



**Regional Awareness Seminar
Working with NAVAREA II and your Primary Charting Authority**

26 and 27 September 2022 Action P-44 of the CBWP 2022

Working with your PCA (Data exchange)

[Risk Assessment -Survey Specification HO's portal]



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Organization

HIDROGRAPHY

- Introduction
- Purpose of Hydrography
- Measuring Equipment
- Survey Platforms
- Survey Standards
- Hydrographic Surveys
- Final Thoughts

- **Cdr Carlos Marques**



- **Hydrography** is the branch of applied sciences which deals with the measurement and description of the physical features of oceans, seas, coastal areas, lakes and rivers, as well as with the prediction of their change over time, for the primary purpose of safety of navigation and in support of all other marine activities, including economic development, security and defence, scientific research, and environmental protection.
- In July 2002, the revised Chapter V of the IMO Safety of Life at Sea (SOLAS) Convention entered into force. Under the new Regulation 9, the Contracting Governments of SOLAS are now required to provide and maintain Hydrographic Services and products.

In the past few decades, the following important factors have emphasized the need for adequate hydrographic survey coverage and the production of nautical charts and publications as required by SOLAS Chapter V;

- the advent of exceptionally deep draught VLCC ships
 - the need to protect the marine environment
 - changing maritime trade patterns
 - the growing importance of seabed resources
 - and the U.N. Law of the Sea Convention affecting areas of national jurisdiction
- Many charts which were adequate a decade ago, may have to be recompiled using new survey data, collected to a higher degree of accuracy and providing improved coverage. This deficiency may not be limited to sparsely surveyed waters of developing nations, but may also apply to the coastal waters of major industrial states. The advent of accurate satellite navigation, has made poorly positioned historical data an even greater problem for navigators. Fortunately, new survey technologies have improved the precision to which modern hydrographic surveys can be conducted.



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HYDROGRAPHY

- Safety of navigation
 - Trade



Navio encalhado – NZ, Foto: AFP



Mindelo, 27 to September 2022

Environmental Protection
Management
Communications
Areas



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HYDROGRAPHY

- Safety of navigation
 - Trade
 - Fishery

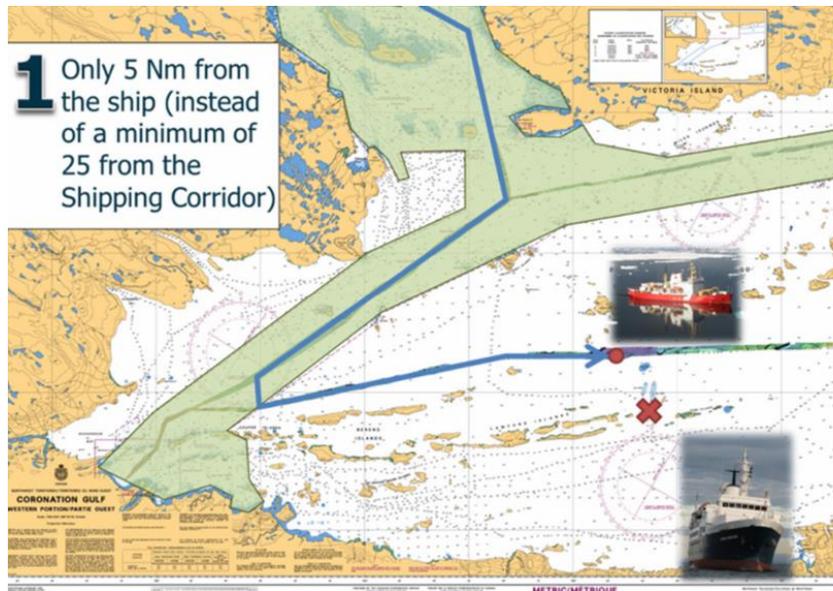


Fig. Foz, Foto: Lusa



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HYDROGRAPHY

- Safety of navigation
 - Trade
 - Fishery
 - Transportation

Overhead View²⁹



Starboard Side View³⁰



Clipper Adventurer Grounding

- Engineering
- Environmental Protection
- Risk Management
- Communications
- Maritime areas
- Science



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HYDROGRAPHY

International Hydrographic Organization



- Safety of navigation
 - Trade
 - Fishery
 - Transportation
 - Tourism



- Engineering
- Protection



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Indestructible & Crash-Proof!

HYDROGRAPHY

- **Safety of navigation**
 - Trade
 - Fishery
 - Transportation
 - Tourism
 - Etc..
- Engineering
- Environmental Protection
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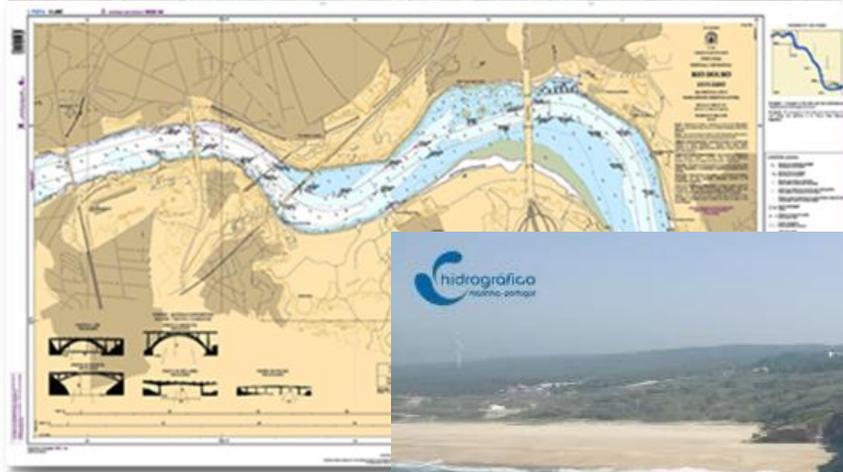
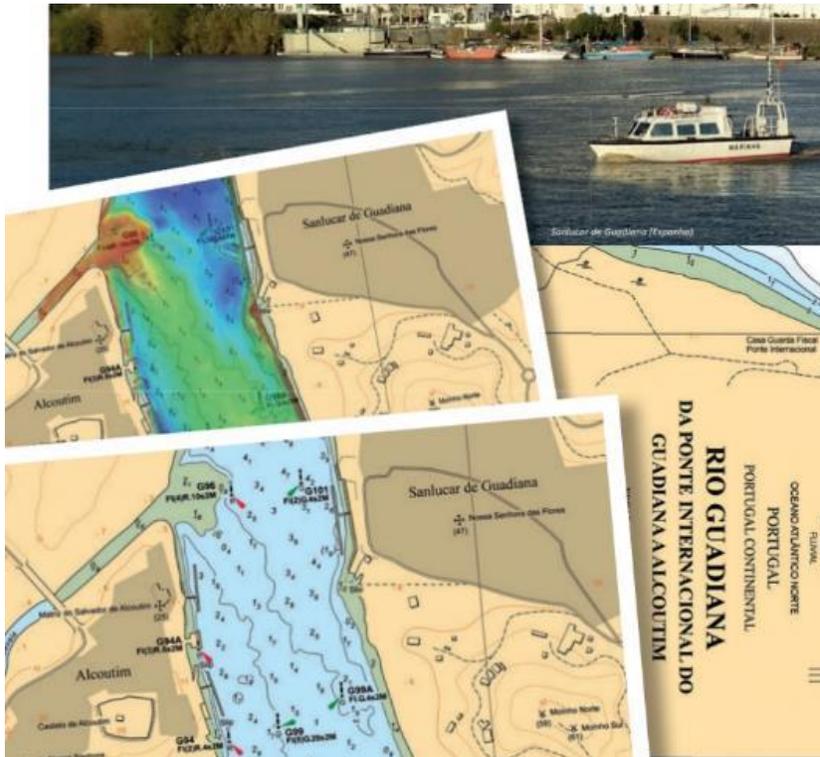
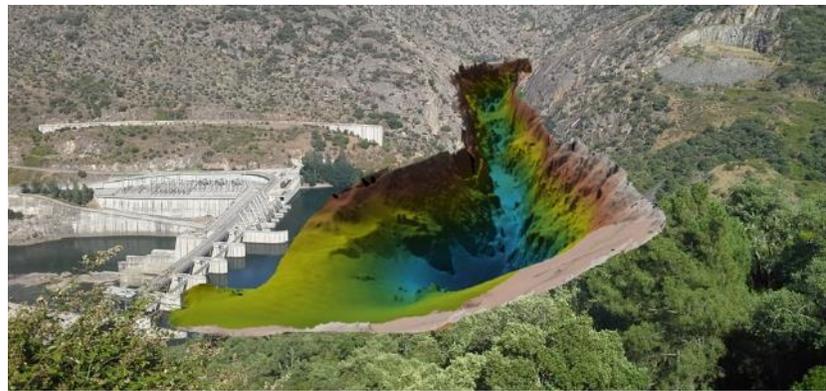


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HYDROGRAPHY

- Safety of navigation
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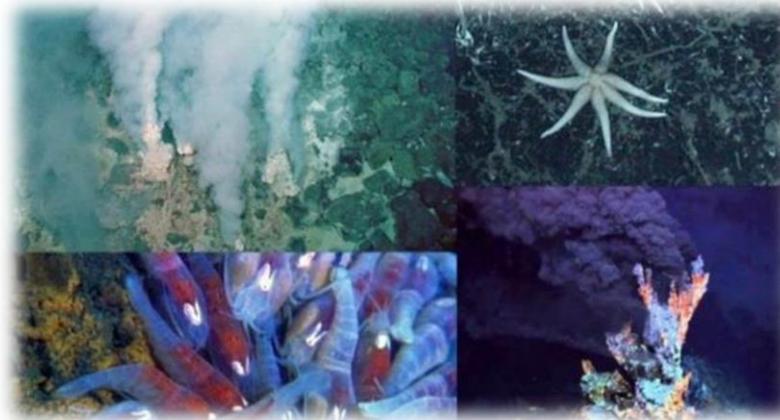
HYDROGRAPHY

- **Safety of navigation**
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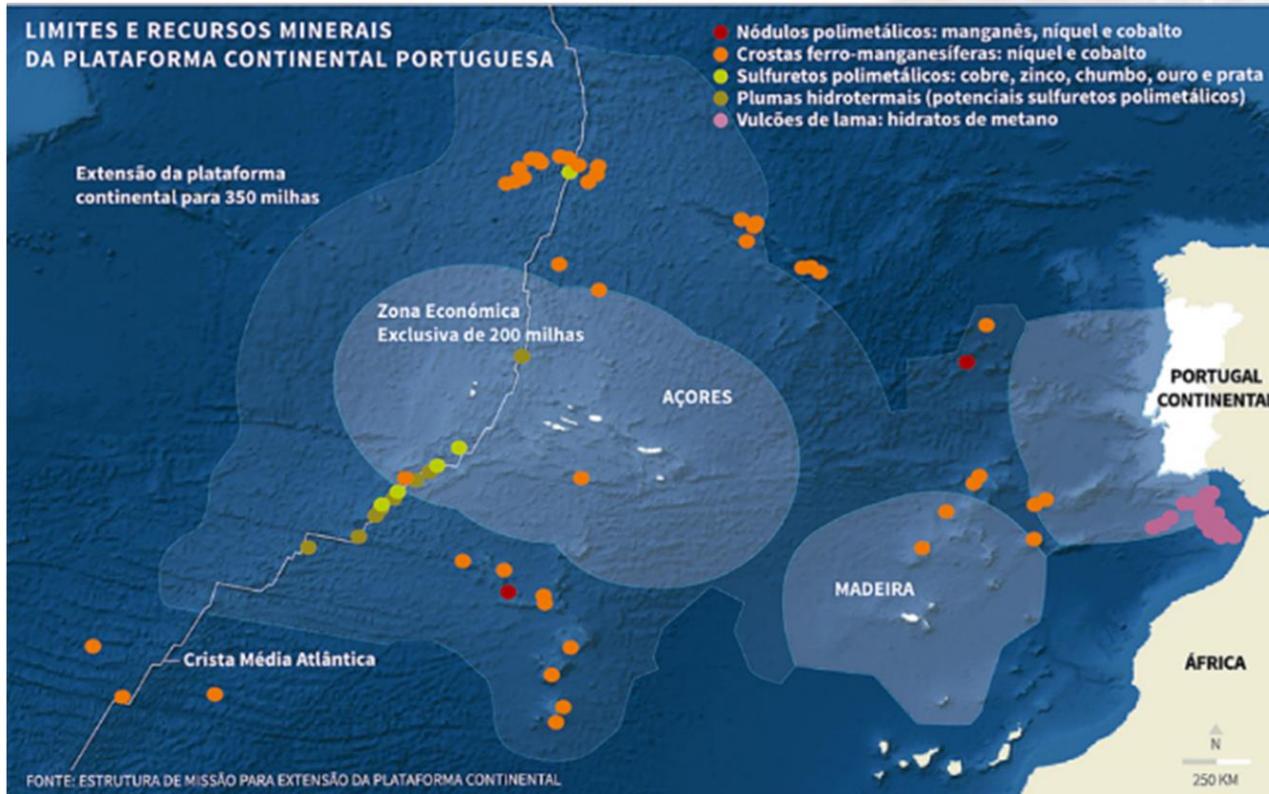
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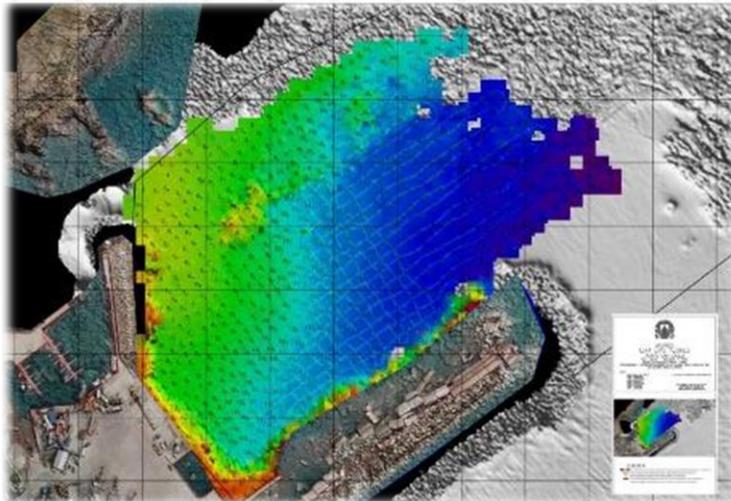




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HYDROGRAPHY



Insight Report

The Global Risks Report 2019 14th Edition

2017	2018	2019
Extreme weather events	Extreme weather events	Extreme weather events
Large-scale involuntary migration	Natural disasters	Failure of climate-change mitigation and adaptation
Major natural disasters	Cyber-attacks	Natural disasters

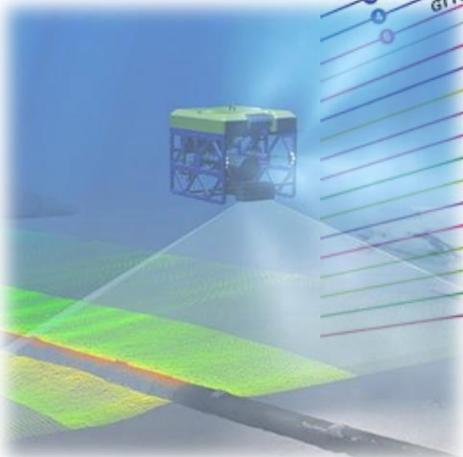
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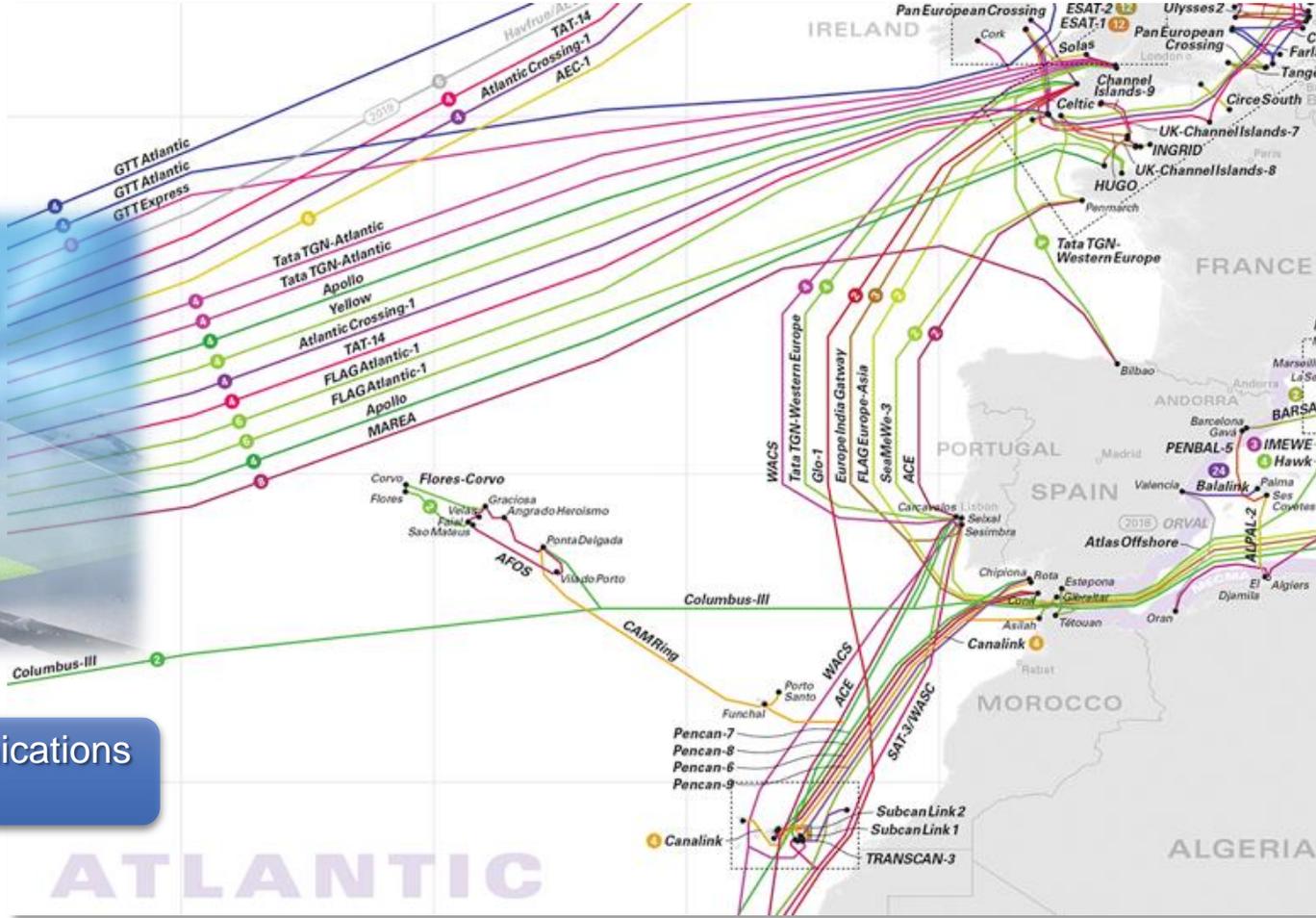
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HYDROGRAPHY

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95 % Communications
99 % internet



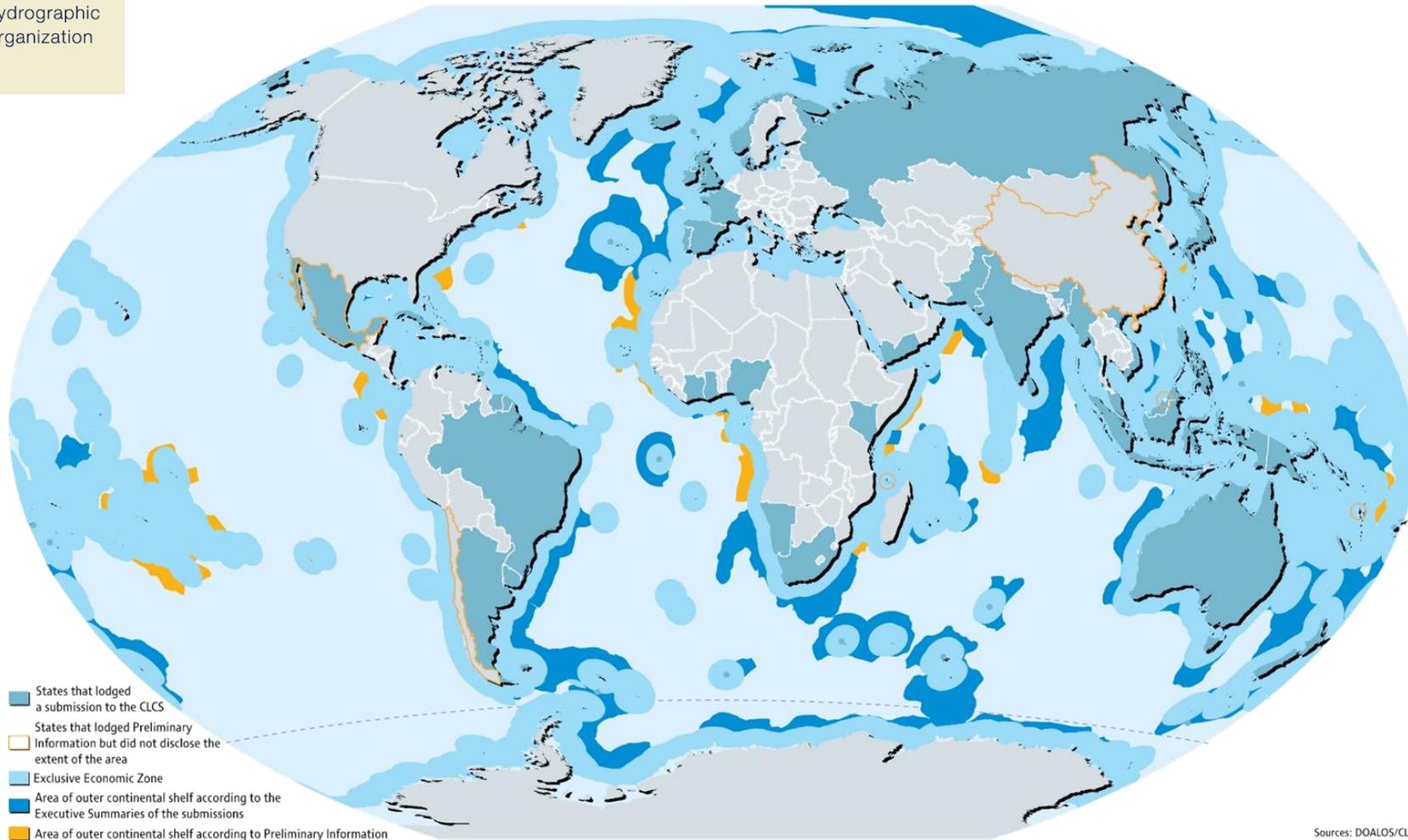
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HYDROGRAPHY

Global distribution of outer continental shelf



- **Safety of navigation**
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Sustainable blue economy vital for small countries and coastal populations



© Unsplash/Benjamin L. Jones - Seagrass meadows - expanses of green, grass-like shoots and flowers - are a hugely effective nature-based solution to climate change.

With the livelihoods of about 40 per cent of the world's population living at or near a coast, the second day of the [UN Ocean Conference](#) under way in Lisbon focused on [strengthening sustainable ocean-based economies, managing coastal ecosystems](#).



The United Nations
Decade of Ocean Science
for Sustainable Development
(2021-2030)



2021
2030 United Nations Decade
of Ocean Science
for Sustainable Development

HYDROGRAPHY

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EQUIPMENT

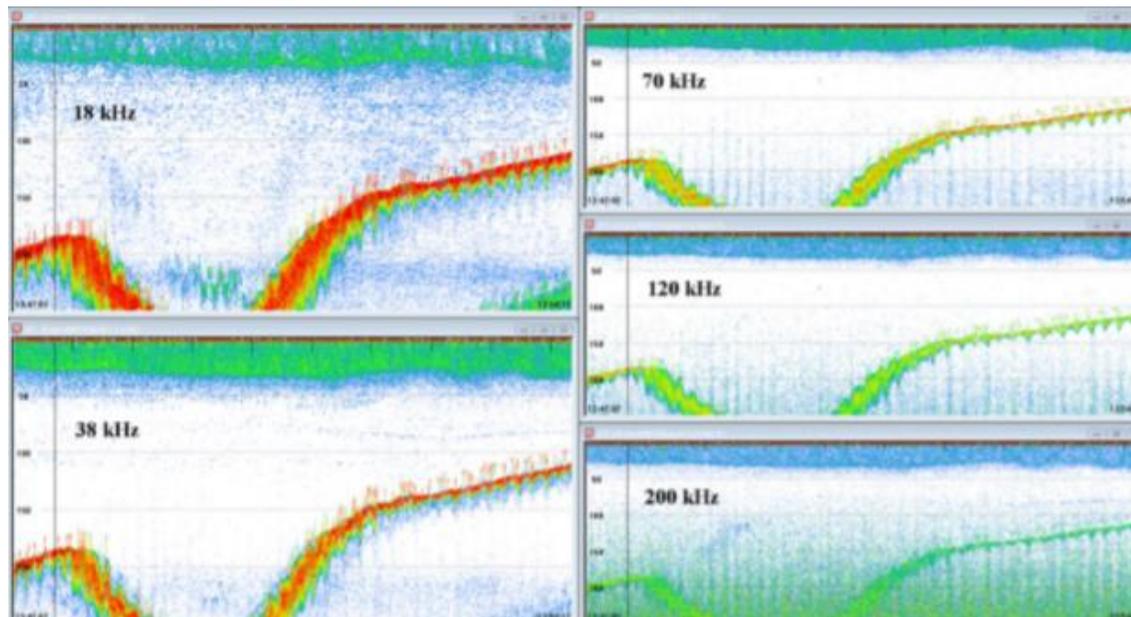
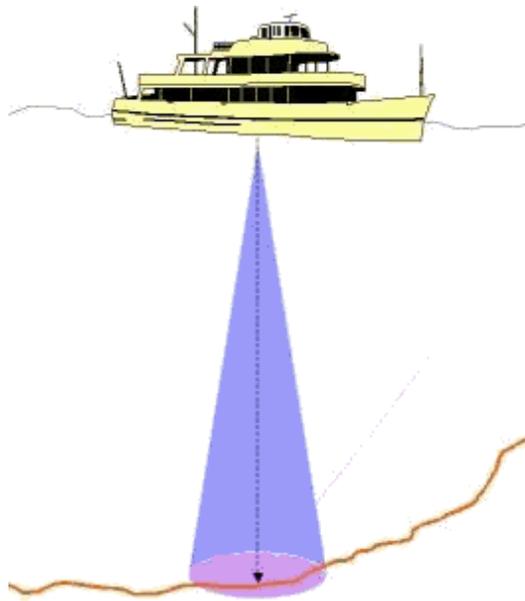
- How to measure?

- **Depth**
- **Tides**
- **Currents**
- **Positioning**
- **Topography**
- **Other**



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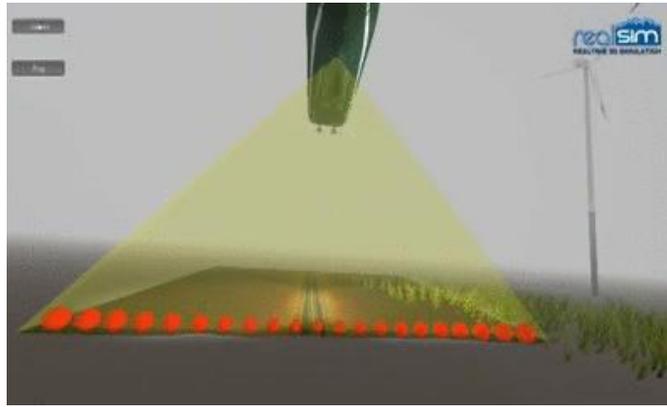
EQUIPMENT

- **Depth**
 - **Single Beam systems**
 - **Multibeam systems**
 - ...
- Tides
- Currents
- Positioning
- Topography
- Other



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EQUIPMENT

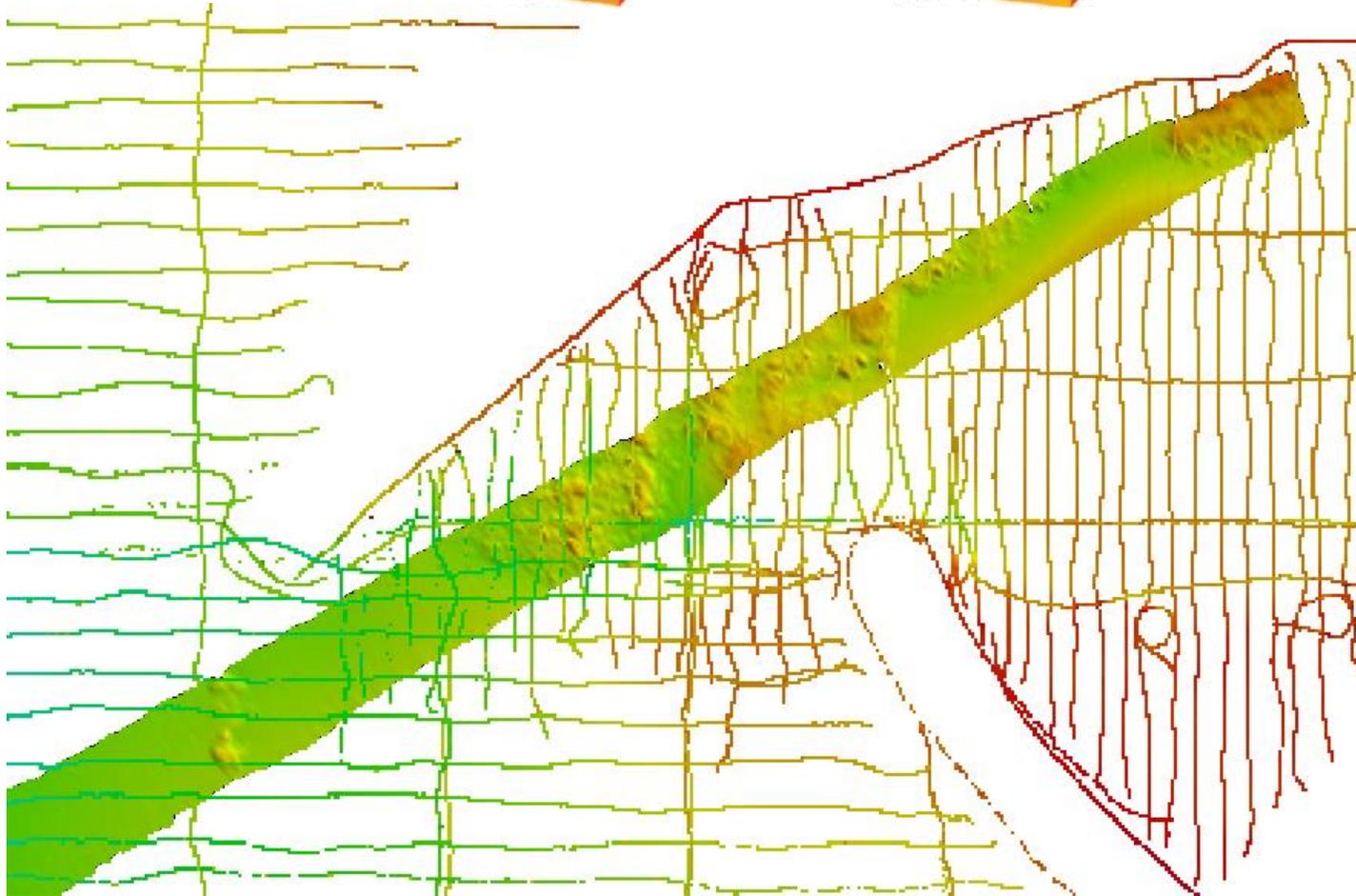
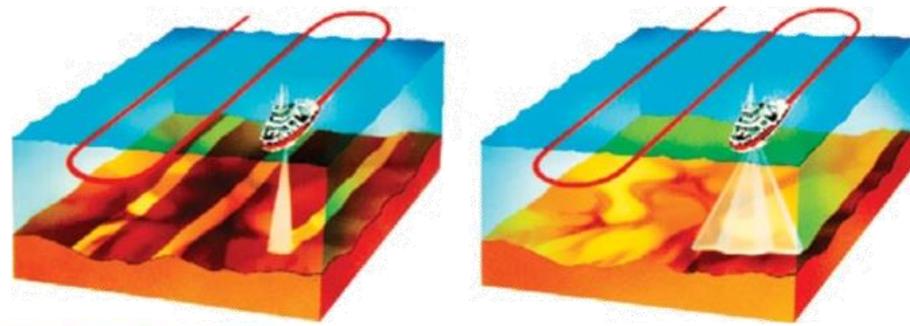
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 - Multibeam systems
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- Other





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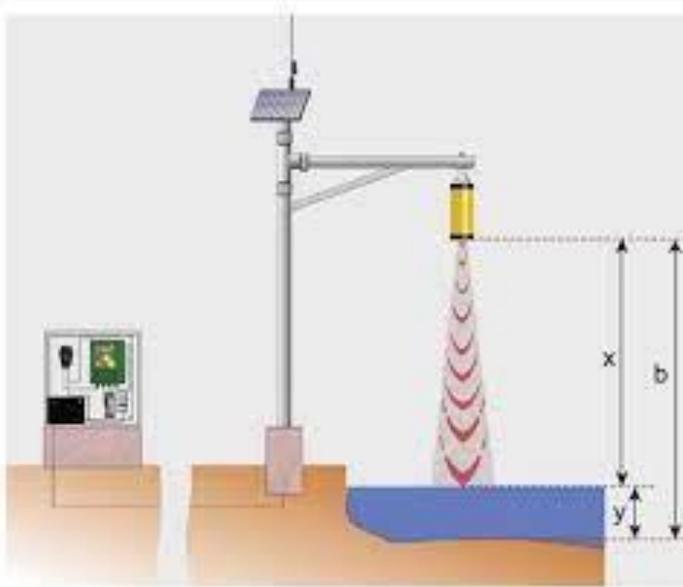
EQUIPMENT

- **Depth**
 - Single Beam systems
 - Multibeam systems
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- Currents
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- Topography
- Other



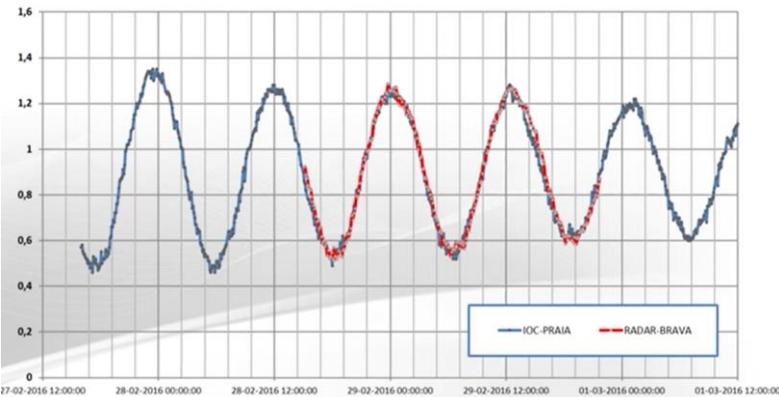
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EQUIPMENT

- **Depth**
 - Single Beam systems
 - Multibeam systems
 - ...
- **Tides**
 - Radar gauge
 - Pressure gauge
 - ...
- Currents
- Positioning
- Topography
- Other





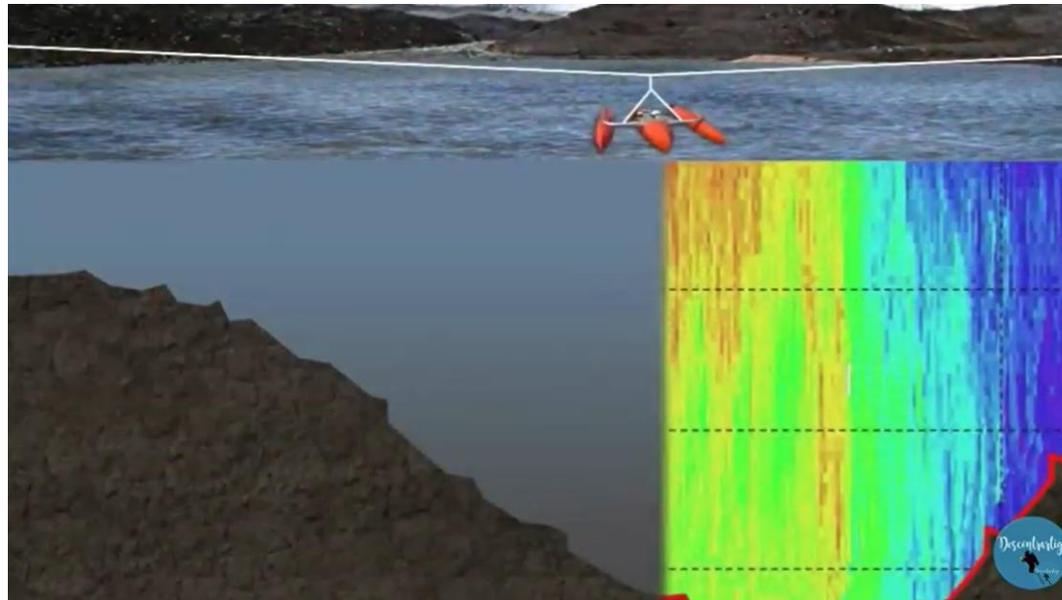
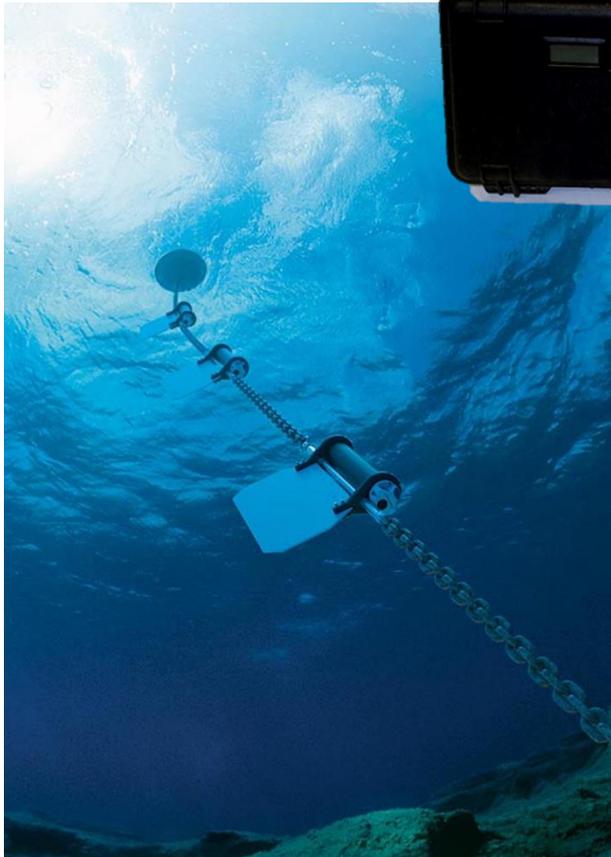
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EQUIPMENT



- **Depth**
 - Single Beam systems
 - Multibeam systems
 - ...
- **Tides**
 - Radar gauge
 - Pressure gauge
 - ...
- **Currents**
 - ADCP
 - Current Meters
 - ...
- Positioning
- Topography
- Other

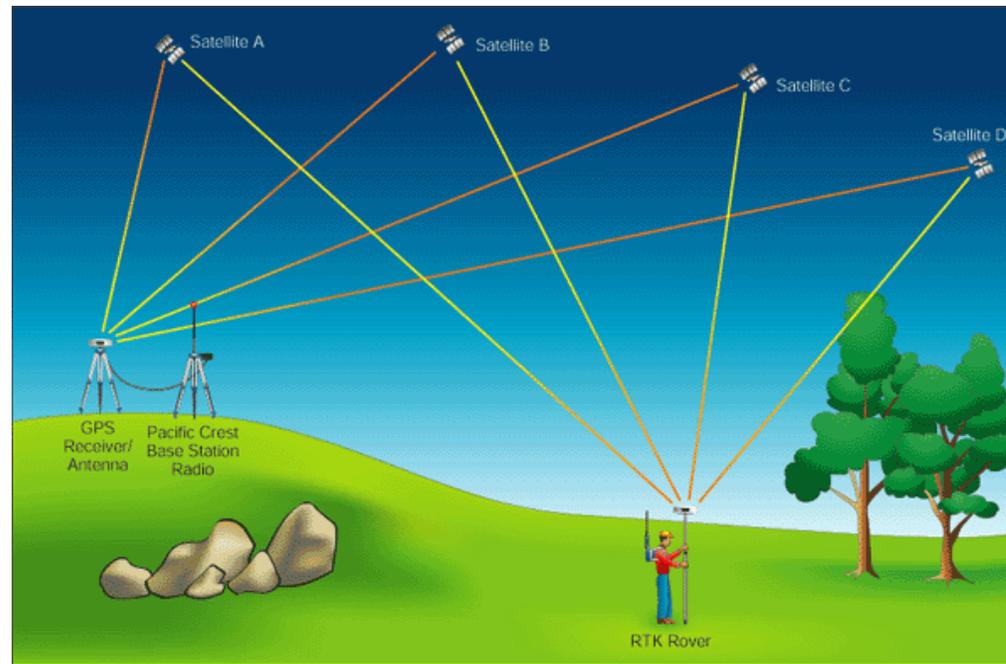


Mindelo, 27 to September 2022



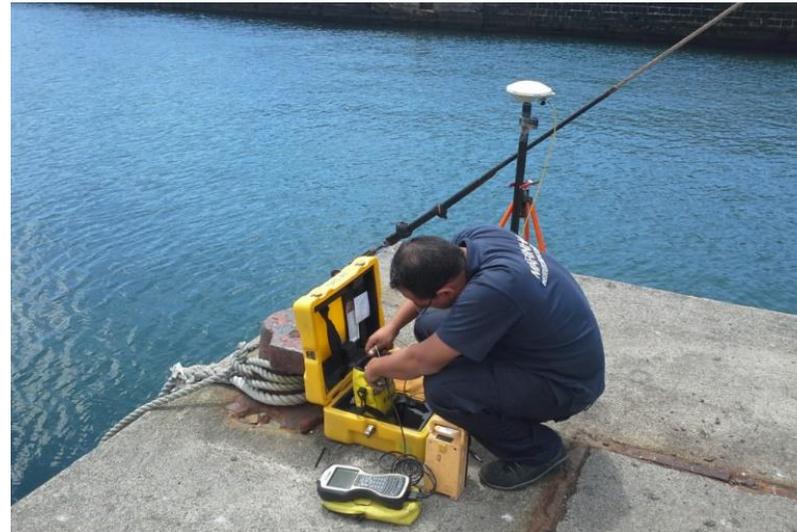
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EQUIPMENT

- **Depth**
 - Single Beam systems
 - Multibeam systems
 - ...
- **Tides**
 - Radar gauge
 - Pressure gauge
 - ...
- **Currents**
 - ADCP
 - Current Meters
 - ...
- **Positioning**
 - GNSS, Dif / RTK
 - ...
- **Topography**
- **Other**

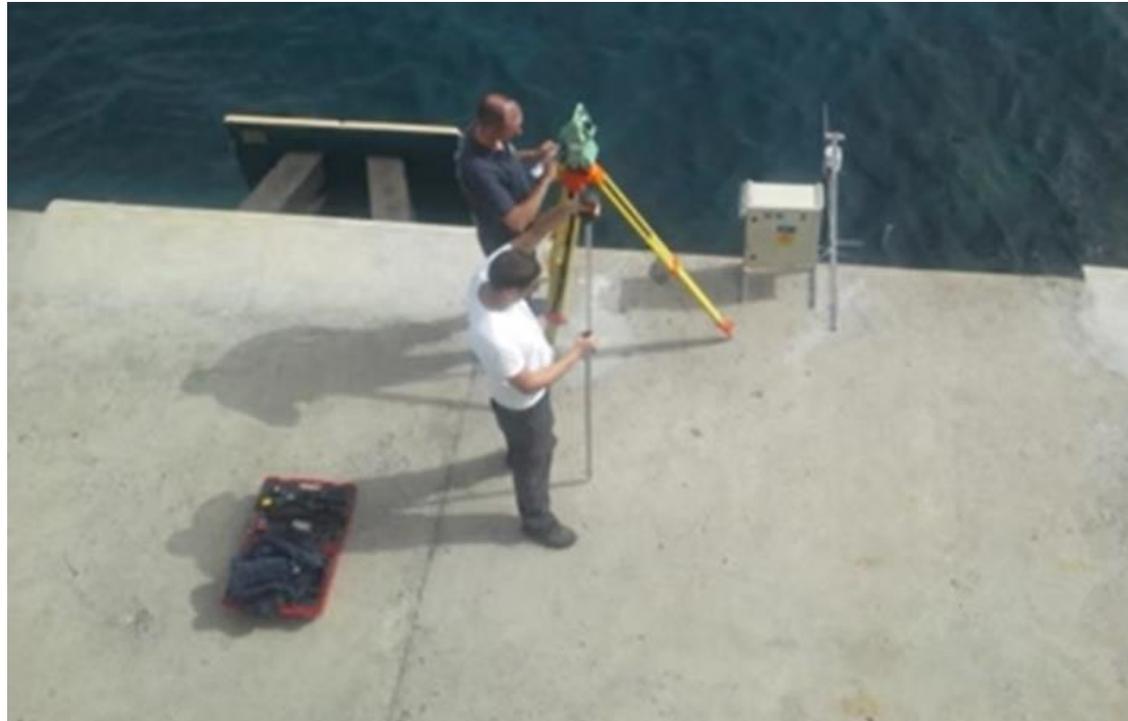




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GNSS Survey on a Geodetic control point



EQUIPMENT

- **Depth**
 - Single Beam systems
 - Multibeam systems
 - ...
- **Tides**
 - Radar gauge
 - Pressure gauge
 - ...
- **Currents**
 - ADCP
 - Current Meters
 - ...
- **Positioning**
 - GNSS, Dif / RTK
 - ...
- **Topography**
 - Total Station / Laser
 - GNSS
 - ...
- **Other**



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SURVEY PLATFORMS

Survey Platforms

- **Oceanic and Coastal Ships**
- **Coastal and Harbour Vessels**
- **Other**

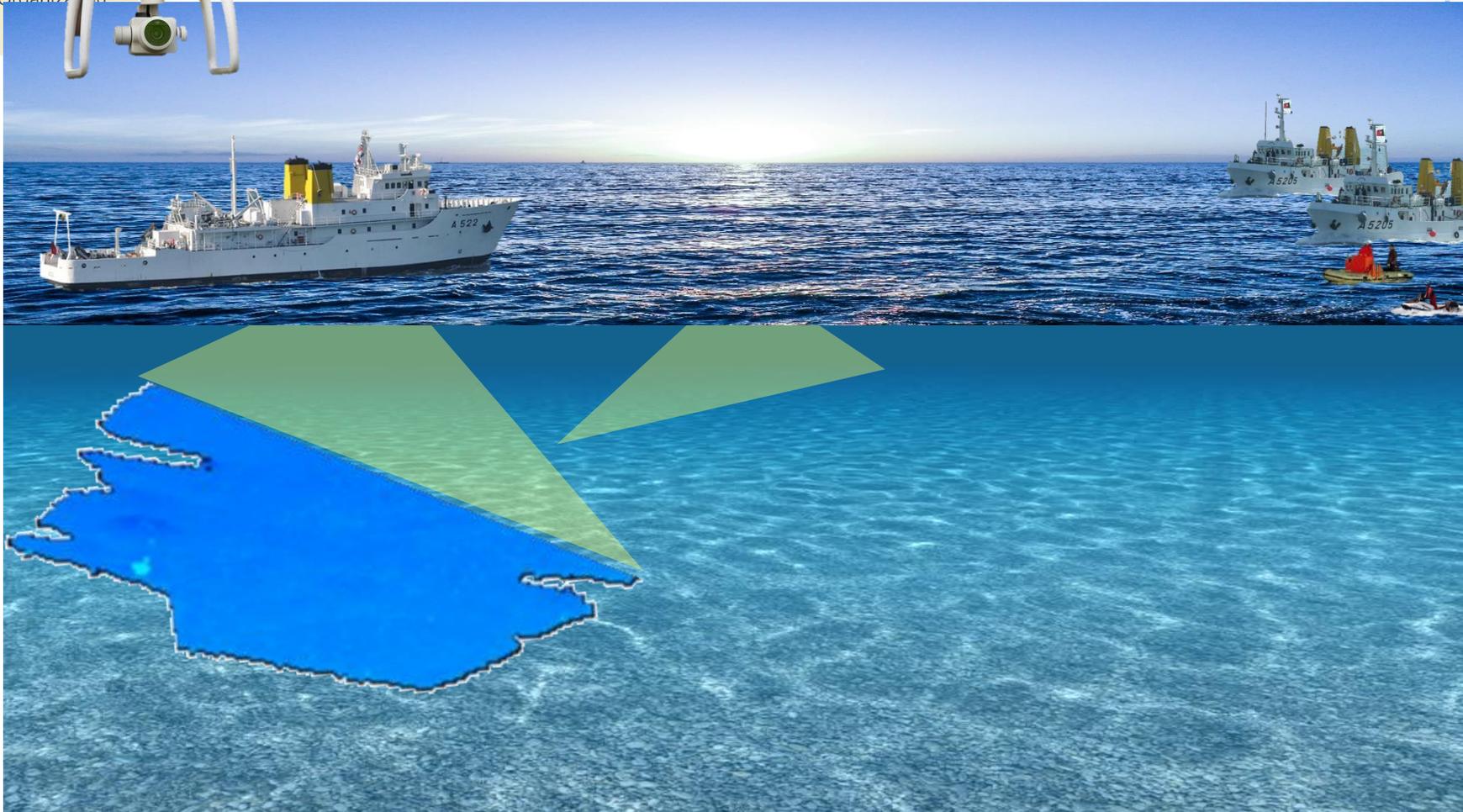


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SURVEY PLATFORMS



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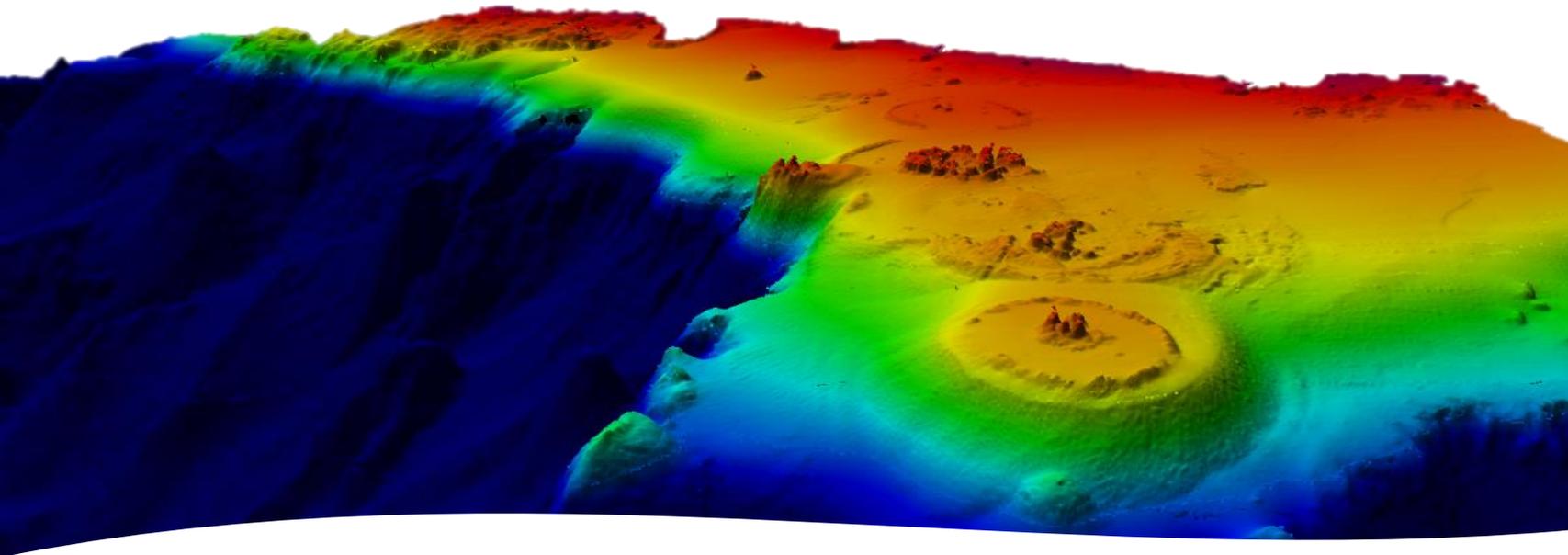
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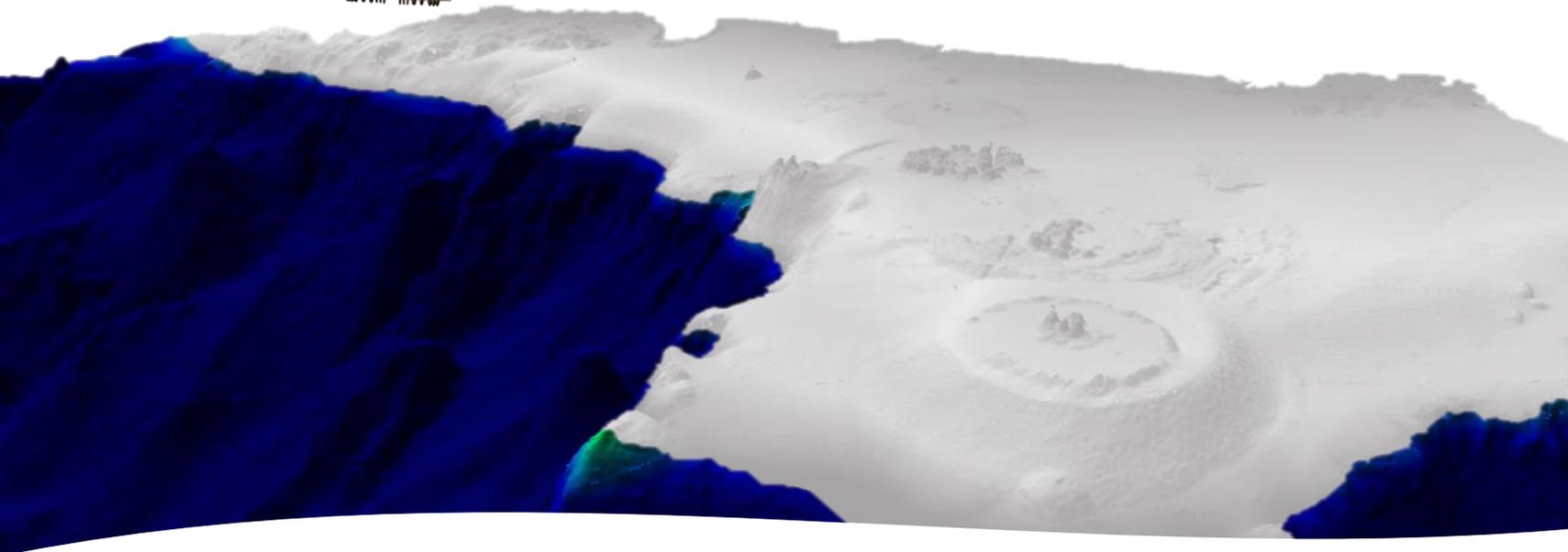
Survey Platforms

- Oceanic and Coastal Ships
- Coastal and Harbour Vessels
- Other

Deep Waters
50 – 11 000 m

Multibeam Systems

- EM 120
- EM 124





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Survey Platforms

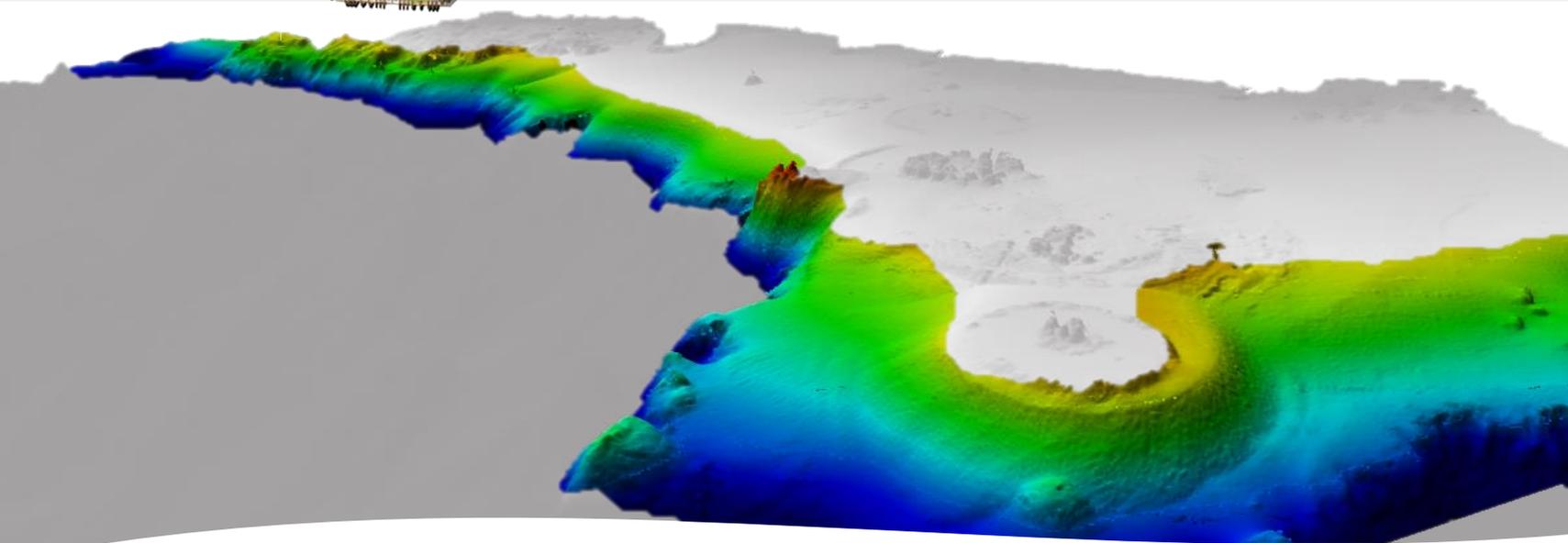
- Oceanic and Coastal Ships
- Coastal and Harbour Vessels
- Other

Medium Waters

3 – 2 000 m

Multibeam Systems

- EM 710
- EM 712





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SURVEY PLATFORMS

Survey Platforms

- Oceanic and Coastal Ships
- Coastal and Harbour Vessels
- Other

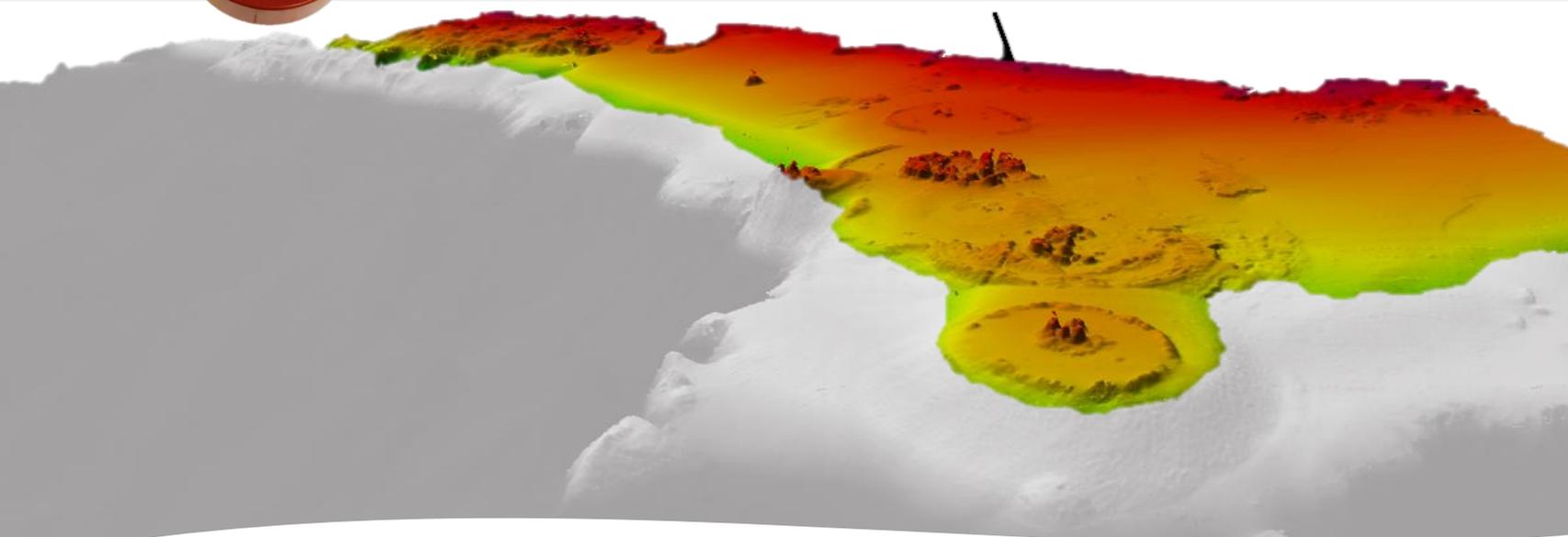
Shallow Waters

1 – 120 m (max 400m)

Multibeam Systems

EM2040C

200 – 400 kHz





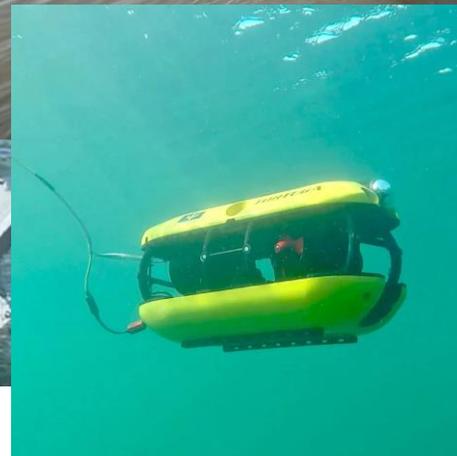
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SURVEY PLATFORMS

Survey Platforms

- Oceanic and Coastal Ships
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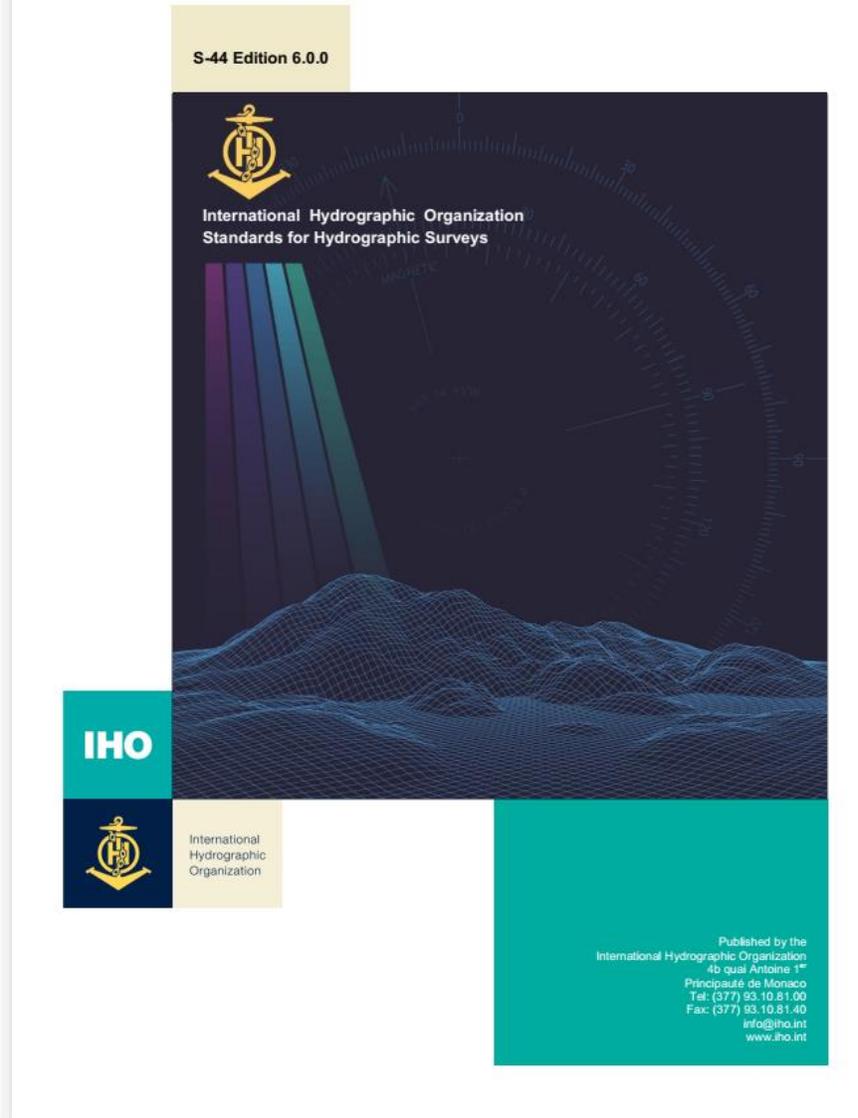


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SURVEY STANDARDS

IHO S-44
Standards for Hydrographic
Surveys (Edition 6.0.0, Sep 2020)



<https://iho.int/uploads/user/pubs/standards/s-44/S-44 Edition 6.0.0 EN.pdf>



IHO S-44 Standards for Hydrographic Surveys (Edition 6.0.0, Sep 2020)

Minimum Bathymetry Standards for Safety of Navigation

7.3 TABLE 1 - Minimum Bathymetry Standards for Safety of Navigation Hydrographic Surveys

To be read in conjunction with the full text set out in this document, m = metres, all [uncertainties](#) at 95% confidence level, * = Matrix Reference.

Reference	Criteria	Order 2	Order 1b	Order 1a	Special Order	Exclusive Order
Chapter 1	Area description (Generally)	Areas where a general description of the sea floor is considered adequate.	Areas where underkeel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.	Areas where underkeel clearance is considered not to be critical but features of concern to surface shipping may exist.	Areas where underkeel clearance is critical	Areas where there is strict minimum underkeel clearance and manoeuvrability criteria
Section 2.6	Depth THU [m] + [% of Depth]	20 m + 10% of depth *Ba5, Bb2	5 m + 5% of depth *Ba8, Bb3	5 m + 5% of depth *Ba8, Bb3	2 m *Ba9	1 m *Ba10
Section 2.6 Section 3.2 Section 3.2.3	Depth TVU (a) [m] and (b)	a = 1.0 m b = 0.023 *Bc7, Bd4	a = 0.5 m b = 0.013 *Bc8, Bd6	a = 0.5 m b = 0.013 *Bc8, Bd6	a = 0.25 m b = 0.0075 *Bc10, Bd8	a = 0.15 m b = 0.0075 *Bc12, Bd8
Section 3.3	Feature Detection [m] or [% of Depth]	Not Specified	Not Specified	Cubic features > 2 m, in depths down to 40 m; 10% of depth beyond 40 m *Be5, Bf3 beyond 40m	Cubic features > 1 m *Be6	Cubic features > 0.5 m *Be9
Section 3.4	Feature Search [%]	Recommended but Not Required	Recommended but Not Required	100% *Bg9	100% *Bg9	200% *Bg12
Section 3.5	Bathymetric Coverage [%]	5% *Bh3	5% *Bh3	≤ 100% *≤ Bh9	100% *Bh9	200% *Bh12





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SURVEY STANDARDS

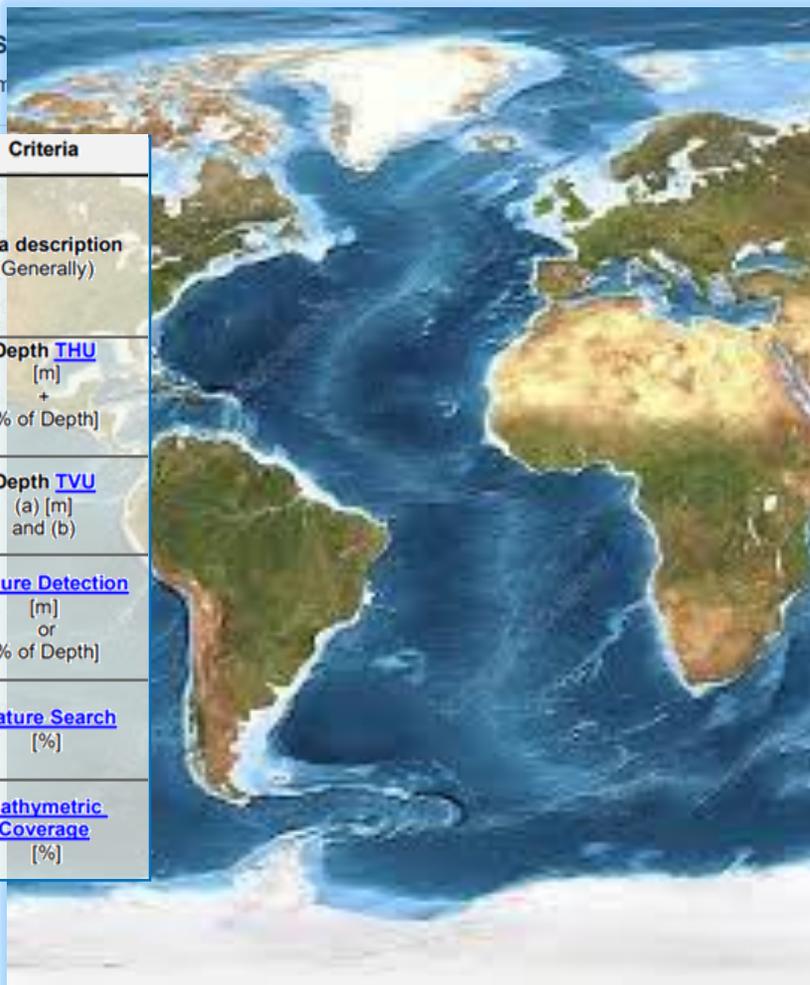
IHO S-44

Standards for Hydrographic Surveys (Edition 6.0.0, Sep 2020)

7.3 TABLE 1 - Minimum Bathymetry Standards for Safety of Navigation

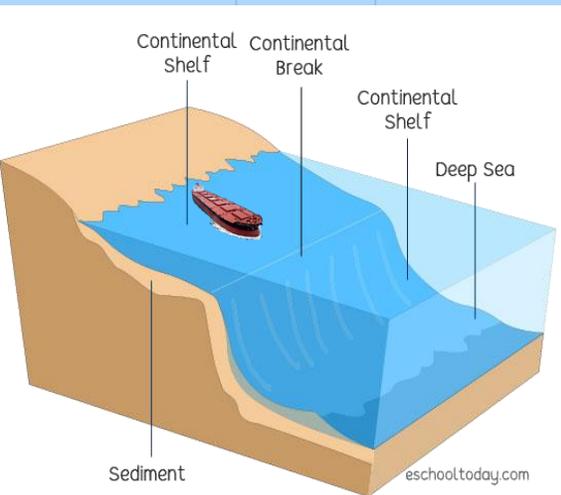
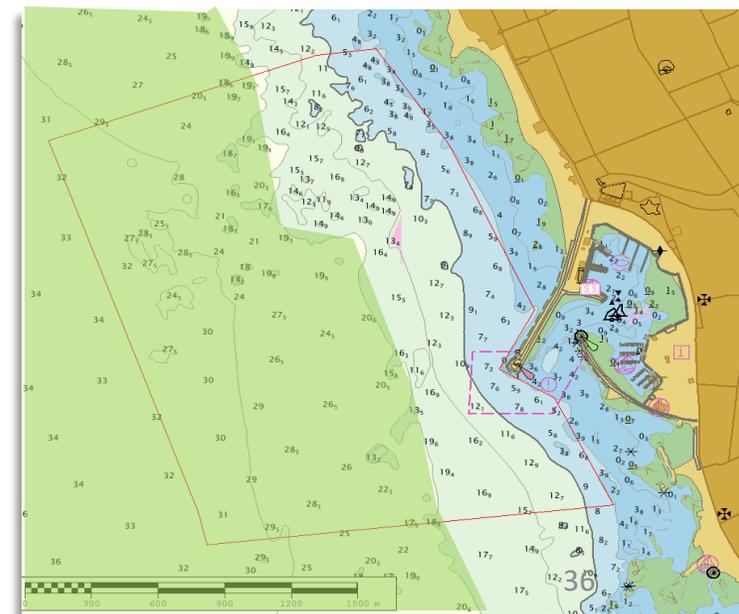
To be read in conjunction with the full text set out in this document

Reference	Criteria	Order 2	Criteria
		Areas where a general description of the sea floor is considered adequate.	Area description (Generally)
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		a = 1.0 m b = 0.023 <i>*Bc7, Bd4</i>	Depth TVU (a) [m] and (b)
		Not Specified	Feature Detection [m] or [% of Depth]
		Recommended but Not Required	Feature Search [%]
		5% <i>*Bh3</i>	Bathymetric Coverage [%]



Minimum Bathymetry Standards for Safety of Navigation

- Order 2
- Order 1b
- Order 1a
- Special Order
- Exclusive Order



S-44



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SURVEY STANDARDS

IHO S-44

Standards for Hydrographic Surveys (Edition 6.0.0, Sep 2020)

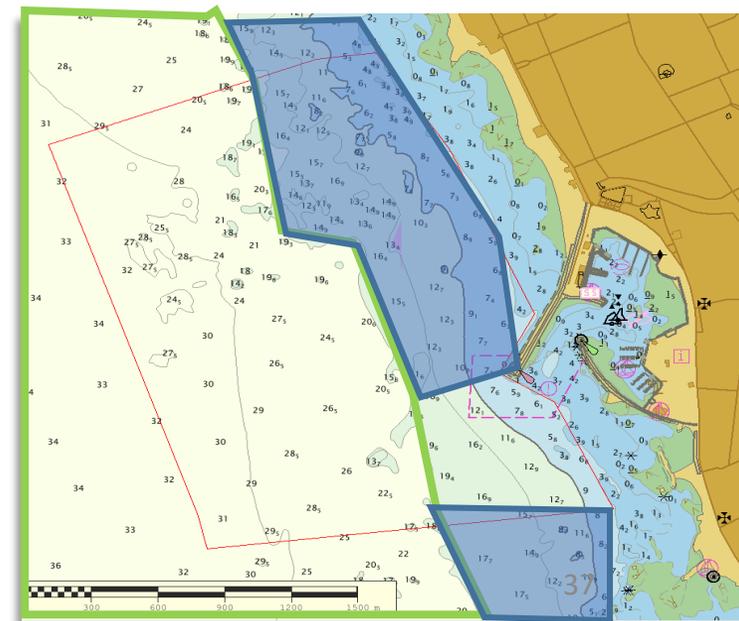
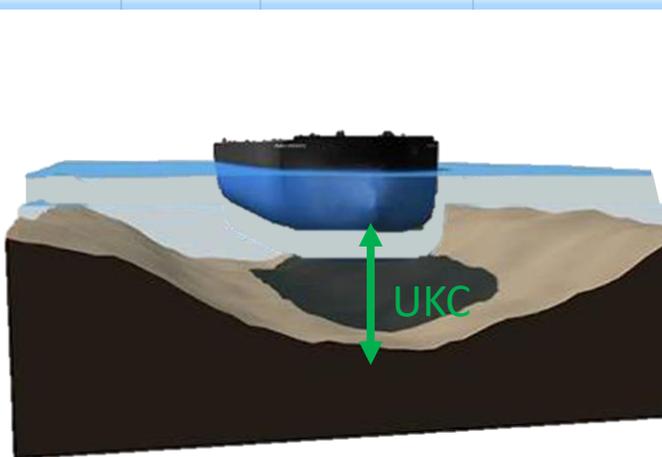
Minimum Bathymetry Standards for Safety of Navigation

Order 2
Order 1b
Order 1a
Special Order
Exclusive Order

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To be read in conjunction with the full text set out in this document, m = metres, all [uncertainties](#) at 95% confidence level, * = Matrix Reference.

Reference	Criteria	Order 2	Order 1b	Criteria	Special Order	Exclusive Order
			Areas where underkeel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.	Area description (Generally)	Areas where underkeel clearance is critical	Areas where there is strict minimum underkeel clearance and manoeuvrability criteria
			5 m + 5% of depth *Ba8, Bb3	Depth THU [m] + [% of Depth]	2 m *Ba9	1 m *Ba10
			a = 0.5 m b = 0.013 *Bc8, Bd6	Depth TVU (a) [m] and (b)	a = 0.25 m b = 0.0075 *Bc10, Bd8	a = 0.15 m b = 0.0075 *Bc12, Bd8
			Not Specified	Feature Detection [m] or [% of Depth]	Cubic features > 1 m *Be6	Cubic features > 0.5 m *Be9
			Recommended but Not Required	Feature Search [%]	100% *Bg9	200% *Bg12
Section 3.5	Bathymetric Coverage [%]	5% *Bh3	5% *Bh3	Bathymetric Coverage [%]	100% *Bh9	200% *Bh12



S-44

September 2020

Edition 6.0.0



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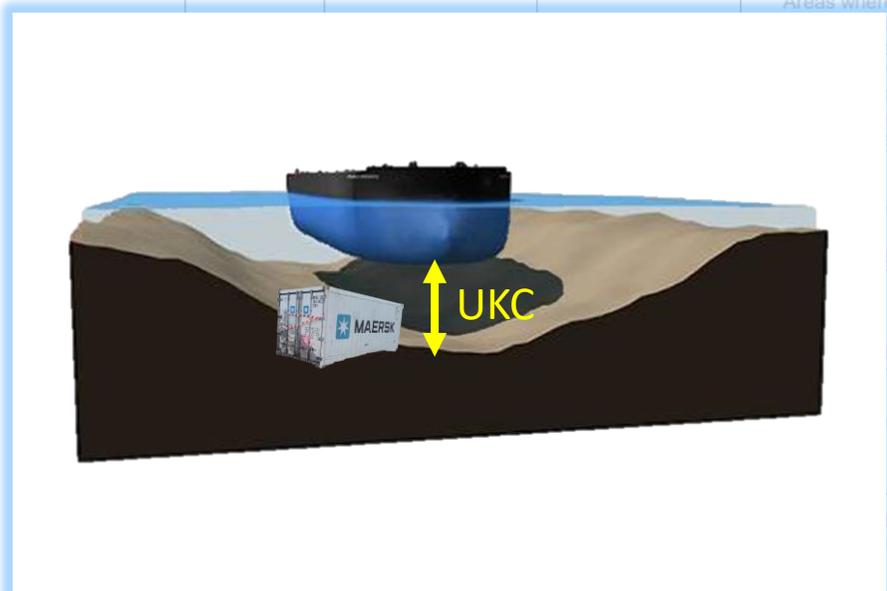
International Hydrographic Organization

SURVEY STANDARDS

IHO S-44 Standards for Hydrographic Surveys (Edition 6.0.0, Sep 2020)

7.3 TABLE 1 - Minimum Bathymetry Standards for Safety of Navigation Hydrographic Surveys

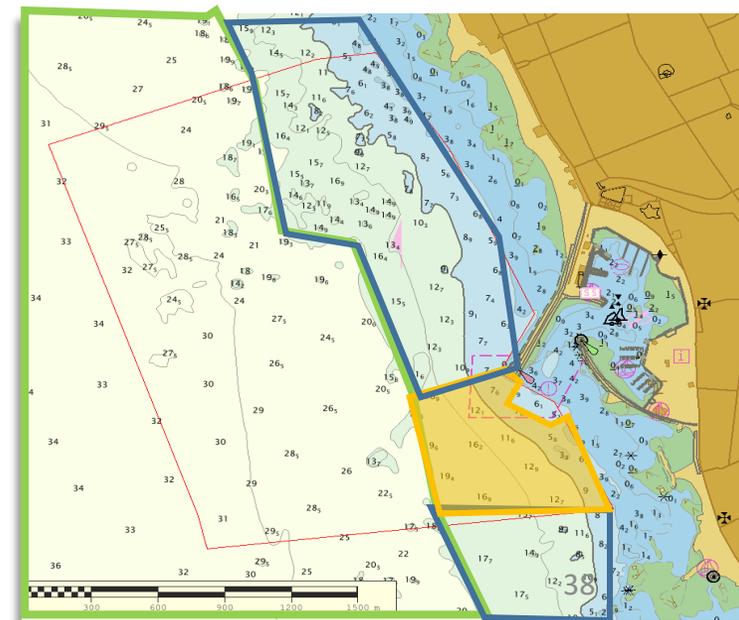
To be read in conjunction with the full text set out in this document, m = metres, all [uncertainties](#) at 95% confidence level, * = Matrix Reference.



Reference	Criteria	Order 2	Order 1b	Order 1a	Criteria	Exclusive Order
			Areas where	Areas where underkeel clearance is considered not to be critical but features of concern to surface shipping may exist.	Area description (Generally)	Areas where there is strict minimum underkeel clearance and manoeuvrability criteria
				5 m + 5% of depth *Ba8, Bb3	Depth THU [m] + [% of Depth]	1 m *Ba10
				a = 0.5 m b = 0.013 *Bc8, Bd6	Depth TVU (a) [m] and (b)	a = 0.15 m b = 0.0075 *Bc12, Bd8
				Cubic features > 2 m, in depths down to 40 m; 10% of depth beyond 40 m *Be5, Bf3 beyond 40m	Feature Detection [m] or [% of Depth]	Cubic features > 0.5 m *Be9
				100% *Bg9	Feature Search [%]	200% *Bg12
Section 3.5	Bathymetric Coverage [%]	5%	5%	≤ 100% *≤ Bh9	Bathymetric Coverage [%]	200% *Bh12

Minimum Bathymetry Standards for Safety of Navigation

Order 2
Order 1b
Order 1a
Special Order
Exclusive Order



S-44

September 2020

Edition 6.0.0



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SURVEY STANDARDS

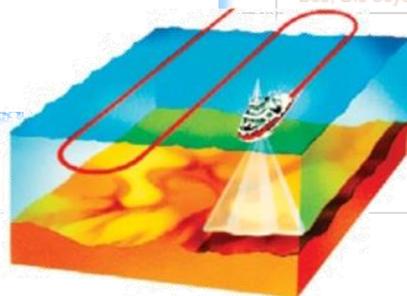
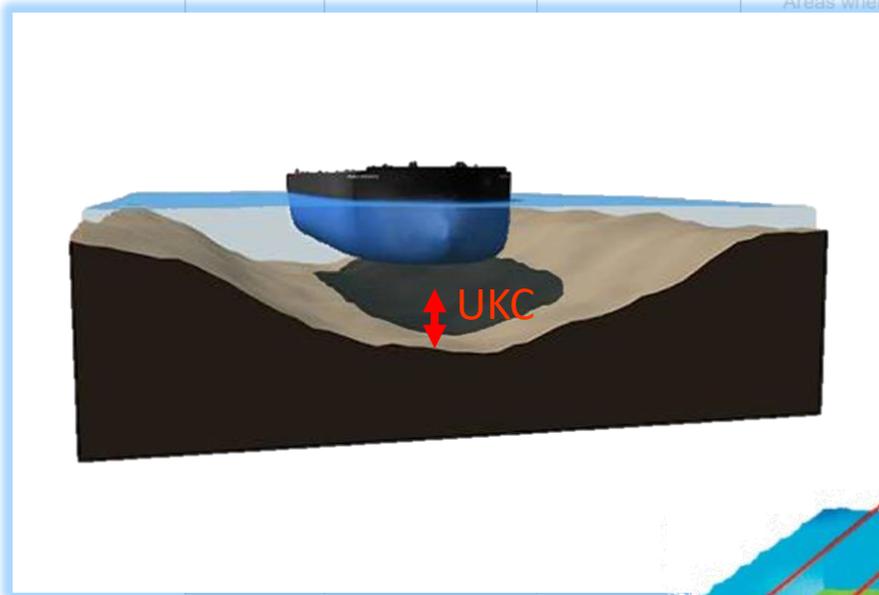
IHO S-44

Standards for Hydrographic Surveys (Edition 6.0.0, Sep 2020)

7.3 TABLE 1 - Minimum Bathymetry Standards for Safety of Navigation Hydrographic Surveys

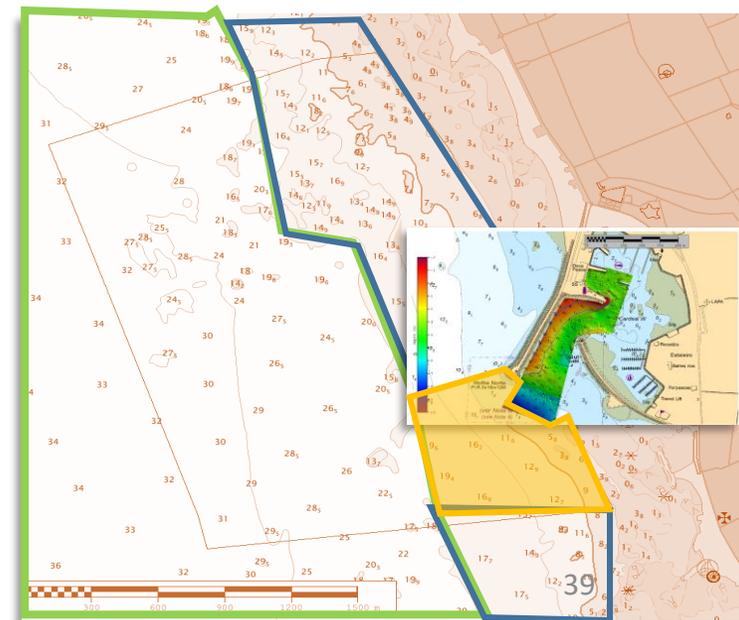
To be read in conjunction with the full text set out in this document, m = metres, all [uncertainties](#) at 95% confidence level, * = Matrix Reference.

Reference	Criteria	Order 2	Order 1b	Order 1a	Special Order	Criteria
			Areas where	Areas where underkeel clearance is considered not to be critical but features of concern to surface shipping may exist.	Areas where underkeel clearance is critical	Area description (Generally)
				5 m + 5% of depth	2 m	Depth THU [m] + [% of Depth]
				a = 0.5 m b = 0.013	a = 0.25 m b = 0.0075	Depth TVU (a) [m] and (b)
				Cubic features > 2 m, in depths down to 40 m; 10% of depth beyond 40 m	Cubic features > 1 m	Feature Detection [m] or [% of Depth]
					100%	Feature Search [%]
Section 3.5	Bathymetric Coverage [%]	5%			100%	Bathymetric Coverage [%]



Minimum Bathymetry Standards for Safety of Navigation

- Order 2
- Order 1b
- Order 1a
- Special Order
- Exclusive Order



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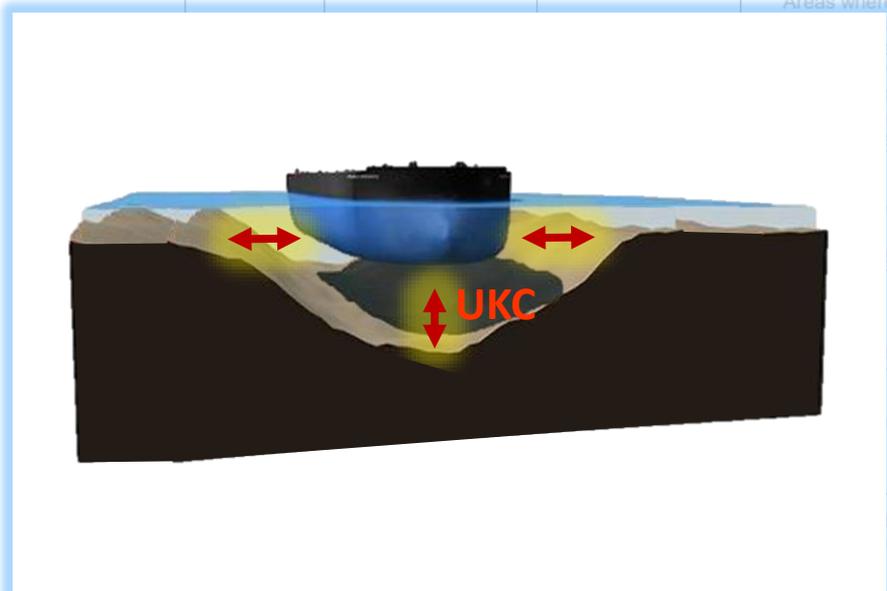
SURVEY STANDARDS

IHO S-44

Standards for Hydrographic Surveys (Edition 6.0.0, Sep 2020)

7.3 TABLE 1 - Minimum Bathymetry Standards for Safety of Navigation Hydrographic Surveys

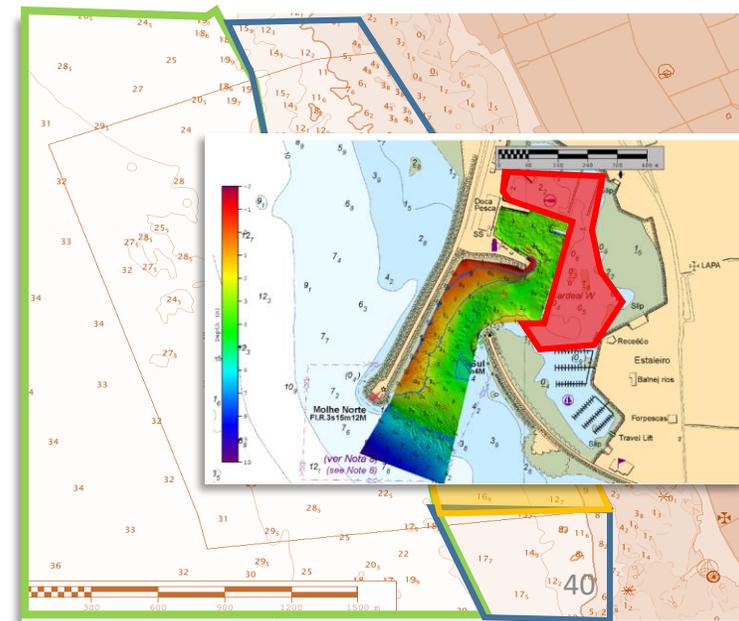
To be read in conjunction with the full text set out in this document, m = metres, all [uncertainties](#) at 95% confidence level, * = Matrix Reference.



Reference	Criteria	Order 2	Order 1b	Order 1a	Criteria	Exclusive Order
			Areas where	Areas where underkeel clearance is considered not to be critical but features of concern to surface shipping may exist.	Area description (Generally)	Areas where there is strict minimum underkeel clearance and manoeuvrability criteria
				5 m + 5% of depth	Depth THU [m] + [% of Depth]	1 m
				a = 0.5 m b = 0.013	Depth TVU (a) [m] and (b)	a = 0.15 m b = 0.0075
				Cubic features > 2 m in depths down to 40 m; 10% of depth beyond 40 m	Feature Detection [m] or [% of Depth]	Cubic features > 0.5 m
				100%	Feature Search [%]	200%
Section 3.5	Bathymetric Coverage [%]	5%	5%	≤ 100%	Bathymetric Coverage [%]	200%

Minimum Bathymetry Standards for Safety of Navigation

- Order 2
- Order 1b
- Order 1a
- Special Order
- Exclusive Order



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September 2020

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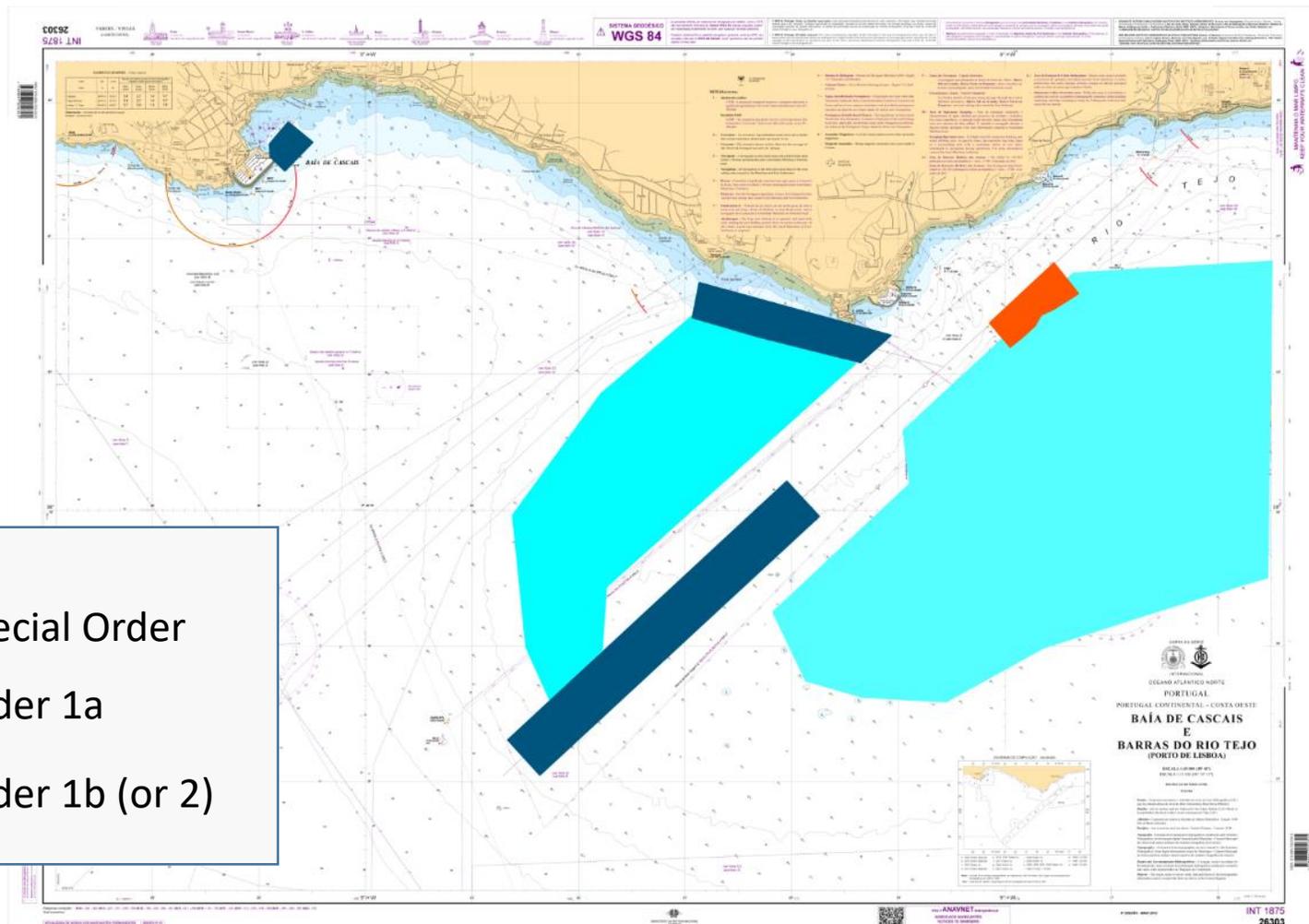
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SURVEY STANDARDS

IHO S-44
Standards for Hydrographic
Surveys (Edition 6.0.0, Sep 2020)

Minimum Bathymetry Standards for
Safety of Navigation

- Order 2
- Order 1b
- Order 1a
- Special Order
- Exclusive Order



Special Order



Order 1a



Order 1b (or 2)



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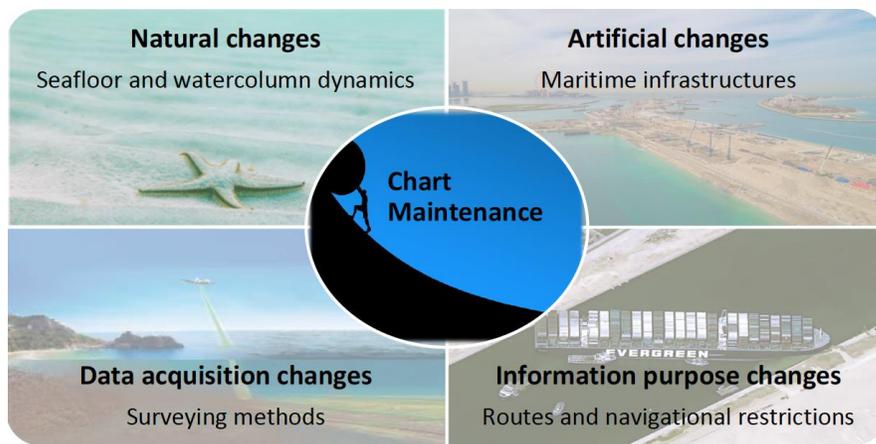
- **Planning**
- Preparation
- Acquisition
- Processing
- Final Products





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HYDROGRAPHIC SURVEYS

Hydrographic survey planning

Where to survey? When to survey?

➔ Some factors to consider:

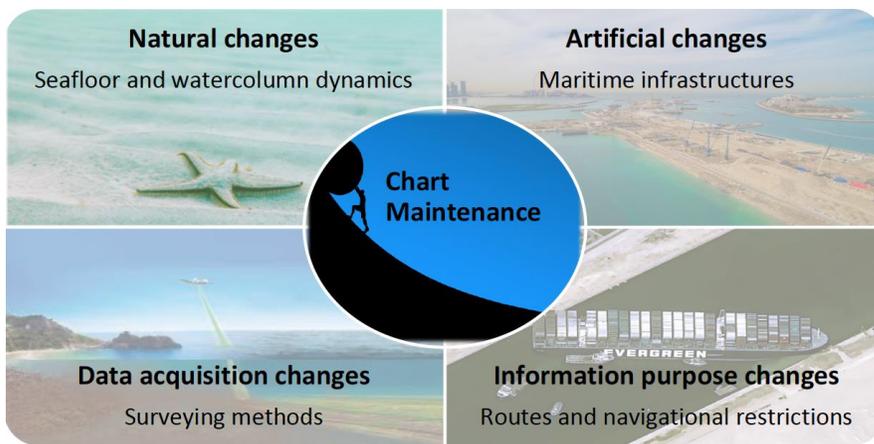
- Ship Under Keel Clearance (AIS)
- Ship Track Density (AIS)
- Seafloor complexity (std dev of the slope)
- Seafloor changeability
- Survey score decay
- ...

- **Planning**
- Preparation
- Acquisition
- Processing
- Final Products



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HYDROGRAPHIC SURVEYS

- **Planning**
- Preparation
- Acquisition
- Processing
- Final Products

Hydrographic survey planning

Where to survey? When to survey?

➔ Some factors to consider:

- Ship Under Keel Clearance (AIS)
- Ship Track Density (AIS)
- Seafloor complexity (std dev of the slope)
- Seafloor changeability
- Survey score decay
- ...

$$\text{Hydrographic Gap} = \text{Desired Survey Score} - \text{Present Survey Score}$$

- Seafloor complexity
- Under keel clearance

- Survey order (S-44)
- Seafloor changeability
- Time elapsed



Hydrographic survey planning

Where to survey? When to survey?

➔ Some factors to consider:

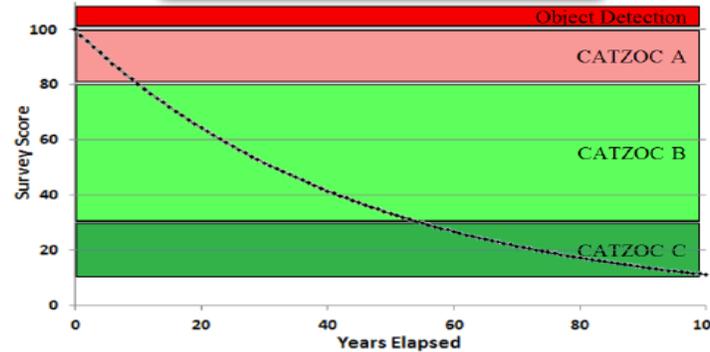
- Ship Under Keel Clearance (AIS)
- Ship Track Density (AIS)
- Seafloor complexity (std dev of the slope)
- Seafloor changeability
- Survey score decay
- ...

$$\text{Hydrographic Gap} = \text{Desired Survey Score} - \text{Present Survey Score}$$

- Seafloor complexity
- Under keel clearance

- Survey order (S-44)
- Seafloor changeability
- Time elapsed

Survey Score Decay



- Planning
- Preparation
- Acquisition
- Processing
- Final Products



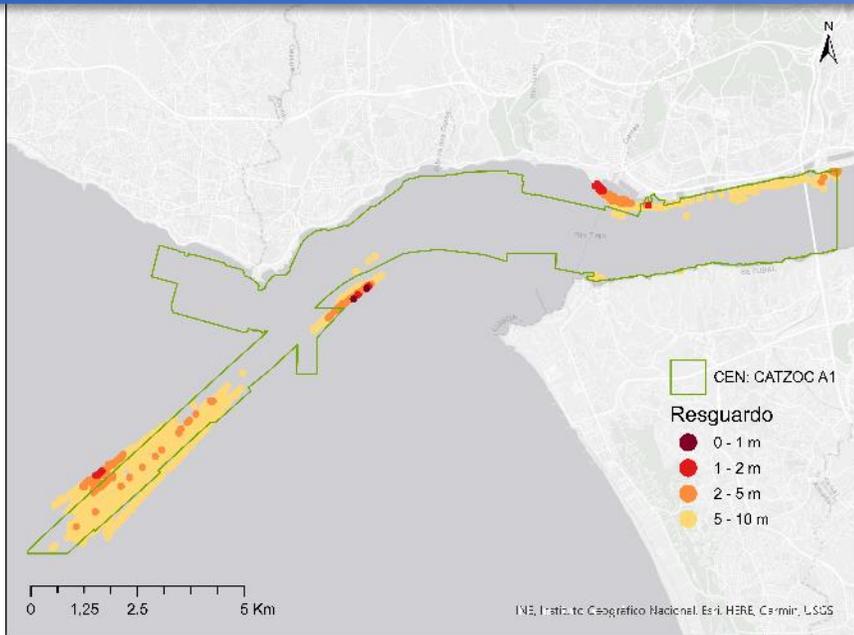
➔ Does ENC bathymetric data has **higher confidence** (CATZOC A1) where ship under keel clearance is **lower** and ship track density is **higher**?

- **Planning**
- Preparation
- Acquisition
- Processing
- Final Products

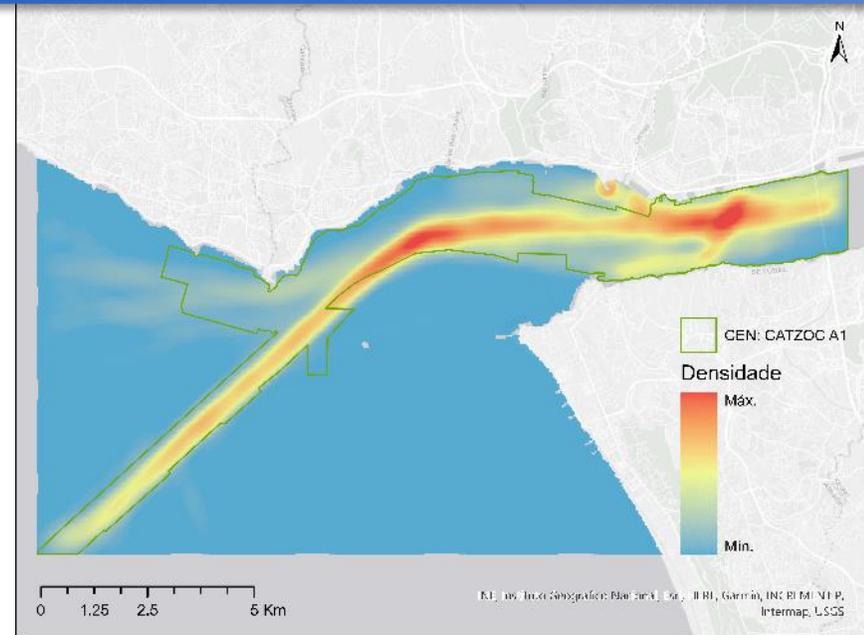
Hydrographic survey planning

Examples of spatial analysis

➔ CATZOC A1 (ENC) – Under Keel Clearance (AIS)



➔ CATZOC A1 (ENC) – Ship Track Density (AIS)





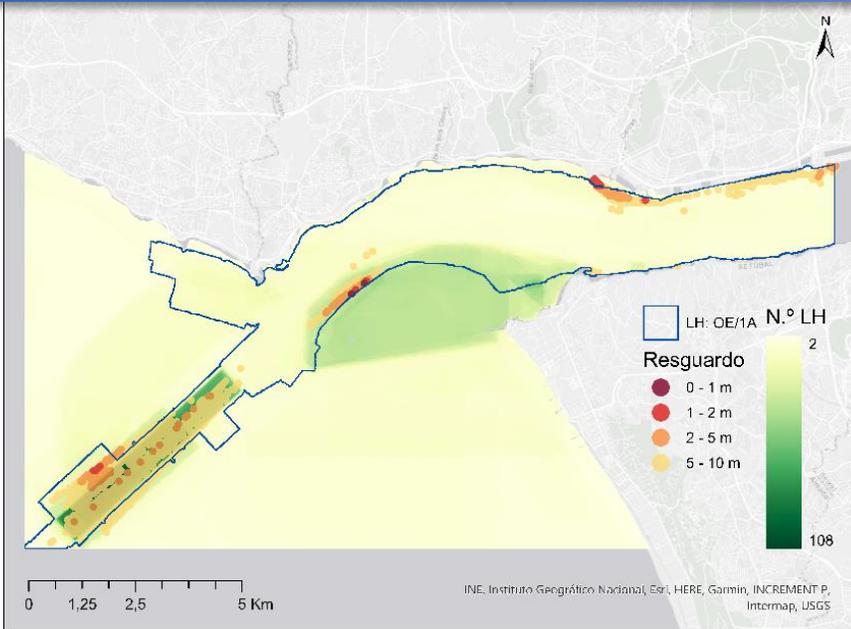
➔ Are surveys being conducted with **lower uncertainty** (special order and 1a) and **more frequently** where ship under keel clearance is **lower** and ship track density is **higher**?

- **Planning**
- Preparation
- Acquisition
- Processing
- Final Products

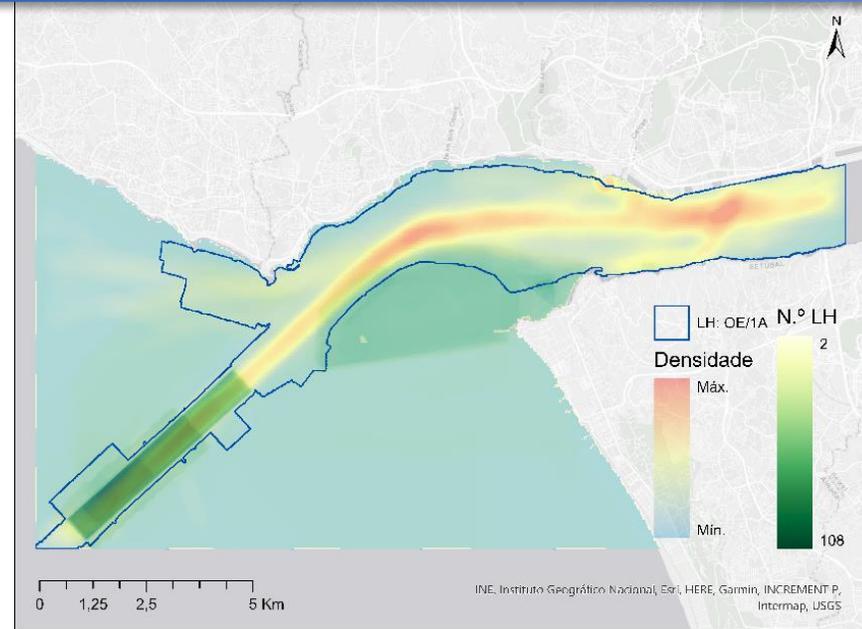
Hydrographic survey planning

Examples of spatial analysis

➔ SO/1A HS Qty – Under Keel Clearance (AIS)



➔ SO/1A HS Qty – Ship Track Density (AIS)





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- **Planning**
- **Preparation**
- Acquisition
- Processing
- Final Products



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- **Planning**
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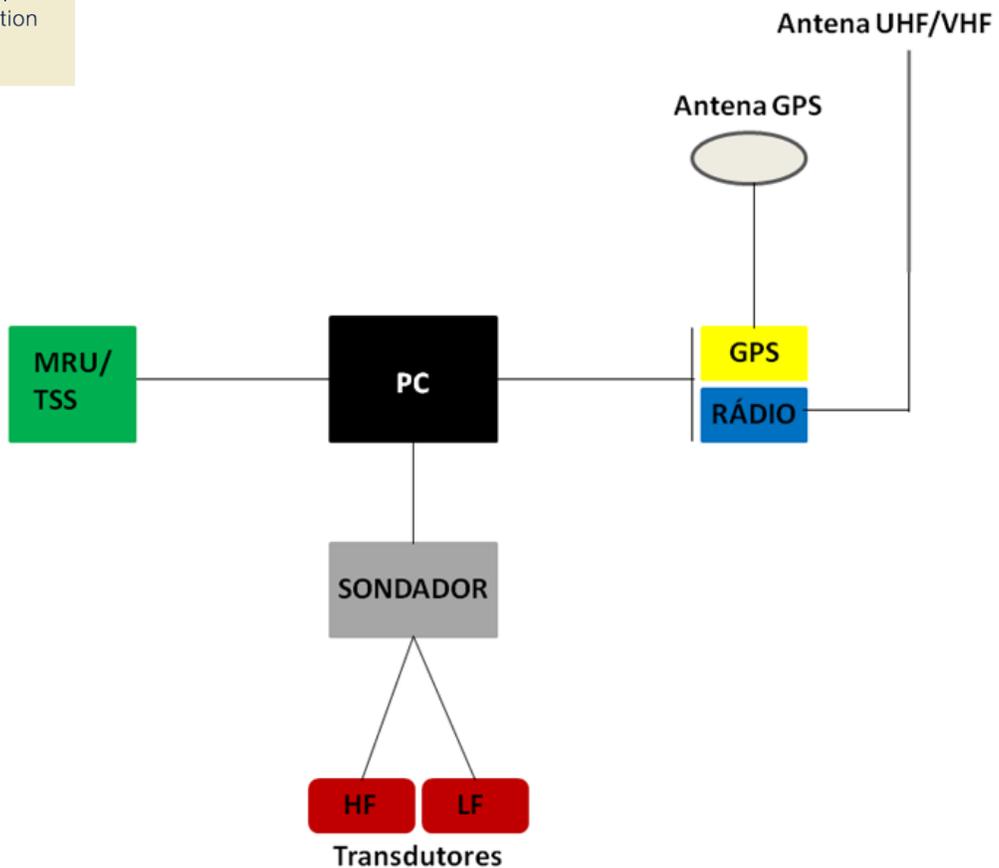
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- **Preparation**
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- Final Products

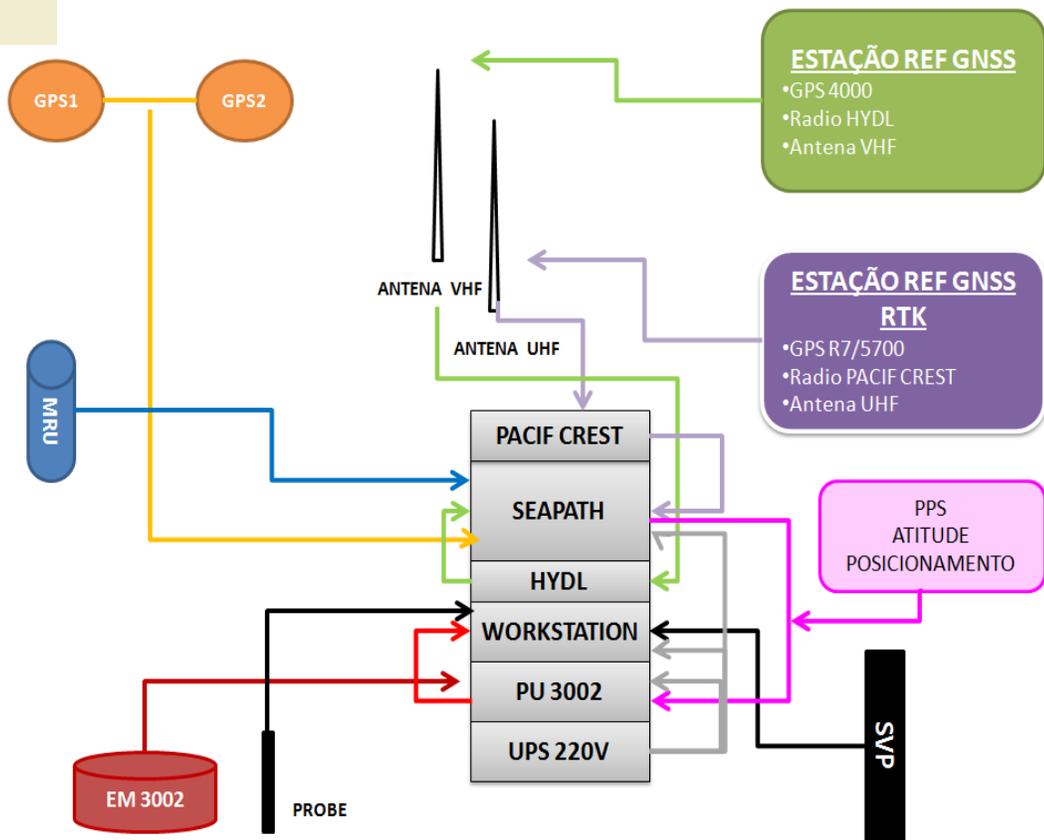




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- Planning
- Preparation
- Acquisition
- Processing
- Final Products

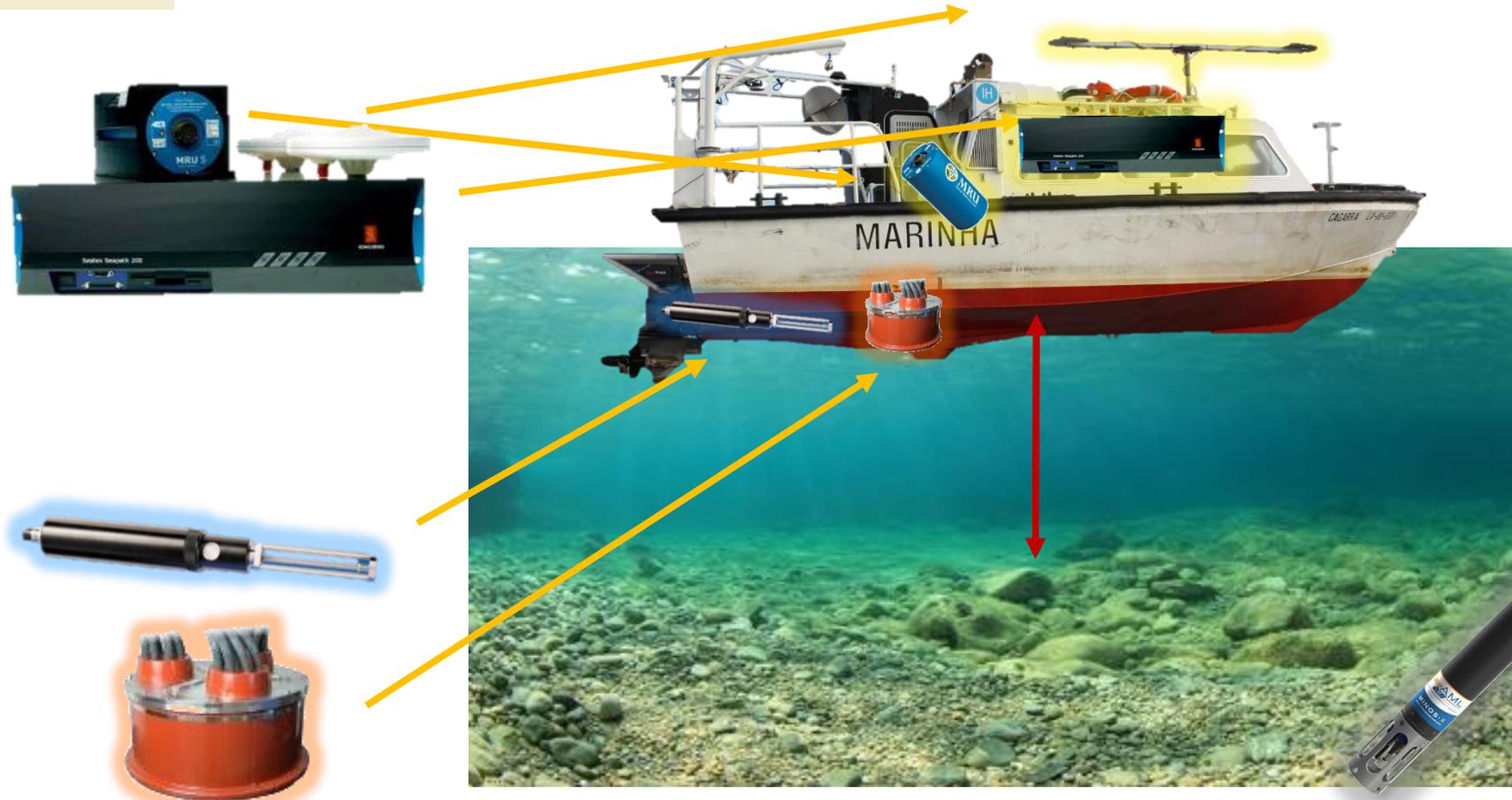




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- Planning
- Preparation
 - Sounding
 - Inertial Movements
 - Positioning
 - Sound Speed
- Acquisition
- Processing
- Final Products



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- Planning
- Preparation
- Acquisition
- Processing
- Final Products



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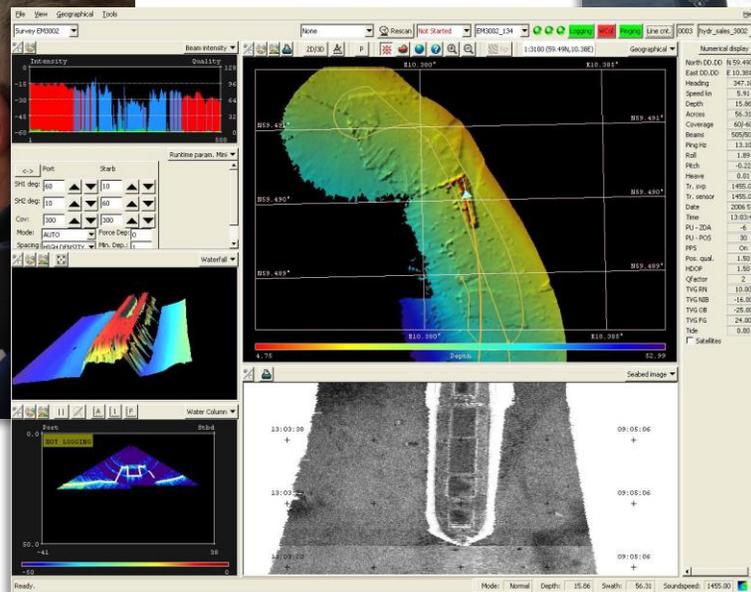
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HYDROGRAPHIC SURVEYS

- Planning
- Preparation
- Acquisition
- Processing
- Final Products





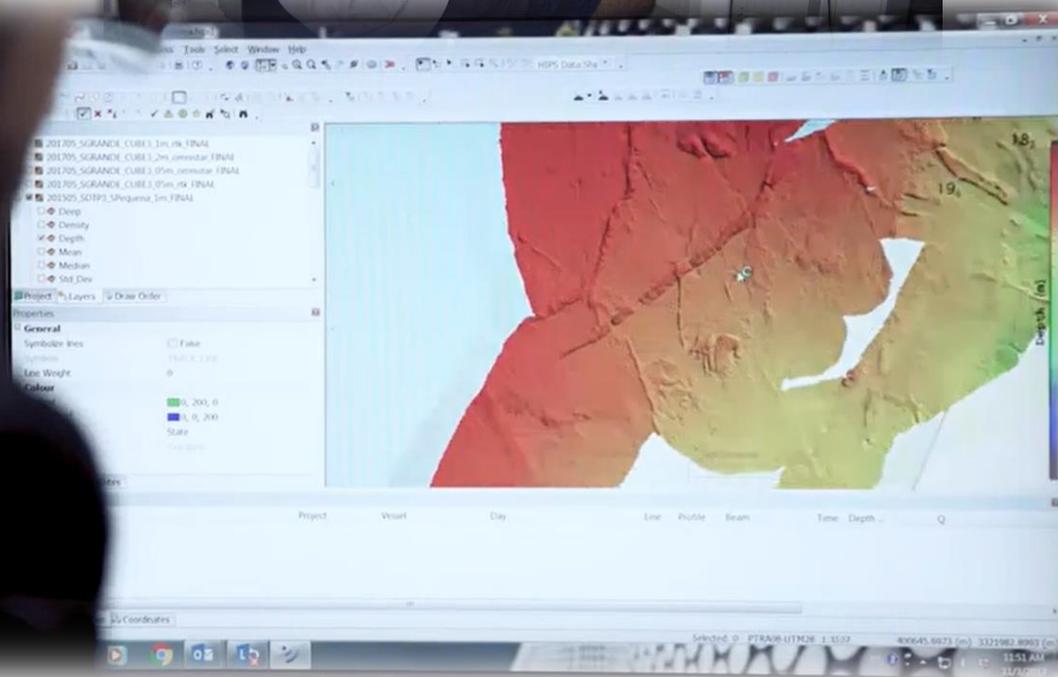
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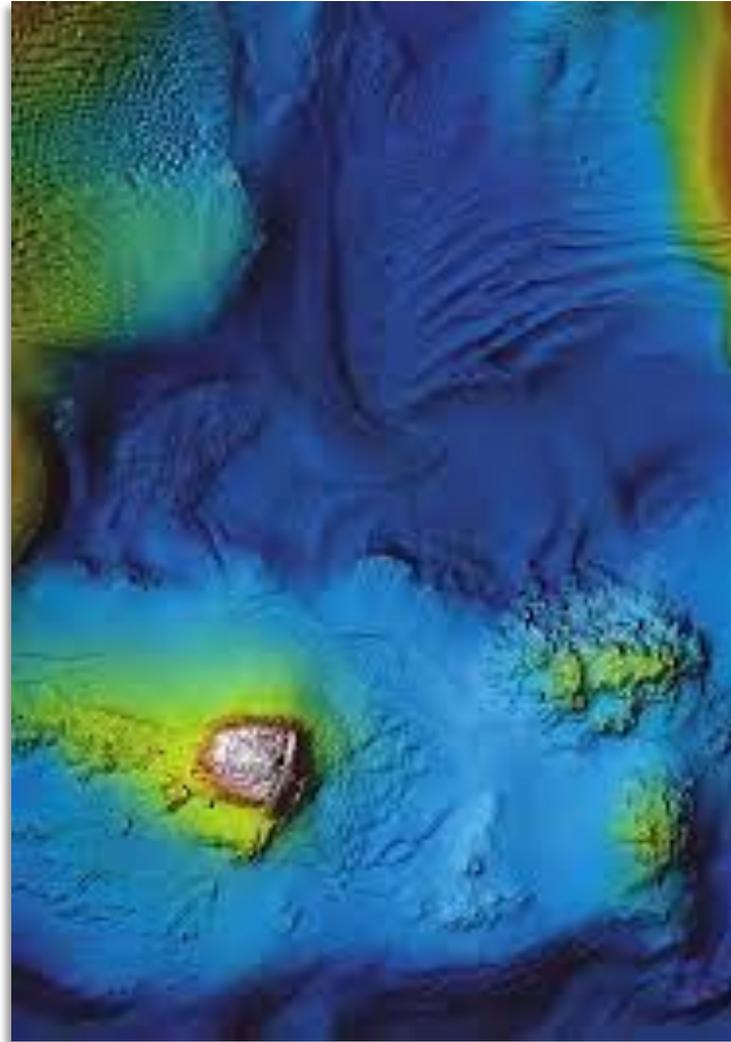
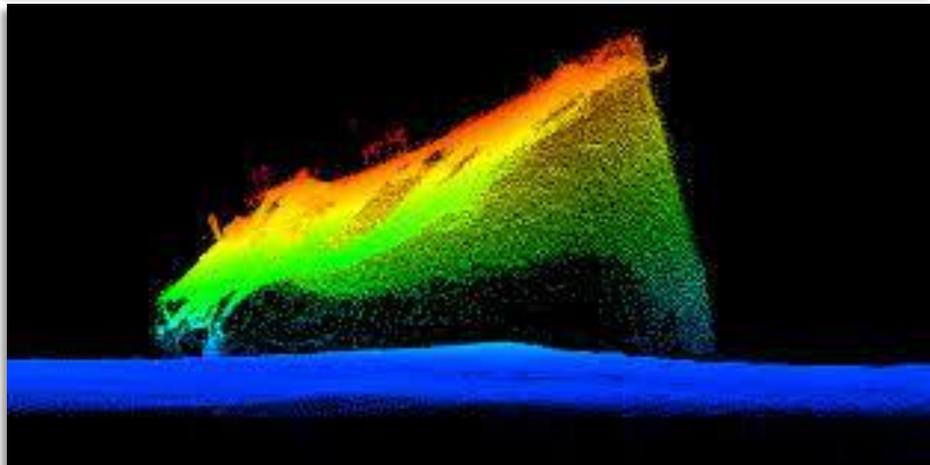
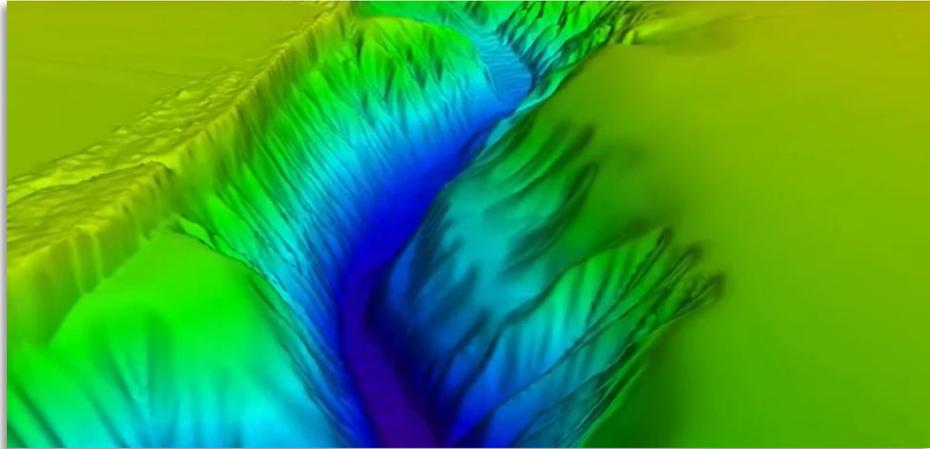




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- **Planning**
- **Preparation**
- **Acquisition**
- **Processing**
- **Final Products**

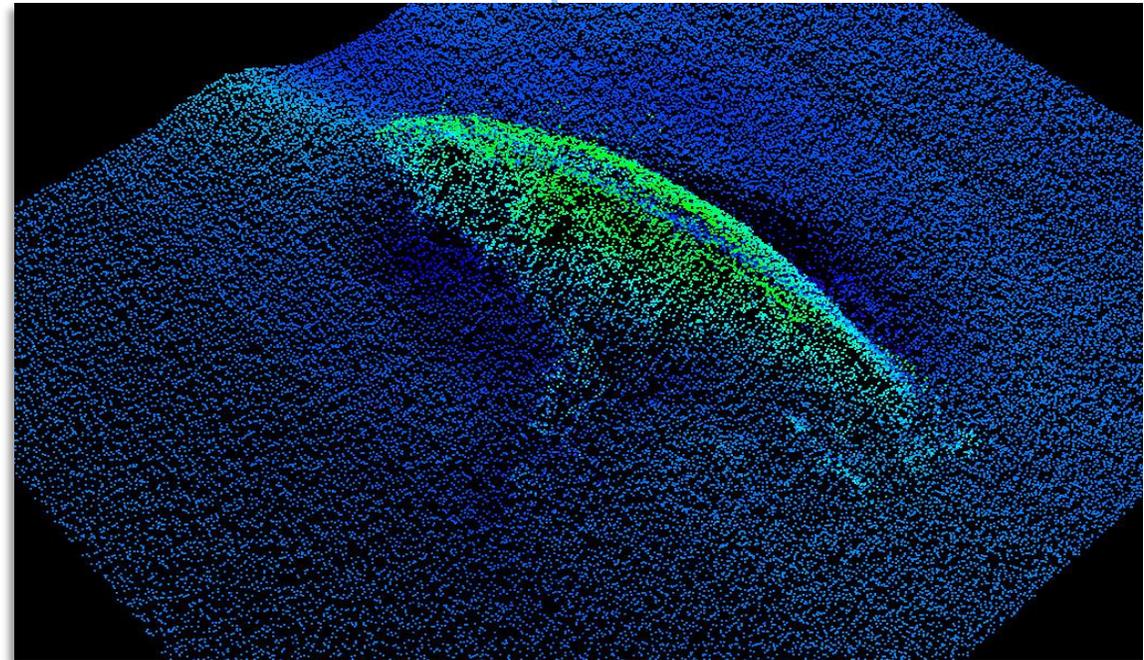
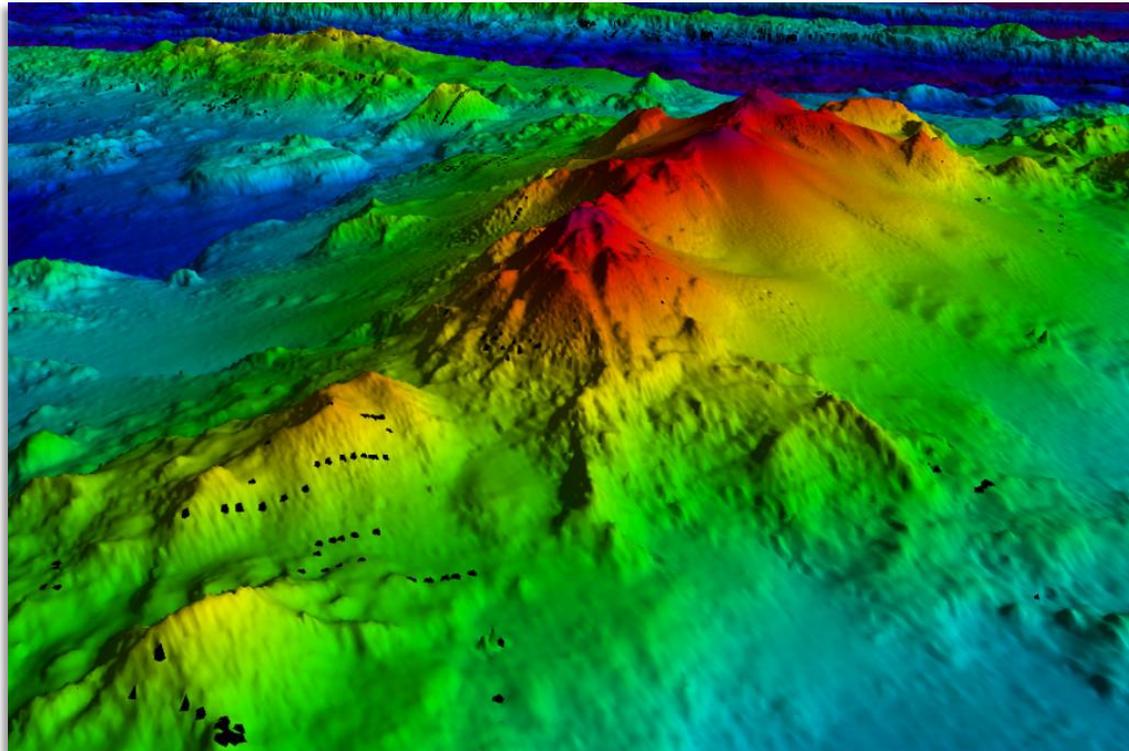


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- **Planning**
- **Preparation**
- **Acquisition**
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- **Final Products**



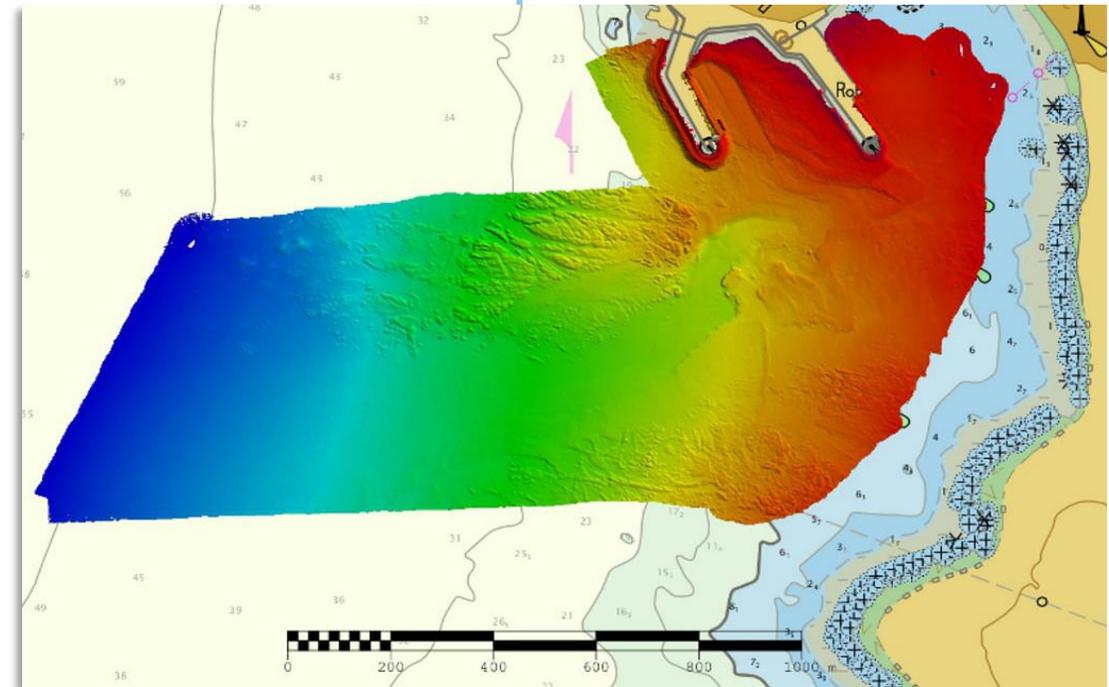
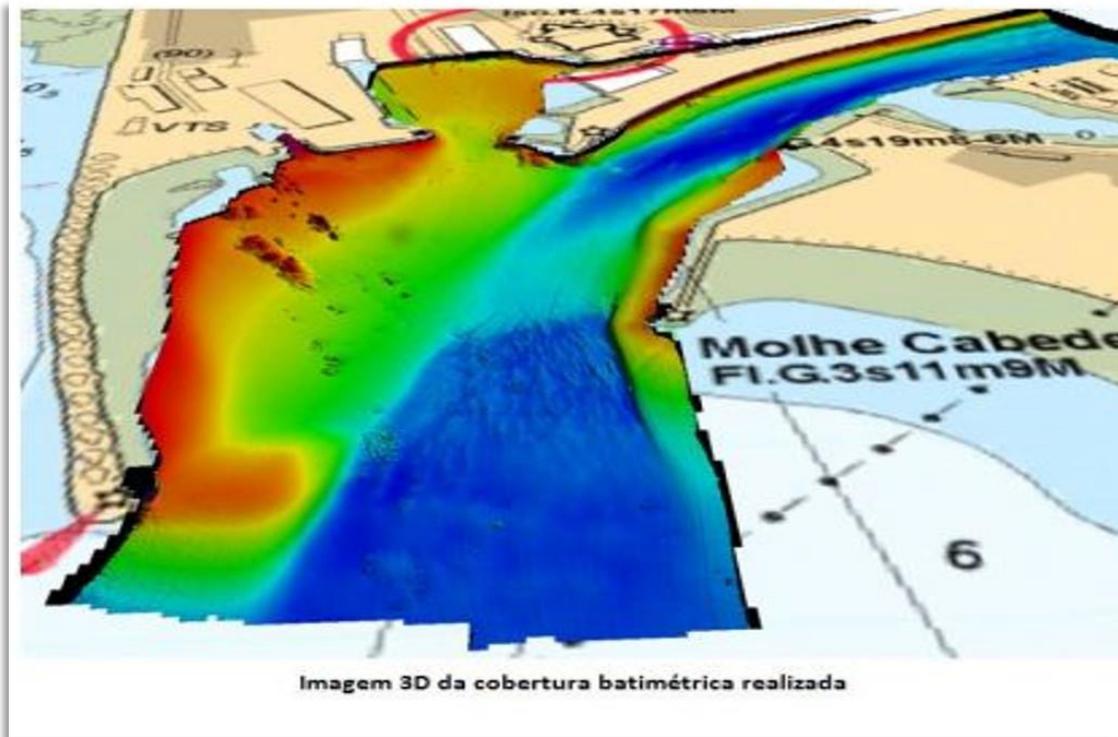


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- Planning
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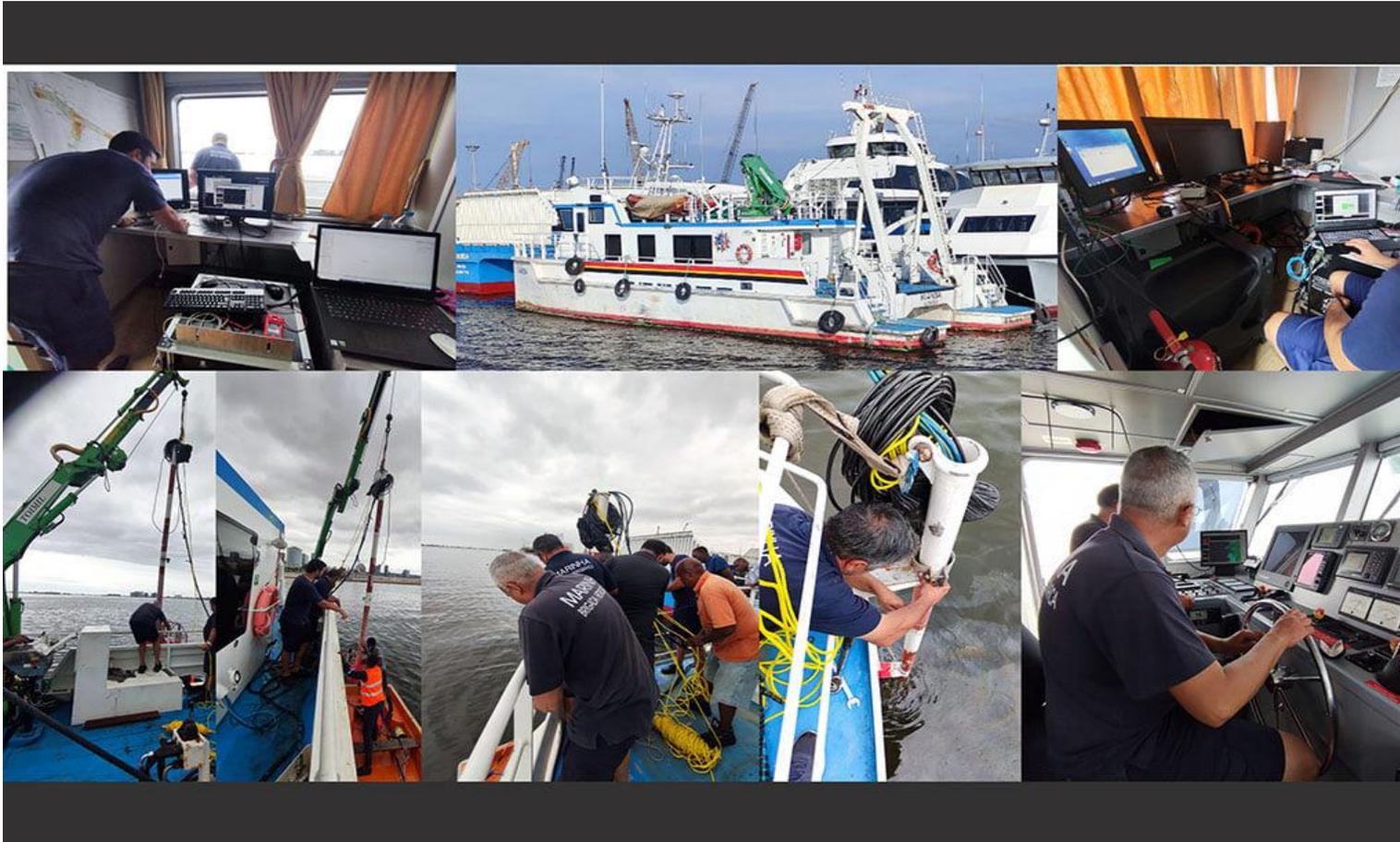




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FINAL THOUGHTS

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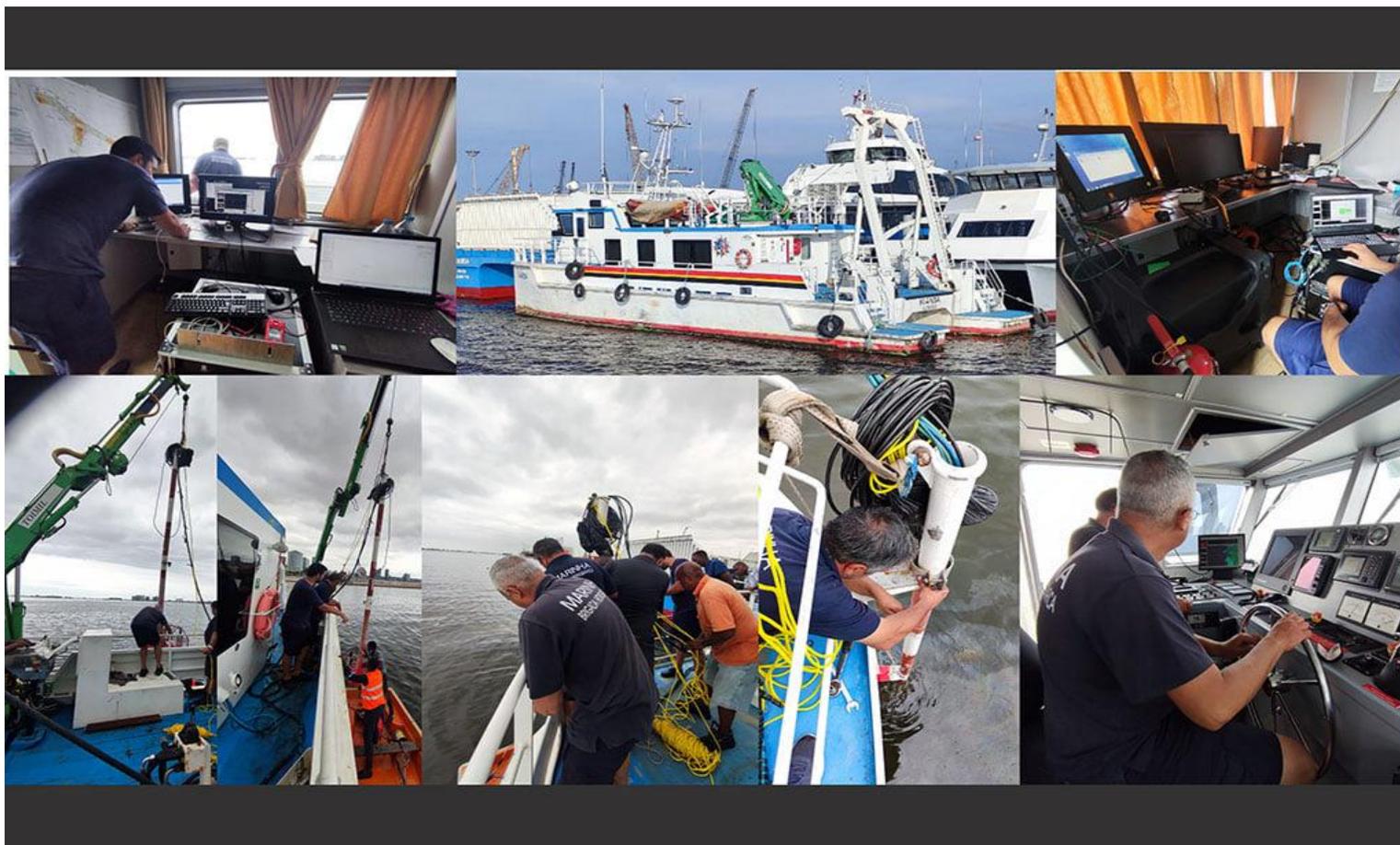
- Hydrography is an essential subject for coastal countries
- Hydrography has a great influence in the economy (medium/long term)
- The investment in Capacity Building and Training is necessary for success
- Currently:
Acoustic multibeam systems and Single beam systems are the key



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THANK YOU

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- In the end, all seen,
All Equipment, Capacity Building
and Training does pay off ..