



# Enhancing ethics and economics in aquaculture using solutions based on IoT and digital automation

*Contamination between marine RRI knowledge and Industry4.0 for future aquaculture*



## 2019

## WORKSHOP REPORT



The MARINA project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under GA No. 710566



Enhancing ethics and economics in aquaculture using solutions based on IoT and digital automation.

## *Workshop Outcomes*

**25<sup>th</sup> March 2019**

**12:30 – 17:30**

National Research Council - Liaison Office

Rue du Trône, 98 1050

**Brussels (Belgium)**

*Contamination between marine RRI knowledge and Industry4.0 for future aquaculture: a view to co-constructing a common understanding of concerns and barriers on the adoption of RRI approach in the context of shared I4.0-marine R&D and policies*



## Why enhancing ethics and economics in aquaculture?

Aquaculture is the world's fastest growing food industry and it has the responsibility to face the growing global population feeding. Indeed, as the world's population continuing to expand rapidly, developing innovative and sustainable food sources is a key priority for Europe (STOA, EPRS, 2015). This consideration identifies a key-issue in the marine sector with **a direct and huge social impact**.

However, there are concerns over the potential environmental implications of such expansion. Ocean pollution and diseases from aquaculture or private fish farming are well known and the growth of sustainable aquaculture is mandatory if one of the targets would be also the preservation of wild fisheries populations and their ecosystem.

Notably, concentrated **fish means concentrated waste, that combined with uneaten food pellets impacts the local environment by polluting the water and smothering plants and animals on the seafloor. Moreover, diseases grown into pens could easily affect** wild fish population, and the typical harvesting chemical treatments could produce direct and indirect effect on human health and other organisms.

Let's just think about the impressive impact that the forecasted multiplier effect of all these problematics could have on the global environment.

It's worth to underline that not all types of aquaculture entail marine pollution, but the whole sector faces a number of challenges around sustainability that new technologies can contribute to overcome. Indeed, several IT-solutions are on the run and other are being developed and field tested. The so called 4.0 approach adopted for the automatization of the industrial field has started to be applied – even partially – to the marine sector. Topic unmanned IoT technologies, based on sensors network for continuous monitoring and management of pens could be applied in large scale. They will help solving several issues, such as: security, fishes health status, food quality and traceability, environmental safety and preservation, wild fish population preservation, economy.

It's a very impacting scenario that leaves unsolved some fundamental questions and opens new ones about the overall governance of aquaculture.

What about overall economy, would the use of more expensive systems increase food prices and change the level of access to food? How to deal with the production of food for fishes? How to ensure digital security? Which processes could be used to decrease the harmful chemicals in the water, such nitrates, maybe reducing them to non-toxic levels so to be reused for other purposes? Does it make sense to match other kind of agro-food productions, such as the emerging aquaponic, listed among the 10 most promising and disruptive technologies?

With these perspectives, the marine domain represents a cross-cutting arena where reasonably multidisciplinary approach and mapping efforts shall lay the basis of a comprehensive framework for sustainable management taking into account digital, environmental, wealth and broader societal aspects. When the industry4.0 and the marine sector overlap, the RRI approach is mandatory. This is a challenge and the planned cross-sectoral workshops will drive a path towards the exploitation of methodologies and policies helping the players and policy makers to remove barriers limiting the adoption of RRI.

We will create added value through a collaborative debate by using participatory and interactive methods, among different subjects, organisations and initiatives invited. Based on a 3 triggering questions, we will use them as interaction start-up enabling the discussion of potential solutions and methods bounding the different stages of aquaculture governance: retrofitting, long-term planning, new mixed methods.



## The Workshop programme and speakers

|       |   |
|-------|---|
| 12:30 | <i>Arrival, registration and light lunch</i>  |
| 13:30 | Welcome and workshop' themes introduction   |
| 13:45 | The MARINA project and its results  |
| 14:00 | The sustainability of aquaculture in the Med area   |
| 14:15 | How the RRI Roadmap may be applied in the sector of Aquaculture?                                  |
| 14:30 | From preventing to recycling marine litter from the aquaculture sector.                           |
| 14:45 | New Methodologies & Technologies for Smart Aquaculture: The Case of Aquaponic Integrated Systems. |
| 15:00 | CETMAR as a specialised interface for the marine realm, COCKLES project as an example.            |
| 15:15 | TERRITORIA –the RRI experience of local and regional authorities.                                 |
| 15:30 | Questions & answers   |
| 16:00 | <i>Coffee break</i>   |
| 16:15 | Sustainable technologies for aquaculture  |
| 16:45 | Perspectives for cross-community engagement   |
| 17:15 | Highlights: the potential connections   |
| 17:30 | <i>End of the workshop</i>  |

### Our Speakers

**Federica Stella Blasi** CORE Lab - University of Salento (ISEPA Project)

**Fien De Raedemaeker** Flanders Marine Institute (Aqua-LIT Project)

**Rosa Fernández Otero** CETMAR - Centro Tecnológico del Mar. Fundación Cetmar (COCKLES Project)

**Fernando Ferri** CNR Institute for Research on Population and Social Policies (MARINA Project)

**Chritopher McInness** EURADA - European Association of Development Agencies – Industry 4.0 team (TERRITORIA Project)

**Xenia Schneider** XPRO Consulting Limited (MARINA Project)

### And with the contribute of

**Ferdinando Boero** University of Naples Federico II (European Marine Board, CoCoNet Project)

## The workshop at a glance

The workshop “*Enhancing ethics and economics in aquaculture using solutions based on IoT and digital automation*”, held the 25<sup>th</sup> March 2019 in Brussels, had the mission to start the analysis of the potential connections between marine RRI knowledge and digital automation technologies applied by the industry4.0 processes. Its main scope was to build a view to co-constructing a common understanding of opportunities for the adoption of RRI approach in the context of shared industry-food-marine R&D and policies.

This “bridge” defines the transferability of the MARINA results in the industry 4.0 related technologies and innovation processes on one hand, and enrich the knowledge base of MARINA and the other participating projects with valuable insights.

After a brief introduction by the moderator, Mr. Francesco Niglia (KOYS), welcoming the participants, introducing the key-leverage elements of the workshop and explaining the planning for the whole day, a round table presentation kicked-off the first session of activities: the analysis of current initiatives cross-relating the domains of a) marine and ocean water, b) pollution and waste recovery, c) aquaculture, d) use of technologies. **14 people joined the discussion**, their composition being: **4** representatives of R&D Centres, **3** representatives of policy making bodies, **3** representatives of industry domain, **1** representatives of Local Administrations, **3** Association of stakeholders, complying with the value chain of the innovation4.0 in food, fisheries and health sectors.

The discussion was preliminarily focused on the introduction of the social problem to overcome or even smooth: the environmental unsustainability of the current aquaculture. Some hypotheses have been made when arguing about the commonalities and shareable results of **5** projects:

- [MARINA](#) engaging actors in order to share knowledge, include the citizens’ vision and societal needs, create a synergy between research & innovation and the environmental safeguard.
- [Aqua-Lit](#) aiming at increasing the understanding, awareness and availability of solutions that tackle marine littering so a potential transformation towards a less polluting sector becomes possible.
- [ISEPA](#) aiming at overcoming the existing technological limitations in aquaponic plants by exploiting research in biology and biotechnology, and by increasing the *functional* and *organoleptic characteristics* of current aquaponic food products (fish and plants).
- [COCKLES](#) providing meaningful environmental, societal, cultural as well as economic benefits to coastal but are threatened by disease and sub-optimal management.
- [TeRRitoria](#) based on the idea that RRI approaches, policies and practices, developed so far at the level of research institutions, should also be adapted and implemented to that of regional and territorial governance.

The workshop was driven towards the evaluation of the interest of the Industry4.0 and the aquaculture-related communities in inheriting the MARINA-RRI knowledge base and update it also by methods developed and services offered by MARINA-RRI partners, the [Roadmap](#) above all. At this aim, the [European Association of Development Agencies](#) provided interesting overviews about the potential mutual opportunities to bridge Industry, RRI and Territories by deploying the MARINA’ results.

A **collaborative debate** was started by introducing two triggering questions “*Is it possible (and how, in case) to scout technologies enabling the ethical approach?*” and “*Which are the economic boundaries that prevent from the adoption of innovation?*”. These have been the start-up enabling the discussion of potential solutions and methods bounding the 3 different layers of aquaculture4.0’ sustainability: technology, economy, environment, paving the way for the **exploitation of results** among different projects and between projects and the stakeholders’ network.

Finally, a brainstorming round-table was used to sketch some hints and recommendations about the questionnaire expected to gather information from the community.

## The social problematic at the base of the debate

The whole workshop focused on the need to find solutions to overcome societal problematic such as the unsustainable aquaculture and the marine littering, by merging the knowledge of the marine and industry sectors.

The **sustainability of aquaculture** in the Mediterranean Area, discussed thanks to the contribution of prof. Ferdinando Boero (University Napoli Federico II – CNR – IOS). It started with the assumption that the economic capital ignores the natural capital, because it dictates a continuous growth and the Nature preservation is perceived as a threat to economic development. This is also a matter of global sustainability.

In recent times the concept of sustainability is becoming prevalent, at least in theory. The report “[Marine sustainability in an age of changing oceans and seas](#)” clarifies that the scope of sustainable development governance has expanded considerably with the conceptualisation that has emerged being one that integrates economic and social development with environmental protection. Progress across all these so-called pillars of sustainable development in a consolidated manner is seen as critical to its achievement. Ensuring that economic and social development occurs within and respects the limits of environmental sustainability is a profound challenge.

Aquaculture takes part in this big sustainability analysis. In the sea we still take resources from natural populations even though we shifted from artisanal fisheries to industrial fisheries. Industrial solutions, till now, had led to greater problems than the ones they solved; the improvement of the technologies and solutions leading to fast economic growth (*indeed fisheries technologies led to enormous gains in terms of economic capital*) had a worst consequence: **the natural capital (fish) became commercially extinct** in overfished areas (the whole world) and the current aquaculture based on carnivores **is not more sustainable**.

The solution to overfishing could be **to rear algae, molluscs and herbivorous fish**, and/or return to artisanal fisheries, and/or abandon industrial fisheries, and/or restore the natural capital with networks of Marine Protected Areas. In line of principle, the main recommendation about this issue is to anticipate demands for increased food biomass from the sea that will come from human population growth, supported by greater commitment to policy development and knowledge building on how to improve the ecological efficiency of ocean harvest. **This includes exploring the potential for ecologically efficient aquaculture and sustainable seafood from species groups from the lower levels in marine food webs.**

The other social and environmental issue discussed has been the **Marine Litter**. Marine litter is now recognised as a persistent problem affecting the seabed, the water column and coastlines. It poses risks to a wide range of marine organisms through ingestion or entanglement. Those risks threaten economic impacts for local authorities and for a number of economic sectors, for example aquaculture, tourism and fishing. OSPAR monitoring in the North Sea has shown that beaches have an average of 712 litter items per 100 m (OSPAR Commission, 2010), but areas where ocean currents converge have substantially higher concentrations. Monitoring of plastic on the seafloor has only just commenced. Some 65 % of items monitored on beaches are plastic, degrading very slowly over hundred-year time scales and prone to breaking up into small particles (microplastics).

Given the harm it causes to marine wildlife, coastal communities, ecosystems and maritime activities, and the effects it has on economies, human health and safety, marine littering is a problem **that must be tackled from different angles**. Even though still not being the most concerning source of marine pollution, the Commission is studying the contribution of aquaculture to marine litter and examine a range of measures to minimise **plastic loss from aquaculture**, including the possible adoption of a Best Available Technique reference document for aquaculture installations. Moreover, the **EU Circular Economy** proposes an aspirational target of **reducing marine litter by 30% by 2020** for the ten most common types of litter found on beaches, as well as for fishing gear found at sea, to address specific waste challenges.



## The MARINA project and its RRI Roadmap

The MARINA project, presented by Dr Fernando Ferri (CNR – IRPSS), focuses on the promotion of the RRI to meet marine challenges. In MARINA, we have been talking about Responsible Research and Innovation as a concept focusing on sustainability. We have identified RRI with sustainable research and innovation, which leads to Sustainable economic and social growth and thus to a blue, green and inclusive society. The **scope** of MARINA has been two-fold:

- creating an all-inclusive Knowledge Sharing Platform for catalysing and federating the convergence of already existing networks, communities, online platforms and services;
- addressing marine research issues and topics according to Responsible Research and Innovation (RRI) principles.

In line with its mandate, MARINA has promoted a large debate on the marine challenges engaging stakeholders from the quadruple helix (i.e. scientists, civil society actors, businesses, policy makers) in a knowledge building and sharing process with a view to discussing those issues and their potential solutions, while adopting the perspective of Responsible Research and Innovation (RRI). Seven main instruments have been deployed: **Information process** (Ontology, Taxonomy, Info Sources), **MML Workshops** (Citizens awareness, Stakeholders Dialogue), **Knowledge Sharing Platform** (Personal pages, Networking, Databases, Events sharing, Knowledge sharing, Working spaces, Community management), **Spillover** (Best practices, Lessons learnt, spillover, roadmap), **Policy mobilization** (Policy briefs, Joint events, Policy needs), **Communication** (Exploitation, Exhibition, Communication, Dissemination), **Open Data** (ICTs: Json, Wiki).

All the knowledge is built and shared in the MARINA Knowledge Sharing Platform

The MARINA platform is used to interact and discuss on innovative and responsible approaches, actions and researches, facing marine and societal challenges. Current **results** of MARINA are:

- MARINA organized 45 Mobilization and Mutual Learning (MML) workshops and their results are shared in the Events section on the MARINA Platform.
- Starting from the MML workshops, 504 Lessons learned and Good practices aiming to facilitate the organization of workshops in the perspective of RRI were extracted, classified and made accessible on the MARINA Platform.
- Based on the MML workshops, the Lessons learned and Good practices, a Roadmap has been defined.
- An RRI Roadmap.

The RRI MARINA Roadmap has been discussed and introduced by Mrs. Xenia Schneider (XPro Consulting limited), and it represents one of the most relevant assets developed in the MARINA project. The RRI Roadmap facilitates research and innovation processes and actions to focus not only on the technical and scientific solutions but also on responsible growth, building trust among actors, mobilising them to share their knowledge and experience, create together new opportunities by defining a common vision and a common action plan, to collaborate and cooperate to implement it and to create more opportunities for sustainable economic and social growth.

**Aims** of the RRI Roadmap are:

- Provide an approach for addressing a challenge through the application of RRI
- Involve diverse and multidisciplinary stakeholders
- Initiate actions effectively using RRI
- Address effectively a societal challenge through active stakeholder involvement



The RRI Roadmap has 8 Milestones. Each Milestone has defined steps and predominant RRI dimensions. Within each milestone and between two milestones there are communication activities. The intensity communication activities increase as we move to the later milestones:

- Identify Needs
- Motivate Change
- Engage
- Ideate and Frame
- Co-Design
- Co-Construct
- Measure and Adjust
- Intensify

Notably, the approach adopted to start understanding the social issues to solve is based on the **STeePLe** (Social Factors, Technological, Economic, Environmental, Political, Legal, Ethical) **methodology**.

- Social factors relate to cultural aspects, attitudes, beliefs that affect addressing the challenge (e.g. history, social ethics, demographic changes, lifestyle factors, labour/social mobility, income, attitudes...)
- Technological factors relate to technological innovations, barriers, enablers, incentives and how these impacts the challenge (e.g. local and global research and development, innovations, funding...)
- economic factors relate to economic policies, economic structures and to what degree the economy impacts the challenge and vice versa (e.g. local economic growth, employment, consumer confidence, seasonality, growth, external influences...)
- environmental factors are ecological and environmental aspects that affect and get affected by the challenge (e.g. environmental protection regulations, stewardship, waste management, sustainability, clean air and water, energy, attitudes towards ecology...)
- Political factors are pressures and opportunities brought by policies and to what degree these impact the challenge (e.g. policy trends, conflicting policies, local/ regional/ national governmental changes, lobbying and pressure groups, lack of governance, global influences...)
- Legal factors relate to policies and regulations that may have direct or indirect impact on the challenge (e.g. industry regulations, competition regulations, taxation, urban and environmental policies, health and safety regulations...)
- ethical factors refer to the range of social factors that affect positively or negatively the challenge (e.g. morality, integrity, behaviour, social responsibility, negligence...)



## The Aqua-Lit project

The Aqua-Lit project, presented by Dr. Fien De Raedemaeker (Flanders Marine Institute), opened the window about the possibility to recycling marine litter from the aquaculture sector, starting with the assumption “*There are no global estimates of the amount of plastic waste generated by the fisheries and aquaculture sector* (FAO technical paper 615, 2017)” and “*Aquaculture is expected to be the sector that meets future demand for food, predicted to rise by 40 percent by 2030* (The State of World Fisheries and Aquaculture, 2018)”.

AQUA-LIT aims at increasing the understanding, awareness and availability of solutions that tackle marine littering so a potential transformation towards a less polluting sector becomes possible, and to provide a sustainable **toolbox of innovative ideas and methodologies** to:

- prevent marine littering from aquaculture activities
- have better monitoring schemes in place, and
- remove and recycle litter from the aquaculture facilities both before litter enters the sea and for litter already existing at sea.

In line with the new [EU Strategy for Plastics in a Circular Economy](#) and considering that aquaculture is the fastest growing food-producing sector, with an expansion rate of 8% per year, AQUA-LIT focuses on:

- Understand better how aquaculture activities (separate from fishing activities) are littering the Ocean through **monitoring and quantification frameworks**.
- Provide littering **preventive measures** that help reduce the input of litter from the aquaculture industry and that can be applied as the sector keeps expanding.
- Provide mechanisms that help **reduce the existing marine debris coming from aquaculture activities**, including the testing of best available techniques for aquaculture installations.
- Provide **solutions for recycling** the collected plastic waste, aiming towards a more circular economy, and
- Examine what **policies** need to be adapted or put in place to underpin these practical actions.

The methodology followed by the Aqua-Lit project includes 4 main steps:

- Mapping the state of play: Literature research, Aquaculture players, Existing tools;
- Set-up “Learning Labs” in the Mediterranean Sea, in the North Sea and in the Baltic Sea;
- Formalise a toolbox acting as a tide against marine litter by Preventing & reducing, Monitoring & quantifying, Removing and recycling. The toolbox will provide existing, upcoming and already implemented tools, case studies, best practices, a database and links between stakeholders in different regions;
- Scaling-up the tide by: providing Policies for less litter, funding a wave of solutions, establishing the transferability of the results, refining an Exploitation plan. In detail: Policy for less litter – it will support the development and implementation of policies to reduce marine litter from sea-based sources, notably from the aquaculture sectors. A set of policy recommendations will be developed and delivered; Funding a wave of solutions – Will gather the available funding opportunities related to tackling marine litter; Transferability of AQUA-LIT - It will scale-up the toolbox to outermost regions and other geographical sea basins by creating webinars with key stakeholders from those other geographical regions and by creating direct links with them along the project; Exploitation plan- It will provide long-term sustainability of the toolbox after the project’s life.



## The ISEPA project

The ISEPA project, presented by Dr Federica Stella Blasi (CoreLab – Università del Salento), is performing a research about New Methodologies & Technologies for Smart Aquaculture: Aquaponic Integrated Systems. ISEPA is the acronym of Improving Sustainability, Efficiency and Profitability of large-scale Aquaponics, is a PPP project whose **main objectives** are:

- Design smart I-s aquaponic plants overcoming the existing technological limitations
- Develop highly innovative products by exploiting research in biology and biotechnology
  - Increase the functional and organoleptic characteristics of current aquaponic food products (fish and plants)
  - Reuse production waste (e.g. fish skin) for pharmaceutical a/o nutraceutical purposes

Aquaponics stands for aquaculture + hydroponics, and it is a combined culture of fish and plants in recirculating *closed-loop* systems, such as:

- FOOD is fed to the FISH which they convert to AMMONIA
- Naturally occurring BACTERIA convert the ammonia into NITRITES and then NITRATES
- The PLANTS absorb these NUTRIENTS while cleaning and filtering the water
- The WATER returns back to the fish tank and the CYCLE repeat

**Why is Aquaponics so promising?** *“The versatility of many aquaponics systems means that they would potentially allow for the growing certain food-types in atypical locations, such as urban areas. [...] this could help to improve the resilience of food supply-chains as food would then be produced much closer to where it would be consumed.”*

This approach is expected to face the two greatest threats to the future food and farming system:

- **Growing** URBAN population
- Environmental, biological, economic, social and geopolitical **stresses** and **shocks**

There are some threats, anyway, that shall be smoothed:

- Aquaponic is still low-tech based;
- It is characterised by a labour-intensive approach;
- Quite all the plants focus on the **same cheap food products**: Nile Tilapia and lettuce.

The design of aquaponic systems closely mirrors that of recirculating systems in general, with the addition of a hydroponic component and the possible elimination of a separate biofilter and devices (foam fractionators) for removing fine and dissolved solids. It is possible to automatize it, making it high-tech and by creating a **stable dynamic balance** between 2 different ecosystems,

- **Collected data** come from deployed sensors, **Database** for data history and statistical analysis and a Cloud application: **Real-time data processing** and operative strategy based on data and algorithms
- **Smart sensors** (low-power devices) for environmental parameters detection (DO, PH, Temperature, etc.), and **Smart actuators** for automatic system management (PH control algorithm, heater, aerator, oxygen system, etc.)
- GUI (User interface), Mobile/Remote control, Alert
- Modular and flexible system

Technology will allow to control the system like a production process, perfecting it in real-time, by relying on the data collected by the sensors. IoT plus Machine Learning will allow to replicate the conditions applying in the natural habitats of fish and plants, provided the set energy consumption restrictions.

## The COCKLES project

The Cockles project, presented by Dr Rosa Fernández Otero (CETMAR), targets at restoring cockle shellfisheries and its ecosystem services in the Atlantic Area. Cockles is expected to provide meaningful environmental, societal, cultural as well as economic benefits to coastal but are threatened by disease and sub-optimal management in ES, PT, FR, IE and UK. COCKLES project will restore and increase cockle production and the services it provides in the Atlantic Area. For this, it will address the characterization and health of natural populations, study the main threats to the species, increase the understanding of the role cockles play in the environment, the services provide it to nature and their value to humans, develop tools and techniques to increase production, enhance biodiversity and improve management of this emblematic asset.

This project will restore and increase cockle production and the services it provides in the Atlantic Area, using the following objectives:

- To assess the health, diversity and interrelationships of cockle populations across the AA by characterizing population dynamics, genetic diversity and larval transport, threats from disease, pollution, invasive species and climate;
- To quantify the wider economic, societal and cultural benefits from ecosystem services provided by cockles (fishery, aquaculture, biodiversity, food for birds, tourism, cultural services), by surveys, interviews and socio-economic analysis;
- To provide new techniques for cockle management by developing new technology and procedures for cockle bed restoration, hatchery technology for seed production, selective breeding programmes to produce disease-resistant and fast-growing strains, and conservation of genetic structure/diversity;
- To provide guidance on best practice for producers, administrations, environmental agencies, and NGOs, by evaluating and sharing best practice across the AA and optimizing management through mutual learning. This will result in improved cockle production, a strong, viable and sustainable industry, with recognized societal and biodiversity benefits.

**Expected outputs** of the project are linked to the strategies for capitalisation, namely:

- Maps and datasets of cockle populations
- Cockles environmental function
- Reproductive health survey
- Population genetics
- Ecosystem services assessment
- Risk management guidelines
- Basic information for selective breeding
- Larvae dispersal
- Guidelines for cultivation
- A GIS platform
- A co-created management plan
- Guidelines and action plan for restoration
- A decision-support-system for promotion from a services perspective



## The TeRRItoria project

The TeRRItoria project, presented by Dr Christopher McInness (EURADA), aims to experiment with the adoption of Responsible Research and Innovation (RRI) approach in European regional and territorial R&I systems. The importance of developing a “Territorial RRI” may be better understood by taking into consideration the broader transitional processes affecting European society. In the view of TeRRItoria, with the shift from modern to the so-called post-modern society, both science and local governance are experiencing critical transformations. Such critical transformations are challenging the usual strategies and measures to promote social cohesion and economic development. In this framework, the overall objective of TeRRItoria is to experiment with the adoption of RRI approaches in European regional and territorial RRI systems, opening these systems to a wider set of actors. TeRRItoria is based on the idea that RRI approaches, policies and practices, developed so far at the level of research institutions, should also be adapted and implemented to that of regional and territorial governance. Therefore, the project will contribute to developing what can be called a “Territorial RRI” by developing a set of transformative experiments in 5 European selected territories – 4 regions and 1 municipality, that is:

- Region of Central Macedonia (Greece)
- Region of Emilia Romagna (Italy)
- Region of Trøndelag (Norway)
- Region of North-East (Romania)
- Municipality of Gabrovo (Bulgaria)

**Overall objectives** of the project are:

- Help R&I ecosystems reach out to society to involve citizens
- Contribute to Open Innovation, Open Science and Being Open to the World
- Introduce RRI to the governance of the region’s R&I system through the keys of Science Education and Public Engagement.
- Creating a structured methodology for RRI’s inclusion in RIS3 (for post-2020).
- Develop and activate a gender equality plan for regional R&I systems including excluded groups (women and minorities).
- Creating a Quadruple Helix action group on R&I Gender and Social Inclusion; including RRI indicators in monitoring phase of S3 implementation.

The **methodologies adopted** are:

- explore how the RRI keys may be inserted in S3 design, implementation, and monitoring.
- explore how R&I systems can be more inclusive.
- experiments thus seeks to input RRI into R&I systems and create institutional change in the direction of RRI.
- experiments will be transformative using policy dialogue.

## The cross-sectoral exploitation among projects

The preliminary joint exploitation activities include also the opportunity to look forward to cooperating into EU-driven initiatives, as outlined in the latest calls available for the workprogramme 2018-2020 and the forthcoming Horizon Europe main programme.

At this aim, the scopes of the cross-sectoral (Industrial-Food-Marine-RRI) community and the initial common understanding of concerns and barriers on the adoption of RRI approach in the context of shared industry-marine R&D and policies, show an interesting alignment with the topic offered by **key-societal challenges** such as:

- Overfishing in marine areas
- Meet the future demand for food
- Decrease marine littering and, overall, take care of the environment
- protect coast area and the marine environment surrounding
- Building the “food democracy”
- Improving job prospects of e.g. young people without upper-secondary qualification (NEETS)

The most interesting topics ask for **solution** providing:

- Contribute to increasing available, accessible, affordable and nutritious food and feed, while conserving natural resources and contributing to climate change mitigation (UN SDG 2).
- Contribute to policymaking in research, innovation and technology.
- Lay the foundations for and contribute to the sustainable management and protection of marine and coastal ecosystems to avoid significant adverse impacts (UN SDG 14) (sub-topic).
- Shorten the time span between research and innovation and foster economic value in the blue economy.
- Boosting technology transfer of AI, especially towards SMEs and non-technology sectors, and disseminating the economic benefits of AI to a large user base.
- Better value-creation from personal and proprietary/industrial data.

These solutions shall be based on **typical innovation assets**, as:

- Improve the professional skills and competences of those working and being trained to work within the blue economy.
- Deliver cloud services with work starting at technology readiness level (TRL) between 4 and 5 and achieving TRL between 6 and 7 or higher (sub-topic A).
- Improved standardisation and interoperability especially in the context of cross-sector applications and technology convergence (data, Cloud, IoT, connectivity a.o.)
- Increased connectedness among members of deep-tech startup ecosystems and their companies (startups and scaleups) and to the larger European business ecosystem seeking maximum synergies

And **require several RRI-related issues** to be ensured:

- Engage researchers, policy-makers, businesses (including SMEs), societal and cultural institutions, including NGOs and CSOs, public and private organisations, investors, experts, innovators and citizens
- Improve regional public policy that supports delivery of RRI to enterprises’ product, process and service design, production and distribution.
- Respect the identity of the coastal and environmental and natural heritage values of each place



- Identify priorities, knowledge gaps and research and innovation needs, identify barriers and propose ways to overcome them
- Promote innovation in its broader sense (e.g. social innovation, governance, regulatory models etc.)
- Promote social cohesion and integration

Additional **opportunities** are sought among members of this Community:

- Joint business / venture:
  - Services and solutions to Associations and Agencies
- Joint research topics:
  - Mapping economic needs in high-populated areas
  - Improved technologies and processes

During the event, the participant started to outline paths of joint and collaborative exploitation among projects and initiatives.

In particular, it is expected that methods, solutions and applied ethics would be the assets shared by the marine-related initiatives, while improved performances and improved security would be the ones shared by the industry-related initiatives.

The **offer**, in terms of tools, services, methods and prototypes, is the following:

- ***Tools for cooperation and communication***
  - The MARINA-RRI Knowledge Sharing Platform
- ***Validated methods***
  - The Mutual Learning (MML) Workshops and World Café
  - Deployment of forecasting scenarios during the stakeholder's dialogues.
  - The RRI MARINA Roadmap
  - Learning Labs, focusing on the creation, observation and promotion of innovation actions, while engaging across all stakeholder groups. These LL bring to the analysis of the socio-economic, environmental and institutional contexts and to the identification of the challenges to move towards reduced impacts and integrated governance.
  - Knowledge Base Sharing about: Prevention & Reduction, Monitoring & Quantification, Removal & Recycling
  - General guidelines for circular economy and innovation planning by helping R&I ecosystems reach out to society to involve citizens in the governance of the changing nature of territory, deterritorialization and hyposocialisation of Scientific Research
  - New cooperative models and 4<sup>th</sup>-Helix approaches for shared governance of circular economy, based on territorial approach of RRI.
- ***Technologies***
  - Sensors / IoT, at the base of the ISEPA solution
  - 3D printing
  - Robots / Drones / Artificial Intelligence
  - Augmented Reality / Virtual Reality for a better monitoring of fisheries
  - Blockchain / Big Data to create a solid base for a new economy

The **leverages** and the **potential needs** are:



- **Potential needs / gaps**

- The decrease in catch and species diversity of fisheries in tropical coral reefs, exacerbated by interactions with other human drivers such as eutrophication and habitat destruction, that could be somehow overcome by restoring the overexploited fisheries and reduction of other stressors on coral reefs delay ecosystem changes. Human adaptation includes the usage of alternative livelihoods and food sources (e.g., coastal aquaculture).
- The low economic gains of the current aquaculture + aquaponic solutions, based on the production of “poor” food such as lettuce and Tilapia. This is a major threat in the scaling-up of these innovative food farming enterprises.
- The widespread presence of microplastics, either from use in products (such as exfoliants or industrial abrasives) or resulting from the fragmentation of larger pieces, and their potential uptake by filter-feeding organisms is of increasing concern, given the capacity of plastic particles to absorb, transport and release pollutants. Microplastics are accessible to a wide range of organisms at least as small as zooplankton, with potential for physical and toxicological harm such as limitations in growth and ecological efficiency. The consequences of plastic enrichment in the food web are still largely unknown and their investigation is a major research need.

- **Leverages**

- The knowledge base in marine, nanotechnologies and Nature and heritage governance, including best practices, technologies and list of potential stakeholders.
- The various EC recommendations, among all the need of a major research initiative into ecosystem-orientated approaches to ocean harvest that can address the demands for increased food biomass from the oceans to meet demographic and economic development. This research should build knowledge to inform options for increasing the overall ecological efficiency of ocean harvest and thereby the sustainable yield from the ocean. These options include examining the potential of sustainable seafood biomass from lower levels in the marine food webs and developing ecologically efficient aquaculture.
- The Sustainable Development Goal 14 'Life Below Water', stating that, by 2025: prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution. Moreover, the OSPAR Convention action plan, that identifies the options to address key waste items from the fishing industry and aquaculture, which could contribute to marine litter, including deposit schemes, voluntary agreements and extended producer responsibility. Both these targets could bring to a wider engagement of citizens and associations in the mutual cooperation for behavioural and technological improvement.

Some **key enabling stakeholders** are:

- The complete network of MARINA project: more than 1000 members contributing to the platform and seven communities federated. It is fundamental to exchange expertise among researchers, policy makers and users of marine heritage products.
- The network of CoreLab and Università del Salento, 10 Universities, 10 Associations / Districts, 3 big territorial Public Administrations, and 27 Industries.
- The EURADA network: agencies of economic and regional development and professionals working in economic development. EURADA builds capacity for its membership to exchange experience, promote RDAs, enhance territorial development programmes (i.e for SMEs). The network provides add value by sharing information on RDA strategies and territorial assistance programmes for enterprises, by acting as a conduit bringing together Europe's RDA, by disseminating EU policy, by managing and advising EU funded projects, by events (annual conferences, brokerage events, summer school and workshops).



- The CETMAR network: 750 overall members, 44 Centres, Institutes and Faculties, within which 170 research groups and 1800 researchers bring their expertise to solve marine and oceanic governance issues within 8 main areas: management of marine resources, international cooperation, training, technology transfer, fishing socio-economic analysis, technology of food production, technologies for marine monitoring.
- The network of Flanders Marine Institute, acting as **the** coordination and information platform for marine and coastal research in Flanders. It also promotes and supports the international image of Flemish marine scientific research and international marine education as a partner in various projects and networks.
- The network of MARIE project. MARIE provides a framework for regional RRI policies, including those with a sectoral scope. <https://www.interregeurope.eu/marie/>
- The European Factories of the Future ETP [www.effra.eu](http://www.effra.eu)
- Belgian industrial Research and Development [www.birdbelgium.com](http://www.birdbelgium.com)
- The Marine Industries Science and Technology Cluster <https://www.mistcluster.org>

## The open debate

The brainstorming session among participants focused on two main themes:

### Sustainable technologies for aquaculture

As general and shared consideration, the participants agreed that it is possible to scout technologies enabling the ethical approach only if the same technologies have been developed and validated along the RRI methods. Indeed, RRI can be understood also as an economic and social quality assurance system that can enable and push companies, public administrations, universities and research organisations towards sustainable research and innovation initiatives. RRI is as a social quality assurance system, which is applicable to private and public funded research and innovation. RRI is simply asking researchers, scientists, businesses, policy-makers and research funders to be responsible socially, ethically, environmentally and politically. At the same time, it's very important to rely on a trustable network of providers, that adopt the RRI methods, as well, in their business and operations. This is a general consideration whose validity goes across all the R&I sectors.

Always **check the impact of technologies** and the impact they could have, along the recommendations made by official EC and other reports

The aquaculture4.0 and the aquaponics system open the debate also on the issue of the education. Promoting education, training and more equal incomes for fishermen is mandatory when considering opportunities of synergies between the fisheries and aquaculture sectors. The advantages in terms of productivity and efficient use of resources are huge in aquaponics. It contributes to the solutions of some of the crucial problems our planet is facing: availability and use of potable and irrigation water, pollution of surface waters through animal farming, and management of fertilizer resources.

Beware that **the high level of qualification needed in aquaculture** and the small scale of the region market are two constraints of the synergies between the fisheries and aquaculture sectors.

The economic boundaries, on the other hand, could prevent from the adoption of innovation, so it's mandatory to start any innovation initiative by having a **clear picture in mind about environmental, profit and social goals**. Current aquaponic solutions, indeed, require a big investment against the low gains due to the (economic) poor fish, poor vegetables produced.

An idea could be to enlarge the market to a big population, through the creation of a common trust or binding the territories to adopt policy measures.

We need **to build trust and markets** (e.g. use of Telapia in cooking shows) or **parallel breeding** with high-gain fishes or **add a third economic food circle to aquaponic**, such as the insects farm breeding, so to enlarge to big market population.

About the marine litter due to the aquaculture, several questions are still open. These are about possible technological advancements in materials/processes, or understanding and monitoring where (and when) the material excites the system and become litter, or how can aquaculture waste be used.

We know that the main sources of litter from land include tourism, sewage, illegal dumping and open waste disposal sites. The main sea-based sources are shipping and fishing, including abandoned and lost fishing gear.

We need to **engage citizens** in the use of innovative solutions to support the decrease of marine littering

Citizen science is an emerging channel which can advance science and empower people interested in science by engaging them actively in data collection and research, particularly in science issues that affect their communities. There is a broad spectrum of citizen science initiatives, from simple observational programmes to coordinated, training-intensive environmental monitoring programmes (e.g. beach litter monitoring organised by local organisations). Citizen science initiatives enable people to learn about science and the ecosystem dynamics of natural communities. Citizen science initiatives can also enable



coordinated networks of volunteers to collect data that can inform our understanding of how human activities may be altering ecosystems.

We expect some of these boundaries to be smoothly enlarged up to a common definition of ethics between public and private sectors, supported by the public agency opinion as it's happening to the nanotech industry. On the other hand, evidence show that wider informed consultation, despite extending the initial timing of intervention on heritage sites, helped to smooth the whole process with a considerable time investment.

The **role of citizens** in the decision process of restoration of cultural heritage arisen some open questions:

*Shall citizens and users be informed about the kind of technology used in aquaculture plants surrounding their cities or coasts?*

*How could we elicit the actual interest of citizens in the technological processes behind innovation?*

### Perspectives for community engagement

This short session was devoted to ask for ideas and hints to maximise the activities and the engagement of the community of interest around this cross-sectoral issue. The first consideration was to increase the participation of the citizens to a behavioural change and towards the cooperation with policy initiatives regarding the Blue bio-economy.

**Increase awareness** about the possibilities to participate in the policy debate and in the global economy.

Another point of discussion was the need to check the resources and the funds available for starting public debates and innovation initiatives among community members. The first step will be to understand the estimated funds that the EC will allocate to specific topics of the forthcoming Horizon Europe programme. In the meantime, the community could discuss about the needs of the private sector, whose interest can be raised by a clear communication about the positive economic impact of RRI to common Research and Innovation activities and the ethic solutions for aquaculture.

We need industries and association to be interested in **ethic innovation**, by communicating and showcasing how the RRI and the proposed solutions comply with the **Global Sustainable Development Goals**.

The discussion focused on the transparency of the research, clearly required by the RRI principles and partially ensured by the **early phase tests** occurring in more and more initiatives. At this aim, the distribution of responsibility among stakeholders, that could increase the efficiency in both communication and operational activities, is mandatory.

The R&D topics of developed and assessed in MARINA shall be shared with the Community and constitute the base for new initiatives, starting from the workshop "Responsible Innovation in Sustainable Environments" to be held in September 2019.

We need to develop an **effective plan of events** for the next 12 months.



## The online survey

The scope of the survey is to complete the open debate occurred during the workshop, enlarging the discussion and the information gathering from a wider audience of experts, stakeholders and citizens.

The **information** we aim to gather are both quantitative (statistics) and qualitative (new ideas, opinions, etc.), such as:

- **Composition of responding audience**, needed to weight and evaluate the answers and, if needed, to improve the balance of the representation of each different target stakeholder;
- **Relevance of one or more RRI pillar** in the cross-sectoral domain of aquaculture and litter reduction in marine environment, with ICTs and responsive technologies;
- **Additional solutions and ideas** to be exploited through research, innovation or business paths among members of the community

The **target** of our survey will be:

- **Researchers** (private and public) representing Universities and Research Centres, in the domain of aquaculture, marine preservation, littering reduction, innovation at large, RRI;
- **Industries** involved in the domains of food production, automatization, monitoring and blockchain;
- **Citizens**, and Civil Society Associations, living the coastal areas or in areas surrounding them;
- **Municipalities** and **Local Administrations** owning or governing the aquaculture and coastal sites;
- **Policy Makers** (local, national, international)
- **Agencies, Associations** and **Organisations** dealing with the implementation of RRI principles, such as: gender equality strategies, open science, education and skills, application of ethics, etc.

The **sections** of the questionnaire will be:

1. Respondent profiling
  - a. Background (organisation, domain of R&D or policy)
  - b. Interest (scientific domain, RRI)
2. Opinion on responsible use of technologies for aquaculture optimisation and litter reduction
  - a. The role of RRI in restoration
  - b. The role of RRI in conservation
  - c. Other issues of RRI to be exploited
  - d. Ideas and solutions for use of technologies for aquaculture optimisation and litter reduction
3. Informed consent
  - a. Full details (name, email, affiliation) *[Optional]*

The survey is available at the following link <https://goo.gl/rA7CU6>



## List of Participants

| <b>Name</b>              | <b>Affiliation</b>   |
|--------------------------|--|
| Federica Stella Blasi    | CORE Lab - University of Salento                             |
| Giulia Bubbolini         | Centre for Innovation and Economic Development (CISE)        |
| Alexandra Caron-Strehlow | European Commission, DG Maritime Affairs and Fisheries       |
| Fien De Raedemaeker      | Flanders Marine Institute                                    |
| Linden Farrer            | European Commission, DG R&I                                  |
| Rosa Fernández Otero     | CETMAR - Centro Tecnológico del Mar. Fundación Cetmar        |
| Fernando Ferri           | CNR Institute for Research on Population and Social Policies |
| Luca Moretti             | CNR  |
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