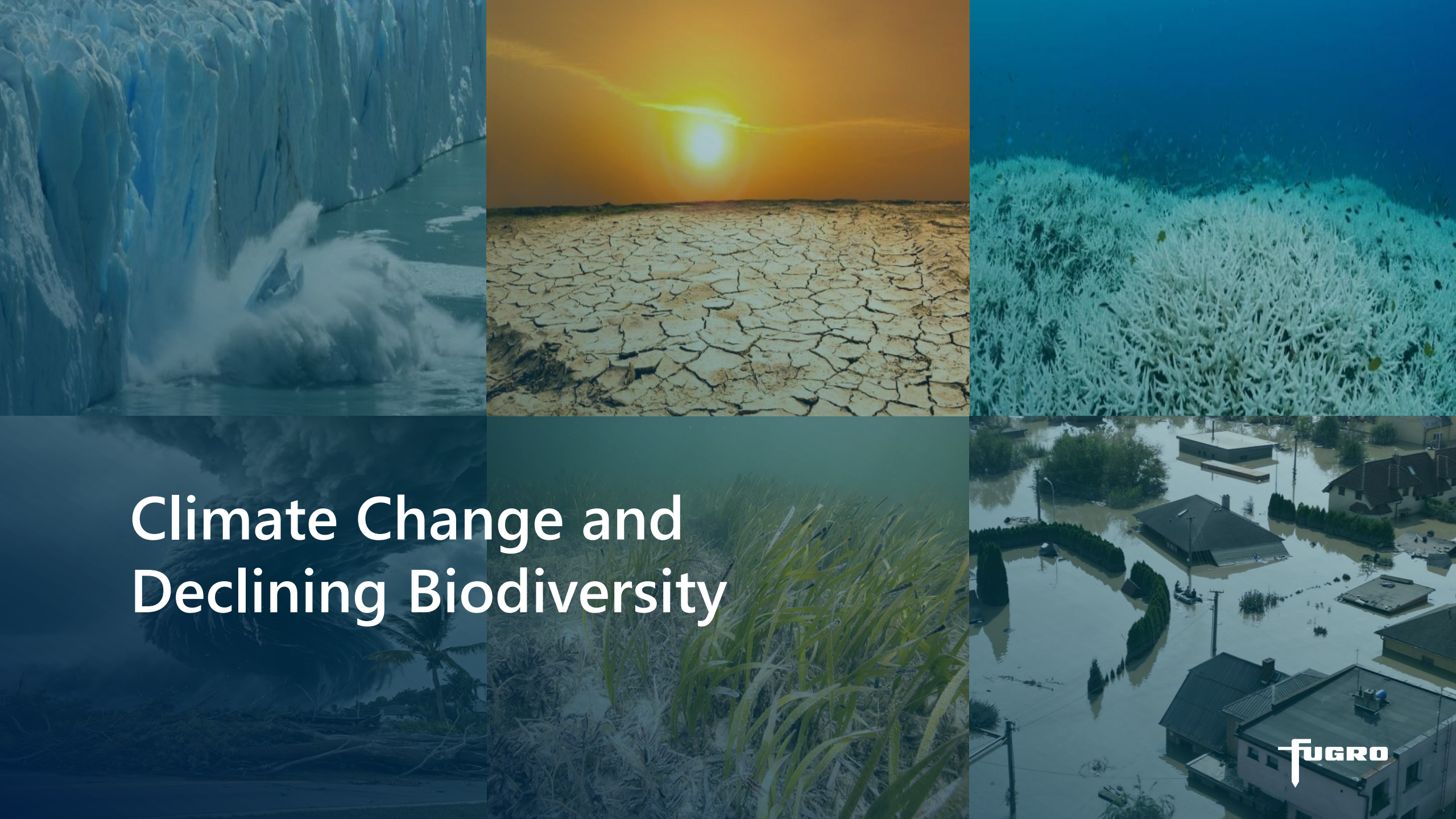
Integration of multi-scale Technologies for Coastal Ecosystem Mapping & Monitoring (Project MER)

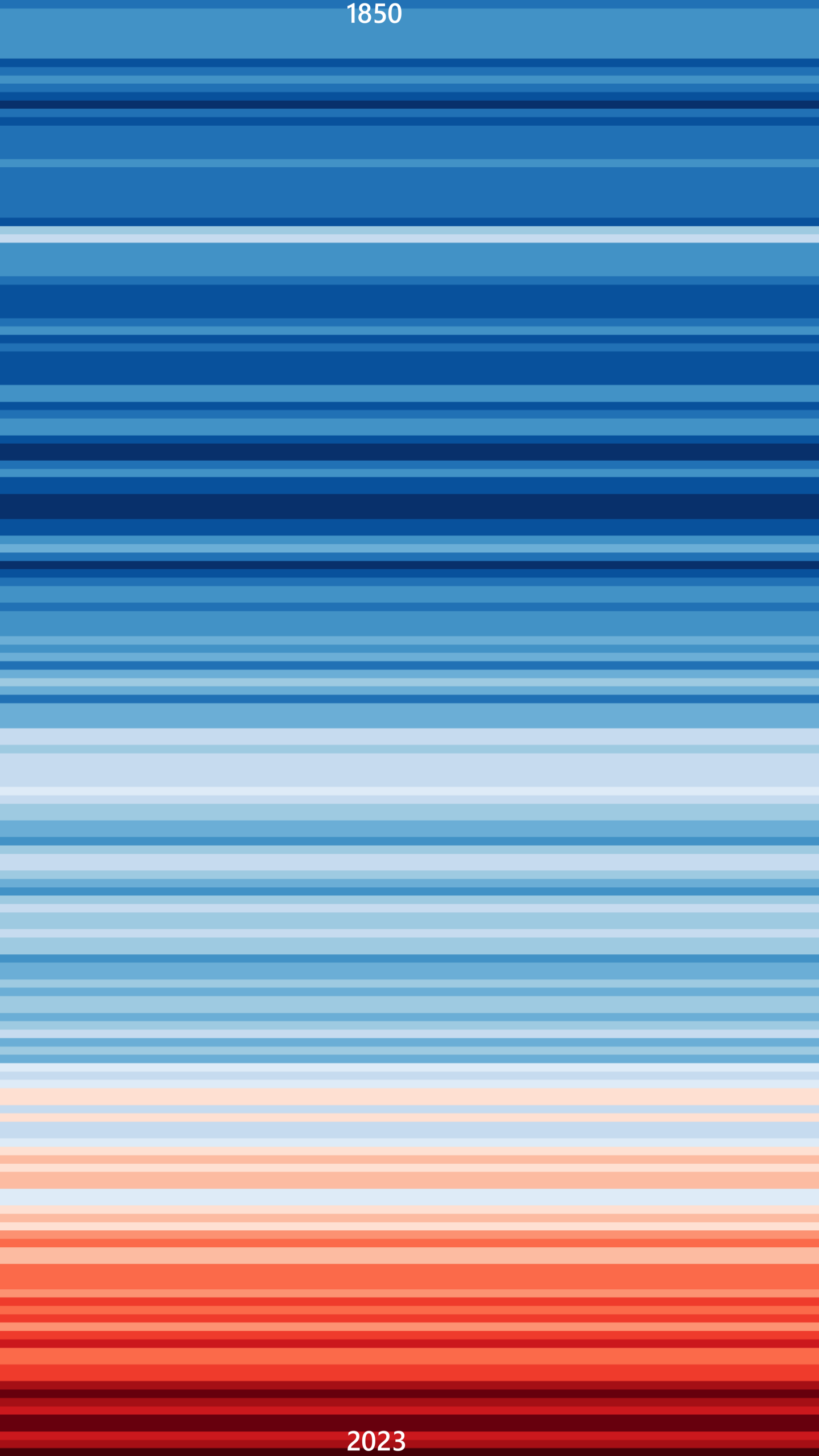
2nd European Seagrass Restoration Workshop

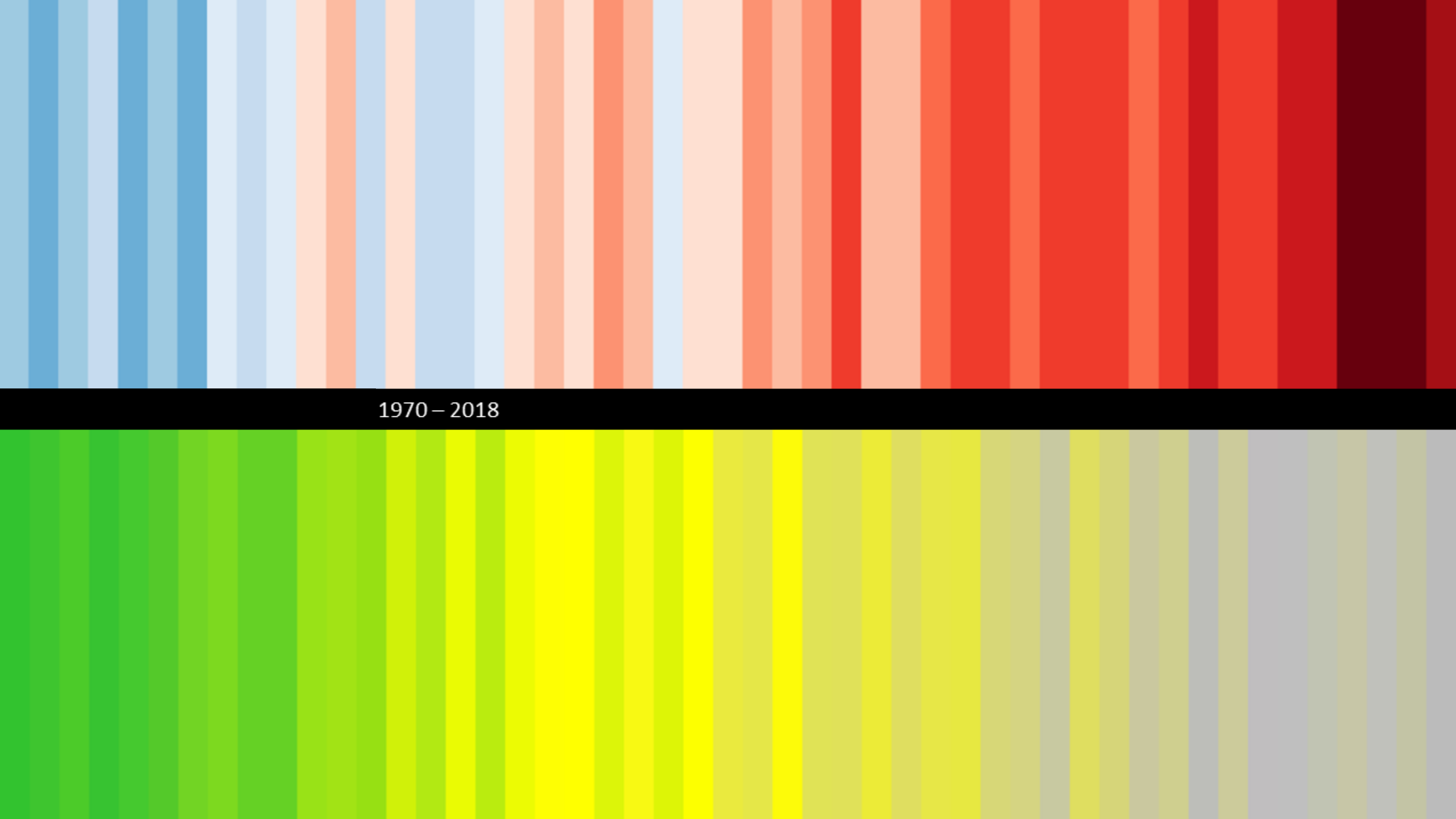
Benoit CAJELOT (8th April 2025)

Funded by the European Union
NextGenerationEU

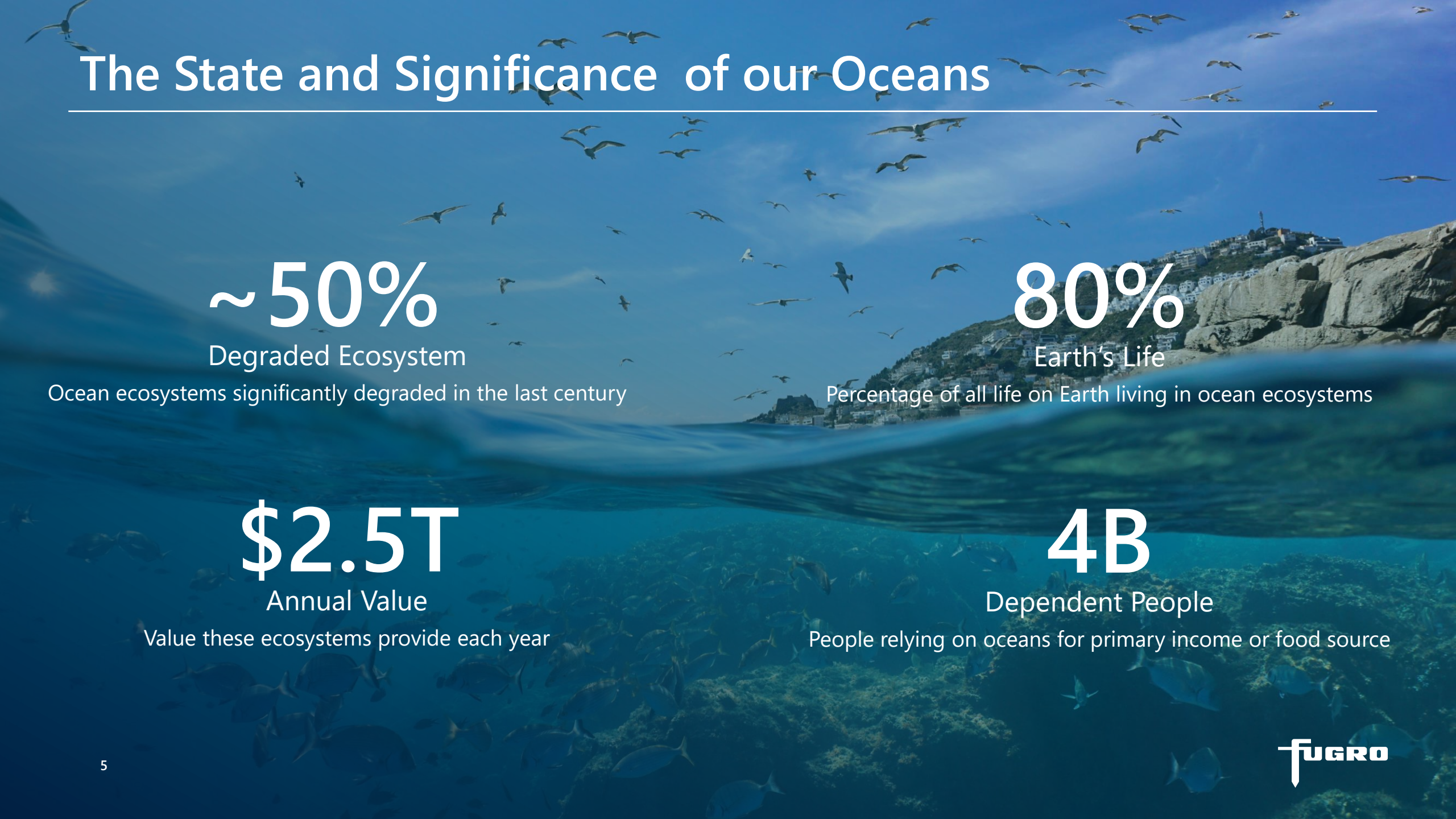


Climate Change and Declining Biodiversity


1850
2023


1970 – 2018

The State and Significance of our Oceans



~50%

Degraded Ecosystem

Ocean ecosystems significantly degraded in the last century

80%

Earth's Life

Percentage of all life on Earth living in ocean ecosystems

$2.5T

Annual Value

Value these ecosystems provide each year

4B

Dependent People

People relying on oceans for primary income or food source

The State and Significance of our Oceans

More than 75% of the world's ocean is unmapped, unobserved and unexplored.

Zooming on seagrass: A Vital Ecosystem

1 Estimated decline

~7% per year on top of historic loses that are described as catastrophic

2 Climate Change Mitigation

35x better at carbon removal than rainforests. Accounts for 10-18% of ocean carbon storage.

3 Biodiversity Powerhouse

Provides food and habitat for marine life. 20% of world's fish stocks rely on seagrass.

4 Coastal Protection

Protects coastlines from erosion by stabilizing the seabed, buffering waves and storms.

Zooming on seagrass: A Vital Ecosystem

More than 80% of the world's seagrass field is unmapped.

Better data enable better decisions.

Mapping the baseline, **modelling** risks, **monitoring** changes – informing your decisions.

The Value of Geodata

1 Mapping and Monitoring

Monitoring **changes over time**, identifying areas of **decline**, and assessing the **effectiveness** of restoration efforts

2 Understanding Env. Conditions

Understand the **environmental conditions** that **support healthy** seagrass meadows

3 Detecting Threats

Monitor threats to seagrass, such as pollution, coastal development, and climate change impacts

4 Guiding Restoration Efforts

The **best locations** for restoration, geodata ensures that efforts are **targeted and effective**

5 Supporting Policy and Management

Geodata provides **the evidence needed** to **support policy** decisions and **management strategies** aimed at seagrass conservation

The Marine Ecosystem Restoration (MER) Project

MARINE ECOSYSTEM RESTORATION

Implementation

ISPRA (Italian Institute for Environmental Protection and Research)

Funding

PNRR (National Recovery and Resilience Plan) of Italy, part of EU's recovery plan

Objective

Restore and protect marine ecosystems, focusing on biodiversity conservation and sustainable resource use

FUGRO

European Nature Restoration Law Targets

1

2030 Goal

Restore at least 30% of the EU's land and sea areas

2

2050 Goal

Restore all ecosystems in need of restoration

3

Marine Focus

Restore seagrass beds, sediment bottoms, and habitats of iconic marine species

The Marine Ecosystem Restoration (MER) Project

Italian Coastline length

~7,600km

The MER project target is to complete the mapping of the entire coastline of Italy by July 2026

Concept of operation

1 **Satellite EO**

Provides SDB and Seafloor classification to visible depth

2 **Airborne LiDAR Bathymetry**

Provides Bathymetry and Habitat Map up to 3x visible depth extending Sat. Coverage

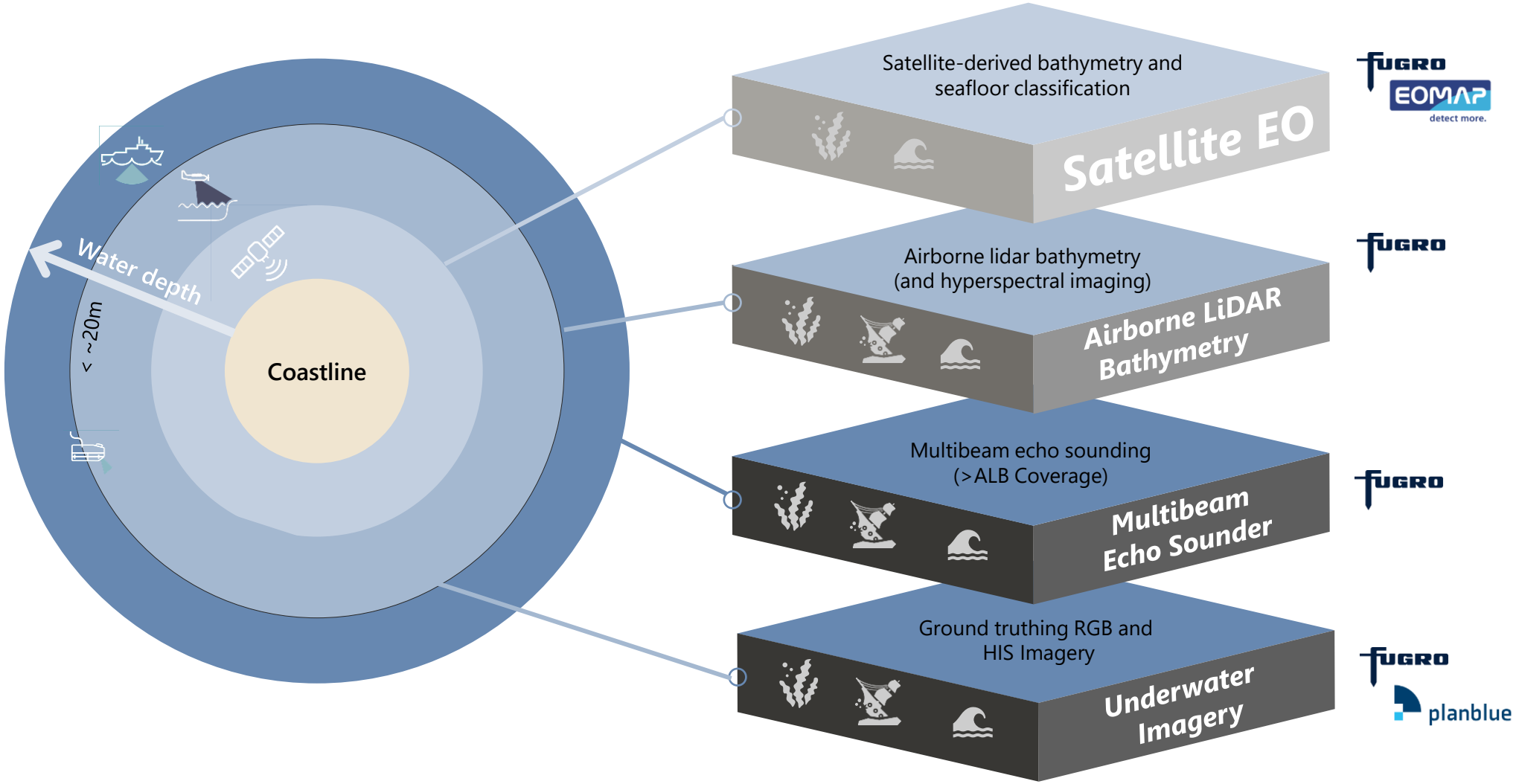
3 **Surface Vessel (MBES)**

Provides Bathymetry and Habitat Map foot of seagrass field extending ALB coverage

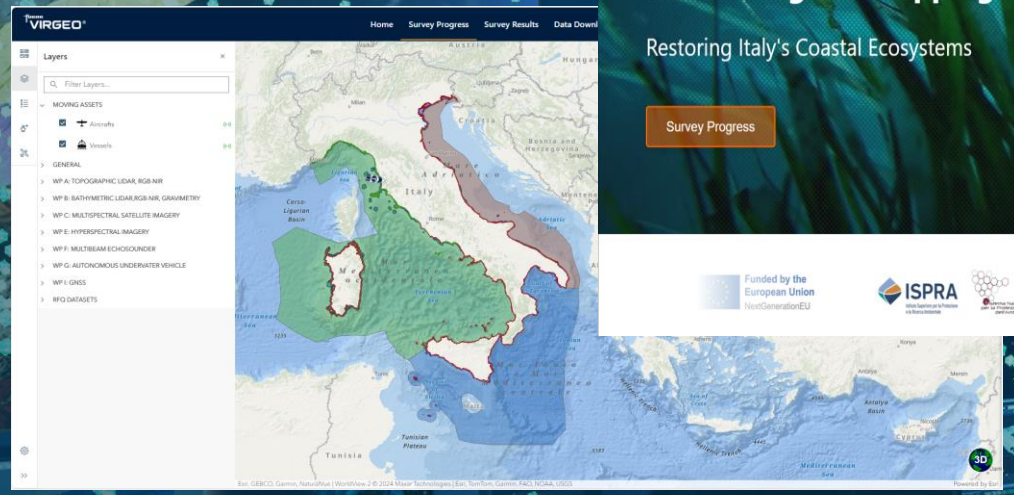
4 **Ground truthing (AUV)**

Provide Very high-res. RGB and HSI Imagery

Concept of operation



Fugro VirGeo®



A cloud-hosted, web-based Geo-data engagement platform

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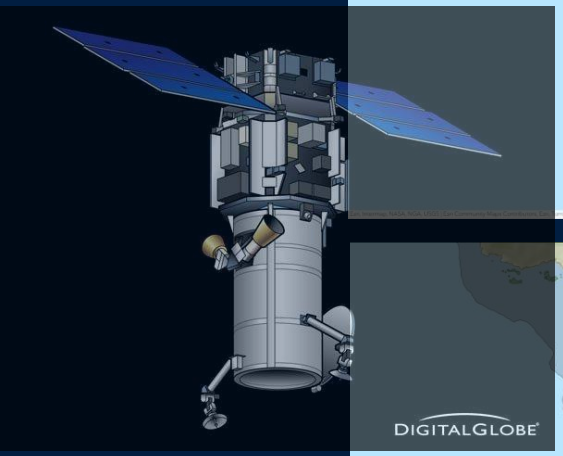
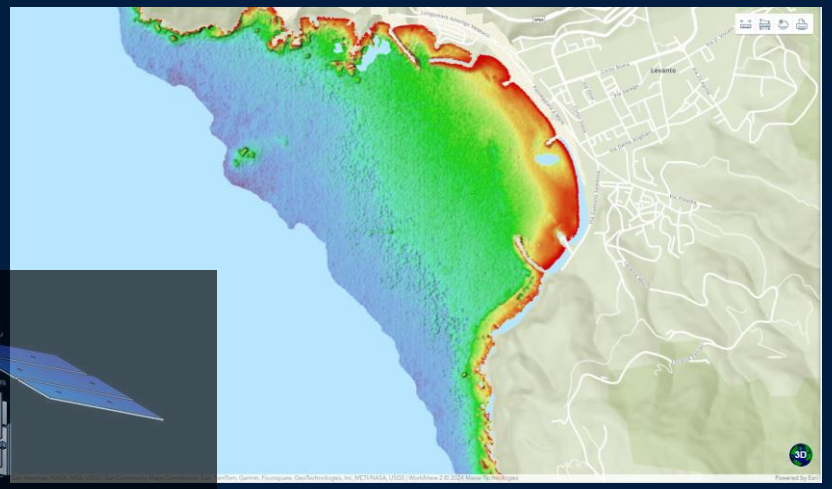
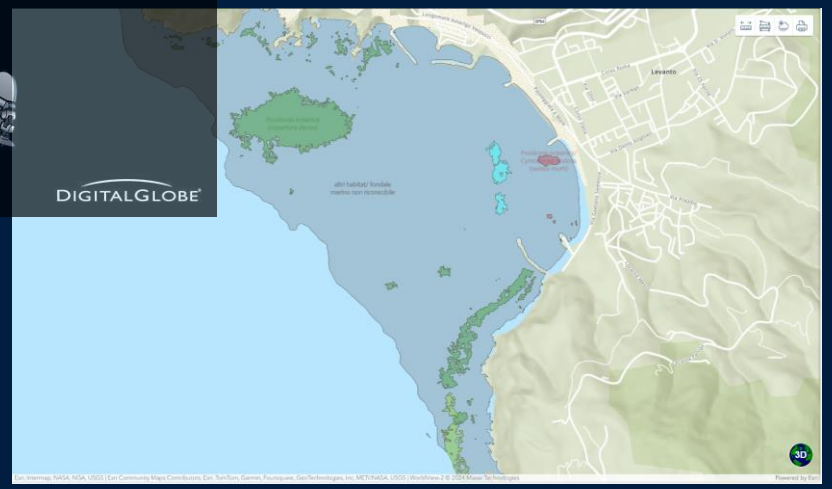
Satellite EO (Multispectral Imagery)







Main data Provider

- MAXAR Technologies

Sensor

- WorldView-2
- WorldView-3

Products

- Seafloor reflectance
- Bathymetry and
- Preliminary Seafloor Classification

SatAnalytics unlocks Geo-data safely and rapidly in coastal zone without stepping foot on site

Solution Satellitaire - Concept

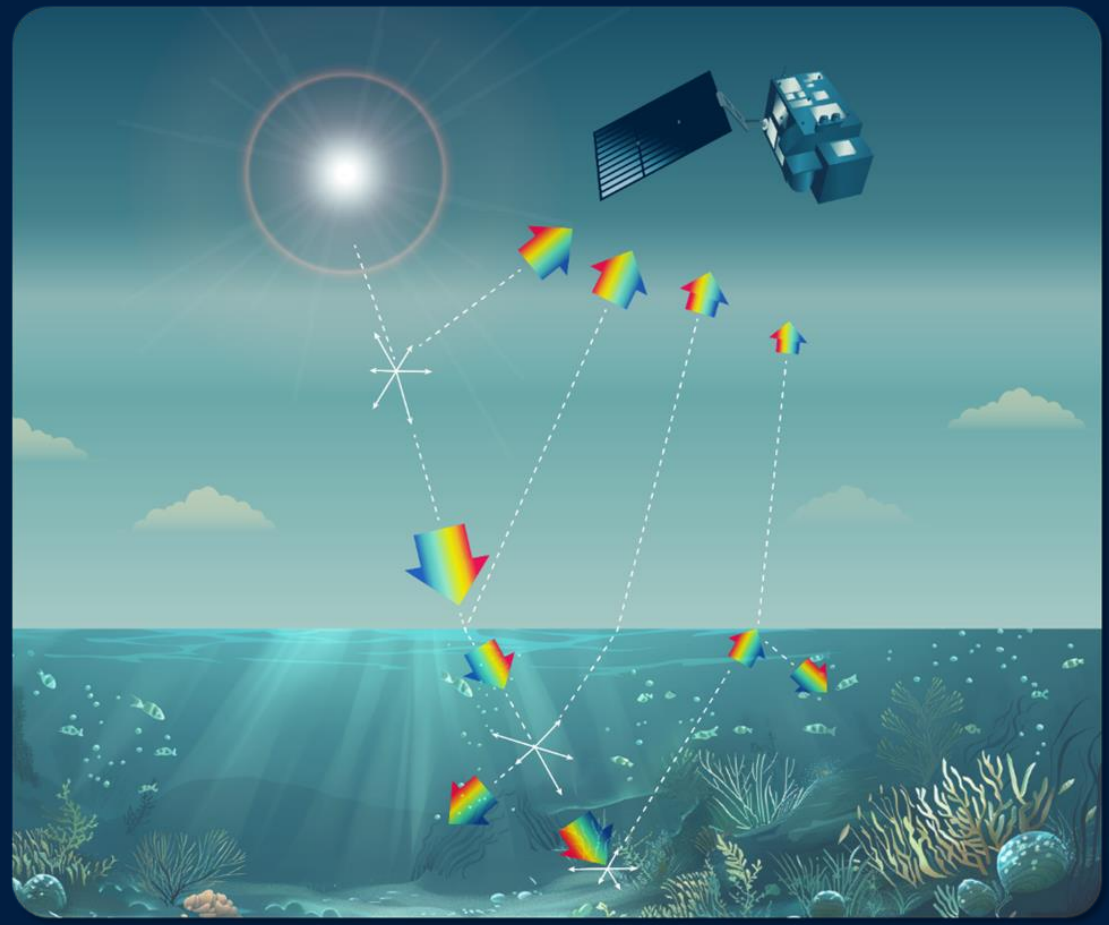
Satellite-Bathymetry

Shallow water mapping and monitoring

Modelling water depth based on multispectral satellite sensors.

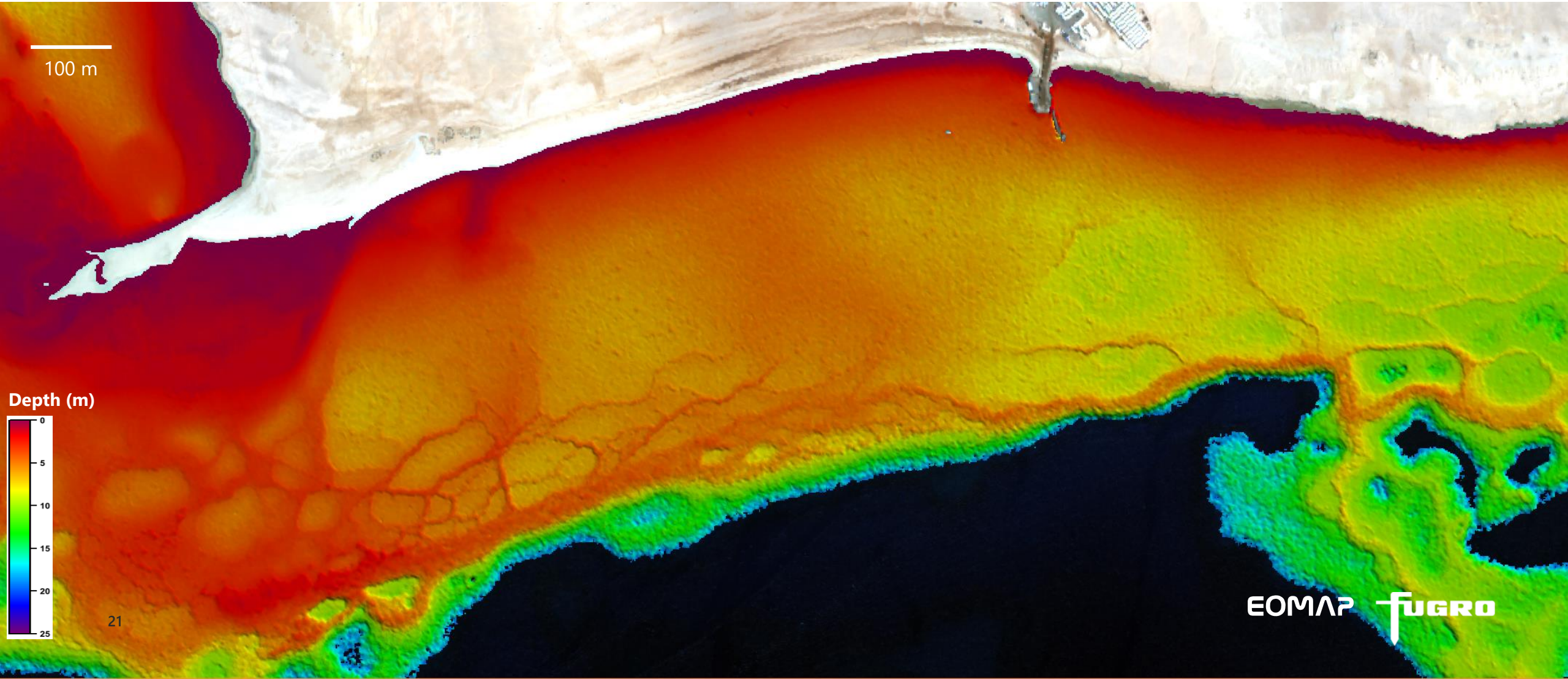
Inversion of the radiative transfer equation (“modelling the light”)

Allows for calculation of depth based on archived data, no mobilisation needed

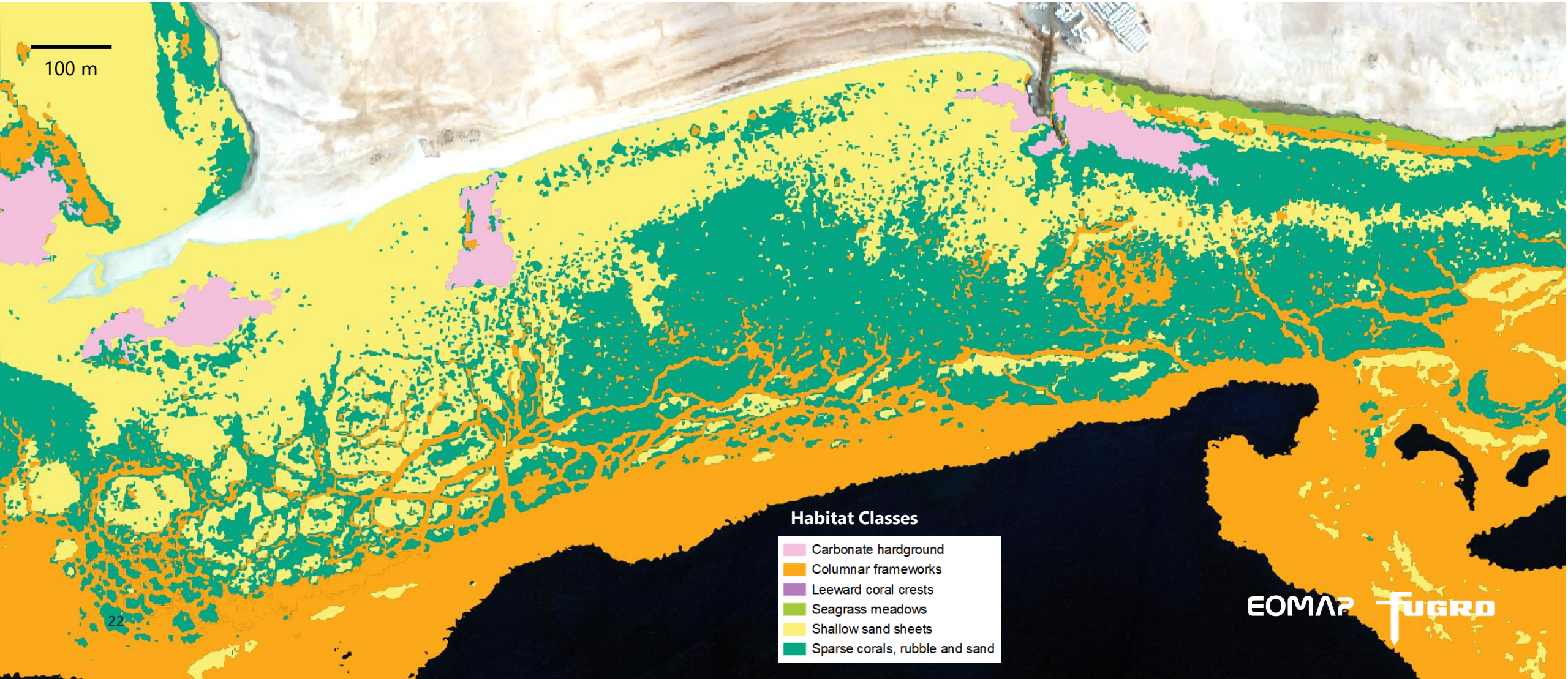


Mapping Remote Coastal Environment

Mapping Remote Coastal Environment



Mapping Remote Coastal Environment

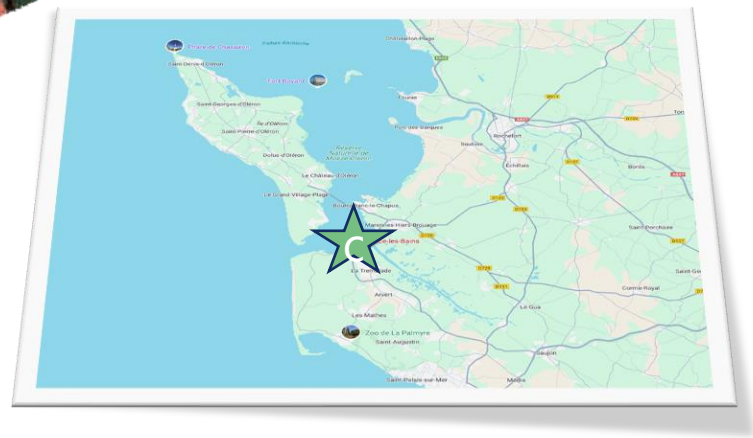


Satellite EO – Seagrass Monitoring examples

Intertidal zone Seagrass density, Ronce-les-Bains - France

Sensor

Maxar's WorldView-2
50cm Resolution



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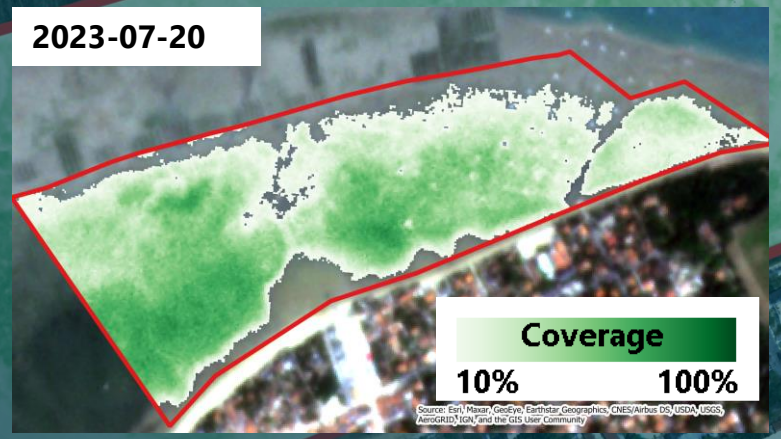
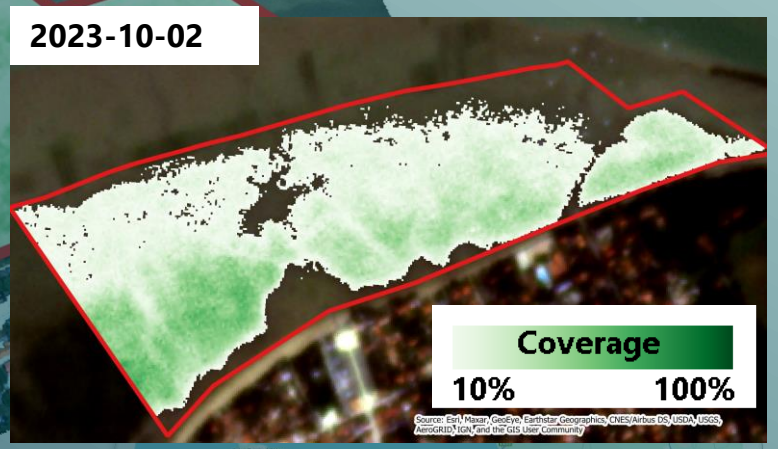
Sensor

Maxar/e WorldView-2





Satellite EO – Seagrass Monitoring examples

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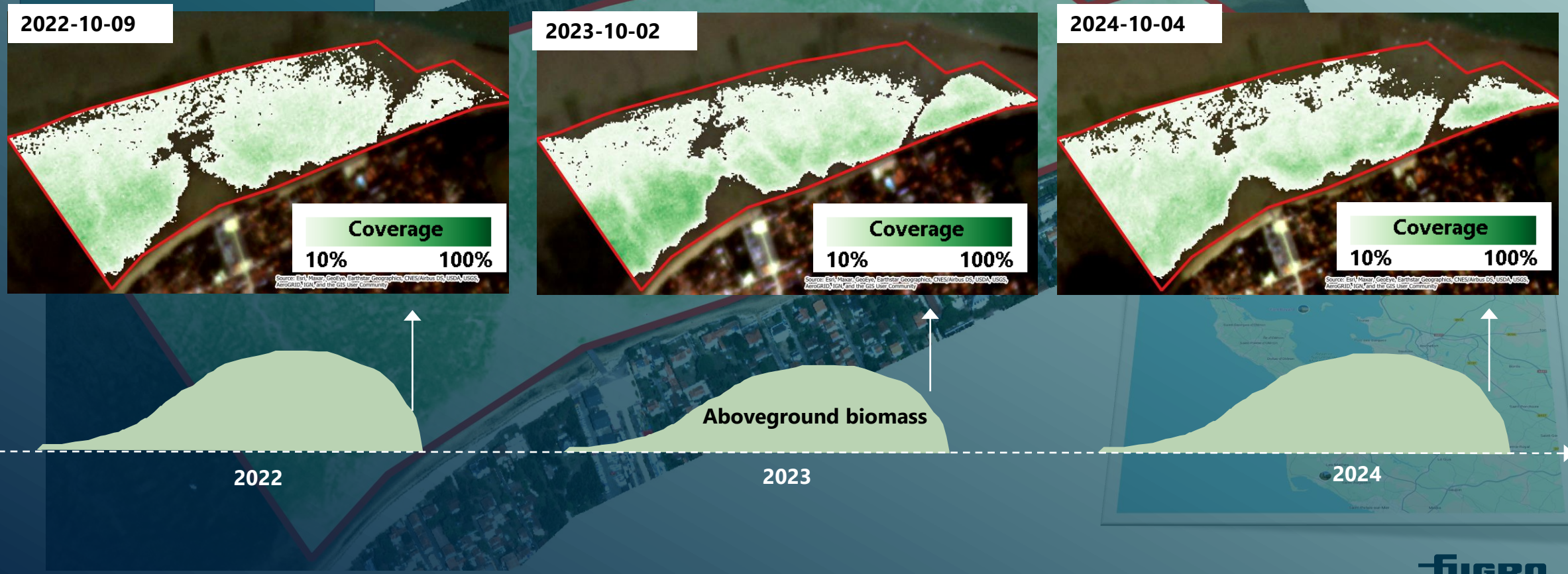
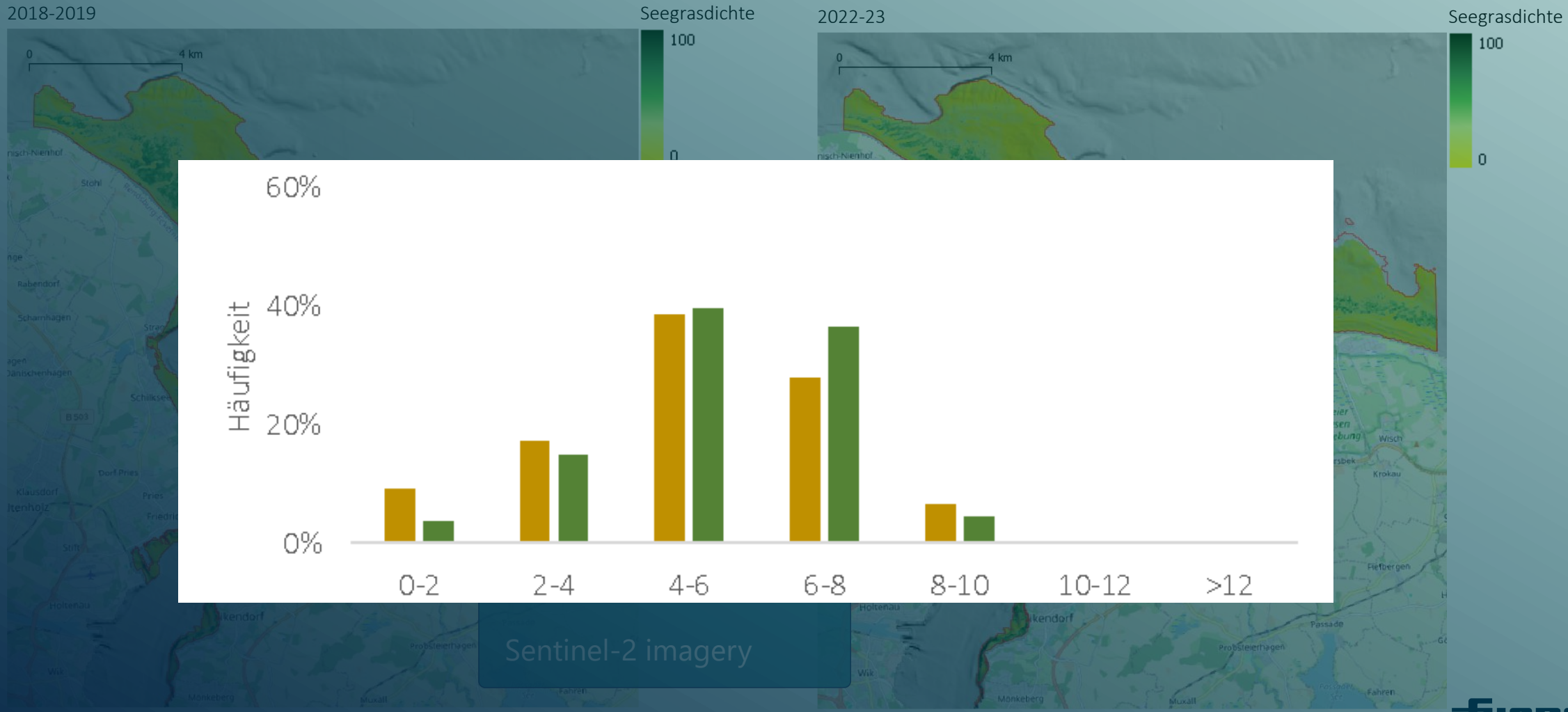
Sensor

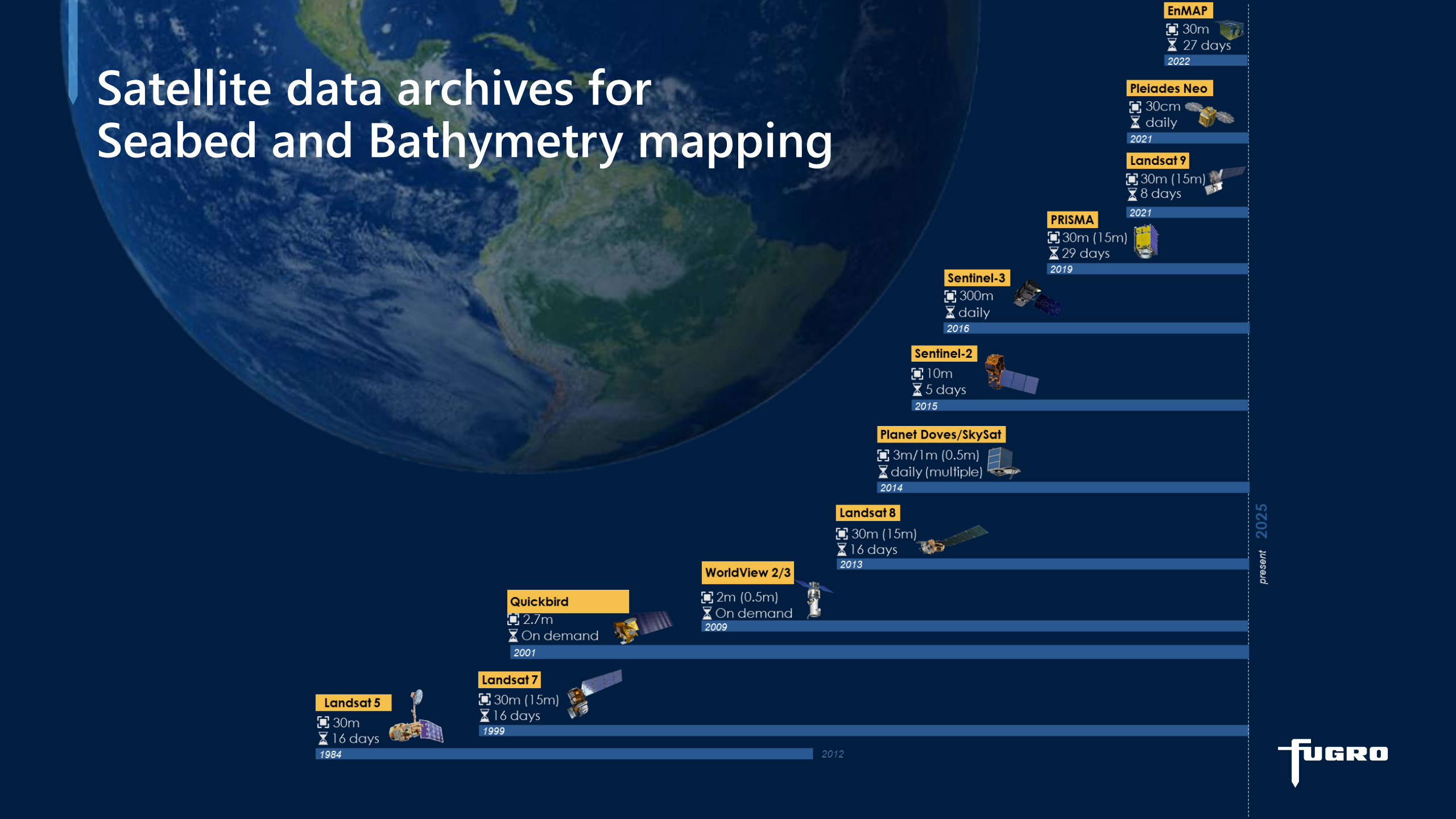


Sat. EO – Seagrass Monitoring Examples

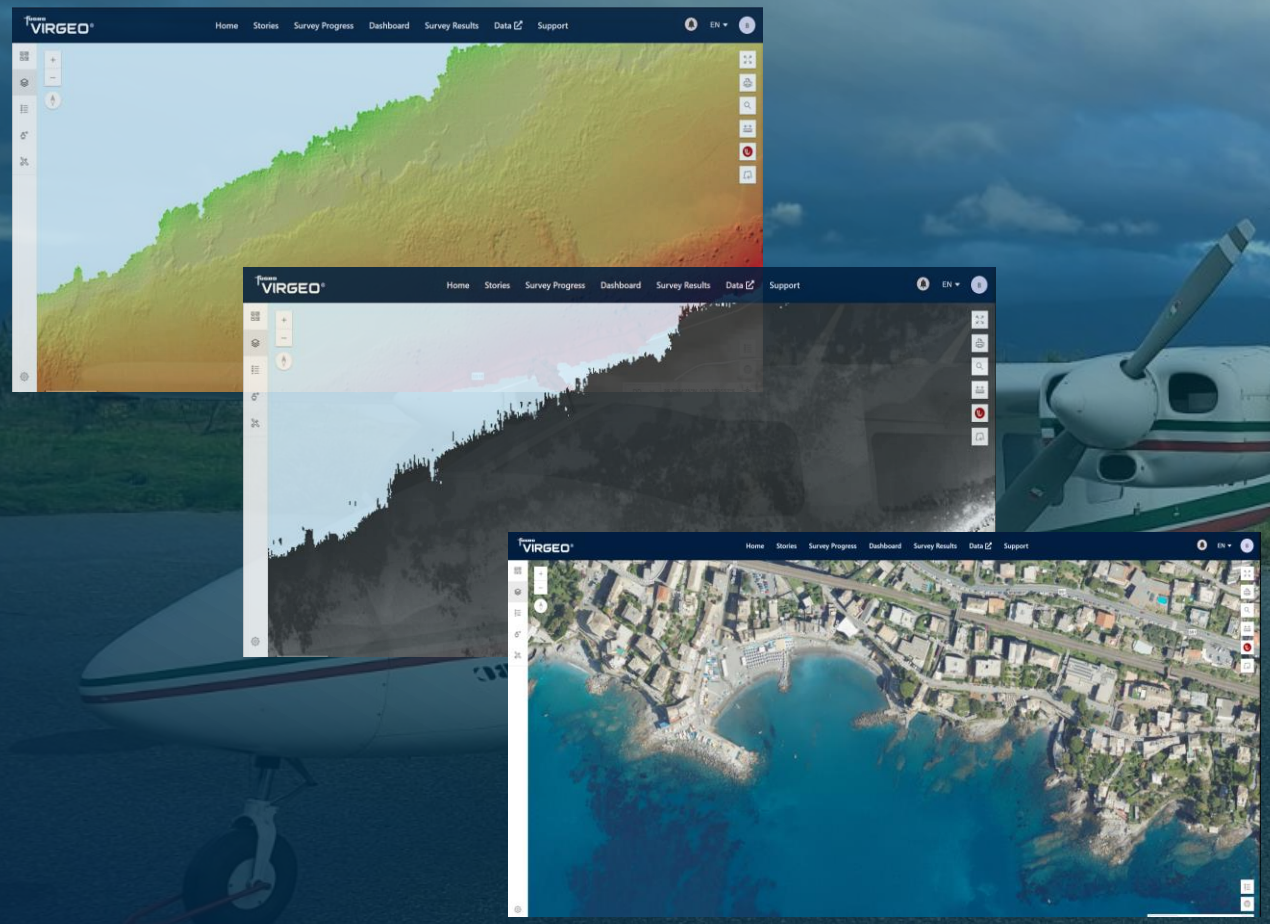
Submerged Seagrass density analysis, German Baltic, Kieler Förde



Satellite data archives for Seabed and Bathymetry mapping



Airborne Lidar Bathymetry



Platform

- Partenavia P68

Sensor

- Fugro RAMMS-2

Products

- Bathymetry
- Seafloor reflectance
- preliminary Seafloor Classification
- Imagery - RGB
- Imagery - HSI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ALB Solution

- Aircraft: Partenavia P68
- Significant CO_2 emission reduction
- Point cloud density: 2.5pts/m^2
- Imagery: PhaseOne 50MPix (QA/QC)
- Machine learning processing
- Survey team on site: 3x staffs

Multibeam Echo Sounder (MBES)

Platforms

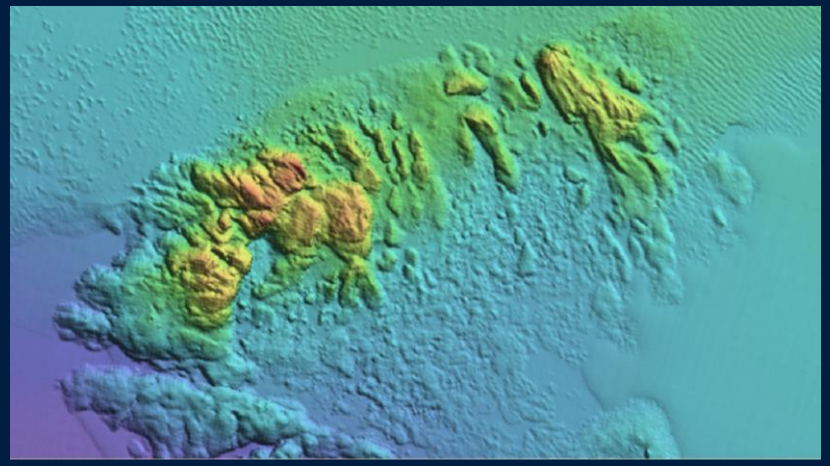
- MV Artic
- MV Fugro Discovery
- Polaris

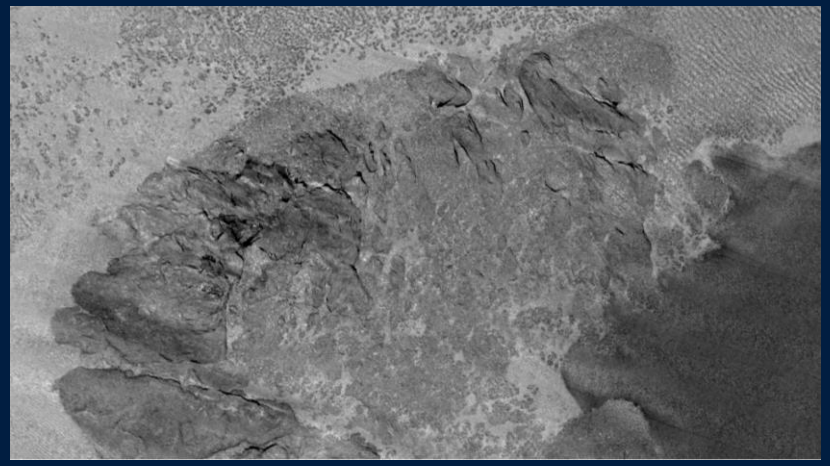
Products

- Bathymetry
- Backscatter
- Preliminary Seafloor classification

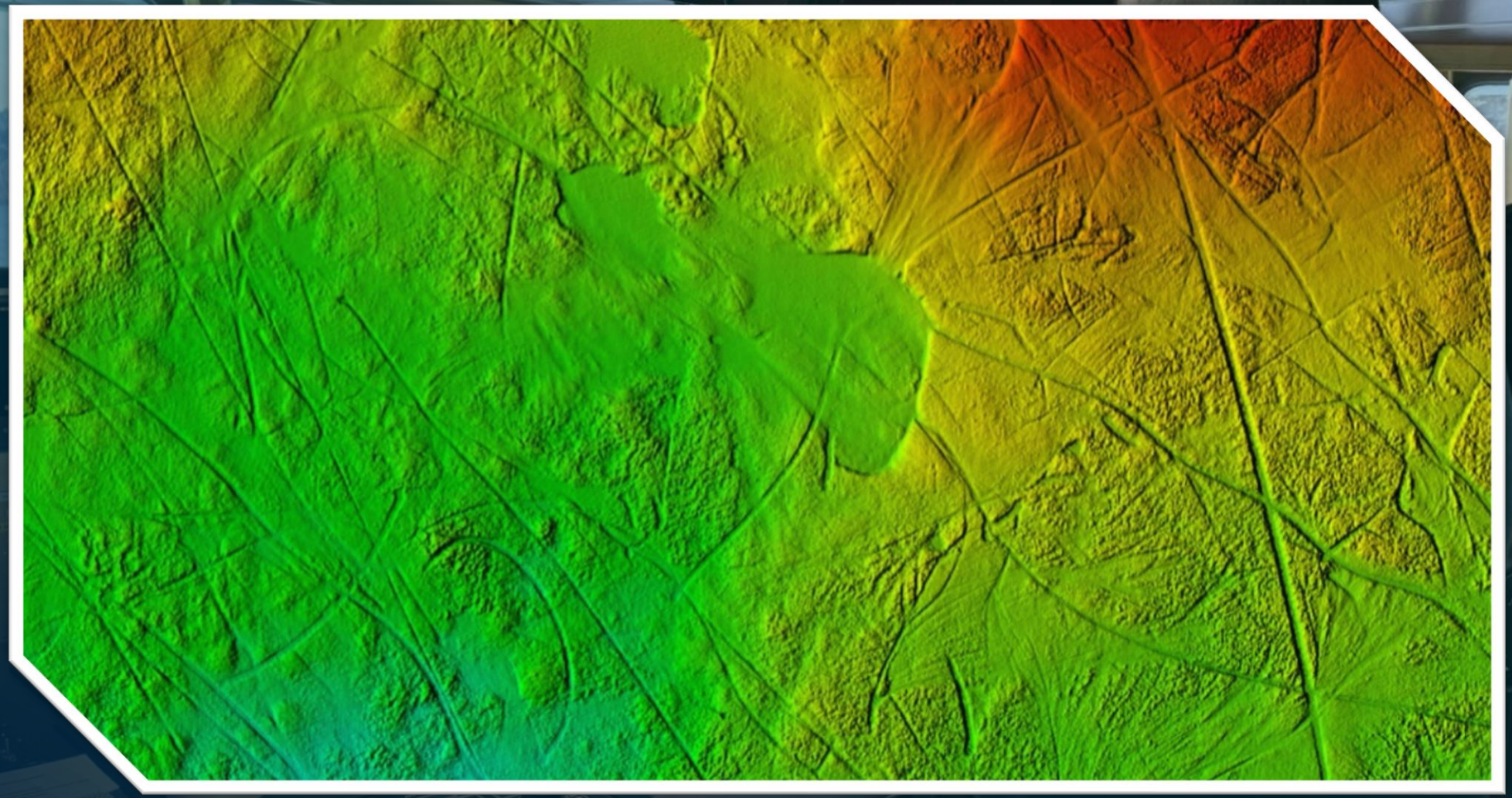
Sensors (Kongsberg)

- EM2040 MKII (0.4°x0.7°)
- EM2042 (0.4°x0.7°)
- EM712 (0.4°x0.5°)





Multibeam Echo Sounder (MBES)



Ground Truthing

Platform

- MV Polaris (support boat) and Seacat AUV

Products

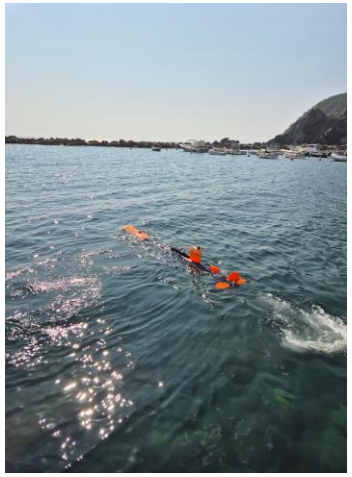
- Seafloor Orthophoto
- Seafloor Video

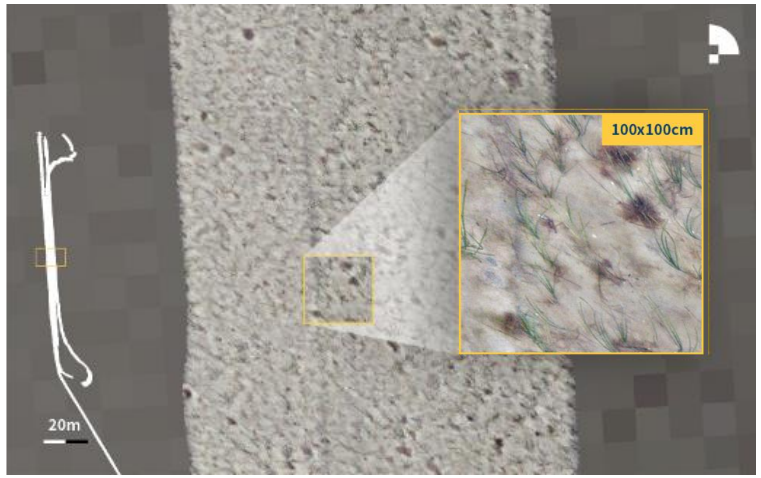
Sensors

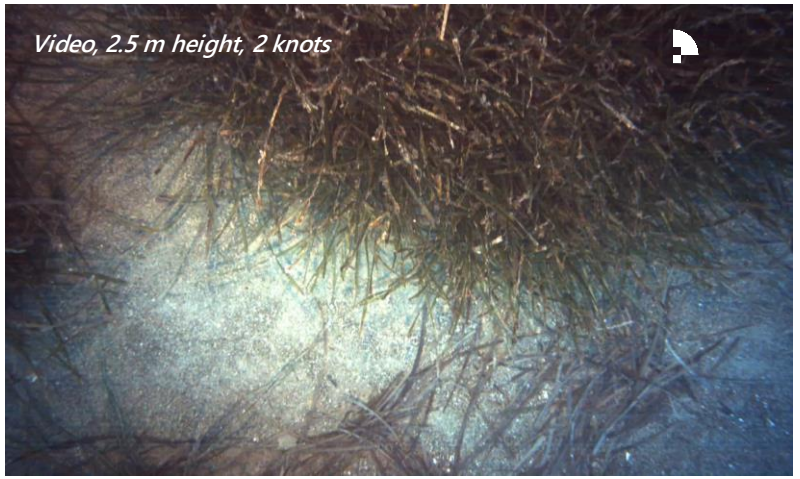
- Camera: PlanBlue RGB-HIS Camera
- SSS: Edgetech 2205 230/850kHz
- MBES: Norbit WBMS

FUGRO planblue

Ground Truthing – Data Acquisition







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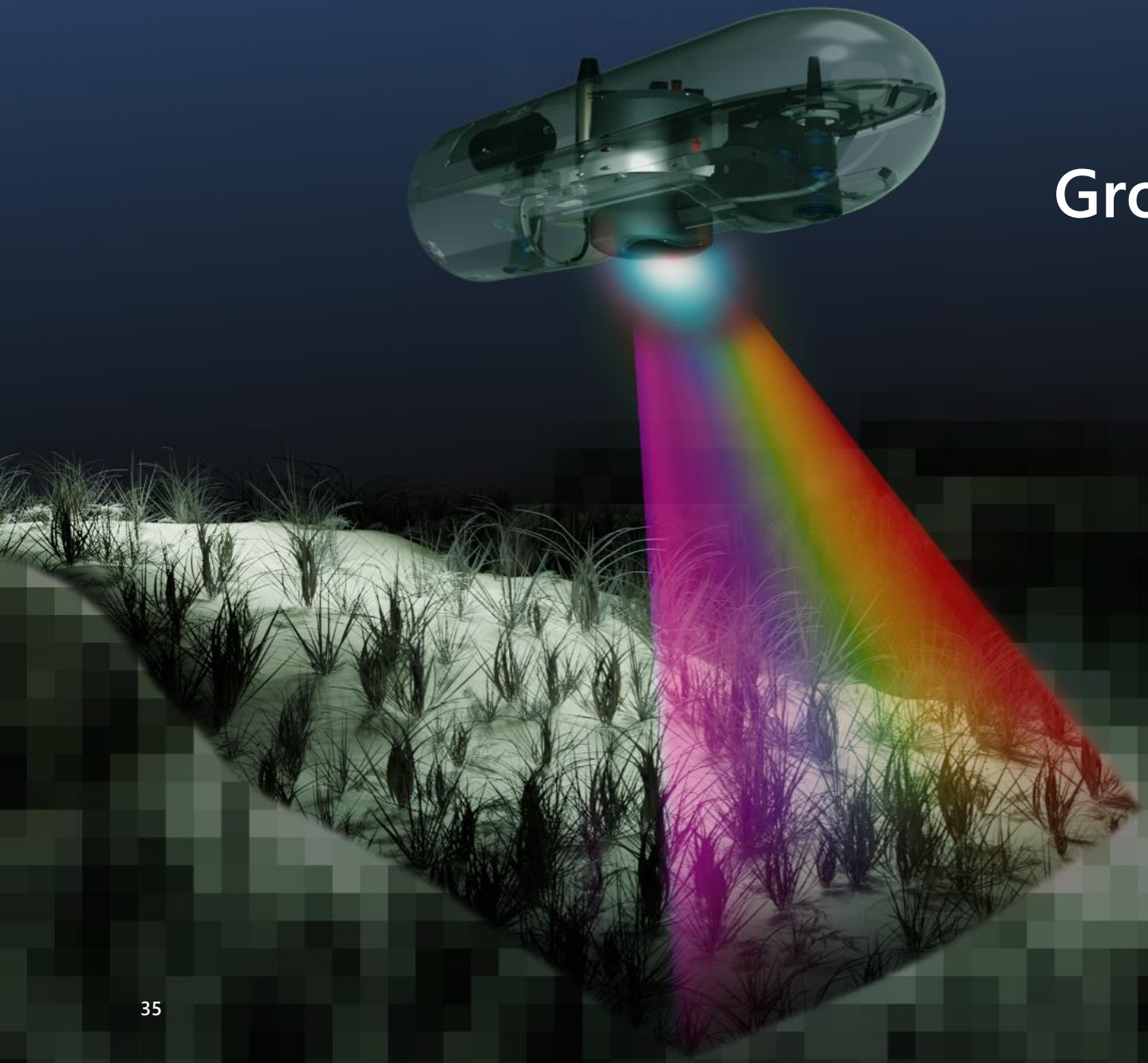
Ground-truthing and more…



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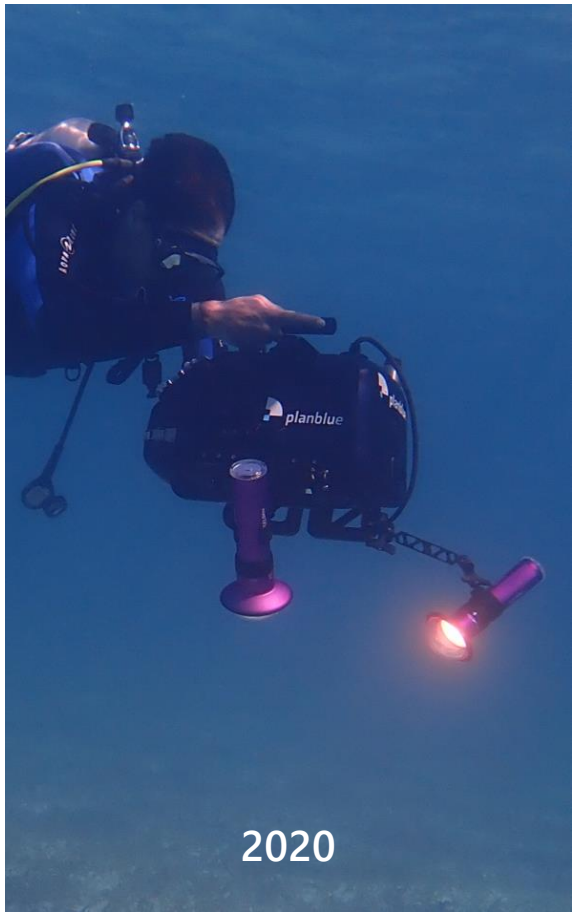
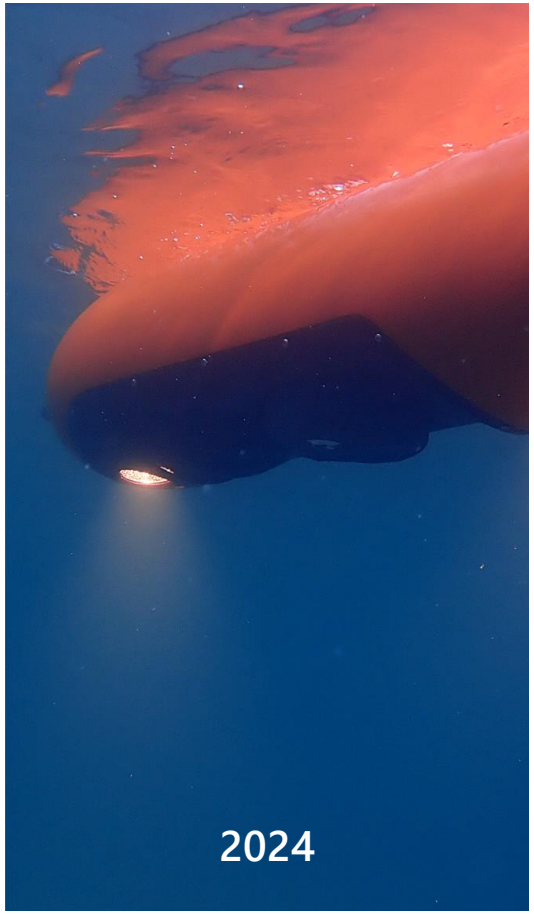
Ground Truthing - Why hyperspectral?

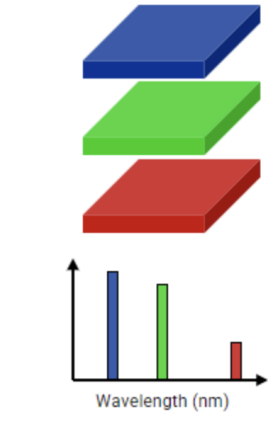




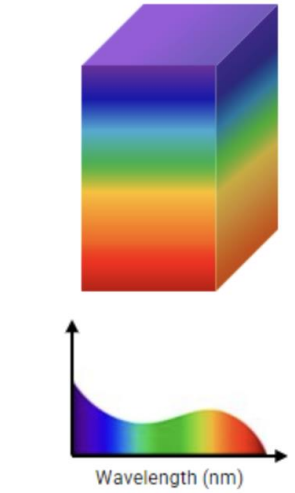
RGB: 3 Bands

HSI: 100s Bands

RGB



HSI



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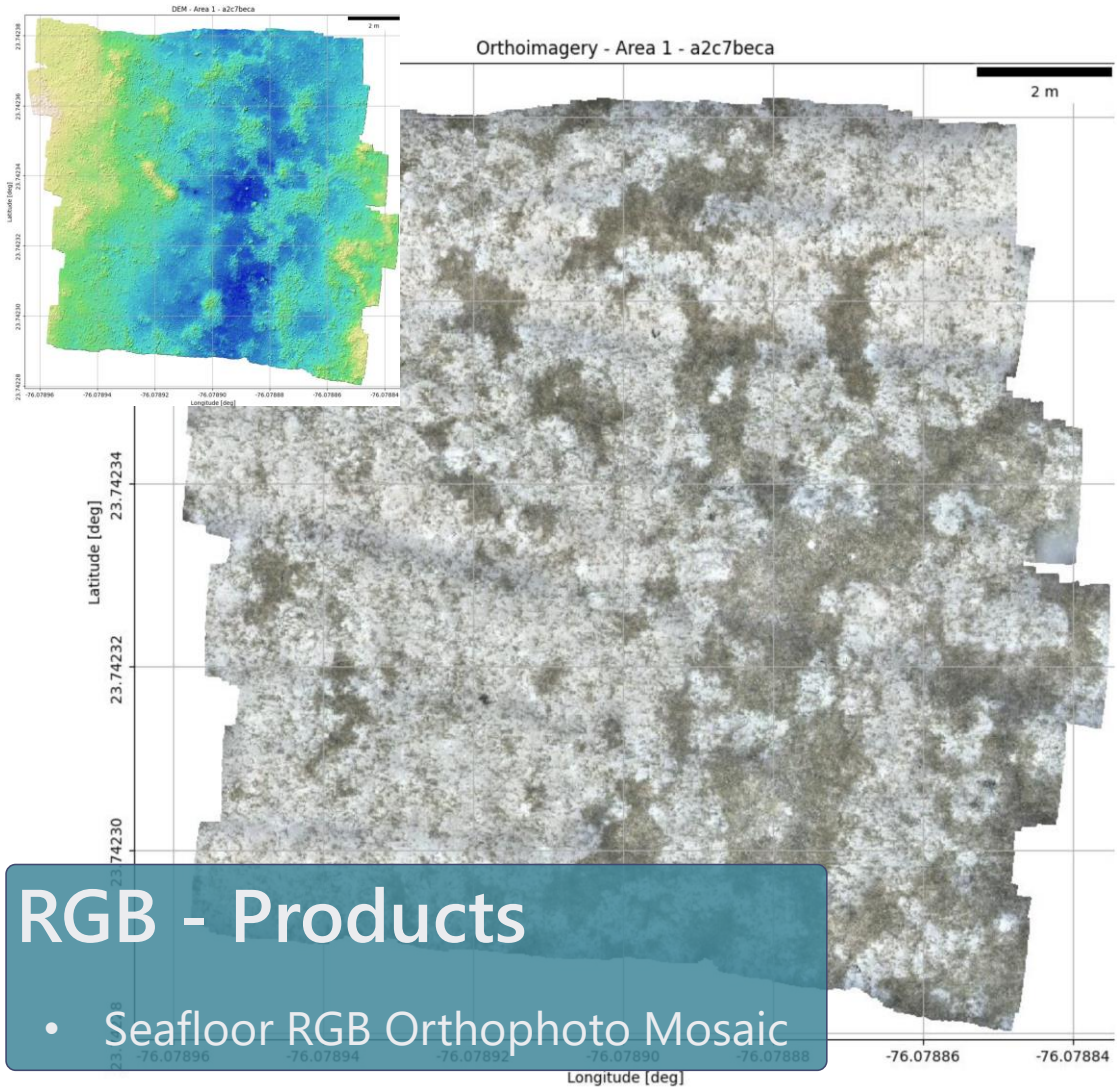
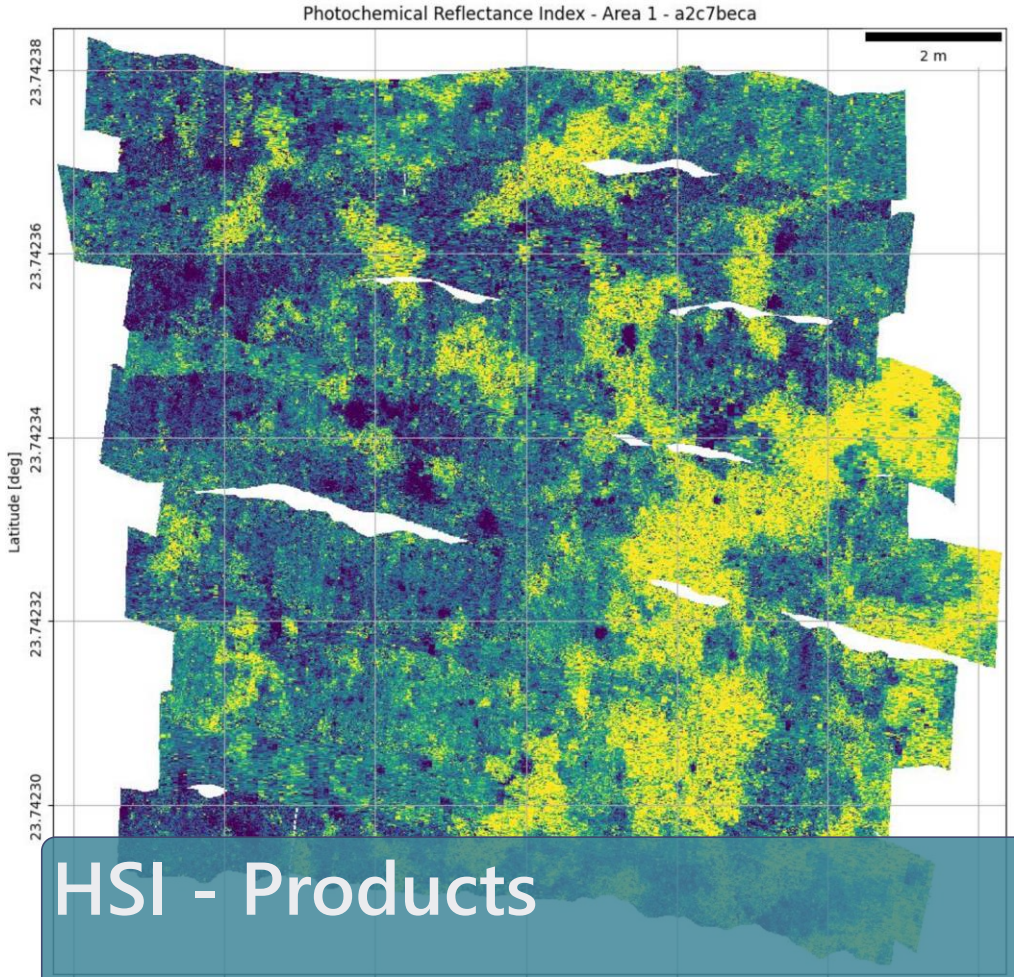
Ground Truthing – Products



RGB - Products

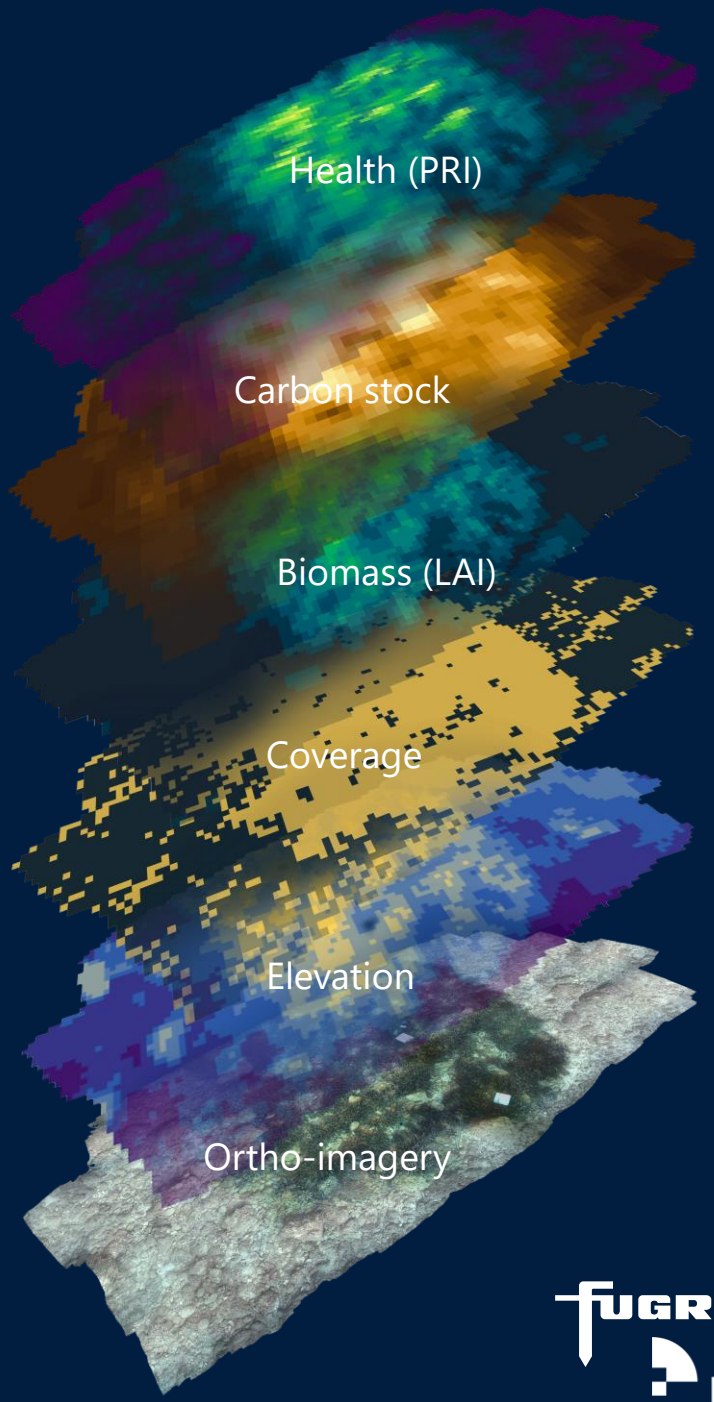
- Seafloor RGB Orthophoto Mosaic



HSI - Products

- Seafloor HSI Orthophoto Mosaic (Seagrass Health Photochemical Reflectance Index)

Ground Truthing - Products



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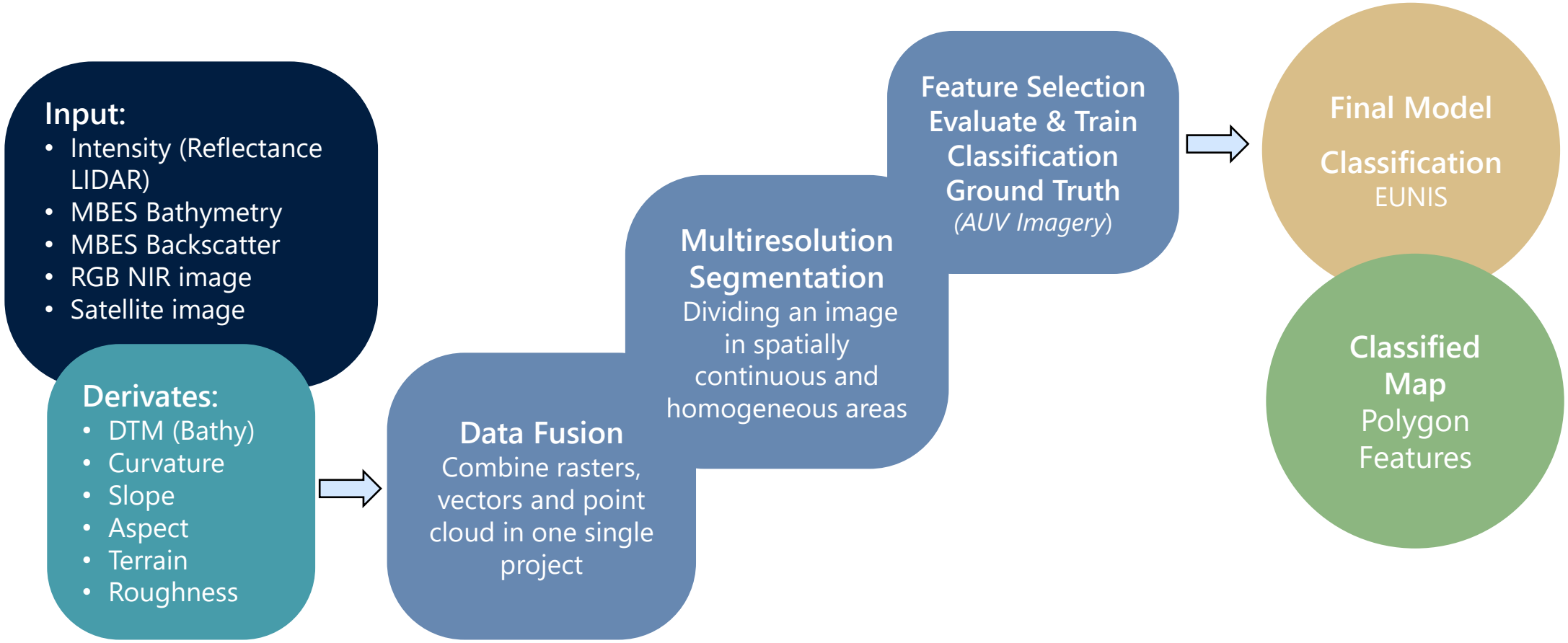
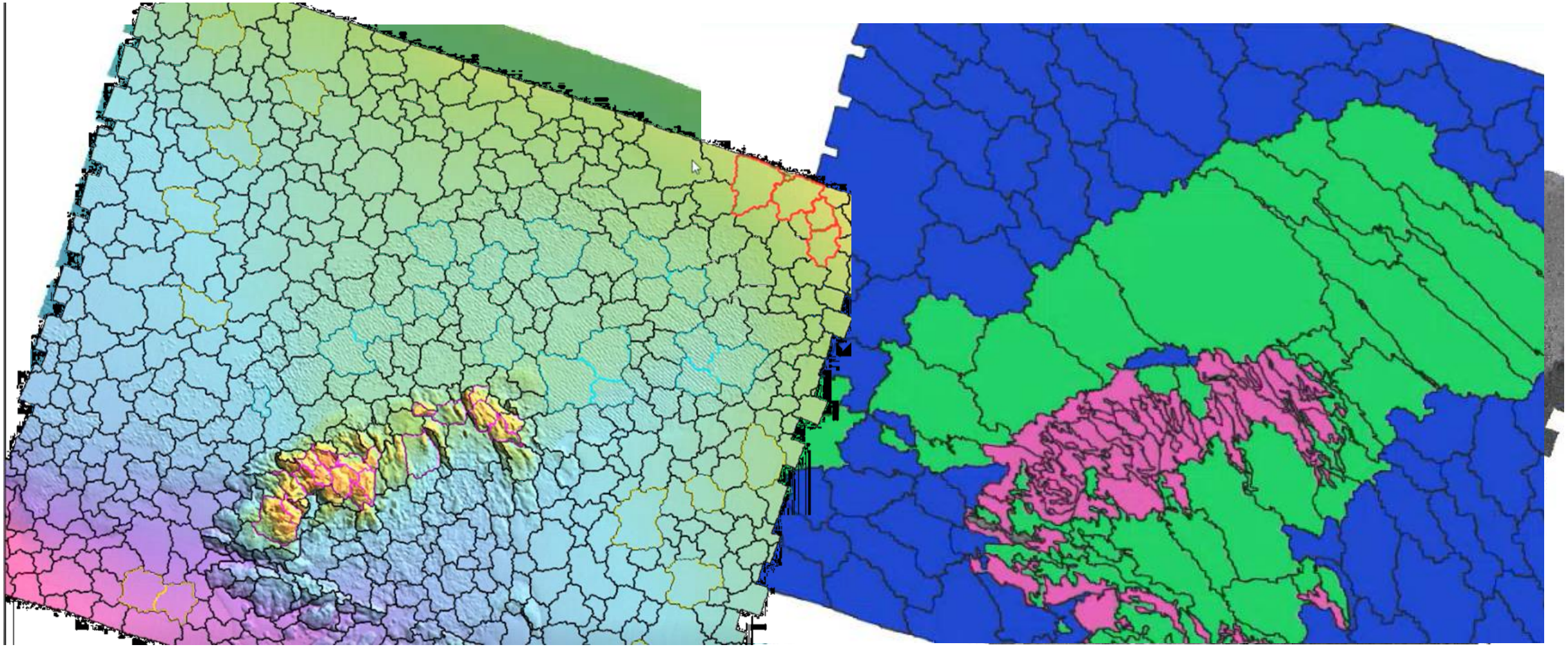
Data Classification

Method: OBIA classification (**O**bject **B**ased **I**mage **A**nalysis)



Data Classification – Input data

Method: OBIA classification (**O**bject **B**ased **I**mage **A**nalysis)



Map -> Model -> Action (Preservation/Restoration)-> Monitor

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A Full Coastal Digital Twins

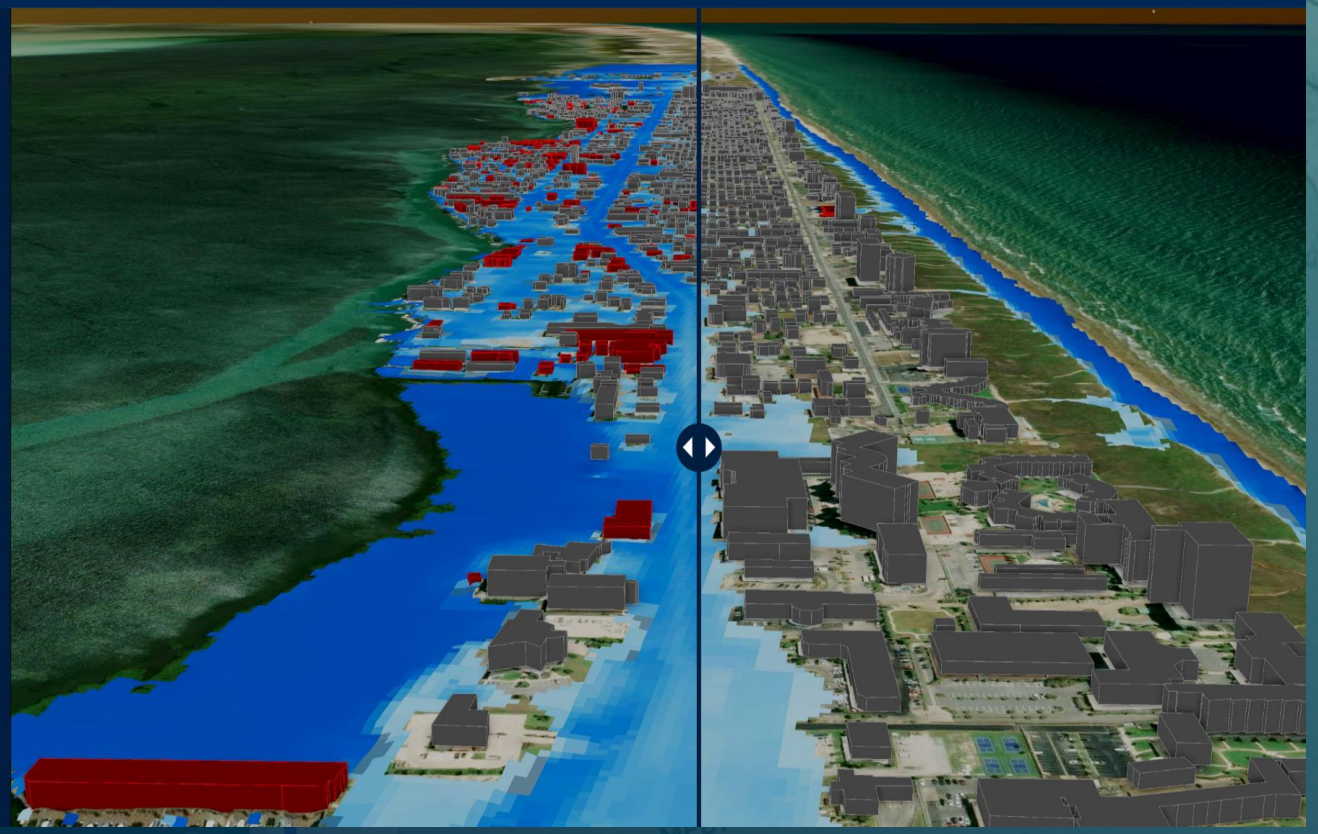
Southwest Texas Coastal Resilience Demonstration Study

Introduction | Fugro's Coastal Resilience Con... | Background | Study Area | Data Collection and Methods | Results | Adaptation Solutions | Adaptation Recommendations

3D 100-Year Storm Impacts to Buildings on South Padre Island

Use slider button to compare the impacts to buildings (in red) of a 100-year storm today with the same storm plus SLR in 2040. The buildings in gray are not impacted. Swiping from left to right will show the increase in flood inundation. The elevation of the base of each building was extracted from the lidar and compared to the modeled water depths to determine specifically which will be impacted.

- 2040 SLR 100-Year Buildings Impacted (Left)
- No SLR 100-Year Buildings Impacted (Right)



05

The Power of Collaboration

Private Sector

Public Sector

Seagrass Preservation and Restoration

Research Institutes

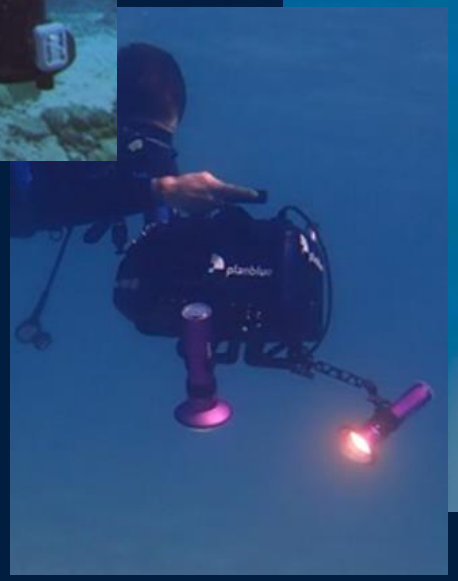
University

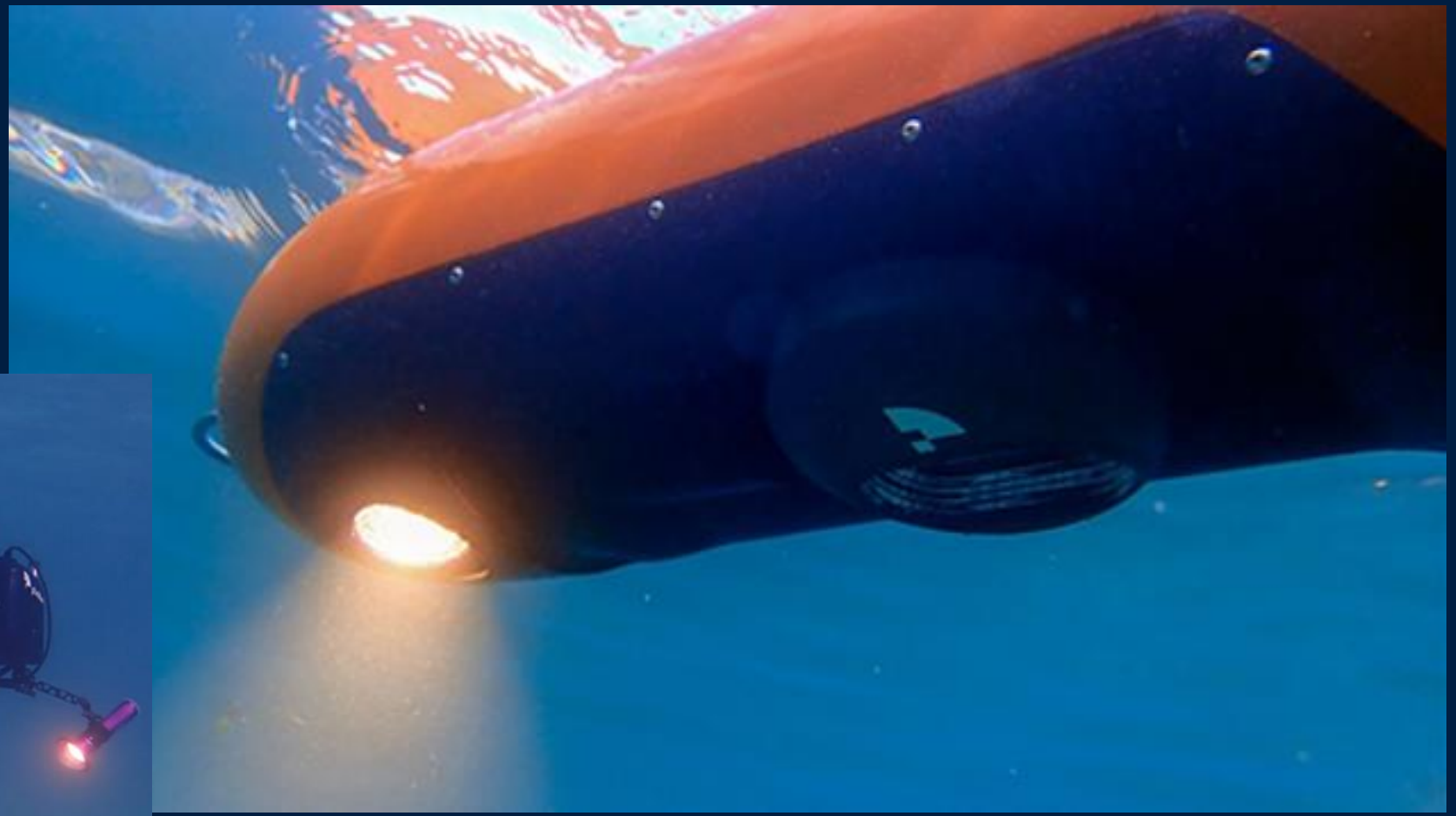
NGOs

Airborne LiDAR Bathymetry at Scale

- Smaller Aircraft
- Significant CO_2 emission reduction
- Increased Point cloud density 2.5pts/m^2
- Faster delivery: Machine learning processing
- Survey team on site: 3x staffs

Ground Truthing at scale





Acoustic & ROV inspection Survey at Scale

Blue Shadow

Hydrography

9m

MBES

SBP, SSS (April 2025)

Blue Essence

ROV Inspection

12m

MBES, SBP, ROV

SSS (May 2025)

Blue Prism

Hydrography and Geophysics

17m

MBES, SBP, SSS, MAG, MVP (Q4 2025)

Blue Eclipse

ROV Inspection

18m

MBES, SBP, ROV

(Q2 2025)

Net Ecosystem Value (NEV)

A geodata approach to bridging science, policy and finance to support investment, action and prioritisation of conservation and restoration at scale

Innovative data driven approach to quantify Net Ecosystem Value (NEV)

Bridges science, policy and finance to accelerate the development of investment scenarios to unlock blue finance & science-based management decisions

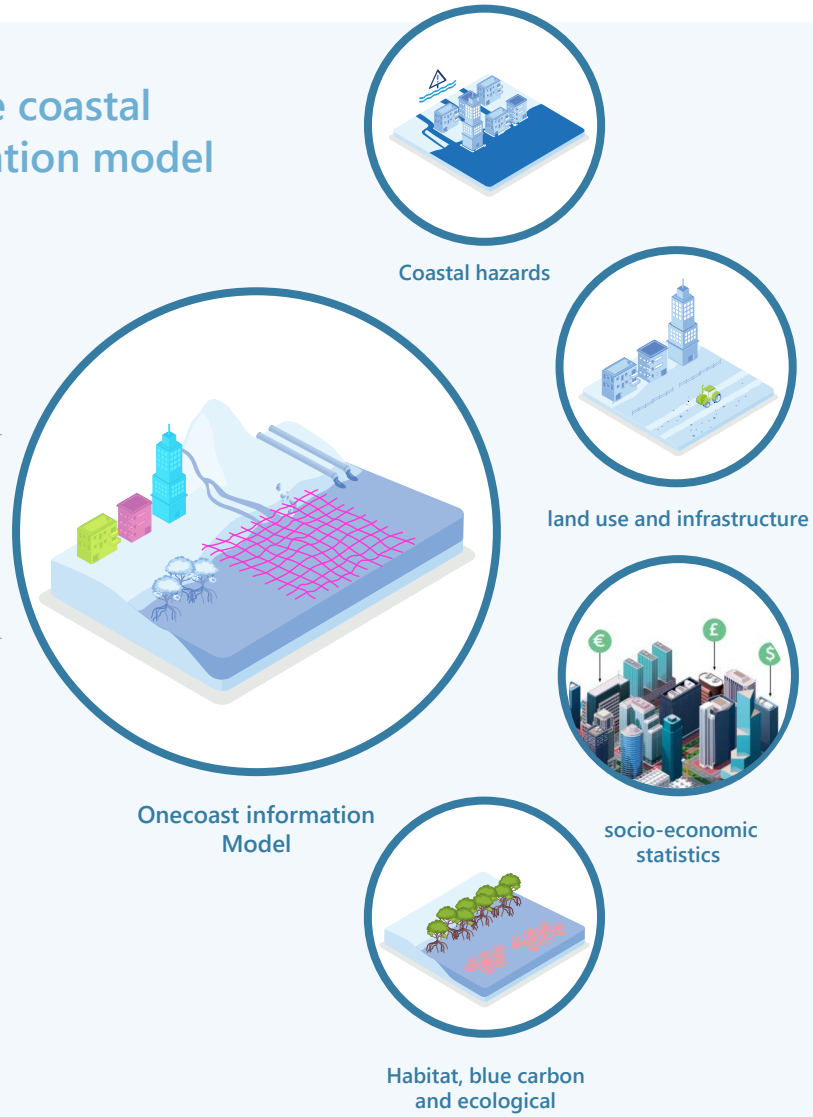
A single coastal information model

Geo Data inputs

Biophysical

Socioeconomic

Statistical Data inputs



7 key coastal ecosystem services

- **Avoided Damages from Coastal Protection:** Calculates the economic benefits of reduced flood and erosion risks
- **Anthropogenic impact :** Quantify habitat loss due to urbanization, agricultural expansion, deforestation, and coastal development
- **Tourism and Recreation Revenue:** Quantifies the economic contribution of healthy ecosystems
- **Socio cultural Value:** mapping cultural, spiritual, and aesthetic value to communities
- **Fisheries Economic Value:** Estimates the market value of fish stocks supported by healthy ecosystems
- **Biodiversity Value:** Measures species richness and ecosystem health
- **Carbon Sequestered**: Quantifies how much carbon is stored and additional sequestration in coastal ecosystems

Measure ROI from nature-based investment

Net Ecosystem Value (NEV) : aggregates the total socio-economic impact of key ecosystem services, guiding investment and policy decisions for sustainable coastal management and to drive blue finance allocation at scale

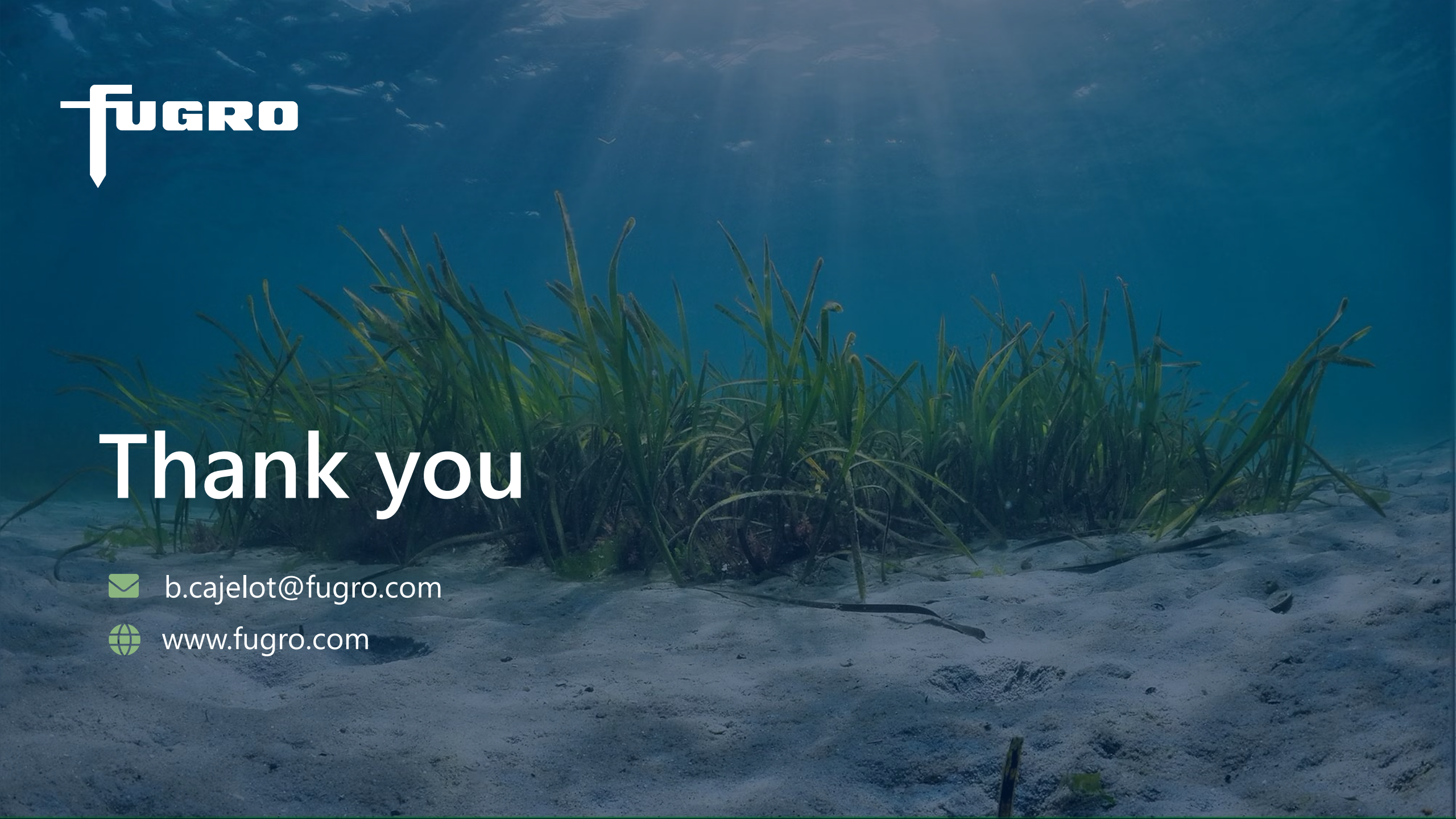
Engineering Matters Podcast

Engineering Ecosystems: Italy's Seagrass Meadows

Published
02 Apr 2025

Seagrass meadows are the engineers of the marine ecosystem. They provide habitats, support biodiversity, prevent coastal erosion and sequester carbon dioxide. For this reason, Italy has embarked upon a world leading project to map these coastal ecosystems at a national scale, enabling it to plan protection and restoration measures that will improve ocean health and meet legislative targets.

SCAN ME



Thank you

b.cajelot@fugro.com

www.fugro.com