



Sustainable fisheries management:

A data-driven approach with Iliad Digital Twins

Fisheries are a cornerstone of the EU's coastal economies, food systems, and cultural heritage. In 2022, the EU fishing fleet landed around 3.3 million tonnes of seafood, generating over €6.6 billion in value and directly supporting more than 120,000 jobs across the Union¹. As fisheries struggle to overcome challenges like climate change and overexploitation while working to meet ambitious EU targets, it's clear that traditional management approaches are no longer enough. Iliad Digital Twins of the Ocean (DTOs) integrate vast amounts of oceanographic data to monitor, predict, and model ocean conditions and can transform fisheries management across the EU. Iliad offerings can contribute to a number of challenges, such as:

1. **Overfishing** is a global concern, as 35.5% of world fish stocks are overfished and the rate of overfishing is rising annually. EU fisheries, particularly those in the Mediterranean and Black Sea are largely overexploited, as nearly 65% of fish stocks are overfished², and fisheries in the Baltic are facing collapse³.

How Iliad DTOs address this: Iliad's fisheries DTOs can map fish populations and plan optimized vessel routes which save time, cut fuel costs, and enable fishers to sustainably exploit stocks while avoiding juvenile fish and sensitive species. Data on catches can be automatically recorded and reported for enhanced monitoring.

2. **Illegal, unreported, and unregulated (IUU) fishing** hinders conservation efforts and leads to massive loss. From 2008 to 2020, IUU cost fisheries across Europe €10.7 billion in lost catches, over 27,800 lost job opportunities, and nearly nine billion in stock depletion⁴.

How Iliad DTOs address this: Increased reporting and data from the Iliad fisheries DTOs reduce instances of IUU; future updates to the Fisheries Ecosystem Indicators- North Sea DTO will bring tagging functionality to landings

¹ <https://publications.jrc.ec.europa.eu/repository/handle/JRC139642>

² <https://doi.org/10.4060/cd5538en>

³ https://www.ices.dk/news-and-events/news-archive/news/Pages/baltic_advice.aspx

⁴ https://www.fishsec.org/app/uploads/2011/03/1226500267_66037.pdf

to improve 'fish to fork' traceability and increase consumer awareness on transparent fishing practices.

3. **Climate change** disrupts fish migration patterns, alters marine ecosystems, and leads to habitat loss, further destabilizing fisheries management. In Europe, the biomass and productivity of key species will decrease by at least 15% by 2050 under moderate emissions scenarios and over 40% by 2100 under high emissions scenarios⁵.

How Iliad DTOs address this: By tracking shifting fish habitats and ocean conditions, Iliad's Habitat Suitability Index DTO and Fisheries Ecosystem Indicators-North Sea DTO help fishers adapt to increased uncertainty and reduce losses. VISTools DTOs integrate data on catch composition, fuel-use, and environmental conditions to map optimal routes which minimize fuel consumption and GHG emissions. Belgian vessel owners report that VISTools DTOs allow them to calculate profitability by comparing estimated fuel costs with fish prices.

4. **EU environmental targets** with rapidly approaching deadlines necessitate a revolution in fisheries management practices. Fisheries and Member States must work to fully achieve the 2020 goal of sustainable management of all fish stocks, eliminate incidental and discarded catches by 2030, and designate 30% of the ocean as Marine Protected Areas (MPAs). Fisheries must also build climate resilience by 2030 and reduce GHG emissions to reach carbon neutrality by 2050.

How Iliad DTOs address this: Iliad's fisheries DTOs transform fisheries management to meet major EU environmental targets for sustainable exploitation, decarbonization, and ecosystem protection by empowering vessel-owners and governments to plan, coordinate, and execute sustainable and effective fishing operations. The fisheries DTOs also advance digitalization and address data fragmentation by integrating diverse datasets, enabling better coordination across sectors and borders for more effective marine planning.

Description of Iliad services

- **Fisheries Ecosystem Indicators- North Sea DTO** collects and compiles data on fisheries (catch/landings) based on the ecological characteristics of stocks (species resilience, thermal preferences, and trophic levels) and environmental parameters (water temperature and chlorophyll levels) to calculate fisheries

⁵ <https://onlinelibrary.wiley.com/doi/10.1111/gcb.70149>

ecosystem indicators that will support robust decision-making. This dataset facilitates real-time monitoring and reporting, sustainable exploitation by vessel-owners, and data-driven fisheries management within the ecosystem context. Improved reporting and data from fisheries reduces instances of overfishing, and future updates will feature tagging functionality for landings, which can improve 'fish to fork' traceability. This DTO can also inform targeted intervention by modelling the spread of invasive species due to warming surface temperatures, and will identify and help avoid the catch of sensitive species and juvenile fish.

- **VISTools DTO** is a suite of three digital applications including Analytics, Fishing Sustainability, and Vessel routing. The digital twin uses catch composition, fuel use, and weather conditions to optimize navigation and cut costs, suggest more efficient vessel routes based on sea and weather data, and help identify the best fishing areas by combining environmental trends with past catch information.
- **Habitat Suitability Index DTO** uses environmental data that include Sea Surface Temperature, Salinity, Primary Production, Sea Surface Height, Currents Velocity, and Dissolved Oxygen (sourced from Copernicus Marine Service - CMEMS), alongside marine fronts derived from temperature products and bathymetry from GEBCO, to identify areas with favorable conditions for specific fish species. This helps optimize fishing activities by highlighting the most suitable locations, particularly as warming ocean temperatures alter habitats.

With that system [VISTools], you can calculate perfectly based on the average price of fuel and the average price of fish. You can link the fuel costs to the yield of the fish, which can improve profitability. Yes, a better understanding of what you're doing. VISTools has had a certain positive influence on the company.

- Dany Vlietinck, Z.483 vessel owner

Further policy implications

- **Sustainable exploitation:** To achieve full success of the Marine Strategy Framework Directive (MSFD) goal of sustainable exploitation of all fish stocks in Europe by 2020, vessel owners can use the Fisheries Ecosystem Indicator DTO to monitor and report their catches, fish in optimal locations, and avoid catching sensitive species and juvenile fish.

- **Reducing unwanted catches:** Iliad's Fisheries Ecosystem DTO gives fishers greater control over what they catch by providing real-time insights into catch composition and fish habitats. By using this information, they can adjust their fishing practices to focus on the right species, avoid sensitive or juvenile fish, and significantly reduce unwanted and discarded catches. This targeted approach supports the EU Biodiversity Strategy and the Farm to Fork Strategy, both of which aim to eliminate incidental catches by 2030.
- **Marine Spatial Planning (MSP):** By providing accurate and comprehensive data for the location and management of fishing activities, the Iliad fisheries DTOs support Member States' implementation of the Marine Spatial Planning Directive (MSPD). In accordance with MSPD requirements, data from Iliad's fisheries DTOs integrates both environmental, economic, and safety aspects, supports an ecosystem-based approach, and facilitates transboundary and third-country cooperation through access to shared information.
- **Decarbonization:** The VISTools DTO monitors fuel-consumption and optimize vessel routing, which are essential to meet EU targets of 55% GHG reduction by 2030 and carbon neutrality by 2050. The Communication on Energy Transition of the Fisheries and Aquaculture sector recognizes a lack of "energy-efficiency data, such as from onboard fuel-monitoring tools" as a central barrier to decarbonization efforts, and pushes for investment in improvements in energy efficiency and reductions in carbon footprint.
- **Climate adaptation:** To achieve climate resilience by 2030 in line with the Strategy on Climate Adaptation, member states must predict, avoid, and mitigate climate impacts on fisheries. The Communication on Sustainable Blue Economy, as well as SDG targets 13.1 and 14.2, necessitate innovation for resilience in coastal and marine ecosystems. Data from Iliad fisheries DTOs can be used on all levels, including local, as emphasized in the Strategy on Climate Adaptation, to adapt to shifting ocean conditions and maintain sustainable production.
- **Digital Transition:** Iliad DTOs accelerate multiple aspects of the Digital Europe Program including the digitalization of blue business, digital monitoring and reporting for fisheries administration, and the digital skills development of the blue workforce. Digital skilling and access to ocean data also advances UN Ocean Decade Challenge 9: 'Skills, Participation, and Technology for All'. The DTOs support the EU mission Restore our Oceans and Water by 2030 by helping achieve remote electronic monitoring using artificial intelligence and computer vision technologies by 2030.

- **Reducing IUU:** Iliad's fisheries DTOs address IUU by improving monitoring and reporting across fisheries, and future updates to the Fisheries Ecosystem Indicators- North Sea DTO will feature 'fish-to-fork' tracking practices as encouraged by the Farm to Fork Strategy and IUU Regulation.

All Iliad DTOs featured in this brief, along with many others, are available through the Iliad Marketplace at ocean-twin.eu/marketplace.

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Increasing productivity, decreasing risk: Aquaculture with Iliad Digital Twins

The EU aquaculture sector achieved a sales volume of 1.2 million tonnes and a turnover of €4.8 billion in 2022. This represents a 1% increase in volume and a 13% increase in value compared to 2021. The total number of enterprises was estimated at 14,000, with around 73,000 individuals employed in the sector, including 41,000 full-time employees⁶.

Nonetheless, despite policymakers' expectations and high economic potential, aquaculture in Europe has mostly stagnated over the last decade⁷. Although the European Green Deal recognizes aquaculture as key to building a sustainable food system and demand for aquaculture products continues to rise, production in Europe has lagged behind global trends and fails to meet that demand. Iliad Digital Twins of the Ocean (DTOs) integrate vast amounts of oceanographic data to monitor, predict, and model ocean conditions, and can transform aquaculture management to unlock its potential across Europe.

How Iliad DTOs mitigate challenges in aquaculture

1. **Environmental damage:** contamination by nutrient discharge and pathogens has severely degraded habitats. These negative effects are exacerbated by climate change as water temperatures increase, ocean chemistry alters, and fish stocks' health is affected.

How Iliad addresses this: Iliad's aquaculture DTOs provide farmers with environmental data and predictive analytics for responsive, species-tailored care. This reduces the use of antimicrobials and feed, reducing nutrient pollution and improving water quality. The aquaculture DTOs also aid adaptation to climate change by tracking shifting ocean conditions for dynamic and responsive care.

⁶ STECF. 2025. The 2024 Aquaculture Economic Report (STECF 24-14). <https://publications.jrc.ec.europa.eu/repository/handle/JRC140767>.

⁷ <https://www.sciencedirect.com/science/article/pii/S0044848624012559>

2. **Spread of diseases:** Pathogens like sea lice or crayfish plague threaten fish health and production yields. When interactions between farmed and wild species are mismanaged, invasive species introduced by aquaculture can spread diseases and parasites which infect and threaten native species.

How Iliad addresses this: Real-time monitoring of environmental conditions, invasive species, and disease outbreaks, along with accurate forecasting of disease and invasive species spread from the Aquaculture Smart Monitoring DTO, Aquasafe DTO, and Lemon DTO, helps farmers respond to biosecurity threats in a timely and appropriate manner.

3. **Inefficient production:** Many aquaculture practitioners, particularly small-scale fish farms, lack high-resolution data and digital skills to correctly mitigate environmental impact while maximizing yield.

How Iliad addresses this: Iliad's SI-AD RTTA DTO integrates environmental data to map aquaculture sites to maximize productivity. The Aquaculture Smart Monitoring DTO, Aquasafe DTO, and Lemon DTO improve production by mapping optimum aquaculture sites, enhancing care, and tracking productivity over time. These DTOs can also cut costs by reducing risk and optimizing resource use. Iliad's Physical/ chemical parameters in mussel farming DTO can improve farmers' access to insurance by providing risk assessment data for companies. Iliad's digital platforms are user-friendly, incorporate accurate data from multiple sources, and can be accessed by diverse stakeholders for collaboration.

4. **Administrative burden:** compliance with stringent environmental and operational standards across national and international frameworks is time-consuming and overcomplicated without streamlined monitoring and reporting mechanisms.

How Iliad addresses this: Iliad DTOs facilitate increased monitoring and data collection, and help avoid data fragmentation to contribute to a seamless reporting mechanism.

Description of Iliad Aquaculture DTOs

Iliad integrates ecological, economic, and regulatory data to bridge the gap between sustainable production goals and the complexities of environmental management and policy compliance.

- **Aquaculture smart monitoring DTO** monitors, tracks, and models environmental data for aquaculture operations, including disease outbreaks, algal blooms, and

pollution from marine traffic. With early warnings and performance tracking, the tool helps farmers reduce disease-related losses, lower the risk of mass die-offs, and cut operational costs through better management and planning.

- **Aquasafe DTO** integrates real-time and modeled data to alert users to biosecurity hazards, simulate disease spread, optimize energy use, and select ideal aquaculture sites. Improved biosecurity management can decrease antimicrobial use, while optimized feed can reduce eutrophication and improve water quality. Results and models are presented on a user-friendly, tailored, and remote-access platform for efficient decision-making, which also supports streamlined reporting.
- **Aquasafe MSP Service** provides support for the implementation and management of EU Marine Spatial Planning (MSP) Directive and the assessment of proper areas to install sea related industries such as for instance offshore waves and wind farms or aquacultures. The tool provides the capability to consider multiple restrictions with specific probabilities of occurrence and allows for a direct incorporation of climate change scenarios in the planning to ensure that space is allocated efficiently and equitably in face of different potentially possible futures.
- **Physical/ chemical parameters in mussel farming DTO** offers a dataset monitoring nutrient availability and biophysical stresses for offshore mussel farms. Sensor data is available for viewing and download, and can serve as evidence for insurance claims in cases of damage or stock loss.
- **SI-AD-RTTA Morocco Aquaculture DTO** simplifies marine spatial planning (MSP) in aquaculture by identifying and assigning productive sites based on environmental and ecosystem data. The tool also monitors aquaculture operations to ensure compliance with environmental regulations.
- **Lemon: Shell-fisheries and Invasive Species Risk Assessment (ISRA) DTO** provides aquaculture practitioners with real-time data on ocean conditions such as surface temperatures, salinity, oxygen levels, and water nutrition through a user-friendly dashboard on the Lemon Android application. A Spatial Multi Criteria Evaluation (SMCE) method combines raw data with citizen feedback, eDNA, and machine learning to forecast location suitability and invasive species and pathogen spread.
- **MSP Challenge** is an interactive simulation which integrates the best available geo, maritime and marine data with simulation models for ecology, shipping and

energy production. Using advanced game technology and game thinking, MSP Challenge engages and immerses stakeholders to design the allocation and management of marine space.

How can Iliad contribute to European and global policy targets in aquaculture

- **Sustainable Food Systems:** The Farm to Fork Strategy recognizes that farmed fish and seafood are carbon-friendly and crucial to the development of sustainable food systems. By advancing the feasibility and productivity of aquaculture operations, Iliad's aquaculture DTOs reduce pressure on fisheries, advancing UN Ocean Decade Challenge 3: 'Sustainably Nourish the Global Population', and promoting sustainable exploitation in compliance with the Marine Strategy Framework Directive (MSFD).
- **Climate adaptation and decarbonization:** The Aquaculture Smart Monitoring and Lemon DTOs track shifting ocean conditions and climate-driven threats, equipping aquaculture operations to build climate resilience by 2030 in line with the Climate Adaptation Law. By monitoring environmental conditions for responsive care, the Aquasafe DTO can cut energy use.
- **Spatial planning:** The EU Aquaculture Guidelines promote coordinated spatial planning for climate-sensitive, synergistic, and environmentally-sound aquaculture activities. Using the SI-AD-RTTA DTO, farmers and policymakers can integrate environmental assessments and habitat suitability analyses into spatial planning, particularly into national maritime spatial plans under the Maritime Spatial Planning Directive (MSPD). To further optimize the distribution of aquaculture operations in marine space, the MSP Challenge application can engage stakeholders to collaborate on coordinated MSP for a variety of marine economic activities.
- **Animal welfare and sustainability:** In line with the Aquaculture Guidelines, Iliad's aquaculture DTOs improve animal welfare by providing species-specific care which is responsive to ocean conditions. Environmental monitoring is crucial for the transition to low-impact species such as molluscs, which is prioritized by the Farm to Fork strategy, the Aquaculture Guidelines, and Mission Restore our Ocean.
- **Reducing pollution:** By reducing the use of feed and antimicrobials, the Aquasafe DTO reduces marine nutrient pollution from aquaculture. Reducing nutrient pollution supports the achievement of good environmental status (GES) under

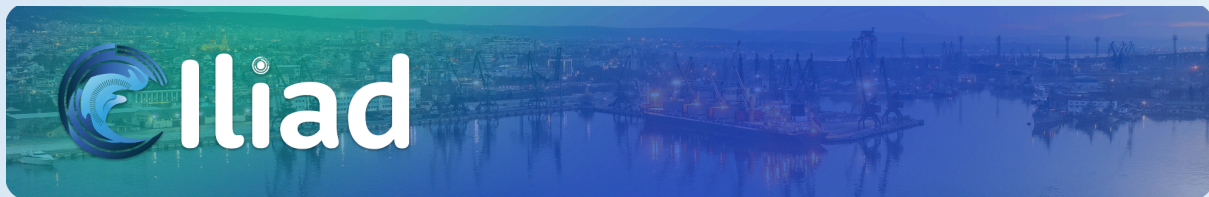
the MSFD and the achievement of high ecological status in coastal waters under the Water Framework Directive.

- **Reducing antimicrobials:** To help reduce EU sales of antimicrobials in aquaculture by 50% by 2030 in line with the Farm to Fork strategy, the Aquaculture DTOs reduce dependency on antimicrobials and veterinary medicine by monitoring and modeling the spread of pathogens. Smart management with Iliad DTOs also accelerates the transition to organic aquaculture as promoted by the Zero-Pollution Action Plan, Aquaculture guidelines, and Communication on Sustainable Blue Economy.
- **Improved monitoring:** The Aquaculture Guidelines call for increased monitoring on the environmental impacts of aquaculture, especially water quality, to be integrated into licensing procedures as well as the implementation of EU-funded projects for aquaculture. Additionally, the Mission to Restore our Ocean calls for increased reporting of environmental indicators to reduce administrative burden. Aquaculture smart monitoring DTO supports this by tracking environmental impacts and to increase alignment with policy targets and regulations.
- **Reducing invasive species:** The Lemon DTO helps achieve the Biodiversity Strategy target to halve the number of Red List species threatened by invasive alien species. By tracking, modeling, and alerting aquaculture producers to the risk of invasive species spread, the Lemon DTO supports procedures for risk assessment, permitting, and surveillance outlined in the Invasive Alien Species Regulation. The Aquaculture Guidelines also call for proactive management of biohazard threats, and reducing invasive species is a requirement to achieving GES under the MSFD.
- **Reducing Risk:** Insurance companies can use Aquasafe DTO's risk assessment and forecasting data to evaluate exposure to marine and coastal hazards, set premiums more accurately, improve underwriting decisions, and design tailored insurance products for aquaculture practitioners. Mussels farmers can also use data on biophysical stresses and nutrient availability as evidence for insurance claims.

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Safer, Smarter, and Greener Ports:

Risk Assessment and Maritime Transport with Iliad Digital Twins

Seaports are the lifeblood of Europe's economy, as 74% of all goods entering or leaving the EU are transported by sea⁸, and European seaports handled around 3.4 billion tonnes of freight⁹ in 2023. With cargo volumes expected to surge by 20% by 2030 and increasing disruptions from extreme weather events, many ports are already struggling to cope. On top of this, meeting ambitious EU environmental targets will require a total transformation of port management. Iliad Digital Twins of the Ocean (DTOs) offer a scalable answer. By integrating oceanographic, environmental, and operational data, Iliad enables ports to monitor, predict, and model ocean conditions, supporting resilience, smarter planning, and greener port operations.

Below, we outline several challenges in port and maritime vessel operations and explain how Iliad DTOs respond to them.

1. **Congestion and capacity constraints** escalate risk and economic loss, particularly as global trade volumes continue to rise. Increased disruptions due to climate change related weather events exacerbate this issue, causing delays and shutdowns.

How Iliad addresses this: Iliad's AR/VR Blind Navigation of Marine Vessels DTO decreases congestion by guiding vessel navigation and positioning in low-visibility conditions, which increases ports' operating days, thereby increasing capacity and reducing delays. Vessel owners can also use the Ship Routing/Harbor Safety DTO for advanced forecasting of weather events, allowing for proactive scheduling and response.

2. **Security hazards** like extreme weather events and high traffic volumes increase the risk of accidents.

How Iliad addresses this: Ports can conduct risk assessments based on ship profile, maneuver type, and weather conditions using Iliad's Risk Assessment

⁸https://op.europa.eu/webpub/mare/eu-blue-economy-report-2025/blue-economic-sectors/port-activities.html?utm_

⁹ https://ec.europa.eu/eurostat/web/transport/database?node_code=mar

Environment for Maritime Traffic Managers DTO. This information, in addition to navigation support from the AR/VR Blind Navigation of Marine Vessels DTO, improves safety at ports. The Ship Routing/Harbor Safety DTO integrates weather data to map optimum routes to improve safety for vessels at sea.

3. **Carbon emissions** from ports have surpassed pre-pandemic levels. Without changes to port management, shipping could account for up to 10% of global GHG emissions by 2050¹⁰. Climate change, in turn, causes rising sea levels, extreme weather events, and coastal erosion, which further threatens port infrastructure and supply chains.

How Iliad addresses this: By mapping optimal shipping routes using weather data and advanced algorithms, Iliad's Ship Routing/ Harbor Safety DTO has been proven to reduce fuel consumption by up to 3.7% on certain Greek shipping routes. This demonstrates a major potential to reduce emissions in the shipping industry, as even a 1% reduction in fuel usage can contribute to a 10.76 million tons of GHG emissions savings annually¹¹. Reduced fuel consumption results in significant cost reductions, as even a 0.1% improvement in fuel efficiency for a RoPax vessel could save €5,970 annually. A 3.6% reduction could save up to €214,920 per year per vessel.

4. **Environmental degradation**, particularly water and air pollution, is accelerated by the discharge of pollutants such as nitrous oxides and sulfur oxides, oil spills, wastewater discharge, and leaching of heavy metals. Pollution harms both human and marine health, resulting in acid rain, respiratory issues, and loss of biodiversity.

How Iliad addresses this: By decreasing fuel consumption, the Ship Routing/ Harbor Safety DTO also contributes to reducing nitrous oxides and sulfur oxides. By reducing the likelihood of accidents with improved navigation and storm forecasts, the AR/VR Blind Navigation of Marine Vessels DTO reduces the chance of oil spills. Iliad's 'I see sea' (ICC) DTO also engages citizen science in pollution monitoring, promoting public engagement and increased monitoring.

Description of relevant Iliad services

- **Ship Routing/Harbor Safety DTO** includes two application packages which

¹⁰ (if other sectors decarbonize more rapidly)

<https://www.transportenvironment.org/topics/ships/climate-impact-shipping>

¹¹ Based on 2018 figures, considering wind, waves, and current forecasts

<https://link.springer.com/article/10.1057/s41278-024-00288-y>

optimize vessel navigation and improve port safety. The first uses weather data and advanced algorithms to calculate vessel paths which minimize distance, travel time, and CO2 emissions. The second application models wave height and direction up to three days in advance and includes alerts for severe weather conditions.

- **AR/VR Blind Navigation of Marine Vessels application built on Varna Bay DTO** can help reduce congestion of marine vessels waiting to enter port Varna and increase port operating days, by allowing some marine vessels to enter the port facilities even during unfavourable weather conditions. It combines precise vessel positioning with AR visualizing the Varna Port Complex infrastructure in low-visibility conditions to allow navigation and manoeuvring in the port channels
- **Risk Assessment Environment for Maritime Traffic Managers application built on the Varna Bay DTO** provides objective risk assessments for marine vessel manoeuvres in Varna Port Complex, depending on the ship profile, load type, and other factors, among which location-specific weather conditions forecasts with high resolution in time (every 15 minutes for the next 3 hours).
- **“I see sea” (ICC)** is a web application that assists in providing additional information fed to the Varna Bay DTO. The citizen-reported observations complement the information obtained from the meteorological and hydrological sensors. Specifically, ICC allows citizens to report images, text, categorical data, etc., observations concerning meteorological conditions, extreme weather events, pollution, jellyfish congregations in the sea or other observations, including the coastal areas, that help detect risk increases in the bay or port zones or to monitor for pollution.
- **Next Port of Call Risk Assessment (NPOCRA) DTO** combines high-resolution forecasting, satellite data, on-site observations, and citizen science data to monitor and model the spread of invasive species and pathogens from ballast water. The DTO provides cargo shipping companies real-time, continuous assessments of invasive species risk, along with advanced forecasting and scenario modeling for invasive species spread.

Following presentations to the Port Authority of Heraklion, local shipping companies' and the Hellenic regional climate authorities' feedback concerns about the complexity of command-line tools prompted the development of a web-based interface.

This new interface allows users to configure simulations through graphical inputs, generating a single, copy-paste command to run complex code effortlessly.

Further policy implications

- **Reducing pollution:** Ship Routing/Harbor Safe DTO enables vessel owners to decrease fuel consumption and pollution, directly supporting the EU Zero Pollution Action Plan's targets of a 55% reduction in premature deaths caused by particulate matter and 25% reduction in ecosystems affected by air pollution by 2030, which are required to achieve zero pollution by 2050. Infrastructural capacity to decrease pollution is also required for ports in the Trans European Network for Transport (TEN-T) network by 2050. This is also essential to meet UN Ocean Decade Challenge 1: 'Understand and Beat Ocean Pollution'
- **Healthier ecosystems:** By reducing port pollution, the Ship Routing/Harbor Safety DTO supports the Marine Strategy Framework Directive (MSFD) and Biodiversity Strategy targets for healthy marine ecosystems. Ports can contribute to Good Environmental Status (GES) under the MSFD by reducing concentrations of contaminants, and underwater noise. The NPOCRA DTO also contributes to GES by reducing invasive species spread through ballast water management. Pollution reduction contributes to the Biodiversity Strategy's goals of achieving positive conservation trends for ecosystems and species by 2030 and halving the number of Red List endangered species threatened by invasive alien species, and the UN Ocean Decade Challenge 2: 'Protect and Restore Ecosystems and Biodiversity'. By sustainably managing their interactions with Marine Protected Areas (MPAs), ports align with management goals of the EU Action Plan to protect and restore marine ecosystems and the Communication on a sustainable blue economy.
- **Decarbonization:** Iliad's Ship Routing/ Harbor Safety DTO can play a central role in achieving a 40% decrease in emissions from international shipping under the International Maritime Organization GHG strategy, and facilitate a 90% decrease in transport emissions by 2050 under the European Climate Law. Optimized shipping schedules and navigation cut fuel consumption and reduce compliance costs with decarbonization mechanisms such as the emissions trading system. Even a 1% improvement in voyage optimization using the Ship Routing/Harbor Safety DTO can contribute to a 10.76 million tons of GHG emissions savings.
- **Climate Adaptation:** Iliad also helps achieve climate resilience by 2030 as outlined in the Climate Adaptation Law, especially at the local level, by 2050 by

helping ports anticipate and adapt to the increasing risk of severe weather events and climate-related disturbances.

- **Safety:** The Ship Routing/ Harbor Safety and AR/VR Blind Navigation of Marine Vessels DTOs support the implementation of port security plans under the Port Security Directive by enhancing surveillance, threat detection, and risk management. A 2023 European Commission Communication on maritime safety identified digitalization gaps as a key barrier to effective security implementation in ports and called for the use of smart, integrated management systems to strengthen resilience and response capacity.
- **Energy security:** Russia's war on Ukraine and conflict in the Middle East, as well as inflation have increased fuel prices and threatened European energy security¹². By decreasing fuel consumption, the Ship Routing/ Harbor Safety DTO helps reduce dependency on Russian energy imports in line with the REPowerEU Plan.
- **Digitalization:** The Ship Routing/ Harbor Safety DTO's digital monitoring and forecasting capabilities can integrate seamlessly with existing digital reporting and administrative systems like the Maritime Single Window Environment, helping ports meet strict EU reporting requirements more efficiently.



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¹² <https://www.mdpi.com/2071-1050/15/18/13660>



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Tracking and Managing Pollutants: Water Quality Monitoring with Iliad Digital Twins

After nearly two decades of concerted efforts to reduce marine pollution, Europe's seas remain at risk of irreversible damage. To achieve the Marine Strategy Framework Directive (MSFD) goal of good environmental status (GES) in all marine waters, member states must reverse trends of worsening of underwater noise, chemicals, and eutrophication. Furthermore, the EU target of zero pollution by 2050 requires member states to halve marine plastic litter and reduce by 30% microplastics released into the environment by 2030. To meet these ambitious targets, European countries must adopt a fundamentally different approach to policy implementation. Iliad Digital Twins of the Ocean (DTOs) integrate vast amounts of oceanographic data to monitor, predict, and model ocean conditions, for a data-driven, responsive approach to environmental management.

1. **Oil spills:** Without proper real-time hazard mapping and forecasting capabilities, authorities struggle to identify oil spills. In the event of a spill, the absence of harmonized frameworks and coordination across jurisdictions results in delayed responses, particularly in cross-border incidents. Oil spills can severely damage ecosystems and cleanup alone for medium-to-large spills costs an estimated \$2.4-9.4 billion¹³.

How Iliad addresses this: The Coastal Crete: Oil Spill Response DTO and North Aegean Oil Spills DTO use satellite imagery to automatically detect oil spills, which triggers a short-term spill trajectory forecasting system. The Oil spill detection- Mediterranean Sea DTO detects oil spills through a combination of satellite data, remote sensing techniques, and continual monitoring of water conditions. Iliad's oil spill DTOs shorten response times, improve risk assessment and scenario planning, and are being used to train coastal authorities on appropriate oil spill response in Crete. Even a 30% reduction in response times for a medium-to-large spill can save hundreds of millions¹ and prevent significant environmental damage.

¹³ Based on assessments of tanker risk on British Columbia North coast
<https://twinsacredtrust.ca/concerns/economic-cost-oil-spill/>

2. **Plastic Pollution:** Data gaps regarding the distribution and sources of marine plastic waste hinder effective policy formulation and enforcement, and the lack of harmonization among EU countries complicates the implementation of directives like the Marine Strategy Framework Directive (MSFD).

How Iliad addresses this: The Environmental Monitoring Twin: biodiversity, water quality, and pollution in Trondheim fjord DTO tracks the quantity and trajectory of microplastics, noise, methane, and marine litter, and includes a feature to identify marine particles. This tool can be used by Member States to target interventions to reduce pollution, monitor existing efforts, and coordinate efforts across regions.

3. **Invasive Species and Public Health Risks:** Insufficient real-time monitoring of invasive species create risks to endangered species and local ecosystems. Jellyfish blooms are affecting public bathing areas as well as desalination and power plants, threatening human health and disrupting underwater infrastructure.

How Iliad addresses this: Iliad's Jellyfish Swarm Forecast with Citizen Science-Meduzot Baam DTO incorporates data from citizen-science observations of jellyfish swarms, historical swarming trends, and advanced modeling of ocean currents to forecast jellyfish swarms in bathing areas or plants up to three days in advance. A map of expert-validated citizen observations of jellyfish are available to bathers and plants on a web app, increasing public awareness, proactive response, and data on jellyfish swarms.

Description of relevant Iliad DTOs

- **Coastal Crete: Oil Spill Response DTO and North Aegean Oil Spills DTO** detect oil spills automatically using satellite imagery, triggering an accurate short-term spill trajectory forecasting system and creating a high-resolution image which combines forecasting data and in-situ observations. The tool also creates what-if scenarios on-demand and assesses the impact of oil spills on key ecosystems, allowing for risk assessment and planning. Monitoring and alerts minimize response time, while the tool's scenario function is used by an oil and gas company and coastguard authorities in Crete to train staff on appropriate oil spill response.
- **Oil spill detection- Mediterranean Sea DTO** monitors water conditions to detect oil spills, facilitating regular assessments for the proactive prevention of oil spills. The tool also relies on satellite data, and combines remote sensing

techniques with advanced machine learning technologies.

- **Environmental Monitoring Twin: biodiversity, water quality, and pollution in Trondheim fjord DTO** tracks the quantity and trajectory of pollutants using sensor data, particle transport models, and ocean conditions. The tool includes a live camera stream and monitoring panels which track the movement of microplastics, noise, methane, and marine litter, as well as a tool to identify marine particles and track algal blooms.
- **Hydromast DTO** uses a low-cost, durable sensor that measures water flow, direction, level, and wave conditions for long-term monitoring of coastal and river environments. Data from the sensor is seamlessly integrated into the Hydromast DTO to improve the accuracy of hydrological modeling and forecasts.
- **Jellyfish Swarm Forecast with Citizen Science- Meduzot Baam:** includes a real-time map of citizen-science jellyfish observations, a forecasting tool based on jellyfish geolocation, and an ocean current model which maps swarms at beaches or power plants three days in advance. The tool protects bathers' health and can save millions by reducing interruptions at plants. The tool also integrates data on historical swarm trends, facilitating research on ocean conditions' impact on jellyfish swarms.
- **Biodiversity and Seascape DTO** aggregates data from Lidar, Multibeam Echo Sounding (MBES), underwater photogrammetry, and underwater cameras. Data is then analyzed by machine learning algorithms and spatial modeling to create a robust model for high resolution mapping of the sea floor along with fish detection and classification. Can also produce spatial predictions of fish biomass, species richness, and Shannon diversity index score across coastal and reef environments.
- **Next Port of Call Risk Assessment (NPOCRA) DTO** combines high-resolution forecasting, satellite data, on-site observations, and citizen science data to monitor and model the spread of invasive species and pathogens from ballast water. The DTO provides cargo shipping companies real-time, continuous assessments of invasive species risk, along with advanced forecasting and scenario modeling for invasive species spread.

In 2023, the forecast successfully predicted a salp swarm, almost a week before it hit our facility. I am certain that it can benefit many clients around the world.

- Alex [Production Engineer, Israel Electric Company]

Additional policy implications

- **Oil spill preparedness:** Iliad's Oil Spill DTOs improve oil and gas operators' compliance with Directive 2013/30/EU, which requires minimization of spill risk through integrated emergency planning, comprehensive risk assessment, and effective cross-border collaboration. Iliad DTO data and scenario modeling can inform internal corporate policy as well as national external emergency plans.
- **Fighting pollution:** Monitoring and predictive modeling with the Environmental Monitoring DTO helps achieve targets in the Zero Pollution action plan, UN Ocean Decade Challenges, ban on single-use plastics, Mission Restore our Ocean, and SDG goal 14. For zero pollution by 2050, the Zero Pollution Action plan requires halving marine plastic litter and a 30% reduction of microplastics released into the environment by 2030. UN Ocean Decade Challenge 1: 'Understand and Beat Ocean Pollution' calls on member states to map ocean pollution, understand its impacts, and develop solutions to mitigate and reduce it. Furthermore, SDG target 14.1 calls on states to prevent and significantly reduce marine pollution of all kinds by 2030. Detailed data-collection, monitoring, and reporting are prioritized by the Zero Pollution action plan and Directive EU 2019/904 on single-use plastics, which encourage the adoption of cutting-edge technologies for monitoring and compliance checks.
- **Protecting ecosystems:** Species detection and classification using the Biodiversity and Seascape DTO can help design, target, and monitor efforts to achieve Good Environmental Status (GES) under the MSFD by measuring seafloor integrity, presence of non-indigenous species, and biodiversity levels. This data can enable the protection and restoration of seabed habitats, which the Common Fisheries Policy Marine Ecosystems action plan considers essential to increasing fish stocks. Seabed and habitat mapping with the Biodiversity and Seascape DTO can also underpin the designation of new marine protected areas (MPAs) according to the Habitats directive to achieve the protection of 30% of Europe's seas as MPAs by 2030. The EU Mission Restore our Oceans and Waters by 2030 supports research and innovation, including through a Blue Parks Platform, to map, monitor, protect and restore biodiversity under anthropogenic pressures. Data from the Biodiversity and Seascape DTO can also be integrated into EMODnet, helping fulfill the 2030 goal of the Mission Restore our Ocean and Waters to centralize biodiversity and habitat information.

- **Reducing invasive alien species:** By conducting invasive species risk assessments and forecasting for ballast water management, the NPOCRA DTO addresses a major source of invasive species spread. Reducing invasive species through ballast water monitoring, ships can better comply with the IMO's Ballast Water Management Convention and help advance the Biodiversity Strategy goal to halve the number of Red List species threatened by invasive alien species by 2030.
- **Achieving Good Environmental Status:** By monitoring and reducing environmental pressures such as litter, nutrients, anthropogenic sound, non-indigenous species, and pathogens as listed in the MSFD, the Environmental Monitoring DTO contributes to achieving good environmental status (GES) in Europe's seas. This DTO also conducts marine research to inform future policy and monitors program implementation as required by the MSFD.
- **Protecting human health:** Iliad's Jellyfish Swarm Forecasting DTO facilitates tracking, modeling, and alerting the public to jellyfish swarms, which pose a risk to bathers' health, as required by the Bathing Directive.
- **Digitalization:** The environmental monitoring and Hydromast DTOs contribute to Mission Restore our Ocean's 2030 goal of creating a digital knowledge system which integrates data from industry, building on existing sources of knowledge such as Copernicus (CMEMS, space observation), the European Marine Observation and Data Network (EMODnet) and EC Knowledge Centres on earth observation, biodiversity and bioeconomy. Iliad's Hydromast DTO directly supports the Mission to Restore our Ocean's goal of a 50% increase in the production and deployment of low-cost, low environmental impact platforms and sensors for ocean observation by 2030.

All Iliad DTOs featured in this brief, along with many others, are available through the Iliad Marketplace at ocean-twin.eu/marketplace.

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Increasing investment, reducing risk: Offshore renewable energy deployment with Iliad Digital Twins

According to the EU Strategy on Offshore Renewable Energy (2020), the EU Commission has set the objective to have an installed capacity of at least 60 GW of offshore wind and at least 1 GW of ocean energy by 2030 and 340 GW by 2050 from offshore wind and ocean energy¹⁴.

At the current rate of production, the EU is not on track to meet these goals. To achieve them, deployment of Offshore Renewable Energy (ORE) infrastructure must scale rapidly, up five times by 2030 and 25 times by 2050. However, without proper planning and data, ORE deployment can cause environmental damage or be limited by uncertainty and lack of capacity. Iliad Digital Twins of the Ocean (DTOs) integrate vast amounts of oceanographic data to monitor, predict, and model ocean conditions, for a data-driven, responsive approach to ORE deployment.

Below we detail a number of challenges in scaling up ORE infrastructure and how Iliad DTOs address them:

1. **Marine Spatial Conflicts:** The overlapping use of marine spaces for activities such as fishing, shipping, and conservation creates conflicts with renewable energy installations.

How Iliad addresses this: The Wave Energy DTO supports Marine Spatial Planning (MSP) by integrating spatial mapping platforms, observations of wave height, and conservation data to map optimal locations for Wave Energy Converter technology. This DTO can support large-scale integration of offshore renewable energy (ORE) into marine spatial planning while maximizing energy productivity and minimizing environmental impact. Another Iliad offering, the MSP Challenge, uses advanced game technology and game thinking to engage and immerse users, making it a perfect environment for stakeholder engagement, and planning through co-design, learning and education.

¹⁴ Offshore Renewable Energy Strategy

2. **Resource Assessment and Feasibility:** Accurate data on wind, wave, and tidal resources are crucial for planning and investment. However, there is limited access to high-resolution, site-specific resource assessments, hindering effective project development.

How Iliad addresses this: Iliad's Tidal Array DTO conducts resource assessments for tidal turbines, and the Wave Energy DTO collects data on wave height to create assessments of wave energy potential to support project planning and investment.

3. **Environmental Impacts:** ORE deployment can cause species displacement and changes to migratory patterns due to underwater noise and changes in electromagnetic field. Improper planning, installation, and safety mechanisms can result in habitat degradation and contamination by leaking chemicals or oil spills caused by collisions.

How Iliad addresses this: The Tidal Array DTO integrates real-time monitoring and modelling of ocean conditions to track environmental impacts from tidal turbines and generate data for environmental impact assessment. The Wind Energy Project Review Tool DTO creates accurate simulations of wind farm installations that incorporate environmental conditions like currents, winds, and waves, allowing for precise maneuvering and reducing the risk of accidents which cause ecosystem damage.

4. **Social impact:** ORE companies are limited by skill shortages and there is a critical need for digital skilling of workers in the ORE sector. Inadequate stakeholder engagement and lack of community buy-in have, in some cases, led to project delays due to public opposition.

How Iliad addresses this: The Wind Energy Project Review Tool DTO provides VR-based training scenarios for wind farm crews, helping address skill shortages and enabling the reskilling of workers from traditional sectors like fisheries.

5. **Regulatory and Permitting Processes:** Complex and fragmented regulatory frameworks can delay project approvals. Streamlining these processes with robust data and evidence is vital to facilitate timely development.

How Iliad addresses this: The Tidal Array DTO generates environmental impact assessment and marine energy resource data. This data provides the necessary documentation and insights to satisfy regulatory requirements, and can be seamlessly integrated into permitting and reporting mechanisms. The Wave

Energy DTO can contribute to permitting and reporting by informing spatial planning and performance assessments through accurate wave data.

Description of Iliad services

- **Wind Energy O&M DTO** optimizes plans for the maintenance of offshore wind farms, scheduling necessary interventions based on weather conditions such as wave height and wind speed. Strategies are tailored to users' logistical needs and technical capacities, and are presented as multiple scenarios with cost breakdowns to choose from.
- **Wind Energy Project Review Tool DTO** creates accurate simulations of wind farm installations which integrate environmental conditions like currents, winds, and waves to plan for precise maneuvering. Crews are trained using VR scenarios, ensuring compliance with EU offshore wind safety policy.
- **Tidal Array DTO** simulates the operation of tidal turbines arranged in an array formation. The tool integrates monitoring and modelling to optimize array design, conduct marine energy resource assessments, and track environmental impacts for sustainable deployment. Data collection, monitoring, and environmental impact assessment also support streamlined permitting processes.
- **Wave Energy DTO** measures wave height and frequency to identify and evaluate optimal sites for wave energy converter (WEC) technologies, maximizing energy generation and reducing investment risks. This tool informs the spatial planning, design, maintenance, and performance assessments of WEC technologies. Data from wave sensors is also used to assess risks to offshore and coastal infrastructure, disaster preparation, and coastal management by understanding erosion patterns.
- **MSP Challenge** is an interactive simulation which integrates the best available geo, maritime and marine data with simulation models for ecology, shipping and energy production. Using advanced game technology and game thinking, MSP Challenge engages and immerses stakeholders to design the allocation and management of marine space.

As a provider of Operation Maintenance services for floating offshore wind technologies, and through our new joint venture with SBM Offshore, Ekwil, we continually seek to integrate accurate operational conditions into our engineering solutions. Thanks to Iliad, we are now one step away from

integrating live metocean data into our interactive decision-making tools for operations design and asset monitoring.

- **Technip Energies**

Additional policy implications

- **Decarbonization:** By facilitating increased deployment of offshore renewable energy, Iliad's renewable energy DTOs support the EU targets of 55% GHG reduction by 2030 and carbon neutrality by 2050. The DTOs also help achieve the targets of 61 GW by 2030 and 340 GW by 2050 of offshore wind and ocean energy as well as UN Ocean Decade Challenge 5: 'Unlock Ocean-Based Solutions to Climate Change'.
- **Climate adaptation:** The Wave Energy DTO helps member states conduct flood risk assessments, maps, and management plans in line with the Floods Directive, and supports the creation of national strategies following the recommendation on Integrated Coastal Zone Management (ICMZ). By collecting data on climate risks and forecasting disasters, this DTO helps achieve the UN Ocean Decade Challenge 6: 'Increase Community Resilience to Ocean Coastal Risks' as well as the Climate Adaptation Strategy target of climate resilience by 2030.
- **Maritime Spatial Planning (MSP):** By February 2026, EU member states must adopt plans to designate renewable acceleration areas in which to ramp up renewables deployment under the Renewable Energy Strategy (REDIII). The Wave Energy DTO is equipped with the spatial mapping platforms, conservation data, and environmental impact assessment tools which are required for this selection process. As deployment scales up, the DTO's MSP tools are essential to integrate offshore renewable energy into national plans under the Maritime Spatial Planning Directive (MSPD). Furthermore, all key strategic documents on offshore renewable energy describe maritime spatial planning as an essential tool to prevent maritime space-based conflict and achieve Biodiversity strategy and Marine strategy framework directive (MSFD) targets for protected marine ecosystems.
- **Environmental Impact Assessment (EIA):** The Tidal Array DTO measures and mitigates environmental impact in line with the rigorous EIA requirements of the ORE Strategy, Trans European Networks for Energy (TEN-E), and REDIII. These call for comprehensive and science-based evaluation of environmental impacts to ensure progress towards achieving the goals of the Marine Strategy

Framework Directive (MSFD), Biodiversity Strategy, and Zero-Pollution Action Plan.

- **Safety:** As acknowledged in the ORE strategy, areas with the highest potential for ORE deployment also have the highest risk level for accidents. The Wind Energy Project Review Tool DTO and Wind Energy O&M DTO enhance operational safety by planning maintenance using environmental forecasts, simulating precise maneuvers, and training crews for emergency scenarios.
- **Skilling:** Under the ORE strategy, member states have committed to supporting workforce education to develop a skill pool in offshore energy. Iliad's Wind Energy Project Review Tool DTO enhances workers' digital and practical skills through VR training and scenario modeling, supporting Digital Europe's goals for the digitalization of blue economy sectors and workforce development. Crew training tools also support workforce skilling for the green transition, aligning with the objectives of the Net-Zero Industry Act and European Skilling Agenda.
- **De-risking investment:** The offshore renewable energy strategy estimates investment needs up to €800 billion for large-scale offshore renewables deployment by 2050. The Tidal Array DTO, Wave Energy DTO, and Wind Energy O&M DTO directly facilitate increased investment by increasing predictability and decreasing risk in offshore renewable operations. Data, monitoring, and environmental impact assessment using Iliad's renewable energy DTOs also promote streamlined permitting and reporting processes, contributing to an enabling environment. The Wind Energy O&M DTO can cut downtime losses. The estimations are dependent on the size of the wind farm. For a 5 by 5 wind farm, over a period of 20 years, the decrease in downtime losses is estimated at 2%. The Tidal Array DTO increases investment by reducing cost. While savings depend on construction costs, a full array deployment with the DTO can accrue savings of around 25.5 million euros for an indicative cost of 30p/kWh. By enabling companies to operate on-site rather than having to tow infrastructure to port, the Project Review Tool DTO can create savings of up to 75% of operation costs.

All Iliad DTOs featured in this brief, along with many others, are available through the Iliad Marketplace at ocean-twin.eu/marketplace.

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How Iliad contributes to the European Ocean Pact

The European Ocean Pact

On 5 June 2025, the European Commission adopted the European Ocean Pact, an initiative aimed at reinforcing the EU's commitment to protecting marine ecosystems, supporting the blue economy, and enhancing ocean governance.

The European Ocean Pact delineates a comprehensive strategic agenda centered around six pillars essential for achieving a sustainable and resilient maritime future:

1. protecting and restoring ocean health by supporting EU countries in their efforts to restore degraded coastal marine habitats
2. enhancement of sustainable competitiveness across all sectors of the blue economy
3. socioeconomic fortification of coastal and island communities
4. enhancing maritime security and defence by strengthening EU coast guard cooperation and maritime border security
5. advancing ocean research, knowledge, skills and innovation by proposing an ambitious EU Ocean Observation Initiative
6. amplification of the EU's international leadership in ocean governance and diplomacy.

How Iliad Supports the Goals of the European Ocean Pact

The Iliad Digital Twins of the Ocean (DTOs) provide a policy-enabling operational framework that address each of these pillars. Through integrated services across fisheries, aquaculture, port and ship operations, pollution control, and renewable energy, Iliad delivers interoperable, scalable, and evidence-based tools that support Pact targets and boost the European blue economy.

Restoring Ocean Health and Productivity

To directly enable the Pact's 2030 protection goals (protecting 30% of EU seas by 2030), Iliad offers integrated real-time monitoring tools and scenario modeling capabilities. The system's [water quality DTOs](#) provide high-resolution assessments of eutrophication, oil spill trajectories, and plastic distribution, enhancing early-warning systems and response coordination. Habitat mapping modules, particularly those used in the [aquaculture](#), [fisheries](#) and [port](#) pilots, assist in designating and managing MPAs, developing tailored strategies to enhance the resilience and economic sustainability of coastal regions, supporting sustainable fisheries, and offer improved

methods of reporting economic and industrial activities. The [Thracian](#) and [Cretan Sea](#) pilots demonstrate how forecasting platforms and observational data are fused to track pollutant dispersion and guide cross-border mitigation. tracking to fulfill targets under the Marine Strategy Framework Directive (MSFD) and Zero Pollution Action Plan, including eliminating oil spill risks. In parallel, in support of the Pact's goal of halving plastic litter by 2030, plastic pollution dashboards developed in [the Trondheim Fjord pilot](#) enable hotspot detection and MSFD-aligned reporting.

Enhancing the Sustainable Competitiveness of the Blue Economy

Iliad contributes to the blue economy's transformation by operationalizing decision-support services across key maritime sectors. For fisheries, dynamic dashboards developed under [the North Sea](#) and [Black Sea pilots](#) integrate stock data, habitat suitability indices, and routing optimization tools, aiding the enforcement of sustainable quotas, aligning with CFP reform and emissions reductions. [Aquaculture-specific services](#), including [real-time water quality monitoring](#) and [disease spread modeling](#), empower producers to optimize site selection and [reduce environmental footprints](#) and insurance companies [to better predict risks](#) and help meet the Pact's target of improving disease control and reducing antimicrobial use in aquaculture by 50%. In [ports](#), as demonstrated by the [Heraklion](#) and [Varna](#) pilots, Iliad tools deliver wave forecasting, ship routing optimization, and risk assessment visualizations, improving logistics and compliance. Iliad also supports Pact objectives for decarbonising maritime sectors, promoting innovation, and doubling offshore renewable capacity by 2030. [Renewable energy pilots](#) in [Portugal](#), [Israel](#), and [Edinburgh](#) incorporate marine spatial planning, resource feasibility modeling, and hydro-environmental impact assessments to support sustainable deployment and integrated siting decisions. The [Iliad Marketplace](#) makes these applications available and easily accessible to all interested stakeholders. It also provides third party developers the opportunity to have their digital services hosted for higher visibility and commercialisation potential. Complementing these sectoral innovations are 1) the [Twin Lab](#), an exclusive section of the marketplace dedicated to pioneering digital data products and oceanic digital twins that are in the nascent stages of development and 2) [the Blue Tech Transfer platform](#), which facilitates commercialization by connecting research outputs with investors, regulators, and end-users.

Advancing Ocean Research, Knowledge, and Innovation

Iliad operationalizes the European Digital Twins of the Ocean vision by delivering a federated architecture that unites national, thematic, and regional digital twins through open APIs and standardized metadata protocols, supporting scalable data flows and interoperability. The project enables scenario simulation, real-time forecasting, and rapid model iteration. The [Iliad Academy](#) serves as the project's capacity development pillar, supporting Pact goals for capacity-building and digital upskilling by offering modular training, product documentation, and demonstrative tutorials that empower diverse stakeholder groups—including national authorities, researchers, and industry actors—to co-develop, scale, and operationalize

data-driven digital ocean solutions. The aforementioned [Blue Tech Transfer platform](#) provides research teams and SMEs information and opportunities to develop and commercialize their innovative ideas into competitive products and services in boosting the blue economy. Together, these components accelerate the transition toward a common European Ocean Knowledge System.

Supporting Coastal and Island Communities

To build adaptive and inclusive coastal governance, Iliad provides tools that integrate socio-economic, environmental, and infrastructure data to support community-level resilience planning. Through scenario builders and participatory platforms as deployed in Valencia, Spain and [Al-Hoceima, Morocco](#), and [in Romania](#), local authorities and stakeholders engage in environmental sensing, are empowered to contribute environmental data and co-create adaptation pathways. Multi-use [marine spatial planning systems](#), [citizen science applications](#) (e.g. for [jellyfish swarm](#) reporting and [harbor safety](#)), enhanced by GIS and geospatial analytics, help reconcile conflicting uses and support cohesive development planning. These functionalities support the development of EU-coordinated resilience plans for outermost regions and island communities, as mandated in the Pact's coastal action framework.

Enhancing Maritime Security and Resilience

Security-oriented services embedded in Iliad's pilots help address illegal, unreported, and unregulated (IUU) fishing, as well as navigation hazards and cyber-physical threats. [VISTools](#) supports the Belgian fishing fleet with advanced decision-making and reporting tools using sensors installed on vessels to capture key operational data. These include weights of catches per species, fuel consumption, and GPS tracking that logs vessel location and movements. A dedicated onboard device integrates all sensor data and transmits it to the cloud for processing and analysis. The results are then displayed on an interactive Power BI dashboard, providing vessel owners with real-time operational insights. Catch traceability modules support digital certification and enforcement. For port operations, an [AR/VR Blind Navigation of Marine Vessels in Varna Port](#) offers ship operators and port authorities enhanced support for [maritime surveillance and collision risk prediction](#), while also simulating vessel traffic management scenarios, including during adverse weather conditions. Across sea basins, high-resolution models forecast oil spills, UXO impacts, and hybrid emergencies, offering authorities the data and tools to implement proactive and coordinated resilience strategies.

Strengthening EU Ocean Diplomacy and International Governance

Aligned with the Pact's goal to enhance international cooperation and treaty compliance, Iliad offers interoperable tools and open data platforms that adhere to OGC standards and facilitate transparent monitoring of global marine targets, including the BBNJ agreement and plastic litter reduction frameworks. Furthermore, Iliad's training and outreach activities— through its Academy, Webinar Series, Summer Schools, and Hackathons— have facilitated regional

collaboration, support for early career researchers, and technical capacity building in partner countries, thereby reflecting the Pact's commitment to strengthening the EU's external ocean agenda and advancing digital diplomacy.

The various Iliad DTOs, developed across thematic areas such as fisheries, pollution control, ports, and renewable energy, serve as robust data-driven decision-support systems for public authorities. These tools allow for the integration of real-time environmental and operational data into national and regional governance workflows, enabling authorities to monitor compliance, track progress against EU targets, and adjust policy measures in a timely and informed manner. For end-users—such as port operators, aquaculture producers, and fishery managers— DTOs offer automated reporting tools, predictive simulations, and standardized dashboards that facilitate adherence to EU directives and international environmental agreements.

Furthermore, the Iliad project has made it easier for policymakers to identify and access the most relevant digital services on the Iliad Marketplace through its dedicated [policy toolkits page](#). This curated platform enables stakeholders to navigate and select thematic services that are aligned to advance both European and global policy objectives—from sustainable fisheries and aquaculture management to pollution and emissions reduction.

Additionally, a browser extension ([SemLinked](#)) and a dedicated [Analytics and Policy Impact page](#) brings forth emerging cross-sectoral insights and highlights the need for policy reforms to include innovation incentives and progress towards a multisectoral marine governance model. As the European Ocean Pact envisages a fully operational Digital Twin of the Oceans by 2030, further R&D initiatives should investigate pathways how Iliad DTOs and other regional and thematic DTOs can be made sustainable and integrated into the wider governance framework. Strategic investments via InvestEU and BlueInvest can accelerate deployment, while the Mission Ocean secretariat should oversee integration across EU agencies. To help ensure the implementation of the priorities of the European Ocean Pact, policymakers are encouraged to make full exploitation of produced innovative solutions (such as Iliad DTOs) in the complimentary Ocean Act - expected by 2027. Anchored in the European Green Deal, Iliad enables a digitally coordinated maritime transition toward the 2030 and 2050 milestones articulated in the Pact.

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