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DELIVERABLE

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Executive Summary

SEADOTs (Social-Ecological Ocean Management Applications using Digital Ocean Twins) aims to advance holistic, just and sustainable ocean management by integrating predictive socio-ecological components into comprehensive Digital Ocean Twins (DOTs). These DOTs will integrate human activities into digital twins of the ocean (DTOs) by combining social-ecological and socio-economic data with physical ocean and ecosystem data, and a variety of models. By developing and demonstrating applications in the Norwegian North Sea, the Southern North Sea and the Baltic Sea, SEADOTs aims to facilitate and inform political decision making, marine spatial planning and adaptive management to help safeguard ocean ecosystems, promote sustainable resource use, and enhance social and economic well-being.

The project builds on synergies with EU Mission and Green Deal projects including Iliad, EDITO, OLAMUR and CLIMAREST, and demonstrates Ocean Management Applications with Digital Ocean Twins on the EU Digital Twin Ocean infrastructure and other platforms for socio-ecological, socio-economic and political endpoints. A key ambition is to provide spatially-explicit social-ecological data beyond the project's lifetime and to strengthen long-term data interoperability.

This deliverable (D5.3: report on ecosystem management, engagement, and policymaking) plays a central role in conceptualizing how project developments and results are aligned with marine policy. It synthesizes methodologies, early results, and planned activities for stakeholder engagement, policy uptake, and integration into the EU DTO. SEADOTs' ecosystem management and engagement strategy is structured along three levels of cooperation:

1. SEAtwins (Integration of Socio-Ecological Aspects into Digital Twins of the Ocean), involving all projects listed under the Horizon Europe grant agreement ID 101156488
2. BlueMission BANOS, involving further projects under der EU Mission "Restore our Ocean and Waters by 2030")
3. The UN Decade for Ocean Science Programme DITTO, involving the global DTO community

As part of Work Package 5 "Engagement: Stakeholder Engagement, Dissemination, and Exploitation" this report describes the planned activities and their outcomes around activities, including joint research meetings, collaborative data management, joint research papers and conference sessions, and public communication formats.

Deliverable D5.3 is tightly connected to the following deliverables: D5.2 and D5.5 (Dissemination plan and communication activities; outlining the strategic framework for communication, dissemination, and stakeholder engagement), D5.9 (Training material and documentation from trainings), D5.10 (Policy briefs), as well as D5.4 and D5.6 (Exploitation strategy report; designing and executing the overall exploitation roadmap for SEADOTs to maximize the utilization of results in wider research activities and commercial application by the private sector). Deliverables D5.7 (Report on ecosystem management, engagement, and policymaking, second version) and D5.8 (Report on ecosystem management, engagement, and policymaking, final version) will build on this deliverable.

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Definitions, Acronyms and Abbreviations

Acronym/Abbreviation	Title
BlueMission BANOS	Mission Lighthouse covering the Baltic and North Sea basin
Case study	In SEADOTs, the specific social-ecological system used to develop the digital ocean twin demonstrators (i.e., Norwegian North Sea, Gotland, German Bight cases).
CLIMAREST	EU-funded project: Climate resilience and marine ecosystem restoration.
Clustering	A practice where related projects work together to share knowledge, co-organize events, and develop joint outputs. SEADOTs clusters with sibling projects under the same call, broader Mission Ocean initiatives, as well as projects under the UN Ocean Decade Programme DITTO.
Demonstrator	A digital application developed for a specific use (e.g., one of the SEADOTs case studies) that demonstrates the implementation of the integrated models.
Digital twin	A digital representation of a system or system(s) and its interactions that incorporates real-time or otherwise updating data streams from the real world.
DITTO	Digital Twins of the Ocean Program within the UN Decade of Ocean Science for Sustainable Development.
DOT	Digital Ocean Twin; DOTs integrate representations of the ocean with models of human activities in maritime sectors, such as marine industries, tourism, and transport.
DTO	Digital Twin of the Ocean; DTOs incorporate ocean data and predictive models to create digital representations of the ocean.
DTO-BioFlow	EU-funded project “Integration of biodiversity monitoring data into the Digital Twin Ocean”.
EcoTwin	EU-funded project “Emulating complex causal socio-ecological models in digital twins of ocean”
Ecosystem	In SEADOTs’ project management, the network of stakeholders, including advisory board, use case communities, and partner initiatives, resources and environments, that collectively develop, test, and sustain project’s outputs and enable value creation beyond the immediate contractual boundaries.
EDITO	EDITO (European Digital Twin Ocean) is a European funded project that serves as the core infrastructure of the European Digital Twin Ocean (EU DTO).
EDITO-Infra	“EU Public Infrastructure for the European Digital Twin Ocean”, a project building the public infrastructure backbone for the EU DTO.
EDITO-Model Lab	A Horizon Europe project developing next generation ocean numerical models to be integrated into EDITO-Infra and providing access to ‘w0hat-if’ scenarios.

EMODnet	European Marine Observation and Data Network.
End user	Individuals who interact with SEADOTs demonstrators and tools through pre-built user interfaces but have no access to tool administration and very little opportunity to customize the tools; primary SEADOTs end users are drawn from the case studies
Engagement	In SEADOTs, the active and ongoing involvement of stakeholders in project activities through consultation, feedback loops, co-design of tools and use cases, as well as use of participatory methods; ensures project inclusiveness, relevance, and social acceptance
EU DTO	The European Digital Twins of the Ocean initiative
FAIR principles	Modern data management principles related to the sharing of data outlining that data should be Findable, Accessible, Interoperable, and Reusable
GEOMAR	Helmholtz Centre for Ocean Research
HEREON	Helmholtz Centre HEREON GmbH
Horizon Europe	EU Framework Programme for Research & Innovation
ICES	International Council for the Exploration of the Sea
Iliad	EU-funded project for the establishment of interoperable, data-intensive, and cost-effective DTOs
Mission Lighthouse	Regionally structured working groups to test, demonstrate, develop, and deploy the Mission activities across four major EU seas and river basins
Mission Ocean & Waters	Short for 'EU Mission to Restore our Ocean and Waters by 2030'; EU initiative focused on ocean health and blue economy
OLAMUR	EU-funded project "Offshore Low-Trophic Aquaculture in Multi use Scenario Realisation in North and Baltic Seas"
SEA	Social-Ecological Ocean Management Applications
SEADITO	EU-funded project "Social-Ecological Analysis and Models for Digital Twin Oceans"
SEADOTs	EU-funded project "Social-Ecological Ocean Management Applications using Digital Ocean Twins"
SEAtwins	"Integration of Socio-Ecological Aspects into Digital Twins of the Ocean" – a cluster involving four EU-funded projects (SEADOTs, SEADITO, SURIMI, EcoTwin) as well as a project under the UN Ocean Decade Programme DITTO
SES	Social-ecological system; encompasses social, ecological, and economic factors within a complex system.
SES actor	An individual, organization or system that interacts with, influences, or is represented within a case social-ecological system of digital twin thereof.
SES framework	The social-ecological systems framework as outlined by Elinor Ostrom can broadly be described as a multidisciplinary conceptual framework which describes how physical, environmental, and social systems interact to effect resources.

SES indicators	Measures that express, in a quantifiable or codeable way and along an internally consistent scale, values of specific phenomena of interest in a social-ecological system.
SOCEAN	Sintef Ocean AS
Social ecology	Social ecology is the study of how individuals interact with and respond to the environment around them, and how these interactions affect society and the environment as a whole.
Stakeholder	In SEADOTs, an individual, group, or organisation with a direct or indirect interest in how the ocean is managed in the context of the case studies, or who interacts with or is impacted by project outputs or outcomes. SEADOTs stakeholders include community representatives, fisheries cooperatives, energy providers, port authorities, local/regional governments, non-governmental organizations, and developers of similar tools, among others
SURIMI	Eu-funded project on Integration of innovative and reliable socio-ecological models and user-driven solutions into the Digital Twin Ocean, to facilitate what-if scenarios and decision support, under a co-creation approach
TRUST principles	The TRUST principles for data management promote responsible data use. The five principles are: Transparency, Responsibility, User-focused data use, Sustainable use of data, and the employment-appropriate Technology.
WP	Work Package

1 Introduction

SEADOTs is a pioneering initiative within the EU's Ocean management strategy and rapidly evolving Digital Twins of the Ocean (DTOs) landscape. The project's core mission is to integrate social-ecological data with advanced digital representations of the ocean – so called Digital Ocean Twins (DOTs). Digital Twins of the Ocean (DTOs) and Digital Ocean Twins (DOTs) are tools to facilitate a comprehensive understanding of the ocean system, and to enable the creation of 'what-if' scenario analyses for ocean conservation, marine spatial planning, and the creation of a sustainable, blue economy.

Both DOTs and DTOs are developed to address specific research questions. By providing real-time, predictive insights, the applications developed in SEADOTs shall empower local communities, industries, and policymakers with information needed to balance human activities and marine conservation. The SEADOTs project showcases the application of diverse DTO frameworks and demonstrates the capabilities of DOTs through three spatially explicit, scenario-based tools. These case studies encompass:

1. Norwegian North Sea (also the 'Utsira case'): assessing the impact of offshore wind farm development on small island communities.

2. German North Sea (also the 'German Bight case'): examining the economic and ecologic advantages and implications of shared marine spaces involving fisheries, offshore wind farms, and aquaculture.

3. Swedish Baltic Sea (also the 'Gotland case'): addressing the challenges of harmonising sustainable fisheries management with marine protected zones.

1.1 Objectives of the deliverable

Deliverable D5.3 "Report on ecosystem management, engagement, and policymaking, version 1", is part of Work Package 5 (WP5) – Engagement: Stakeholder Engagement, Dissemination, and Exploitation within the SEADOTs project. The aim of this deliverable is to outline a strategy for proper ecosystem management, engagement and policymaking in alignment with SEADOTs' objectives and work plan. It includes information on SEADOTs' exploitation, dissemination and communication strategy.

This report specifically describes the planned activities and their outcomes around activities that include: (i) joint research meetings, (ii) exchange of knowledge and results, (iii) improvement of technical and socio-environmental analysis of the results as well as new possibilities for scalability, (iv) collaboration on data collection, (v) joint research papers, (vi) creation of a common website, (vii) invitations of researchers from other activities to give talks, (viii) launch of common special issues and conference sessions, (ix) launch of common brochures and newsletters.

It is the first version of three deliverables (D5.3, D5.7, and D5.8) defining and establishing the SEADOTs ecosystem revolving around integration of the social-ecological component into DOTs to advise policymaking. These deliverables are produced under Task 5.2 ("Ecosystem bootstrap, Cluster, and Collaboration with the UN Decade for Ocean Science Program DITTO and Integration of SEADOTs Outputs into DITTO Initiatives") and tightly linked to Task 5.3 (Capacity Building, Knowledge Transfer and Policy Making). D5.3 is also connected to D5.2 and D5.5 (Dissemination plan and communication activities; outlining the strategic framework

for communication, dissemination, and stakeholder engagement), and informs D5.9 (Training material and documentation from trainings), D5.10 (Policy briefs), as well as D5.4 and D5.6 (Exploitation strategy report; designing and executing the overall exploitation roadmap for SEADOTs to maximize the utilization of results in wider research activities and commercial application by the private sector).

By synthesizing methodologies, early results, and planned activities, this report plays a central role in conceptualizing how project developments and results are aligned with marine policy. It connects extensively to all work packages (WPs) of the project. Specifically, WP2 (SES: Social-Ecological Systems: definitions, models, indicators and policy briefs) with Tasks T2.2 (SES model construction for the predictive capabilities of the DOTs) and T2.3 (Definitions of SES indicators towards targets and policy making), WP3 (Applications and framework: Development of SEADOTs Framework & Decision-Support Process and Tools) with T3.1 (Define functional and non-functional requirements for the use cases) and T3.4 (Develop end user applications and visualization tools), WP4 (Demonstrators: Use cases combining SEA and DOTs within European Digital Twin Ocean and Local Twin infrastructures), and WP6 (Project management: Project management, technical and scientific coordination) with T6.2 (Scientific and Technical Coordination, Advisory Board).

2 Definition of SEADOTs' ecosystem

The SEADOTs ecosystem consists of interdependent and heterogenous stakeholders, resources, and environments, that collectively enable value creation beyond the immediate contractual boundaries [REF-01]. It includes individuals, organizations, communities, government bodies, and other entities within the international social ecological ocean management and digital twin landscape. Value is created as strategic innovation, knowledge dissemination, and wider economic, social, and environmental impact.

SEADOTs' core consortium involves individuals and organizations with scientific and technical expertise across various disciplines and domains. The experts within the consortium include physical oceanographers, economists, social scientists, applied ethicists, philosophers of science, ecologists, and ecosystem modellers. The core consortium is supported by an Advisory Board with expertise within spatial planning, "serious" gaming, social science, political science, and experts on Ocean Best Practices.

Target groups from the blue economy cover sectors such as fisheries and aquaculture, shipping and transportation as well as offshore wind farms. Stakeholders from governmental agencies include coastal and port authorities responsible for managing and planning coastal zones, harbours, and port facilities. They provide extensive knowledge of local regulations, environmental conditions, and marine ecosystems, helping SEADOTs to align its solutions with regional regulatory requirements and environmental priorities, target groups from the research community include research organizations, universities, marine biologists, environmental scientists, oceanographers, and data scientists. Stakeholders from the public and civic sector include citizens, coastal communities, non-specialized media, NGOs; coastal communities may not be direct users of SEADOTs, but they stand to benefit indirectly from the project's results.

In addition, local stakeholders from the local case studies and stakeholders from the EU (and global) DTO landscape shape SEADOTs' ecosystem. The project's ecosystem leverages existing ecosystems and communities to strengthen the EU's digital twin capacities with new technologies and data spaces. Integration into and collaboration with existing ecosystems and communities involves clustering activities on three scales (i) with projects from the same call, (ii) with further projects within the EU Mission Ocean and Waters, (iii) with global initiatives gathered under the UN Ocean Decade Programme DITTO.

2.1 European Digital Twin infrastructures and initiatives

The SEADOTs project is strategically positioned within the European DTO landscape, leveraging core infrastructure and collaborating with several flagship initiatives (Figure 1): European ocean observing, monitoring and data programs Copernicus Marine Service and EMODnet supply high quality, standardized ocean data (satellite and *in-situ* monitoring) that feed into the European DTO infrastructure. The core infrastructure of the European Digital Twin is EDITO; EDITO offers tools to develop digital twins, support science-based decision-making, and ensure maximum impact for research and innovation. EDITO-Infra and EDITO-Model Lab form the backbone of the EU DTO. EDITO-Infra is both the name of the project and the name of the platform that shall provide the foundation for the EU DTO, "hosting the deployment of multiple digital twin applications from ongoing and future digital twin projects, supporting the deployment of new generation of ocean models (i.e., EDITO-Model Lab) and

other related initiatives, including Horizon Europe Mission Lighthouses projects" [REF-02]. Horizon Europe Mission Lighthouses are regionally-structured working groups that address challenges and pilot solutions in major sea and river basins. Covering the Baltic and the North Sea, the BlueMissionBANOS Lighthouse is the most important for SEADOTs.

Among SEADOTs and its sibling projects SEADITO, SURIMI and EcoTwin (gathered under "SEAtwins"), other related projects and initiatives within the European DTO infrastructure include Iliad, OLAMUR, CLIMAREST, and DTO-BioFlow. Iliad develops localized digital twins across Europe, focusing on interoperability, scenario modelling, and a marketplace for DTO applications; OLAMUR and CLIMAREST focus on ocean management applications, ecosystem restoration, and climate adaptation; DTO-BioFlow aims to support the access to and sustainable integration of both existing and new biodiversity data from various sources. The UN Ocean Decade Programme DITTO provides a link to the global DTO community.

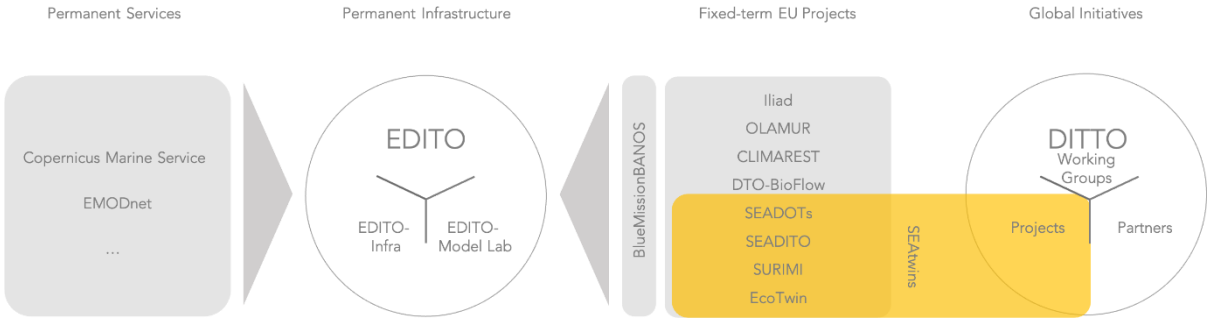


Figure 1: DTO landscape: Within EDITO, EDITO-Infra and EDITO-Model Lab integrate and upgrade essential services from Copernicus Marine Service and EMODnet into a unified digital framework. Among SEADOTs and its sibling projects within SEAtwins (highlighted in yellow), connections to further projects and initiatives including Iliad, OLAMUR, CLIMAREST, DTO-BioFlow, and DITTO have been established within the first 12 months of the SEADOTs project.

Users from the EU DTO community include those developing similar DOTs for different case studies (e.g. from projects within the SEAtwins cluster) and owners of infrastructure sharing data (e.g. EMODnet), data products (e.g. EMODnet, Copernicus Marine Services), and infrastructure for hosting the EU DTO (EDITO). These stakeholders may also interact with the applications developed in SEADOTs for more technical use than local stakeholders that are looking for information and decision-support. Stakeholders from EU DTO emphasized the need to open and accessible data, software, and data products.

2.2 SEADOTs use cases

SEADOTs aims to provide local stakeholders with the information needed for data-driven decision making. The project is structured around three distinct use cases (the Utsira, Gotland, and German Bight cases). In addition to stakeholders from the EU DTO landscape, the needs from local stakeholders surrounding each use case inform the datasets selected for use in the project's DOTs. While EU DTO user needs are assessed via engagement in arenas such as EU Ocean Days, One Ocean Week in Bergen, Norway, the Digital Ocean Forum, and in future Mission Ocean events, prioritization of local stakeholder's needs are assessed based on outcomes from stakeholder mapping using a Power-Interest Matrix approach [REF-03]. The Social-Ecological Systems (SES) framework, first developed by Elinor Ostrom [REF-04], is used to select the general data streams (e.g. ecological, social, and economic) that are included in each case study and mapped to components of the SES framework. Stakeholder

mapping was initiated in parallel to the creation of the data inventory to ensure that the needs of DOT end users were accounted for when identifying relevant data sets and defining user requirements.

Understanding case stakeholder landscapes is critical to developing applied understandings of case dynamics that are grounded in local expertise and responsive to local needs, as well as for identifying potential DTO users. Thus, partners leading each case study are in the process of developing case-specific stakeholder maps. Case stakeholders are those who can influence the specific case context (e.g., regulatory agencies with oversight of wind turbine siting), are likely to be affected by case developments (e.g., wind developers, coastal residents, fishers) and other interested parties (e.g., environmental non-profit organizations). More details on stakeholder mapping can be found in Deliverable D1.1.

In conjunction with the second SEADOTs General Assembly (October 2025), stakeholder maps that have been aligned across cases to identify overlapping stakeholders/clusters of stakeholder types, which will be collated and extended by the consortium as a whole to define a set of potential users of the DOTs (e.g., local public decision-makers, regulatory agencies, actors from industry).

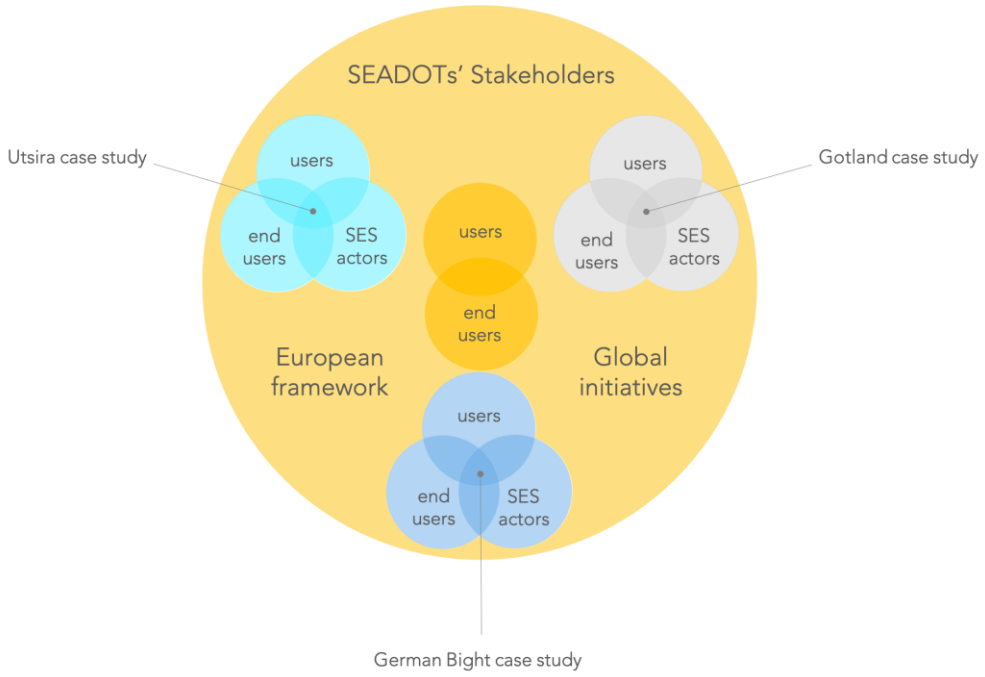


Figure 2: SEADOTs' ecosystem: individuals, organizations, communities, government bodies and further entities from global, European, and local groups form the project's ecosystem. While users and end users may be case study specific (blue, light blue, and grey) or independent (yellow), SES actors are case study specific. For detailed definitions see "Definitions, Acronyms and Abbreviations" at the beginning of this report (see pages 7-9).

2.2.1 Norwegian North Sea

The Utsira case centers on the development of Utsira Nord, poised to become the world's largest floating offshore wind park. The first tender for two of the three designated areas is scheduled for September 15, 2025, marking a significant milestone in Norway's offshore wind strategy. This initiative supports national goals to designate areas for the production of 30 GW of offshore wind energy by 2040, contributing to renewable energy expansion, industrial

growth, and technological innovation. Utsira Nord spans approximately 1,010 km², located ~7 km west of Utsira Island, with potential for 110–250 floating wind turbines. Environmental management includes extensive environmental surveys with avian tracking using AI-powered cameras to map bird migration pathways. These efforts aim to mitigate ecological impacts, particularly on seabird populations, and ensure minimal interference with local fisheries.

Stakeholder engagement has been a central focus of the Utsira Nord development. The project has involved regular dialogue with local fishermen, open supplier meetings, and educational initiatives with schools and universities in Haugesund and Utsira. Notably, the consortium has committed to local ownership, making it the only partnership where the community holds a stake in the wind farm.

Anthropological research under the "People on Offshore Wind" initiative has explored local perceptions and justice dimensions. Findings underscore the importance of procedural justice (fair and transparent processes), distributive justice (equitable sharing of benefits and burdens), and recognition justice (acknowledging local perspectives).

While Utsira Nord is framed as a flagship of Norway's green transition, local stakeholders have expressed skepticism about the tangible benefits and long-term impacts. To address these concerns, researchers and policymakers have proposed a framework for participatory processes, including early and clear planning, independent facilitation, trust-building through recognition, transparent and accessible information sharing, respect for local conditions, flexibility and openness to change, documentation of diverse perspectives.

The development of a digital twin is poised to help stakeholders engage in "what-if" scenarios. Preliminary conversations with the municipality of Utsira suggests that a digital tool to aid in scenario discussions will be very important for dialogue among the citizens of Utsira, the municipal authorities, and the wind park industry members.

2.2.2 German Bight

The German Bight case is generally focused on the integration of low-trophic aquaculture in an existing wind park located near Helgoland, Germany. Located about 20 km from Helgoland, the existing wind park is maintained by Helgoland port. The park has been operating since 2015 and has initiated wind park tourism. The area is being explored for multi-use by low trophic aquaculture. The park is associated with artificial reefs, and it is planned to incorporate aquaculture in the area of the wind park. Multi-use of the area both faces technical challenges (to aquaculture), and regulatory hurdles. Wind farms may also have effects on sedimentation on the coast by reducing wind and wave intensity. The wind farm replaced fishing in this area, which also has social and economic implications, e.g. by enabling fishing activity for crabs in the vicinity of offshore wind farms. Test installations for mussel production are currently underway. The integration of low-trophic aquaculture with the wind park is expected to improve the ecological footprint of renewable energy production by increased efficiency of use of space, removal of excess nutrients, and forwarding environment-friendly food production. Since a great portion of the energy produced in the region is exported by large energy companies, aquaculture production may increase the share of local businesses such as aquaculture producers, the maintenance industry, and tourism. This may positively affect local business and welfare and support acceptance of offshore wind energy production by coastal dwellers.

The wind park area is managed by an energy production company and monitored by the Federal Maritime and Hydrographic Agency (BSH). Key stakeholders include the energy company and the fisheries sector. Nutrient availability for mussel and algae cultivation is being simulated, with the results used to support feasibility assessments. “What-if” scenario modelling enables the evaluation of different implementation strategies to identify the most suitable approach for integrating aquaculture into the offshore wind park while balancing the interests of all stakeholders. Stakeholder engagement in the German Bight case focuses on contacts with offshore wind energy producers, aquaculture producers and federal agencies. The private stakeholders have been met in bilateral format working on data exchange, mutual understanding and co-design aspects. SEADOTs has been explicitly presented to BSH upon their invitation to an on-site workshop on downscaling and digital twin initiatives relating to or making use of Copernicus services like the EDITO.

2.2.3 Gotland

The Gotland case, situated in the Baltic Sea along the eastern coast of Sweden, investigates potential trade-offs and synergies between pelagic fisheries and offshore wind farm development. In the Swedish Baltic Sea, commercial fisheries primarily target pelagic fish species, notably herring (*Clupea harengus*) and sprat (*Sprattus sprattus*), which are typically harvested as part of a mixed fishery. While fishing activity in the waters around Gotland is predominantly carried out by Swedish fleets, vessels from other countries, including Finland, Poland, Denmark, and Germany, also operate in the region. Currently, only a limited number of individual offshore wind turbines are installed in the area. However, several zones have been designated as areas of particular interest for larger scale offshore wind energy development. These plans have raised concerns among pelagic fishers, particularly in the context of declining herring and sprat stocks and increasing regulatory pressures, such as the decision to relocate the trawling boundary further offshore in 2025.

In the Gotland case, several what-if scenarios will be assessed to explore the interactions between pelagic fishery and off-shore wind production. These scenarios will consider technical characteristics of wind parks (e.g., park size, spatial density, location), as well as interactions with existing and proposed marine spatial plans, including international biodiversity targets such as the 30x30 initiative. Additional regulatory factors will be examined, such as the extent of exclusion zones for fisheries around wind farm installations and adjustments to trawling boundaries (i.e. distance from shore). The cumulative impacts and uncertainties related to climate change, including marine heatwaves, will also be explored within the context of windfarm placement and resulting displacement of fisheries.

Key stakeholders in this case include pelagic fishers and their representative organizations, regional and national marine spatial planners, and offshore wind energy developers. Many of these actors will be accessed through other ongoing research initiatives running in parallel with the SEADOTS project. Particularly, understanding the decision-making of fishers and fishing fleets under different ocean use scenarios is central to the DTO application being developed.

A critical factor shaping the trajectory of offshore wind development in this case is national and regional security policy. In late 2024, the Swedish government halted offshore wind development plans around the Gotland area due to national security concerns related to defence operations and strategic surveillance capabilities. Despite these challenges, the regional goal—established through the Marienborg Declaration—remains to increase offshore

wind energy production in the Baltic Sea sevenfold by 2030. This ambitious target underscores the need to evaluate the trade-offs between offshore wind energy expansion and other marine sectors, particularly fisheries and marine biodiversity conservation.

3 Overall objectives of planned activities

SEADOTs uses direct contacts and long term established collaboration with project stakeholders to provide dialogs and organise meetings to collect requirements, promote knowledge exchange, data collaboration, and technical alignment, as well as to co-create and involve end users. Participation in events such as scientific conferences, stakeholder workshops, and policy forums to showcase project aims and results and to connect with relevant actors increases awareness and visibility of the project and expands the network within the digital ocean twin, marine sustainability, and socio-ecological modelling communities. These activities shall increase stakeholder engagement and policy impact to create sustainable and secure services for the targeted communities.

Contributions such as conference posters, publications, training material, technical outcomes and insights will be documented and shared online; a dedicated online repository has been established [REF-05]. In addition to project training materials (D5.9) and peer-reviewed publications, non-scientific publications such as articles, blog posts, and position papers, shall broaden awareness and ensure a shared comprehension of the project's results amongst a diverse audience.

4 Stakeholder Engagement Strategy

SEADOTs is designed to be highly collaborative, involving stakeholders from research, industry, policy, and civil society to ensure the effective integration of social-ecological data into DOTs. The stakeholder engagement strategy, outlined in deliverable D5.2, aims to maximize the uptake and impact of SEADOTs' findings, tools, and methodologies while fostering long-term cooperation. The table in D5.2, pp16-18 provides an overview of the potential key stakeholders, their relevance to the project, their objectives, engagement strategies, and key messages tailored to their specific interests.

5 Clustering activities

SEADOTs ecosystem management, engagement and policymaking revolves around three distinct clusters. (i) projects from the same call (ii) EU Mission Ocean and Water (iii) global initiatives under the UN Ocean Decade Programme DITTO. With clustering activities, SEADOTs aims to increase stakeholder engagement and policy impact as well as to broaden dissemination of project results. Engaging in clusters avoids duplication and ensures access to and provision of shared resources and harmonized methodologies as well as joint contributions to EU and global digital twin activities.

5.1 Clustering with projects from the same call: SEAtwins

A cluster with projects from the same funding call, acting under the acronym SEAtwins (Integration of Socio-Ecological Aspects into DTOs), was established in January 2025. The SEAtwins cluster includes all the projects listed under the Horizon Europe grant agreement ID 101156488, addressing the Horizon Europe call HORIZON-MISS-2023-OCEAN-01-8. With SEAtwins, we aim to bring the four EU projects closer together – by identifying common activities, delivering common messaging (e.g., in joint policy briefs), and avoiding redundant work. At the same time, it is a platform for sharing lessons learned. Externally, SEAtwins aims for a more coherent presence – for example, aligning communication efforts, showing the added value of the cluster as a whole, and coordinating inputs into broader policy processes for amplifying impacts.

With case studies across European seas, SEAtwins fosters innovative integration of socio-ecological models into the European DTO framework, enabling advanced scenario analysis, decision support, and ecosystem-based management. The project brings together novel methodologies, tools, and standards ensuring data interoperability, FAIR principles compliance, and participatory co-design. SEAtwins aims at empowering various stakeholders, including local communities, policymakers, and researchers to advance sustainable ocean management, enhancing societal and ecologic well-being.

Planned activities include: (i) identification of synergies and potential shared resources (ii) establishment of thematic expert groups concentrating on main aspects of SEA and DOTs to exchange knowledge and results, improve technical and socio-environmental analysis of the results as well as new possibilities for scalability, and to discuss collaboration on data collection and management (iii) joint research meetings, research papers, common special issues and conference sessions, (iv) launch of common brochures and press releases (v) creation of a common website.

In June 2025, SEAtwins was officially endorsed by UNESCO's Intergovernmental Oceanographic Commission as a part of the UN Ocean Decade Programme DITTO. The cluster defined six thematic cross-project working groups: (1) Project Management/ Coordination, developing common project outcomes, (2) Policy, involving people working towards policymaking advise, (3) Communication, covering dissemination and outreach activities, (4) Data Management, including collaboration on compliance to FAIR, and, if applicable, TRUST and CARE principles, (5) Modelling, with a focus on integration of social-ecological and socio-economic data (6) Data Visualisation and Interaction. The working groups operate independently and schedule regular meetings to define their actions and work towards reaching their goals.

SEADOTs and SURIMI lead the SEAtwins project coordination in the first year; SEADITO and EcoTwin will lead coordination in the second year. The collaboration on policy briefs and initiatives within the UN Ocean Decade has been initiated in a meeting involving representatives from SEADOTs and SURIMI in March 2025 (cf. Milestone 10). The development of a common glossary of key terms to be included in a joint fact sheet/policy brief started in April 2025. Defining key terms that are shared among the sibling projects helps to identify common themes and to align the understanding of terms that are critical for success of all funded projects in SEAtwins.

The consortium will publish a joint press release on SEAtwins' endorsement as a project under the UN Ocean Decade programme DITTO in September 2025; whereas a common website to disseminate common project outputs has already been established in July 2025 and can be accessed under [REF-06]. An in-person cross-project symposium as well as a joint workshop at the ICES 2026 meeting are planned for fall 2026 (see Table 3).

5.1.1 Description of the three sibling projects involved in SEAtwins

5.1.1.1 SEADITO

SEADITO [REF-07] focuses on the need for a targeted set of analytical methods and tools to support the development of the EU DTO including integrating social-ecological models in order to establish a comprehensive decision support platform. SEADITO aims at increasing transdisciplinary abilities of social-ecological models by updating and integrating outputs for improved Ecosystem-based Management.



Figure 3: Logo of the SEADITO project

SEADITO includes a set of case studies in the Baltic Sea, the North Sea and the Mediterranean, as well as a Pan-European case study will provide the contexts for the multi-actor processes identifying user needs, as well as co-designing and testing components and services in the targeted user communities. The results of SEADITO will include sets of interoperable, spatial explicit, and DTO compliant social-ecological decision-support components based on FAIR principles (e.g. to be integrated with EDITO-Model Lab), as well as scalable and multi-level social-ecological models, integrated quantitative and qualitative social-ecological indicators, and workflows quantifying and integrating cultural and behavioral aspects. The components will be tested through an interactive spatial platform, the SEADITO Explorer equipped with visual demonstrators of social-ecological models and a Scenario Toolkit (WIST). Learning materials will target young researchers, decision-makers, and the public.

5.1.1.2 SURIMI

SURIMI [REF-08] supports the development of the European Digital Twin Ocean (DTO) by integrating socio-ecological models that help assess the ecological, social, and economic impacts of fisheries management decisions. The project delivers open-source, user-friendly tools that enable stakeholders to run “what-if” scenarios and explore sustainable solutions for marine ecosystems. SURIMI is developing a modular toolbox of nine models, including established systems like Ecopath with Ecosim (EwE), POSEIDON, and CMSY++, along with a new system dynamics model and a management strategy evaluation (MSE) model. These tools are designed to be interoperable with the DTO and support evidence-based decision-making.

Figure 4: Logo of the SURIMI project

Advanced features like AI and natural language processing (NLP) help translate complex outputs into clear summaries, while a visual dashboard allows users to define scenarios and explore outcomes, even without technical expertise. SURIMI places strong emphasis on co-design with end users, including fisheries managers, policymakers, and NGOs. A dedicated Stakeholder Forum and regular workshops ensure the tools reflect real-world needs, promote transparency, and build trust in digital decision support systems. By combining ecological and socio-economic modelling with intuitive interfaces, SURIMI makes marine data more accessible and actionable. The project builds on existing data infrastructures like ICES, EMODnet, and Copernicus, and contributes to wider EU efforts to support the Common Fisheries Policy and the Mission Ocean objectives.

5.1.1.3 EcoTwin

The EcoTwin project [REF-09] aims to enhance the European Digital Twin Ocean (EDITO) and local Digital Twins of Ocean (DTOs) by integrating socio-ecological (SE) models, making ocean data and knowledge more accessible for a broad audience, including citizens, entrepreneurs, scientists, and policymakers. By developing innovative SE models and analysis tools, EcoTwin seeks to improve decision-making and scenario analysis related to ocean health and coastal management.



EcoTwin

Figure 5: Logo of the EcoTwin project

The EcoTwin project focuses on four key coastal regions: the Southern North Sea, Celtic Sea, Thracian Sea, and Waterford Estuary. These areas will serve as case studies to test and refine the models, supporting the EU's initiatives to protect marine environments and promote sustainable development. EcoTwin addresses current challenges in combining social and ecological data, which are often difficult to integrate due to their differing natures. The project uses graph theory to link these data types, creating comprehensive models that capture the complexity of socio-ecological systems. EcoTwin will develop four classes of SE models: quantitative and qualitative causal models, network models with participatory feedback, and generative AI models. These models will use data from various sources, including Copernicus, EMODnet, and EUROSTAT, and will involve collaboration with the European Open Science Cloud to ensure best practices in data management. The goal is to create interoperable, reliable, and sustainable models. The project also emphasizes stakeholder involvement, co-designing tools and processes for effective engagement and policy scenario assessment. This ensures that the models are practical and relevant for decision-makers. Additionally, EcoTwin will develop AI tools tailored to marine ecosystems, enhancing the accessibility of ocean data and enabling more efficient decision-making.

5.1.2 SEAtwins logo and visual identity

The SEAtwins logo and visual identity ensures a recognizable and coherent visual presence. The logo serves as a key instrument for both internal and external communication, providing the cluster with a unifying identity within the field of Digital Ocean Twins.

The SEAtwins logo was developed by GEOMAR. It depicts the overall theme – digital twinning of real-world ocean data – and features colours from each of the four projects. The key visual is accompanied by the cluster's acronym. The logo has been confirmed by the consortium in July 2025.



Figure 6: Logo of the SEAtwins cluster

5.1.3 SEAtwins under the UN Decade for Ocean Science Programme DITTO

SEAtwins aims at empowering policymakers, researchers, and further stakeholders to advance sustainable ocean management, enhancing societal and ecologic well-being in line with the UN Ocean Decade goals. As a project under the UN Ocean Decade programme DITTO, SEAtwins connects the European community working on the integration of socio-ecological and socio-economical models into a Digital Ocean to the global Digital Twins of the Ocean (DTO) community. Lead institution is GEOMAR.

Start date: 02/01/2025

End date: 31/12/2027

5.2 Clustering with other projects within the EU Mission Ocean and Water

The EU Mission “Restore our Ocean and Waters” (Mission Ocean) aims at protecting and restoring the health of our ocean and waters through research and innovation, citizen engagement, and blue investments by 2030. The creation of the European Digital Twin Ocean (EU DTO) supports this mission as well as the key initiative of the European Commission, Destination Earth (DestinE), aiming at developing a highly accurate digital model of the Earth to be able to monitor, simulate, and predict the interaction between natural phenomena and human activities.

Horizon Europe Mission Lighthouses are regionally structured working groups that address challenges and pilot solutions in major sea and river basins (Atlantic and Arctic basin, Mediterranean Sea basin, Baltic and North Sea basin, Danube River and Black Sea basin). SEADOTs seeks to strengthen alignment with EU Mission Ocean objectives and enhance visibility and uptake of project results within EU Mission Ocean frameworks by integrating into the BlueMissionBANOS Lighthouse. The BlueMissionBANOS Lighthouse covers the Baltic and the North Sea basin. It is one of four Mission Lighthouses. Each of the four Lighthouses focuses on a specific objective, which shall later be applied across all the basins. Within this framework, the BlueMissionBANOS focuses on Carbon-neutral & circular economy (Figure 7).

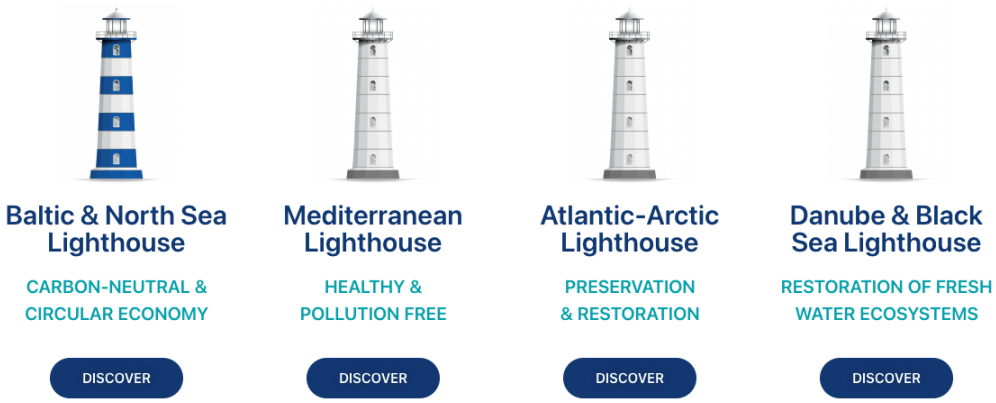


Figure 7: The four Mission Lighthouses. Credit/ Source: [REF-10]

BlueMissionBANOS emphasizes pollution elimination, biodiversity restoration, and inclusive stakeholder engagement. SEADOTs supports these goals by providing digital tools that enhance marine spatial planning, model climate change impacts, and facilitate stakeholder co-design of sustainable solutions. By contributing actionable insights and predictive capabilities, SEADOTs serves as a technological backbone for the BANOS mission, helping to align ecological protection with economic development in marine environments. Planned activities in BlueMissionBANOS cover (i) identification and mapping of relevant Mission Ocean activities and partnerships, (ii) participation in Mission Ocean working groups and events (iii) formal agreements to facilitate knowledge and data exchange.

SEADOTs has signed the Mission Charter in July 2025. The Mission's Charter's purpose is to rally all stakeholders, fostering cooperation, aligning efforts, and amassing the necessary momentum for the Mission's aim. Being part of the Mission Charter offers a flexible framework cooperation, aligning intentions with partners, mobilising resources, and developing activities.

Members of the SEADOTs consortium are also involved in the European Energy Research Alliance (EERA) Wind Innovation Forum and curating pan-European collaborations on wind research, leading the EERA Sub-Program 4 on Circularity and Sustainability.

5.3 Clustering with the global DTO community under DITTO

The Digital Twins of the Ocean (DITTO) Programme is an international community-based initiative endorsed by the UN Decade of Ocean Science for Sustainable Development. The program aims to support ocean protection, governance, and a sustainable blue economy through the use of DTOs. A common understanding, the establishment of best practices and a digital framework to empower ocean professionals worldwide are means to achieve this. DITTO connects communities that already have experience with digital twinning with those who seek capabilities and expertise.

The DITTO program is led by GEOMAR and has four co-chairs of which one leads SEADOTs' work package 4 (WP4; Demonstrators: Use cases combining SEA and DOTs within European Digital Twin Ocean and Local Twin infrastructures). DITTO is structured around working groups that focus on main aspects of DTOs, ranging from data interoperability to capacity development and training [REF-11]. The working groups are co-chaired by international experts from a range of sectors (science, private, government). DITTO further shares international use cases and best practice examples to raise awareness for the opportunities and potential of DTOs. The use cases are featured on the DITTO website [REF-12]. Affiliated projects connect to the global DTO landscape and shape the development of an overarching DITTO framework.

Ecosystem bootstrap, clustering, and collaboration with this initiative increases international recognition, and enables the creation and use of shared resources and harmonized methodologies, as well as joint contributions to EU and UN Ocean Decade goals. Planned activities include (i) identification and mapping of relevant DITTO activities and partnerships, (ii) engagement in DITTO working groups, including joint research meetings and exchange of knowledge and results to identify overlapping themes and technical needs, which enables improvement of technical and socio-environmental analysis of SEADOTs' results as well as new possibilities for scalability, (iii) use of the DITTO website to promote SEADOTs'/SEAtwins' aims and project results, (iv) launch of common special issues and conference sessions.

As a project under DITTO, SEAtwins (a cluster involving SEADOTs and its sibling projects; cf. p. 23 of this report) connects the European community working on the integration of socio-ecological data into DOTs to the global DTO community. Global visibility is increased by being recognized on the DITTO website as well as on the Ocean Decade website [REF-13], and by being included in Ocean Decade communications materials and assets (e.g. social media channels, reports, Ocean Decade events). Project outcomes and tools for endorsement and adoption by DITTO and/or the UN Ocean Decade cluster can be promoted on the DITTO website, e.g. under “use cases”. SEADOTs/ SEAtwins will be represented at the next DITTO Summit, which is scheduled for fall 2026.

5.4 Overview of past, ongoing, and future clustering activities

The following tables list past, ongoing, and future clustering activities.

Table 1: Past clustering activities

Date	Activity
01/2025	Meeting with representatives from SEADOTs, SEADITO, SURIMI, and EcoTwin to prepare joint application as a project under the UN Decade of Ocean Science for Sustainable Development 2021-2030
03/2025	Meeting with representatives from SURIMI to explore collaboration on policy briefs and other joint activities
04/2025	SEADOTs’ representation at SEADITO project meeting and general assembly, discussing collaborative efforts (see Appendix)
05/2025	Meeting with representatives from SEADOTs, SEADITO, and SURIMI to coordinate SEAtwins cluster project management
07/2025	Meeting with representatives from SEADOTs, SEADITO, SURIMI, and EcoTwin to discuss next steps for collaboration
07/2025	Launch of a common website (https://seadots-project.eu/seatwins)
07/2025	Formal agreement to integrate into EU Mission Ocean and Water BlueMission BANOS

Table 2: Ongoing clustering activities

Date (starting)	Activity
03/2025	Formation of thematic working groups to identify synergies and potential shared resources within SEAtwins cluster; cross-project online repository including contact list has been established in 07/2025
03/2025	Peer-to-Peer Learning Sessions: A monthly peer-to-peer learning session has been established. The learning sessions started as a

	means of internal communication and will be open to externals in the future.
04/2025	Glossary work: an internal glossary of key terms has been compiled and aligned; this feeds into a joint glossary of key terms within the SEAtwins cluster
06/2025	Integrating into Integrative Research Focus (IRF) Digital Twin Ocean activities of GEOMAR, including joint research meetings, exchange of knowledge and results, collaboration on data collection, and conference attendances.
06/2025	SEAtwins endorsement by UNESCO's Intergovernmental Oceanographic Commission as a part of the UN Ocean Decade Programme DITTO – awaiting onboarding

Table 3: Planned clustering activities

Date (planned)	Activity
09/2025	Launch of joint press release from projects under the same call (SEAtwins)
Fall 2025	Establishment of cross-project SEAtwins symposium organizing working group
Fall/winter 2025	Integration into further Mission Ocean/ BlueMission BANOS working groups
Fall/winter 2025	Integration into DITTO working groups
Summer 2026	SEAtwins representation and networking at IRF Digital Twin Ocean Symposium at GEOMAR, Kiel, Germany
09/2026	Joint session at 2026 ICES Annual Science Conference, Brest, France
10/2026	SEAtwins cross-project symposium in Copenhagen, Denmark; including parallel sessions, keynote speakers, poster presentations, and probably ICES training workshops)
Fall 2026	Fostering international cooperation on DTOs at DITTO Summit

6 Conclusions

This document outlines the methodological foundations, strategic frameworks, and initial implementation steps for ecosystem management, stakeholder engagement, and policymaking within the SEADOTs project. SEADOTs uses a multi-level engagement strategy to connect with projects under the same Horizon Europe call (acting under “SEAtwins”), the Horizon Europe Mission Lighthouse (“BlueMissionBANOS”), and the global Digital Twins of the Ocean community (via the UN Ocean Decade Programme DITTO). The report maps the ongoing collaboration formats across research meetings, data collection, outreach, and communication activities. The important role of both the EU DTO community and local stakeholders for managing the project’s ecosystem is underlined. SEADOTs aims to provide local stakeholders, i.e. the target users of the DOTs under development, with information needed for data driven decision making for a sustainable blue economy while integrating smoothly into the EU DTO.

This deliverable provides an initial synthesis; several elements are under development and will be elaborated in future project phases. Consolidated outputs from stakeholder engagement involving co-creation processes, policy-relevant impact assessments, and integration of project results into the European digital twin landscape are expected to emerge and will be addressed in deliverables D5.7 and D5.8.

This report informs stakeholder engagement and data coordination, supports communication and co-design formats, and feeds directly into impact analysis and policy recommendations. The next steps will operationalise the approaches described in this report. As the project progresses, the ecosystem management, engagement, and links to policymaking outlined here will be iteratively refined and expanded, ensuring that the project’s DOTs remain socially relevant, ecologically grounded, and policy-responsive.

7 References

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[REF-12]	Digital Twins of the Ocean Website. Use cases. https://ditto-oceandecade.org/use-cases/
[REF-13]	Ocean decade. Integration of Socio-Ecological Aspects into DTOs. https://oceandecade.org/actions/integration-of-socio-ecological-aspects-into-dtos

Appendix

Cross-project collaboration needs

The needs of cross-project collaboration through expert/ working groups were evaluated at the SEADITO project meeting in April 2025 (Figure 8).



Figure 8: Wordcloud showing needs of cross-project collaboration through expert/ working groups

SEAtwins press release

A press release informing about SEAtwins' endorsement by the UNESCO and introducing the cluster to the public is scheduled for September 2025.



Figure 9: Page 1 of draft press release on SEAtwins' endorsement under the UN Ocean Decade Programme DITTO



Figure 10: Page 2 of draft press release on SEAtwins' endorsement under the UN Ocean Decade Programme DITTO

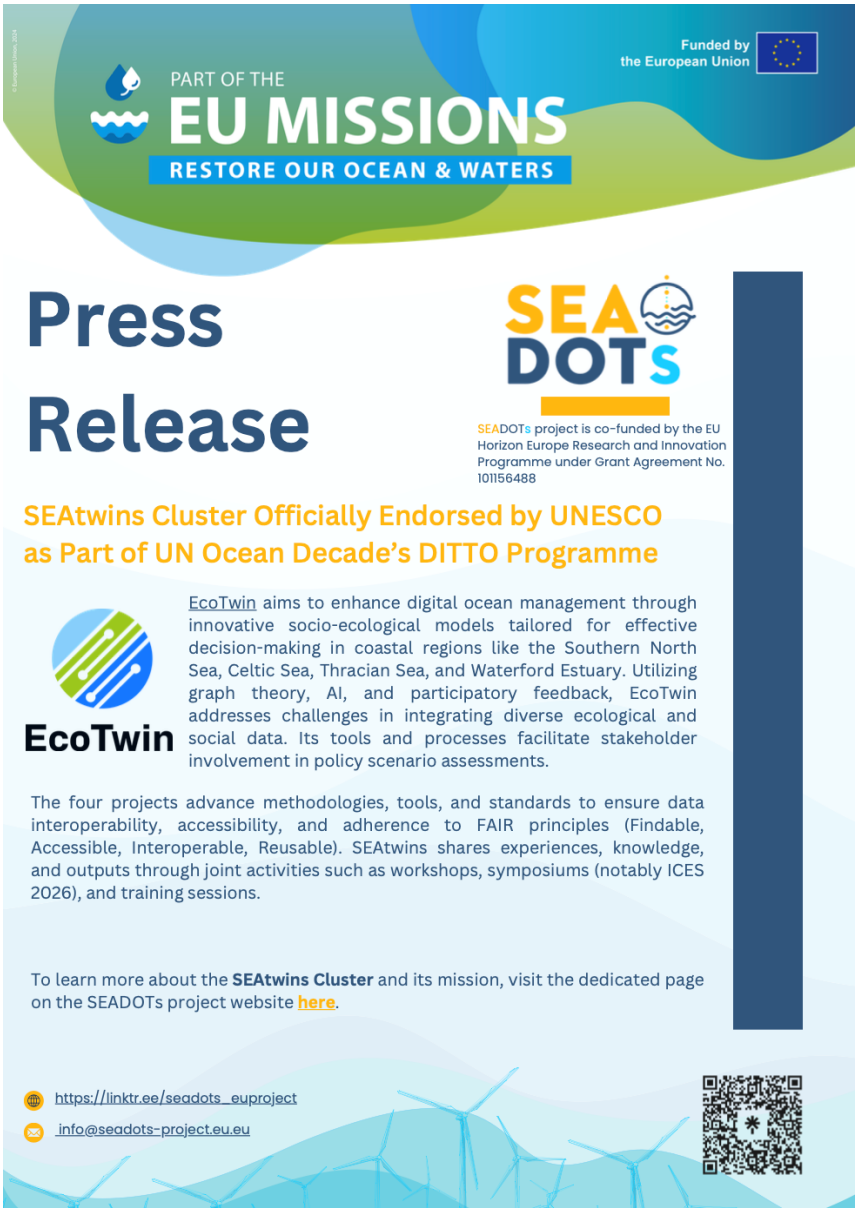


Figure 11: Page 3 of draft press release on SEAtwins' endorsement under the UN Ocean Decade Programme DITTO