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Designing innovative services for marine environment monitoring using earth-observation tools in the frame of the Pre-Commercial Procurement project MARINE-EO

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Abstract. MARINE-EO is a Research and Development project using a Pre-Commercial Procurement (PCP) mechanism with the scope to develop innovative beyond the state-of-the-art downstream applications which meet the demand of maritime authorities and stakeholders, leveraging on the existing services and other products from the Copernicus portfolio. More specifically, MARINE-EO aims to meet the procurers' demands in the thematic areas of *Marine*

monitoring and *Maritime security*. In this study we present the consultation three-step-procedure, which was designed and launched in order to define the services to be procured and developed within MARINE-EO project, with focus on the set of features addressing *Marine monitoring* (called SATOCEAN). These features deal with information on ocean parameters' variability in time and space, best probable fishing areas, fish farm locations, water quality and sea ice extent for safe navigation and maritime operations. The EO-based services, mainly related to satellites and Copernicus Sentinel missions, aim to be established in the areas of Mediterranean, Atlantic and Arctic, by adapting Copernicus data and information on the marine environment. Upon the completion of this consultation procedure, three SATOCEAN feature services and use-case scenarios were finally proposed to be procured and developed: i) Marine environmental status in hot spots (in Gulfs and Marine Protected Areas), ii) Detection of fish farms threats (in aquaculture sites), and iii) Detection of vessels and icebergs in the Arctic Sea.

INTRODUCTION

"MARINE-EO: Bridging Innovative Downstream Earth Observation and Copernicus enabled Services for Integrated maritime environment, surveillance and security" is the first European Earth Observation (EO) Pre-Commercial Procurement (PCP) project [1]. The overall scope of MARINE-EO is the use of the PCP mechanism [2, 3] for the development of innovative beyond the state-of-the-art downstream applications which meet the demand of maritime authorities and stakeholders, leveraging on the existing Copernicus Services and other products from the Copernicus portfolio [4]. PCP has been a powerful tool to strengthen the collaboration between the supply (i.e. SMEs, industries) and the demand side (End-users). MARINE-EO intends to establish EO-based services covering the areas of Mediterranean, Atlantic and Arctic by adapting Copernicus data and information on the Marine Environment in order to meet the procurers' demands.

There are two thematic areas to be addressed: (i) *Marine monitoring*. This set of features is called SATOCEAN and it deals with information on ocean parameters' variability in time and space, best probable fishing areas, fish farm locations, water quality and sea ice extent for safe navigation and maritime operations in the Arctic, and (ii) *Maritime Security*. This set of features is called SATSURVEILLANCE and deals with vessel detection, risk assessment and management of immigration flows. MARINE-EO aims at the following objectives: (i) Develop, test and validate the demand-driven EO-based services, adopted on open standards, bringing incremental or radical innovations in the field of maritime awareness and leveraging on the existing Copernicus Services and products, (ii) Propose a set of "support" / "envelop" services which will better integrate the EO-based services to the operational logic and code of conduct, (iii) Strengthen transnational collaboration in maritime awareness sector by facilitating knowledge transfer and optimization of resources for the public authorities participating in the procurers' group. The MARINE-EO consortium teams up a group of 5 maritime authorities (the End-users/procurers' group: DGPM, GUCI, HCMR, FRCT, NCA) and a group of 4 prestigious scientific and technical organizations with significant experience in EO and maritime matters (the technical advisors: NCSRD coordinator, NOA, EUSatCen, SINTEF).

As mentioned above, the project will be leveraging on the existing Copernicus services and products. Copernicus is the European programme for the establishment of a European Earth Observation infrastructure, coordinated and managed by the European Commission [4]. Copernicus collects data from multiple sources: earth observation satellites and in situ sensors such as ground stations, airborne and sea-borne sensors. The observation infrastructure is operated by the European Space Agency for the space component and by the European Environment Agency and the Member States for the *in-situ* component. Copernicus processes these data and provides a set of reliable and up-to-date services related to environmental and security issues to End-Users, mainly public authorities and policymakers. Copernicus Marine Environment Monitoring Service (CMEMS) is one of the six thematic areas, offering access to oceanographic data and products to be downloaded by End-users through an online catalogue [4]. CMEMS is related to four thematic areas: Maritime Safety, Marine Resources, Coastal and Marine Environment, and Weather, Seasonal Forecasting and Climate activities.

The aims of this study are to present: i) the whole set of features called SATOCEAN and addressing the thematic area of *Marine monitoring*, ii) a consultation three-step-procedure designed and launched in order to define and rank the SATOCEAN services and their requirements, and iii) the feature services and use-case scenarios, which were finally selected to be procured and developed within the MARINE-EO project.

METHODOLOGY

In order to compile EO services and user requirements that are currently implemented in various domains of marine research, a review of recent and existing related research projects was conducted, e.g. EMODnet, DEVOTES, AQUA-USERS, MEECE, ArkGIS, NORSEWIND etc. Based on this review, we constructed a catalogue with different marine research domains and the currently applied EO services. The catalogue was circulated among the End-users/procurers' group to give their perspective.

For the definition of the SATOCEAN services to be procured and developed within MARINE-EO and their requirements, a consultation three-step-procedure was followed: i) construction of a survey addressed to the End-users/procurers' group. Furthermore, the survey was combined with the collection of background information from bilateral discussions and interviews with domain experts outside the consortium, ii) launch of a Request for Information on the MARINE-EO platform in order to get insights from the industry, and iii) organization of an Open Market Consultation Day in order to actually meet with the industry sector and receive direct feedback from the potential interested parties to bid for the PCP Tender [5].

The means and steps that were used for defining SATOCEAN services are presented in fig. 1. The Work flow follows a typical procedure, which starts with End-User feedback and consultation, analysis of the user inputs and documentation, adapted by [6]. After the completion of this process, the feature services and the use-case scenarios to be procured and developed for the *Marine monitoring* thematic area, were finally selected.

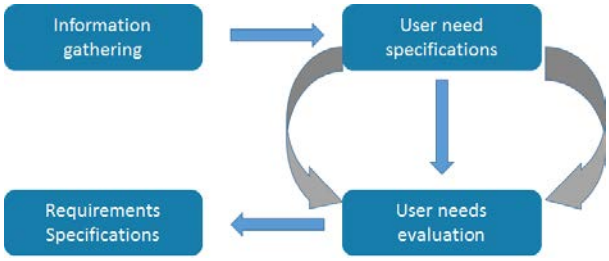

FIGURE 1. Schema of the consultation procedure followed for the definition of the SATOCEAN services and requirements for the *Marine monitoring* thematic area (adapted by [6]).

RESULTS AND DISCUSSION

Considering the thematic areas of MARINE-EO and the existing Copernicus Services, possible contributions to the services are presented in fig. 2. The SATOCEAN services cover the thematic areas of *Marine environment monitoring*, while the border monitoring scope of SATSURVEILLANCE is planned to build on the existing Border Surveillance services under *Security*.

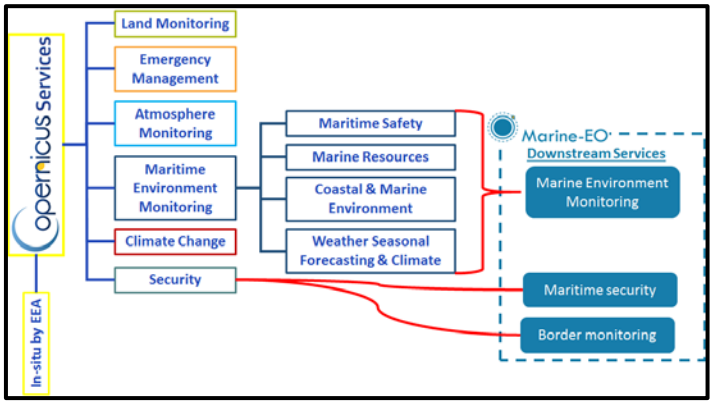

FIGURE 2. MARINE-EO thematic areas of proposed downstream services and their connection to existing Copernicus Services which they can support.

Ongoing and past projects and initiatives have made significant efforts to collect and analyze earth-observation services and requirements from various entities and sources. Partners of the MARINE-EO consortium have been engaged in past R&D projects for the development of services for various target applications. This knowledge was taken into consideration for the definition of present SATOCEAN services and user requirements [7, 8, 9]. The steps that were followed for defining MARINE Monitoring Services are presented in fig. 3. The Work flow follows a typical procedure, which starts with End-user feedback and consultation, analysis and prioritization of the End-user inputs, and finally integration and selection.

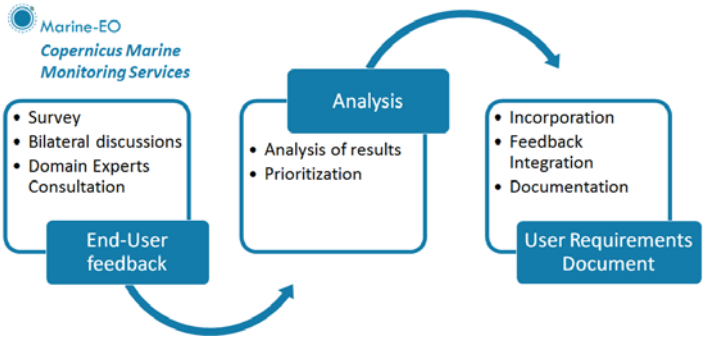

FIGURE 3. Work flow for the definition, prioritization and final selection of the SATOCEAN services for the *Marine monitoring* thematic area.

According to the review of recent and existing related research projects and the feedback of Scientists and domain Experts within and outside the End-users/procurers group, the catalogue of various marine research domains, using earth-observation services was structured (Table 1).

TABLE 1. Extended catalogue of marine monitoring services of interest (in random order) implementing earth-observation tools.

Marine monitoring services	
1)	Ocean biotic and abiotic parameters, climatological information and historical statistics
2)	Fish farm monitoring
3)	Phytoplankton and harmful algal blooms detection and mapping
4)	Regular monitoring of Marine Protected Areas
5)	Pelagic fisheries support information
6)	Information about oil spill events in the water and their development in time and space
7)	Detection of vessels and icebergs in Arctic areas
8)	Detection of open channels in the ice in the Arctic
9)	Prediction of possible locations of jellyfish blooms

Following the cataloguing of the marine monitoring services of interest, a survey was constructed based on tailored questions to address the End-users group needs and requirements on the use of earth-observation tools for various marine research domains (for more details see ANNEX I in [10]). The survey was launched on the SurveyMonkey ® platform and it consisted of five main parts:

1. Basic information and guide was given to the MARINE-EO consortium End-users,
2. Contact information of the individual responding to the survey, so as to allow monitor the answers and revert in case of any clarification,
3. End-users have to prioritize SATOCEAN services according to their needs,

4. In case an End-user was interested for a service, there was a set of seven questions based on which the appropriate information was gathered. Namely, some questions requesting:
    a. a narrative description of the need,
    b. the main End-users of the feature service,
    c. whether they are using CMEMS (satellite and/or *in-situ*) products and services,
    d. whether they are using any other (non-CEMS) satellite data, products and services,
    e. to indicate at what level (1-5) End-users' needs are currently met,
    f. further information whether there are any further potential improvements and additional / future needs
5. To indicate the importance (N/A, Very Low – Very High) of each feature service.

This survey was distributed to a large number of Scientists and domain Experts from the End-users/procurers group (HCMR, FRCT, NCA, GUCI, DGPM), who were asked to complete their responses with the support of the technical advisors' group (NOA survey supervisor, NCSRD project coordinator, EUSatCen, SINTEF). At the beginning of the survey, the End-users were also asked to rank the services according to their *priority of needs* (top priority '1' and lowest priority '9'). At the end of the survey, an additional quote was introduced allowing the End-users to rate *the importance of the services* according to their needs. The End-users had the option to rate the importance from "Very important" to "N/A (Not applicable)". The purpose of having this additional request was double: i) to cross-check if the initial choice of prioritization and the importance are consistent, and ii) to be able to discriminate among services with equal ranking. It is important also to highlight that it was agreed among the End-users to select three services based on the above methodology, among which one of the three would be dedicated to the Arctic area in order to address all the consortium member needs.

The ranking of the services is presented in fig. 4. Both prioritization and importance columns are the sum of the feedback and ranking reported by End-users. "Priority" column follows an ascending order with lower values showing high priority, while for "Importance" column, high values indicate great importance. It appears that the feature services related to "*Regular monitoring of Marine Protected Areas*" received the highest ranking of priority and importance while the "*Prediction of possible locations of jellyfish blooms*" received the lowest. A moderate ranking was given to "*Phytoplankton and harmful algal blooms detection and mapping*" and "*Information about oil spill events in the water and their development in time and space*" related services.

Some important considerations from the survey results are that most responses were quite short providing very few information. This can be explained from the fact that some partners from "End-users/buyers group" were actually responding as interfaces to the End-users. As a remediation action, several bilateral discussions took place and information was requested also from other parties and experts outside the Consortium. However, the overall feedback received from the partners was very comprehensive and helpful, keeping in mind that it was crucial to be specific and assist on indicating concrete scenarios, AOIs, parameters, products that should be provided for each feature service. Finally, it was imperative for each feature service to agree upon tangible objectives, in terms of AOIs, temporal and spatial resolution of the service and of other parameters, so as to clearly define both data and user requirements.

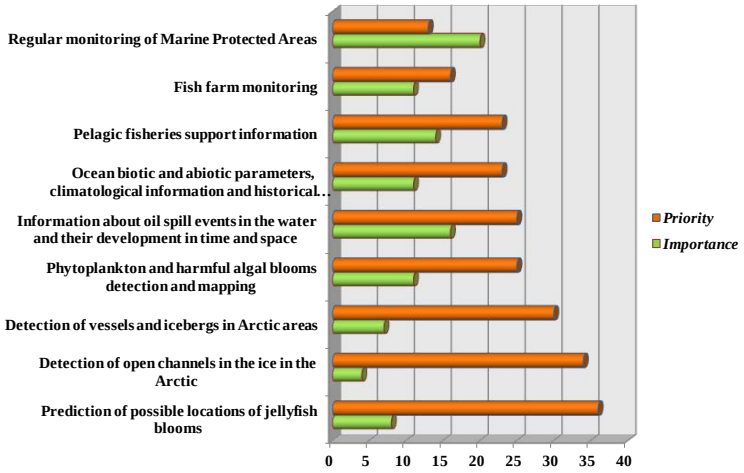

FIGURE 4. The ranking given by the MARINE-EO End-users group for marine monitoring services according to *Priority of needs* (from top priority '1' to lowest priority '9') and *Importance of the services* (from "Very important" to "Not applicable"). The sum of the rankings per feature service is presented in each column.

In parallel with the survey process, a Request for Information (RFI) was compiled as a part of the Market Study conducted towards the definition of the services and requirements and the preparation of the Procurement. The Questionnaire of the RFI was launched on the Marine-EO platform [11] and answers from eighteen Earth Observation companies were received. The industry feedback was grouped in four main sections regarding: i) the solutions available in the market, ii) the funds available for the public procurement, iii) operational aspects of the procurement process, and iv) technical aspects of the data acquisition. The messages coming from the companies' experience and comprehensive market knowledge, allowed the consortium to fine-tune the Tender specifications, meet the market needs and approach the available technology.

After the end of the survey process and the ranking of the marine monitoring feature services, an Open Market Consultation event was organized (Industry Day), aiming to inform the industry about the PCP procedure of MARINE-EO and the requirements needed for the implementation phase of the project [12]. During the Industry Day event, we managed to collect insights of the industry, broadly disseminate the project, and clarify the PCP process to companies and interested parties, explaining how to benefit from it. Through this process, the consortium was able to fine-tune the PCP procedure with the suggestions and comments of the industry, verify the latest developments in the industry, and discuss current projects and technical solutions deployed in the market.

Upon the completion of this consultation three-step-procedure, three downstream feature services were finally selected for the thematic area *Marine monitoring*, as SATOCEAN services (fig. 5):

1. SATOCEAN-UCS-1: Marine environmental status in hot spots (Areas of Interest AoIs e.g. Gulfs, MPAs etc.).
2. SATOCEAN-UCS-2: Fish Farms, detection of Fish farms threats (AoIs e.g. aquaculture sites)
3. SATOCEAN-UCS-3: Detection of vessels and icebergs in Arctic areas.

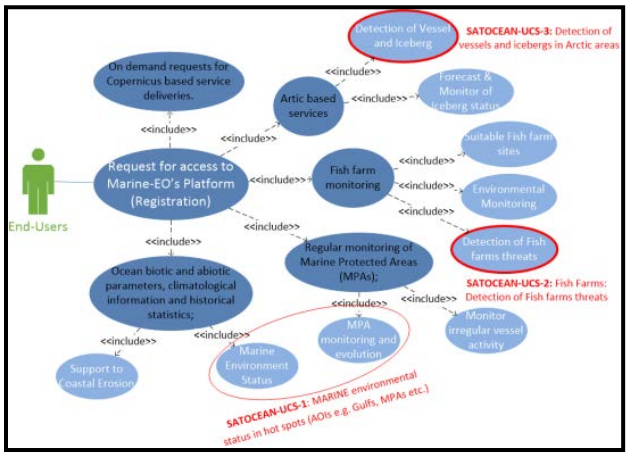

FIGURE 5. Selection of three downstream feature services and use-case scenarios (as SATOCEAN-UCS in red circles), among a set of features proposed for the *Marine monitoring* thematic area in the frame of the MARINE-EO project.

These three SATOCEAN services were finally qualified for the procurement phase. They will have to apply specific operation scenarios serving needs of End-Users (storing of historic data, data acquisition, data analysis etc.) and exploit already developed data and services (e.g. Sentinel data, CMEMS data, services and products), thus overcoming limitations (obstacles) related to storing, searching, acquiring and processing of data. A generic use case model for the three SATOCEAN services is presented in fig. 6. In the next paragraphs, a brief presentation of the SATOCEAN services is given.

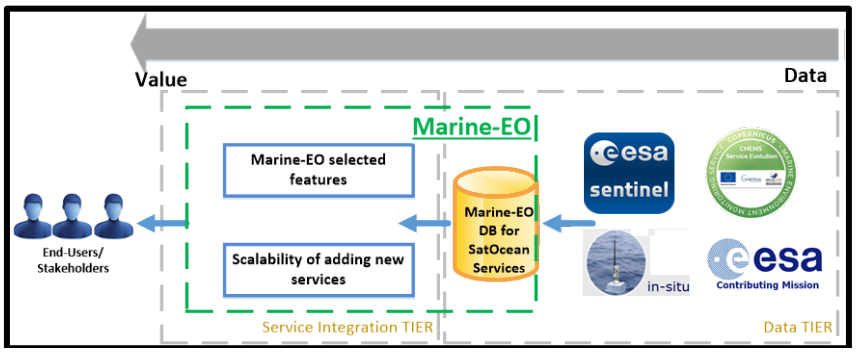

FIGURE 6. Generic use case model for the three selected SATOCEAN services to be procured and developed within MARINE-EO project.

***SATOCEAN-UCS-1: Marine environmental status in hot spots*:**

A relevant issue to be addressed is to consolidate all required data from diverse sources in one single web application at typical operating conditions (e.g. in-situ historical data from various national databases, long time series of buoy measurements, in-situ data collected during multidisciplinary oceanographic cruises, in-situ experiments for biological parameters). This service will also be connected with the European Marine Strategy Framework Directive (MSFD 56/2008 EC) and the environmental status assessment process [10; 11]. Marine-EO is a unique opportunity to develop innovative tools of EO for the environmental status assessment by the European Member States. Actually this is a drawback that has been highlighted by the Gap analyses of other EU projects, e.g. DEVOTES, EcApRHA, Action-Med etc. All the above will be integrated in the MARINE-EO platform, showing all types of data services and other products (e.g. CMEMS), statistical analysis results, interpolated parameter maps and an alert functionality based on long term data and the detection of essential changes and/or extreme values.

Potential End-users of these services involve: Environmental Agencies in Ministries and Prefectural units, Agencies related to the implementation of MSFD and MSP European Directives, Port authorities, other Marine authorities, Policy makers, Marine Spatial Planners, Environmental and urban engineering companies, Scientific community in Research and Academia, NGOs etc. After subscription to the MARINE-EO platform, End-users will be able to select which types of data/parameters to see/download, such as sea surface temperature, salinity, chlorophyll-a, suspended matter, turbidity, transparency, currents, winds, water-leaving radiances and primary production. They will be provided with information (a master file) related to the status of the marine environment in a selected area of interest (AoI) on regular intervals (weekly). Moreover, a tool to integrate satellite-derived chlorophyll-a concentrations with environmental assessment thresholds will be developed in order to give scores and thematic maps for environmental assessment. Finally, the detection of changes over time (trends, anomalies, etc.) will be based on historical data. Mainly raw Sentinels data, CMEMS data and products/services and in-situ data will be used. A detailed definition of user and data requirements has derived from the combination of users' feedback and state-of-the-art solutions, currently used in gathering vital ocean parameters. Target operational areas will be coastal areas receiving pollution pressures (hot spot) and Marine Protected Areas (MPAs), such as AoIs in Greece – Saronikos Gulf and National Marine Park of Zakynthos, or any other relevant site with similar data available in Spain - Golfo de Cádiz & Alboran Island; Portugal - Marine Park of Azores and selected areas of the Natural Islands Parks of the Azores, Littoral Norte, Berlengas, Sintra-Cascais, Ria Formosa; and Norway - Svalbard and Bjørnøya, Coral reef complexes (Røstrevet) that lie west of Lofoten Islands, and Ytre Hvaler national park.

***SATOCEAN-UCS-2: Fish Farms: Detection of fish farm threats*:**

Freely accessible ocean parameters (e.g. from CMEMS) will be applied to the fast growing sector of Fish Farming. Fish Farmers are not aware of such information availability. Information on fish farm status and detection of threats can be provided as data services to End-users, such as aqua farming companies, associations of aqua farmers, environmental Agencies in Ministries and Prefecture units, fish farming control related Agencies, other marine authorities, administration services, decision makers, policy makers, Marine Spatial Planners, law-enforcement authorities that are interested (e.g. awareness and illegal activities in fish farm areas), environmental and urban engineering companies, scientific community in Research and Academia, NGOs etc. Focus will be given to specific fish farming areas identified by the End-users (e.g. allocated zones for aquaculture, fjord), serving

/addressing the detection and prediction of fish farms threats (e.g. harmful algal blooms, HABs). After subscription to the MARINE-EO platform, End-users of will be provided with information (a master file) related to chosen key parameters on regular intervals (weekly), such as sea surface temperature, salinity, chlorophyll-a, suspended matter, turbidity, transparency and water-leaving radiance. A tool will be developed with the definition of critical levels of satellite-derived chlorophyll a concentrations to give alert signals for potential fish farm threats.

Environmental data will derive from different sources, e.g. CMEMS, Sentinel missions, in-situ. All the above information will be integrated in the platform that will be self-sustained on operational activities. Efficiency and sustainability of fish farming will be increased through: i) the incorporation of satellite and geospatial data from various satellite missions (different modes of Sentinel 1-2-3) and data repositories (e.g. CMEMS, C-TEP) for higher spatial and temporal resolution; ii) combining information on sea surface temperature, harmful algal blooms, fish diseases or anomalies, extracted by using systematically EO and in-situ measurements through well adapted algorithms / modeling / automated workflow. The target operational areas will be selected in aquaculture sites of central Greece (mostly farming seabream and seabass) and/or in any other European site with available data. In addition, the service shall be able to run in both coastal and off-shore areas. A map will indicate the extent of all areas that the service can be applied, giving also the functionality to End-Users for on demand requests in other areas.

SATOCEAN-UCS-3: Detection of vessels and icebergs in the Arctic area:

The main gap to fill is the need for high level of trust for iceberg and vessel detection (including mobile offshore units and structures), reliable information on sea ice status and advanced forecast models. Ship's navigators in the Arctic Sea need to operate in effective ways, choosing optimum routes prior and during their voyage. Compilation of satellite images, weather and wave height forecast are therefore critical. To achieve safety, security, and efficiency, and the reduction of emission to air, this service needs to provide to the user on demand, a mean for communication and digital information sharing or information retrieval of the processed data, taking into consideration the challenges of communication and broadband limitations in the Arctic remote area.

Identified End-users include the Norwegian authorities, e.g. the "Norwegian Coastal Administration - NCA"; the "Search and Rescue – SAR"; the "Fisheries"; the "Customs"; etc., ships navigators on board, shipping industries (ship owners from all countries with interest in the Arctic operations), the offshore industries, and the R&D institutions. Identifying and monitoring threats of Icebergs to vessels and ocean structures is of great importance for better decision making to ensure the safety, security and operation efficiency. Data for managing safety, security and efficiency are expected from Copernicus, KSAT, Sentinel, CMEMS data/services. Additional data sources could be commercial available satellites (for example: RadarSat; TerraSAR-X; Cosmo Skymed), Aircraft photo as well as AIS-satellites services by NCA and others, LRIT by EMSA, VDE-SAT (if possible). Target operational area is NAVAREA XIX under the responsibility of Norway. Reliable information for the discrimination between an iceberg and a vessel will be obtained through the combination of images from the different positioning sources of AIS, LRIT and VMS, advance discrimination algorithms to reduce false alarm rate, and develop a more accurate model for the object position and recognition.

CONCLUSIONS

A three-step procedure of consultation was designed and launched for the selection of earth-observation based feature services to be procured and developed in the frame of the R&D MARINE-EO Pre-Commercial Procurement project. This consultation procedure proved to be very efficient for the collection and analysis of the feedback received by the End-users regarding their research and operational needs. three downstream feature services were finally selected for the *Marine monitoring* thematic area: i) *Marine environmental status in hot spots* (in Gulfs, MPAs etc.), ii) *Fish Farms, detection of Fish farms threats* (in aquaculture sites) and iii) *Detection of vessels and icebergs in Arctic areas*.

REFERENCES

1. MARINE-EO: Bridging Innovative Downstream Earth Observation and Copernicus enabled Services for Integrated maritime environment, surveillance and security. Project Overview https://marine-eo.eu/project-overview

2. COM(2007) 799 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. *Pre-commercial Procurement: Driving innovation to ensure sustainable high quality public services in Europe*. 11 pp.
3. European Commission portal about Pre-commercial Procurement (PCP). https://ec.europa.eu/digital-single-market/en/pre-commercial-procurement
4. Copernicus Services list: http://copernicus.eu/main/services
5. Call for Tender https://marine-eo.eu/call-tender
6. A. Faisandier, *Systems Architecture and Design*, (Belberaud, Sinergy'Com, France, 2013)
7. M. Schmitt and X.X. Zhu, IEEE Geosci. Remote Sens. Mag. **4**, 6-23 (2016).
8. J. Zhang, Int. J. Ima Data Fusion, **1**, 5-24 (2010).
9. X.X. Zhu, D. Tuia, L. Mou, G.S. Xia, L. Zhang, F. Xu, F. Fraundorfer, IEEE Geosci. Remote Sens. Mag. **5**, 8-36 (2017).
10. A. Trypitsidis, A. Tsouni, K. Topouzelis, H. Kontoes, I. Varkitzi *et al.* Deliverable 2.2 User Requirements for the Copernicus Marine Environment thematic area, (2017), MARINE-EO project H2020 https://marine-eo.eu, coord. Dr. SCA Thomopoulos, NCSRD, 71 pp.
11. Request for Information https://marine-eo.eu/request-information-rfi
12. The Open Market Consultation for the first Earth Observation PCP project was successfully held in Lisbon https://marine-eo.eu/article/open-market-consultation-first-earth-observation-pcp-project-was-successfully-held-lisbon
13. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) (Text with EEA relevance).
14. European Commission Decision 2018/229/EU: Commission Decision (EU) 2018/229 of 12 February 2018 establishing, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, the values of the Member State monitoring system classifications as a result of the intercalibration exercise and repealing Commission Decision 2013/480/EU (notified under document C(2018) 696)Text with EEA relevance.

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