Marine Data to Support Aquaculture in the Mediterranean and Black Seas

A virtual workshop by EATiP, Copernicus Marine and EMODnet

March 24-25, 2021

Contents

Executive summary

The virtual event 'Marine Data to Support Aquaculture in the Mediterranean and Black Seas' was held on March 24th-25th 2021. It followed the first workshops on 'Marine Data for Aquaculture', held in Athens on September 2019, and the virtual workshop for the North-Atlantic region, held in October 2020. This event was organised by the European Aquaculture Technology and Innovation Platform (EATiP), the European Commission's programmes Copernicus Marine (Copernicus Marine Environment Monitoring Service – CMEMS) and the European Marine Observation and Data Network (EMODnet), and the European Commission's general directorates for Maritime Affairs and Fisheries (DG MARE) and Defence, Industry and Space (DG DEFIS).

More than 70 participants from 17 different countries joined this invitation-only workshop. The participants were invited based on their, role and expertise, with an approximately equal distribution of representatives from public administration-government, academia and research, the aquaculture industry, non-governmental organisations (NGOs) and wider marine data providers and marine data services.

The overall mission of this event was to increase awareness and foster collaborative opportunities for the use of marine data to support the aquaculture sector in the Mediterranean and Black Seas.

EMODnet and Copernicus Marine Service are two key long-term EU data services providing access to integrated marine data spanning diverse marine environmental thematic areas, and human activities related to the sea (EMODnet). Both services are complimentary with principal focal areas on *in situ* data (EMODnet) and satellite-derived data and model outputs (CMEMS), including data flow and exchange between the two services, where relevant. In addition, each data service produces added value data products, including some where both EMODnet and CMEMS integrated data are used. These open access data resources already benefit a wide range of marine users, including policy makers, scientists, private industry and the public, and open up new opportunities for the sustainable blue economy, innovation and growth. In addition, Copernicus Marine and EMODnet are already collaborating at coordination and operational levels, with the first Memorandum of Understanding (MoU) in place since 2016, and others ongoing.

Building upon open data services, the objectives of the workshop were threefold. Firstly, to allow the aquaculture community to share experiences across regions, identifying gaps in marine data and the underlying challenges for the management of aquaculture farms. Secondly, to define the overall needs of a collaborative platform that would build upon existent marine datasets to improve the management and operation of aquaculture applications. And third, to define the structure of this platform as to support data ingestion from private stakeholders and redistribute it into the Copernicus Marine and EMODnet portfolios.

The workshop brought together a diverse group of stakeholders to share and exchange experiences on existing services, and to identify bottlenecks and opportunities for marine environmental data to support the aquaculture sector.

After an introduction to the existing EU data services, three consecutive break-out sessions were held in order to discuss needs and data requirements, followed by the organisational, management and financial aspects of the potential collaborative platform.

A large potential was identified to increase the visibility of showcases and best practices, and provide more targeted training sessions for the aquaculture sector.

There was a general consensus on the benefits that open access marine data could provide to the aquaculture sector, through existing services and initiatives, such as Copernicus Marine, EMODnet, and coastal agencies. Moreover, it was recognised there is a large opportunity for the aquaculture industry and value chain to share data – in particular baseline environmental marine data. Data sharing, from small-scale to large producers, would increase transparency, build trust in the sector, and support consumer awareness. Indeed, public acceptance was a strong argument and incentive to overcome the reluctance of the industry to share data. In addition, win-win benefits for the aquaculture industry through data sharing were explored, including the open and free access to higher resolution, standardised and integrated data and maps that could help inform operations at sea, thus reducing risk, uncertainty and costs.

Several gaps were identified when assessing the industry needs for marine data. It was recognised that spatial and temporal resolution – particularly in coastal areas - remains a challenge for the effective use of marine data by the aquaculture industry, e.g., for the allocation of zones to new aquaculture farms, and for the monitoring of environmental impacts in the operational phase.

Another outcome of the discussion was the suggestion to develop a standardised certification to go together with the collaborative platform. It was recommended that this certification should be free of charge for small-scale farms.

The definition of a clear strategy was deemed essential to the organisation and management of the proposed collaborative platform for marine data and aquaculture. As a start, a vision building process, involving key stakeholders, needs to be established. In this process, producer associations and clusters could act as transmitters to the smaller scale stakeholders. Moreover, the development of a mission statement and business plan was also discussed. It was proposed that it could profit from the experience of existing platforms and IT enterprises that are familiar with the corresponding models and data management. This step was seen to be the key to the successful initiation, organisation and management of the platform.

It was noted the initiation of the platform would most probably need some project-based financial support, including the support from national agencies. Financing for the ongoing management and operation of the platform needs to be based on a long-term vision, and include stakeholders at all levels. Whilst Copernicus Marine and EMODnet will continue to offer free of charge data, it was recognised that training and skill development, e.g., in the use of marine data for aquaculture operations would also be an important step forward to further stimulate the use of the existing data services by the aquaculture community.

All inputs from the discussions would be further considered by co-organisers and the wider community and, where possible, taken up.

Introduction

The workshop "Marine Data to Support Aquaculture in the Mediterranean and Black Seas" was held on March 24th-25th. It was organised by EATiP, Copernicus Marine Service and EMODnet, DG MARE, and DG DEFIS and followed the workshop held in October 2020 for the North-Atlantic region (virtually), and the first one on 'Marine Data for Aquaculture' that took place in Athens, in September 2019.

Seventy-five stakeholders from 17 different countries participated in the event – equally deriving from public administration-government, academia and research, the aquaculture industry, NGOs and wider data suppliers and marine data services (see Figure 1).

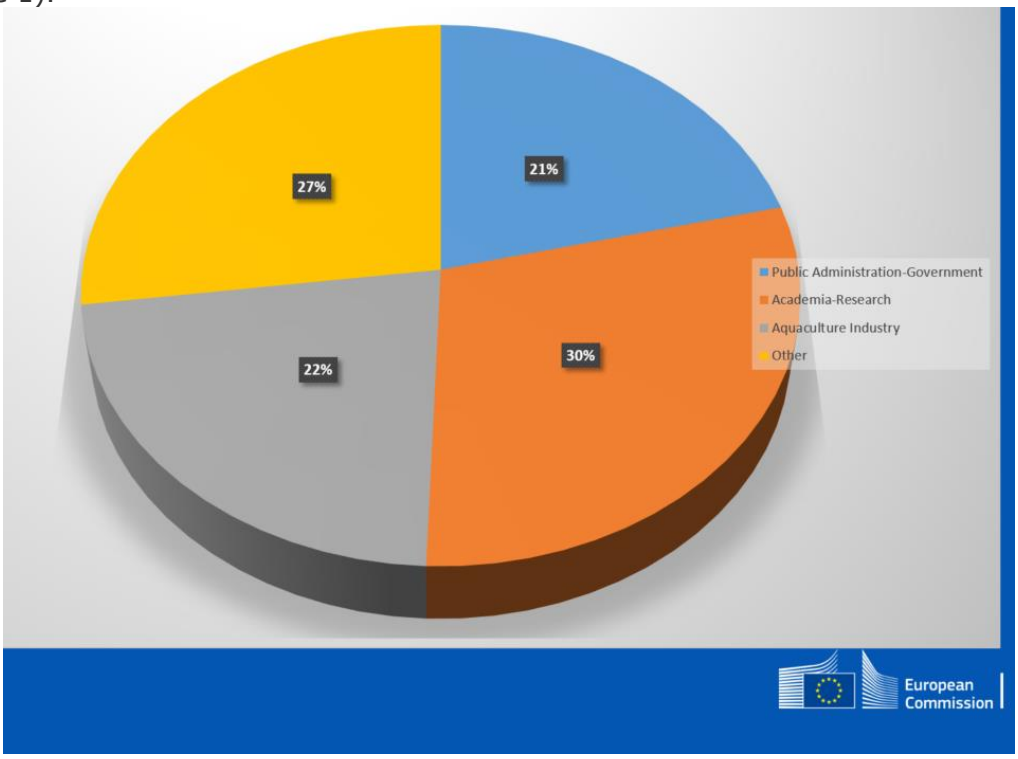

Figure 1. Pie Chart showing the distribution of participants, according to stakeholder categories, at the event 'Marine data for aquaculture' held on 24th to 25th March 2021.

The overall goal of this series of events was to connect the aquaculture industry to existing open access marine data services to promote and enable the use of marine environmental data for operations and evidence-based decision making in the aquaculture sector, and to assess the needs, feasibility and organisation of collaborative platforms based on open-source data.

The mission of the workshop on 24th to 25th March 2021 was to connect aquaculture stakeholders across the Mediterranean and Black Seas with EU marine data services and to increase the awareness on the use of EU marine open data services to support the aquaculture sector in these sea-basins. One of the main objectives was to share experiences across regions in the Mediterranean and Black Seas, identifying data gaps and requirements, and underlying challenges for the management of aquaculture farms. For this, in advance of the workshop, EATiP coordinated the collection and collation of national data monitoring requirements for the aquaculture sector across the region (see Annex to this report.

Another objective was to assess the overall needs of a collaborative platform that would improve the management and operation of aquaculture applications, using data tools and indicators derived from existing marine data sets. This workshop also aimed to outline the structure of this collaborative platform, e.g., to support data ingestion from private stakeholders, and redistribute it into the Copernicus Marine and EMODnet portfolios. Possibilities for the financing, governance and organisation of this platform were also analysed.

Opportunities and applications for open-source marine environmental data and data products as a means to support and innovate the aquaculture sector in the region were explored. For that purpose, a plenary session was held, as well as three consecutive break-out sessions for deeper discussion. In these sessions, key stakeholders were invited to express their needs in terms of using existing data sets, data products, tools and methodological approaches that can support the implementation of a sustainable aquaculture development.

Introductory words by the organisers

Zoi Konstantinou (EC DG MARE) highlighted that the European Commission invests a lot of resources to provide integrated open marine data services, following common standards. Research and academia comprise a considerable user base of these services, amongst other users from wider stakeholder groups. The Commission aims to work with services, e.g., EMODnet and CMEMS, to further expand the stakeholder user base, including working closely with industry users to find win-win opportunities for improving the usability of the services and the uptake of data, improving the data and data products provided, and increasing data sharing from wider stakeholders. She noted this series of workshops was a step forward to foster these collaborations with the aquaculture sector.

Kate Larkin (EMODnet) and Laurence Crosnier (Copernicus Marine Service) raised interest in working with the participants to further develop collaborations with the aquaculture sector for data sharing and to co-design use cases that demonstrate marine environmental data use by the aquaculture sector. The results of a polling informed the meeting that many participants were aware of the EMODnet and Copernicus Marine data services, and that to some extent they were already users of these two data services. They welcomed participants to actively exchange on the relevance and applications of EMODnet and Copernicus Marine data by the aquaculture industry, in addition to the other related users from the private, public, scientific, and policy sectors.

Alexandra Neyts (EATiP) presented the overall needs of the aquaculture sector when it comes to marine monitoring data. In the process towards the definition of its strategic recommendations, EATiP identified the potential for better use of existing environmental data for the governance and management of marine aquaculture sites. This workshop enabled the interaction between producers, providers of technology and services, and public authorities to discuss how to use marine environmental data to improve such operations and applications.

Integrated marine data products

The workshop started with two presentations about the Copernicus Marine Environment Monitoring Service, and the European Marine Observation and Data Network (EMODnet) data services. Data product portfolios offered by both services were presented, and examples of latest developments and use cases by the wider community were provided. A brief Q&A session followed the presentations.

The Copernicus Marine was presented as a European Commission funded programme managed by DG DEFIS including European member states in its governance. A single portal provides online access to all Copernicus Marine data, ocean monitoring indicators and ocean state reports, which provide an overview of the ocean and climate over the past 25 years. All data are open and free, providing essential marine variables originating from satellite observations, some *in situ* observations, and ocean model computation, and that can be categorised into parameters corresponding to blue, green, and white ocean themes. These variables include currents, wind, waves, primary production, and nutrients, to name a few. Data from the past 25 years, real-time data and forecasts are available. The portal has more than 29,000 users coming from different sectors, with around 50% coming from business and private companies, 25% from academia and 25% from the public sector. In 2020, around 7,000 new subscribers joined Copernicus Marine, half of which were coming from Europe.

A demonstration of the Copernicus Marine data was also provided. It was shown how the visualisation tool can be used to apply data from selected parameters. The image can then be copied, downloaded, made into a video, or embedded into a web portal.

EMODnet was presented as a complementary marine data and knowledge initiative of the European Commission, managed by DG MARE. EMODnet is a network of subject-matter experts from over 150 organisations across Europe. The network collects disparate data from the diverse data collection community and works to harmonise, standardise and integrate it, creating high resolution integrated datasets, maps and added value data products across European sea-basins, and beyond. The EMODnet Central Portal serves as a gateway to *in situ* marine data, spanning seven broad thematic areas, of bathymetry, biology, chemistry, geology, human activities, physics and seabed habitats, all with tens to hundreds of parameters available per thematic. Data follows the Findable, Accessible, Interoperable and Reusable (FAIR) data principles and European e.g. INSPIRE and International e.g. ISO standards. EMODnet is currently undergoing centralisation of all its data and data products, including a centralised metadata catalogue and common map viewer, which will be progressively implemented for each thematic over the coming years, with the first thematic – Bathymetry centralising in 2021 and the rest by the end of 2022.

Questions and answers

A brief Q&A followed the presentations on Copernicus Marine and EMODnet.

One of the questions concerned the Copernicus Marine data and its coverage limit in terms of proximity to the coastline. Laurence Crosnier explained that *in situ* data can cover areas very close to the coastline, whereas most satellite and model computation have a buffer of around 2-5km from the coast. The next phase of the Copernicus Marine Service will work on this aspect to provide higher resolution coastal data.

One participant inquired about the existence of an Application Programming Interface (API) for Copernicus Marine and EMODnet. It was confirmed that both have APIs, and new APIs are being developed for the Copernicus Marine visualisation tool to allow more data to be downloaded, whilst APIs are already available for all EMODnet thematics with a range of web services.

Another question concerned the provision of real-time data from smart sensors. Kate Larkin explained that the data ingestion portal is open to any data collector or provider, and that EMODnet does include near real-time data for some thematics e.g. on EMODnet Physics, whilst other thematics are delayed mode due to the complex nature of the parameters and the need to first quality control, harmonise, standardise and integrate results e.g., for biological parameters and for geology and seabed habitats. EMODnet

and Copernicus Marine have a common and linked data ingestion that is accessible from both service websites.

Answering a query on the spatial resolution of Copernicus Marine products, Laurence Crosnier clarified that it differs across products. Some products covering the global ocean have around 8km resolution, while global biogeochemistry products have a resolution of 25km. Satellite data currently ranges from 1-4km resolution, and from May 2021 on, a 100m resolution Sentinel-2 product will be provided.

One participant wanted to know if data is available for coastal lagoons. Laurence Crosnier explained that this kind of coastal data is not covered by the Copernicus Marine.

Another question concerned whether web coverage services could collect EMODnet and Copernicus Marine data. Laurence Crosnier clarified that Copernicus Marine currently does not offer this possibility, but it will be provided in the coming months. Conor Delaney confirmed that this feature is available on EMODnet (the full EMODnet web service documentation was provided – see end of report for related links), and that the technical teams of EMODnet and Copernicus Marine cooperate through the MoU.

Monitoring requirements of aquaculture in the Black and Mediterranean Seas – national differences

Allocations of marine zones for aquaculture and granting of production licences are subject to strict regulations that vary across countries in the Mediterranean and Black Seas (see Annex in this document for an overview of national status). These consider the suitability of a site, based on a set of marine physical and environmental parameters (e.g. temperature, salinity, currents, bathymetry, wave heights, oxygen levels) along with the physiological requirements of the target species and the need for space by other marine activities. Reliable marine data are key to inform this decision-making process. From the EMODnet Biology's perspective, despite increased data sharing, data archaeology and expanding coverage in the past few years, the main regional "data gaps" are precisely the Black Sea and the Mediterranean Sea.

The discussion session explored the current status for the use (and production of) marine data for/by the aquaculture sector at Member State (national) level; further needs for data products, models and services; how Copernicus Marine and EMODnet may support these needs; and finally, how the aquaculture sector may contribute as a data provider.

The following challenges were identified in the discussions, with a focus on *in situ* data collected in the water:
Different methods are used to gather *in situ* data across countries from the Mediterranean and Black Seas. There is the need to harmonise *in situ* data to set the stage for industry innovation. However, the sector is generally under resourced. Thus, one of the main challenges is to identify who will provide the necessary funding for *in situ* data gathering, and how this action can be incentivised.

Copernicus Marine and EMODnet provide free and open data services. However, there is a lack of awareness about the opportunities these services provide and their usefulness to the aquaculture sector.

While there is an online submission process for *in situ* data through the joint EMODnet/Copernicus Marine ingestion tool, some participants remarked that it is not always clear to the user what information should be included. EMODnet confirmed that the online submission service offers expert advice and explanatory services to facilitate

in situ data and metadata input by those providers not familiarised with the methods. *In situ* Data packages can be submitted online, and EMODnet then initiates a process of data stewardship and management to harmonise the *in situ* data so it can be fully integrated into its datasets.

One of the main obstacles is the reluctance of the aquaculture sector to share its *in situ* data. One of the reasons is that small farms and operators find it time consuming to provide *in situ* data - a point that has been raised in several of the break-out discussions. Another issue is commercial sensitivity and the need for confidentiality of the data. Still, the participants acknowledged the benefits of data sharing, such as contributing to create better products and increase transparency, and recognised the public data services of EMODnet and Copernicus Marine offering support for the data ingestion process. All are key to encourage public awareness and to create a social license for aquaculture to further develop.

The following needs and requirements were identified in the discussions
Current and future efforts should focus on building the existing capability and current successes rather than reinventing the wheel. There are already significant EU and national investments in data collection and open data services. Now, there is the need to build upon these services to engage and support data collectors and providers, and increase data sharing.

There are a wide range of data available that is organised, integrated, and standardised across Europe through the EMODnet and Copernicus Marine services. These shared data and data products can be further used to improve the perception of the sector, and demonstrate the specific regulatory framework available to ensure that the environmental impact is within the carrying capacity of the ecosystem.

The data needs for the aquaculture sector are dependent on the specific uses of the information e.g., for zoning, siting, monitoring impact, production management, assessing environmental risks or the effects of climate change, etc. The aquaculture and the wider spectrum of the Blue Economy sectors could greatly benefit from higher resolution, integrated data layers that can be used for operations at sea and for modelling purposes e.g. calibration of existing models. That would require the increase of *in situ* data sharing through established *in situ* data ingestion services, and ensuring an optimised data flow from coastal sensors/observations (both from authorities and aquaculture farms) into EMODnet /Copernicus Marine (often via national data centres or government authorities). In addition, farmers could get more involved in the process of contributing *in situ* data to fill the gap on local data. Farmer associations may play a vital role in that process to provide additional guidance to small and medium-sized companies on how to get the *in situ* data they need.

Robust, high-resolution data are required to enable effective planning and environmental monitoring at a local level. For instance, bathymetry data are critical to identify suitable farming zones and optimal conditions for the installation of sea cages. As stated above, reluctance to share data is still one of the main barriers to obtain large and high-resolution datasets on baseline marine environmental parameters for the aquaculture sector. Institutions must work together to overcome this challenge. EMODnet and Copernicus Marine play a vital role in demonstrating the benefits of open and free data provision. EMODnet already offers high resolution maps of European seas across the seven thematic areas. Nevertheless, it is always looking to improve the spatial and temporal resolution of existing parameters, as well as expanding the data offer, by including new data parameters and collecting data from increasingly diverse sources.

The efforts to expand the offer of high-resolution data were discussed specifically for bathymetry data. One of the participants informed that in the last 4 years, EMODnet has been complementing *in situ* data from field surveys with the General Bathymetric Chart of the Oceans (GEBCO) through a collaboration and MoU with Seabed 2030, with EMODnet being the third largest contributor of bathymetry data to Seabed 2030 worldwide. Moreover, EMODNet has been using for a number of years satellite-derived bathymetry data in coastal regions to complement and cross-validate *in situ* data. EMODnet representatives promoted the use of the EMODnet *in situ* data ingestion service, to ensure the sharing of bathymetric data – where possible, making these datasets openly available. An EMODnet representative replied that to those using the bathymetry, EMODnet has static bathymetry data and is increasingly developing dynamic bathymetry e.g., the EMODnet Digital Terrain Model. Copernicus Marine is studying the possibility to provide satellite-based dynamic bathymetry products.

There is also a need for the provision of the size of phytoplankton for shellfish (oyster and mussel) farming, in addition to chlorophyll-a.

In general, a need was expressed to improve data accuracy in coastal areas. One proposed solution is to increase the use of smart sensor systems, installed by authorities, for overall coastal monitoring purposes. These facilities will enable the collection of *in situ* data and enhance modelling in these areas.

The aquaculture representatives also commented on the importance of the "degree of spatial scales" available for data, noting that the spatial resolution often needs to be be very high and further improved to be of value for use by the aquaculture. It was recommended that aquaculture stakeholders should clearly define the needed data quality and resolution for each of the sector application (i.e. planning, siting, operation, risk management, etc). There is a need for both historical and real-time data, not only to analyse the current situation, but also to allow taking preventive actions (e.g. related to disease outbreaks, harmful algal blooms, storm events, drop in water quality). The aquaculture monitoring system needs to evolve from a control system into a production management system when looking at sharing of *in situ* data.

From a technical point of view, it was remarked that NetCDF is the preferred data format due to the large amount of data that needs to be downloaded. As a binary format, the NetCDF data is compressed, thus minimising data file size.

Different data gaps were identified for specific sectors of aquaculture. For example, there is a need for more chlorophyll-a and phytoplankton size data, especially in shellfish farming. There is also an increased demand for high resolution, biological data for the emerging algae aquaculture sector (eg. species distribution and marine environmental parameters).

The limited resources available were considered as one of the main obstacles for the aquaculture farms to actively collect data. On the other hand, farmers are often not aware of the usefulness of the data available, which in general remains not stored nor shared.

A participant from the regional administration in Italy reported that they are carrying out identification of areas suitable for aquaculture plans. They have successfully downloaded and used Copernicus Marine data for that purpose. They have also used EMODnet data to get the necessary information on bathymetry, and to validate satellite and model products. The main issues they experienced are connected to the validation of data on areas close to the coast.

A contribution from a delegate from academia confirmed this by stating they have developed national guidelines as a tool to inform the regional authorities. Regional plans have to be implemented, so they developed the guidelines by setting different criteria on the final suitability of different parameters for aquaculture. These guidelines were mainly developed for sea bass, sea bream and mussels. Marine data are received, downscaled, and classified according to the suitability index, then entered into a GIS system, where they can be analysed.

How should a collaborative platform look like

Advances in evidence-based aquaculture governance and management will rely on collaboration, data integration and interoperability between data services, projects, public bodies and private stakeholders.

Different aspects of how a collaborative platform for aquaculture should look like e.g., needs for access, level of knowledge needed for its use, means of data ingestion, avoidance of duplication, training offers, were discussed in this break-out session.

Alexandra Neyts (EATiP) delivered a short presentation, on the concept of the potential collaborative platform. Then, the discussion groups reflected on the needs of such a network. They discussed ways to link the existing incentives to achieve maximum efficiency in data use, and to provide the best models for operation. They also identified key areas where the platform could help the aquaculture sector beyond what is already offered by Copernicus Marine and EMODnet.

The discussion is summarized as follows:
The participants agreed on the added value of a collaborative platform, building on existing systems and initiatives already in place. Examples of similar platforms were also pointed out (e.g. environmental services). The proposed collaborative platform would provide the interface between EU services like Copernicus Marine and EMODnet, and national services, facilitating access to all available data. One of the main advantages is that it would increase the awareness of different providers about the availability and value of other existent services out there.

From a user perspective, it was noted it can prove challenging to find the type of data needed amongst all the data that is available. This must be taken into account in the set-up, management, and information about the platform. It is essential to provide a comprehensive list with what type of data can be found where. It was also recognised that EMODnet and Copernicus Marine data are available through web services so a metadata catalogue describing all existing data would be very useful for a user to then discover and access the data required for any given use.

An EMODnet representative expressed the current difficulties of collecting data from aquaculture farms, noting that mechanisms to encourage and support data collection by all – including small-scale, coastal - aquaculture farms must be considered when creating the platform. It was proposed that producer associations could play an intermediary role in this process by assisting farms with poor or inexistent communication infrastructure. This role would depend on the associations' capacity to employ people with the necessary skills to collect marine environmental data, which remains a challenge.

Farmers themselves wouldn't be expected to use the platform and its services directly, as this could be channelled through an intermediate service. The platform could help these intermediate services to develop and facilitate tailored services for the aquaculture sector, as well as encouraging farmers to share data by explaining the benefits of doing so.

The platform was strongly suggested to be organized with a clear border between regional and national services, and here especially linked to the various sea basins. It was noted this in turn overlaps with some of the EU research funding instruments which are often based on sea basins. Given the European Commission's move to a more basin-centric approach, narrowing the service down to basin level could be a driver for funding, and present a credible and viable way to structure the platform.

The high resolution data that the aquaculture sector requires was noted by Copernicus Marine and EMODnet who work to continuously move towards finer spatial scales and higher resolution, which in turn is dependent on people and organisations sharing their data. It was recognised that the aquaculture sector must have an active voice in the process, i.e. ensuring the platform to be user-driven, whilst EMODnet and Copernicus Marine would apply quality controls and harmonisation standards, including descriptions in the metadata to describe the quality and quantity of data.

Other relevant stakeholders (beyond EMODnet, Copernicus Marine and the aquaculture sector) that were identified as key stakeholders are: the General Fisheries Commission for the Mediterranean, environment agencies (including HABs observation), Marine Spatial Planners, science communities, certifiers, and private companies conducting intermediate services.

It was proposed that national authorities making the regulations should also be consulted, as each country has very specific governance regimes and control tools. Moreover, many countries already possess IT platforms that should be contacted for the possible provision of in situ data.

The development of a standardized certification – to go hand in hand with the platform – was also debated. The Norwegian standards could be converted to national requirements and address questions of missing standards in the Mediterranean and Black Seas. The Aquaculture Stewardship Council could also assist with the certification. A free option for certification or support was recommended for smaller farms.

The increasing need for traceability and the availability of block chain tools were also considered important to be taken into account.

Besides needs and requirements, benefits have also been mapped:
The platform would be especially helpful in countries where aquaculture isn't as developed, as it would provide strong evidence to authorities on optimal zones, encourage installation, and eventually lead to increased self-sufficiency of seafood and more sustainable practices. Undoubtedly, clear procedures and a transparent evidence base was considered important to help the aquaculture industry to assert itself as environmentally sustainable, and encourage further development.

The involvement of the aquaculture sector from the beginning would help demonstrating the benefits of the collaborative platform, and to encourage a wider sharing of data.

Dedicated training through the platform could also provide new learning opportunities, and the possibility to exchange experiences between aquaculture users.

Governance and funding

In a discussion on governance and funding, an open data platform was proposed, dedicated to the sector needs to be built upon existing services and networks, contributing to a collaborative approach and avoiding duplication. The discussion

explored the governance of such a platform. Issues such as ownership, funding mechanisms, and business plans were also discussed in order to ensure long-term sustainability.

Organisational level

Following the earlier discussions, the potential future platform was strongly suggested to be built upon existing systems, initiatives and skills that are already in place and consolidated, instead of creating a parallel flow of data on top of the existing systems. All stakeholders, as well as workshop organisers agreed that complementing and filling data gaps of the present platforms will be a win-win situation.

It was also widely agreed that the collaborative platform should be user-driven. The research and administration participants highlighted the need for an assessment of the current state-of-the-art on what is available in terms of data and services, which could further help the industry. EMODnet confirmed that thematic data are still maintained by thematic experts and currently available through thematic webpages, but that the centralisation of all EMODnet data and data products had begun in a step-wise implementation, which would have a common map viewer and metadata catalogue across all seven thematics and the hundreds of parameters. This would further enhance the user-friendliness and the discovery and access of EMODnet data and data products, described by metadata that record the data provenance, so the data provider is clearly recognised together with the data management and curation process, so the data can be used by anyone, for multiple uses. It was reiterated that it would be of high added value for the aquaculture industry to enter the dialogue with EMODnet, and also share new data not yet available in their system.

Planning and management

There was consent among the participants that a step-by-step approach would be needed to comply with the needs, requirements, organisational level, and most of all, mid- and long-term sustainability of the collaborative platform. The following procedure was devised.

Firstly, a vision building process should be implemented, including the identification of a unique selling point and the development of a mission statement. This would help maintain the focus, as not all services could be developed simultaneously. The involvement of intermediate associations and users was also suggested as an approach to minimise dispersion, and to include the valuable knowledge provided by the small farmers who otherwise lack the resources to contribute.

The mission statement should be clear, practical, and efficiently communicate what the initiators and organisers of the platform are set to achieve. It should set a path for the business plan and objectives which can then again be shared by the wider community.

A catalogue or map of the different sectors, needs, and existing services was noted to be essential for an efficient business plan.

Financing

There was a differentiation made between the initiation of the platform and its ongoing operation once it has been installed. The initiation of the platform could be project based, possibly seeking funding through the European Maritime Fisheries and Aquaculture fund (EMFF). The operation of the platform once it was set up could be financed in different ways. In principle, the data should be freely available with a clear distinction between providing metadata and access to original data. One suggestion was that as soon as the data were processed or tailored for aquaculture, the users should

pay for it. Alternatively, aquaculture associations could fund access for their members. In both situations mentioned, there is the disadvantage that smaller companies would most likely not be able to raise the funding. Possibly, national agencies or authorities could provide funding at national level. The monitoring could also be taken over by national agencies who handle the national oceanographic data.

Financing was considered to be likely multi-level, with a requirement to provide funding in the long-term to maintain the platform. Scoping exercises could be undertaken to help identify how the platform could be self-sustaining, and look at where commercial companies could be charged for services. Farmer associations could be encouraged to pay for the platform if they could see that it offers a competitive advantage. The platform could work in collaboration with the GFCM in the region as they will know of other funding possibilities.

IT capabilities and knowledge on the sector could be used to develop more standardised and harmonised data and data services. The aquaculture industry could try to engage with IT providers already running with funding in some other schemes and seek a collaboration. The connection to food safety issues or green deal funding (e.g. from cage to fork) will also have to be considered. Furthermore the aquaculture industry could further align with the goals of the European Green Deal by seeking funding from parts of the EU Horizon Europe Framework Programme.

Conclusions

The full value chain was represented in the workshop, from the marine data collectors and providers, to marine data services, e.g., Copernicus Marine Service and EMODnet, to the private sector and aquaculture farmers.

All participants from the aquaculture industry, as well as providers and public authorities provided valuable input. They acknowledged the potential for a future collaborative platform to better connect marine data and services – at multiple geographical scales – with national and regional authorities and the aquaculture industry, to support more cost-effective and evidence-based operations and in turn increasing the positive visibility and activities of the sector. The delivery of targeted training sessions e.g. by EMODnet and Copernicus Marine, for aquaculture end users was considered to be of value to increase the use of such platform. In addition, having clear procedures, and a transparent evidence base was noted as clearly important to prove the aquaculture industry's contribution to the green transition and wider sustainability efforts.

Copernicus Marine and EMODnet will continue to offer public data services that are open and free of charge to use and all inputs from the discussions will be considered for further enhancing the current services and for promoting collaboration with the aquaculture sector and stakeholders across the value chain. The Copernicus Marine Service and EMODnet also expressed an interest to build upon discussions from this workshop and the previous one on the North Atlantic, to develop further cooperation and dialogue with the aquaculture sector in terms of data sharing, data use, needs and requirements, trainings, and use case development.

Generally, there was agreement on the benefits of providing open access data, following the model of existing platforms from Copernicus Marine, EMODnet and national agencies, and promoting data sharing across multiple levels, from bigger to smaller scale producers. These efforts will lead towards transparent, consumer-oriented systems.

Several data gaps were identified, with a required increase in spatial and temporal resolution of existing parameters representing one of the main challenges. In particular, there remains the need for high-resolution data to enable the identification of farming areas, and to underpin effective planning and environmental monitoring at the local level.

On a sector level, a demand for data to support emerging industries such as algae and biomass cultivation was also identified. Moreover, providing user-friendly interfaces for discovery of relevant data by the aquaculture farmer was also considered a priority. Science and administration stakeholder communities were suggested here as facilitators, translators and knowledge brokers to connect marine data with aquaculture industry operators, in particular with smaller-scale farmers with less access to technology.

It was felt that a standardised certification should be developed in parallel to the platform. For smaller farms there should be a free option for certification.

It was also recognised that a clear strategy would be needed to set up the collaborative platform. Thus, a vision building process including key stakeholders has been suggested. Intermediate associations could act as multipliers and transmitters of information to the smaller-scale producers. Moreover, a mission statement and business plan should be

created, including the already existing platforms, as well as IT enterprises with knowledge on the corresponding models and data management.

In terms of financing, a differentiation was made between the initiation of the platform, and its ongoing management. A project-based start would be welcomed, as well as support from national agencies who have access to the corresponding data. Financing should take into account a long-term vision, and include stakeholders at all levels.

Finally, training would facilitate the use of the existing platforms. EMODnet and Copernicus Marine offers tutorials for each thematic to assist the user exploring and using the data. Both Copernicus Marine Service and EMODnet have ongoing work to further develop more sector specific and user-tracked information. If there are industries and users that are interested in a closer dialogue, there is also an EMODnet Associated Partnership scheme that is free to join, subject to approval, and offers a win-win collaboration opportunity with EMODnet and the wider expert network.

Other sources of information

(1) **CMEMS - Copernicus Marine Service**: https://marine.copernicus.eu/
Marine Food | CMEMS (copernicus.eu)
CMEMS Training Workshop for the Mediterranean Sea - Main session - YouTube
CMEMS Training Workshop for the Black Sea - Main session - Part 1 - YouTube

(2) **EMODnet - European Marine Observation and Data network**: https://www.emodnet.eu/en
EMODnet web service documentation: https://www.emodnet.eu/en/data
EMODnet video gallery with tutorials and the EMODnet for Aquaculture video:
https://www.emodnet.eu/en/videogallery
https://www.youtube.com/playlist?list=PLdD_cUwUtVy6dUcUVgNv8OPfdtvrKm2u4
EMODnet Associated Partnership Scheme: https://www.emodnet.eu/en/emodnet-associated-partnership-scheme

(3) **European Atlas of the Seas**, EC communication tool for society, powered by open marine data from EMODnet and other providers e.g. EC (DG MARE and other DGs), Copernicus, European Environment Agency (EEA), Eurostat, etc: https://ec.europa.eu/maritimeaffairs/atlas_en

(4) **EATIP – European Aquaculture Technology and Innovation Platform:** www.eatip.eu

(5) **Quadrige:** https://www.gbif.org/fr/dataset/aeeff4d1-a1e0-454e-ae87-2748138279d3

(6) **EuroSea H2020 project:** https://eurosea.eu/

(7) **ForCoast H2020 project:** https://forcoast.eu/

(8) **Blue-Cloud H2020 project:** https://www.blue-cloud.org/

(9) **European Green Deal:** https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

(10) **Marine Data to Support Aquaculture in the North Atlantic:** Marine data to support aquaculture in the North Atlantic - Save the date! | Maritime Forum (europa.eu)

Annex: Marine data from the aquaculture industry in the Mediterranean and Black Seas

This note provides a template for the provision of what and how mandatory parameters are monitored by the aquaculture sea-based sector in the different European countries of the Mediterranean and Black Sea region. The countries covered in the document are:

The information is being assembled by EATiP, its regional EATiP Mirror Platforms and by key national stakeholders, based on information from national and regional authorities that are responsible for aquaculture management and spatial planning.

The content of the note is by no means complete, but is intended to introduce the participants at the Marine data to support aquaculture in the Mediterranean and Black Seas meeting to the current state of play in the different countries.

Further information on the state of aquaculture, categorized by country, is provided by the UN Food and Agridculture Organisation (FAO)[1].

It will provide as a basis for further discussions and to stimulate exchange of knowledge and best practice.

[1] FAO Fisheries & Aquaculture - FI fact sheet search

France

Along the French coasts (Atlantic and Mediterranean), environmental monitoring of water parameters (chlorophyll-a concentration, turbidity, phytoplankton diversity, phytoplankton cell numbers, and toxic species), oyster reproduction, growth and mortality is managed by IFREMER.

The following data are available on public repositories:

- Water quality, phytoplankton, and harmful algae[2]
- Oyster reproduction[3]
- Oyster mortality and growth[4]

Different programmes are available to visualise the data on-line, such as:

- Cell numbers of different toxic phytoplankton species (REPHY network)[5]
- Oyster mortality rate and seawater temperature (ECOSCOPA national shellfish observatory)[6]
- Oyster larvae abundance (VELYGER observatory)[7]

For these monitoring networks, the sample strategy is based on weekly to monthly standardized sampling at fixed stations. The results acquired at the national scale on the main French oyster sites are archived in a common database "Quadrige" [8][13], since 1987 for REPHY, 1993 for ECOSCOPA, and 2008 for VELYGER.

The results are made available to the French ministry, but also to the aquaculture industry and water quality managers as soon as possible. The follow-ups are carried out on a bi-monthly basis due to the access to the sites (accessible on foot only when tidal coefficients are higher than 75) and are put online on the website a few days later, with the quasi-automated processing of the acquired data. All these data are also used to model growth and egg-laying capacity under different climate scenarios. The aquaculture industry could be also interested by observations acquired at higher resolution, both spatially and temporally. Earth Observation (EO) could contribute to water quality monitoring, HAB risk alert, and site selection for aquaculture spatial planning. The use of EO for aquaculture monitoring and modelling has been previously demonstrated.

[2] https://www.seanoe.org/data/00361/47248/
[3] https://www.seanoe.org/data/00308/41888/
[4] https://www.seanoe.org/data/00419/53007/
[5] https://envlit.ifremer.fr/surveillance/phytoplancton_phycotoxines
[6] https://wwz.ifremer.fr/observatoire_conchylicole
[7] https://wwz.ifremer.fr/velyger/
[8] https://wwz.ifremer.fr/Recherche/Departements-scientifiques/Focus/Quadrige

Croatia

In Croatia, the Ministry of the Economy and Sustainable Development, and the Ministry of Agriculture, Fisheries administration are in charge of aquaculture governance. Their target is to develop a resource-efficient and competitive economy, ensuring climate neutrality, protecting the environment and ensuring the sustainability of natural resources.

Based on Environmental Impact Studies (SUO) related to the intended intervention of marine aquaculture farms, Decisions are adopted on their acceptability in the ecosystem. The abovementioned Ministries prescribe and determine environmental protection measures as well as an environmental monitoring program.

The Croatian environmental monitoring program includes the following indicators:

- marine sediment analysis: the concentration of organic carbon, total nitrogen and phosphorus and the redox potential profile in the surface layer of sediment. Monitoring is performed once a year and at the time of highest expected impact
- Review of marine habitats on transects once a year
- the condition of marine habitats of the coastal zone once a year

The results of these monitoring and measurements are available to the regional states, the Ministry of Economy and Sustainable Development, but also to the Ministry of Agriculture, which, on an annual basis, collects socio-economic data in aquaculture and processing industry.

Sustainability in the seafood sector is extremely important to all participants in the sector but also to consumers. Certification provides proof to stakeholders, customers and consumers that production is managed responsibly in accordance with best social and environmental practices.

To be certified according to the ASC standard, breeders have to monitor additional indicators related to the planning, development and implementation of breeding and production systems.

Spain

The Ministry of Agriculture, Fisheries and Food is the main responsible national body for environmental regulation of aquaculture in Spain. But as Spain is divided in many autonomous regions, each regions has its own specific aquaculture regulations. In the Production License of an aquaculture company, provided by each region, it is stated the information/reports that its mandatory to send periodically to the autority to comply with their Environmental Monitoring Plan. An aquaculture company will hire a certified consultory to take samples and to do the reports. The consultory need to be cerficied in UNE-EN ISO 14001 and UNE-EN ISO 9001.
Its difficult to point out what it is measured in each analysis as it varies from one to another region. In general, the consultory will take samples of:

- Water Quality (temperature, salinity, dissolved oxygen, turbidity, chlorophyll a, pH, irradiance, etc.)
- Sediments
- Macroinvertebrates
- Plankton

The Spanish Institute of Oceanography (IEO) [9] collects and provides data for the Mediterranean within the frame of the RADMED campaigns on a seasonal basis[10] for the following parameters:

- temperature,
- salinity,
- sea level,
- current,
- nutrient concentration,
- harmful algal blooms[11].

The regulation of aquaculture and the coastal spatial planning are the responsibilities of autonomous regions. A central legislation applies if an autonomous region does not have one of its own. The regulating bodies are the following:

- Galicia: General Directorate of Fisheries, Aquaculture and Technological Innovation[12]
- Cantabria: FUNDACIÓN INSTITUTO DE HIDRÁULICA AMBIENTAL DE CANTABRIA[13] (spatial planning), DIRECCIÓN GENERAL DE URBANISMO Y ORDENACIÓN DEL TERRITORIO[14] (environmental assessment)
- Basque country: Dirección de Pesca y Acuicultura[15]

[9]http://datos.ieo.es/geonetwork/srv/spa/catalog.search#/home
[10]Visor de datos IEO (http://www.indicedeafloramiento.ieo.es/index1_es.php)
[11]https://marine.copernicus.eu/services/use-cases/harmful-algae-bloom-monitoring-aquaculture-farms-spain
[12]https://www.abtemas.es/en/index.php/portfolio-item/aquaculture-master-plan-of-the-coast-of-galicia/
[13]https://www.aeeolica.org/sobre-aee/socios/socio/item/215-fundacion-instituto-de-hidraulica-ambiental-de-cantabri
[14]https://www.territoriodecantabria.es/evaluacion-ambiental-urbanistica/objeto-y-tramitacion
[15]https://www.euskadi.eus/autorizacion-instalaciones-plantas-acuicultura/web01-a2arraku/es/

- Andalusia: Dirección General de Pesca y Acuicultura.[16]
- Murcia: Servicio de Pesca y Acuicultura de la Dirección General de Agricultura, Ganadería, Pesca y Acuiculturade la Consejería de Agua, Agricultura y Medio Ambiente de la Comunidad Autónoma de la Región de Murcia.[17]
- Valencia: La generalitat Valencia[18] [19]
- Canary Islands: Consejería de Agricultura, Ganadería y Pesca.[20]
- Balearic Islands: Direcció General de Pesca i Medi Marí [21]
- Catalonia: Departament d'Agricultura, Ramaderia, Pesca i Alimentació[22]

[16]http://www.juntadeandalucia.es/medioambiente/site/portalweb/menuitem.6ffc7f4a4459b86a1daa5c105510e1ca?vgnextoid=2ab8c40f81172310VgnVCM10000055011eacRCRD

[17]http://www.carm.es/web/pagina?IDCONTENIDO=36755&IDTIPO=11&RASTRO=c672$m26661

[18]https://www.gva.es/es/inicio/procedimientos?id_proc=13627#p_4

[19]Responsible organisms for non-mediterranean Autonomous Communities: https://www.mapa.gob.es/es/pesca/temas/acuicultura/enlaces/Enlaces_autonomicos_default.aspx

[20] https://www.gobiernodecanarias.org/pesca/temas/cultivos_marinos/

[21] http://www.caib.es/govern/organigrama/area.do?lang=ca&coduo=2390901

[22] http://agricultura.gencat.cat/ca/ambits/pesca/dar_aquicultura/

Greece

The Hellenic National Oceanographic Data Center which is part of the Hellenic centre for marine research provides data for the following parameters:

- Temperature,
- bathymetry,
- salinity,
- current speed,
- wave height.

Data are retreived by both private and public organisations.[23]

The Ministry of rural development and food is responsible for issuing permits. [24]

The laboratory of Marine Toxic Microalgae is responsible for the monitoring of harmful algal blooms. Samples are taken on a weekly basis at 42 stations in the 9 mussel cultivation and bivalve mollusk fishing areas of the country and results are announced every 1-2 days[25].

The Ministry of Environment and Energy / Directorate for Environmental Permits is responsible for the water monitoring system for aquaculture operations.

Data to be monitored by the aquaculture industry at farm and zone levels are as follows:

- Main currents dirrection and velocity / every 10 years
- Benthic fauna and flora bellow and 50 m radius / every 3 years, June - Sep
- Sediment granularity Total Organic Carbon, P, N, Cu, Zn / every 3 years, Jun – Sep
- Water Disolved O2 on surface, 15m and 30m / monthly
- Water Turbidity on surface, 15m and 30m / monthly
- Water NO2, NO3, NH4, N, P, C, on surface, 15m and 30m / yearly

[23] https://hnodc.hcmr.gr/services/

[24] http://www.minagric.gr/index.php/en/farmer-menu-2/livestock-menu/aqua-cult-animals-menu

[25] https://www.yumpu.com/en/document/read/22464884/harmful-algae-monitoring-programme-in-greek-coastal-waters

Italy

Aquaculture in coastal and marine waters is managed by the 14 coastal Regions, which are the competent authorities for blue economy development policies, strategic planning of sea uses (tourism, transport, sailing, renewable energy, aquaculture, coastal defense interventions, etc.) and the sub-regional Plan for Maritime Spatial Planning (MSP)[26], including aquaculture zones (Allocated Zones for Aquaculture, AZAs). Regions are also responsible for aquaculture site licensing and for the implementation of the Environmental Impact Assessment (EIA), requested in case of new fish farms (surface >5 ha), according to the EIA national decree[27] and technical guidelines provided by ISPRA[28]. The Ministry of Infrastructures and Transport is responsible for the policies regulating marine concessions (lease) and applicable fees.

Environmental monitoring of marine and coastal areas is under the responsibility of the National System for Environmental Protection (SNPA)[29], a network made up of 21 Territorial Environmental Protection Agencies (ARPA / APPA) coordinated by ISPRA. SNPA also implements the Marine Strategy, Water, Nitrate and Floods Directives supporting the Italian Ministry for Ecological Transition (MiTE), General Directorate for Sea and Coasts and General Directorate for Soil and Water.

The Ministry of Agriculture, General Directorate for Fisheries and Aquaculture, is responsible for national aquaculture policies and for socio-economic data collection[30].

Marine data for aquaculture

Environmental Impact Assessment, EIA - multiple physical and biogeochemical parameters, among others: water currents, temperature, dissolved oxygen, pH, salinity, Chl-a, turbidity, nutrients, sediment granulometry, organic carbon, biotic indexes and benthic community assessment, bathymetry.

Environmental Monitoring Program, EMP at farm site - EMPs are defined during the EIA process on a case-by-case basis and are prescribed to be performed by fish companies on an annual basis. The technical guide for AZA (2020), published by ISPRA, includes several schemes of EMPs for aquaculture sites, according to biomass and marine environment (current speed, bathymetry) [31]. EMPs at aquaculture sites include the following parameters:

- Water column: salinity, temperature, pH, turbidity, ammonia, nitrites, nitrates, orthophosphates, suspended solids, Chl-a , total nitrogen, total phosphorus, dissolved oxygen.
- Sediments: granulometry, total organic carbon, total nitrogen, total phosphorus, sulphides, total organic matter, redox potential, benthic community assessment

Marine Strategy Directive – MSFD – (1-12nm) In-situ environmental monitoring program for 11 Descriptors. For aquaculture sites, the regional Agencies for environment protection (ARPAs)

[26] Decree 201/2016 (Directive 2014/89/UE)

[27] Decree 104/2017 (Directive 2014/52/EU)

[28] https://www.snpambiente.it/2020/05/08/valutazione-di-impatto-ambientale-norme-tecniche-per-la-redazione-degli-studi-di-impatto-ambientale/

[29] https://www.isprambiente.gov.it/en/national-system-for-environmental-protection

[30] Regolamento (CE) n. 762/2008

[31] https://www.isprambiente.gov.it/en/publications/technical-documents/allocated-zones-for-aquaculture-azas-technical-guide?set_language=en

implement EMP campaigns for monitoring water eutrophication (D5) and sediment quality status (D6) in impact, influence and control stations at aquaculture sites. ISPRA is responsible for MSFD national coordination, data analysis, digitalization and reporting at national and UE levels. Environmental data resulting from the MSFD monitoring activity are made available by ISPRA through a portal[32].

Water Framework Directive - WFD - transitional and coastal waters (0-1 nm)

- Quality of shellfish water bodies: pH, O2, salinity, T°, suspended material; Heavy metals; Organohalogen Compounds; Bacteria (fecal Coliformes); Saxitoxin- harmful algae
- Water discharges of coastal fish farms: pH, O2, salinity, T°, suspended solids, Nutrients, COD, BOD
- Quality of marine-coastal waters. Qualitative and quantitative analyses of phytoplankton, Chl-a, dissolved oxygen, nutrients.

Marine data are collected by regional ARPAs, transferred to SINTAI, the National Information System for Italian Water bodies[33], managed by ISPRA.

The National Wavemetrics Network (Rete Ondametrica Nazionale - RON) provides wave data from fifteen oceanic buoys along Italian coasts. The network is managed by ISPRA and the wave measurement datasets are available online[34]

Other marine data sources

Regulation EU 627/2019 (Reg. EC 854/2004) - Classification of shellfish production areas (farms and natural banks). A regular monitoring activity is carried out by regional authorities of the Ministry of Health (Government Veterinary Institutes-IIZZSS and Local Sanitary Authorities-ASL) to verify the complying to the sanitary requirements; it includes the quantification/detection of

- Bacteria (E. coli; Salmonella; Vibrio)
- Viruses (Enteric and hepatic viruses)
- Biotoxins- harmful algae

[32] http://www.db-strategiamarina.isprambiente.it/app/#/data_consultation
[33] www.sintai.isprambiente.it
[34] http://dati.isprambiente.it/id/website/ronRmn/html

Malta

In 2013, the Malta Environment and Planning Authority issued a report on coastal water monitoring, presenting a network to be used for establishing long term monitoring. [35]

The Department of Fisheries and Aquaculture is responsible for the monitoring of aquaculture and issuing permits. [36]

The Pollution Control Co-ordinating Unit of the Environmental Protection Department entered into an agreement with the Marine Ecotoxicology Laboratory (Department of Biology) of the University of Malta to monitor in-shore water quality.

Monitored parameters are

- pH,
- Temperature,
- Salinity,
- Water Visibility,
- Water Transparency,
- Chlorophyll,
- Dissolved Nitrates,
- Dissolved Phosphates,
- Phytoplankton species and abundance

Annual reports are available on the website of the Environment and Resources Authority.[37]

Nutrient levels are assessed on a 3-monthly basis, nitrates 6-monthly, Chlorophyl-a monthly at in-shore stations and 6-monthly at stations at 6 nautical miles from the coast, whereas transects are taken 3-monthly. Phytoplankton is monitored 3-monthly at in-shore stations, 6-monthly at stations at 6 miles and 3-monthly for transects. [38]

[35] https://era.org.mt/wp-content/uploads/2019/05/CW-Mon-Final-Part-1.pdf

[36] https://agrikoltura.gov.mt/en/fisheries/Pages/missionStatement.aspx

[37] https://era.org.mt/wp-content/uploads/2019/05/MonitoringProgramme-Part1.pdf

[38] https://era.org.mt/wp-content/uploads/2019/05/MonitoringFactsheet_D5_Eutrophication.pdf

Albania

The entity responsible for issuing licences is the Albanian Ministry of Environment, Forestry and Water Administration.

Licences are required for each production unit.[39]

The organism responsible for monitoring water quality is the National Environment Agency (NEA), both for the freshwater and the marine environment, based on the Water Framework Directive. It is accredited for 10 basic water quality parameters.[40]

The Ministry of Environment is responsible for the regulation and sustainability of water resources and the regulation of environmental pollution.[41]

The Directorate of Fishery Service and Aquaculture fulfils the services related to infrastructure and data management for fishing and aquaculture. It also monitors compliance to legal requirements and the inspection of fishing activity.[42]

Monitored parameters include

- temperature,
- pH,
- salinity,
- dissolved oxygen,
- Nitrogen levels (nitrite/nitrate, ammoniac)
- Phosphate levels (Ptotal/dissolved phosphates).

Measurements occur 4 times a year and data are available on the website of the national environment agency (AKM).[43]

The public body responsible for monitoring toxic algal blooms is the Food Safety and Veterinary Institute.

[39] http://images.mofcom.gov.cn/al/accessory/200903/1235980669427.pdf
[40] https://wetmainareas.com/who-is-involved/national-environmental-agency-albania/
[41] https://www.wareg.org/members.php?q=view&id=2#:~:text=REGULATION&text=Water%20Regulatory%20Authority%20(WRA)%20is,and%20treatment%20in%20a%20Albania.
[42] http://documents.rec.org/publications/Raporti_Env.MonitoringDataInformation_final.pdf
[43] http://www.akm.gov.al/index.html

Montenegro

The Environmental Protection Agency (EPA) is responsible for the preparation of the environmental reports.[44]

Monitoring of the sea water quality is measured in 12 locations determined in the Programme of monitoring of the coastal ecosystem of Montenegro. Measured parameters include:

- water temperature,
- pH,
- transparency,
- salinity,
- Phosphate levels (orthophosphates (P-PO4), total phosphorus (TP),
- Nitrogen levels (total nitrogen (TN), nitrates (NO3-N), nitrites (NO2-N), ammonia (NH4)),
- silicate levels,
- Oxygen levels
- Chlorophyll-a,
- Bacterial concentrations
- Plankton (qualitative and quantitative analysis of phytoplankton and zooplankton groups and species).

Parameters are monitored on a monthly basis.[45]

Licences are issued by the ministry for agriculture and rural development of Montenegro.

[44] https://www.eea.europa.eu/soer/2015/countries/montenegro

[45] https://www.medqsr.org/sites/default/files/inline-files/EO5_Case_Studies.pdf

Slovenia

The Marine Biology Station of the Institute of Biology (NIB) is the only Slovenian institution monitoring sea water quality.[46] Monitoring is under the responsibility of the Environmental Agency of the Republic of Slovenia, with the relevant regulation being the Decree of chemical status of surface waters.

Monitoring and water quality status evaluation is one of the key tasks of the Environmental Agency of the Republic of Slovenia.

The quality of marine water is evaluated on a chemical and trophic level, with parameters including:

- Chlorophyll-a,
- Oxygen saturation,
- Transparency of the sea,
- Nitrogen concentrations
- Phosphorus concentrations[47] [48]

The ministry of the environment and spatial planning is responsible for issuing licences. The public body responsible for the monitoring of aquaculture development is the Inspectorate of the Republic of Slovenia for Agriculture, Forestry, Hunting and Fisheries which is part of the ministry of agriculture, forestry and food.[49]

[46] https://www.nib.si/eng/index.php/services-and-products#example-2-tab-3
[47] https://www.arso.gov.si/en/water/reports%20and%20publications/Kakovost%20voda-ANG.pdf
[48] https://www.gov.si/en/state-authorities/ministries/ministry-of-the-environment-and-spatial-planning/
[49] https://www.gov.si/en/state-authorities/bodies-within-ministries/inspectorate-for-agriculture-forestry-food-and-environment/o-inspektoratu-za-kmetijstvo-gozdarstvo-lovstvo-in-ribistvo/

Turkey

Licences are issued by the Ministry of Food, Agriculture and Livestock, General Directorate of Agricultural Research and Policies, Turkey.

Monitoring is the responsibility of the Monitoring and Water Information System Department within the ministry.[50]

The Directorate General of Environmental Impact Assessment, Permit and Inspection of the Ministry of Environment and Urbanization can also issue permits for aquaculture licenses. It is also responsible for monitoring water quality parameters, including eutrophication and algal proliferation.[51] Coastal and territorial waters (up to 12 nm) have been monitored since 2004.

Monitored parameters include:

- Chlorophyl-a,
- Nitrogen,
- phosphorus,
- silicate,
- oxygen[52]

The Department of Environmental Inventory and Information Management is responsible for data exchange with public and private organisations.[53]

Reports on water quality for the Mediterranean and the Black Sea are issued annually.[54] [55]

[50] https://www.tarimorman.gov.tr/SYGM/Menus/61/Monitoring-And-Water-Information-System-Department

[51] https://ced.csb.gov.tr/en/duties-i-100045

[52] NUTRIENTS, CHLOROPHYLL-A AND DISSOLVED OXYGEN DYNAMICS IN THE COASTAL WATER BODIES AND MARINE WATERS OF THE SOUTHERN BLACK SEA, Polat et al 2019 https://www.researchgate.net/publication/334224616_NUTRIENTS_CHLOROPHYLL-A_AND_DISSOLVED_OXYGEN_DYNAMICS_IN_THE_COASTAL_WATER_BODIES_AND_MARINE_WATERS_OF_THE_SOUTHERN_BLACK_SEA [accessed Feb 22 2021].

[53] https://ced.csb.gov.tr/en/units/department-of-environmental-inventory-and-information-management/2032

[54] https://webdosya.csb.gov.tr/db/ced/icerikler/mar-ne-qual-ty-bullet-n-2018_black-sea-20180319074753.pdf

[55] https://webdosya.csb.gov.tr/db/ced/icerikler/mar-ne-qual-ty-bullet-n-2018_med-terranean-sea.docx-20180319075021.pdf

Romania

The organization that is responsible for environmental regulation of aquaculture in Romania is the National Agency for Fisheries and Aquaculture (NAFA), as part of the Ministry of Agriculture and Rural Development.

In Romania, marine aquaculture is at this moment practically non-existent. The only offshore marine mussel farm has suspended its activities since 2016, due to an unclear legislative framework. Therefore, there is currently no reporting of environmental parameters by the aquaculture sector.

Albeit not for aquaculture purposes, a range of environmental parameters are monitored along the Romanian coast at the Black Sea. This is managed by the National Institute for Marine Research and Development "Grigore Antipa" Constanţa (NIMRD), which also issues annual reports.

Monitored ocean parameters include:

- temperature,
- water transparency,
- salinity,
- nutrient concentrations in the water column and in the sediment,
- phytoplankton communities,
- algal blooms.[56]

NIMRD also holds the responsibility for implementing the Marine Strategy Framework Directive and national responsibility to collect fisheries data and to assess living resources.[57]

[56] http://www.rmri.ro/Home/Downloads/EnvStatusReport/ESR_2015.pdf

[57] http://www.ciesm.org/online/institutes/institute.php?instID=ROM1

Ukraine

In Ukraine, the Ministry Of Ecology And Natural Resources Of Ukraine and Ministry of Agriculture are in charge of protecting the environment and nature, and the sustainability of natural resources.
Along the Ukrainian Black Sea coasts, environmental monitoring of water parameters (chlorophyll-a concentration, phytoplankton diversity, phytoplankton cell numbers, and toxic species), hydrobiological parameters (algae, zooplankton, macroinvertebrates, fish, marine mammals) managed by Odessa national I.I. Mechnikov university (ONU), Institute of marine biology (IMB) and Ukrainian scientific centre of Ecology of Sea (UkrSCES).

The environmental monitoring program includes the following indicators:

- Surface water monitoring in accordance with the EU Marine Strategy Directive
- Review of marine habitats on transects (periodicaly)
- Monitoring the condition of marine habitats of the coastal zone (periodicaly)

The results of these monitoring and measurements are available to the regional states

There is no marine aquaculture in Ukraine, because of the difficult environmental conditions for the development of aquaculture in coastal zones, due to the following reasons:

- water temperature changes (ice in winter);
- prolonged storms in autumn;
- appearance of zones of hypoxia on the shelf NWBS;
- introduction of alien organisms (Rapana, Mnemiopsis, & others);
- climate change (reduction of rainfall in the northern BS region, reduced runoff of small rivers & increase the salinity of limans);
- socio-economic reasons;
- complexity in the legislative framework.

Future perspective for Ukrainian mariculture may include the cultivation of mollusks (especially mussels) and turbot. Ukraine is interested not only in obtaining of aquaculture products of turbot but also in its restocking in the Black Sea. For mussel farms, more favorable conditions exist in the Karkinitsky Bay, where there are no fish-kill zones. Here it is necessary to carry out experiments on the cultivation of oysters.