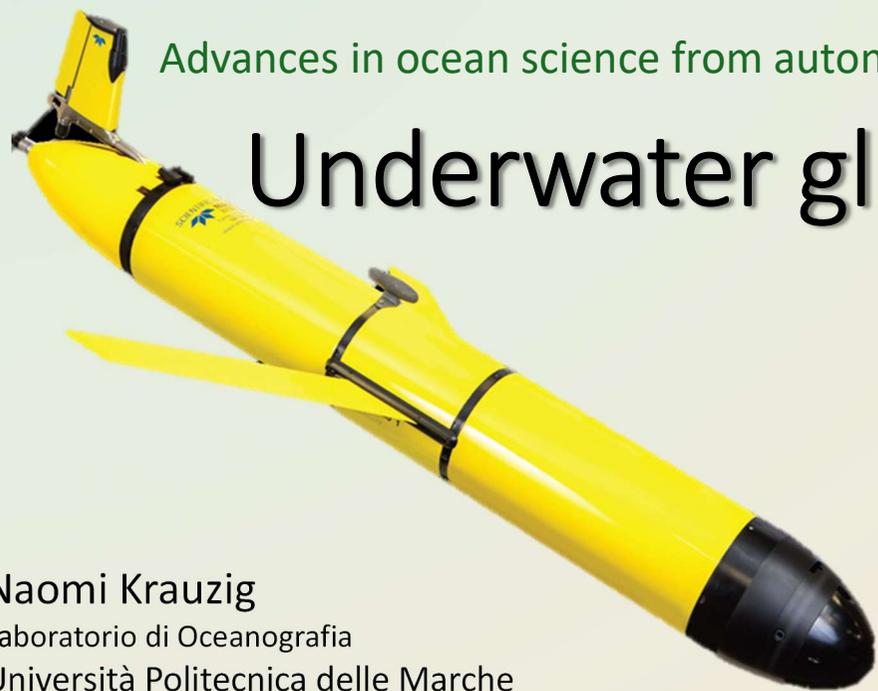




Advances in ocean science from autonomous gliders



# Underwater gliders

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Laboratorio di Oceanografia

Università Politecnica delle Marche

Autonomous Instruments in Oceanography

Università degli Studi di Napoli Parthenope

10-14 February 2025

**IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System**

(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-  
Mission 4 "Education and Research" - Component 2: "From research to business" - Investment  
3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"



Finanziato  
dall'Unione europea  
NextGenerationEU



Ministero  
dell'Università  
e della Ricerca



## Contents

### **1) Introduction to underwater gliders**

*Overview, history, design  
Principles of operation*

### **2) Technical aspects and instrumentation**

*Energy efficiency, communication & navigation system and scientific sensors*

### **3) Real-life applications and usages in different disciplines**

*Capabilities and insight into diverse glider operations  
Exercise on realistic mission planning with the GLIMPSE simulation software*

### **4) Glider data analysis and interpretation**

*Data output, existing processing tools and community efforts  
Practical session with sample data from recent missions*

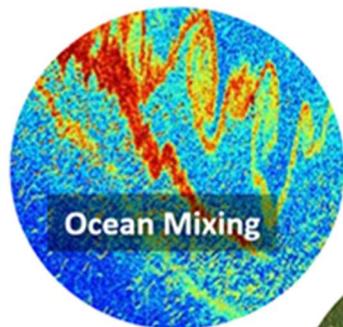
### **5) Challenges, innovations and future perspectives**

*Current limitations and challenges, tips and tricks  
Ongoing innovations and future directions in glider technology*

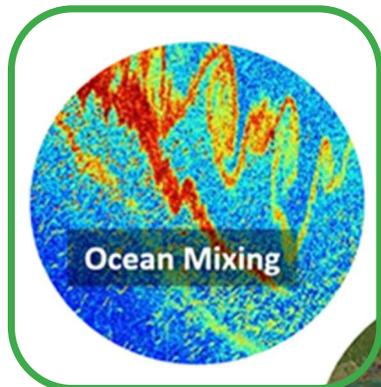
# Capabilities & applications in different disciplines



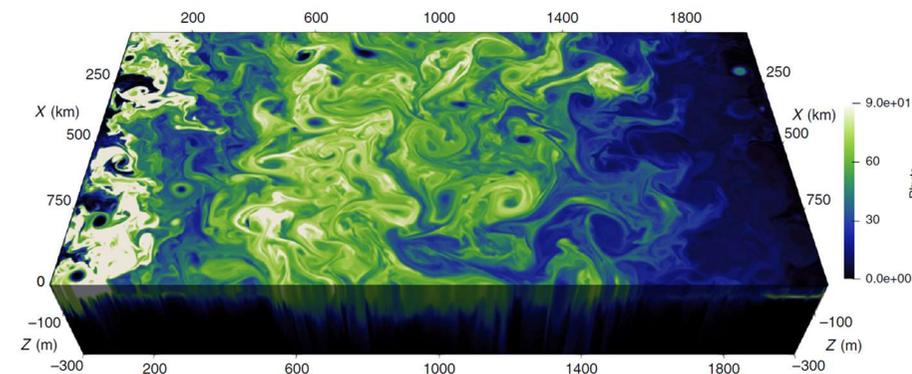
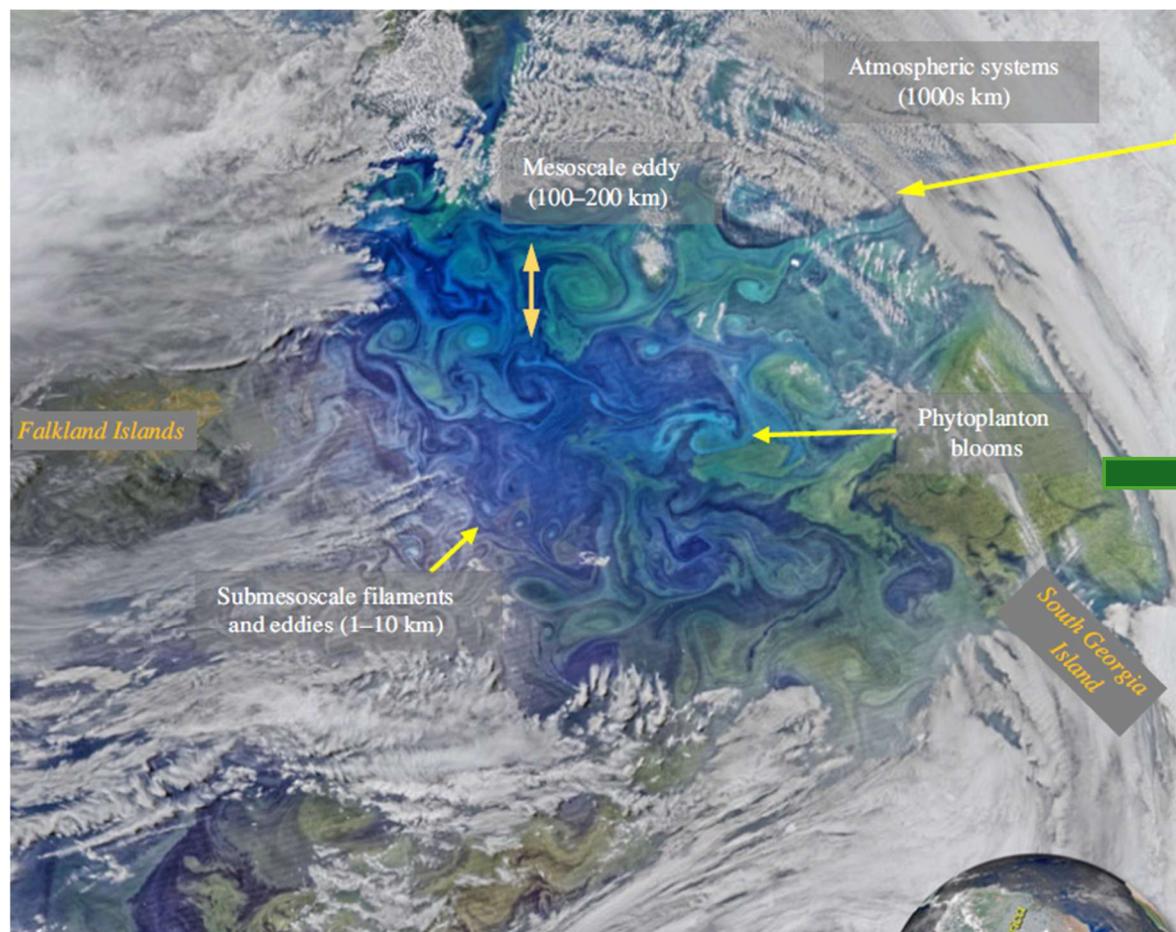
# Capabilities of underwater gliders



# Capabilities of underwater gliders



## Capabilities: submesoscale processes



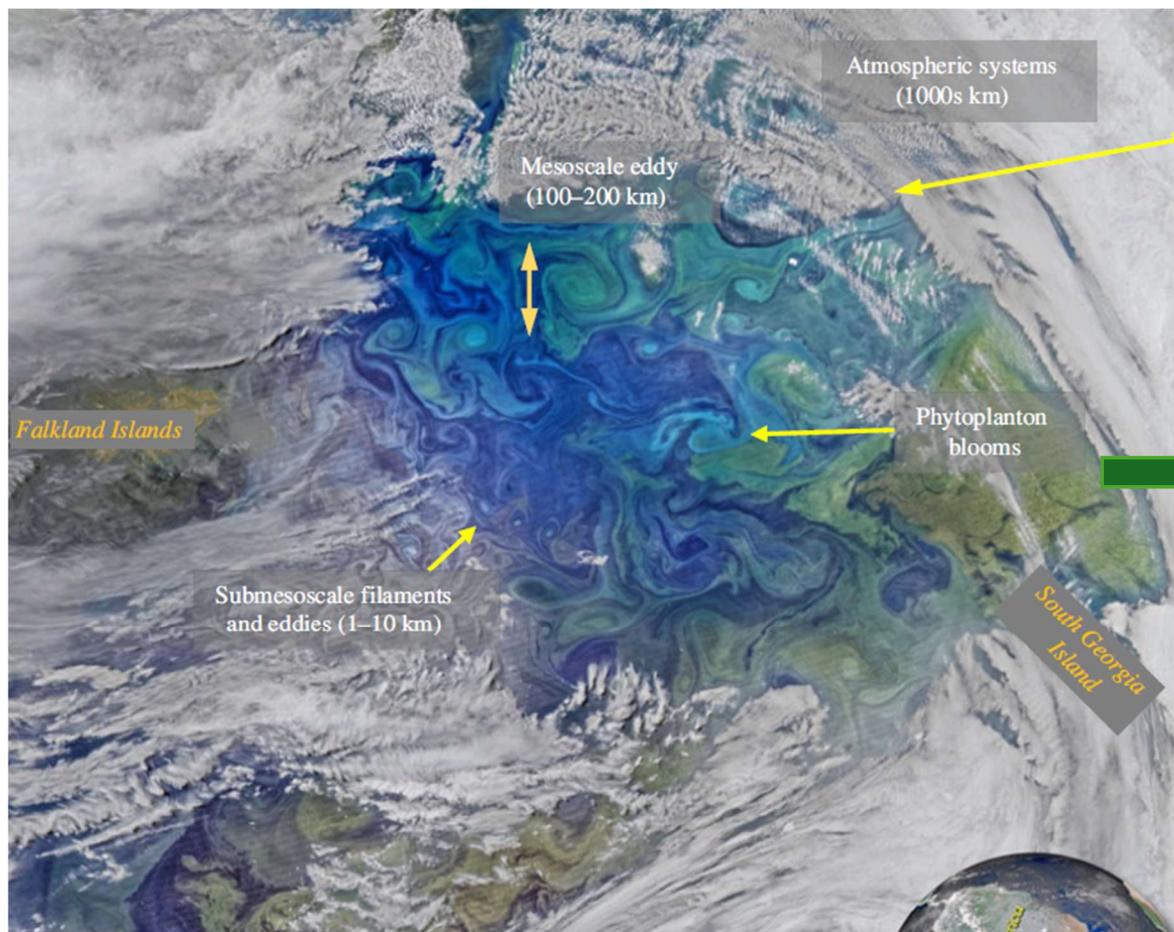
Important processes driven by dynamics on:  
-horizontal scales of **less than 10km**  
- temporal scales of **hours**

**Few observations exist for such a complex system!**

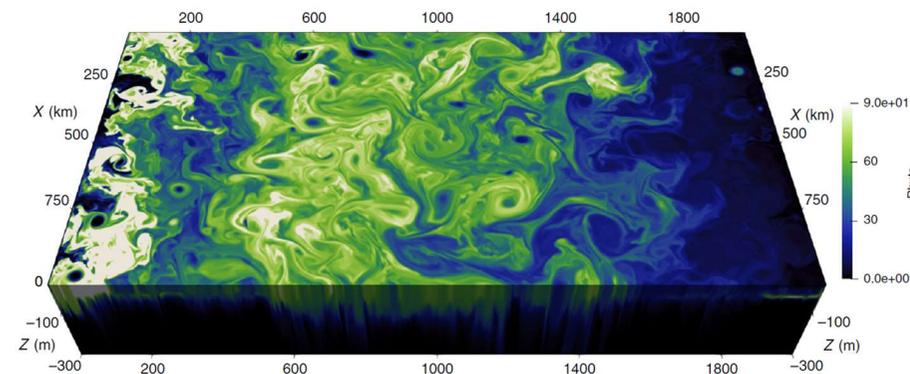
Swart et al., 2023

Uchida et al., 2020; Nicholson et al., 2019

## Capabilities: submesoscale processes



Swart et al., 2023



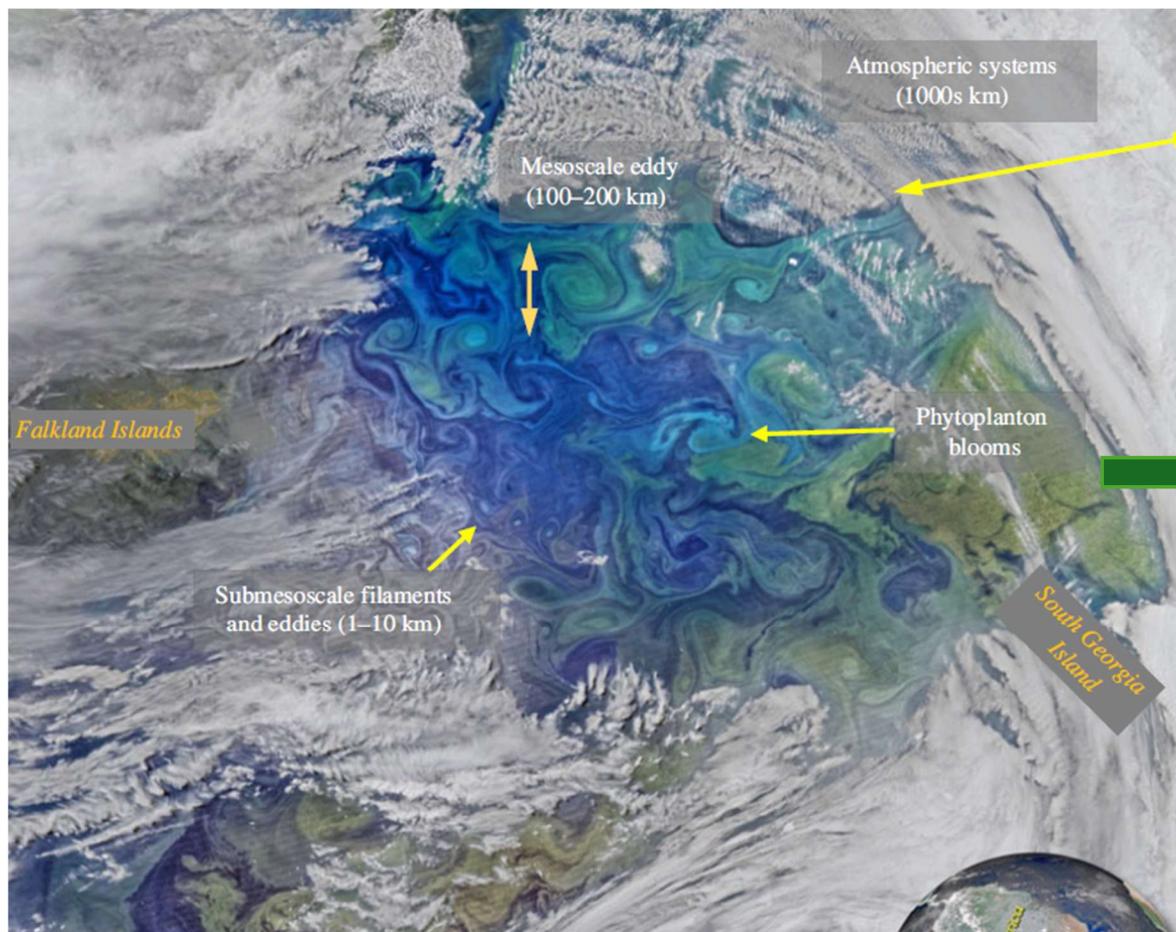
Important processes driven by dynamics on:  
- horizontal scales of **less than 10km**  
- temporal scales of **hours**

**What about Argo floats ?**

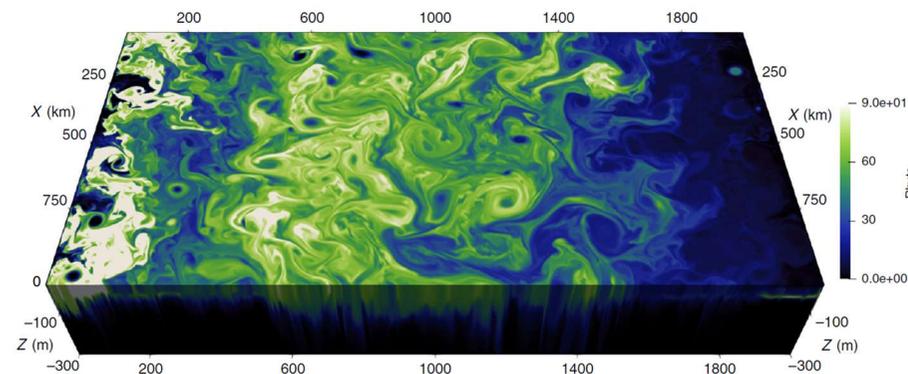


Uchida et al., 2020; Nicholson et al., 2019

# Capabilities: submesoscale processes



Swart et al., 2023



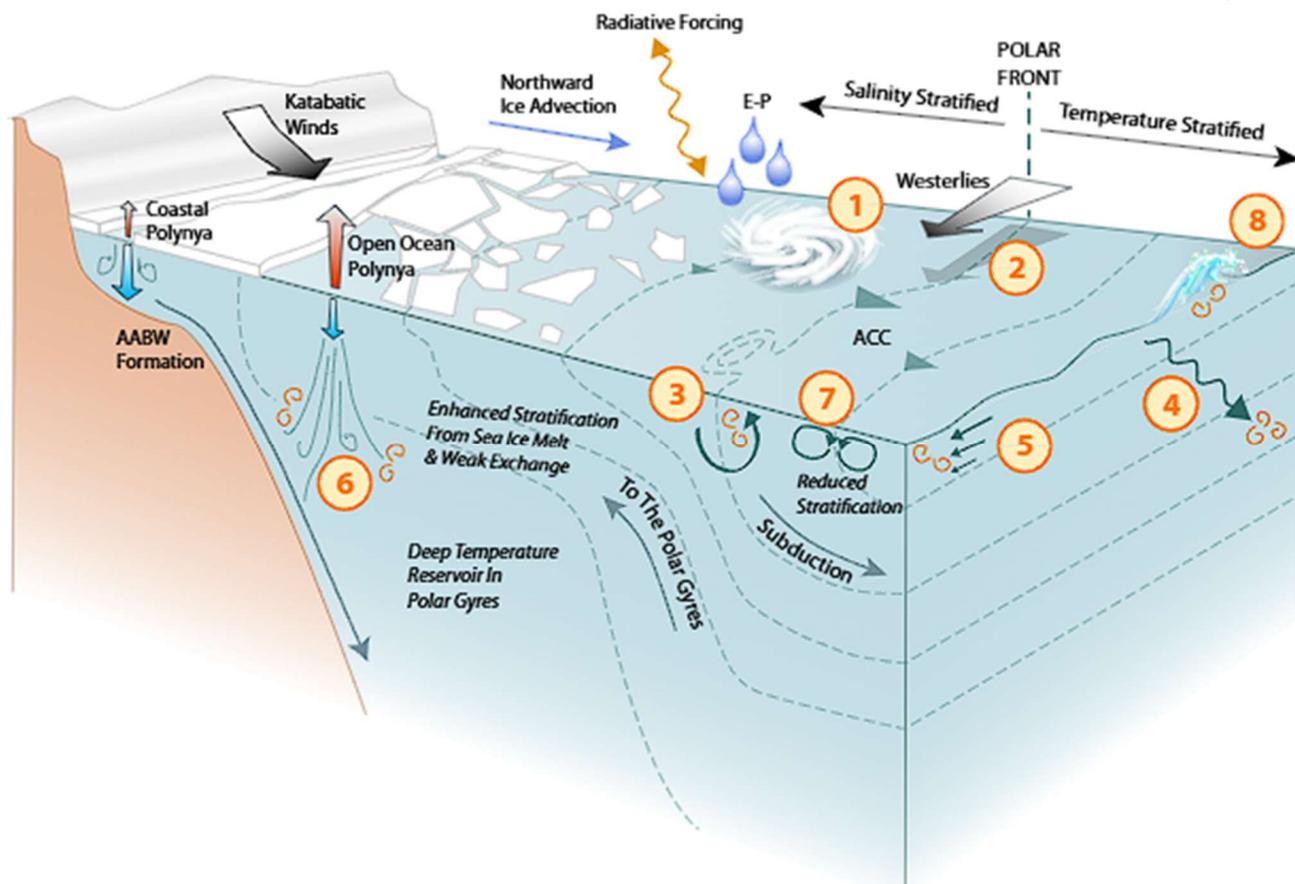
Important processes driven by dynamics on:  
- horizontal scales of **less than 10km**  
- temporal scales of **hours**

What about Argo floats ?



Uchida et al., 2020; Nicholson et al., 2019

# Observational needs: submesoscale processes

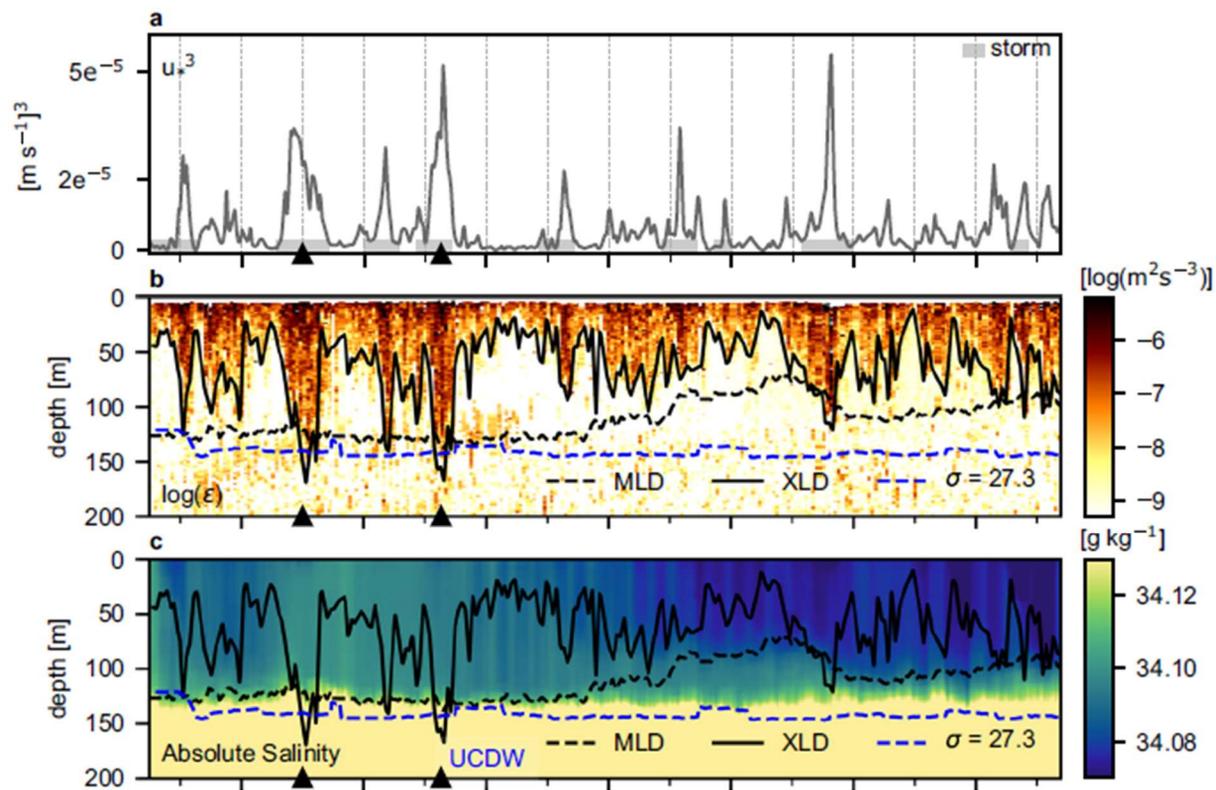
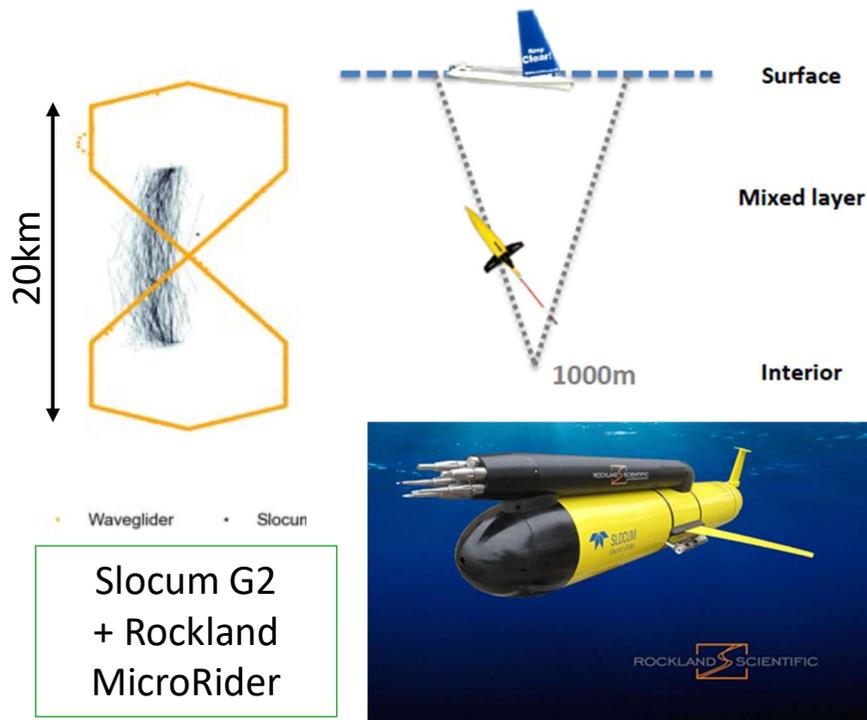


- 1 Surface forcing from storms  
*O*(10 km - 1000 km)
- 2 Wind-front interactions  
*O*(1 km - 100 km)
- 3 Submesoscale eddies & jets  
*O*(0.1 km - 10 km)
- 4 Downward propagating internal waves  
*O*(10 m - 100 m)
- 5 Near surface shear & mixing  
*O*(10 m - 100 m)
- 6 Heat loss, brine rejection & deep convection in polynyas & leads  
*O*(10 m - 1000 km)
- 7 Langmuir Circulation  
*O*(10 m - 100 m)
- 8 Wave breaking  
*O*(1 m - 10 m)



Gille et al., 2022 (<https://doi.org/10.1016/b978-0-12-821512-8.00019-0>)

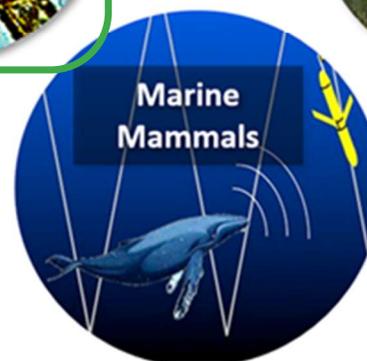
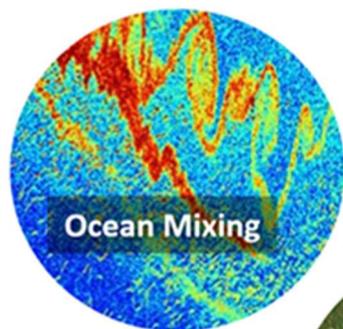
# Example of fine-scale observations during storms



## Storms drive outgassing of CO<sub>2</sub> in the subpolar Southern Ocean

Sarah-Anne Nicholson<sup>1,2</sup>, Daniel B. Whitt<sup>2,3</sup>, Ilker Fer<sup>4</sup>, Marcel D. du Plessis<sup>1,5,6</sup>, Alice D. Lebéhot<sup>1,6,7</sup>, Sebastiaan Swart<sup>5,6</sup>, Adrienne J. Sutton<sup>8</sup> & Pedro M. S. Monteiro<sup>1,6</sup>

# Capabilities of underwater gliders



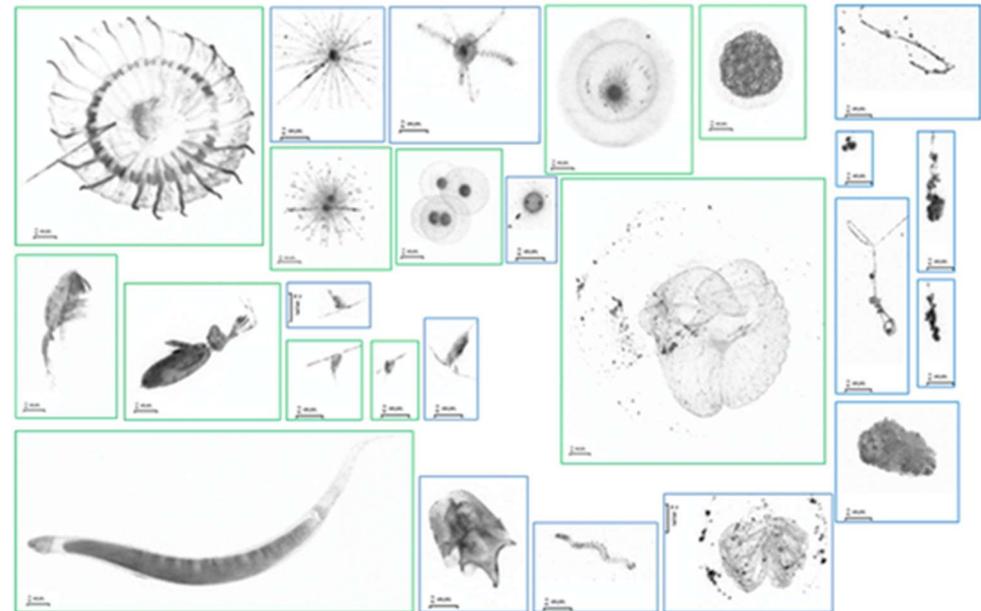
## Example of Zooplankton classification

### Underwater Vision Profiler

- Designed for large ( $>80\ \mu\text{m}$ ) particles and zooplankton ( $>700\ \mu\text{m}$ )
- Real time processing of images
- Compatible with ECOTAXA and ECOPART

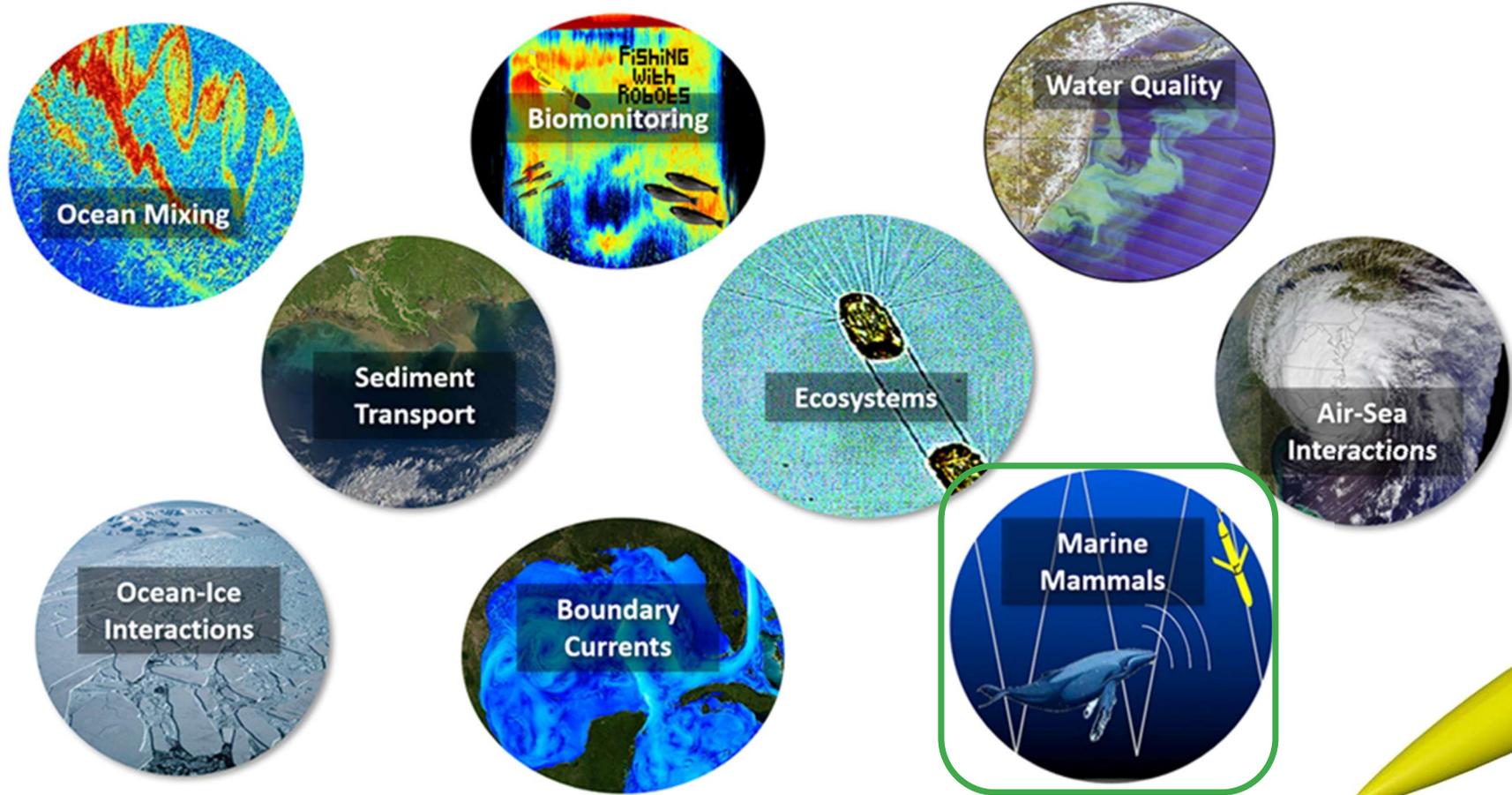


<https://www.jasco.com/oceanobserver-slocum-glider>

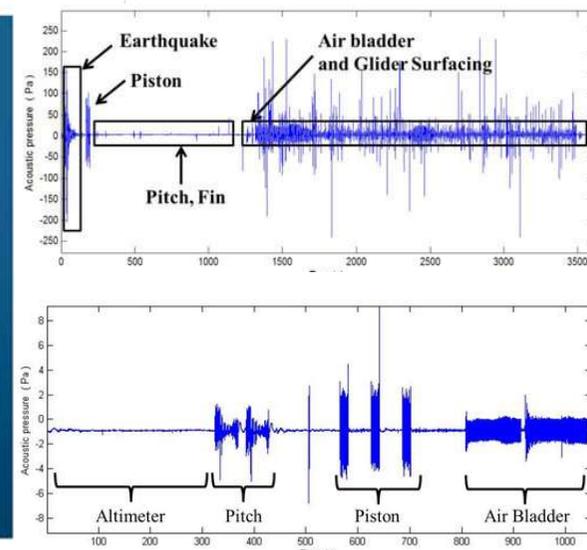
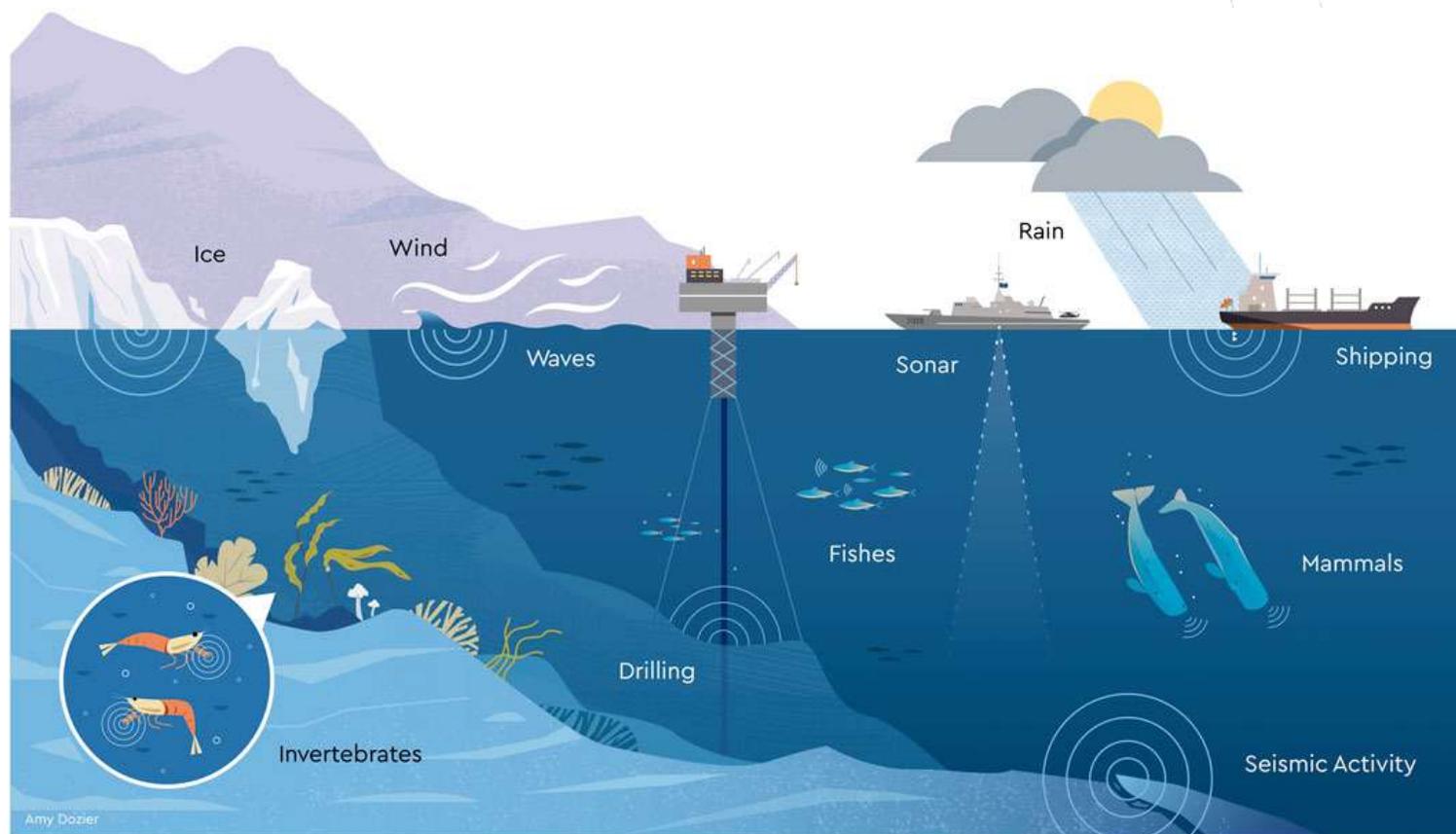


*Images gathered with the UVP6-LP mounted on the SeaExplorer Glider and taxonomically classified through the ECOTAXA automatized application*

# Capabilities of underwater gliders



# Acoustic capabilities



<https://www.mdpi.com/2076-3417/9/18/3860>

# Mammal monitoring & tracking

## Passive Acoustic Monitoring:

- WHOI DMON Sensor
- JASCO Ocean Observer



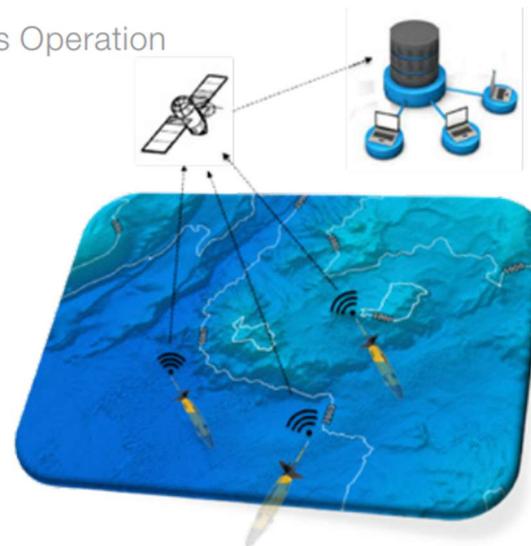
## Mammal monitoring & tracking

### Passive Acoustic Monitoring:

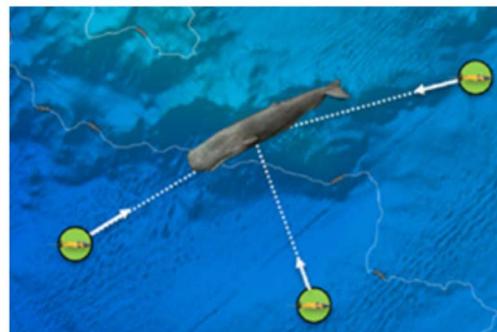
- WHOI DMON Sensor
- JASCO Ocean Observer



Multi-Gliders Operation



Triangulation



## Mammal tracking with backseat driver

### Passive Acoustic Monitoring:

- WHOI DMON Sensor
- JASCO Ocean Observer



### What is backseat driving

All modern gliders are split into a multiprocessor architecture

#### Flight

- Managing flight Dynamics
- Navigation
- Surfacing
- Vehicle safety

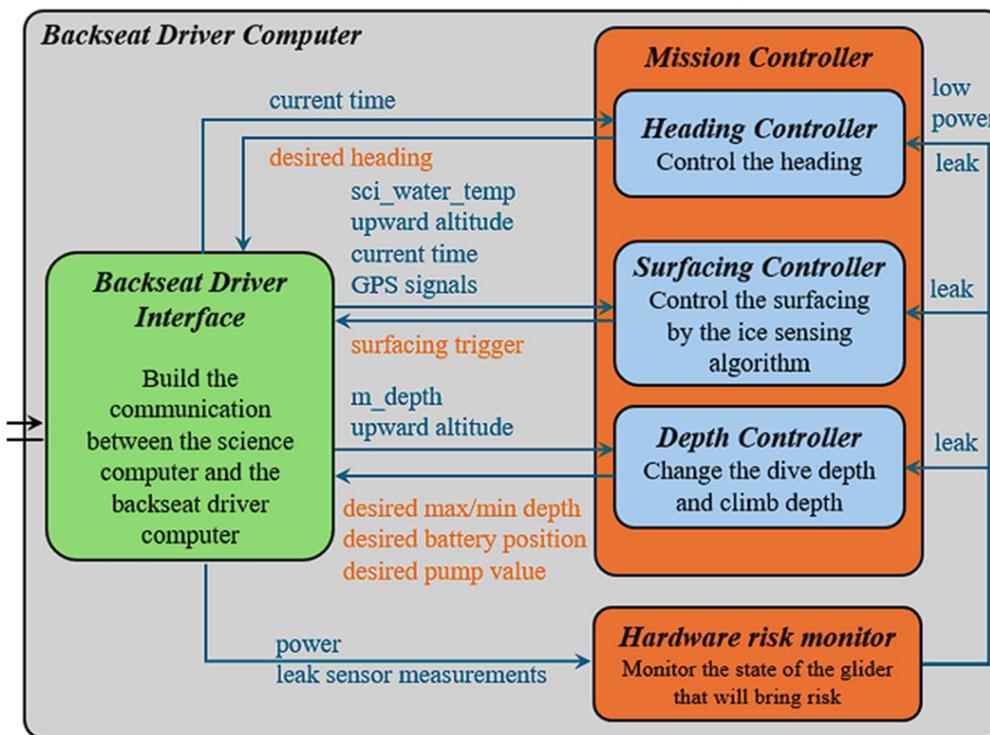
#### Science

- Manages science sensors
- Updates science parameters for storage in archive

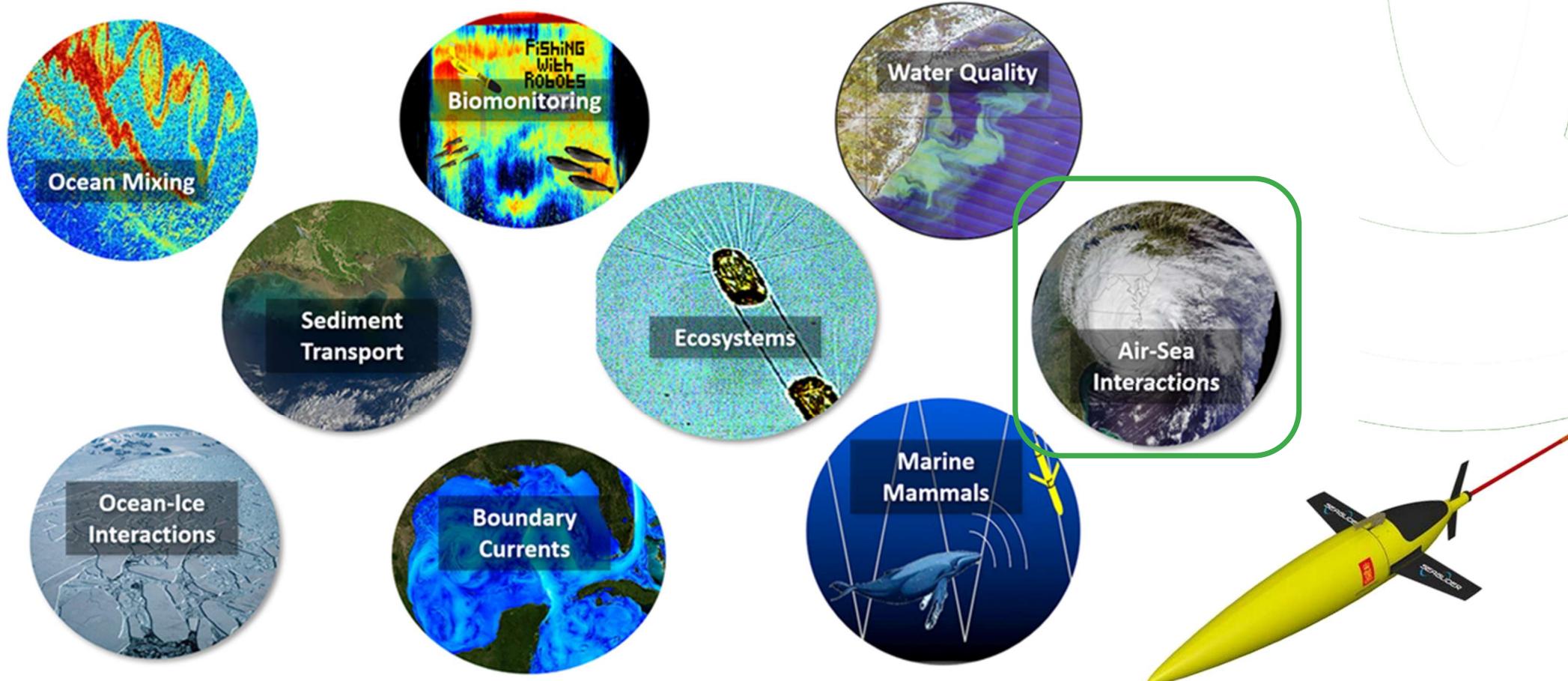
# Mammal tracking with backseat driver

## Passive Acoustic Monitoring:

- WHOI DMON Sensor
- JASCO Ocean Observer



# Capabilities of underwater gliders



# Hurricane observations and forecasting

**NATIONAL ACADEMIES**  
Sciences, Engineering, Medicine  
GULF RESEARCH PROGRAM

**Notes:** The cone contains the probable path of the storm center but does not show the size of the storm. Hazardous conditions can occur outside of the cone.

**Tropical Storm Idalia**  
Current location: X  
Forecast positions: ●  
1 AM CST Aug 21 7 AM CST Aug 22 1 AM CST Aug 23 7 AM CST Aug 24 1 AM CST Aug 25 7 AM CST Aug 26 1 AM CST Aug 27 7 AM CST Aug 28 1 AM CST Aug 29 7 AM CST Aug 30 1 AM CST Aug 31 7 AM CST Sep 1 1 AM CST Sep 2 7 AM CST Sep 3 1 AM CST Sep 4 7 AM CST Sep 5 1 AM CST Sep 6 7 AM CST Sep 7 1 AM CST Sep 8 1 AM CST Sep 9 1 AM CST Sep 10 1 AM CST Sep 11 1 AM CST Sep 12 1 AM CST Sep 13 1 AM CST Sep 14 1 AM CST Sep 15 1 AM CST Sep 16 1 AM CST Sep 17 1 AM CST Sep 18 1 AM CST Sep 19 1 AM CST Sep 20 1 AM CST Sep 21 1 AM CST Sep 22 1 AM CST Sep 23 1 AM CST Sep 24 1 AM CST Sep 25 1 AM CST Sep 26 1 AM CST Sep 27 1 AM CST Sep 28 1 AM CST Sep 29 1 AM CST Sep 30 1 AM CST Oct 1 1 AM CST Oct 2 1 AM CST Oct 3 1 AM CST Oct 4 1 AM CST Oct 5 1 AM CST Oct 6 1 AM CST Oct 7 1 AM CST Oct 8 1 AM CST Oct 9 1 AM CST Oct 10 1 AM CST Oct 11 1 AM CST Oct 12 1 AM CST Oct 13 1 AM CST Oct 14 1 AM CST Oct 15 1 AM CST Oct 16 1 AM CST Oct 17 1 AM CST Oct 18 1 AM CST Oct 19 1 AM CST Oct 20 1 AM CST Oct 21 1 AM CST Oct 22 1 AM CST 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4 1 AM CST Sep 5 1 AM CST Sep 6 1 AM CST Sep 7 1 AM CST Sep 8 1 AM CST Sep 9 1 AM CST Sep 10 1 AM CST Sep 11 1 AM CST Sep 12 1 AM CST Sep 13 1 AM CST Sep 14 1 AM CST Sep 15 1 AM CST Sep 16 1 AM CST Sep 17 1 AM CST Sep 18 1 AM CST Sep 19 1 AM CST Sep 20 1 AM CST Sep 21 1 AM CST Sep 22 1 AM CST Sep 23 1 AM CST Sep 24 1 AM CST Sep 25 1 AM CST Sep 26 1 AM CST Sep 27 1 AM CST Sep 28 1 AM CST Sep 29 1 AM CST Sep 30 1 AM CST Oct 1 1 AM CST Oct 2 1 AM CST Oct 3 1 AM CST Oct 4 1 AM CST Oct 5 1 AM CST Oct 6 1 AM CST Oct 7 1 AM CST Oct 8 1 AM CST Oct 9 1 AM CST Oct 10 1 AM CST Oct 11 1 AM CST Oct 12 1 AM CST Oct 13 1 AM CST Oct 14 1 AM CST Oct 15 1 AM CST Oct 16 1 AM CST Oct 17 1 AM CST Oct 18 1 AM CST Oct 19 1 AM CST Oct 20 1 AM CST Oct 21 1 AM CST Oct 22 1 AM CST Oct 23 1 AM CST Oct 24 1 AM CST Oct 25 1 AM CST Oct 26 1 AM CST Oct 27 1 AM CST Oct 28 1 AM CST Oct 29 1 AM CST Oct 30 1 AM CST Oct 31 1 AM CST Nov 1 1 AM CST Nov 2 1 AM CST Nov 3 1 AM CST Nov 4 1 AM CST Nov 5 1 AM CST Nov 6 1 AM CST 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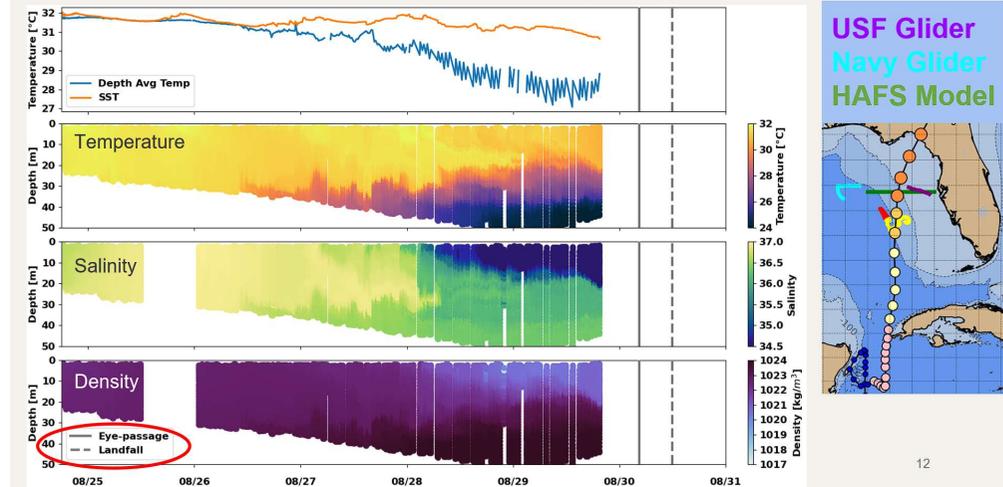
## Observations and Forecasts of Hurricane Interactions with the Loop Current: *Hurricane Idalia*

- NASEM GRP UGOS WG-C
- NOAA/Navy Hurricane Glider Team
- IOOS Hurricane Model/Data Comparison Team

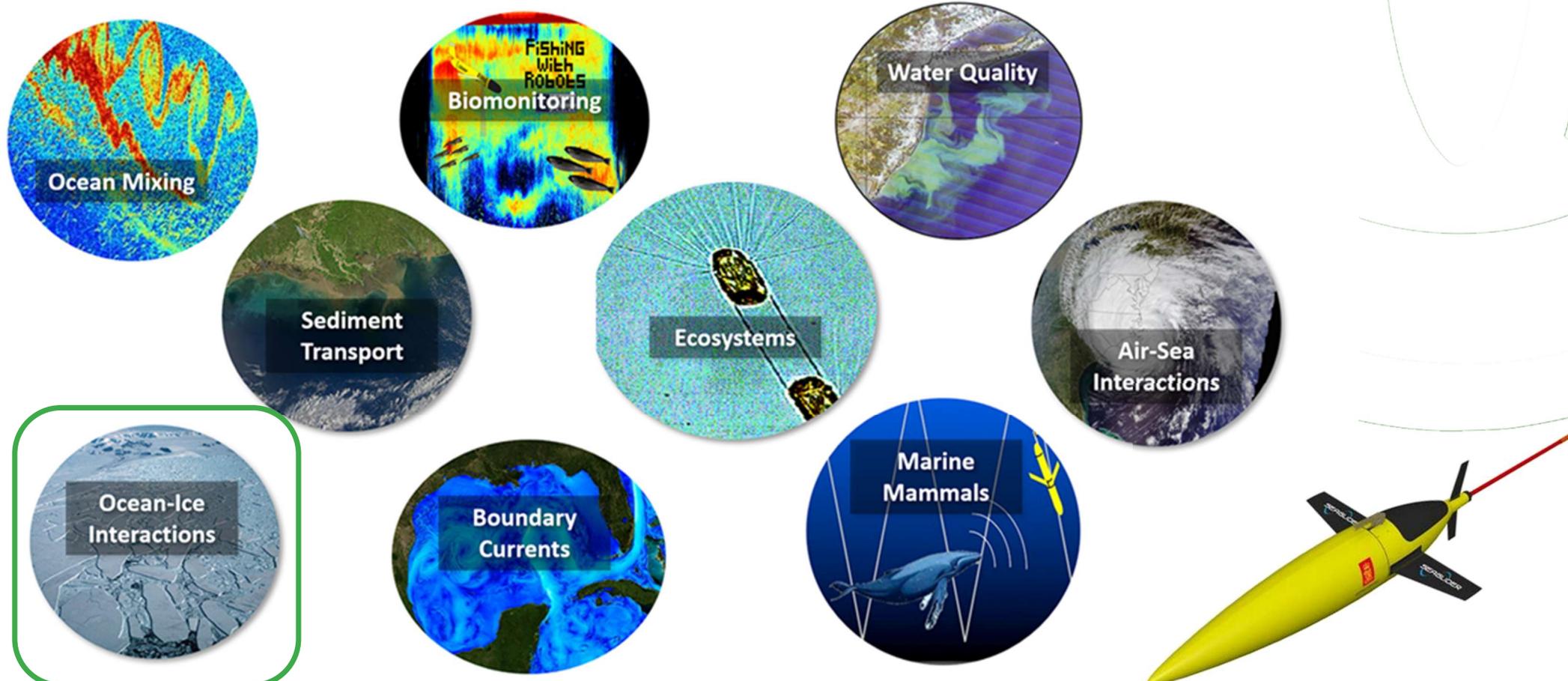
Scott Glenn, Travis Miles, Michael Smith, Julia Engdahl, Tim Stolarz, Tony Knap, Steve DiMarco, Andy Dancer, Sakib Mahmud, Uchenna Nwankwo, David Salas de Leon, Rosalinda Monreal Jimenez, Edgar Escalante Mancera, Miguel Angel Gomez Real, Pelle Robbins, Heather Furey, Amy Bower, Miguel Tenreiro, Enric Pallas Sanz, Rafael Ramos, Bruce Magnell, Jill Storie, Samantha Longridge, Anneliese Schmidt, Ben Jaimes de la Cruz, Nick Shay, Pierre Lermusiaux, Patrick Haley, Chris Marabito, Paula Perez Brunius, Nathali Cordero Quiros, Bruce Cornelle, Stephan Howden, Alexandra Boze, Ganesh Gopal, Matthieu LeHenaff, Hyun-Sook Kim, Pat Hogan, Jan van Smirren, Kathy Bailey, Bill Lingsh, Corbin Brooks, Doug Wilson, Catherine Edwards, Julio Morell, Jorge Brenner, Kevin Martin, Chad Lembke, Natalia Sidorovskaia, Yonggang Liu, Bob Weisberg, Bob Carrier, Dawn Petraitus, Kevin O'Brien, Avichal Mehra, Zulema Garraffo, Dmitry Dukhoy, Maria Aristizabal, Dan Iredell, Jim Cummings (60)

## Hurricane Idalia - Stage 3

### USF Slocum Glider Gansett on the West Florida Shelf



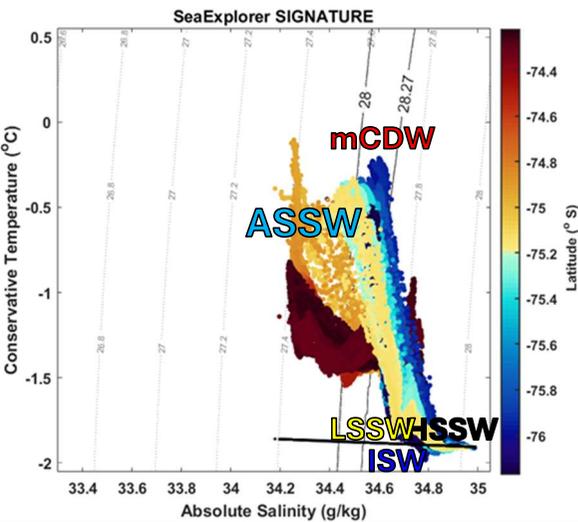
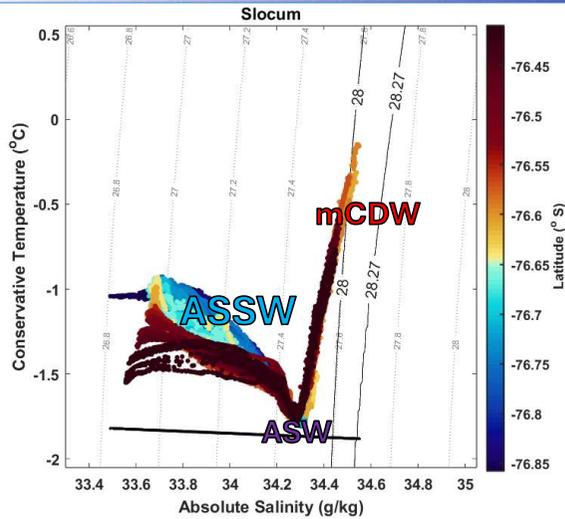
# Capabilities of underwater gliders



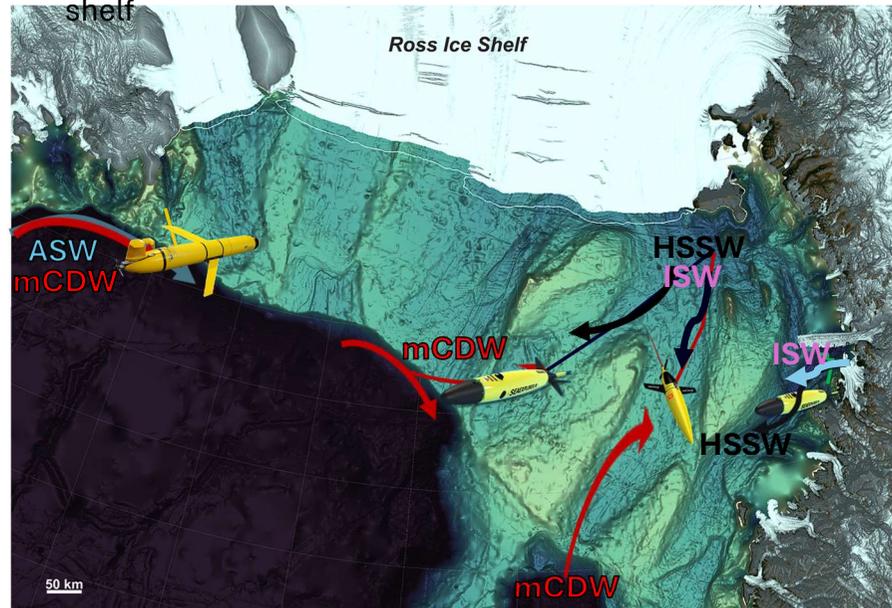
Polar missions: Multi-glider survey in 2024 with 3 different gliders covering ~700 km



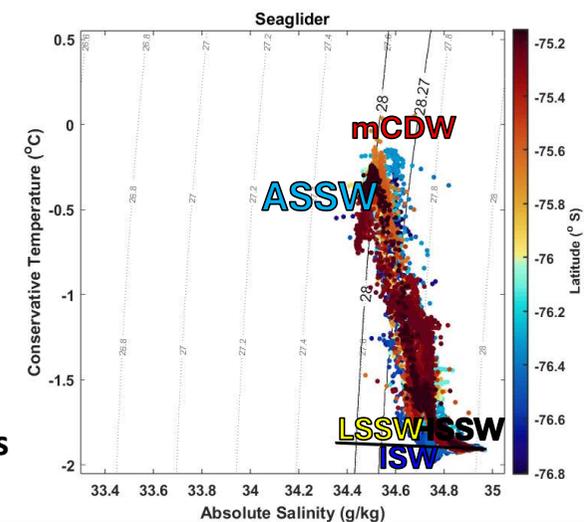
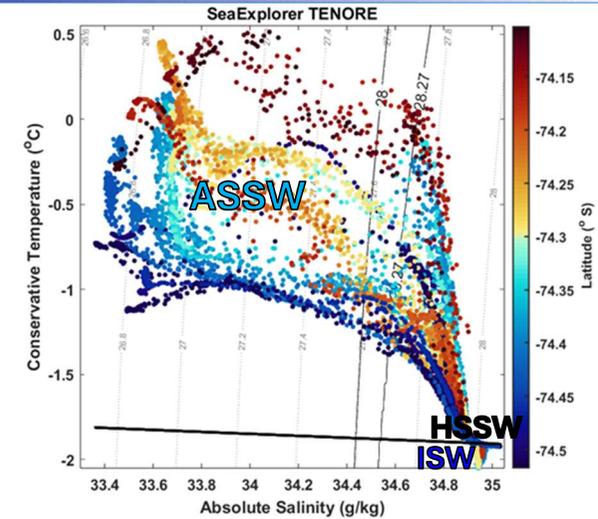
## Polar missions: Multi-glider survey in 2024 with insight into key water mass properties on the continental shelf



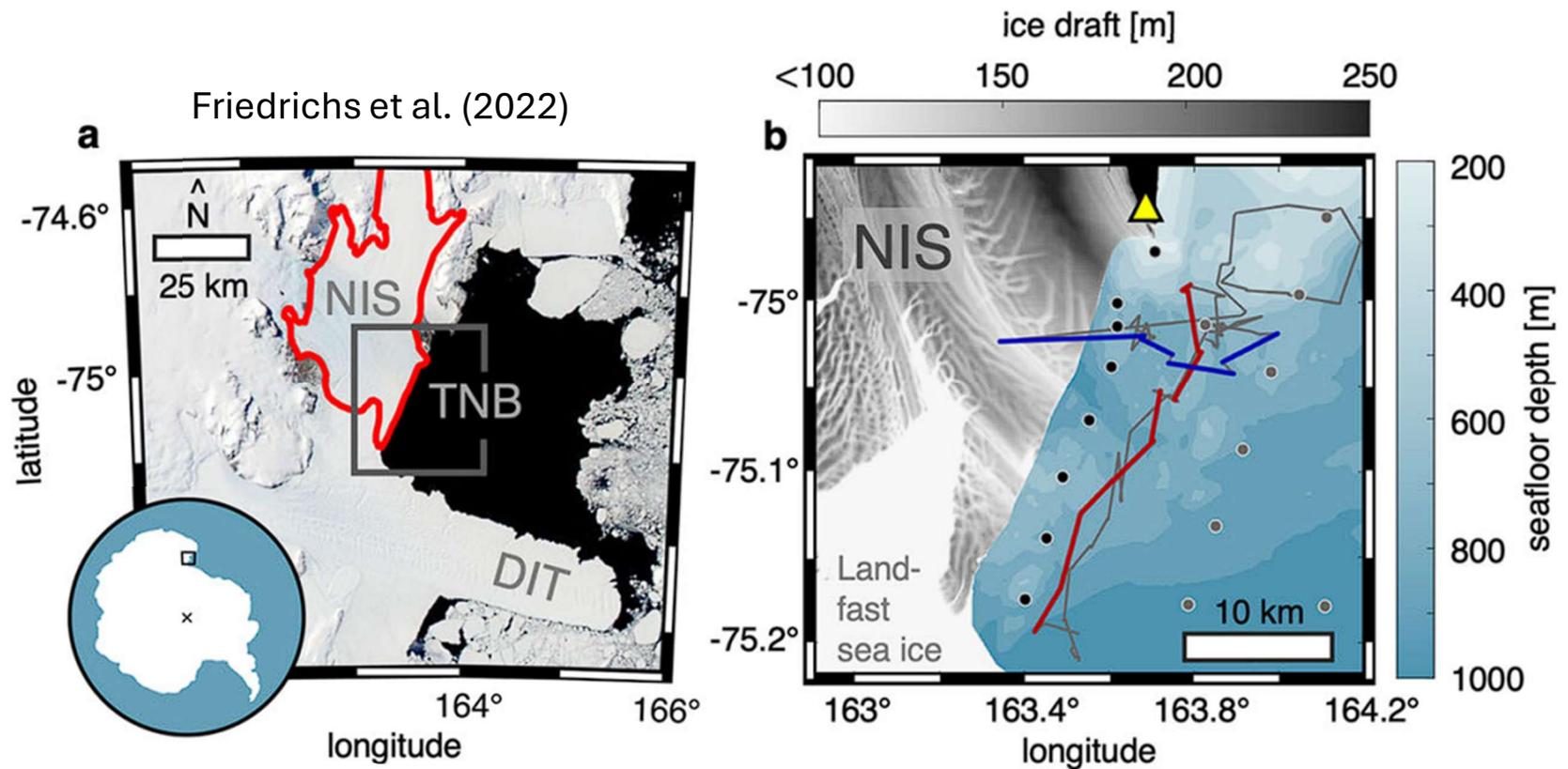
~760 km in strategic areas of the Ross Sea continental shelf



- HSSW in its formation and export areas
- ISW flowing out of the ice shelf cavity vs. locally produced
- Inflowing ASW at the eastern gate
- mCDW at the eastern slope break edge & in both throughs



## Polar missions: At ice shelf fronts



<https://doi.org/10.1038/s43247-022-00460-3>

OPEN

### Observations of submesoscale eddy-driven heat transport at an ice shelf calving front

### Microstructure turbulence at the Nansen Ice Shelf calving front

Drew M. Friedrichs<sup>1,2</sup>, Jasmin B. T. McInerney<sup>1,2,3</sup>, Holly J. Oldroyd<sup>1</sup>, Won Sang Lee<sup>4</sup>, Suyoung Yun<sup>4</sup>, Seung-Tae Yoon<sup>5</sup>, Craig L. Stevens<sup>3,6</sup>, Christopher J. Zappa<sup>7</sup>, Christine F. Dow<sup>8</sup>, Derek Mueller<sup>9</sup>, Oscar Sepúlveda Steiner<sup>10</sup> & Alexander L. Forrest<sup>1,2</sup>



Rockland Scientific MicroRider

Zhou et al. (2018) off the coast of Newfoundland, Canada

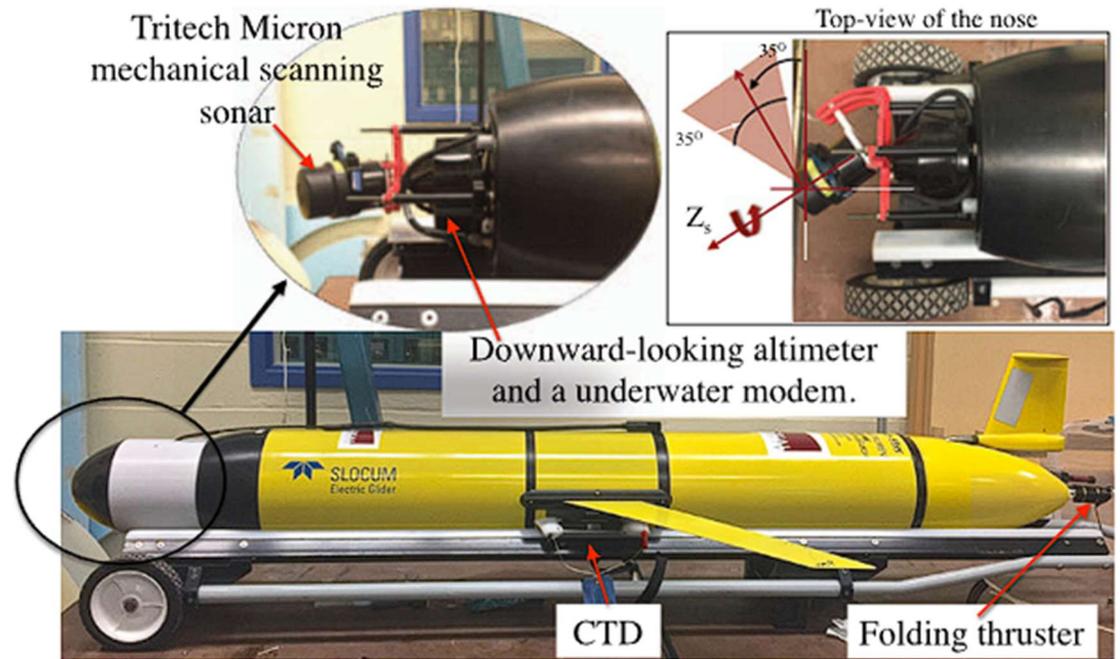
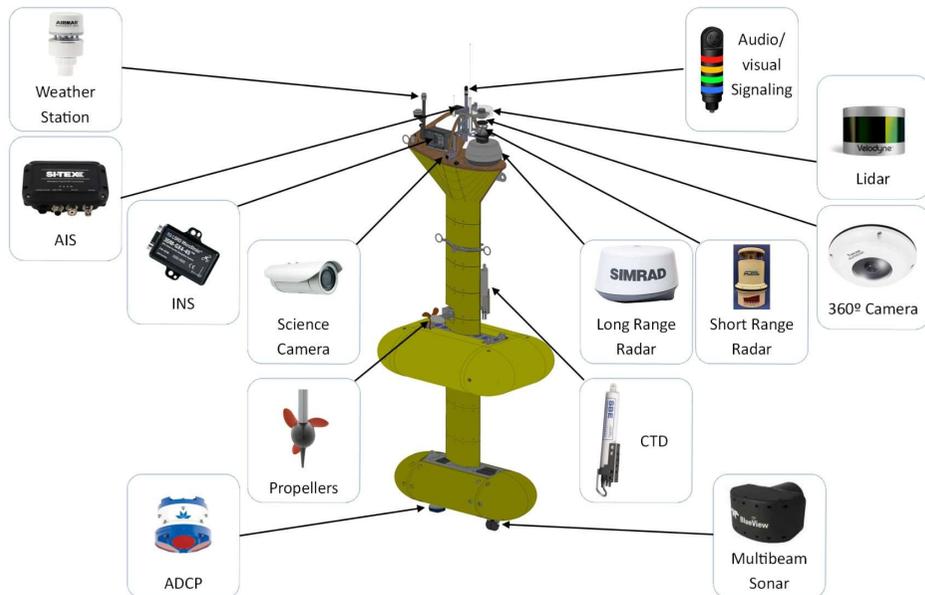
Received: 15 September 2018 | Revised: 15 March 2019 | Accepted: 4 April 2019  
DOI: 10.1002/rob.21873

REGULAR ARTICLE

WILEY

Mapping the underside of an iceberg with a modified underwater glider

Mingxi Zhou<sup>1</sup> | Ralf Bachmayer<sup>2</sup> | Brad deYoung<sup>3</sup>

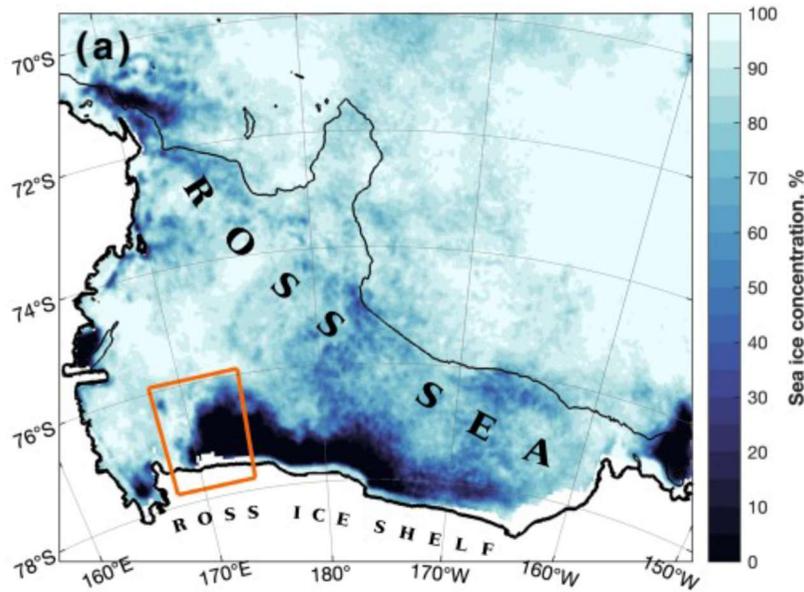


Integration of a mechanical scanning sonar (Tritech Micron)  
+  
multivehicle surface crafts

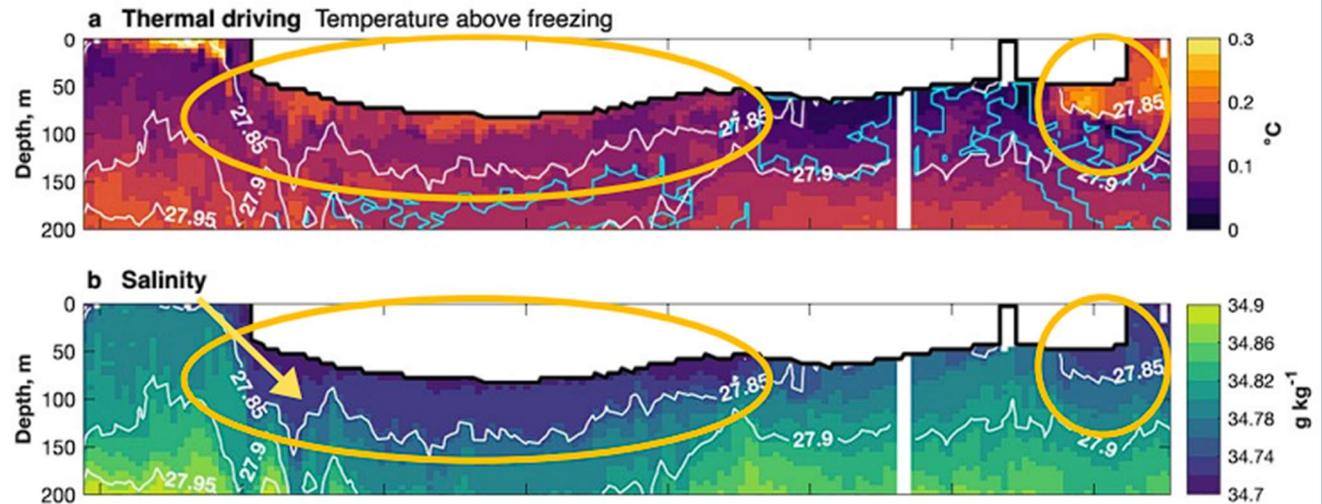
## Polar missions: Underneath ice shelves (unplanned)

Team of Karen Heywood, University of East Anglia, UK

Figure from P. Sheehan



© Esther Portela



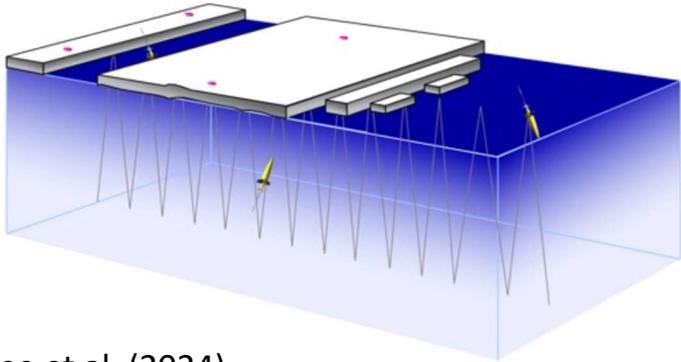
- Warm, fresh surface water subducted beneath the ice shelf along isopycnals

## An unauthorized 3-day expedition underneath the Ross Ice Shelf

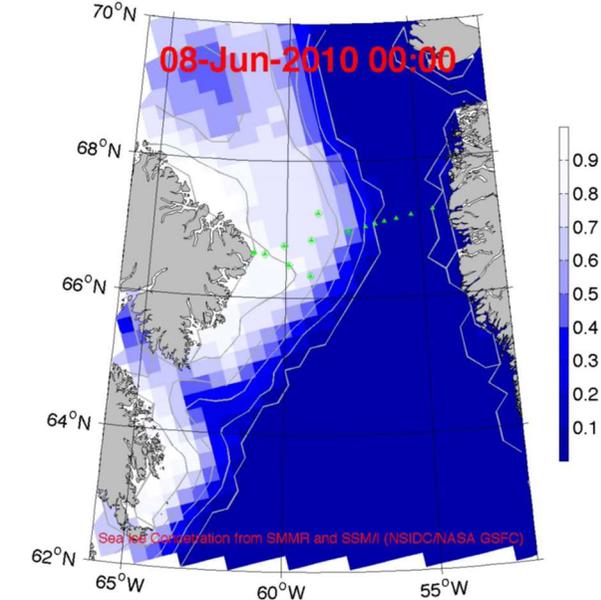


Polar missions: In MIZ and underneath ice shelves (planned)

## The University of Washington's Applied Physics Laboratory



Lee et al. (2024)

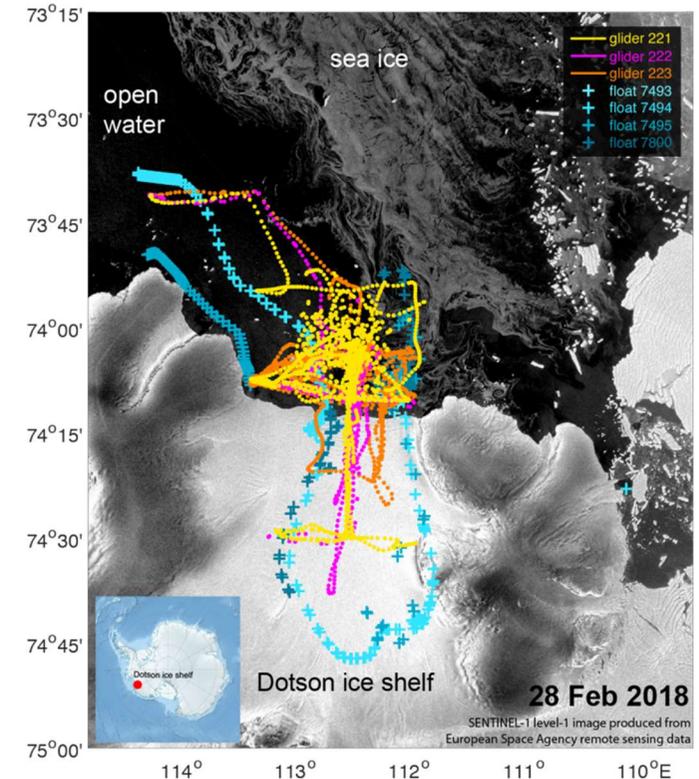


Seagliders in Davis Strait (2010-2020)  
&  
Dotson Ice Shelf (2018-2019)

with a range of acoustic  
communication and navigation  
sources

- 10 kHz:** short-range com. and localization
- 260 Hz, 780 Hz:** Fixed sources, geolocation
- 900 Hz:** Fixed and mobile sources, geolocation, limited com.
- 35 Hz:** Fixed sources, long-range geolocation

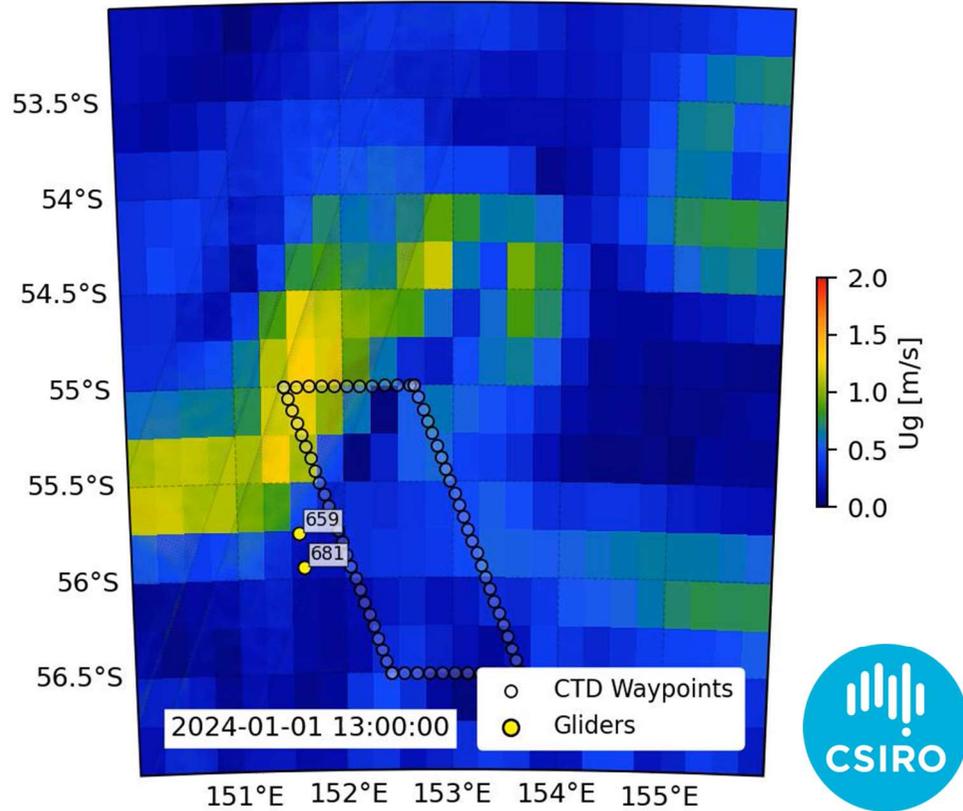
## Ocean Robots Beneath Ice Shelves (ORBIS) Seaglider and EM-APEX profiles Jan. 2018 to Jan. 2019



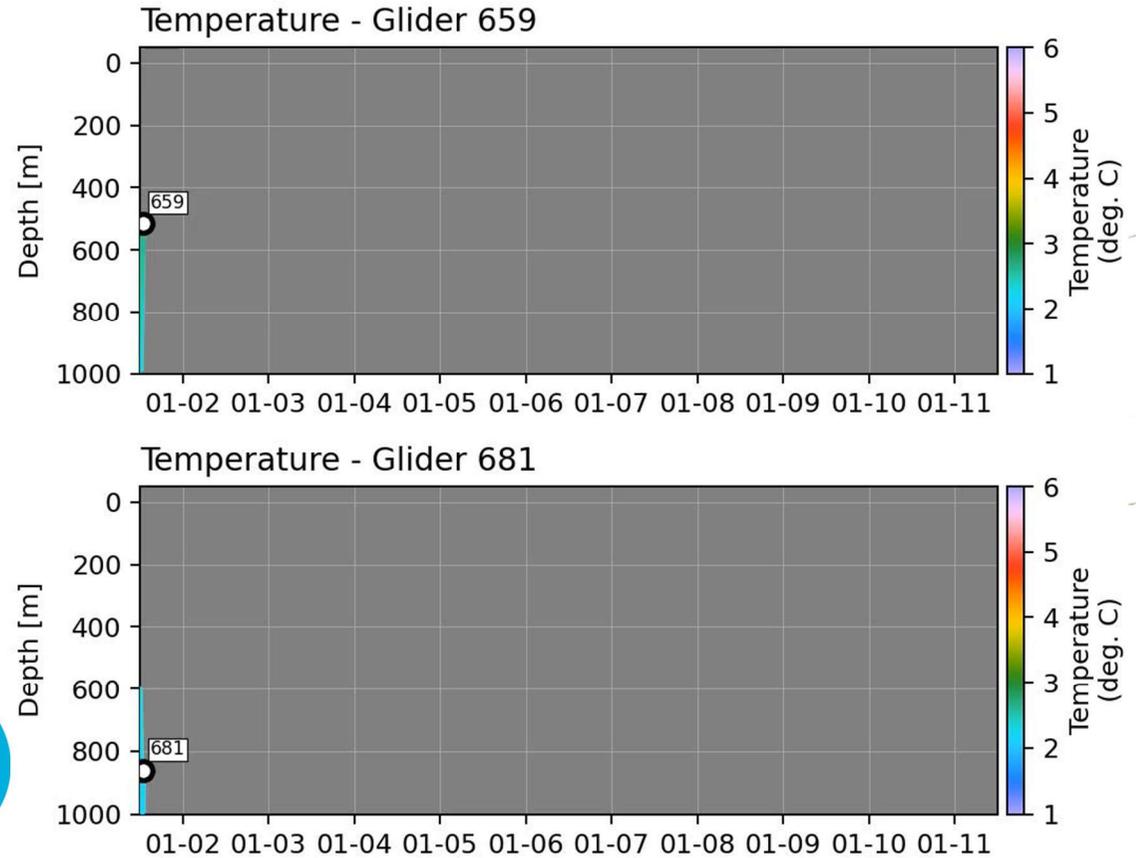
Luc Rainville/University of Washington

# Step-changer in ocean observing capabilities

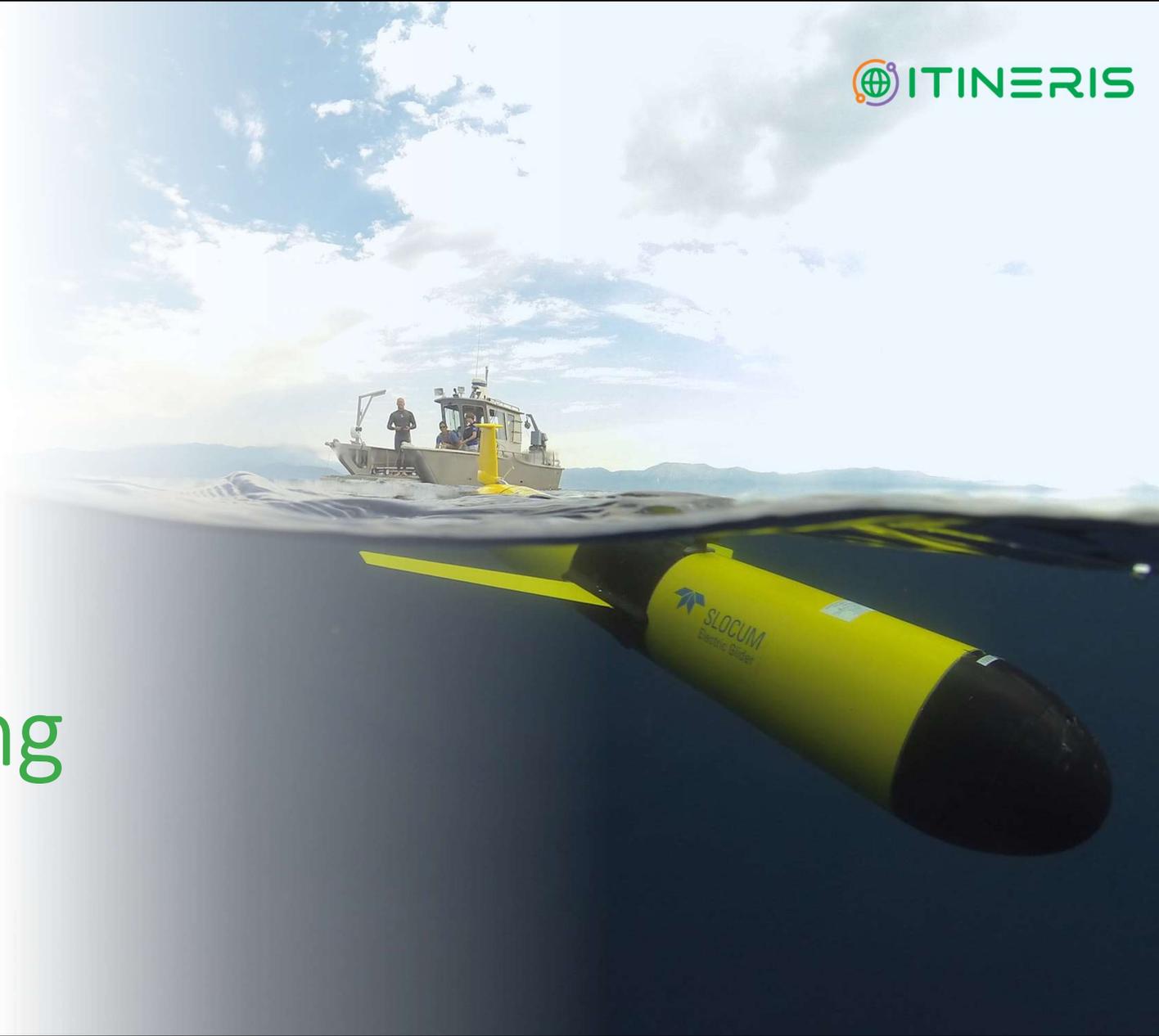
### Surface geostrophic currents



### Polar front profiling the Antarctic Circumpolar Current at 2-4km



# Preparations & mission planning



## Preparations & practices for a succesful mission

**Before you get even close to the water... do all the test you possibly can on land !**

1. Ballasting and compass calibration
2. Functional tests and checks
3. Mission preparation based on area of interest
4. Plan deployment & recovery
5. Pre-deployment tests
6. Maintenance

## Before the deployment



PLOCAN

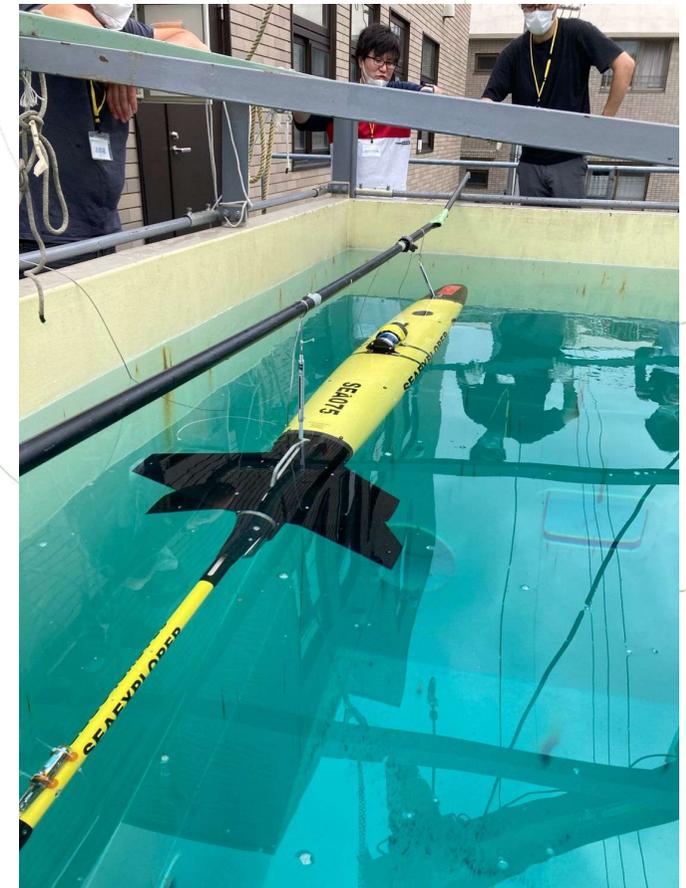


University of Las Palmas de Gran Canaria

## Before the deployment

### 1) Ballasting before compass calibration

- Fresh or saltwater tank
- External weights or syntactic foam for a neutral buoyancy in the targeted water density sea surface
- Find the linear position for a neutral pitch



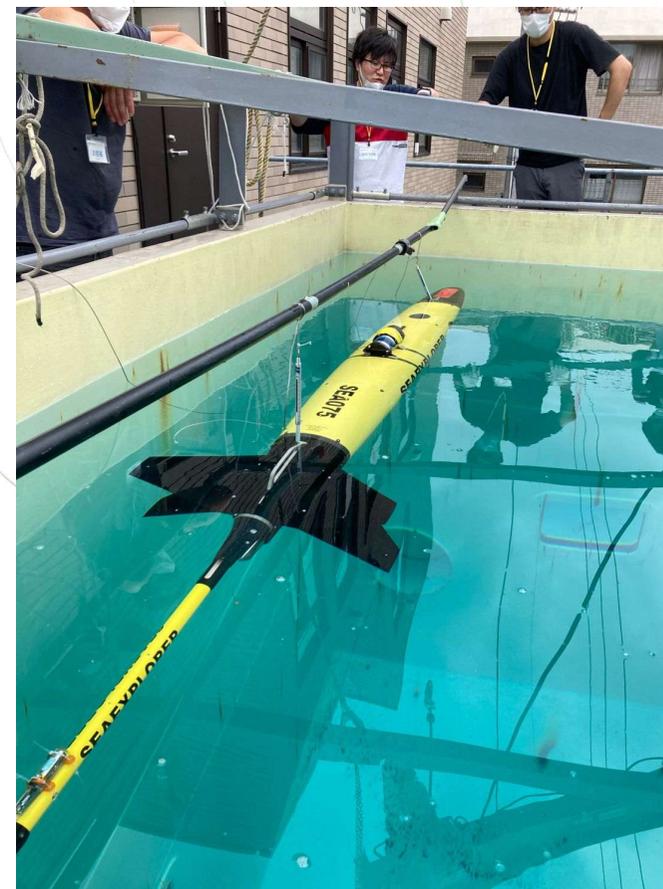
<https://drive.google.com/drive/folders/1boaKJy6UGxLf74Q6v5ZBxqU19ooljSCs?zx=avlgu68vc27l>

## Before the deployment

### 1) Ballasting before compass calibration

### Why?

- Fresh or saltwater tank
- External weights or syntactic foam for a neutral buoyancy in the targeted water density sea surface
- Find the linear position for a neutral pitch



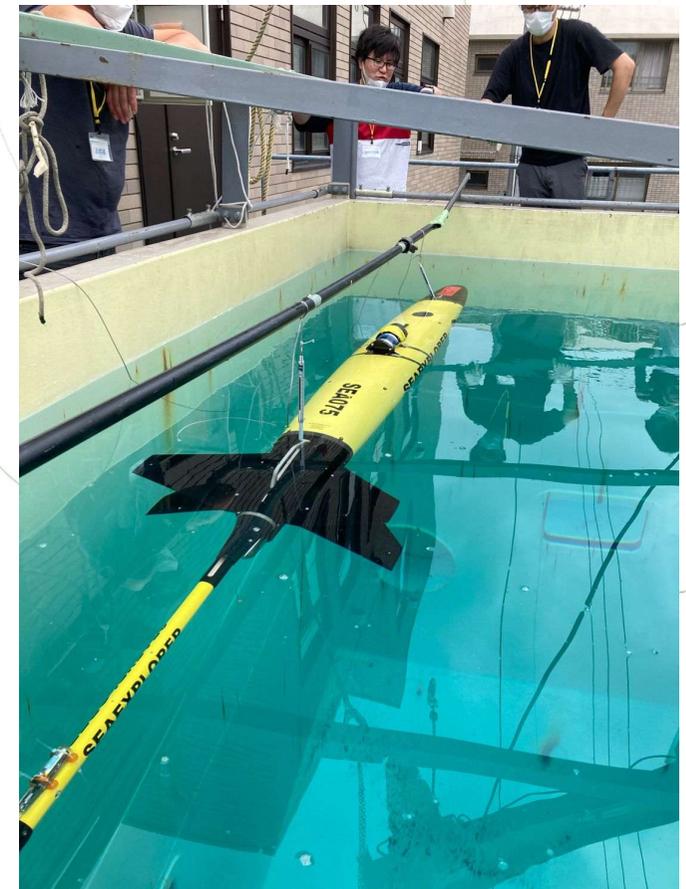
<https://drive.google.com/drive/folders/1boaKJy6UGxLf74Q6v5ZBxqU19ooljSCs?zx=avlgu68vc27l>

# Before the deployment

## 1) Ballasting before compass calibration

- Fresh or saltwater tank
- External weights or syntactic foam for a neutral buoyancy in the targeted water density sea surface
- Find the linear position for a neutral pitch

Buoyancy and Trim Spreadsheet									
Product:	SeaExplorer	N°	SEA059_M015	S/N					
Writer:									
Version:	E-28/08/2019 adapted from ALSEAMAR								
Object:	Sea Explorer buoyancy and Trim setting								
Mission:									
Date:		Ref fichier :	#N/A						
<b>Semiconductors:</b>									
1 inox washer (g) =	29								
water density	1.028								
inox density	8.01	29 g in the air is	25.28	g in water	1 g to be added in water is	1.35	g in air	Number of inox to be added	0.04
Foam density =	0.35	1 g in the air is	-1.71	g in water	1 g to be removed in water is	-0.59	g in air	grams of foam to be added	-0.59
<b>Configuration of the payload</b>									
Nose sensor	<input type="checkbox"/>								
Top sensor	<input type="checkbox"/>								
Bottom sensor	<input type="checkbox"/>								
starboard sensor	<input type="checkbox"/>								
Port sensor	<input type="checkbox"/>								
Payload weight - number of 250 g plates	<input type="checkbox"/>	optional							
Payload weight - number of 100 g plates	<input type="checkbox"/>	optional							
Payload weight - number of 50 g plates	<input type="checkbox"/>	optional							
Weight of the Payload	<input type="checkbox"/>	optional							
<b>Configuration of the vehicle</b>									
Weight of the ballast section	<input type="checkbox"/>	optional (with release and spring, not ULB not ARGOS)							
Weight of the battery section	<input type="checkbox"/>	optional (with release and spring)							
Total weight of the glider (kg)	<input type="checkbox"/>	(with payload, release weight, spring - without foam/washers)							
Argos beacon	<input type="checkbox"/>	YES							
ULB	<input type="checkbox"/>	YES	Position:	<input type="text" value="None"/>					
<b>Ballasting</b>									
Ballast water density	<input type="text" value="1000"/>	kg/m3	(w)						
Ballast water temperature	<input type="text" value="20"/>	°C	(w)						
Target Sea mass density	<input type="text" value="1028"/>	kg/m3	(usea)						
Target Sea temperature	<input type="text" value="20"/>	°C	(usea)						



<https://drive.google.com/drive/folders/1boaKJy6UGxLf74Q6v5ZBxqU19ooljSCs?zx=avlgu68vc271>

# Before the deployment

## 2) Compass Calibration

- Non-magnetic environment
- Show different headings to the compass

Every time there is a change in the configuration of the glider or a change of mission location!

	MUM	SEA-MUM003- Compass calibration report - 18.00
	CR Compass Calibration	Revision : B
		Date :
		Page : 1/1

Job N°:	
P/N :	
S/N:	
Date :	
Author :	
Procedure reference	SEA06-50-MUM-UsermanualSeaExplorer-revB
Equipment ID used :	
Laptop and ethernet cable	
1 Cardinal points before calibration	C* NC* NT*
1.1 North: _____	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
1.3 East: _____	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
1.5 South: _____	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
1.7 West: _____	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
If all values are within +/-3°, the calibration is ok and does not need to be redone.	<input type="checkbox"/>

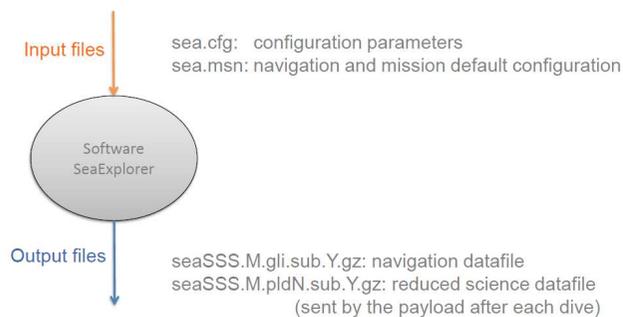


<https://drive.google.com/drive/folders/1boaKJy6UGxLf74Q6v5ZBxqU19ooljSCs?zx=avlg68vc27l>

# Before the deployment

## 3) Functional tests and checks

- Set up the configuration files of the navigation and payload
- Test actuators and navigation sensors (pressure, voltage...) using tester mode
- Run a simulation with actuators and check data



```
root@seaxplorer:~# ./SeaExplorer -t
SeaExplorer (c)
-----
Version v2.1.2-r
Date Jul  4 2016
-----
Config File (sea.cfg) loaded.
Mission File (sea.msn) loaded.
-----
Main
h : To print Help
c : To read Compass
d : To read Depth sensor
e : To read Echo sounder
g : To read Gps
v : To read Vacuum
i : To enter Iridium menu
w : To read Water inlet
o : To write SNAV string to Payload 1
p : To write SNAV string to Payload 2
a : To read Energy level
0 : To turn off all devices
1 : To turn on all devices
b : To enter Ballast menu
l : To enter Linear menu
a : To enter Angular menu
r : To enter Release menu
t : To toggle Flasher
q : To enter thruster device
q : To Quit
>
```

```
SeaExplorer (c)
-----
Version v2.1.2-r
Date Jul  4 2016
-----
Config File (sea.cfg) loaded.
Mission File (sea.msn) loaded.
id Mission : 10
LOG : sea018.10.gli.sub
Init mission ...New goto: 1
done
Mission defined (gl=NULL).
SecurityManager.mGlobalTimeout = 2592000 sec (30 j)
SecurityManager.mFlyTimeout = 10800 sec (3 h)
SecurityManager.mDepthLimit = 725 m
SecurityManager.mDepthStabilityLimit = 10 m
SecurityManager.mDepthStabilityError = 2 m
SecurityManager.mDepthStabilityDuration = 180 sec
SecurityManager.mLowBatteries = 25 v
SecurityManager.mMaxConFailedLimit = 3
SecurityManager.mWaterInletCpt = 0
SecurityManager.mVacuumLimit = 90000 Pa
doInit...
$SEAMB_1.105,-10.9,-1.0,100.0*725b;
done Init
$SEAMB_1.105,-10.1,-1.0,100.0*64d3;
doSurfacing...
$SEAMB_1.115,-10.1,-1.0,100.0*4802;
done Surfacing
$SEAMB_1.115,-10.1,-1.0,100.0*4802;
doTransmitting...

OT E0 v0 s0=1 +CBST=7,0,1

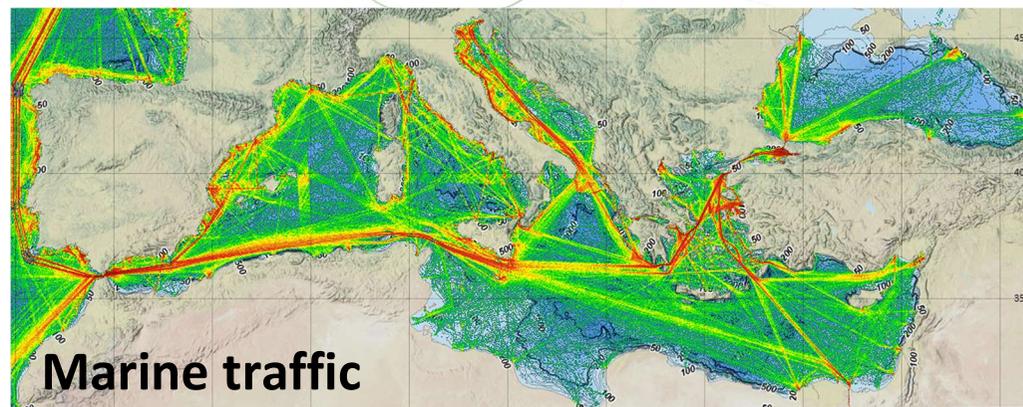
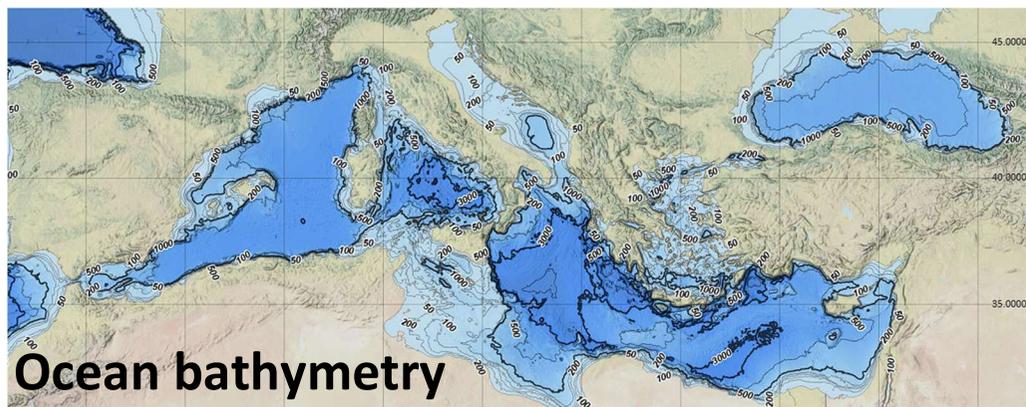
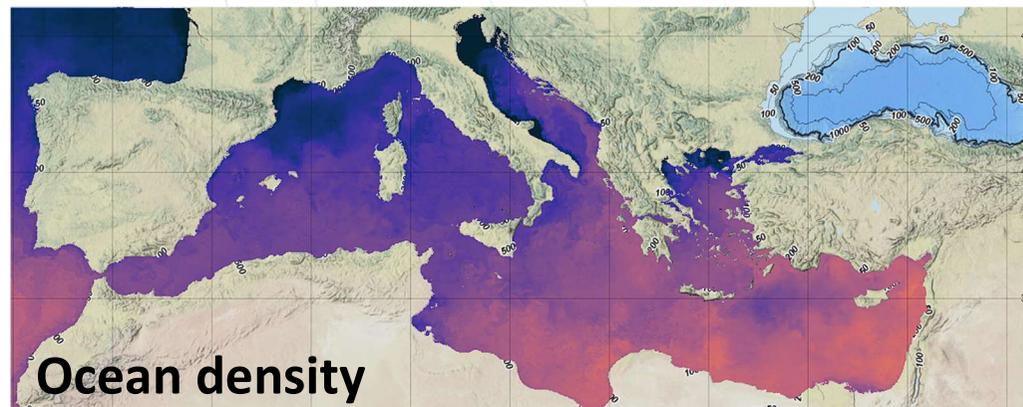
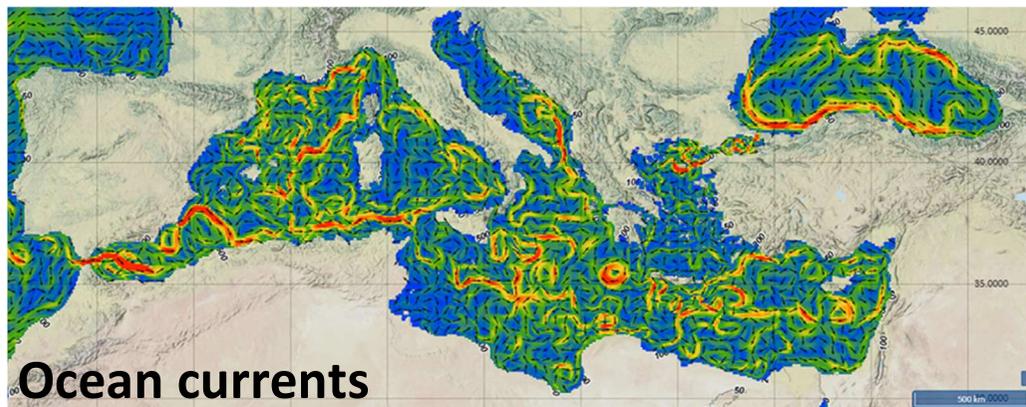
done (a): waiting for RESUME
$SEAMRS_SEA018.10.1.0.285,000000,000040,*,*e675;
$SEANAV_1,-9999,-10,10,200,-200,30,10,10,1*a328;
$SEAMB_1.110,-10.1,-1.0,100.0*673;
```

**4) Mission preparation based on area of interest**

**We are going to deploy a glider**

**What is the most important thing that we need to know  
to prepare a safe mission ?**

# Mission planning factors

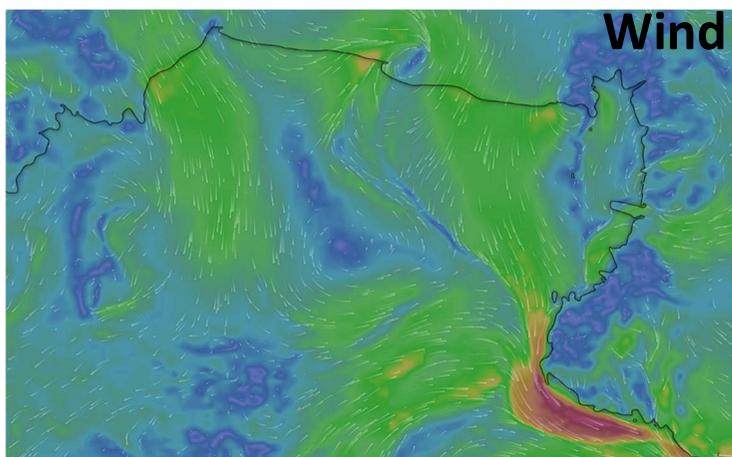


Mission planning factors in polar regions

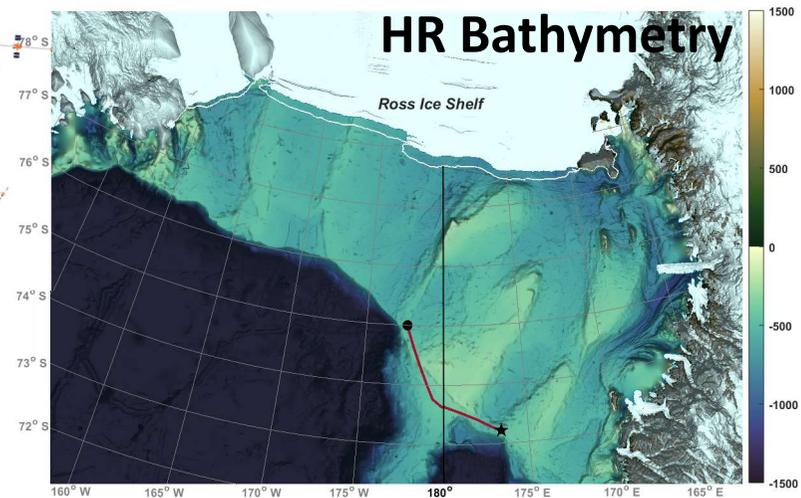
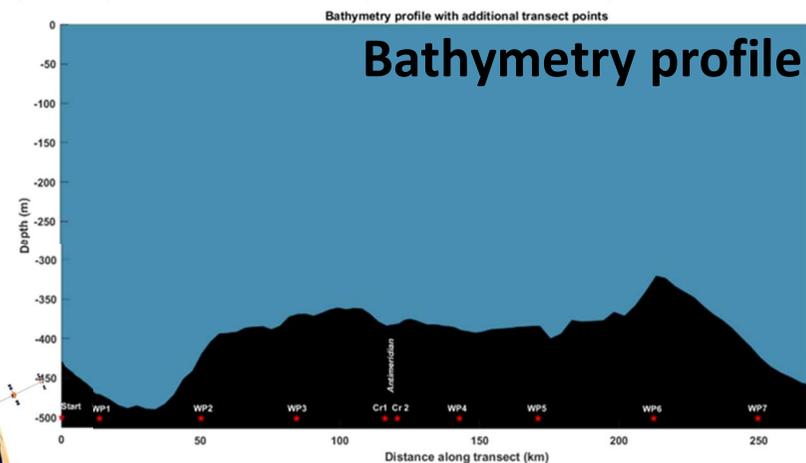
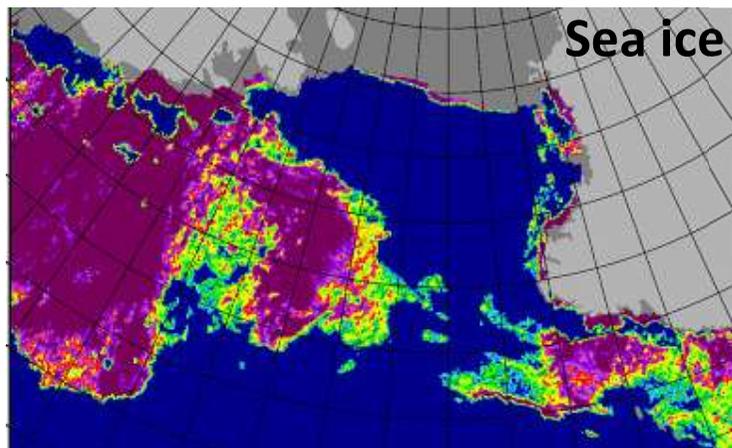
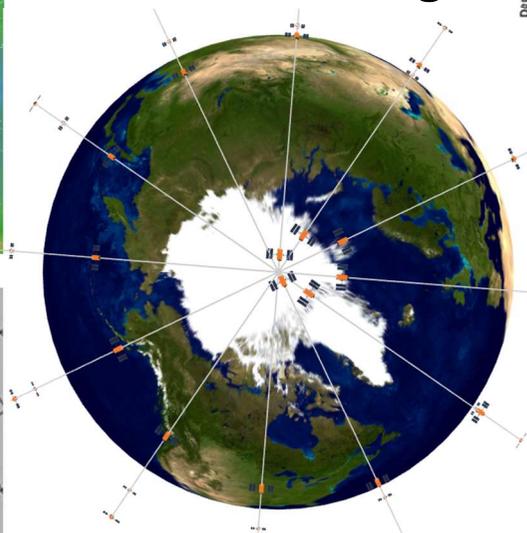


**What about polar regions?**

# Mission planning factors in polar regions



### Iridium coverage

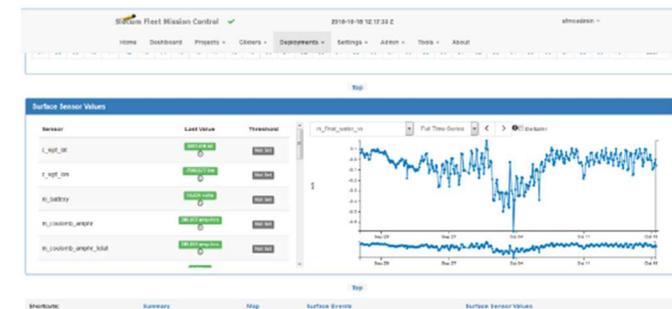
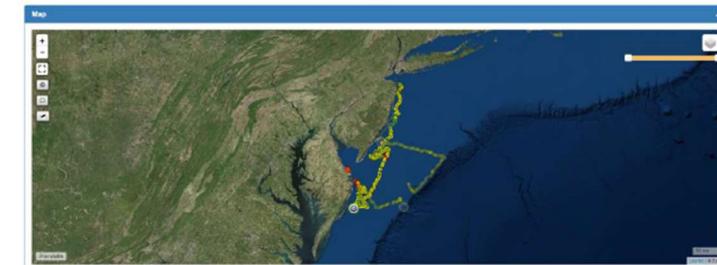


## Glider Software: Slocum Fleet Mission Control (SFMC)

**Deployments - 4 being watched**

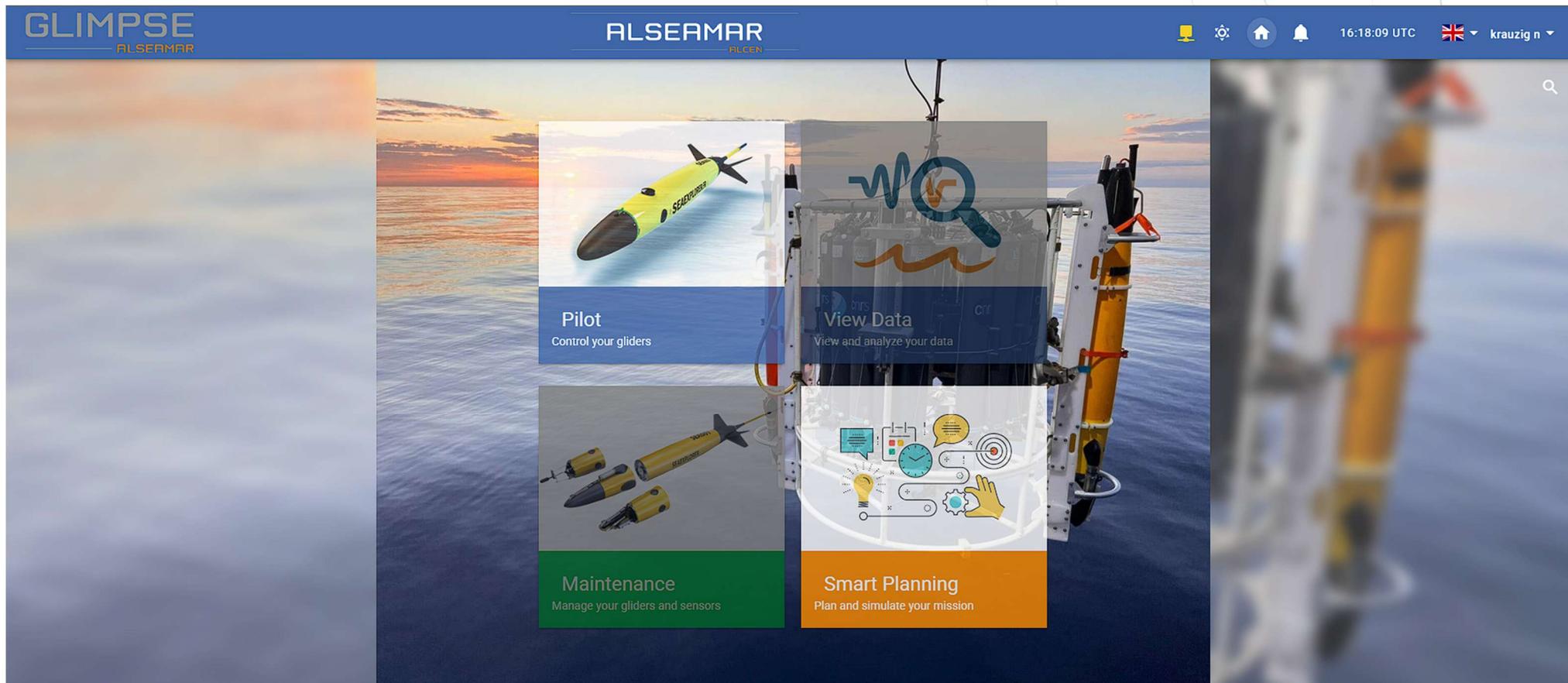
ID	Script	Last Location	Next Waypoint	Speed/VMO	Connection Status	Log Notes
n23-2015-09-24T10:10	Script	38°51.12N 73°41.88W	38°18.17N 74°20.43W 103570m 328°	Speed: 0.18m/s VMO: 5.0m/s	Disconnected @ 2015-10-18 09:51:05Z Hrs/Mins Since: 02:21	Log Notes: 0 Notes
n29-2015-08-25T20:55	Script	33°10.89S 17°06.21W	04°15.00S 15°00.00W 224150m 120°	Speed: 0.34m/s VMO: 5.0m/s	Disconnected @ 2015-10-18 03:48:53Z Hrs/Mins Since: 06:26	Log Notes: 0 Notes
u4_134-2015-09-29T18:13	Script	38°12.64N 73°52.51W	38°08.15N 73°48.40W 14870m 165°	Speed: 0.27m/s VMO: 5.0m/s	Disconnected @ 2015-10-18 11:34:20Z Hrs/Mins Since: 00:38	Log Notes: 0 Notes

Glider	Time Disconnected (Hrs/Mins)	Deployed	Last Location	Waypoint	Range Bearing	Total Distance	Mission	Segment	Script	Log Notes
u4_134	01:38	2015-09-17 11:25:2	38°51.12N 73°41.88W	38°18.17N 74°20.43W	36209 8°	701.00km	30_mine	0047:1701	u4_134	Full Script (PDF) and



Comprehensive Slocum Fleet Mission Control (SFMC) software suite allows glider tracking, mission planning, and piloting from around the world

# Mission Planning Tools



The screenshot displays the GLIMPSE ALSEAMAR mission planning interface. The header includes the logos for GLIMPSE and ALSEAMAR, along with navigation icons, the time 16:18:09 UTC, and a user profile 'krauzig n'. The main content area features four primary functional tiles: 'Pilot' (Control your gliders), 'View Data' (View and analyze your data), 'Maintenance' (Manage your gliders and sensors), and 'Smart Planning' (Plan and simulate your mission). The background of the interface shows a yellow glider being deployed from a ship's deck over the ocean.

# Mission Planning Tools

**GLIMPSE**  
ALSEAMAR

**ALSEAMAR**  
ALLEN

16:18:09 UTC krauzig n

**Pilot**  
Control your gliders

**View Data**  
View and analyze your data

**Maintenance**  
Manage your gliders and sensors

**Smart Planning**  
Plan and simulate your mission



Mission planning  
with the GLIMPSE  
simulation software

# Mission planning & simulation



Ocean Engineering  
Volume 269, 1 February 2023, 113514



## A simulator of underwater glider missions for path planning ☆

Aurélien Merci<sup>a, b, c</sup>, Cédric Anthierens<sup>b</sup>, Nadège Thirion-Moreau<sup>c</sup>, Yann Le Page<sup>a</sup>

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<https://doi.org/10.1016/j.oceaneng.2022.113514>

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### Highlights

- SeaExplorer glider trajectory simulator.
- Modeling in a time-varying marine environment.
- Experimental validation.
- Vehicle routing problems.

Prepare a mission (offline mode)  
&  
during the execution of the mission (online mode)

Environmental data from the Global Marine  
Copernicus Forecast 8 days ahead

Output of high level path planning algorithms (i.e.  
Hamiltonian path Rahman and Kaykobad, 2005)



<https://doi.org/10.1016/j.oceaneng.2022.113514>

# Mission planning & simulation



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### 4D time-varying environment

- Mission duration prediction
- Glider trajectory simulation
- Distance estimation
- Battery estimation
- Fleet coordination

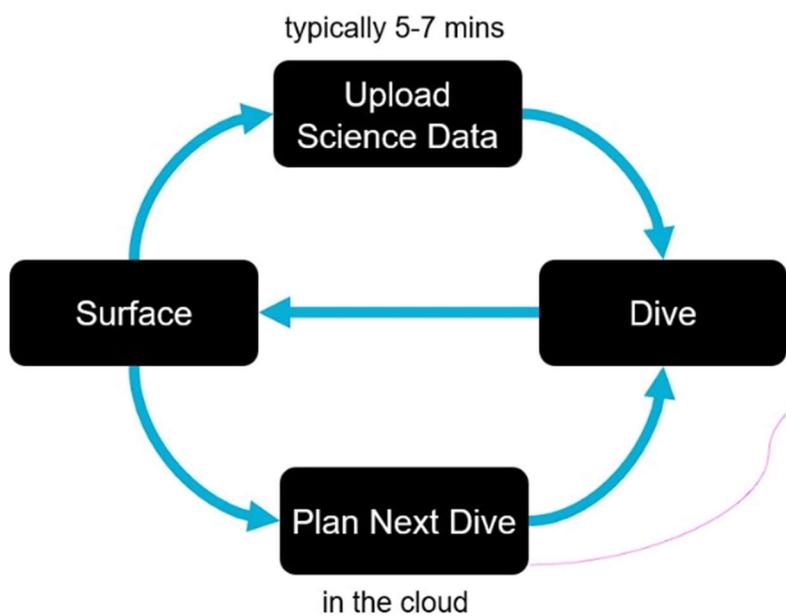


<https://doi.org/10.1016/j.oceaneng.2022.113514>

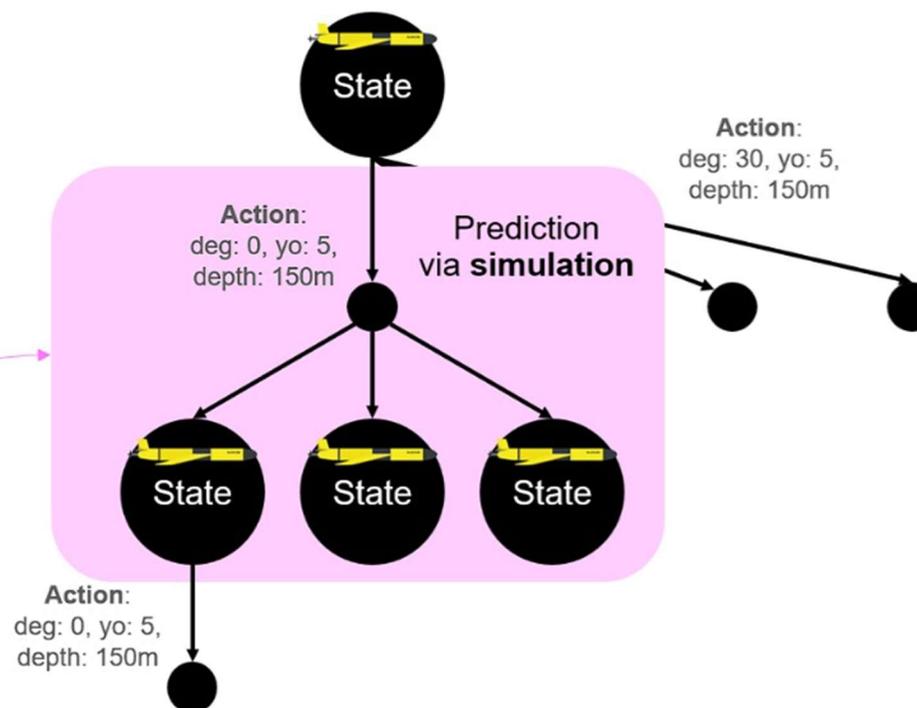
# Mission planning & simulation video

The screenshot displays the ALSEAMAR Glimpse web interface. The top navigation bar includes the Glimpse and ALSEAMAR logos, a search icon, a home icon, a notification bell, the time 12:36:40 UTC, and a user profile dropdown for 'krauzig n'. The main content area features a background image of a yellow glider being deployed from a ship's deck. Overlaid on this are four interactive panels: 'Pilot' (Control your gliders) with a glider image, 'View Data' (View and analyze your data) with a magnifying glass icon, 'Maintenance' (Manage your gliders and sensors) with an image of glider components, and 'Smart Planning' (Plan and simulate your mission) with a flowchart icon. A mouse cursor is positioned over the Smart Planning panel.

# New mission planning & simulation tools



## Planning



## Automatisation to remove/reduce human error



## Take-home message

**Only trained personnel should operate and maintain a glider !**



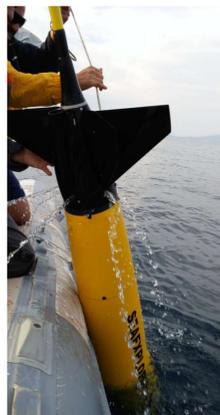
# Glider Training



# In-field testing and deployment

## 5) Plan deployment

30m dive with rope and buoy when possible



## In-field testing and deployment

### 5) Plan recovery

- Handle at the back of the glider and telescopic pole
- LARS (Launch and Recovery System)
- Rinsing the glider
- Download full data with Ethernet
- Cleaning the sensors



## Deployment & recovery years ago



Questions?



## Quiz 3



Are You QRious?



<https://www.menti.com/al2pkzjuc8vg>

## Offline quiz

### **What factors must be considered when planning an underwater glider mission?**

Select all correct answers.

- a) High-resolution bathymetry to plan profiling depths conservatively
- b) Ocean density profiles to optimize buoyancy adjustments
- c) Potential sea ice coverage for navigation and surfacing considerations
- d) Daily diver availability to adjust sensors during the mission
- e) Vessel traffic to avoid collisions during surfacing and to ensure operational safety
- f) Ocean currents to plan the glider's trajectory and energy efficiency
- g) Exact locations of marine mammals to avoid collisions

## Offline quiz

### What factors must be considered when planning an underwater glider mission?

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