3rd IHO ASSEMBLY 2-5 MAY 2023 MONACO

Digital Twins of the Ocean Opportunities to future-proof sustainable development

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GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University, Germany

GEOMAR

IHO International Hydrographic Organization

DITTO Digital Twins of the Ocean

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Digital Twins of the Ocean

GEOMAR Helmholtz Centre for Ocean Research Kiel

DITTO Digital Twins of the Ocean

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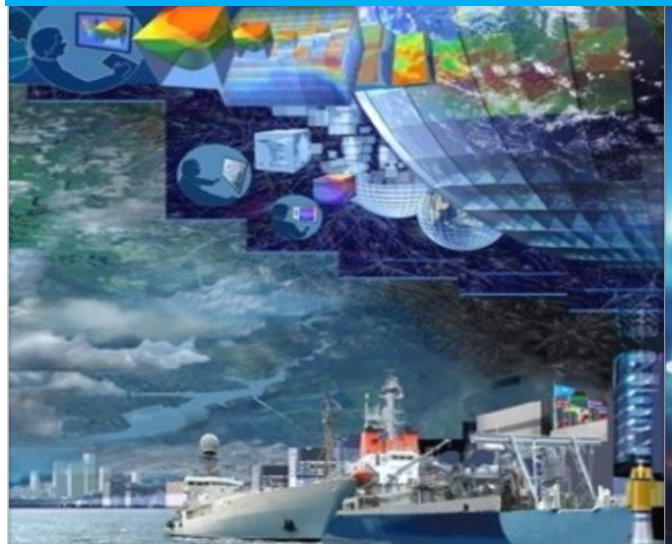
Observations | Data | Knowledge



Digital Twins of the Ocean are a virtual representation of the real ocean and have a two-way connection with it. Observations from the real ocean change and refine the twin; manipulating the twin can highlight regions of the real ocean in need of better or different observations.

Digital Twins will enable users to address **'What if' questions** based on shared data, models and knowledge.

UN Decade of Ocean Science for Sustainable Development (2021-2030)

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Vision

The science we need for the ocean we want

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Mission

Transformative ocean science solutions for sustainable development, connecting people and our ocean.

Moving from the ocean we have to the ocean we want

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DITTO Digital Twins of the Ocean

GOOS | CoastPredict with The Global Ocean Observing System

GOOS | Observing Together by The Global Ocean Observing System

Ocean best practices

Ocean Prediction UN DECADE COLLABORATIVE CENTRE

Marine Life 2030

GOOD Global Ocean Oxygen Decade

Digital Twins of the Ocean - DITTO

An **accessible ocean** with open and equitable access to data, information, and technology and innovation.

Develop a comprehensive digital representation of the ocean.

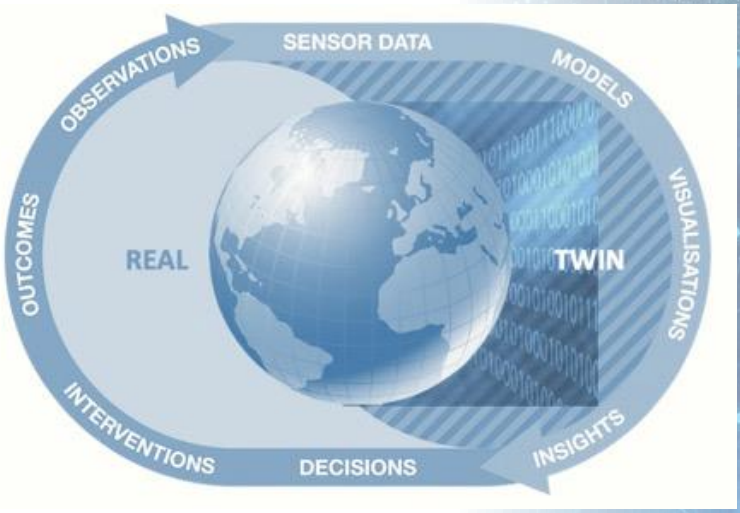
- **Digital Twins of the Ocean** are a virtual representation of the real ocean and have a two-way connection with it. Observations from the real ocean change and refine the twin; manipulating the twin can highlight regions of the real ocean in need of better or different observations.
- **Digital Twins** will enable users to address **'What if' questions** based on shared data, models and knowledge.
- **Digital Twins** empower ocean professionals, citizen scientists, policymakers, and the general public alike to visualise and explore ocean knowledge, data, models and forecasts.

Digital Twins of the Ocean - DITTO

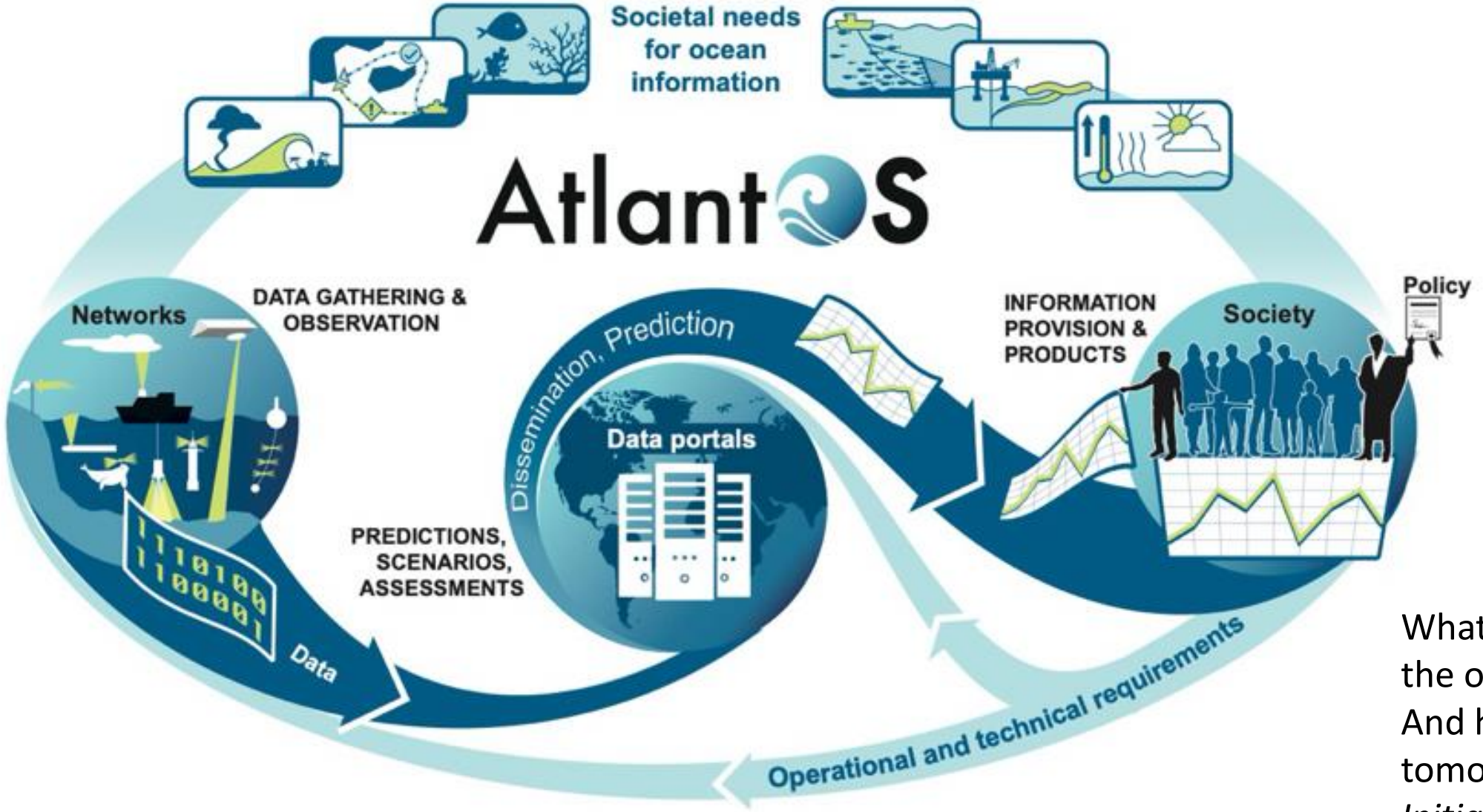
Value chain and frames of intervention

Ocean Information **supporting Services**

Ocean Information **assessing Interventions**



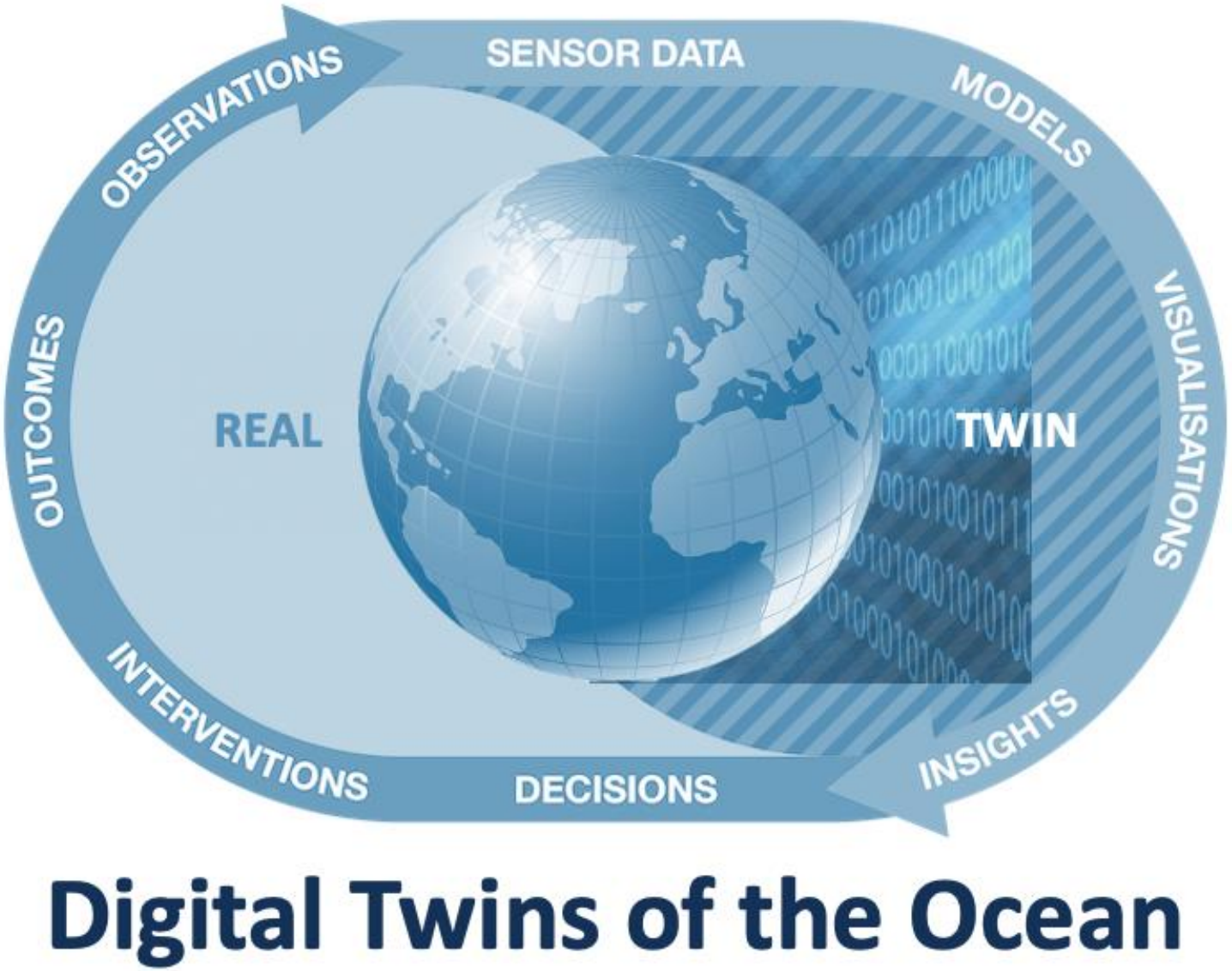
Ocean Observation and Information Value Chain



Ocean Information **supporting Services**

What is the state of the ocean today?
And how will it change tomorrow?
Initial Value Probelm

Ocean Simulation Digital Twin Framework

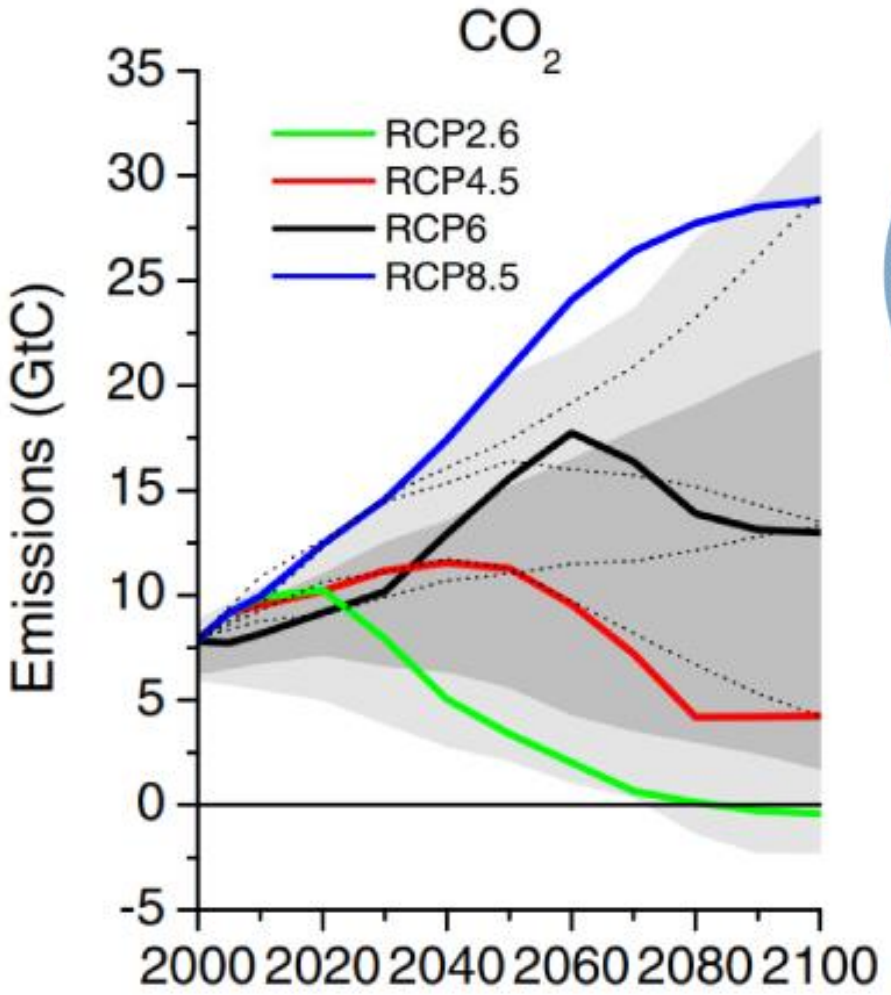


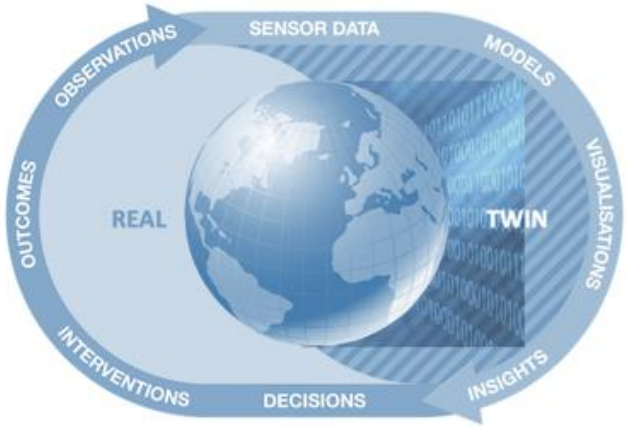
Ocean Information **assessing Interventions**

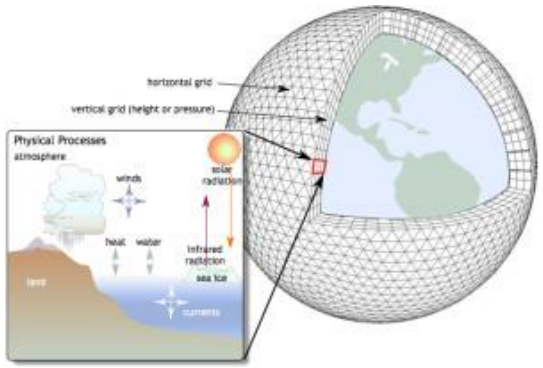
What – If Scenarios
How will the ocean change if humans act?
Boundary Value Probelm

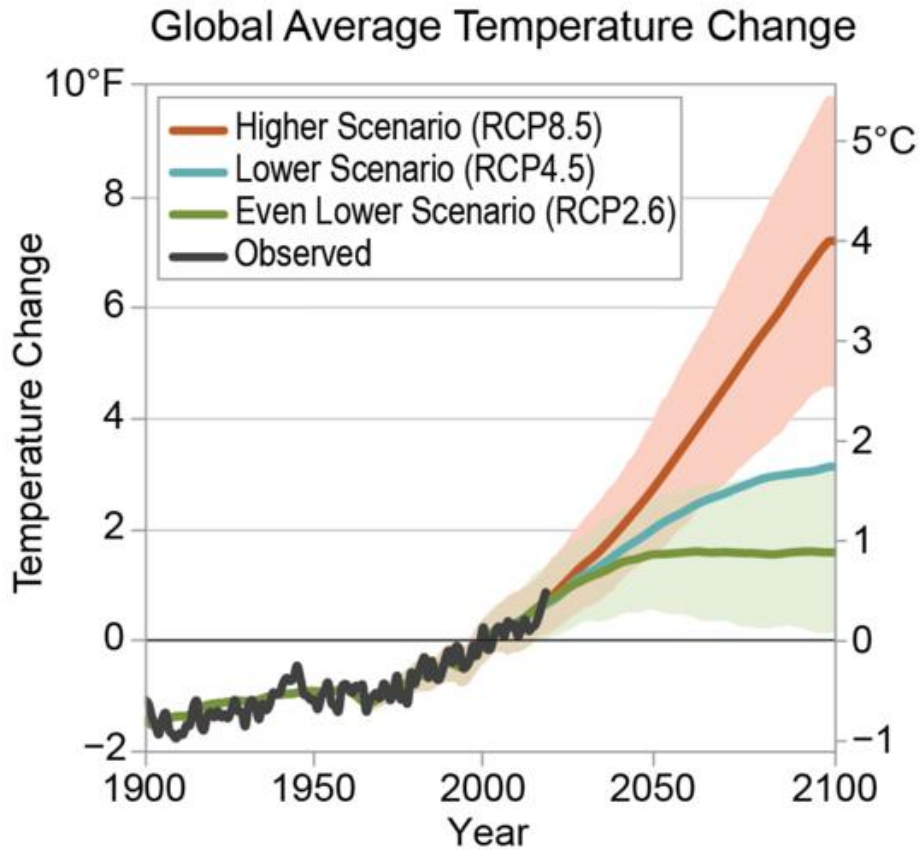
Digital Twin ‚Prototype‘

What would the global temperature look like if we put CO2 in the atmosphere?









Digital Twin “Prototype”

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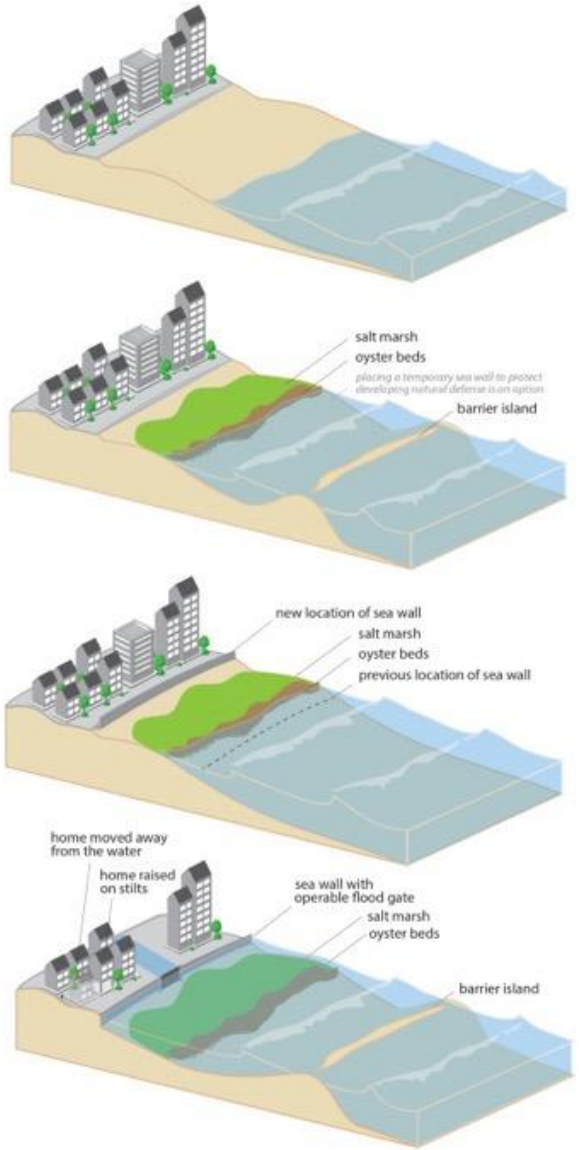
Minimal Defense
Many communities have developed right along the ocean with only minimal natural defenses from a small strip of beach between them and the ocean.

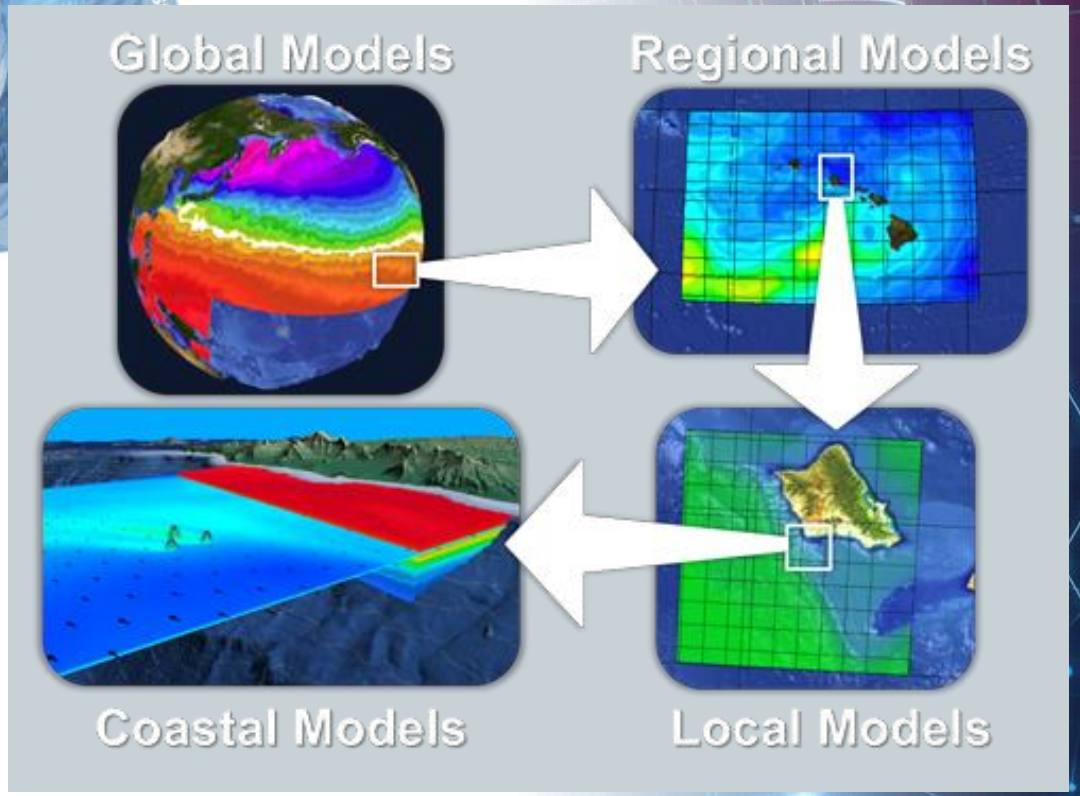
Natural
Natural habitats that can provide storm protection include salt marsh, oyster and coral reefs, mangroves, seagrasses, dunes, and barrier islands. A combination of natural habitats can be used to provide more protection, as seen in this figure. Communities could restore or create a barrier island, followed by oyster reefs and salt marsh. Temporary infrastructure (such as a removable sea wall) can protect natural infrastructure as it gets established.

Managed Realignment
Natural infrastructure can be used to protect built infrastructure in order to help the built infrastructure have a longer lifetime and to provide more storm protection benefits. In managed realignment, communities are moving sea walls farther away from the ocean edge, closer to the community and allowing natural infrastructure to recruit between the ocean edge and the sea wall.

Hybrid
In the hybrid approach, specific built infrastructure, such as removable sea walls or openable flood gates (as shown here) are installed simultaneously with restored or created natural infrastructure, such as salt marsh and oyster reefs. Other options include moving houses away from the water and raising them on stilts. The natural infrastructure provides key storm protection benefits for small to medium storms and then when a large storm is expected, the built infrastructure is used for additional protection.



What is the most cost effective option to mitigate the coastal impact of sea level rise?



Digital Twin ‚Challenge‘

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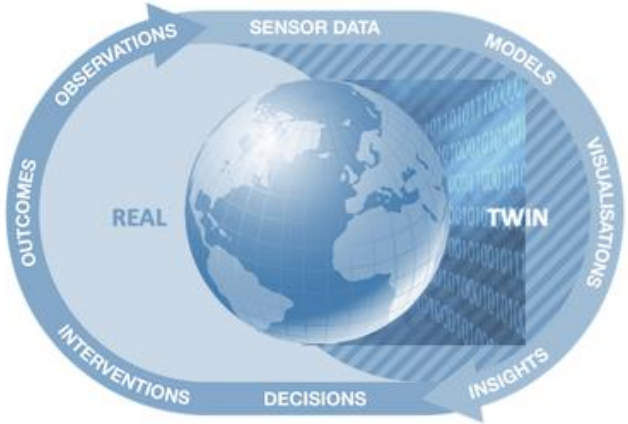
How can we best implement wind energy capture systems at sea?



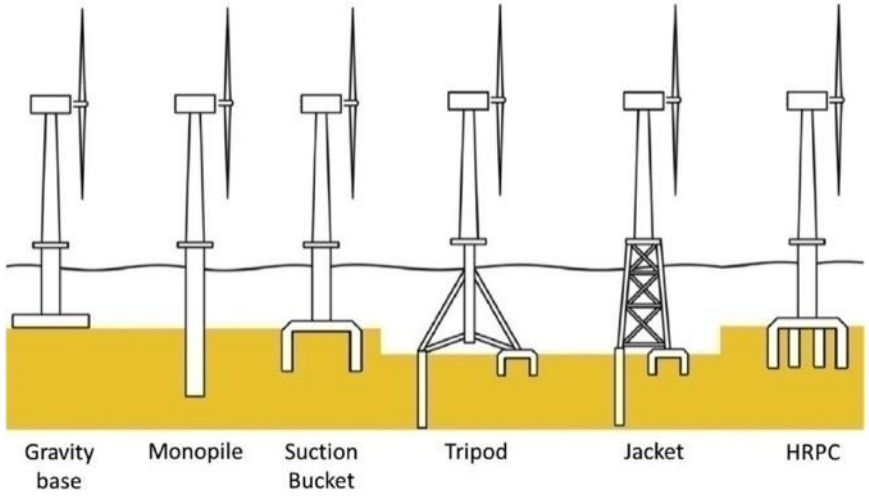
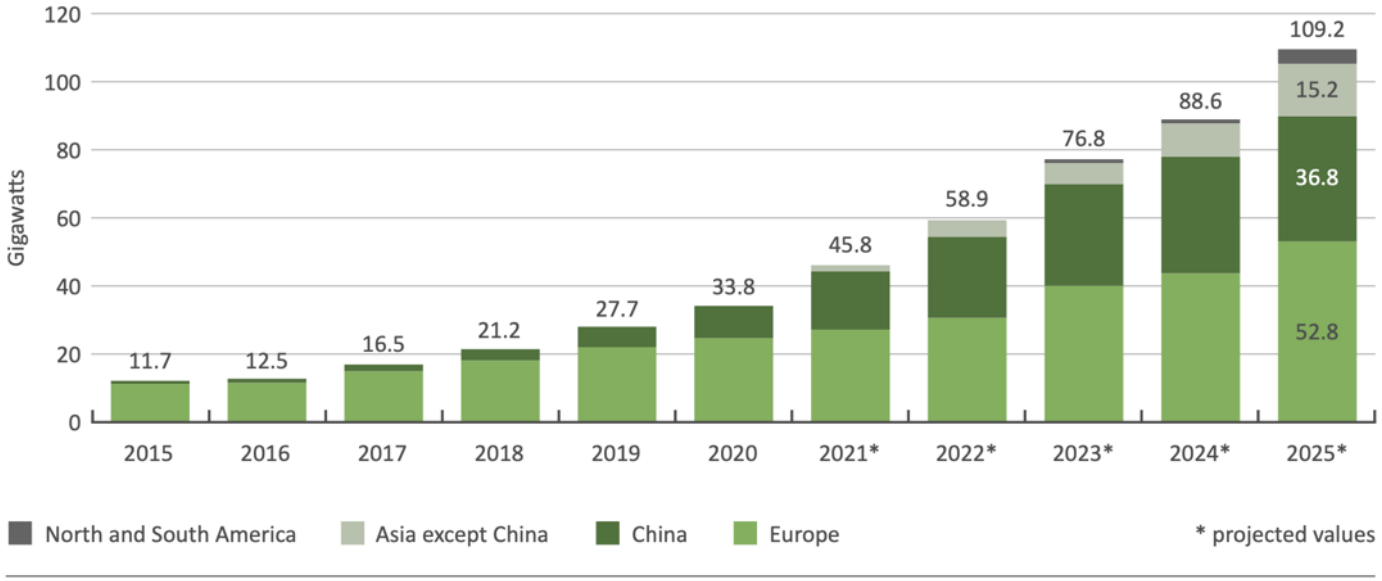
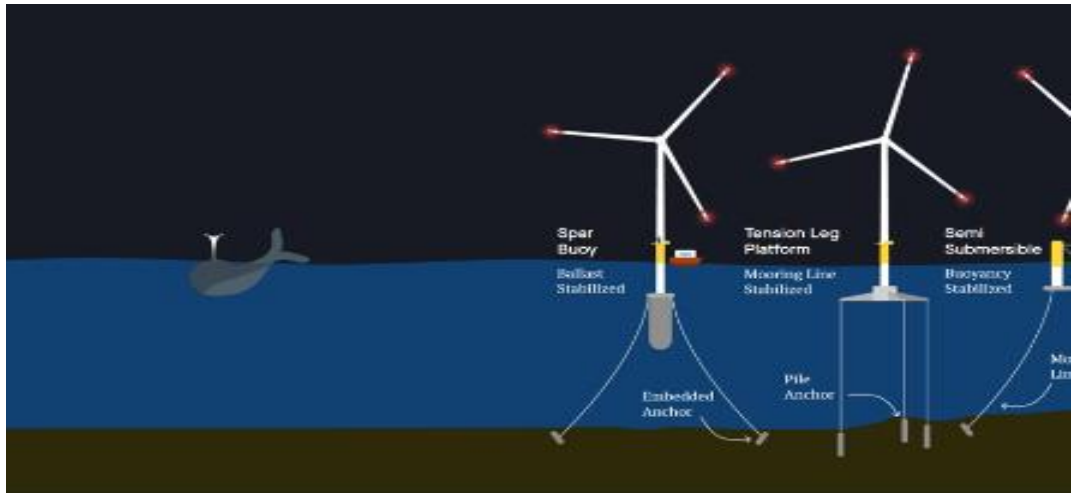


Figure 5: Installed Offshore Wind Power (OSW) Capacity





Digital Ocean - Ocean Observing Needs

An observing system is the fundamental underpinning to any digital twin

- **Detailed Hydrography is critical**
- **A co-design approach to developing the observing networks needed for Digital Twins**
- **DTOs will create a ‘virtuous circle’, where information from the Digital Twin can be used to provide key inform**
- **DTOs will optimise the observing network, whilst benefiting from it.**

Digital Ocean - Ocean Prediction

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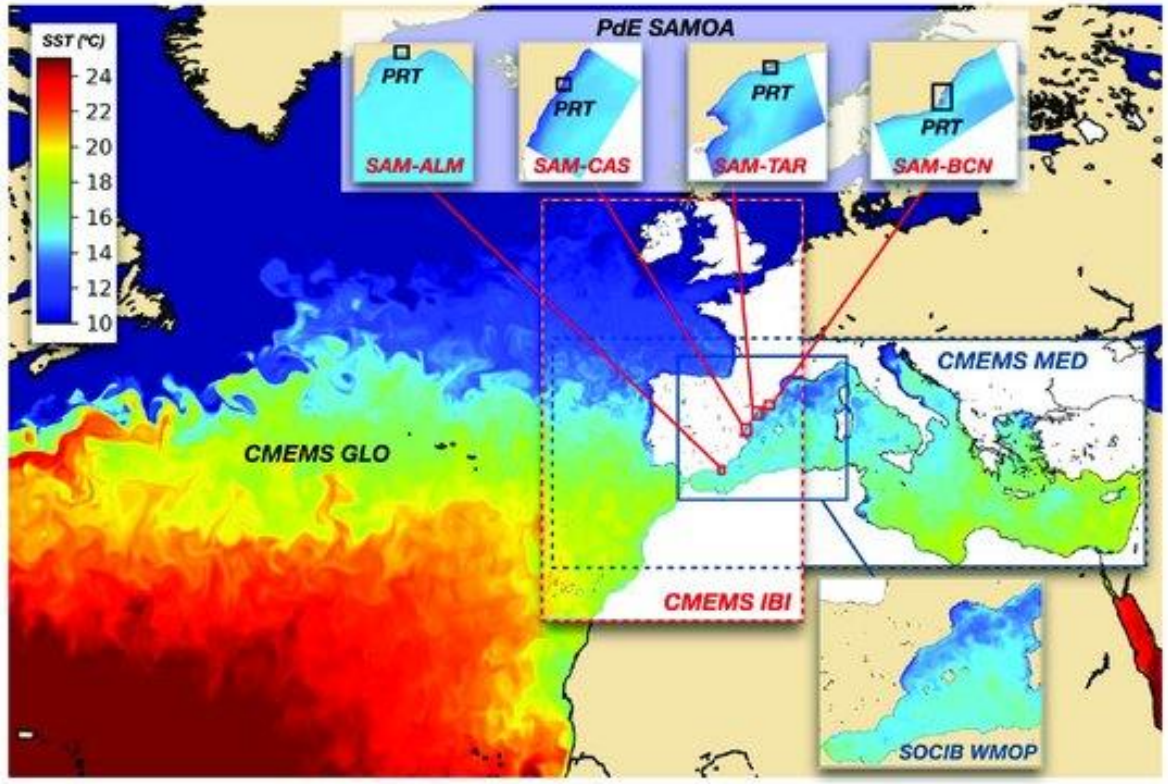
OceanPredict
Advancing the science of ocean prediction

GOOS | CoastPredict
with The Global Ocean Observing System

Copernicus
Marine Service

The Decade Collaborative Centre for Ocean Prediction



- Ocean predictive multi scale modelling frameworks.
- Artificial intelligence / machine learning to create, manipulate and analyse marine information.
- The ability to simulate change to the system by human intervention and to explore their consequences.

Digital Ocean - Data Perspective – Digital Ecosystem Needs

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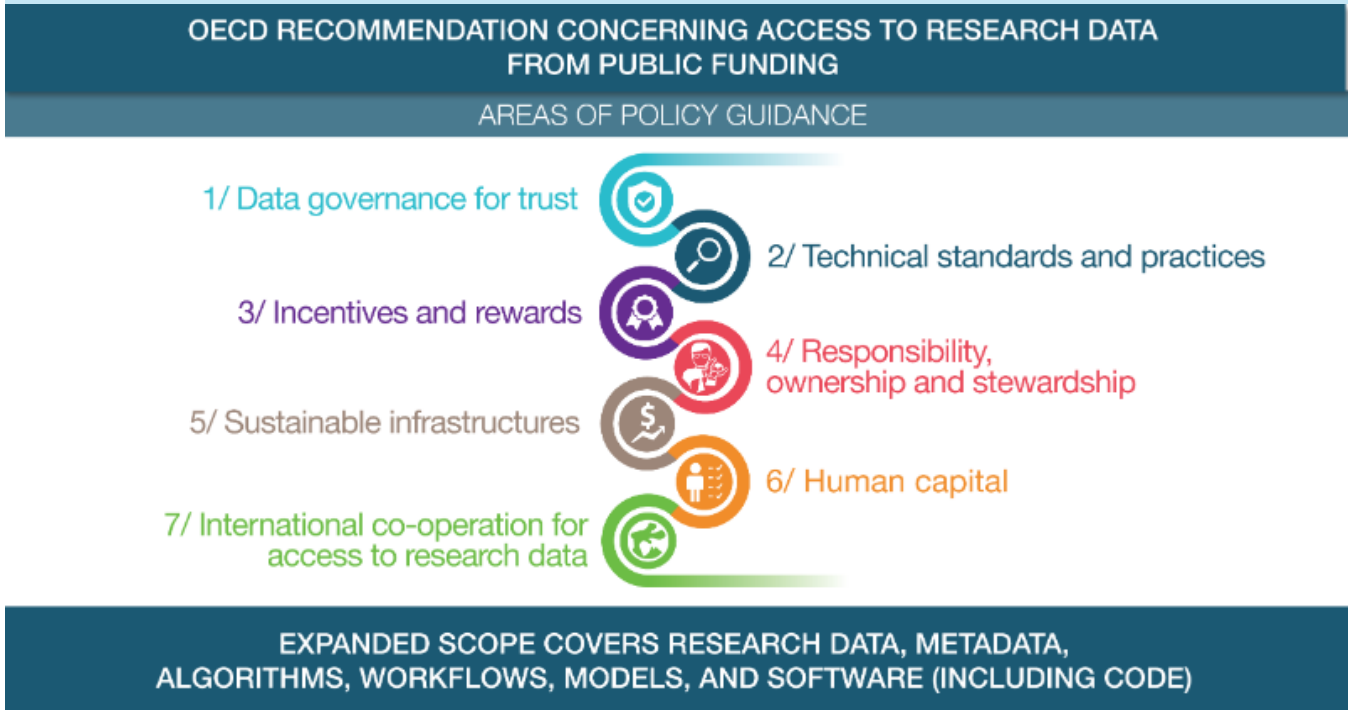
IODE ODIS Copernicus Marine Service EMODnet European Marine Observation and Data Network

The Mission: Creating a robust and extensible foundation of our planet's digital ocean ecosystem



- **We need to 'democratize' the data world.**
- **We need to establish 'trust' in open data.**
- **Who need to ensure wide and equitable access.**

Delivering Digital Twin Information

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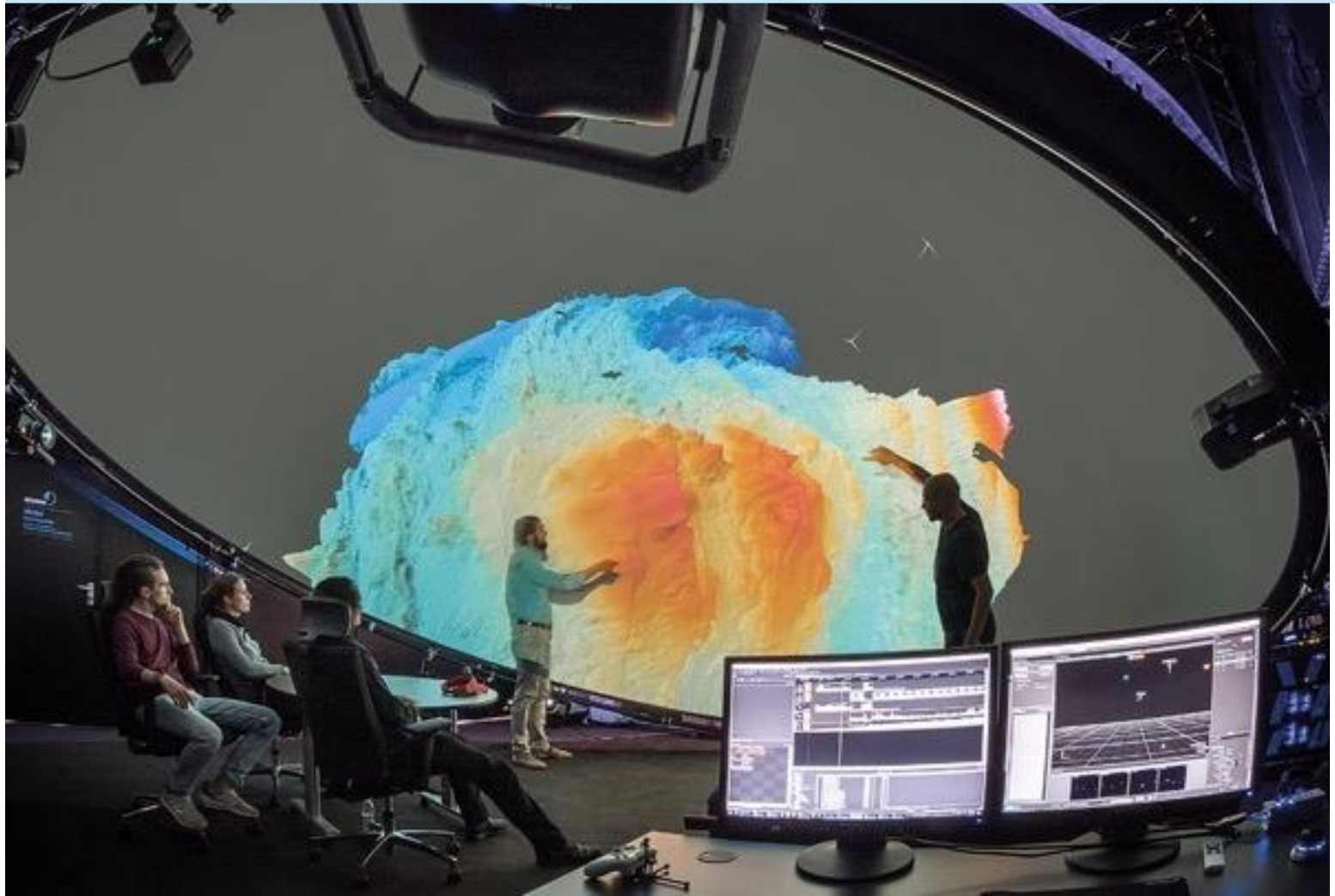
Decision making theaters – Browser based systems – Jupiter Notebooks – 3D immersive environments



Digital Twins of the Ocean – DITTO Working groups

DITTO establishes and advances a digital framework to explore ocean related development scenarios and develop a comprehensive digital representation of the ocean.

WG1. Supportive ocean observations and data systems
WG2. Data analytics and prediction engines
WG3. Data lakes and interoperability
WG4. Interactive layers and visualizations
WG5. Framework - architecture, design and implementation (TURTLE)
WG6. Education, training and capacity development
WG7. Outreach and communication

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Digital Twins of the Ocean

ditto-oceandecade.org

UK Government | National Oceanography Centre | G7 | G7 | United Nations Decade of Ocean Science 2021-2030 | DITTO | GEOMAR | MERCATOR OCEAN INTERNATIONAL | DITTO Digital Twins of the Ocean

International Digital Twins of the Ocean Summit

DIGITAL TWINS OF THE OCEAN

4 to 5 May 2022

High-level in-person event in Central London, UK, with live strea

www.g7fsoi.org/digital-twin-ocean-summit

Many Virtual Satellite Events

Programme: ditto.geomar.de

10 May 2022

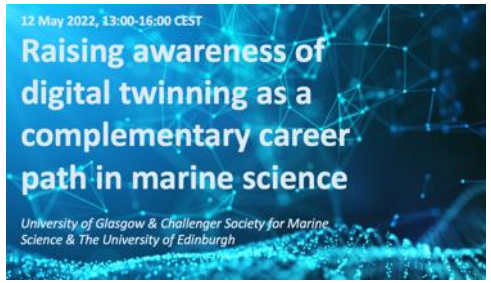
A Digital Twin for Grenada

Linda Peters, ESRI, USA

12 May 2022

Digital Twin Interoperability - Architectures of Digital Ocean Twins (by TURTLE)

Ute Brönner, Fraunhofer IGD Rostock, Germany & Arne Jørgen Berre,SINTF, Norway



12 May 2022

Raising awareness of digital twinning as a complementary career path in marine science

Anna McGregor (University of Glasgow & Challenger Society for Marine Science) Ben Fisher (The University of Edinburgh), UK

13 May 2022

International symposium on digital twin of estuarine and coastal system

East China Normal University & State Key Laboratory of Estuarine and Coastal Research, East China Normal University,

13 May 2022

Co-designing applied ocean models to support communities in NE Pacific

Kathryn Sheps, Decade Collaborative Center for the NE Pacific & Kim Juniper, Oceans Network Canada

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DIGITAL TWINS OF THE OCEAN

International Digital Twins of the Ocean Summit 2023

November 9 - 12, 2023 • Xiamen, China

Call for Abstracts	Deadline for Abstract Submission	Announcement of Abstract Acceptances	Early-bird Registration
May 25, 2023	July 20, 2023	August 15, 2023	August 15, 2023

MEL
State Key Laboratory of Marine Environmental Science

https://ditto-summit2023.scimeeting.cn

GEOMAR

Become a Partner of the Digital Twins of the Ocean (DITTO) Programme

Partner Application

The objective of the partnership is to support each other through a network of DITTO partners.

- Once you have submitted the application the DITTO team will review the information and
- send you a **memorandum of understanding (MOU)** to be mutually agreed on.

Interested to join the DITTO community?

ditto-oceandecade.org/join-the-ditto-community

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