The Seabee project and mapping of the coast and aquatic environments with unmanned ariel vehicles

13th November 2023 TEKNA

MEDYAN GHAREEB (NIVA)

SeaBee RESEARCH INFRASTRUCTURE

www.seabee.no

Forskningsrådet

Project owner:

NIVA Norsk institutt for vannforskning

Host institutions:

NINA

NTNU Kunnskap for en bedre verden

NR Norsk Regnesentral NORWEGIAN COMPUTING CENTER

INSTITUTE OF MARINE RESEARCH

UN environment

GRID ARENDAL

Industry partners

Andøya Space

TIEPOINT

SPECTROFLY

Content

1. Drones and mapping of benthic habitats
2. The SeaBee Research Infrastructure

Project owner: NIVA Norsk institutt for vannforskning

Host institutions: NINA, NTNU Kunnskap for en bedre verden, NR Norsk Regnesentral Norwegian Computing Center, Institute of Marine Research, UN environment, GRID Arendal

Industry partners: Andøya Space, TIEPOINT, SPECTROFLY

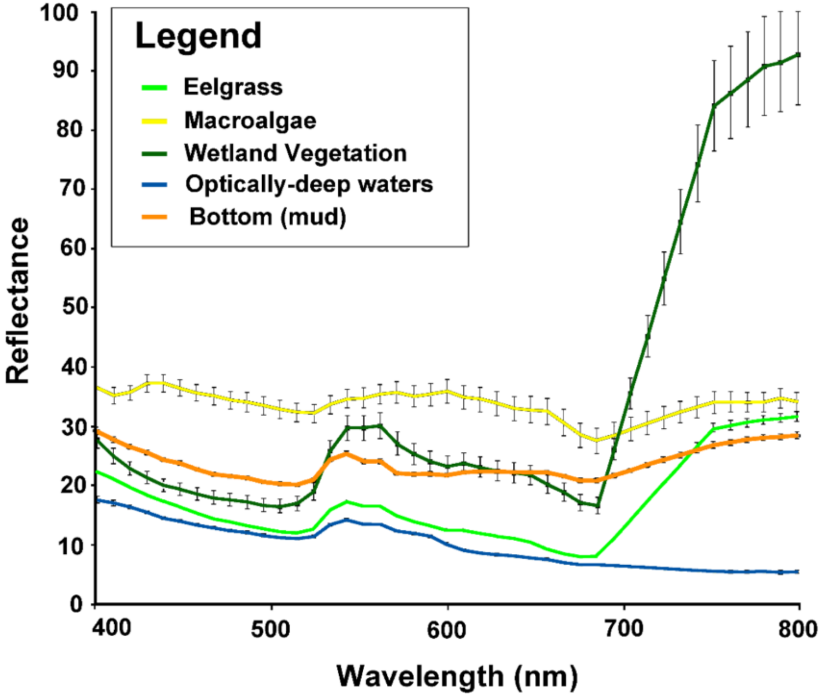
Commen benthic habitats (in Scandinavia)

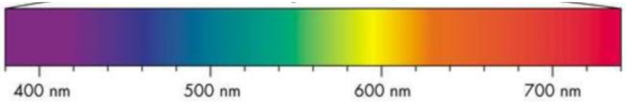





Photo: Trine Bekkby, Hege Gundersen, Kasper Hancke (SeaBee/NIVA)

Spectral reflectance of benthic habitats

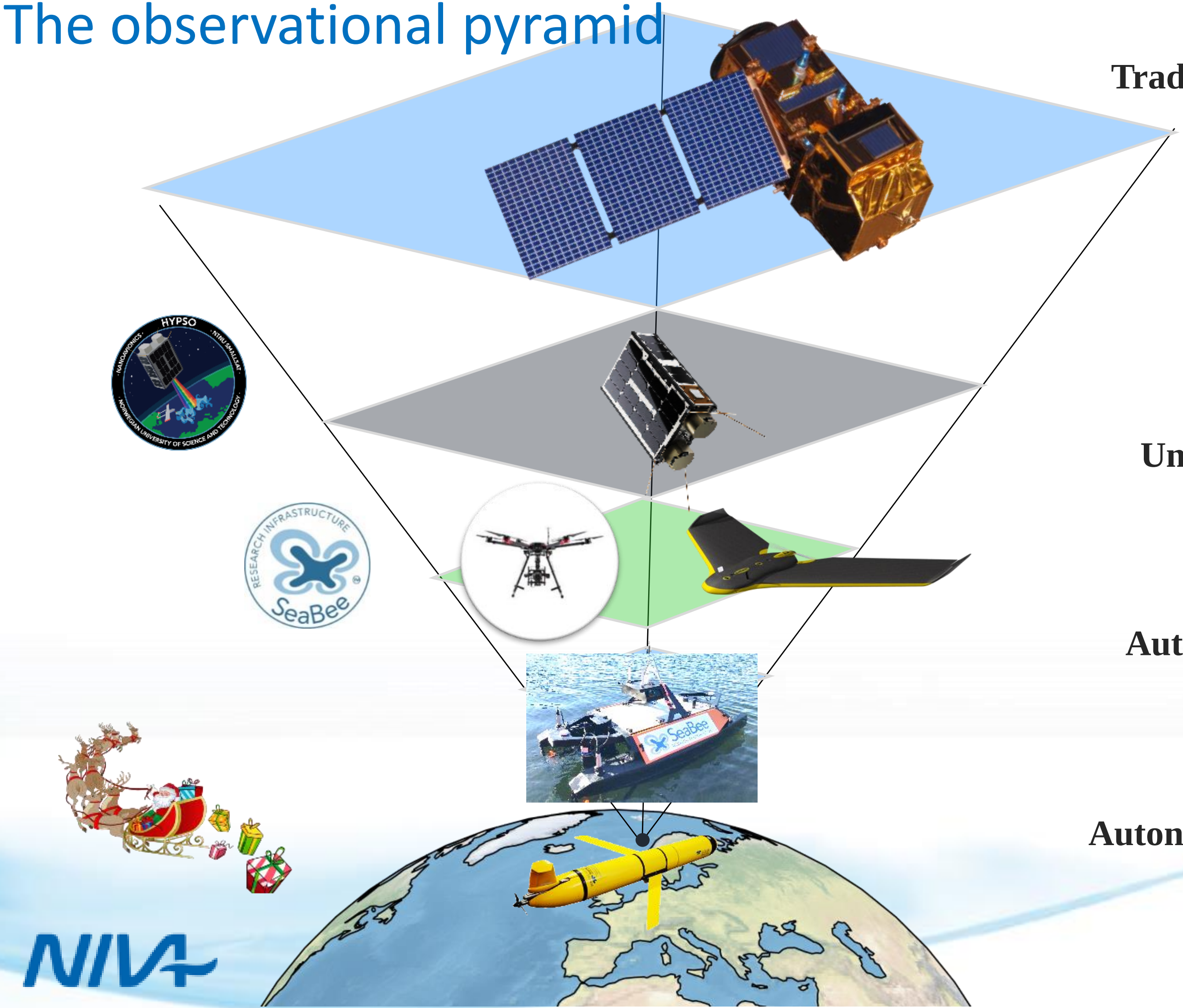




I.e. Optical signature

Shachak et al., 2016

The observational pyramid



Traditional Remote Sensing Satellites
Optical remote sensing
Area: Globally (< 300 km)
Resolution: 1-100 m

LEO Small CGI Satellites
Optical remote sensing
Area: Globally (< 100 km)
Resolution: ~100 m

Unoccupied Aerial Vehicle (UAV)
Optical remote sensing
Area: <5 km^2
Resolution: 1-10 cm

Autonomous Surface Vehicle (ASV)
Optical + Acoustic sensing
Area: <1 km^2
Resolution: ~meters

Autonomous Underwater Vehicle (AUV)
Optical + Acoustic sensing
Area: <1 km^2
Resolution: ~meters

Slide modified from TA Johansen, 2022 NTNU/AMOS

Short about the rapid development of benthic remote sensing

ACCESS

FEATURE ARTICLE

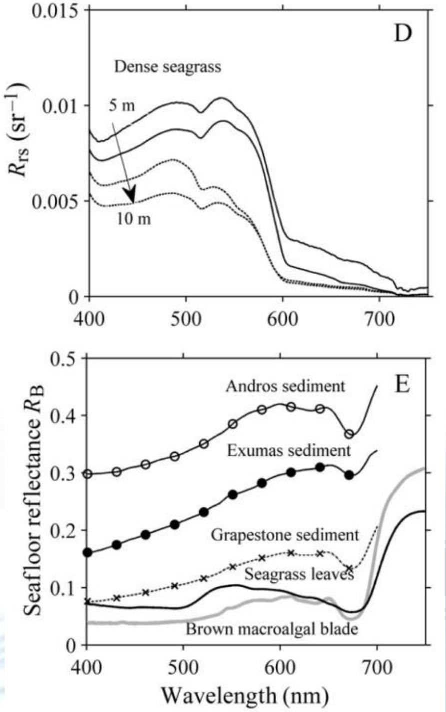
2010

Benthic ecology from space: optics and net primary production in seagrass and benthic algae across the Great Bahama Bank

Heidi M. Dierssen[1,*], Richard C. Zimmerman[2], Lisa A. Drake[2,3], David Burdige[2]

[1]Department of Marine Sciences/Geography, University of Connecticut, Groton, Connecticut 06340, USA

- **Satellite** remote sensing
- **250 meter** pixel resolution
- **Multispectral** data, index based



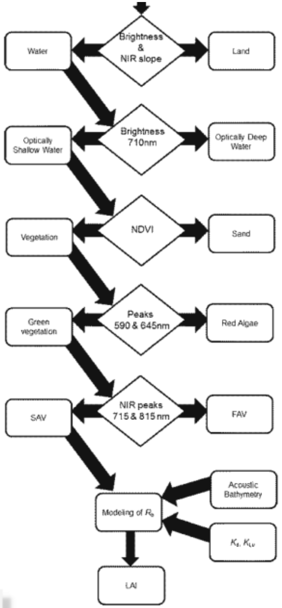
Short about the rapid development of benthic remote sensing

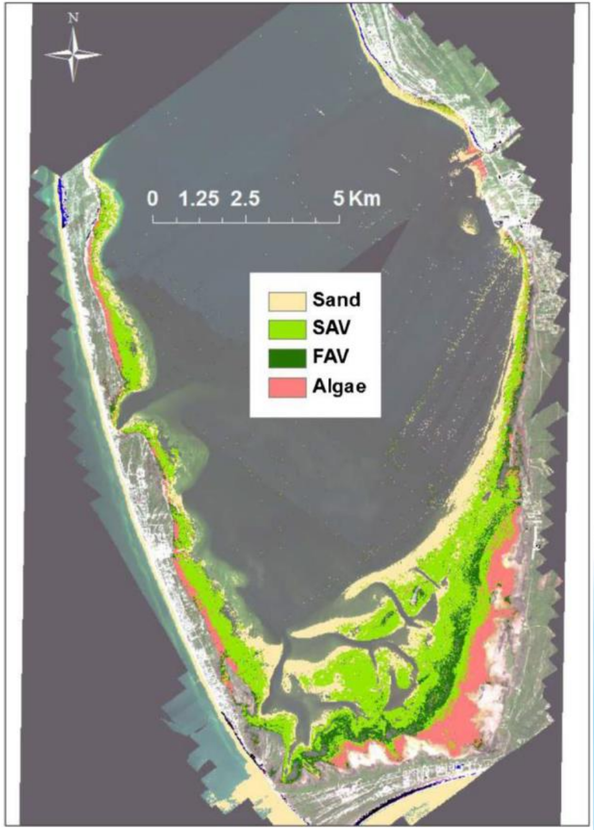
2014

Evaluating Light Availability, Seagrass Biomass, and Productivity Using Hyperspectral Airborne Remote Sensing in Saint Joseph's Bay, Florida

Victoria J. Hill · Richard C. Zimmerman ·
W. Paul Bissett · Heidi Dierssen · David D. R. Kohler

- **Airplane** remote sensing
- **1 meter** pixel resolution
- **Hyperspectral** data, index based





Short about the rapid development of benthic remote sensing

Spatial assessment of intertidal seagrass meadows using optical imaging systems and a lightweight drone

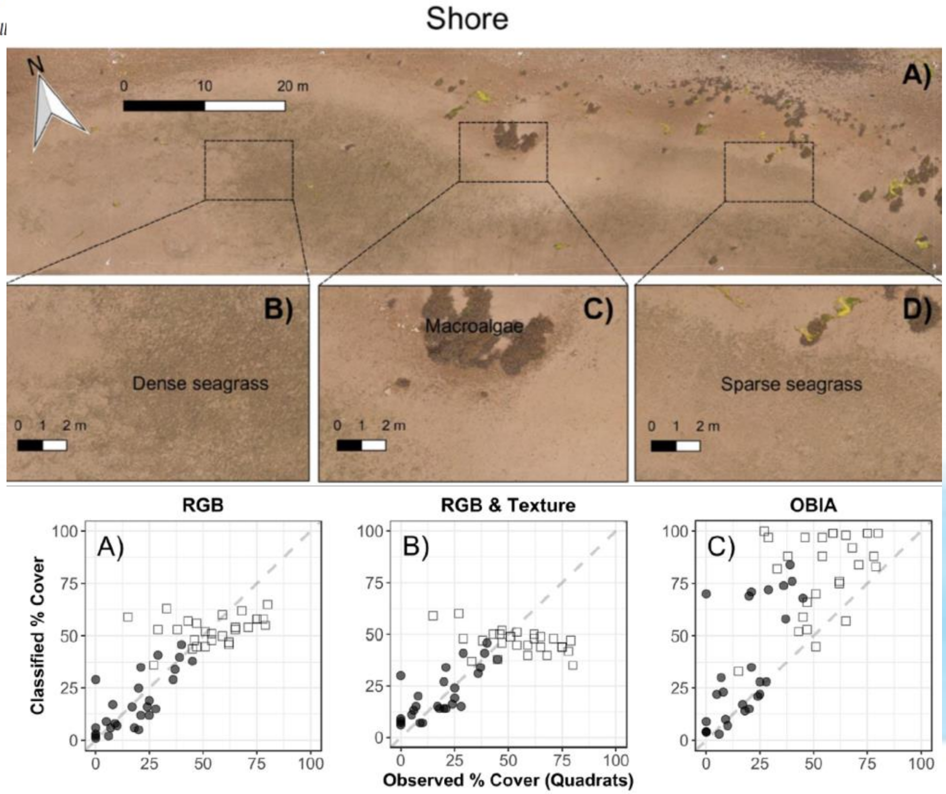
CrossMark

2018

James P. Duffy[a,*], Laura Pratt[b,c], Karen Anderson[a], Peter E. Land[d], Jamie D. Shutler[e]

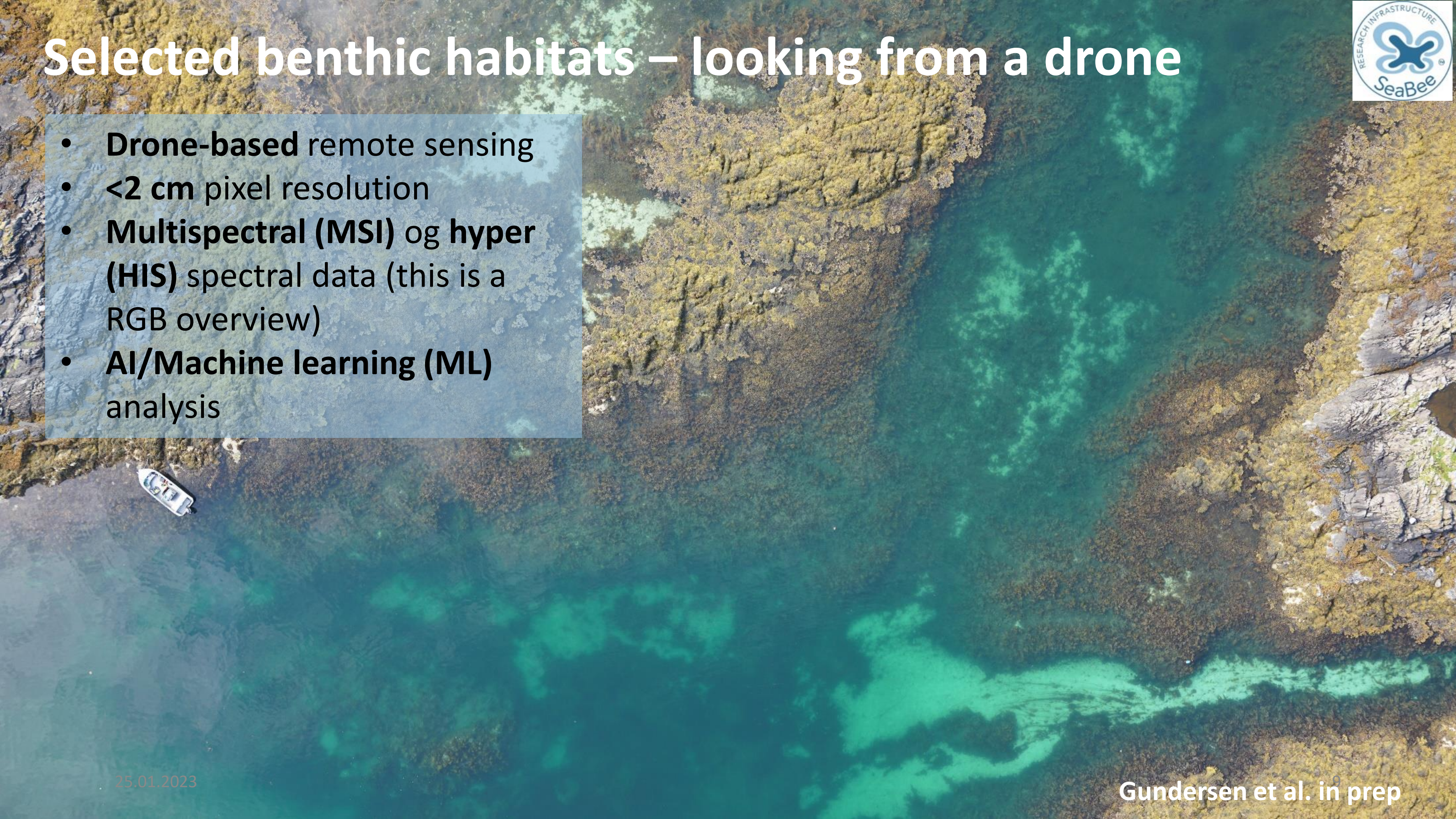
[a] DroneLab Research Group, Environment and Sustainability Institute, University of Exeter, Penryn Campus, Penryn, Cornwall
[b] Project Seagrass, Sustainable Places Research Institute, Cardiff University, Cardiff, CF10 3BA, UK
[c] School of Biosciences, Cardiff University, The Sir Martin Evans Building, Museum Avenue, Cardiff, CF10 3AX, UK
[d] Plymouth Marine Laboratory, Prospect Place, The Hoe, Plymouth, PL1 3DH, UK
[e] Centre for Geography, Environment and Society, University of Exeter, Penryn Campus, Penryn, Cornwall, TR10 9FE, UK

- **Drone** remote sensing
- **<1 cm** pixel resolution
- **RGB** data, Object detection and clustering algorithm



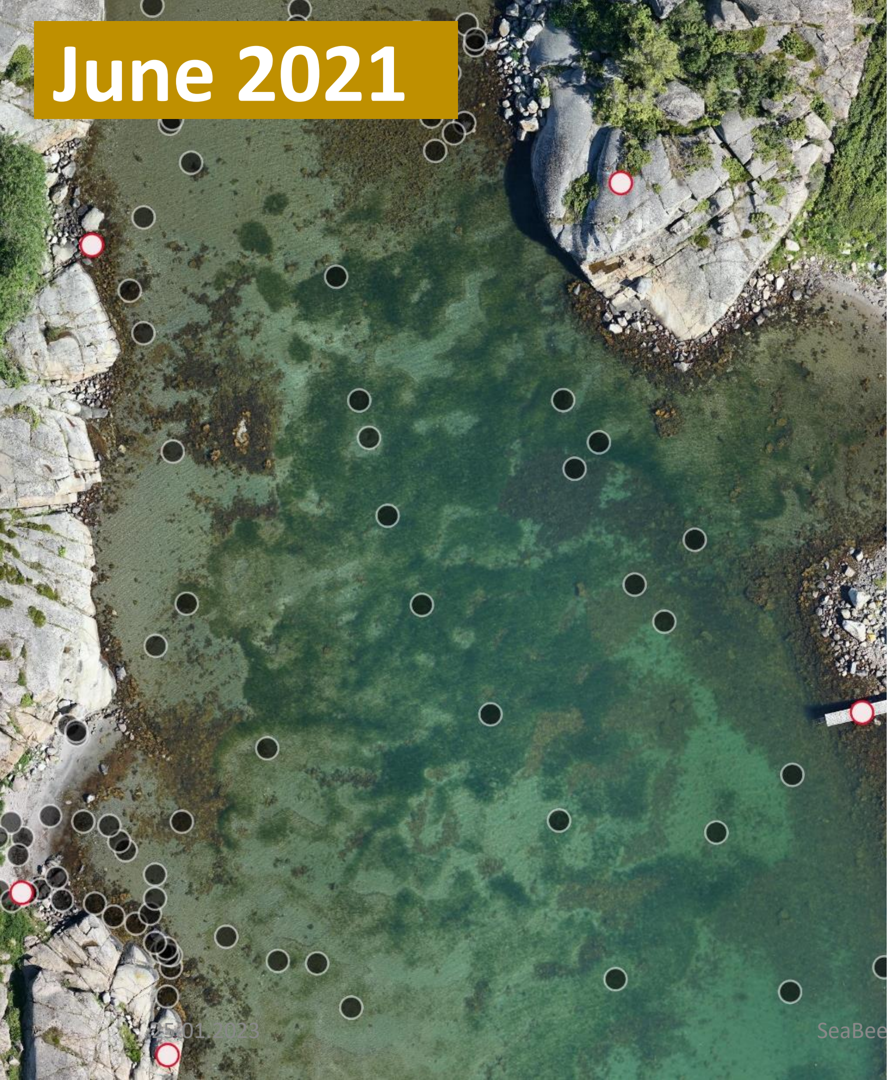
Selected benthic habitats – looking from a drone

- **Drone-based** remote sensing
- **<2 cm** pixel resolution
- **Multispectral (MSI)** og **hyper (HIS)** spectral data (this is a RGB overview)
- **AI/Machine learning (ML)** analysis



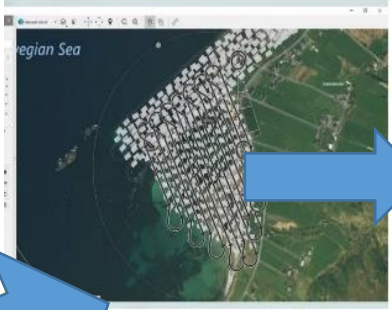
Gundersen et al. in prep

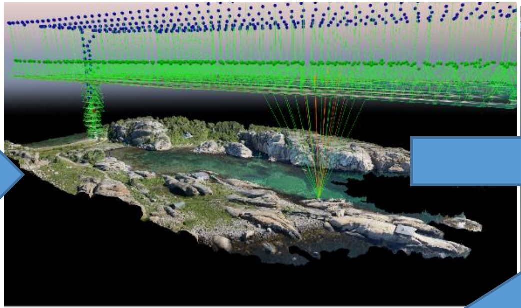
Selected benthic habitats – looking from a drone

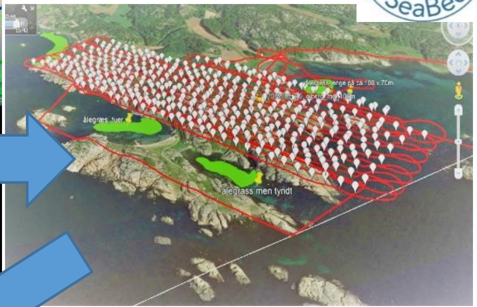

June 2021
SeaBee


Aug 2021
Hancke et al. in prep

How does it work? - Drones and sensors







DRY FACTS

- **Drones**: Fixed-wing and rotor-drone
- **Fly height**: 10 to 120 meters
- **Areal coverage**: 0.1 to 5 km^2 per day
- **Images**: ~3000 RGB/spectral per km^2 (video only for demonstration and visual overview)
- **Spectral coverage**: VIS + NIR (490, 550, 670, 700, 720, & 840 nm)
- **Spatial image resolution**: 0.5 to 12 cm pixel^{-1} (dependents on fly height)
- **Fly time**: 0.2 to 4 hours

How does it work? - Image analysis

‘Ordinary’ RGB analysis

Multi- and hyperspectral cameras

Machine Learning

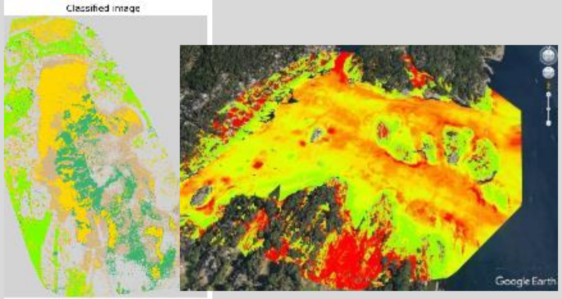
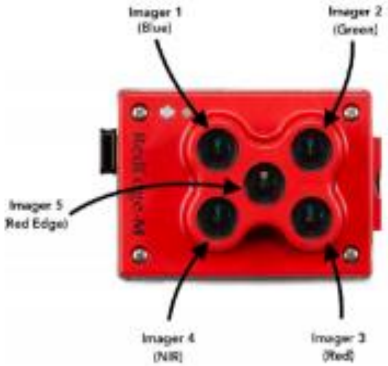
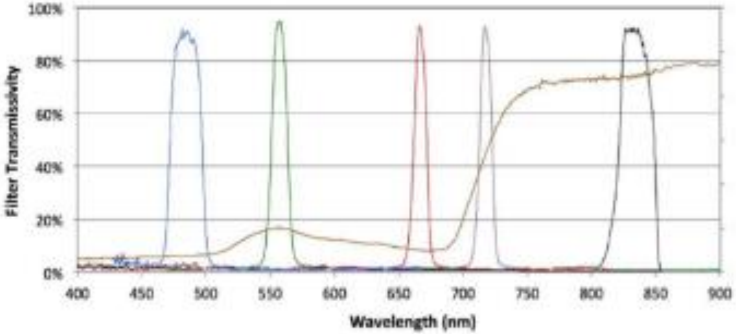
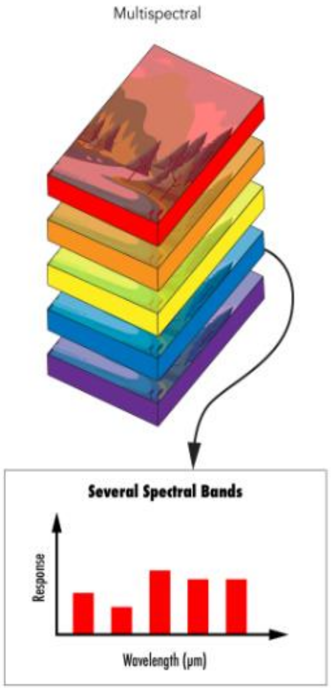


Image analysis Multispectral Imagery (MSI) data







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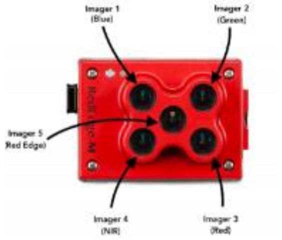
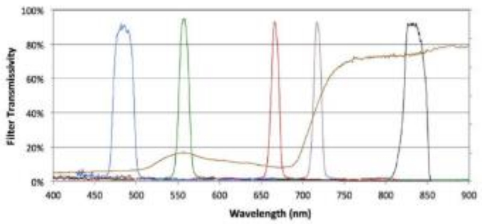
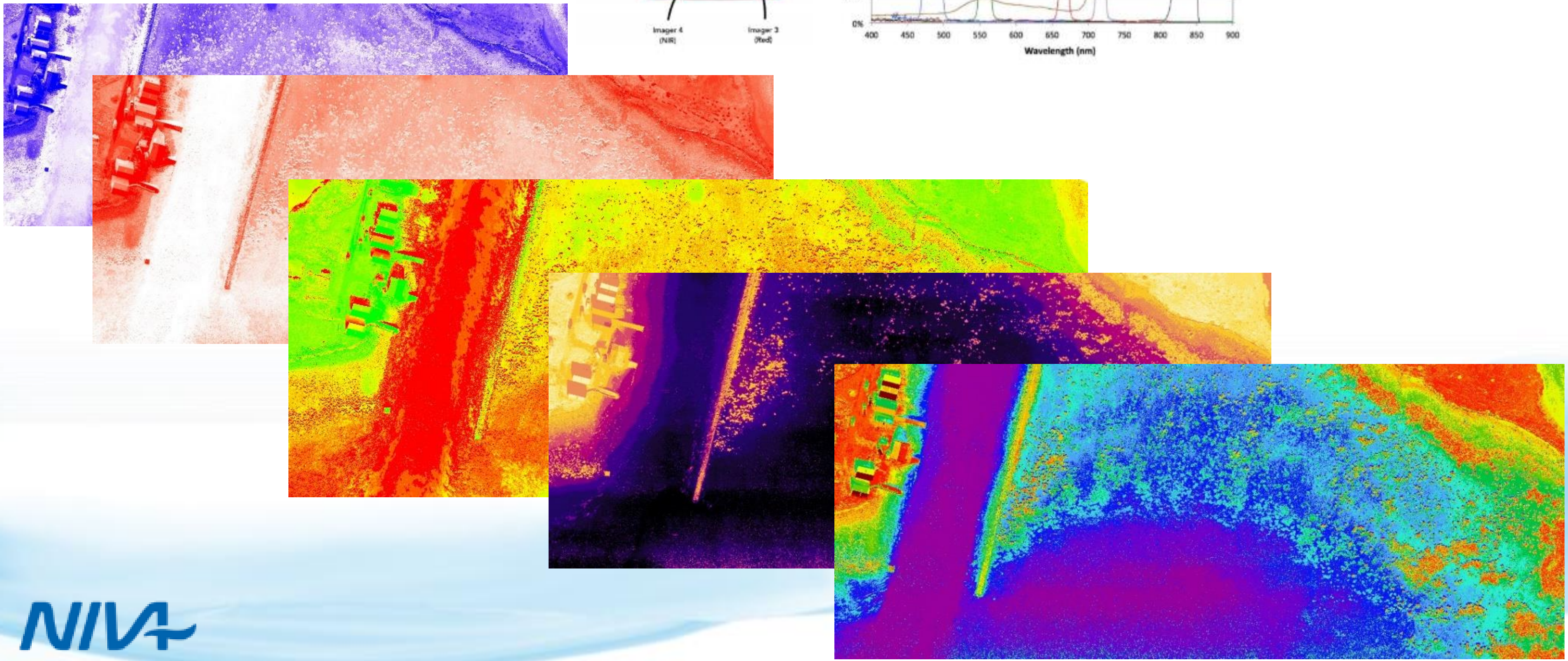




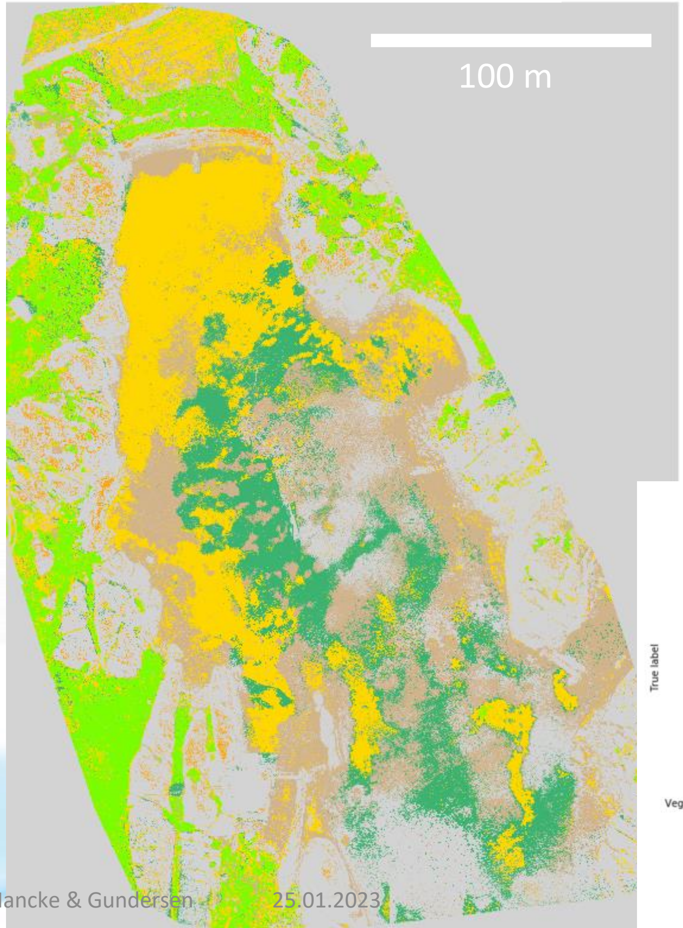


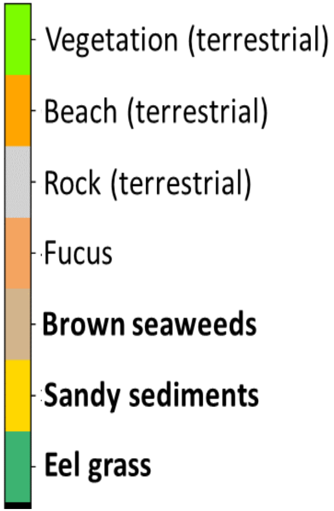
3D habitat modelling

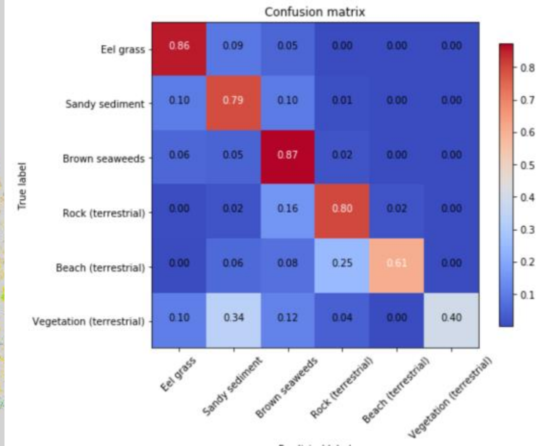
Analysis: Eelgrass and seaweed coverage mapping

Orthomosaic image (~500 single images)

Categorized mosaic image

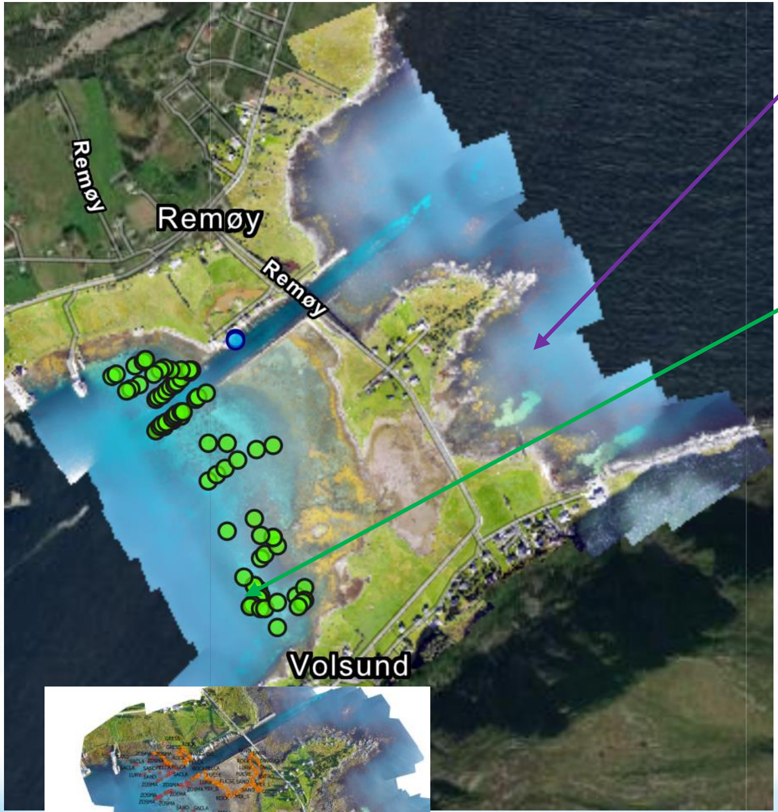


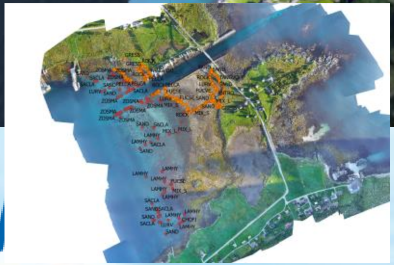




Hancke et al. in prep.

Extent of operations





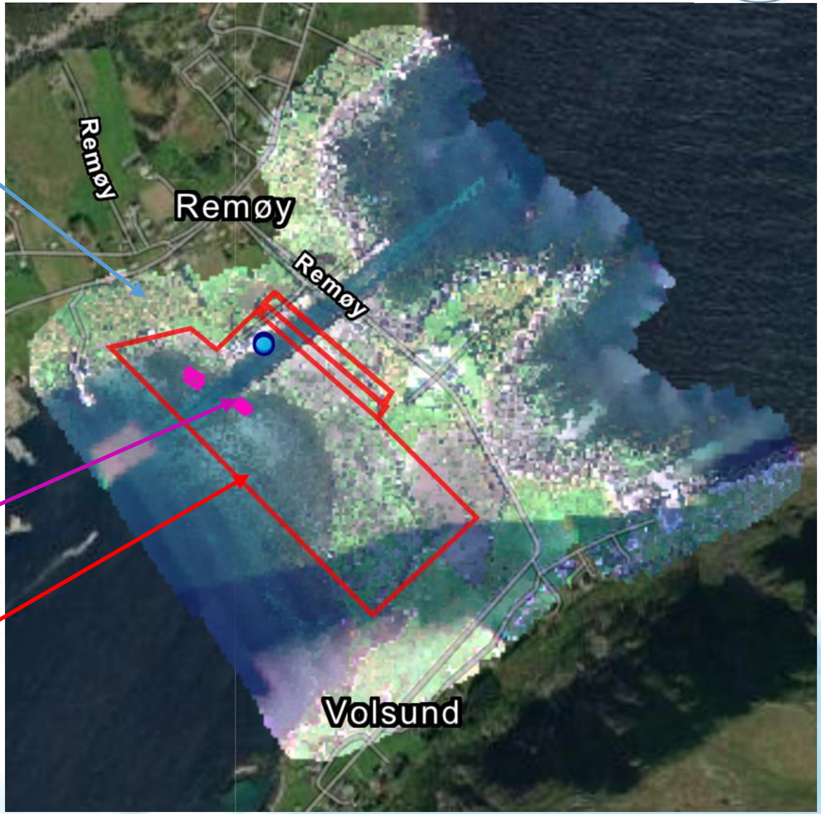
RGB 120 m

MS

Ground truth
Cm precision

Otter
(HSI, plan)

HIS area

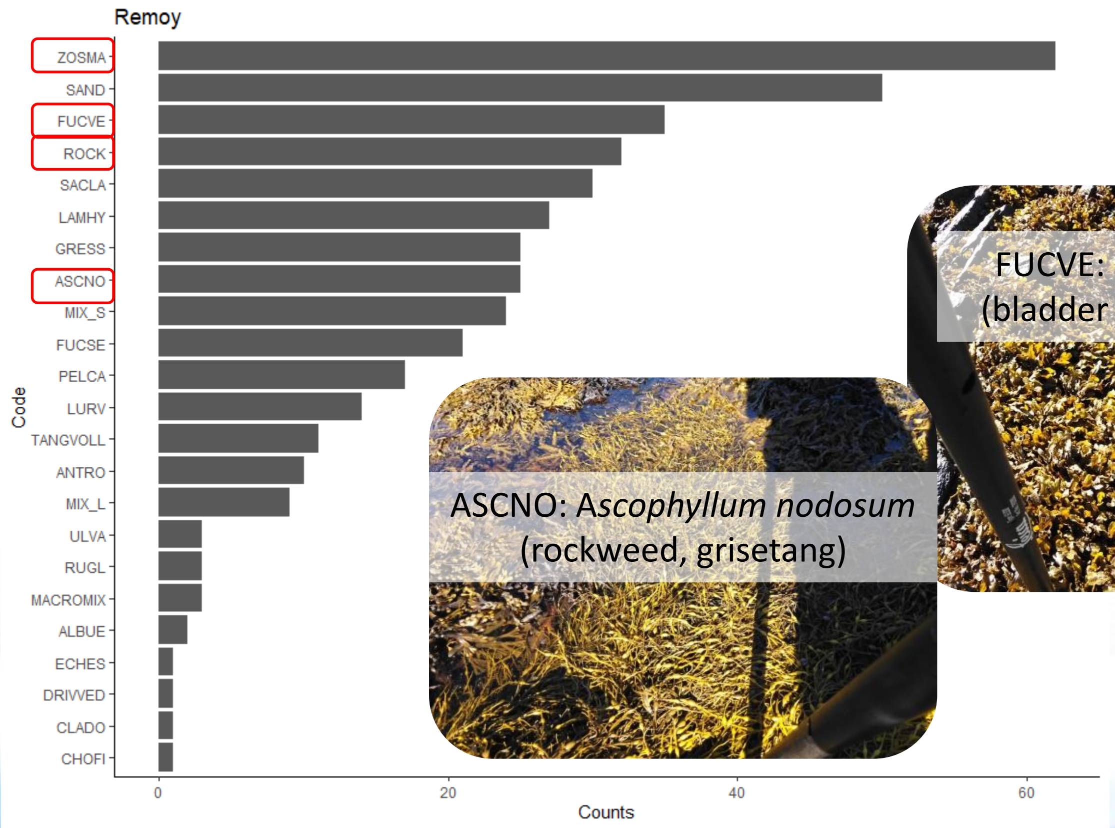


+ Ground truth Leica

+ Otter (NIVA)

SeaBee, in prep

Distribution in "habitat classes"



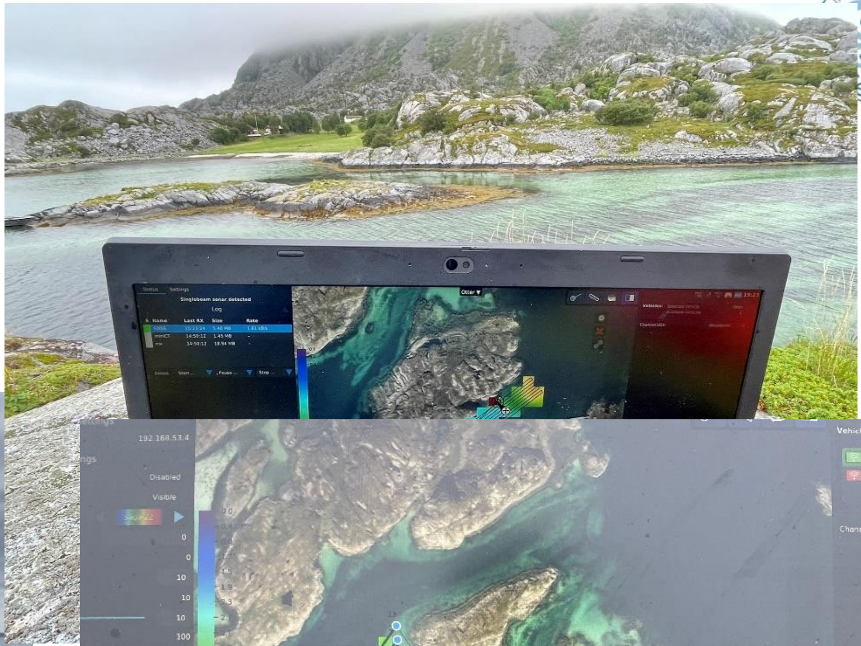
SeaBee, in prep

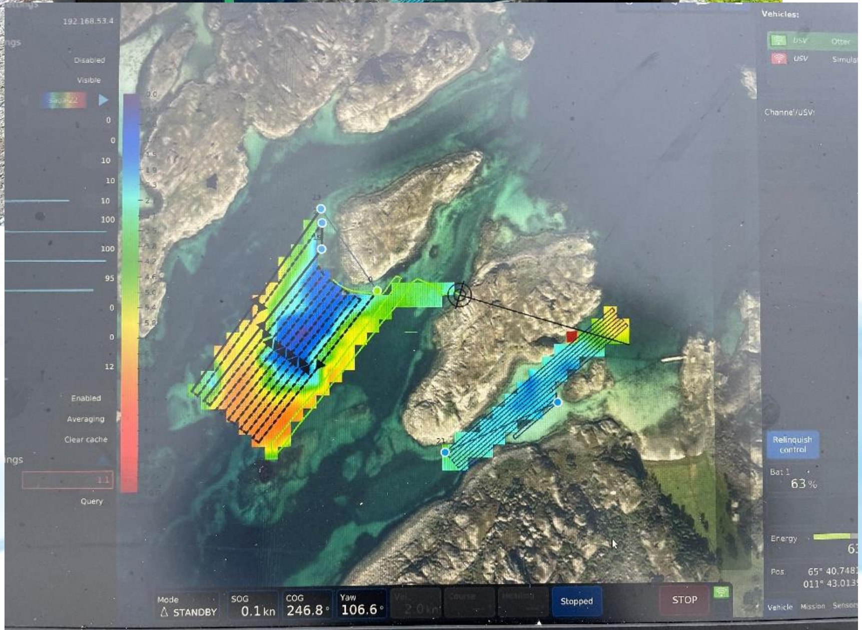
Autonomous Surface Vehicle (ASV) for benthic habitat mapping

Sensors

- **Acoustics** for bathymetry and habitat classification
- **Optics** for water column properties
- **Temp + sal.**
- **RTK – GPS** for high resolution positioning

Autonomous Surface Vehicle (ASV)





SeaBee - Norwegian Infrastructure for Drone-based Research, Mapping and Monitoring in the Coastal Zone

SeaBee hard facts

Duration: 2020-2025 + 2025-2030 (5+5 years)

Budget: 6 MEURO, funded by RCN Research Infrastructure

Contact: Kasper Hancke (NIVA, kasper.hancke@niva.no)

SeaBee RESEARCH INFRASTRUCTURE

www.seabee.no

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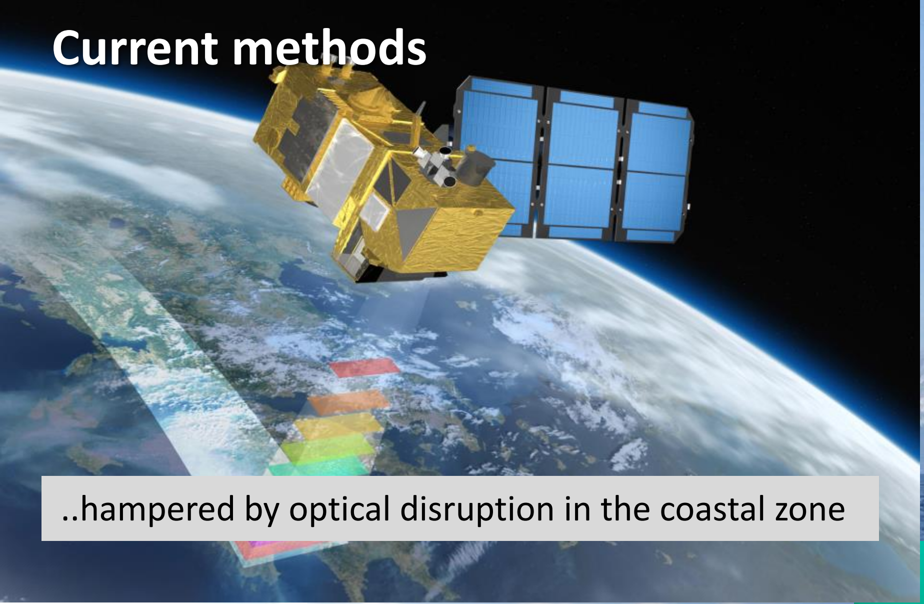
Industry partners

Andøya Space

TIEPOINT

SPECTROFLY

Current methods



..hampered by optical disruption in the coastal zone

.. don't go shallow (<10m)

.. labor intensive and cumbersome

.. limited spatial coverage

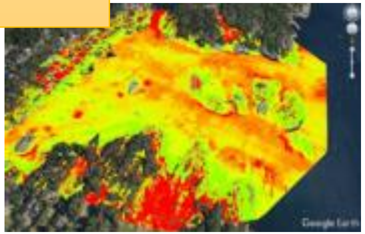
Aim of infrastructure project

SeaBee will establish a national center for drone-based services for use in coastal and aquatic research, mapping and monitoring

Primary objective:
Deliver a beyond state-of-the-art infrastructure to facilitate research on present and future environmental challenges in coastal ecosystems, using portable flying drones, machine learning and cloud-based data sharing technology

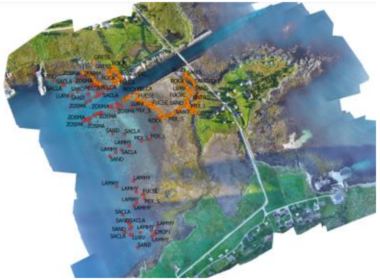
In other words:
We will develop a cost-efficient toolbox for environmental research and monitoring



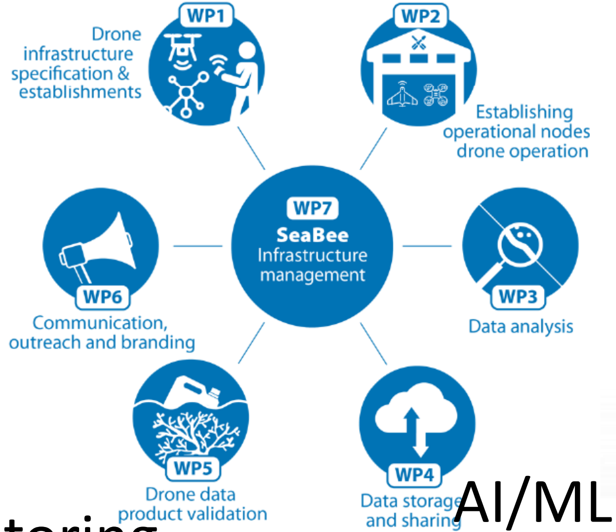



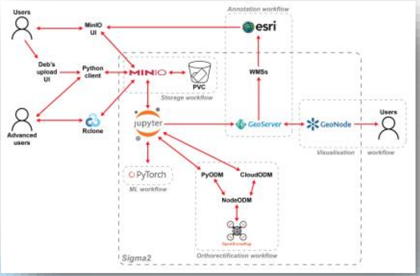
Infrastructure components

Visualization



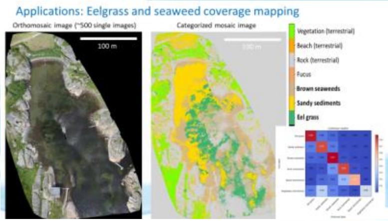
Drones and sensors





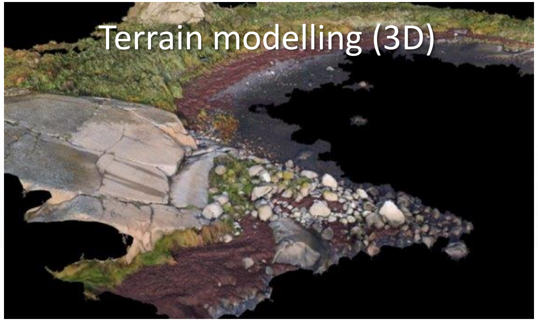
Data storing

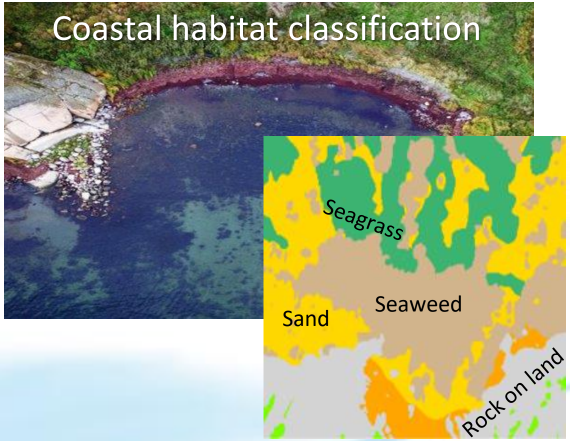
AI/ML data analysis



NIVA

Applications using drones

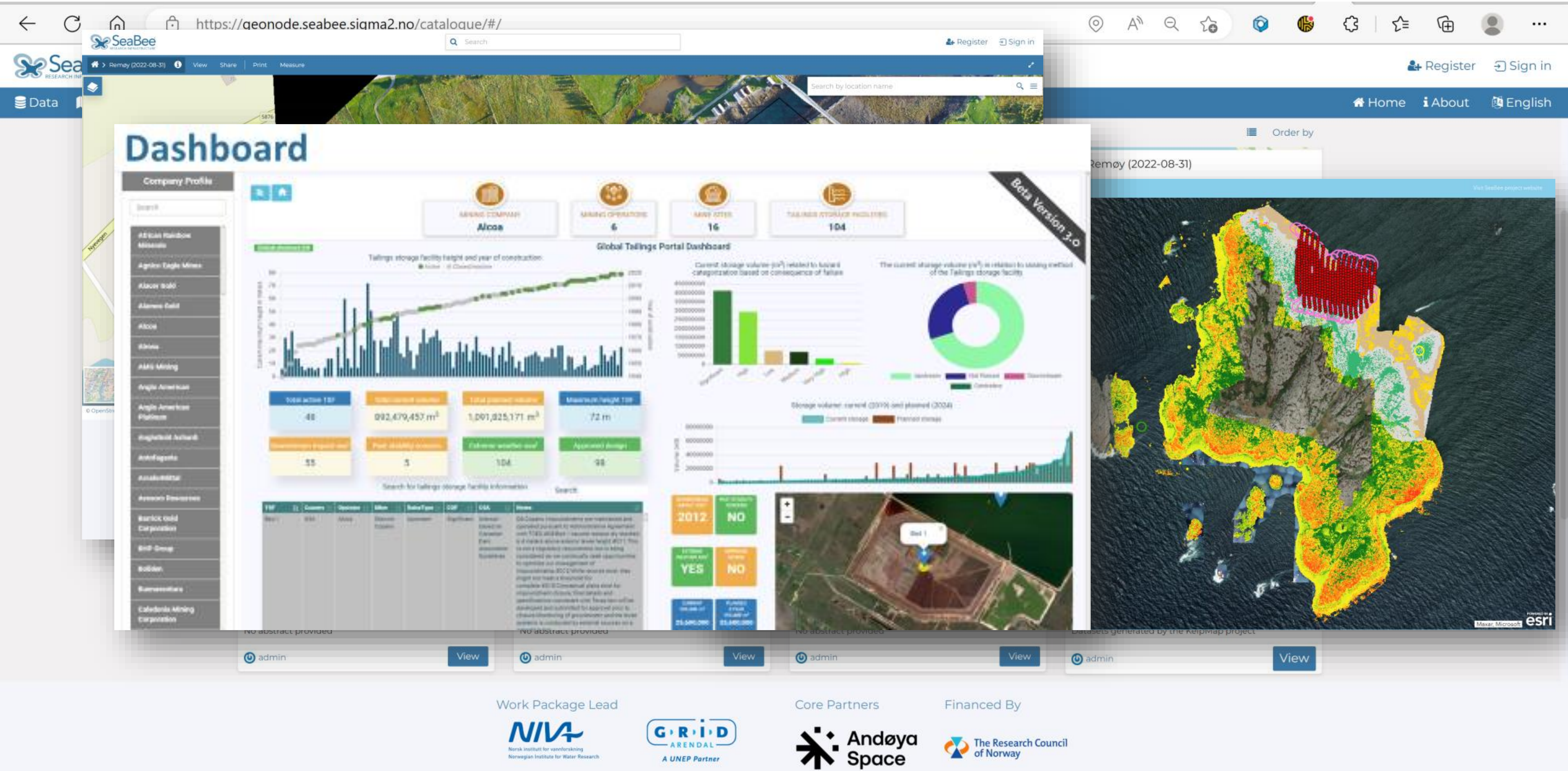




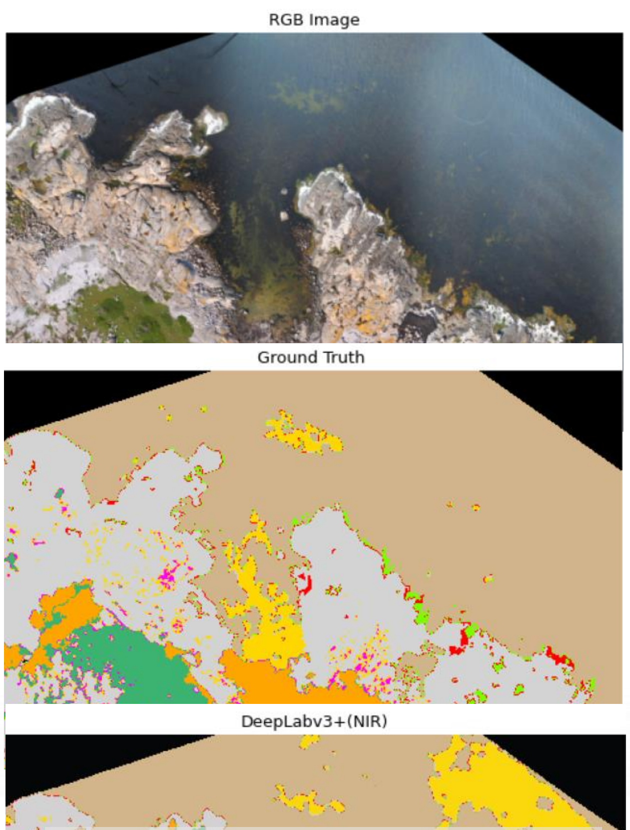
NIVA

SeaBee
RESEARCH INFRASTRUCTURE

SeaBee data visualization platform – work in progress



Quantifying marine litter
(Torsvik et al 2020)



Coastal habitat mapping with UAV multi-sensor data
(Lui et al., 2022)

Quantifying beach casts carbon deposits
(Li et al., 2023)

Summing up – SeaBee and drones for habitat mapping
Aims for the real world….

- **Flying and surface drones** offers a novel tool to aquatic research, mapping and monitoring

- Combined with **sensor technology**, **machine learning** and **data visualization** it provides cost-efficient solutions

- **SeaBee** – a new Norwegian research infrastructure – will deliver novel solutions for research and managing of **coastal habitats, animal populations, climate** and **environmental impacts** and **pollution clean-ups**

Thank you for your attention

Please visit www.SeaBee.no for more information

Acknowledgement to (at least):
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