**Provisioning services (Products / Goods)**
- Food (oysters)
- Fish (fisheries & aquaculture from improved conditions)

**Regulating services (processes)**
- Water quality

**Cultural services (non-material)**
- Local ecological knowledge (for community)

**Supporting services (underlying functions)**
- Prevention against coastal erosion
- Improved overall ecosystem health

## 6. CUSTOMERS / TARGETS / AUDIENCE

- Local communities
- Fisheries & aquaculture sector
- Tourism operators
- Policymakers & public sector
- Researchers & academic institutions

## 7. CHANNELS / DISTRIBUTION

| Direct engagement | Digital engagement | Scientific dissemination |
|---|---|---|
| Round tables, Workshops | Social media | Papers, Conferences, Policy briefs, Technical guidelines |

## 8. COST STRUCTURE

### Direct costs

- Coordinating team: salaries, team expenses (meetings)
- Field activities of restoration: salaries, expenses of structures and logistics of placing them
- Monitoring

### Indirect costs

- Conservation (No trawling – No income)
- Eco-tourism, boats
- One-time, short-term and long-term costs

## 9. REVENUE STRUCTURE

**Blended model: financing from different sources**

1. EU funding
2. Companies that want to finance the project (Blue carbon credits, Biodiversity offsets for environmental damage, Image of the company)
3. Companies – Beneficiaries contribute at a smaller level (Local eco tourism owners, Hotels, groups, divers, restaurants)
4. Investors (larger level investment) contribute on a bigger scale (Aquaculture, Fisheries)

**Restoring oyster habitats today for a resilient ocean, thriving communities and a sustainable future.**

# What do we need from the Municipality?

## 1. Community Mobilisation & Engagement

- Facilitate citizen participation and local ownership, Support outreach and dissemination (events, communication channels)

## 2. Institutional Support & Representation

- Strengthen alignment between local needs and policy decisions
- Support permitting processes through coordination with relevant agencies

## 3. Strategic Partnership

- Formal collaboration as a project partner
- Integration of restoration into local planning and sustainability strategies
- Long-term commitment to stewardship and coastal resilience

## 4. Enabling Resources

- In-kind support (venues, staff time, logistics, spaces for workshops, co-creation, and stakeholder meetings)
- Potential co-funding or facilitation of funding opportunities

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# Remote Sensing (Satellite Data)

## Turbidity / Suspended Sediments

Dredging and oyster harvesting disturb the seabed → sediment rises → water becomes more turbid.

**Satellite Use:**

- Sentinel-2 (2015 onwards)

  (10m, better for coastal detail)
- Landsat (1970's onwards)

  (30 m, longer time series)

**Indices Tested:**

- NDTI (Normalized Difference Turbidity Index)

**Useful Indices:**

- Simple Red / Green reflectance increase
- TSS (Total Suspended Solids proxies)

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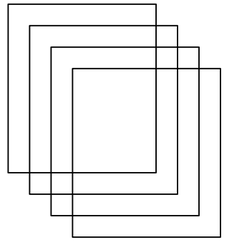
# Normalised Difference Turbidity Index (NDTI)

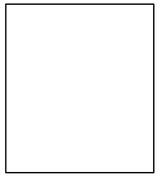
Annual Mean

Time Series Stacking

Red and Green Band

Cloud Cover  10%







Sentinel-2

2019

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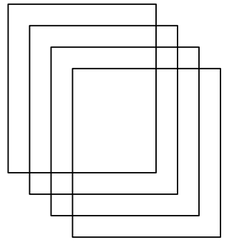
# Normalised Difference Turbidity Index (NDTI)

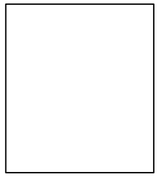
Annual Mean

Time Series Stacking

Red and Green Band

Cloud Cover  10%







Sentinel-2

2023

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# 🌊 Policy Dimension: Oyster Reef Restoration (North Adriatic, Croatia)

**What policies enable our solution?**

**EU Policy Framework (Main Drivers)**

- **Nature Restoration Law (2024):** Directly relevant as it mandates projects like oyster reef restoration
  - Restore **20%** of EU seas by **2030**
  - Requires national restoration plans (by 2026)

*Other Policy drivers:*

- **Marine Strategy Framework Directive (MSFD)**
  - Achieve **Good Environmental Status (GES)**
  - Oyster reefs improve biodiversity & water quality
- **Maritime Spatial Planning Directive**
  - Organises **sustainable use of marine space**
  - Enables allocation of areas for restoration
- **Common Fisheries Policy (CFP)**
  - Reduces destructive fishing impacts
  - Protects restored reefs
- **EU Biodiversity Strategy 2030**
  - **Promotes nature-based solutions**
  - Supports funding & prioritisation

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MAKE WAVES FOR COASTAL RESTORATION

# Thank you :)

# Any questions?

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