DIGITAL TWINS
OF THE OCEAN

Ute Brönner

Ocean Data Enthusiast at SINTEF Ocean

Member of the UN Decade
- Ocean Data Coordination Group

Leader of the TURTLE project and
- working group under DITTO on digital twin interoperability

Work package lead for pilot demonstrators in
- ILIAD, one of the EU Digital Twins of the Ocean projects

https://oceanexpert.org/expert/50093

www.linkedin.com/in/utebroenner

Ute Brönner

Passionate about understanding the ocean environment through data from the combina...

DIGITAL TWINS
IN OCEAN SUSTAINABILITY

Image : https://www.americanoceans.org/facts/how-much-oxygen-produced-by-ocean/

photo Michiel Vos / Ocean Image Bank

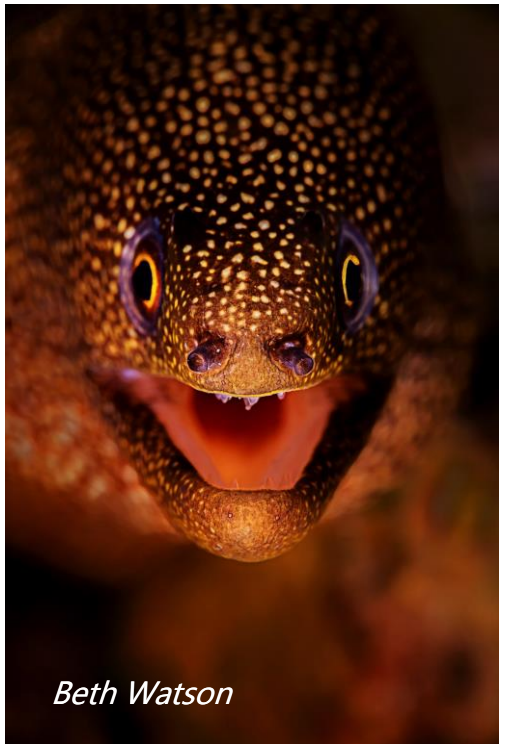
photo Gabriel Barathieu / Ocean Image Bank

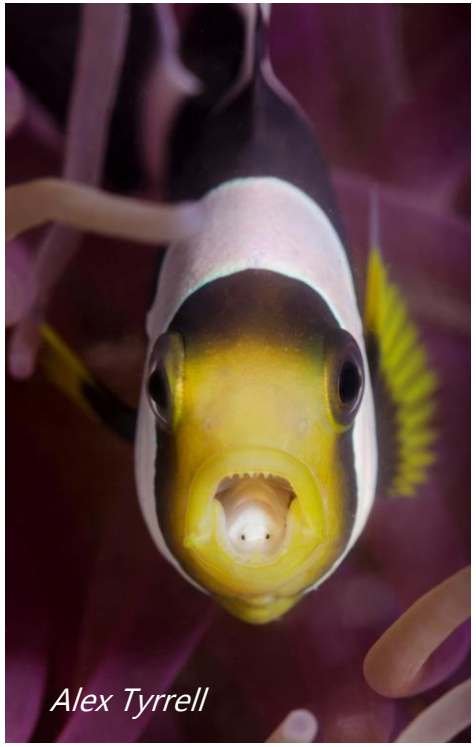
photo by Nicholas Doherty on Unsplash

photo by Tapani Hellman on pixabay

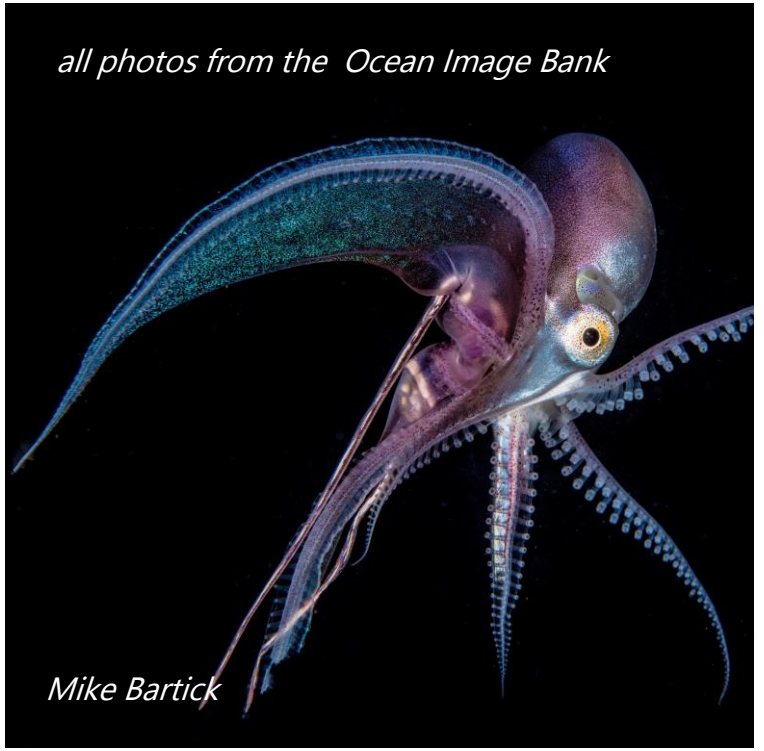
photo by Paul Einerhand on Unsplash

photo by Nate Cheney on Unsplash


Beth Watson


Alex Tyrrell

Vincent Kneefel


all photos from the Ocean Image Bank

Mike Bartick

This photo: Kyler Baden,
Ocean Art Competition 2018

Bart Lukasik

Gregory Piper

photo Richard Barnden / Ocean Image Bank

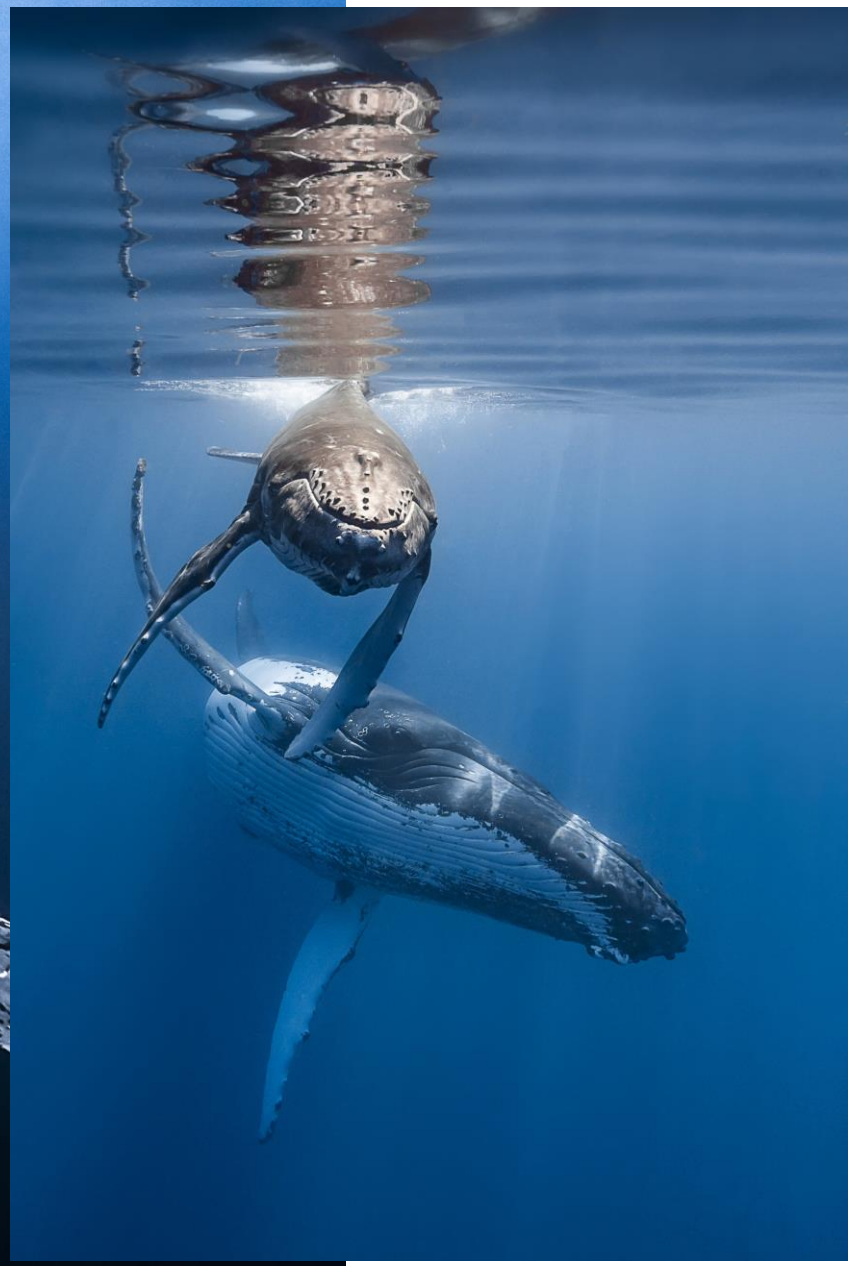
photo Grant Thomas / Ocean Image Bank

photo Anett Szaszi / Ocean Image Bank

photo Amanda Cotton / Ocean Image Bank

photo Jeff Hester / Ocean Image Bank

photo Fabrice Dudenhofer / Ocean Image Bank



photos Francoise Baelen / Ocean Image Bank

photo: WWF: https://www.wwfmmi.org/?5947466/Plastic-contamination-of-the-ocean-is-irreversible-warns-WWF

photo C. Ortiz Rojas - http://www.photolib.noaa.gov/htmls/fish2172.htm

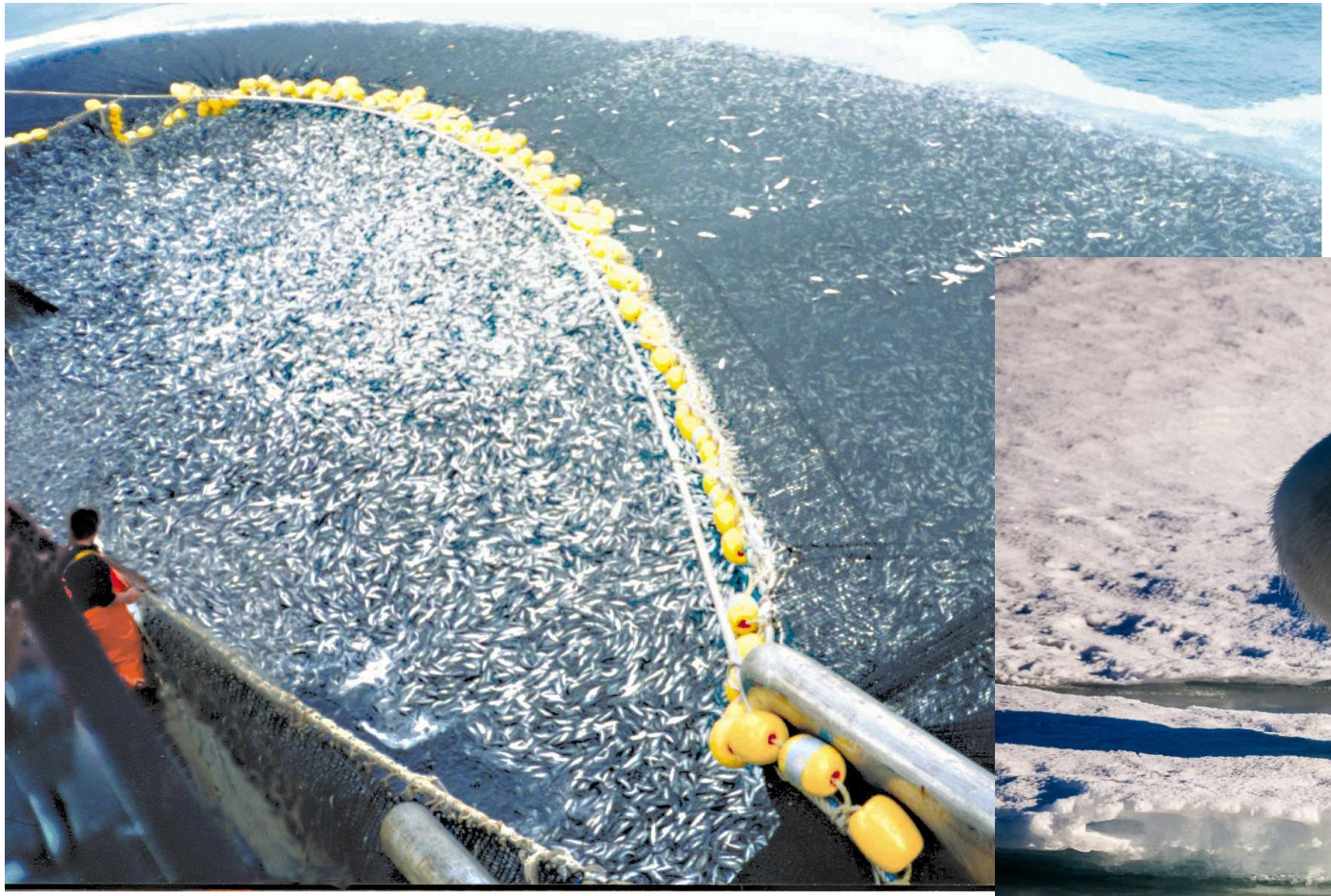


photo: Mario Hoppmann (distributed via imaggeo.egu.eu)

SINTEF

80% of the ocean has never been mapped, explored, or even seen by humans.

70% of the world's surface is covered by the Ocean.

30% 30x30 is a campaign to protect 30% of the global ocean by 2030.

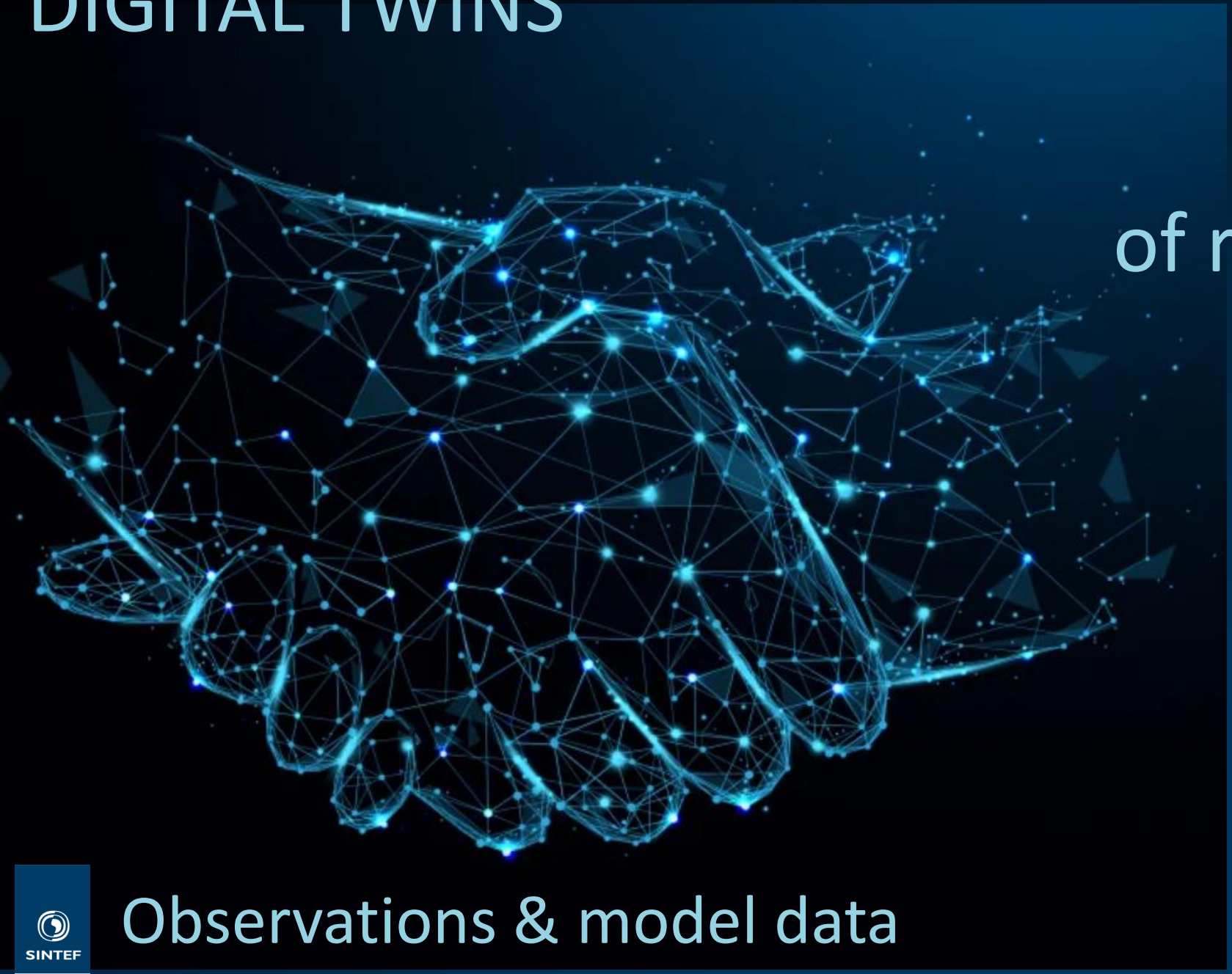
~7.65% of the ocean is covered by marine protected areas (MPAs). This is about the size of North America (by January 2023).

<3% of the ocean lies within a highly protected zone.

https://indigenousoceans.ca/en/marine-spatial-planning/

Marine Spatial Planning – what if ?

DIGITAL TWINS



Virtual representations of real-world 'things'

assets (physical twin), processes, people, places, systems, and devices

Synchronised at specific frequency and fidelity

Observations & model data

SINTEF

Insights through predictive capability

Simulate scenarios
Make decisions

image:
https://www.expresscomputer.in/news/what-is-a-digital-twin-why-is-it-important/45995/

REAL WORLD

DIGITAL TWIN

Adapted from https://www.mercator-ocean.eu/en/digital-twin-ocean/

https://www.i-scoop.eu/industry-4-0/

Industry 5.0 places the wellbeing of the worker at the centre of the production process and uses new technologies to provide prosperity beyond jobs and growth while **respecting the production limits of the planet.**

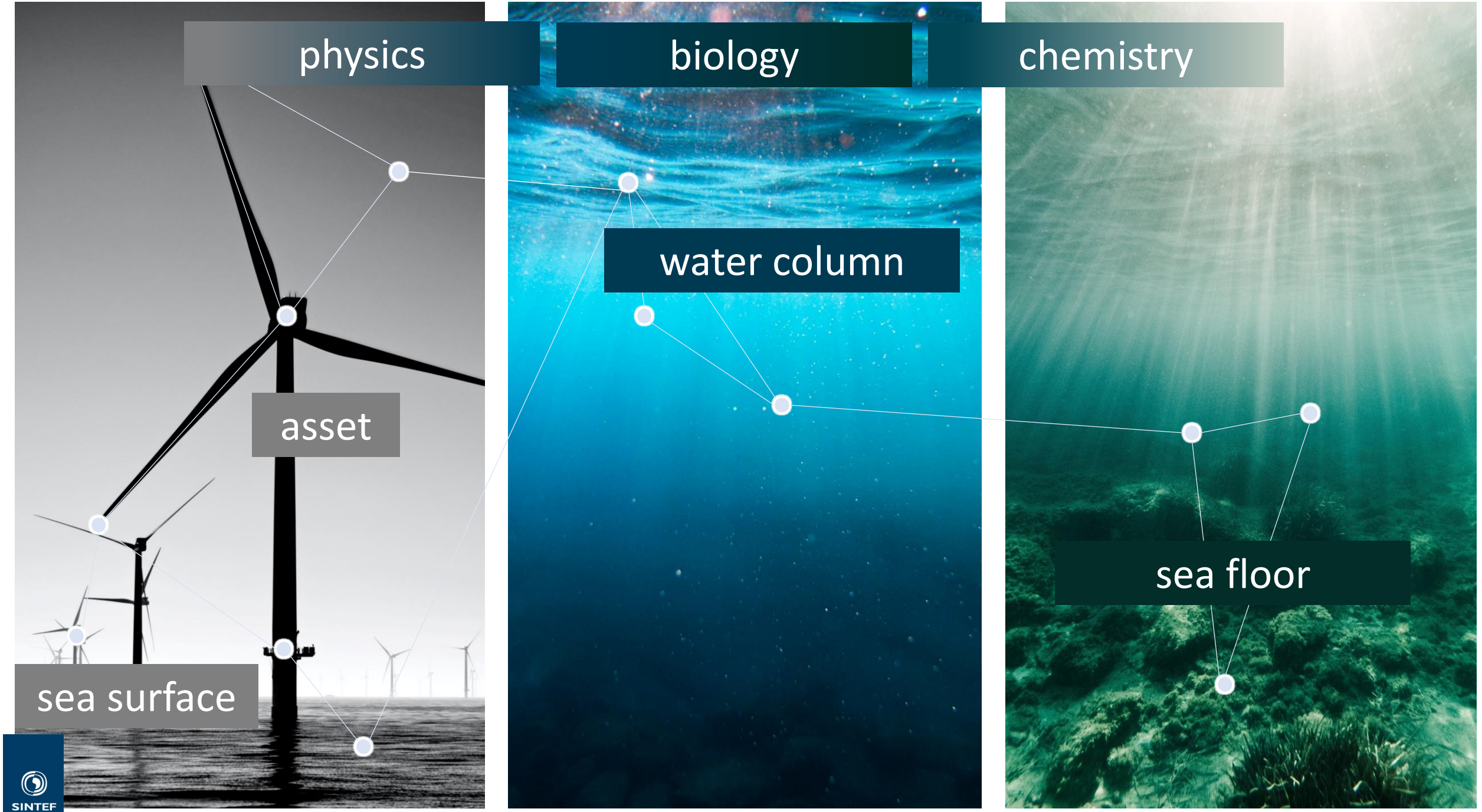
SUSTAINABILITY

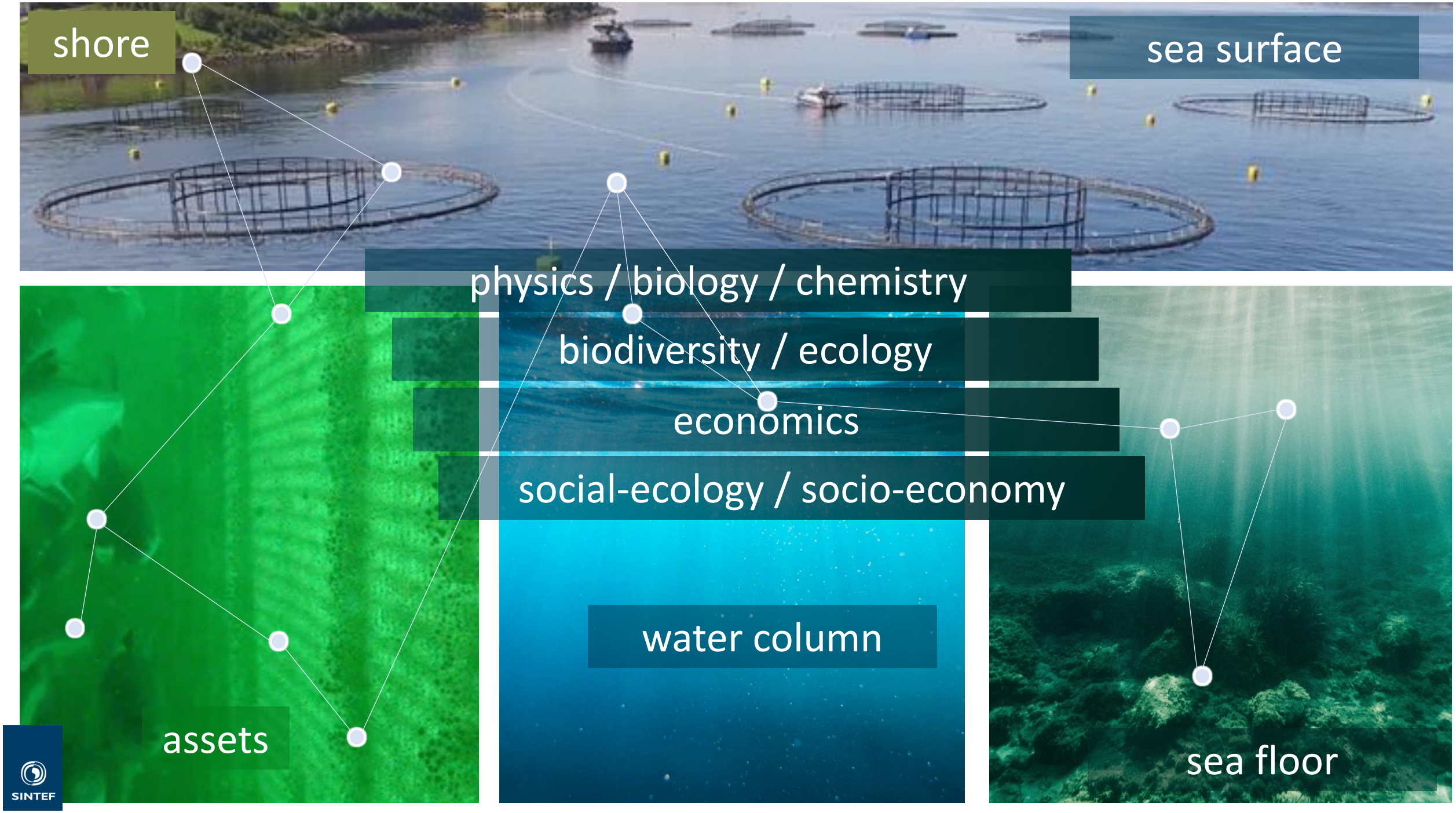
SINTEF

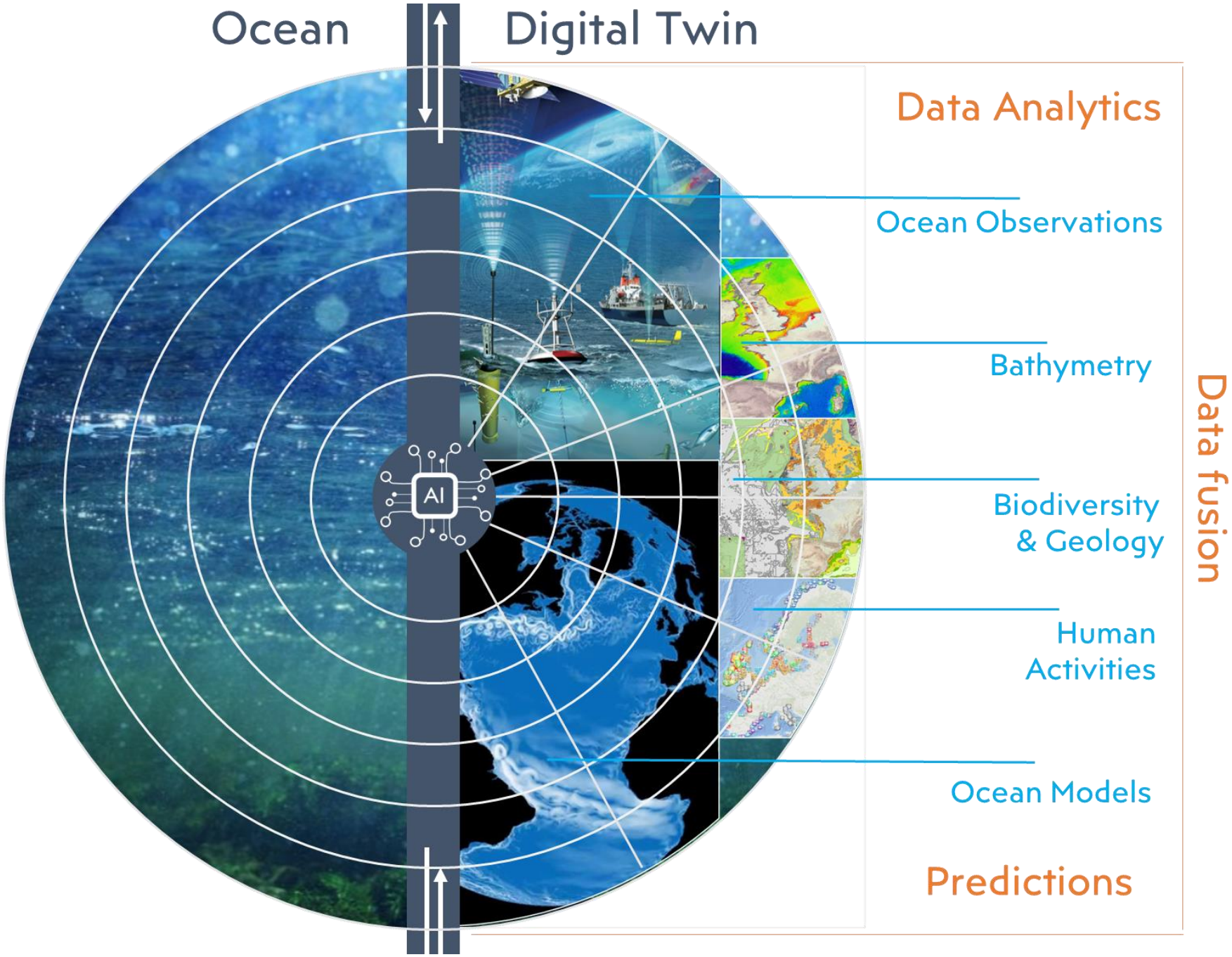
THE SUPERPOWER OF DIGITAL TWINS IS
CONTEXTUALISATION
SINTEF

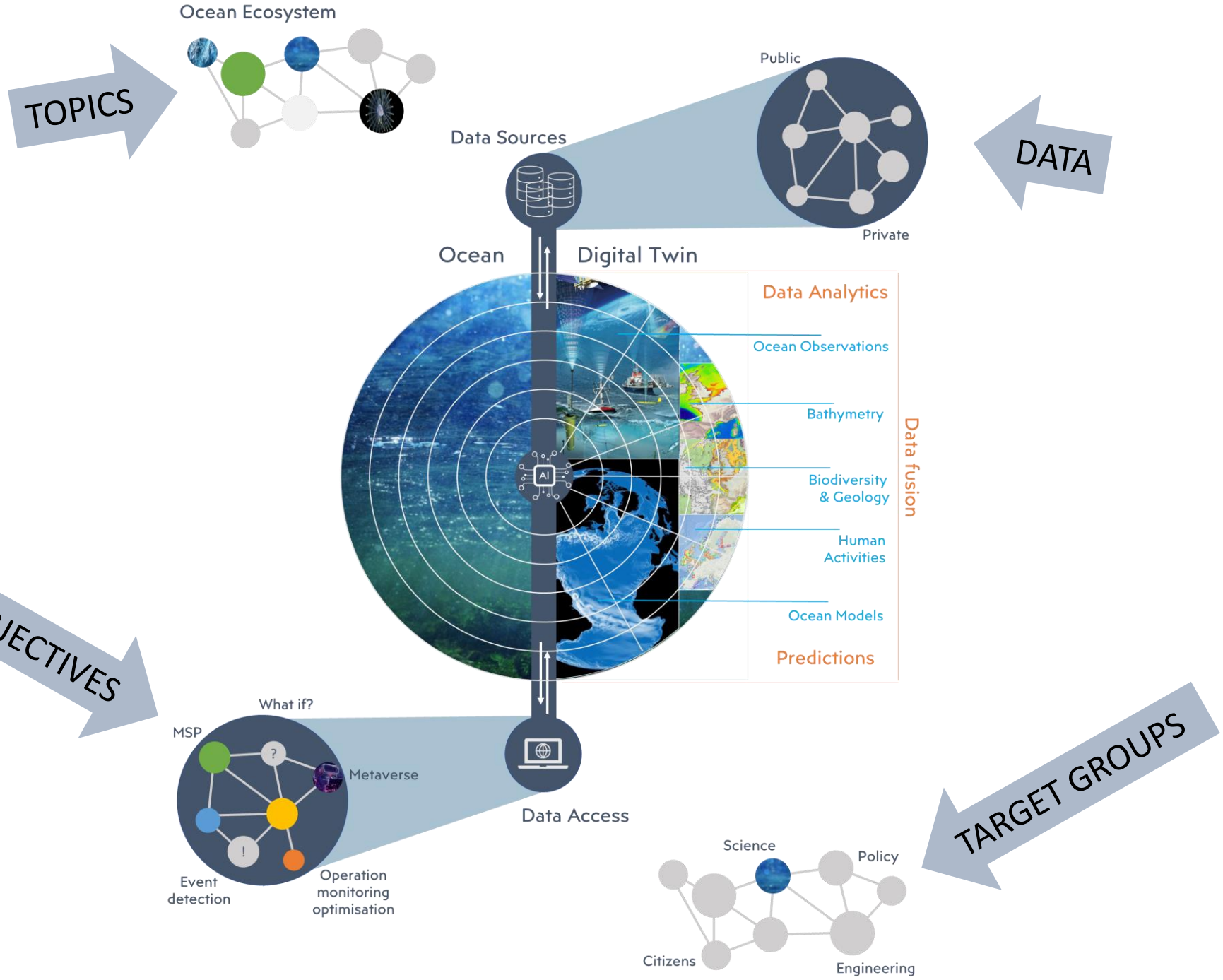
Digital Twins of the Ocean make existing and future Ocean Data Systems **interoperable.**

SINTEF


physics
biology
chemistry
asset
water column
sea floor
sea surface


shore
sea surface
physics / biology / chemistry
biodiversity / ecology
economics
social-ecology / socio-economy
water column
assets
sea floor


Ocean
Digital Twin
AI
Data Analytics
Ocean Observations
Bathymetry
Biodiversity
& Geology
Human
Activities
Ocean Models
Predictions
Data fusion


Ocean Ecosystem
TOPICS
Public
Private
Data Sources
DATA
Ocean
Digital Twin
Data Analytics
Ocean Observations
Bathymetry
Biodiversity
& Geology
Human
Activities
Ocean Models
Predictions
Data fusion
AI
OBJECTIVES
What if?
MSP
Metaverse
Event
detection
Operation
monitoring
optimisation
Data Access
TARGET GROUPS
Science
Policy
Citizens
Engineering

You can change the world for good - but only if people care about what you do.

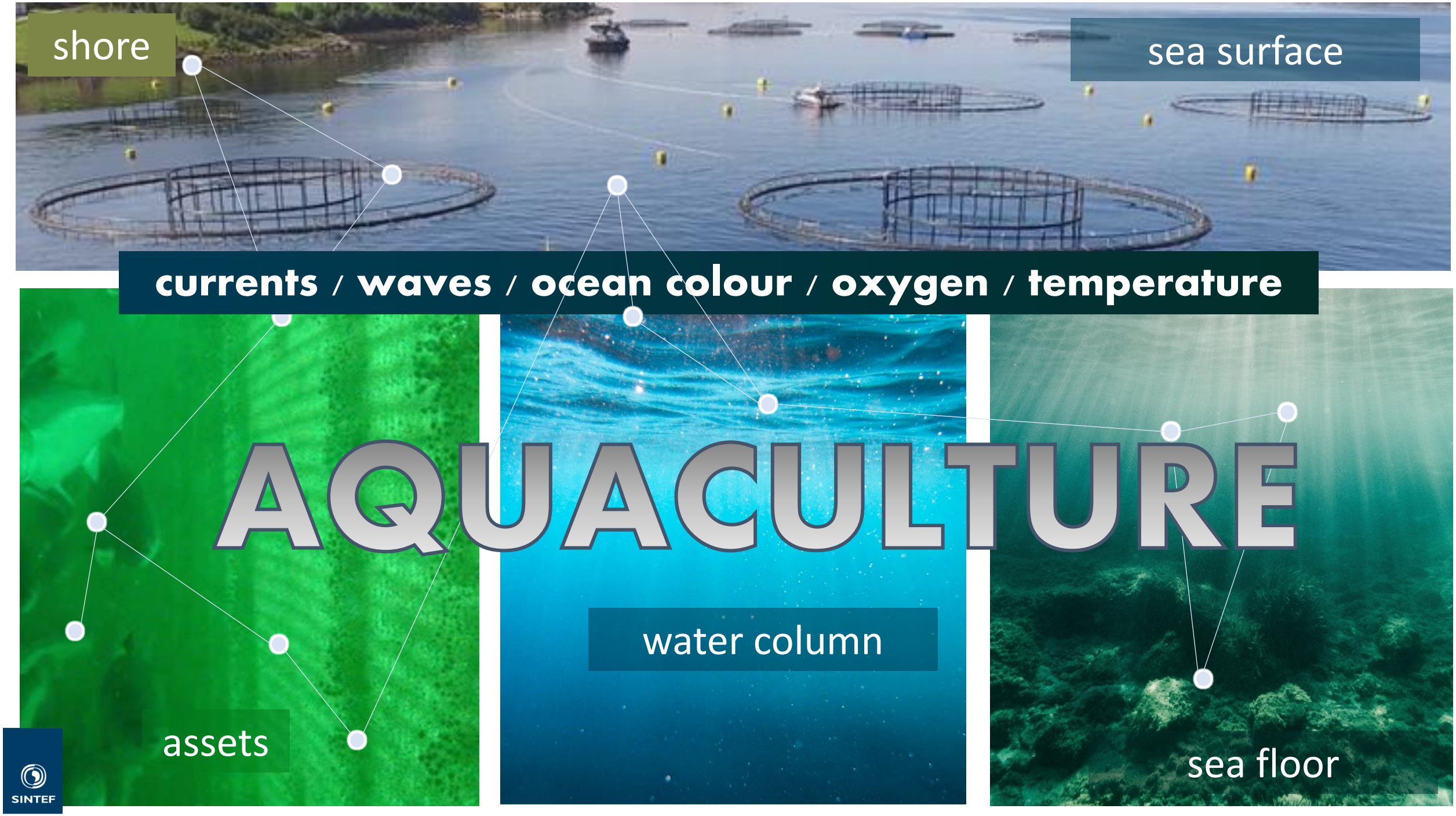
Visualisation & monitoring

Predictive analysis for informed decision making

Enhancing protective environments

"a photorealistic picture of a yellow research buoy in a peaceful fjord with blue sky and mountains in the background"

"a steampunk digital twin of the ocean with virtual reality"


shore
sea surface
currents / waves / ocean colour / oxygen / temperature
AQUACULTURE
water column
assets
sea floor
SINTEF

MARITIME TRANSPORT

currents / waves / mammals / biochemistry / invasive species

SINTEF

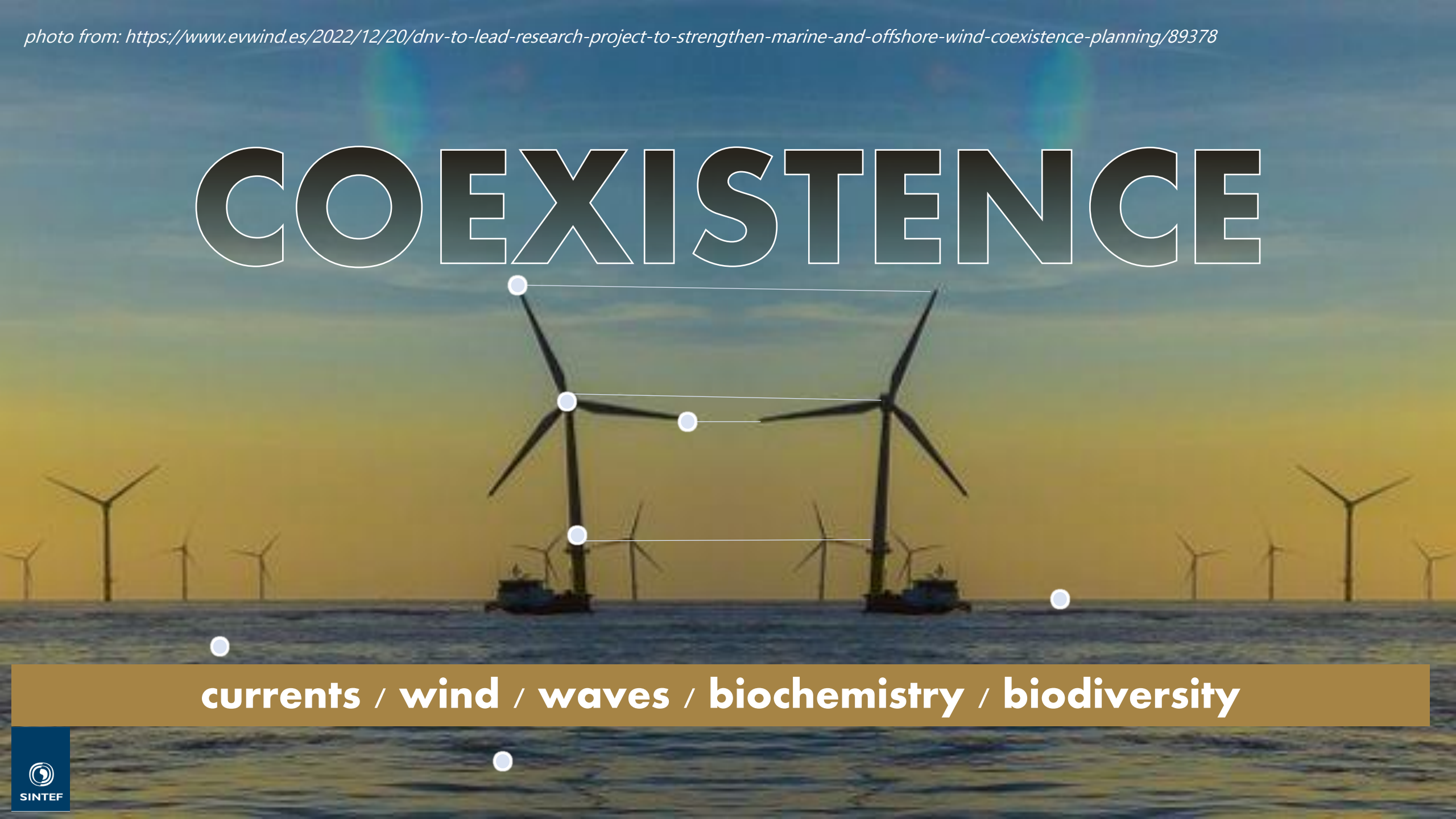
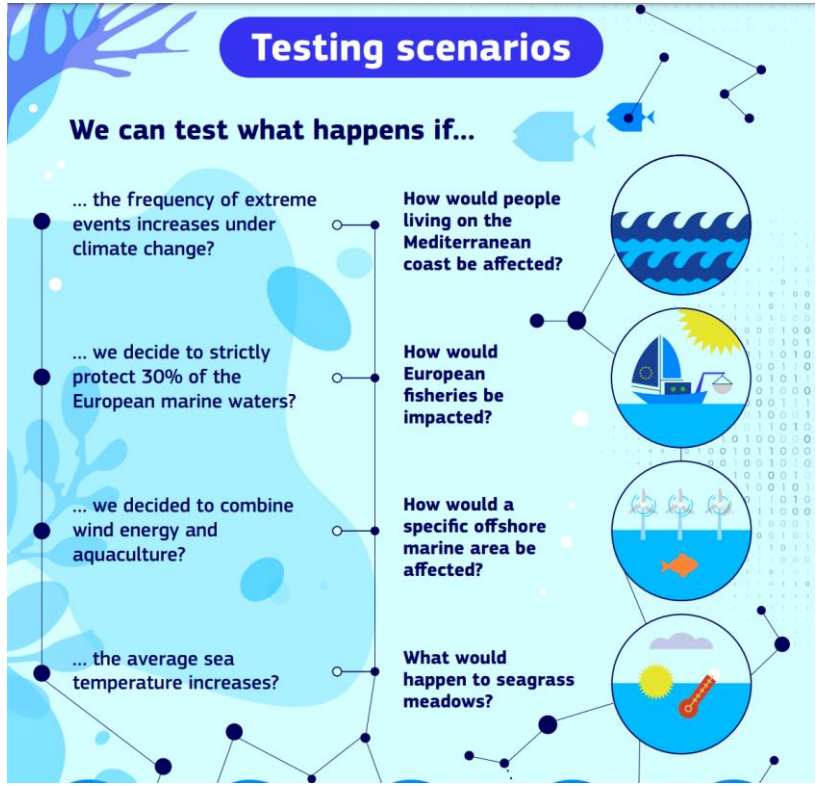


photo from: https://www.evwind.es/2022/12/20/dnv-to-lead-research-project-to-strengthen-marine-and-offshore-wind-coexistence-planning/89378
COEXISTENCE
currents / wind / waves / biochemistry / biodiversity
SINTEF

GOVERNANCE
currents / wind / waves / pollution / eutrophication / biodiversity
SINTEF

The European Commission is investing €10 million to develop a core European Digital Twin Ocean through the sister projects EDITO-Infra and EDITO-Model Lab.

This complements the €19 million project, Iliad, funded under the Green Deal Call for research proposals to pilot the Digital Twins of the Ocean concept.



https://www.edito-modellab.eu/news/what-will-the-european-digital-twin-of-the-ocean-be

European Digital Twin of the Ocean

A leap in ocean knowledge and sustainable action

EU MISSIONS
RESTORE OUR OCEAN & WATERS

MERCATOR OCEAN INTERNATIONAL

VLIZ

https://www.ocean-twin.eu/

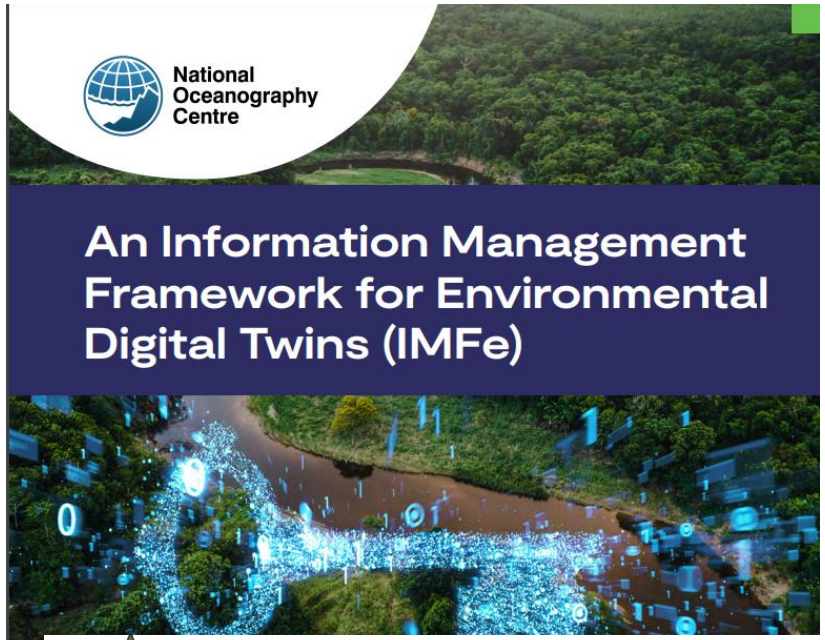
Iliad

Integrated Digital framework for comprehensive maritime data and information services

What are the Iliad Digital Twins of the Ocean?

Iliad aspires to create interoperable, data-intensive, and cost-effective Digital Twins of the Ocean

The Iliad Digital Twins of the Ocean build on the assets resulting from two decades of investment in policies and infrastructures for the blue economy and aims at establishing a variety of Digital Twins of the Ocean for different applications.



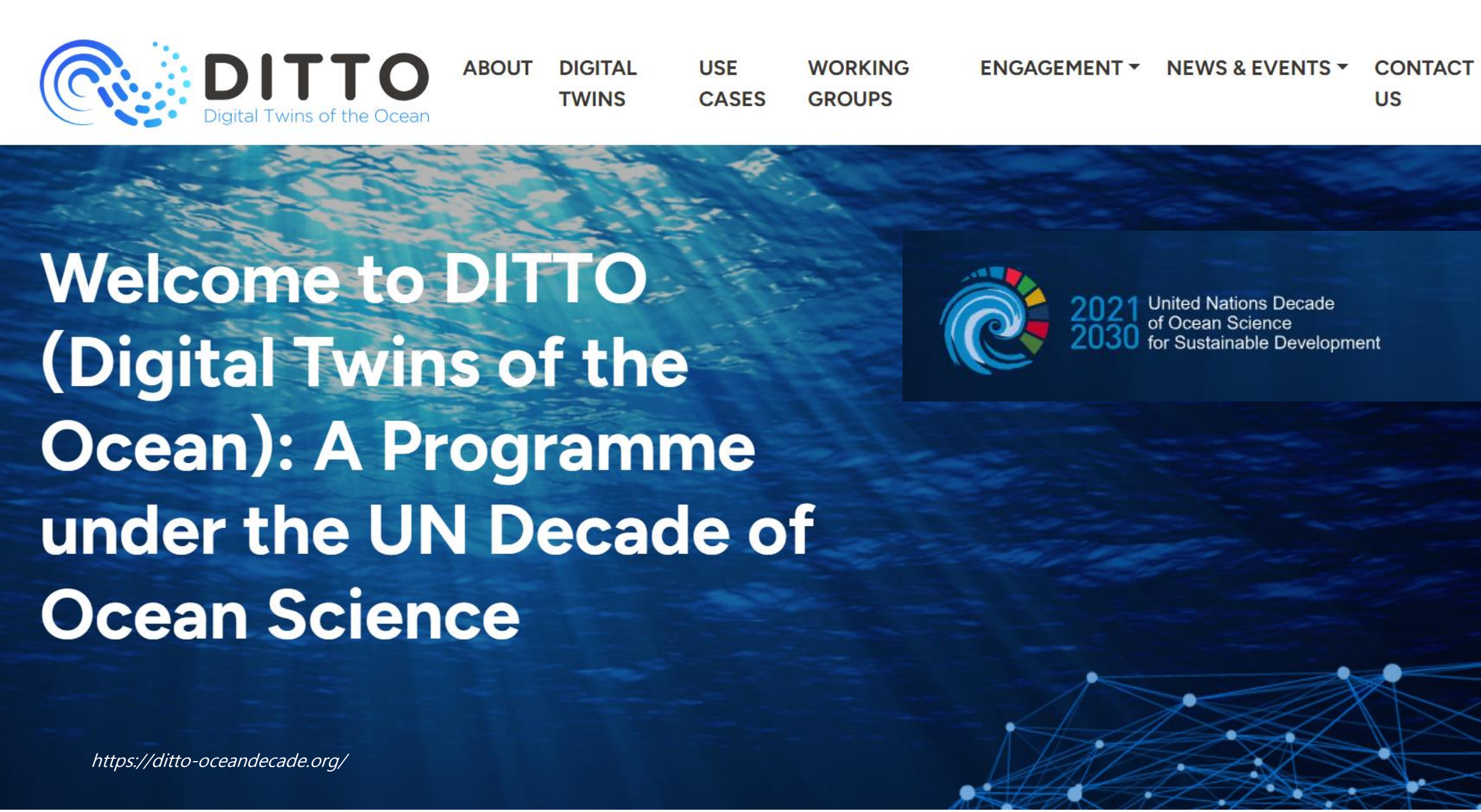
PORT OF ROTTERDAM DEVELOPING INTO MAJOR DIGITAL PLATFORM

The port of Rotterdam has long been recognised for its excellent physical infrastructure. To safeguard its strong competitive position in the decades ahead and to maximise the impact of its activities, the Port Authority is steadily expanding these assets with a digital component. As a result, a completely new port is coming into being against the familiar backdrop of massive ships, towering cranes and water spray. A digital 'doppelganger', which runs on data, laptops and mobile phones. A port made of 'apps', in which algorithms continuously track the movements of sea-going vessels, containers, inland vessels, trains and trucks. A port where everything is interconnected and where objects independently exchange information.

https://www.portofrotterdam.com/en/to-do-port/futureland/the-digital-port

https://nora.nerc.ac.uk/id/eprint/533054/1/NOC%20IMFe%20Summary%20Report3%20V3.pdf

https://biodt.eu/


DITTO
Digital Twins of the Ocean
ABOUT
DIGITAL TWINS
USE CASES
WORKING GROUPS
ENGAGEMENT
NEWS & EVENTS
CONTACT US
Welcome to DITTO (Digital Twins of the Ocean): A Programme under the UN Decade of Ocean Science
2021 2030 United Nations Decade of Ocean Science for Sustainable Development
https://ditto-oceandecade.org/

Interoperability Architecture for a Digital Ocean (TURTLE)

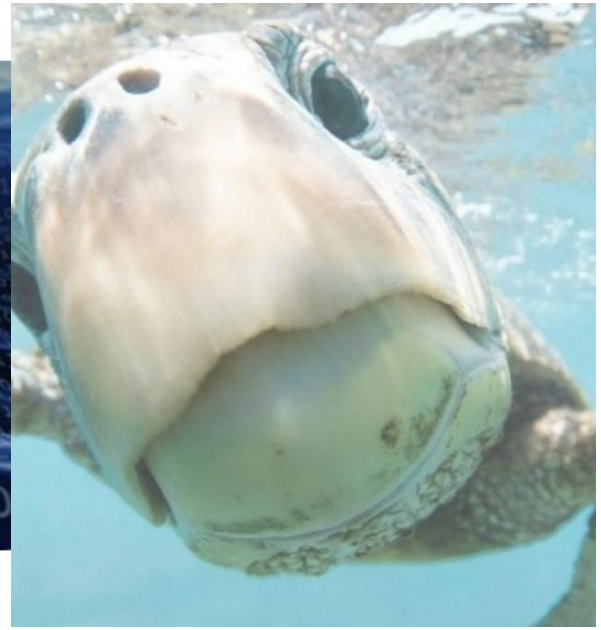


photo: Kyler Badten,
Ocean Art Competition 2018

The "Interoperability Architecture for a Digital Ocean" (TURTLE) project is implemented by SINTEF Ocean, Norway. Its goal is to coordinate ongoing international Digital Twins of the Ocean projects and work towards an interoperability architecture. As initiatives around the globe begin to enhance ocean-oriented digital capacity, there are unprecedented opportunities to power digital twinning.

Currently there are many initiatives that work toward or in support of a Digital Twin of the Ocean, e.g. the EU Digital Twin Ocean system, NOAA's National Centre for Environmental Information, the IOC Ocean Data and Information System ODIS, the IOC Ocean Best Practice System OBPS, the Ocean Data Action Coalition and the UN Data Coordination Group.

Project date:
01/09/2022 - 31/12/2025

Contact for this project:
Ute Brönner

Ísland
Suomi / Finland
Sverige
Беларусь
Deutschland
Україна
Türkiye
العراق
ایران
Algérie
الجزائر
ليبيا
مصر
السعودية

Iliad

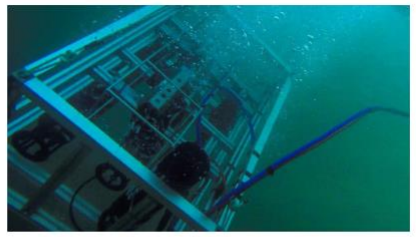
OceanLab_

Full-scale ocean space laboratory that can be used by national and international partners, academia and industry

OceanLab Node 1: Subsea Facility

OceanLab Node 2: National Test Area for Autonomous Vessels

OceanLab Node 3: Aquaculture

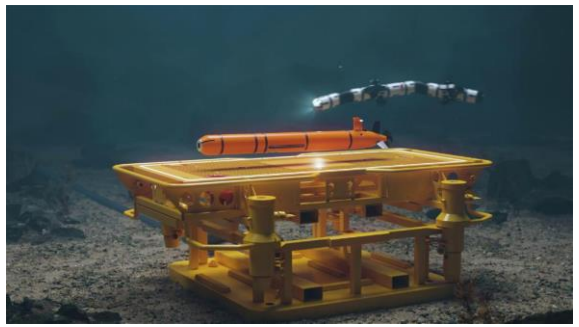


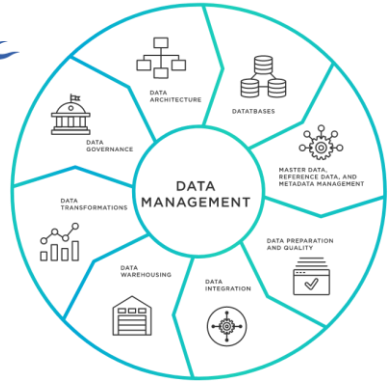
OceanLab Node 4: Marine Observatory

Water quality / pollution & environmental monitoring pilot

Data acquisition from OceanLab infrastructure

- Ocean observatory
- Subsea / applied underwater robotics





Data management and API access via TIBCO data virtualisation (under development)

ML for particle quantification and classification

External data sources:

- Ocean model (Norkyst800 or better (SINMOD))
- Satellite data on ocean colour

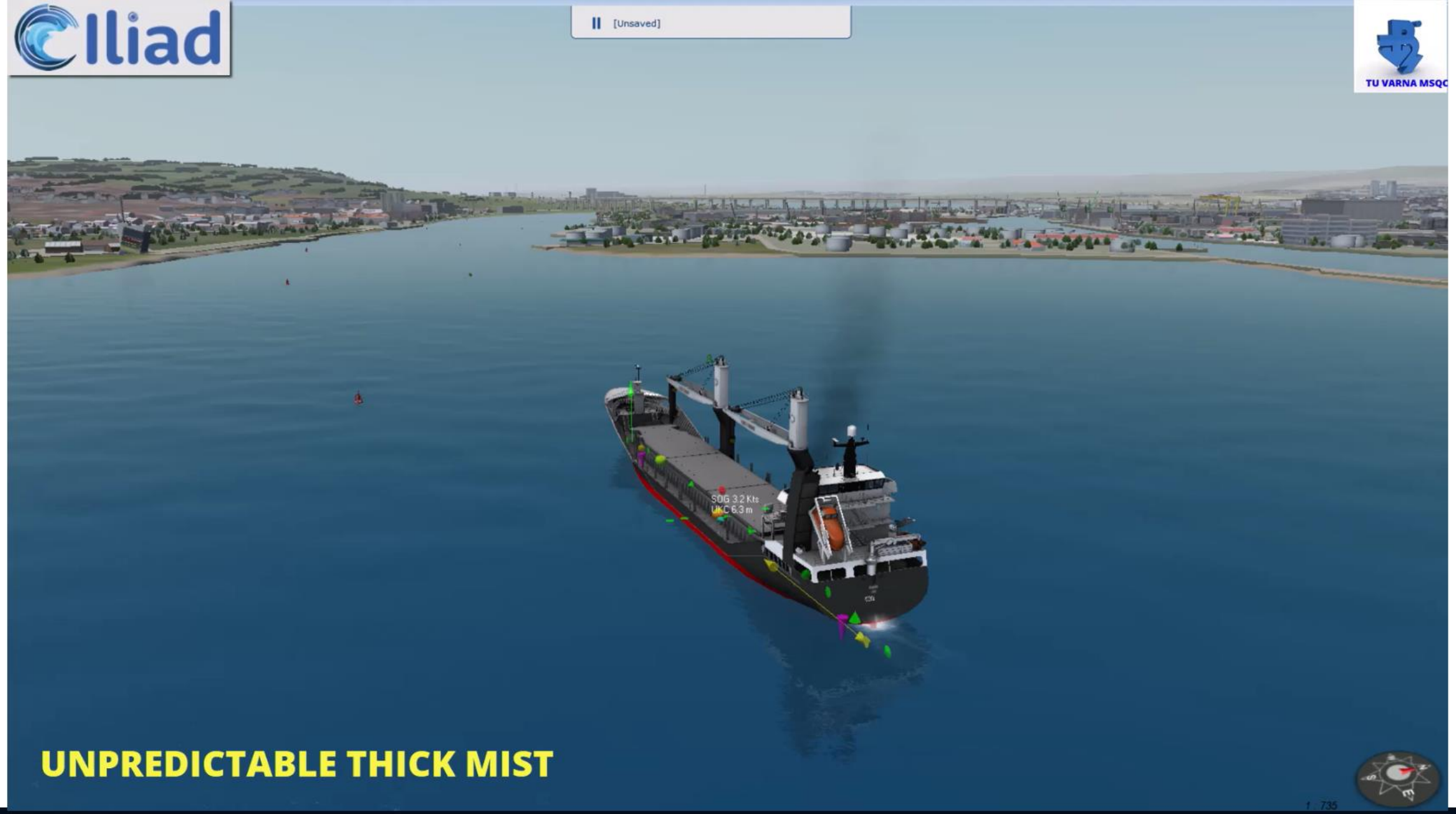
Digital twin core:

- Monitoring of temperature, salinity, currents and particles in the water
- Transport patterns in the area from forward and backward modelling (OpenDrift or better)
- In case of an event, increase transport modelling and deploy autonomous vehicles to follow pollution

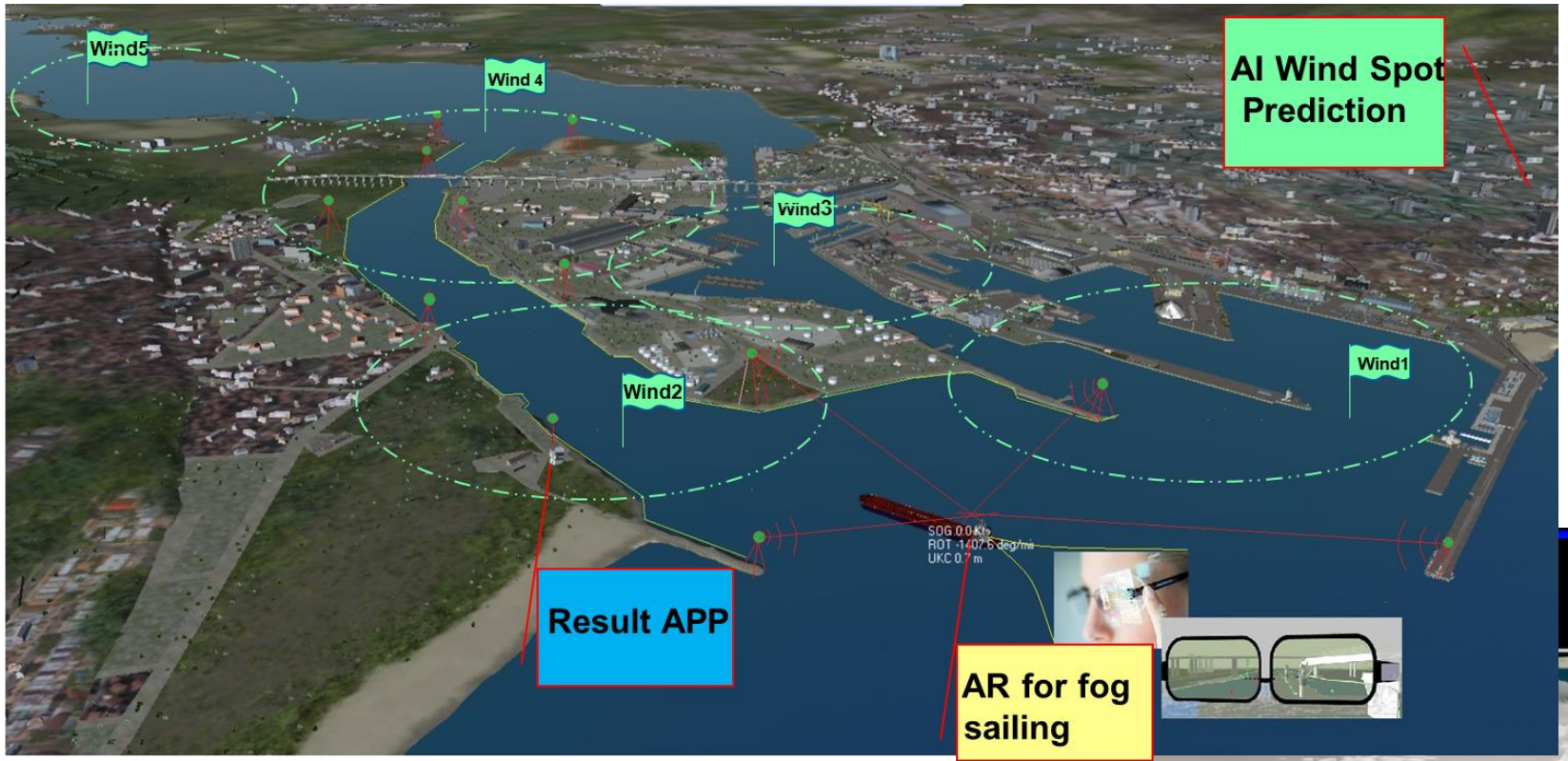
Visualisation / decision support:

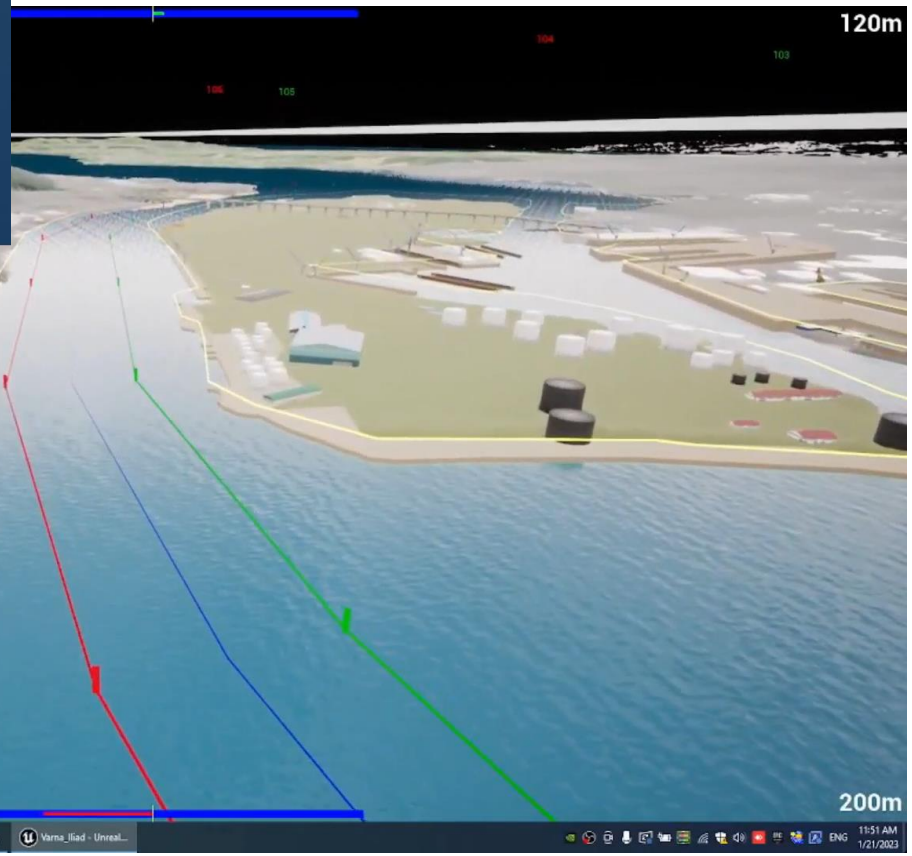
- Where might marine litter origin?
- Where will pollution be transported to (VR/AR)?
- What ships are in the area which might be the cause of pollution?
- What are the current environmental conditions?

Port safety


Iliad
[Unsaved]
TU VARNA MSQC
SOG 3.2 Kts
UKC 6.3 m
UNPREDICTABLE THICK MIST

Port safety Varna





TRL – 8 Phase

TU VARNA MSQC
BLACK AREA IS TRANSPARENT IN GLASSES
THICK MIST SAILING WITH
AUGMENTED REALITY
Iliad

Digital Twin of North Sea fisheries with catch prediction and fuel efficiency for improved sustainability

Catch profile (species&location)

Fish auction data

Predicted fuel consumption

Catch Prediction Model

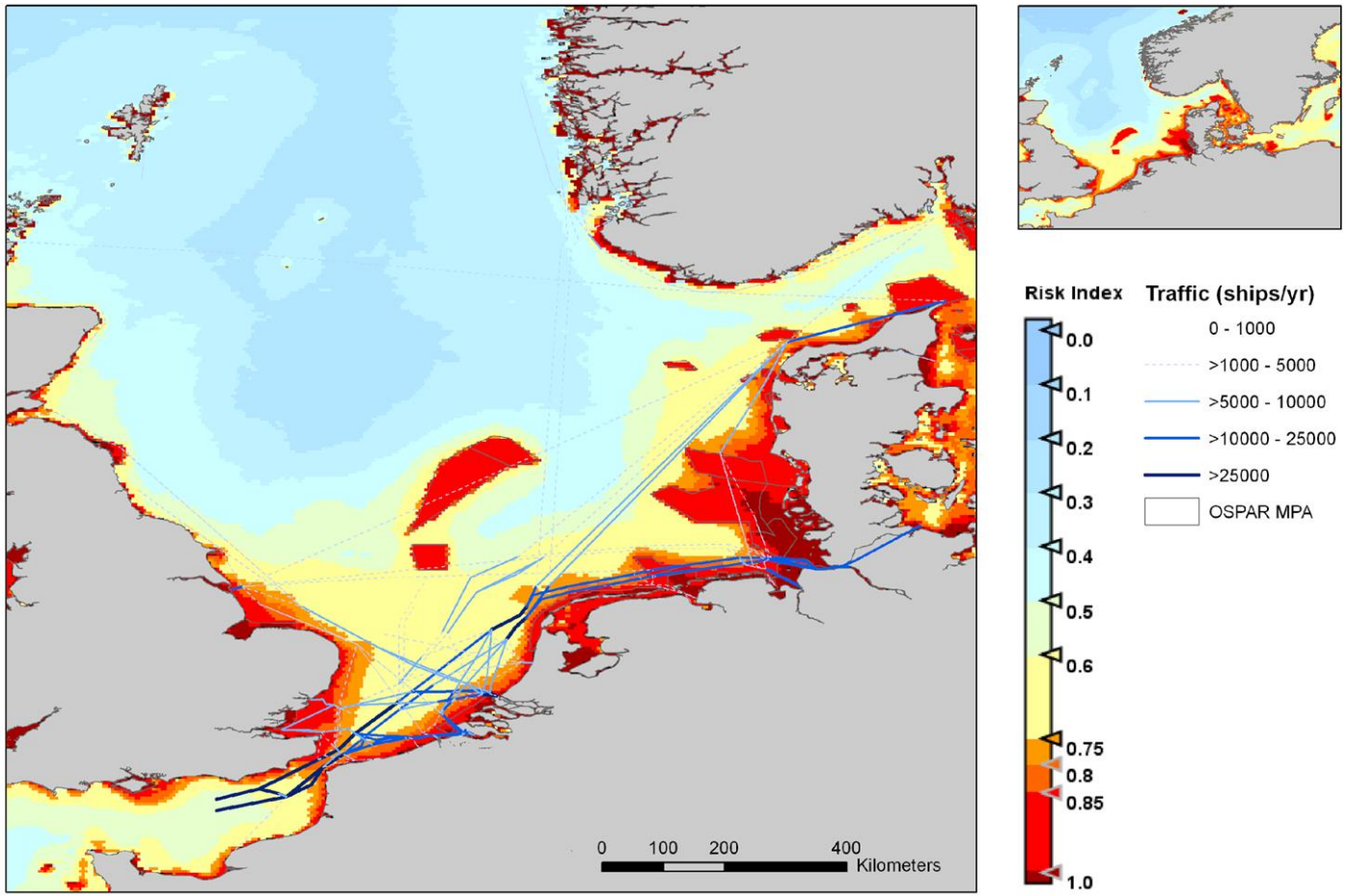
The short-term daily prediction of catches of sole or plaice is shown here. The initial version will show catch probabilities. Later versions will work towards predictions in kg (depending on model accuracy).

Fuel Efficiency Model

The user has to specify start and end points. The algorithm then suggests a segmented path that uses fuel efficiently. Each segment will suggest the optimum speed. *(Note: We will most likely use the ship-routing model from FORTH.)*

Ballast water risk assessment

Spreading of Harmful Aquatic Organisms and Pathogens



- Provide accurate short-term invasive species trajectories and species spread forecasting (and backtracking to link to potential sources assisted by EO and AIS information), combining high-resolution met-ocean forecasts, EO, in-situ, and citizens science data;
- Adjust risk assessment to observations by reinitializing the model with updated observational patterns so that the invasive species spread can be timely updated and improved;
- Provide the operational picture for the deployment of response measures, and;
- Help to simulate of different “what-if” scenarios, incl. uncertainty assessment, visualizing the HAOP pollution hazards, their economic consequences, and the simulation of the impact of different mitigation measures.

Aquaculture / Aquaculture insurance

Aquaculture sites transport connectivity potential

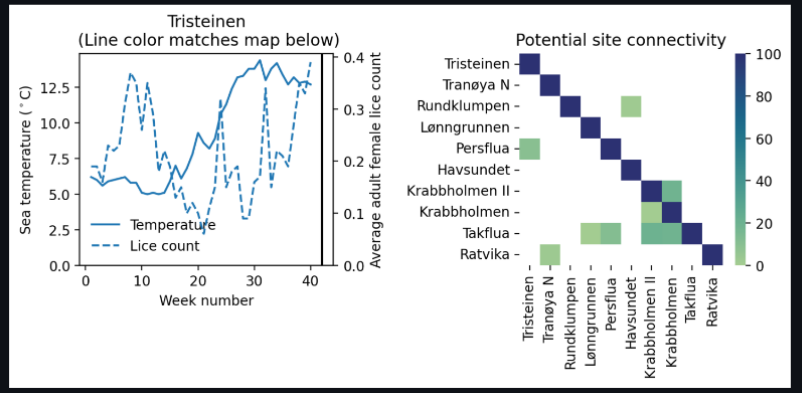
Transport potential between aquaculture sites, based on NorKyst800 ocean model forecast data (+24 hours). Reported sea temperatures and lice counts are retrieved via BarentsWatch.

Simulation start time: 2023-10-16T10:47:09.323409920.

Simulation end time: 2023-10-17T10:47:09.323409920.

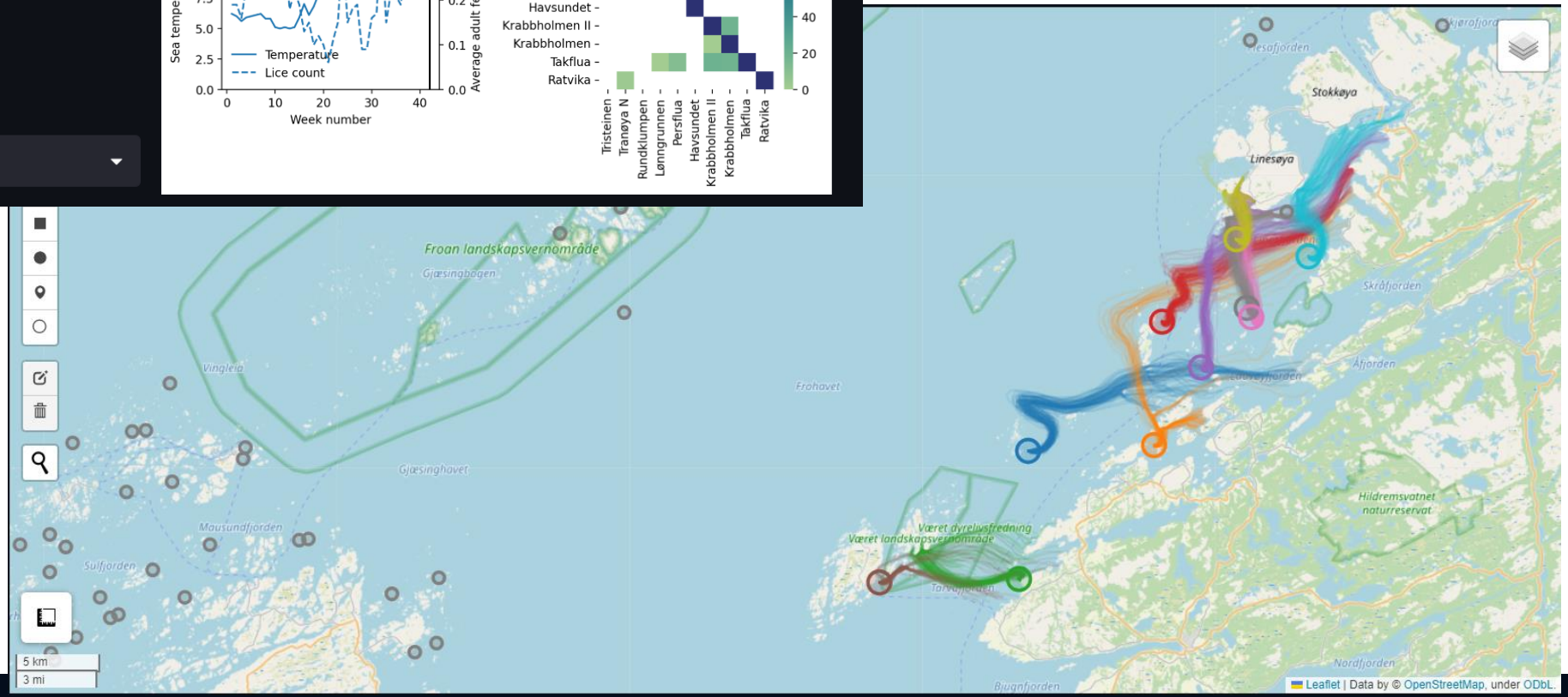
Select site to update map and data for 2023

Tristeinen



Risk assessment of sites for insurance purposes

Environmental monitoring for conditions that affect feed consumption and biomass development



DIGITAL TWINS
OF THE OCEAN
What if you had one, what would you do with it?