RAPID JELLYFISH DETECTION

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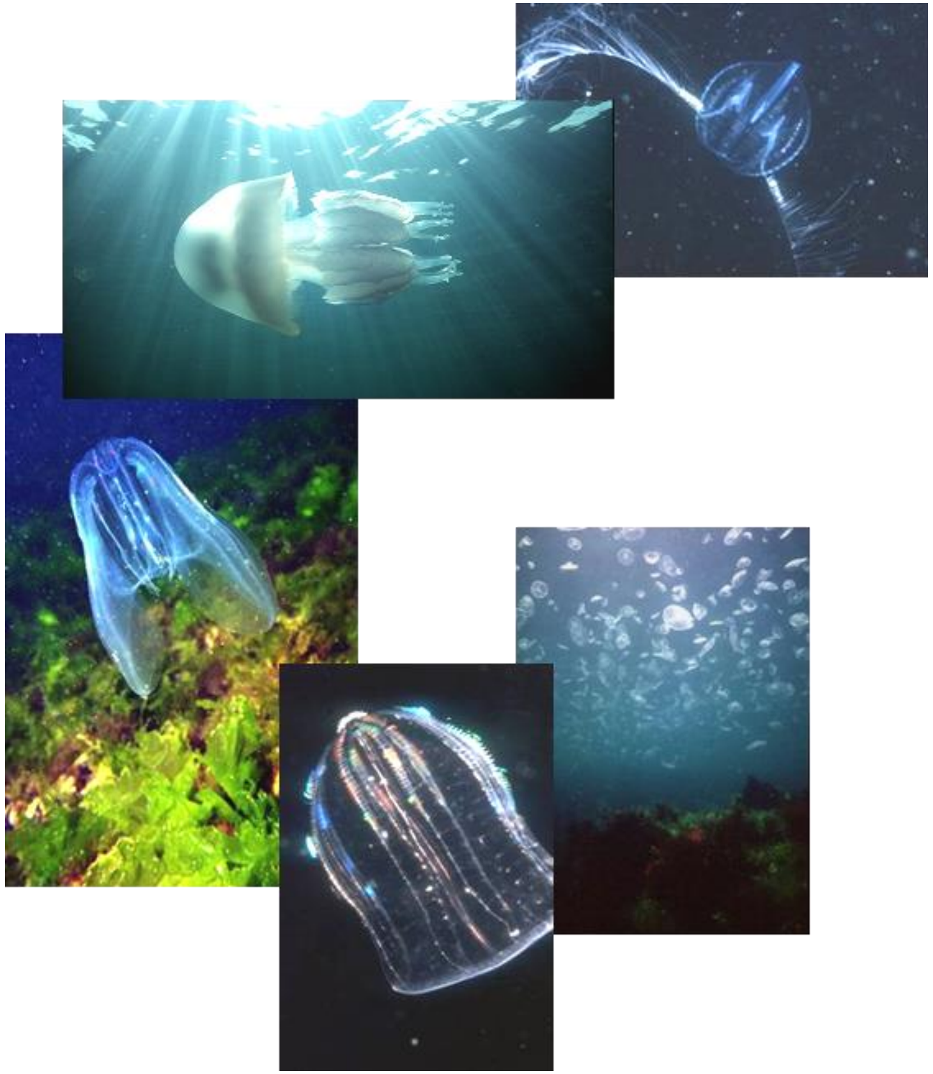
Background

Jellyfish are attracting growing global attention due to the severe impact of blooms on local ecosystems and, in some species, the medical and economic consequences of their painful and potentially deadly stings. In various regions, a sharp rise in the number and density of scyphozoan species has led to fishery collapses and substantial losses in aquaculture

Jellyfish often form dense aggregations and significantly influence ecosystem processes, affecting predation and competition, enhance carbon transfer to the deep waters, and alter the dissolved organic matter pool that sustains the microbial loop

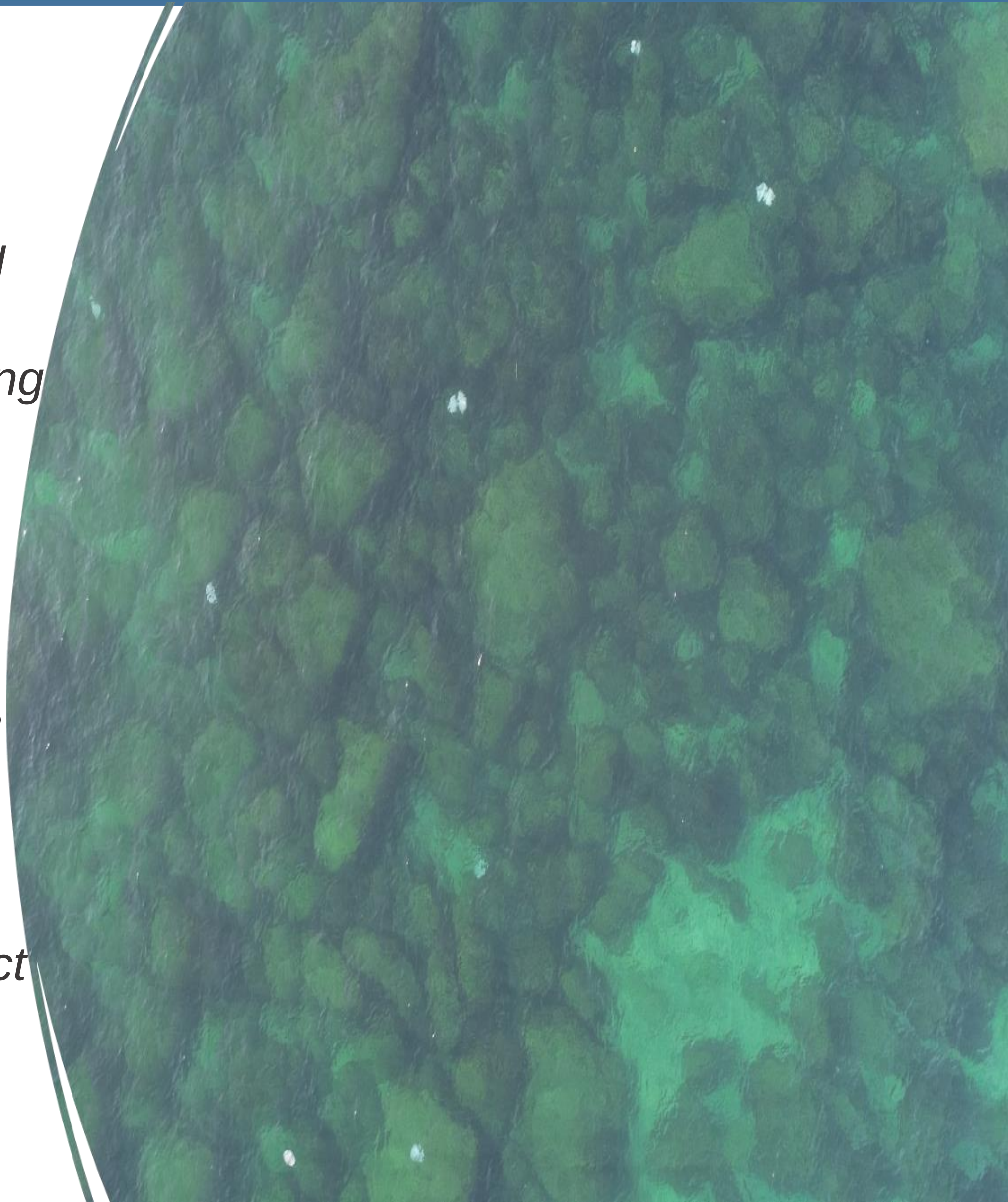


Photos: Lyubomir Klisurov

Research and Innovation Questions

In the beginning

- *Can drones detect and quantify jellyfish blooms more efficiently and non-invasively than traditional methods? How reliable are drone-derived estimates of jellyfish biomass compared to classical sampling techniques?*
- *What are the optimal technical parameters (altitude, camera/sonar settings, software) for aerial and underwater jellyfish monitoring?*
- *What are the benefits and limitations of combining UAV and ROV technologies for vertical and spatial jellyfish distribution monitoring?*
- *Can machine learning improve jellyfish detection and reduce post-processing time?*
- *What is the potential for real-time alerts for jellyfish blooms to protect fisheries, tourists, and aquaculture?*

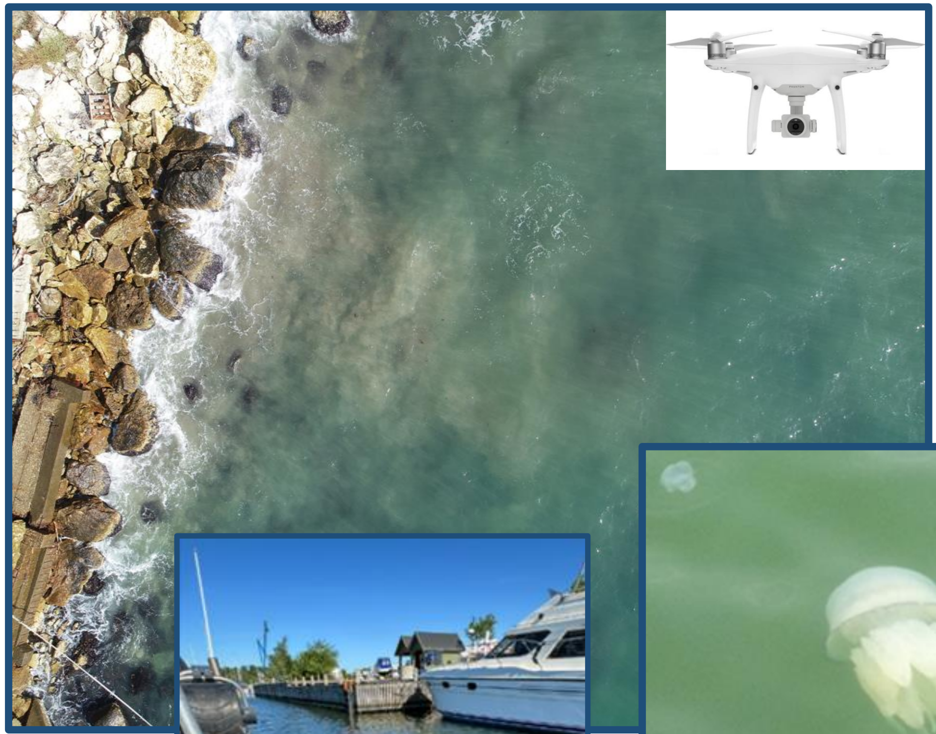


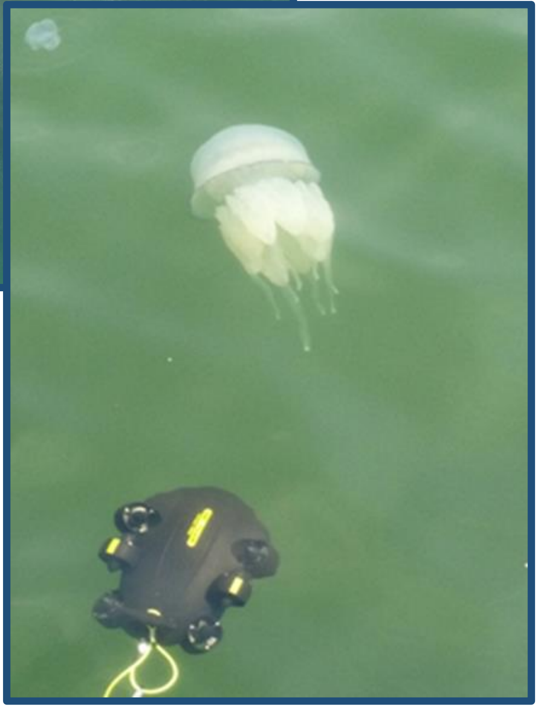
Specific Aims

Develop and validate an innovative, non-invasive jellyfish monitoring system for the Black Sea

Demonstrate operational feasibility and accuracy across coastal zones

Integrate results into early-warning systems and policy-relevant marine management tools





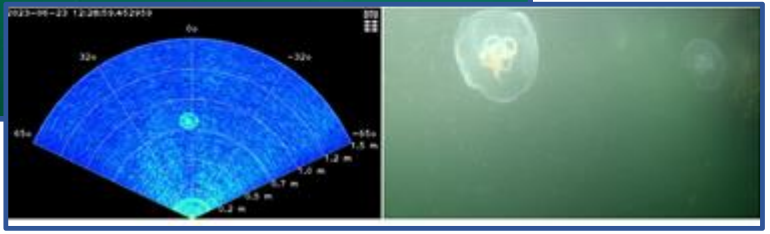
Technology Overview

UAVs

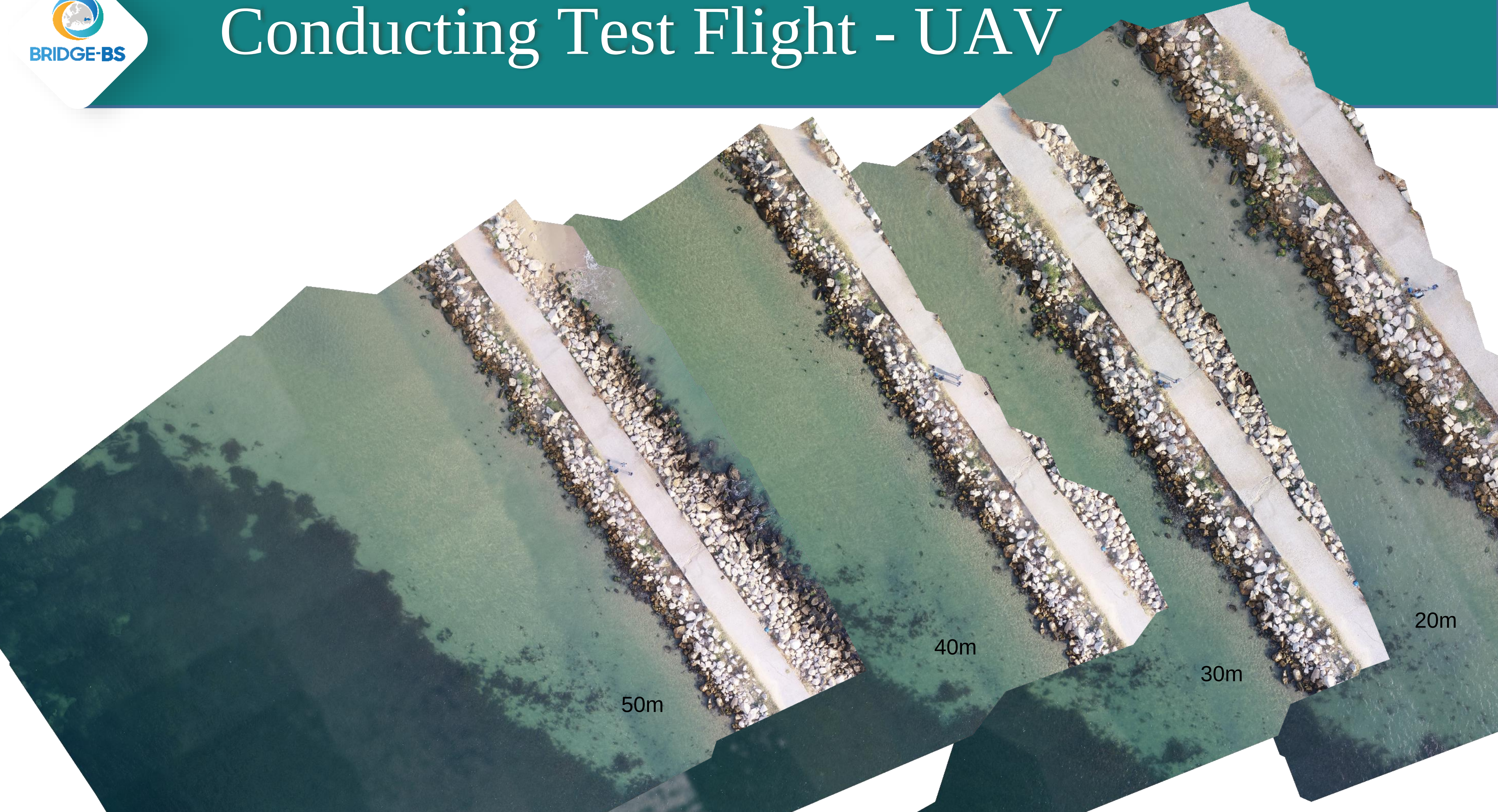
- Detect jellyfish aggregations in **shallow, coastal waters**
- Equipped with **RGB cameras**

ROVs or AUVs

- Deployed below the surface
- Capture close-up footage or sonar imaging of jellyfish in 3D space



Conducting Test Flight - UAV



Technology Overview - UAV

Orthophotomosaic generation - AgiSoft v1.8.4

Mission design and flight

PIX4Dcapture Pro

Image processing to map generation

Selection of area to perform the jellyfish detection

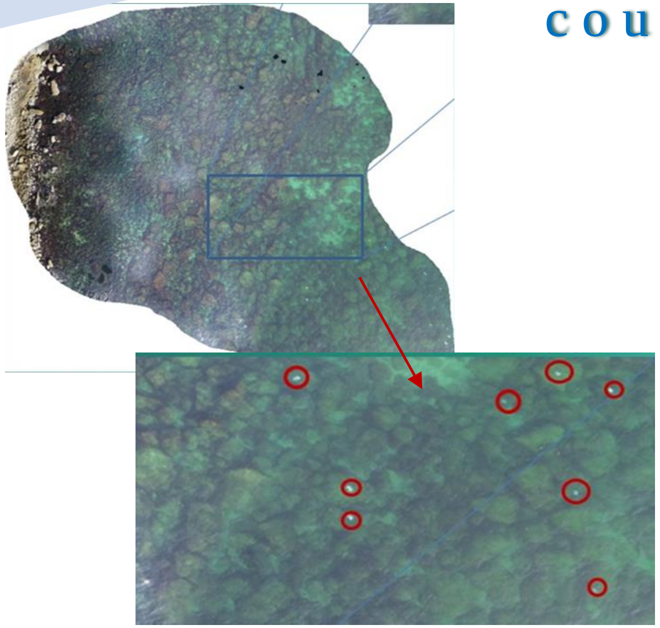
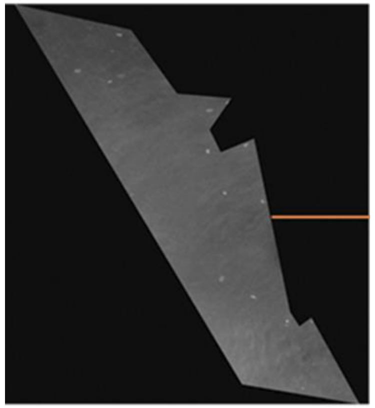


Image post -procession - QGIS

Image segments preprocessing

Automatically detection and counting (ImageJ)



Technology Overview – underwater

UNDERWATER DRONE

Mission Design

Mission Accomplishment - video footage recording

Post-processing of video records

UNDERWATER ACOUSTIC DETECTOR

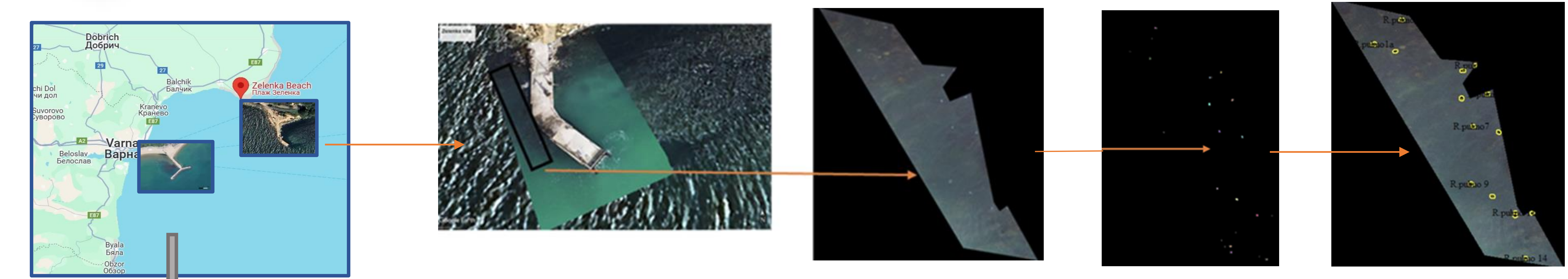
Evaluation of sonar solutions

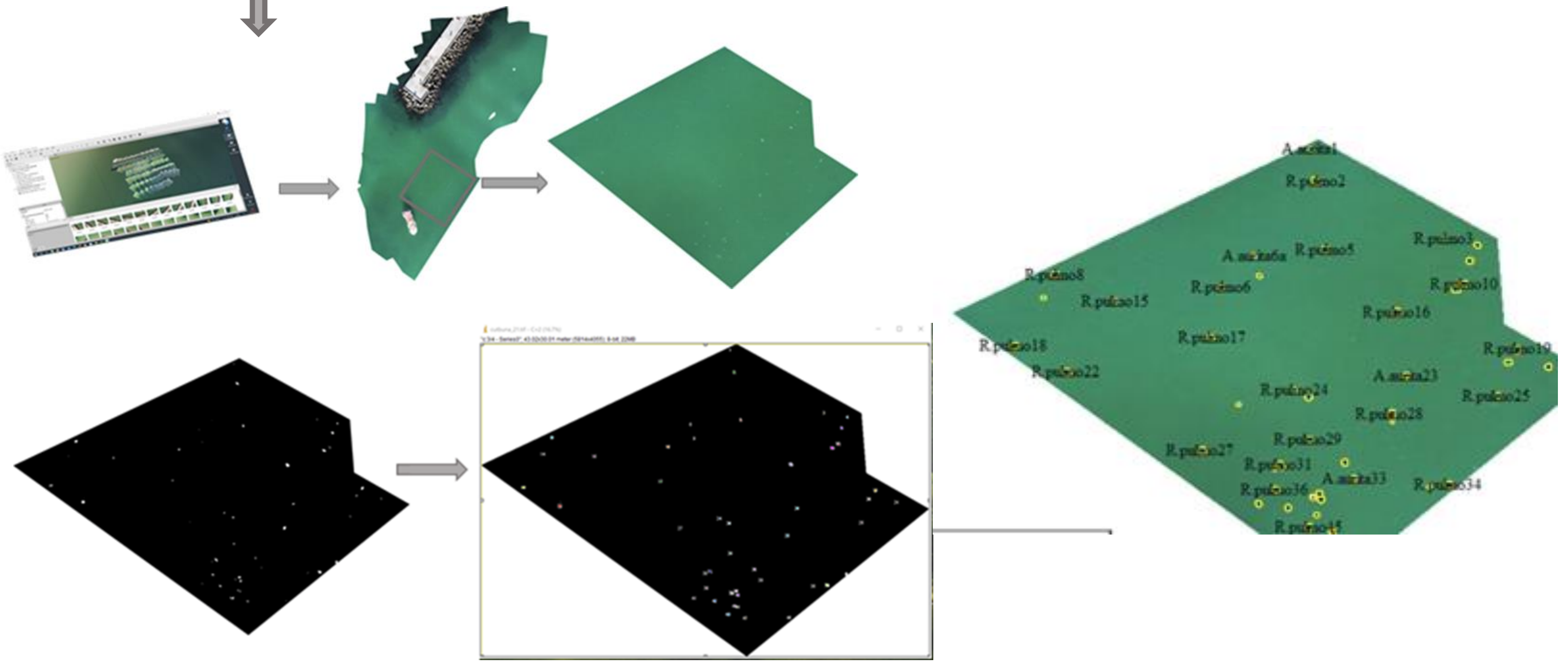
Development of Sonar Support System (SSS)

Field trials of jellyfish detection system at longer range

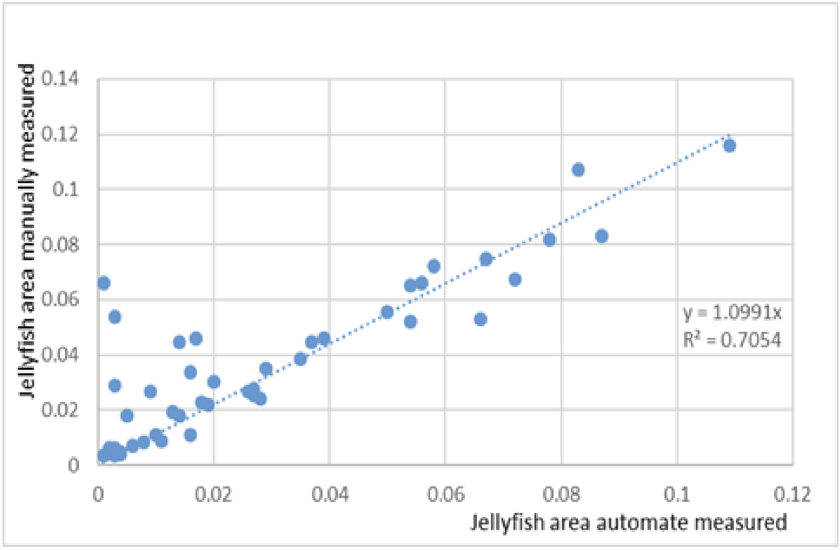
Evaluation of collected data for jellyfish detection

Demonstration – Key Results UAV





Data validation



Demonstration – Key Results UAV

Biomass calculation - empirical relationships between bell diameter (D), area (A), and wet weight (WW) for Rhizostoma pulmo (Fuentes et al., 2011) and Aurelia aurita (Shiganova etal, 2021) were used.

Data processing - obtained area of each identified jellyfish specimen allows the diameter of the individual to be determined

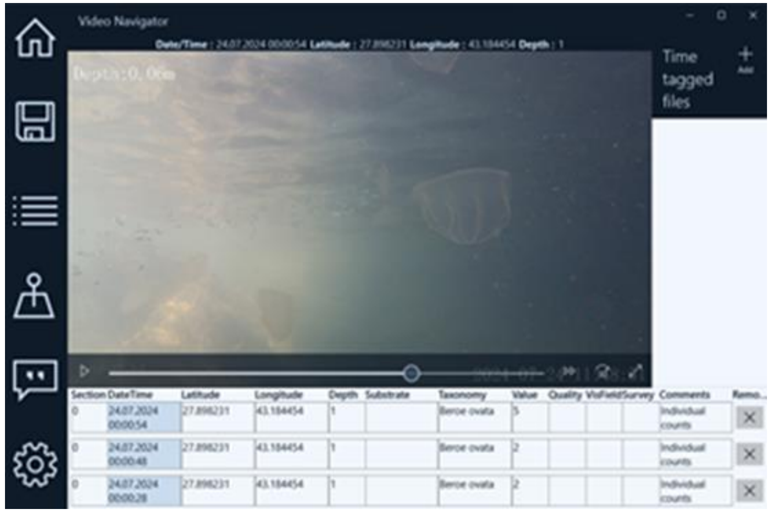
Diameter [cm]≈ 2 × sqrt (area / π)

Consequently - wet weight calculation

WW [kg] =0.0014D^2.5 (for R. pulmo)

*WW [mg] =0.05*D^2.99 (for A. aurita)*

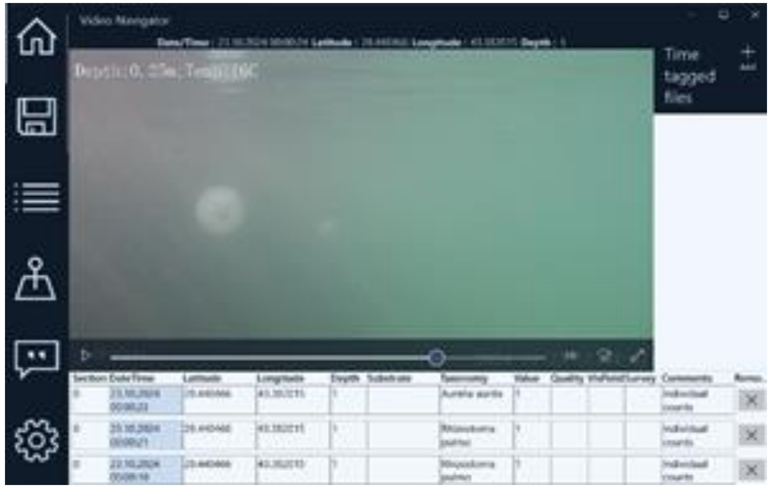
Demonstration – Key Results ROV

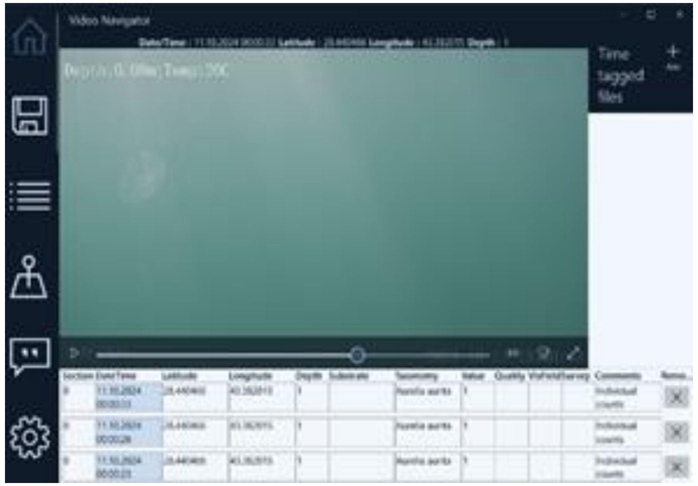


Due to the lack of spatial scaling, results focus on relative abundance rather than absolute density. Key metrics include:

- Number of jellyfish per time interval
- Encounter rate (e.g., individuals per minute)
- Frequency of presence

These metrics allow comparison between stations, depth zones, or time periods, and can serve as indicators of bloom activity or distribution patterns.



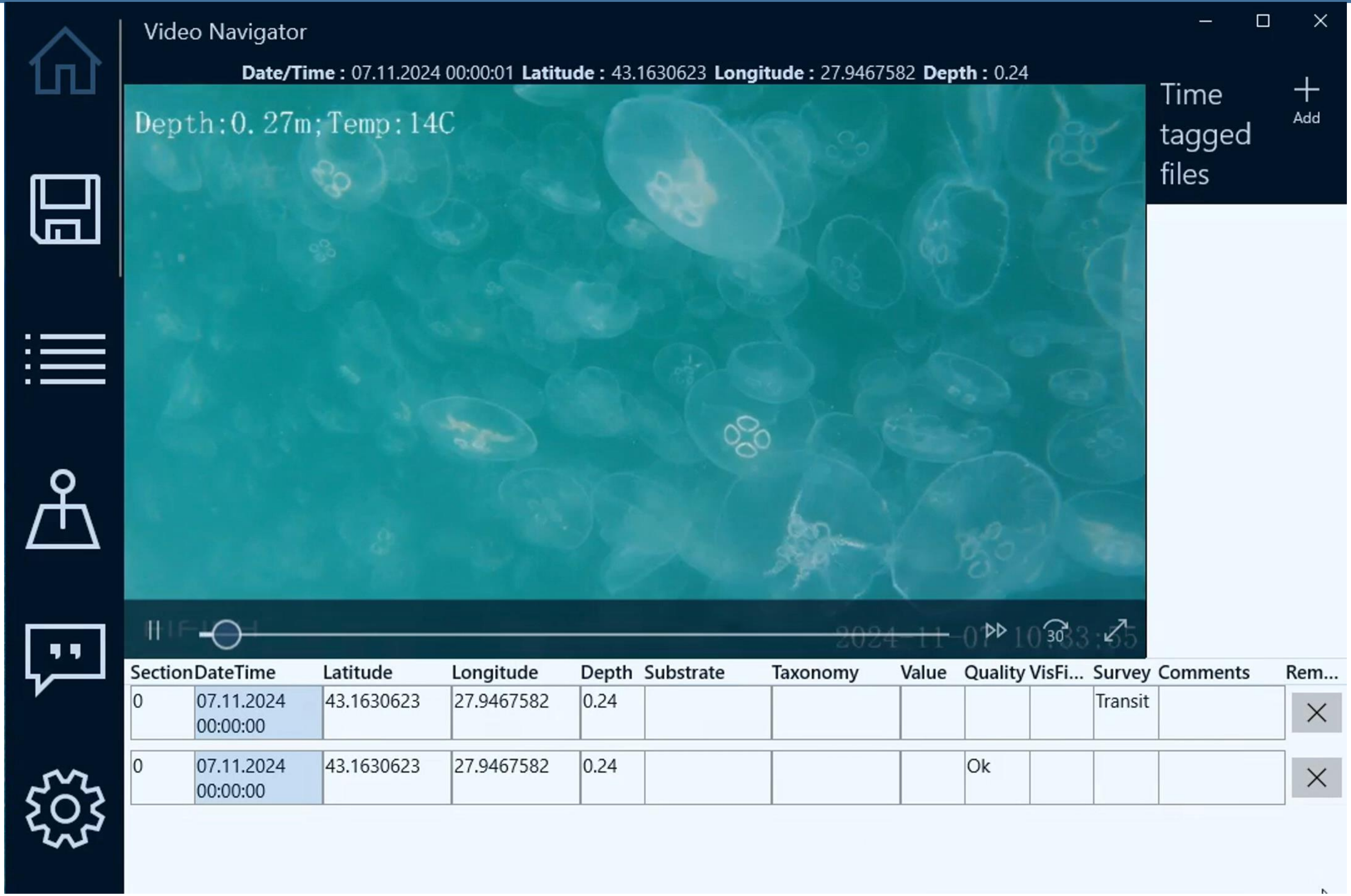


Date	Time	Latitude	Longitude	Depth	Taxonomy	Value	VideoQuality	VisualField	SurveyMode	Comments
26.6.2024	0:00:02	27.898231	43.184454	1						sea snow
26.6.2024	0:00:02	27.898231	43.184454	1			Poor			
26.6.2024	0:00:02	27.898231	43.184454	1					Transit	
26.6.2024	0:00:14	27.898231	43.184454	1	*A. aurita*	1		Individual counts		
26.6.2024	0:00:17	27.898231	43.184454	1	*M. leidyi*	1		Individual counts		
26.6.2024	0:00:25	27.898231	43.184454	1	*M. leidyi*	1		Individual counts		
26.6.2024	0:00:42	27.898231	43.184454	1	*M. leidyi*	1		Individual counts		
26.6.2024	0:00:43	27.898231	43.184454	1	*M. leidyi*	1		Individual counts		
26.6.2024	0:00:51	27.898231	43.184454	1	*M. leidyi*	1		Individual counts		
26.6.2024	0:00:52	27.898231	43.184454	1	*M. leidyi*	1		Individual counts		
26.6.2024	0:01:05	27.898231	43.184454	1	*M. leidyi*	1		Individual counts		
26.6.2024	0:01:12	27.898231	43.184454	1	*M. leidyi*	1		Individual counts		
26.6.2024	0:01:26	27.898231	43.184454	1	*M. leidyi*	3		Individual counts		
26.6.2024	0:01:39	27.898231	43.184454	1	*A. aurita*	1		Individual counts		
26.6.2024	0:01:40	27.898231	43.184454	1	*A. aurita*	1		Individual counts		
26.6.2024	0:01:40	27.898231	43.184454	1	*M. leidyi*	4		Individual counts		
26.6.2024	0:01:43	27.898231	43.184454	1	*A. aurita*	2		Individual counts		
26.6.2024	0:01:58	27.898231	43.184454	1	*M. leidyi*	1		Individual counts		
26.6.2024	0:02:06	27.898231	43.184454	1	*M. leidyi*	1		Individual counts		
26.6.2024	0:02:16	27.898231	43.184454	1	*M. leidyi*	1		Individual counts		
26.6.2024	0:02:43	27.898231	43.184454	1	*M. leidyi*	1		Individual counts		

VideoNavigator tool (vs. 2.133.0)

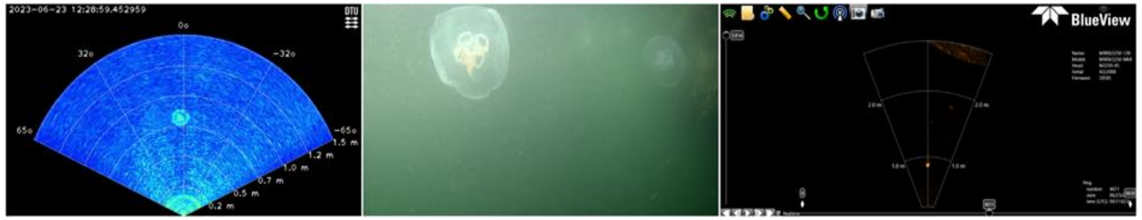
Demonstration – Key Results

ROV

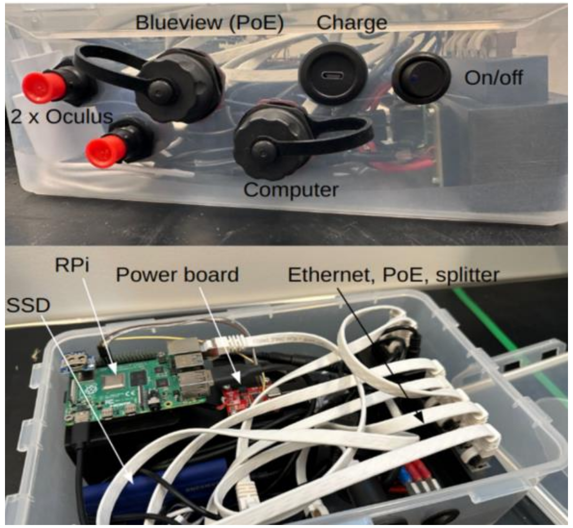


Demonstration – Key Results AUV

Two Forward Looking Sonar (FLS) echosounders FLS for evaluation: the Oculus M750d from Blueprint Subsea and the BlueView m900-2250-130-mk2 from Teledyne Marine



View of Moon Jelly and corresponding sonar views from M750d (left) and M900-2250-130-Mk2 (right). The M750d resolves the jellyfish with more detail, since the BlueView uses more filtering functions to boost signal to noise.



Second SSS prototype, capable of supporting multiple sonar heads at once

Development of Sonar Support System (SSS)

To support the FLS for compliance with specifications 2-5, a lightweight computer, storage, and power delivery system is required. Between 2023 and 2024, two prototype SSS's were developed

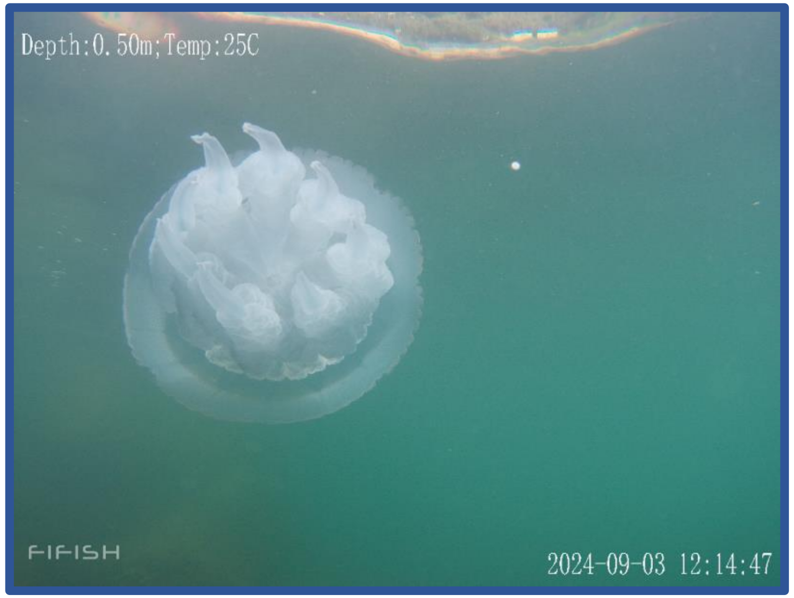
The system is demonstrated to work well in a simulated environment of the Black Sea

DTU results

Advantages & Disadvantages

Method	Pros	Cons
UAV (Drones)	✓ Non-invasive ✓ Wide area coverage High-resolution imagery for ID ✓ Cost-effective for long-term monitoring ✓ Real-time data collection	✓ Limited to surface observations ✓ Weather dependent (e.g., wind, rain) ✓ Limited battery life ✓ Surface reflection/turbidity may obscure visuals ✓ Requires skilled operators and post-processing

The use of UAVs in jellyfish monitoring serves a dual role as both a demonstrator of innovative marine assessment technologies and a valuable component of early warning systems. As demonstrators, UAVs showcase the feasibility and effectiveness of non-invasive, real-time monitoring methods, making them ideal tools for pilot studies, public engagement, and stakeholder education.



ROV

Aspect	*Advantages*	*Disadvantages*
Data Quality	High-resolution video and images Real-time observation	Jellyfish transparency affects visibility
Environmental impact	Non-invasive method with minimal jellyfish disturbance	Bright lights or propeller noise may still affect sensitive species
Integration	Can be combined with UAVs for surface + underwater coverage	Data synchronization across platforms requires extra planning
Data Processing	Frame extraction enables photogrammetry and detailed analysis	Processing is time-consuming With high storage requirements
Logistics	Portable and easy to deploy in small boats or coastal zones	Limited battery life Needs skilled operator
Cost	Long-term investment for repeated use across multiple projects	High initial cost and maintenance expenses

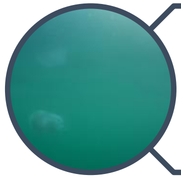
Implications of Results

- Scientific - new ecological insights into jellyfish distribution patterns across space and depth.
- Operational - viable replacement or complement to costly and invasive net sampling.
- Technological - progression toward fully automated, AI-enhanced marine monitoring systems

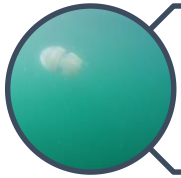
End Users and Applications

Fisheries & Aquaculture Operators: Early alerts to jellyfish threats to stock and nets

Tourism Authorities: Real-time bloom detection to ensure swimmer safety



Environmental Agencies: Cost-effective monitoring for marine biodiversity and invasive species.



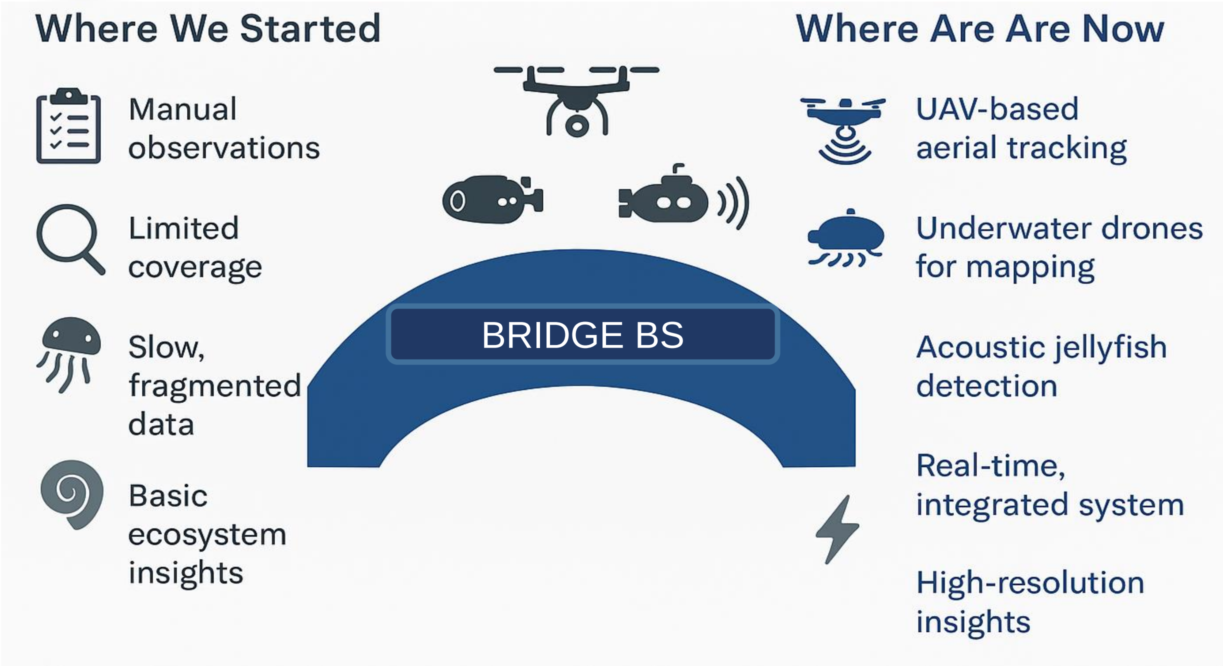
Policy Makers: Evidence-based management under EU directives (e.g., MSFD).

Public Engagement: Visual drone data supports citizen awareness and education

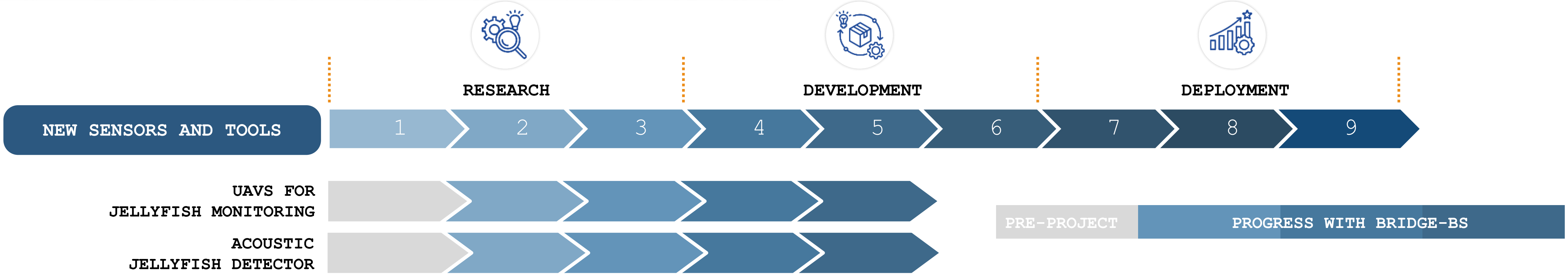
Broader Policy and Upscaling Potential

- Direct alignment with **EU Green Deal**, **Biodiversity Strategy**, and **MSFD**.
- Scalable across **other semi-enclosed seas** (e.g., Mediterranean, Adriatic, Baltic).
- Methodology transferable to other surface-visible species and floating pollution (e.g., marine litter).
- Supports **transboundary monitoring frameworks** (e.g. Black Sea Commission)

BLACK SEA TECHNOLOGICAL READINESS LEVEL (TRL)



To fully integrate unmanned vehicles and automated monitoring systems into operational marine observation programs, it is critical to advance the technology beyond initial prototypes and proof-of-concept demonstrations. Specifically, efforts should now focus on reaching Technology Readiness Levels (TRL) 6 and 7—where technologies are demonstrated in relevant environments and validated under operational conditions.
From observation to innovation – BRIDGE is transforming marine monitoring.



Next Steps and Investment Needs

Technological Advancement

- Improve AI-driven jellyfish recognition for automated real-time alerts.
- Extend drone operations to deeper zones.
- Enhance integration of aerial and underwater data streams.

Investment & Support Needs

- Funding for drone upgrading, robust field testing across regions and seasons.
- Access to advanced UAV/ROV platforms and high-performance computing infrastructure.
- Support for capacity building and training of operators.
- Cross-border collaboration to harmonize protocols and share data regionally

Conclusions

\+

= **New Era of Jellyfish Monitoring**

UAV **ROV/AUV**

- Cost-effective, scalable, real-time marine biodiversity management
- Help us scale this technology to protect marine ecosystems and economies

THANK YOU!

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