Future Marine Navigation Technology

Research at the University of New Hampshire

Center for Coastal and Ocean Mapping/Joint Hydrographic Center

Presented by Captain, NOAA (ret.) Andrew Armstrong

Co-Director of the Joint Hydrographic Center

Complementary Centers

- NOAA/UNH Joint Hydrographic Center (JHC)
  - A NOAA and University Partnership
  - Congressionally authorized and appropriated
  - Funded through a competitive Cooperative Agreement

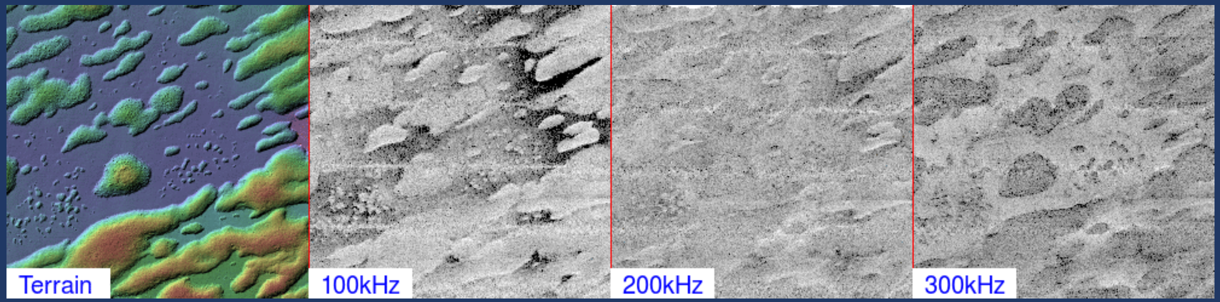
- UNH Center for Coastal and Ocean Mapping (CCOM)
  - Provides for participation of private sector and other government agencies

Center for Coastal and Ocean Mapping
Joint Hydrographic Center

Center Goals

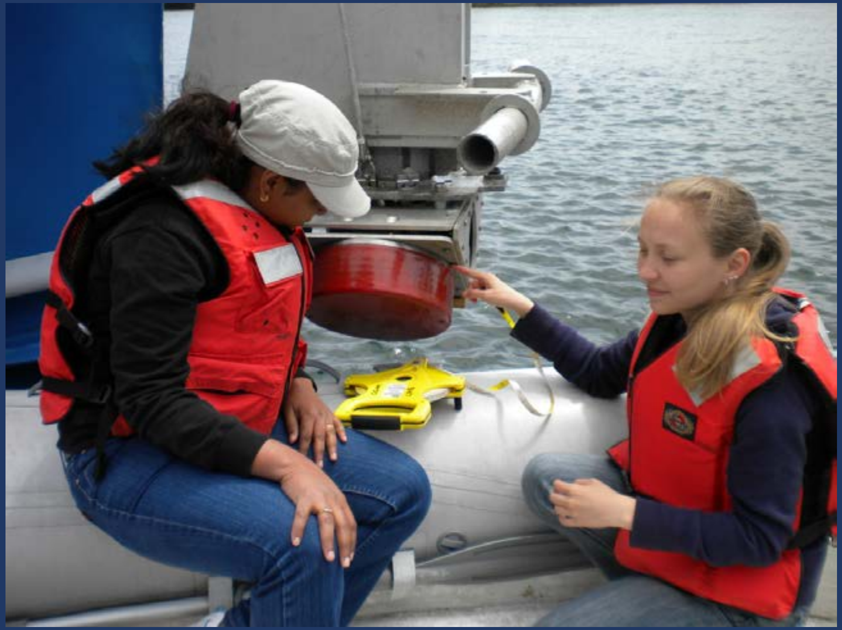
To be a world leader in the development of hydrographic and ocean mapping technologies and approaches.

To expand the scope of ocean mapping clients and constituencies through the development of innovative applications and collaborative work with both the private sector and government labs.



Center Goals

To educate a new generation of hydrographers and ocean mappers who can meet the growing needs of both government agencies and the private sector.



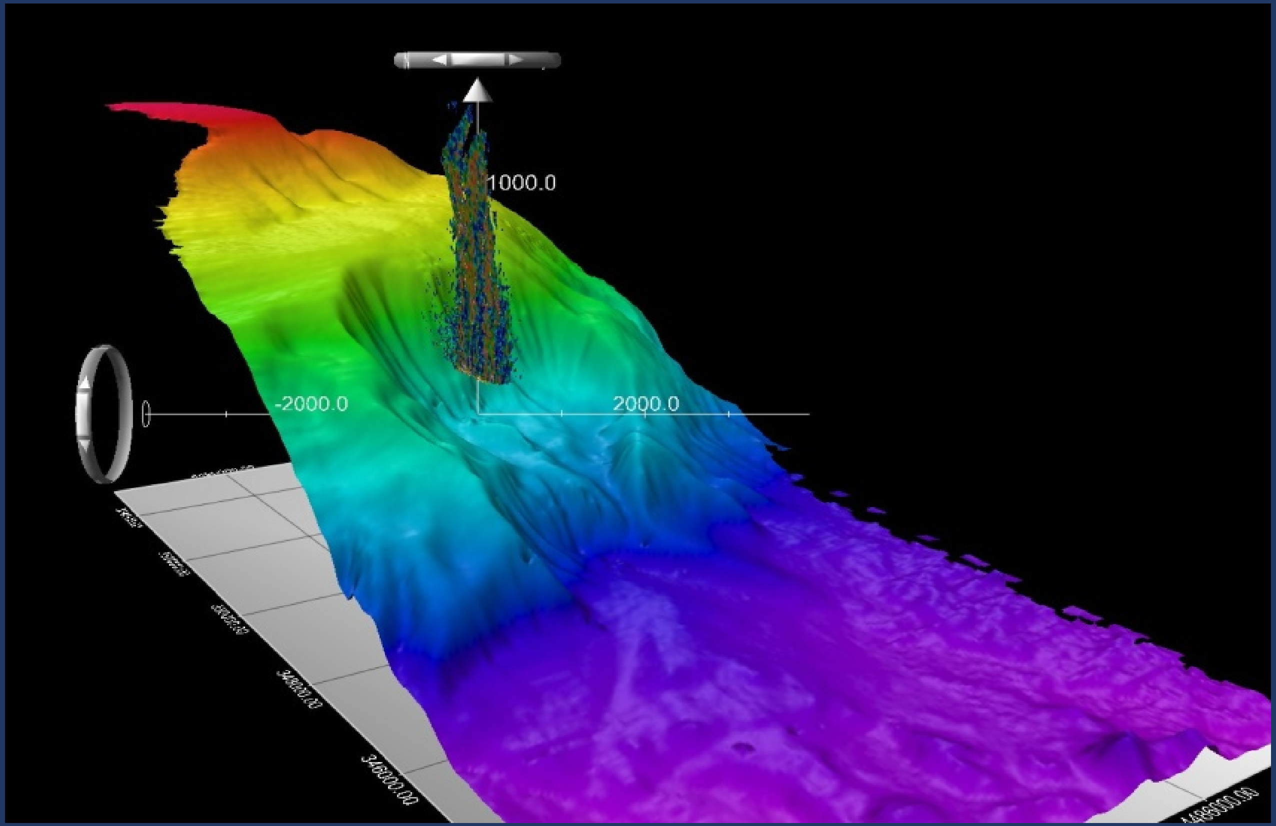
Staffing

- 17 Research and Teaching Faculty
- 12 Affiliate Faculty members
- 21 Research Scientists and Staff
- 9 Support Staff (Admin, IT, Design, Facility, Outreach)
- 12 NOAA Scientists
- 25 M.S. and Ph.D. graduate students
- 6 GEBCO Scholars

Applied Research

Emphasis on Research to Operations

- Hydrographic data processing and analysis
- Underwater acoustics
- Lidar & coastal & ocean remote sensing
- Electronic Chart of the Future
- Seafloor characterization
- Water column mapping
- Ocean data visualization
- Autonomous vessels
- Continental shelf mapping
- Crowd-sourced bathymetry
- And many more….

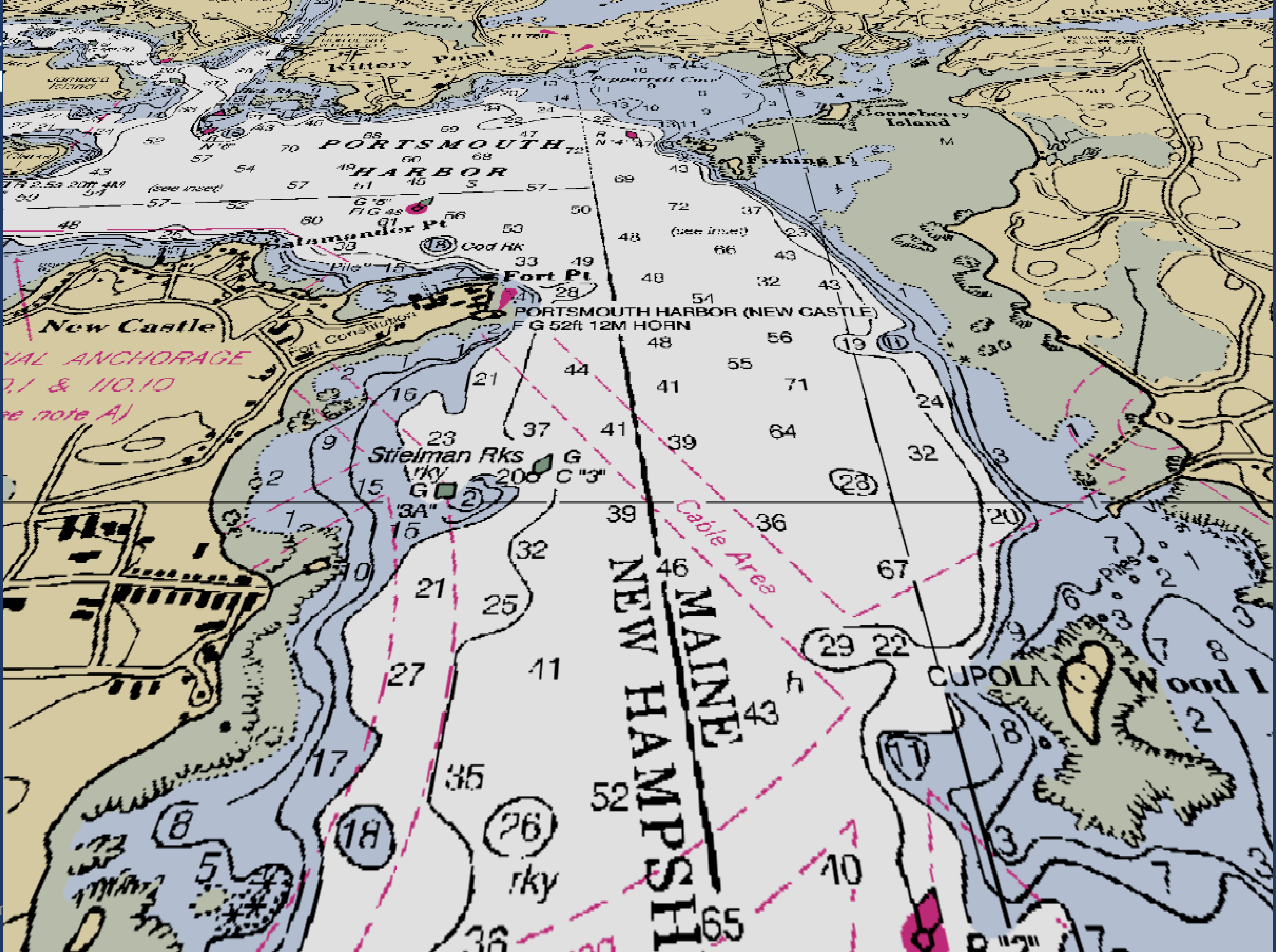


46 CCOM Industrial Associates

ACOUSTIC IMAGING
ALIDADE HYDROGRAPHIC
AML OCEANOGRAPHIC
ANTHROPOCENE INSTITUTE
ASV GLOBAL
BOULDER EQUITY ANALYTICS
CHESAPEAKE TECHNOLOGIES
CLEARWATER SEAFOODS
EDGETECH
EIVA
ESRI
EXXON MOBIL
FUGRO USA MARINE
GARMIN
GENERAL DYNAMICS BLUEFIN ROBOTICS
HIGGS HYDROGAPHIC TEK
HYDROID
HYPACK
IFREMER
IIC TECHNOLOGIES
iXBLUE
KLEIN MARINE SYSTEMS
KONGSBERG UNDERWATER TECHNOLOGY
LEIDOS
NORBIT SUBSEA
NOVATEL
OCEAN HIGH TECHNOLOGY INSTITUTE
PHOENIX INTERNATIONAL
QPS
R2SONIC
SEA MACHINES ROBOTICS
SEA ID
SEVEN Cs
SMT KINGDOM
SUBSTRUCTURE
SURVICE ENGINEERING
TELEDYNE BENTHOS
TELEDYNE CARIS
TELEDYNESOCEAN SCIENCE
TELEDYNE ODOM HYDROGRAPHIC
TELEDYNE OPTECH
TELEDYNE RESON
TRITON IMAGING INC
TYCOM LTD

Outline

- Drivers for future marine navigation technology
- Technology coming soon, but still in need of R&D
- Technology that is farther in the future


Kittery Point
Pepperrell Cove
Gooseberry Island
PORTSMOUTH
HARBOR
Fishing I
(see inset)
Salamander Pt
Cod Rk
Fort Pt
PORTSMOUTH HARBOR (NEW CASTLE)
F G 52ft 12M HORN
New Castle
Fort Constitution
IAL ANCHORAGE
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G "3A"
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CUPOLA
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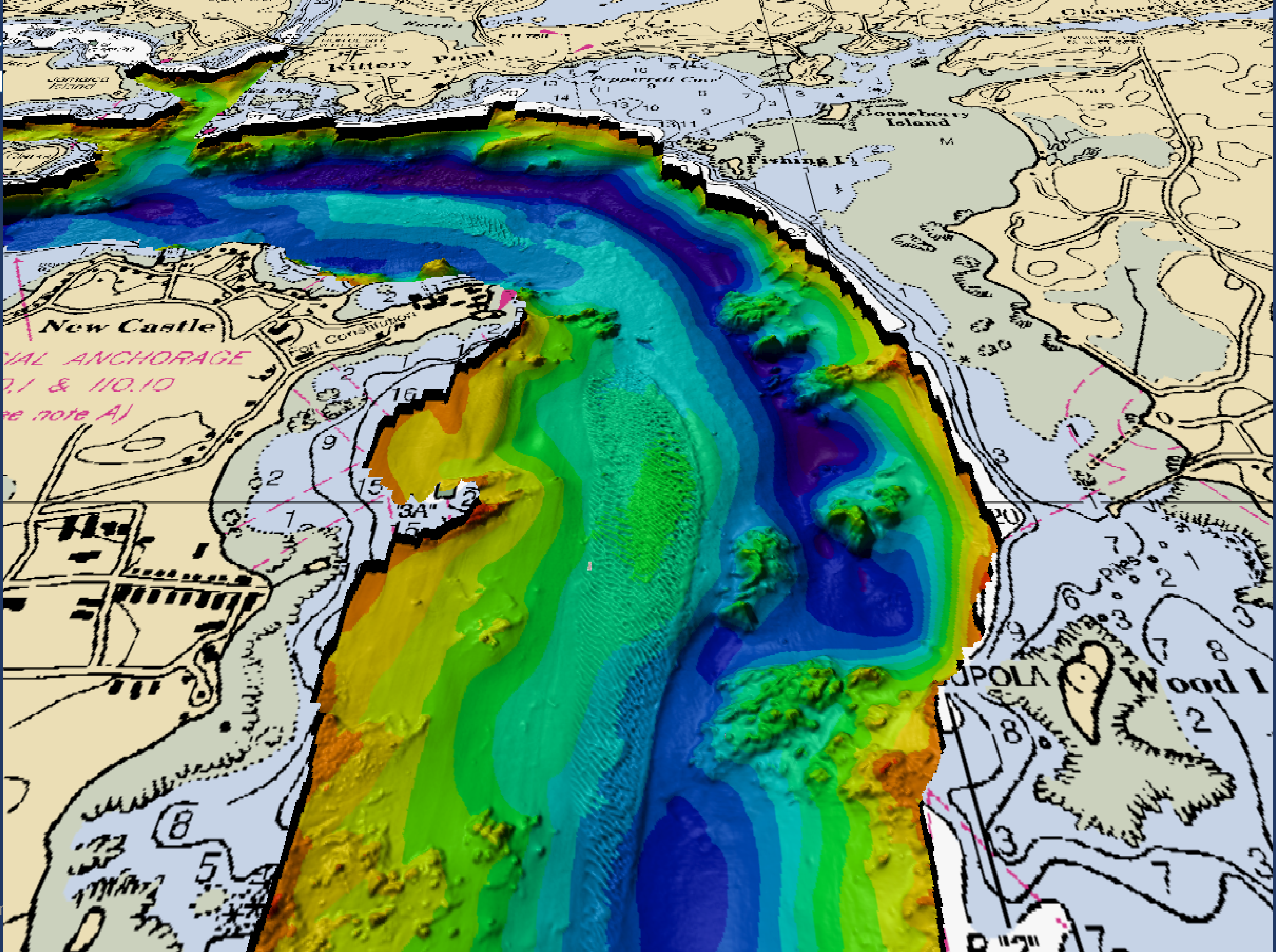
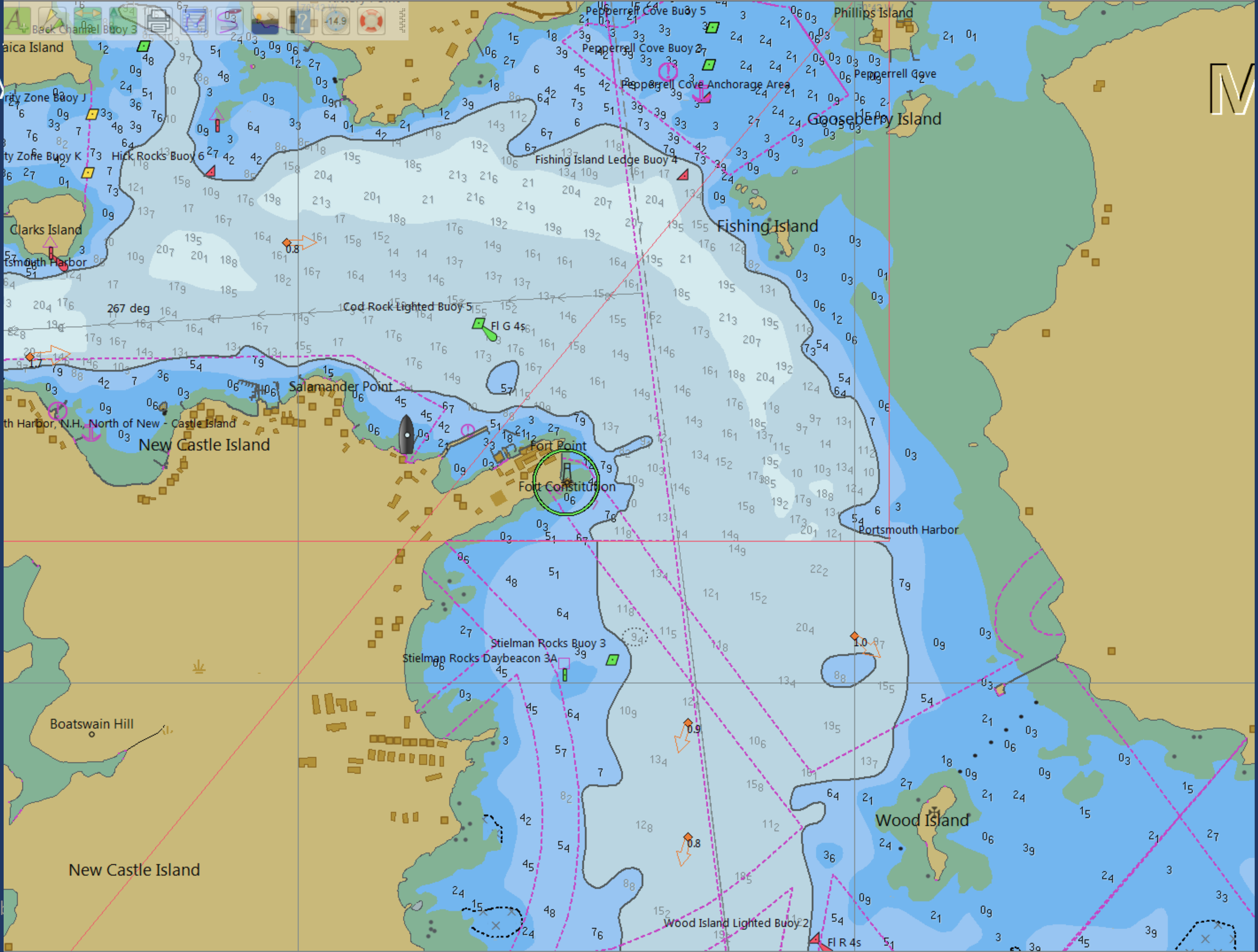


Center

Joint Hy



2002: Hydrographic Data Paradigm Shift

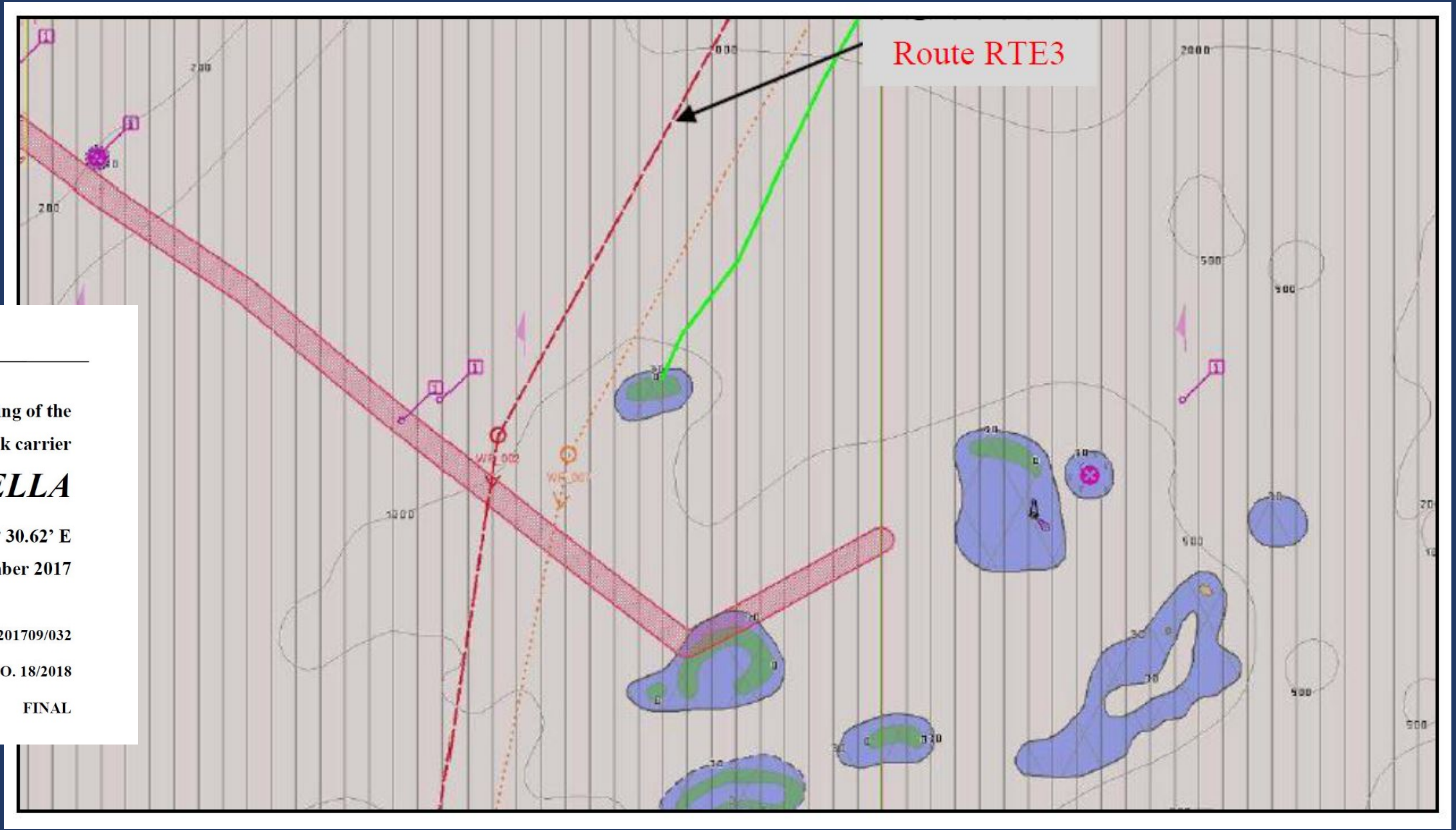
CUBE—Hydrographic data processed, presented and managed as a grid of depth values rather than as individual depth soundings. Multiple hypotheses identify areas for review and depth uncertainty is associated with the depth value. (Brian Calder)

Navigation Surface—Depth information for charting directly derived from the grid model. (Shep Smith)

IHO S-102 is based on this gridded depth concept

Today's technology and the developing IHO S-100 family of standards bring the display of high resolution bathymetry, variable water level, surface currents, navigation support information, weather, and more, near to reality for the mariner in the pilot house…

Research Challenge—How should this information be delivered and portrayed?



MARINE SAFETY INVESTIGATION REPORT

Safety investigation into the grounding of the
Maltese registered bulk carrier

MARBELLA

in position 17° 06.8’ N 111° 30.62’ E
on 28 September 2017

201709/032

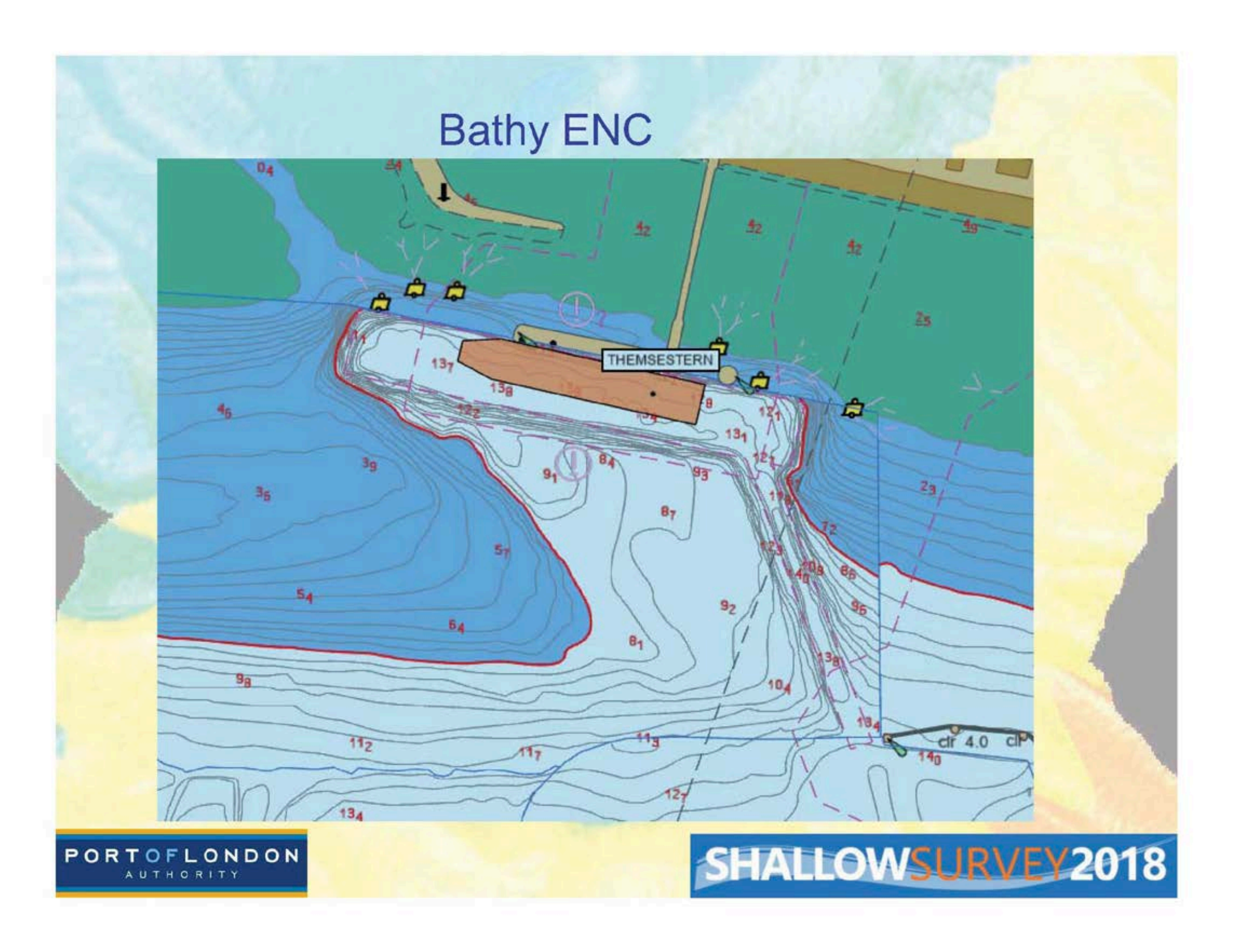
MARINE SAFETY INVESTIGATION REPORT NO. 18/2018

FINAL

Just having information doesn’t mean it can or will be used effectively

Depth portrayed with dense depth contours, no soundings

Depth portrayed with dense, but smoothed, depth contours plus soundings



Slide presented at Shallow Survey 2018 conference; courtesy of John Pinder, Port of London Authority

Combination of shaded relief and tide-aware 3-way depth by color

This demo is from 15 years ago in a UNH research computing environment (GeoZui 4D)

A similar portrayal was prepared by NOAA for the Los Angeles/Long Beach Precision Navigation Demonstration Project

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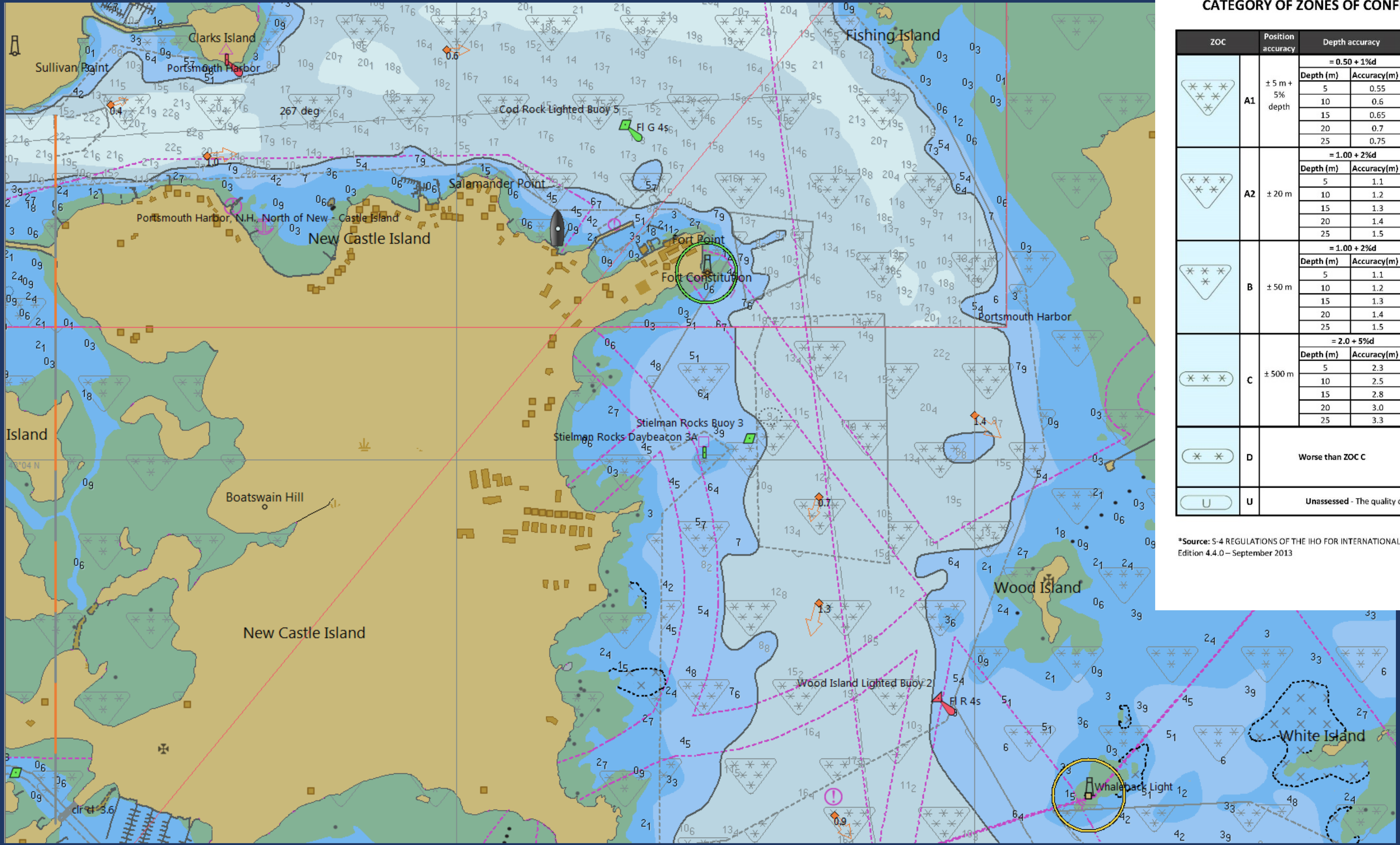
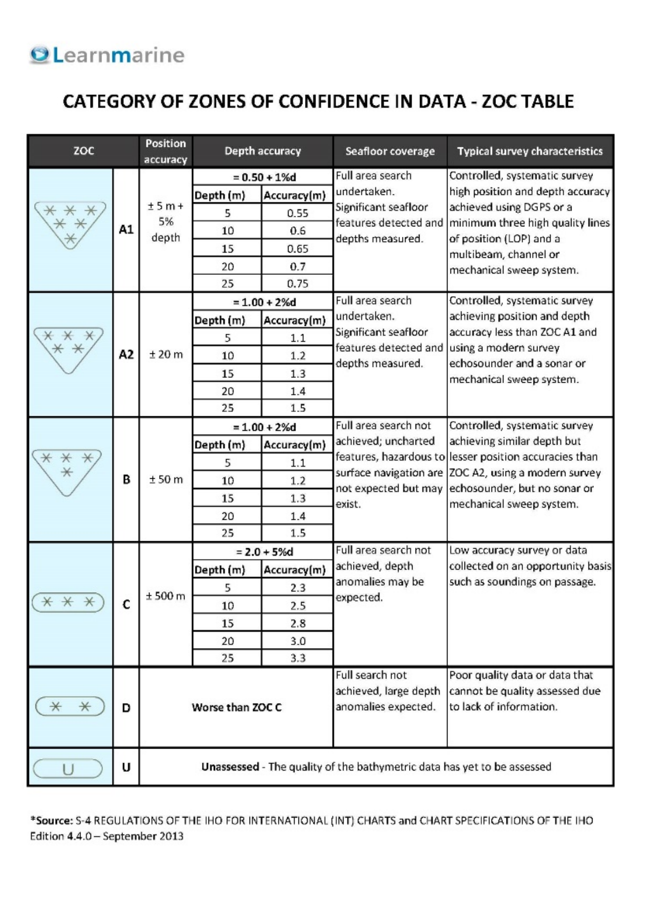
Uncertainty by CATZOC





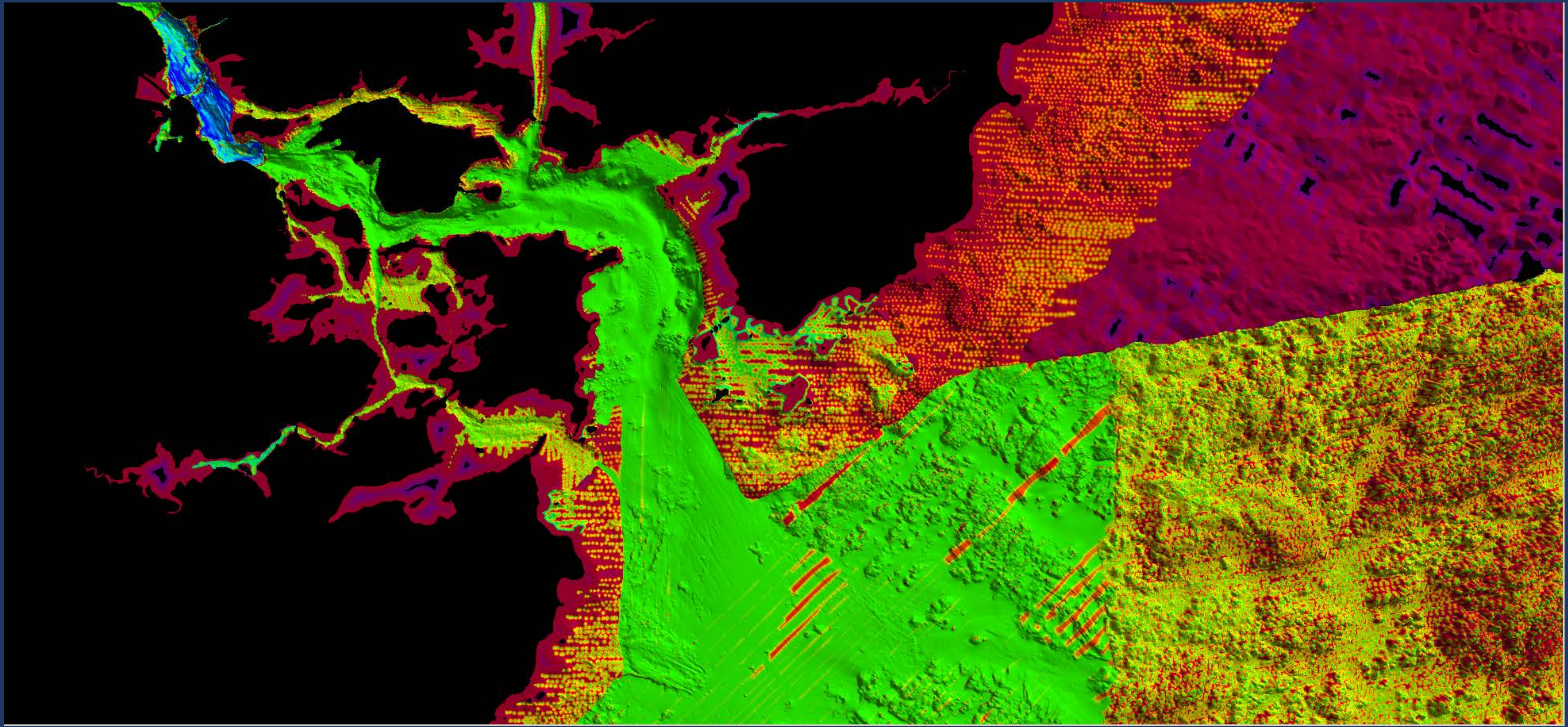
Learnmarine

CATEGORY OF ZONES OF CONFIDENCE IN DATA - ZOC TABLE

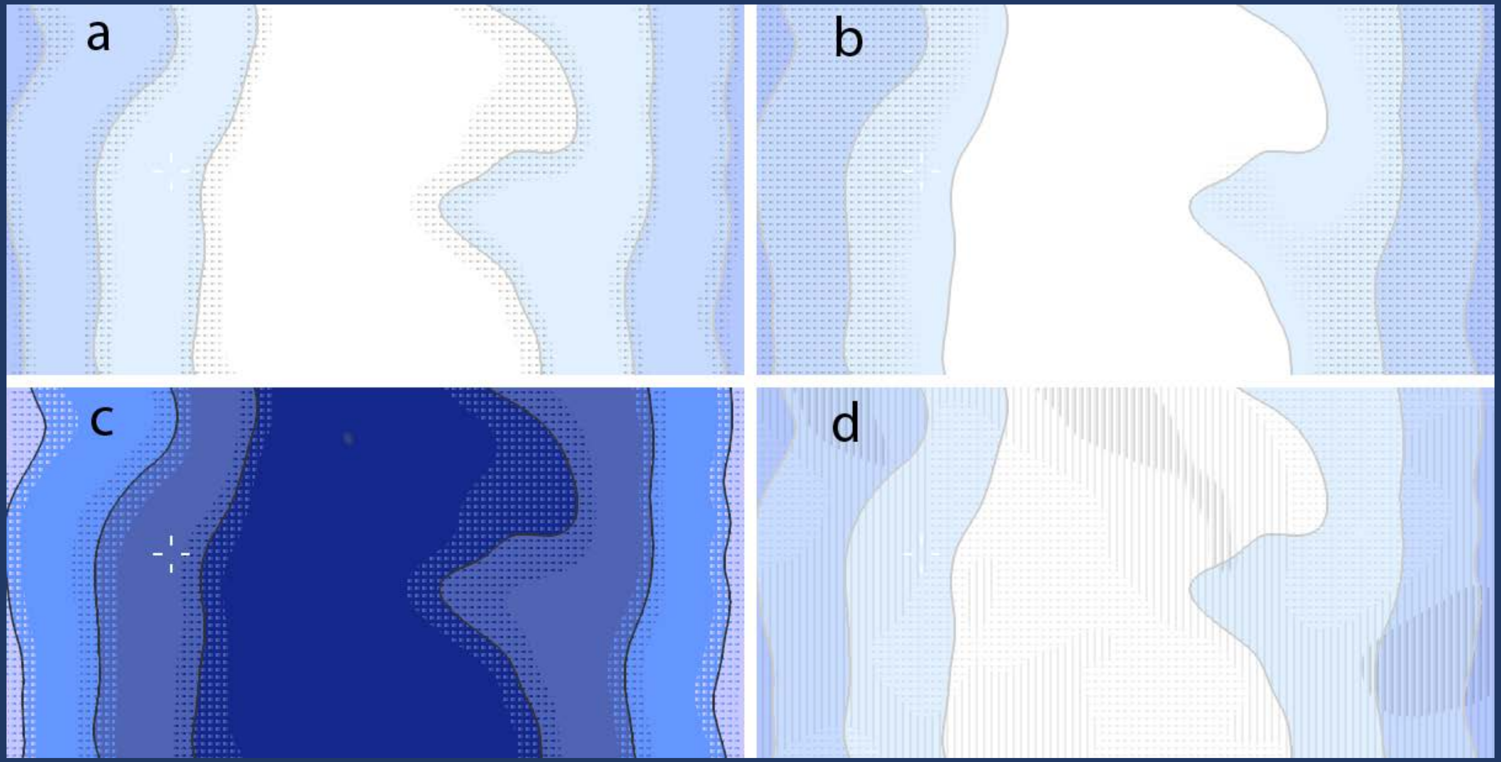
ZOC		Position accuracy	Depth accuracy	Seafloor coverage	Typical survey characteristics
	A1	± 5 m + 5% depth	= 0.50 + 1%d Depth (m) / Accuracy(m) 5 / 0.55 10 / 0.6 15 / 0.65 20 / 0.7 25 / 0.75	Full area search undertaken. Significant seafloor features detected and depths measured.	Controlled, systematic survey high position and depth accuracy achieved using DGPS or a minimum three high quality lines of position (LOP) and a multibeam, channel or mechanical sweep system.
	A2	± 20 m	= 1.00 + 2%d Depth (m) / Accuracy(m) 5 / 1.1 10 / 1.2 15 / 1.3 20 / 1.4 25 / 1.5	Full area search undertaken. Significant seafloor features detected and depths measured.	Controlled, systematic survey achieving position and depth accuracy less than ZOC A1 and using a modern survey echosounder and a sonar or mechanical sweep system.
	B	± 50 m	= 1.00 + 2%d Depth (m) / Accuracy(m) 5 / 1.1 10 / 1.2 15 / 1.3 20 / 1.4 25 / 1.5	Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.	Controlled, systematic survey achieving similar depth but lesser position accuracies than ZOC A2, using a modern survey echosounder, but no sonar or mechanical sweep system.
	C	± 500 m	= 2.0 + 5%d Depth (m) / Accuracy(m) 5 / 2.3 10 / 2.5 15 / 2.8 20 / 3.0 25 / 3.3	Full area search not achieved, depth anomalies may be expected.	Low accuracy survey or data collected on an opportunity basis such as soundings on passage.
	D	Worse than ZOC C		Full search not achieved, large depth anomalies expected.	Poor quality data or data that cannot be quality assessed due to lack of information.
U	U	**Unassessed** - The quality of the bathymetric data has yet to be assessed			

*Source: S-4 REGULATIONS OF THE IHO FOR INTERNATIONAL (INT) CHARTS and CHART SPECIFICATIONS OF THE IHO Edition 4.4.0 – September 2013

Uncertainty in the bathymetric grid: Not all data on the chart are equal



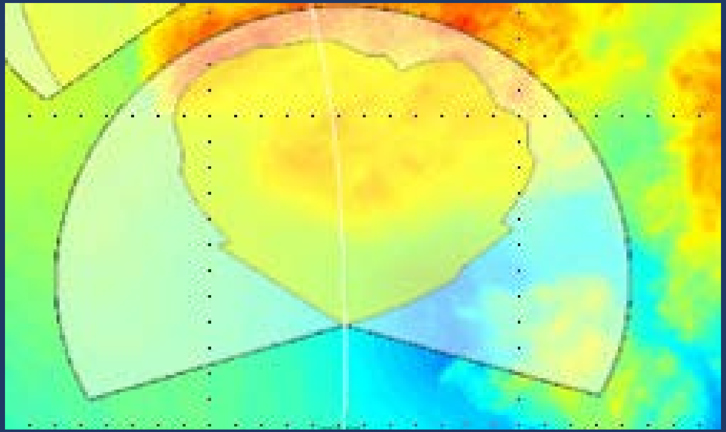
Studies of optimal approaches for representing bathymetric uncertainty

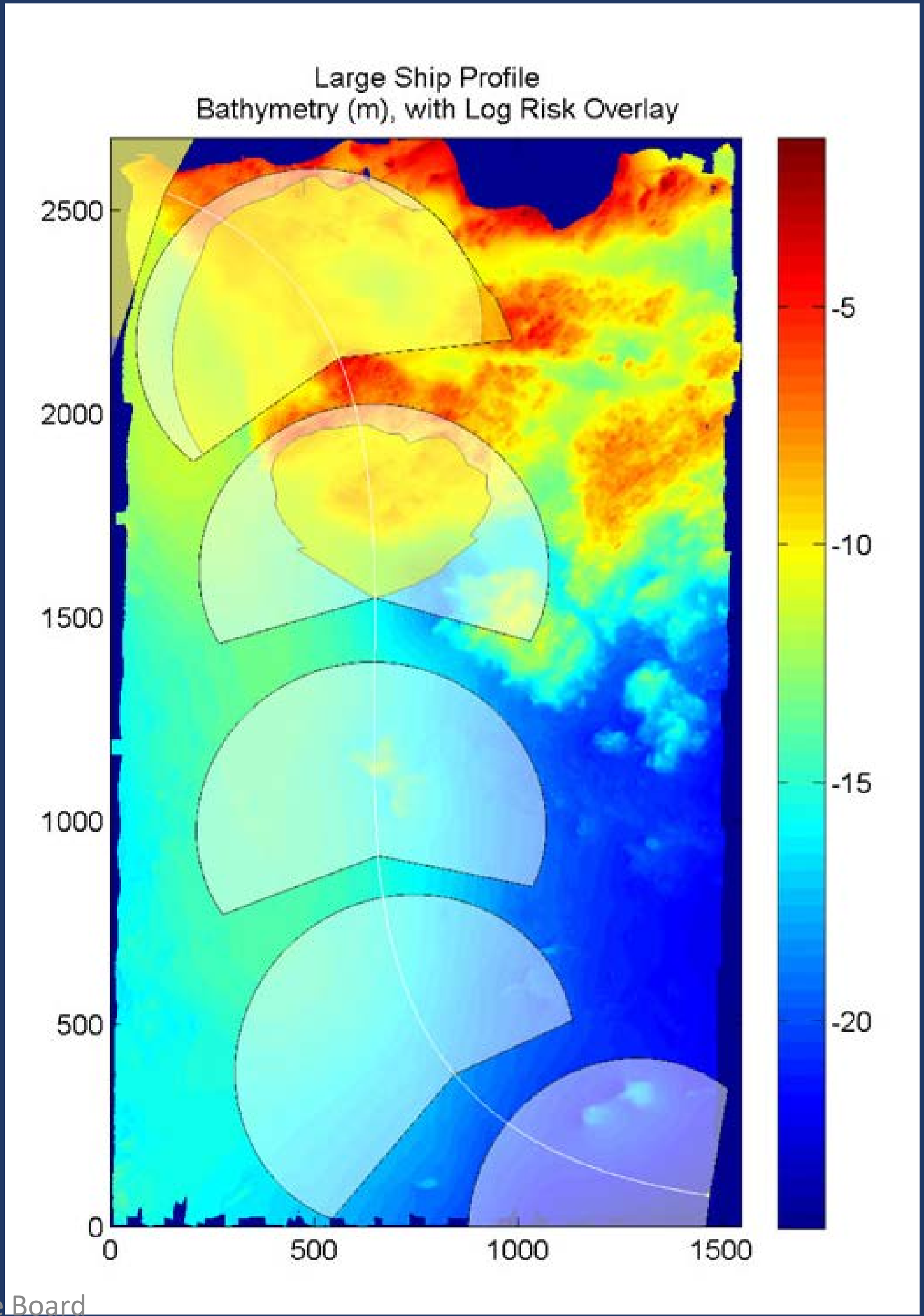


Four methods for representing bathymetric uncertainty. (a and c) Texture shows uncertainty ranges around contours. (b) Texture is used to designate no-go areas. (d) A sequence of textures is used to represent the degree of depth uncertainty over the entire chart.

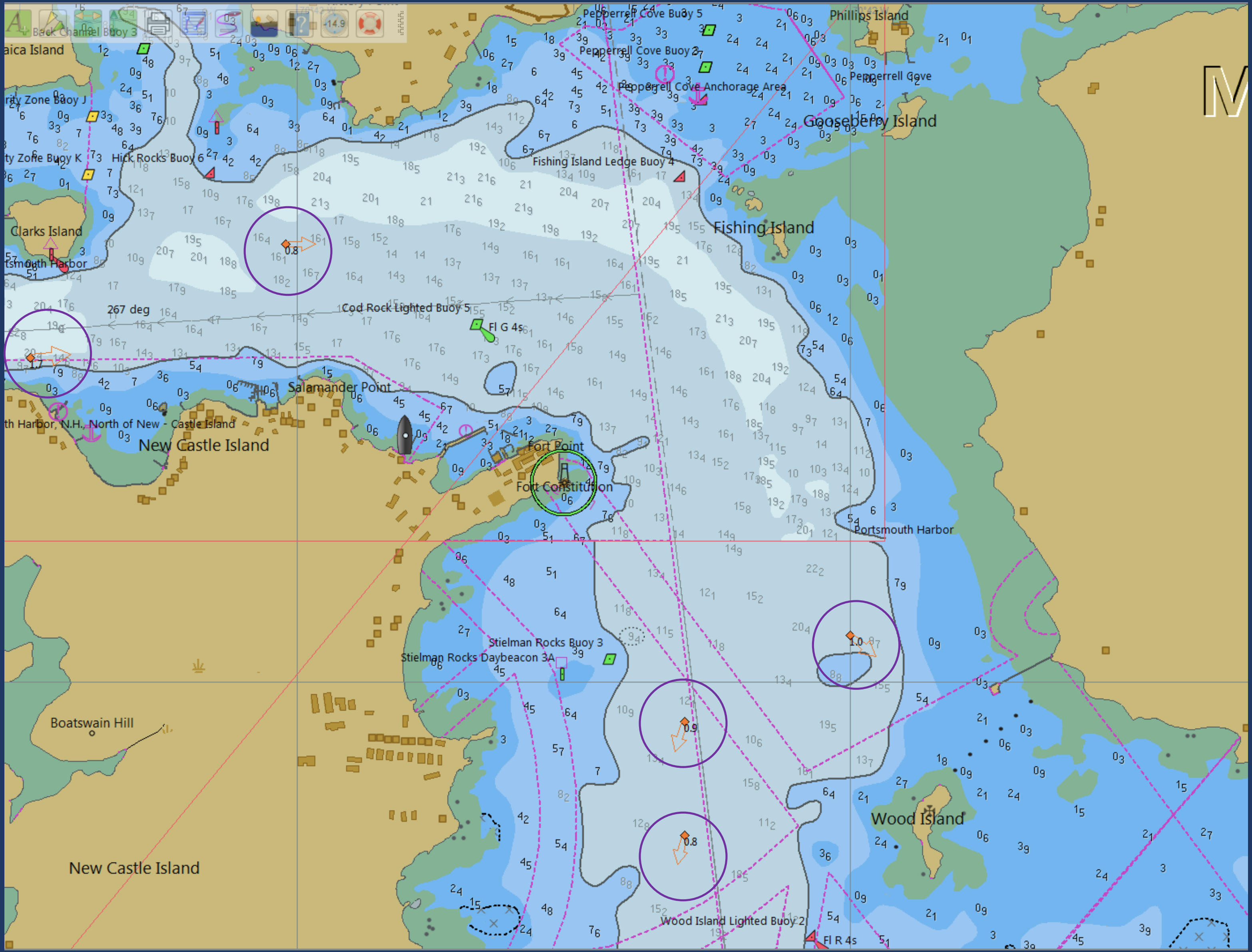
Relative Risk

Takes into account: draft, depth and depth uncertainty, potentially other factors like bridge clearances..





Surface Current Portrayal



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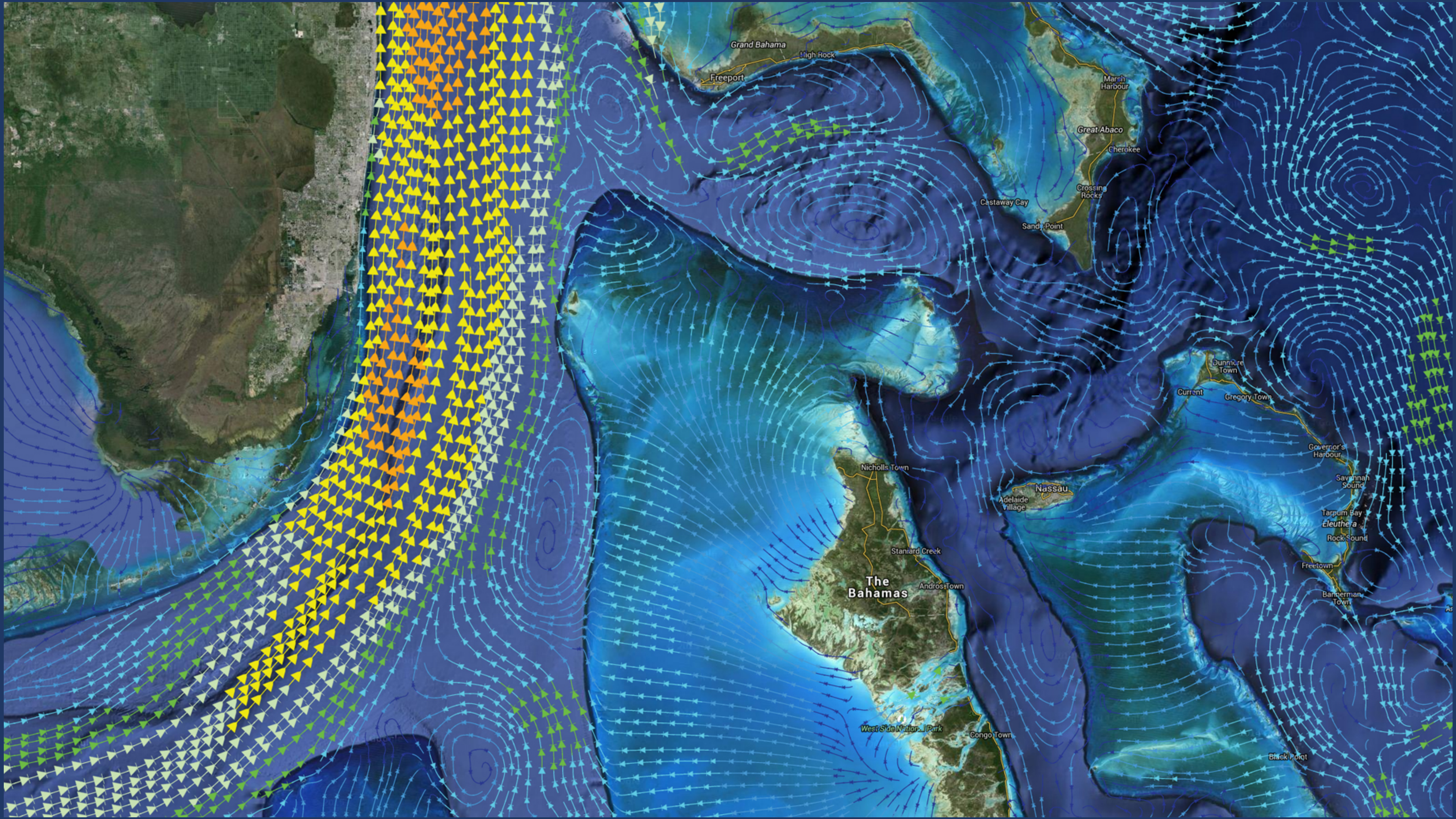
Forecast Model Currents over Google Maps



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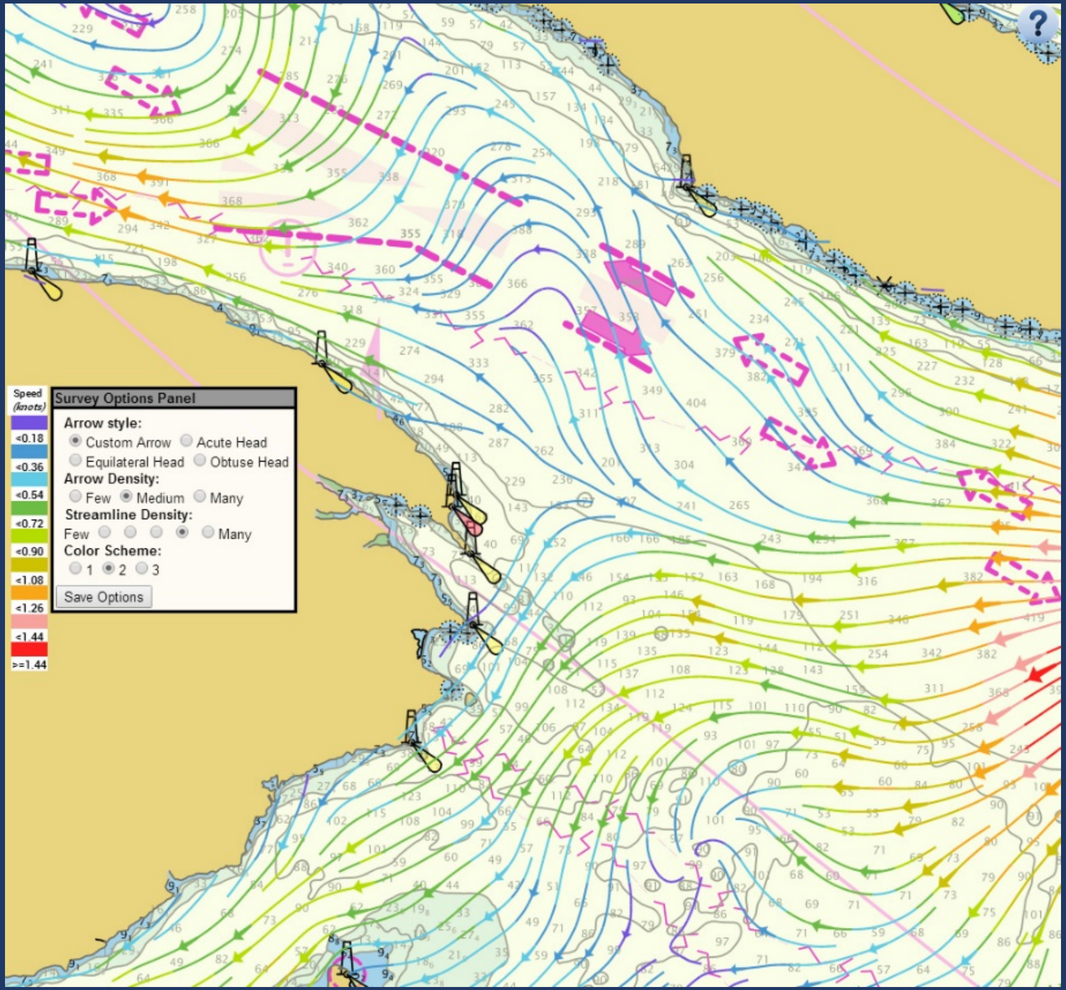
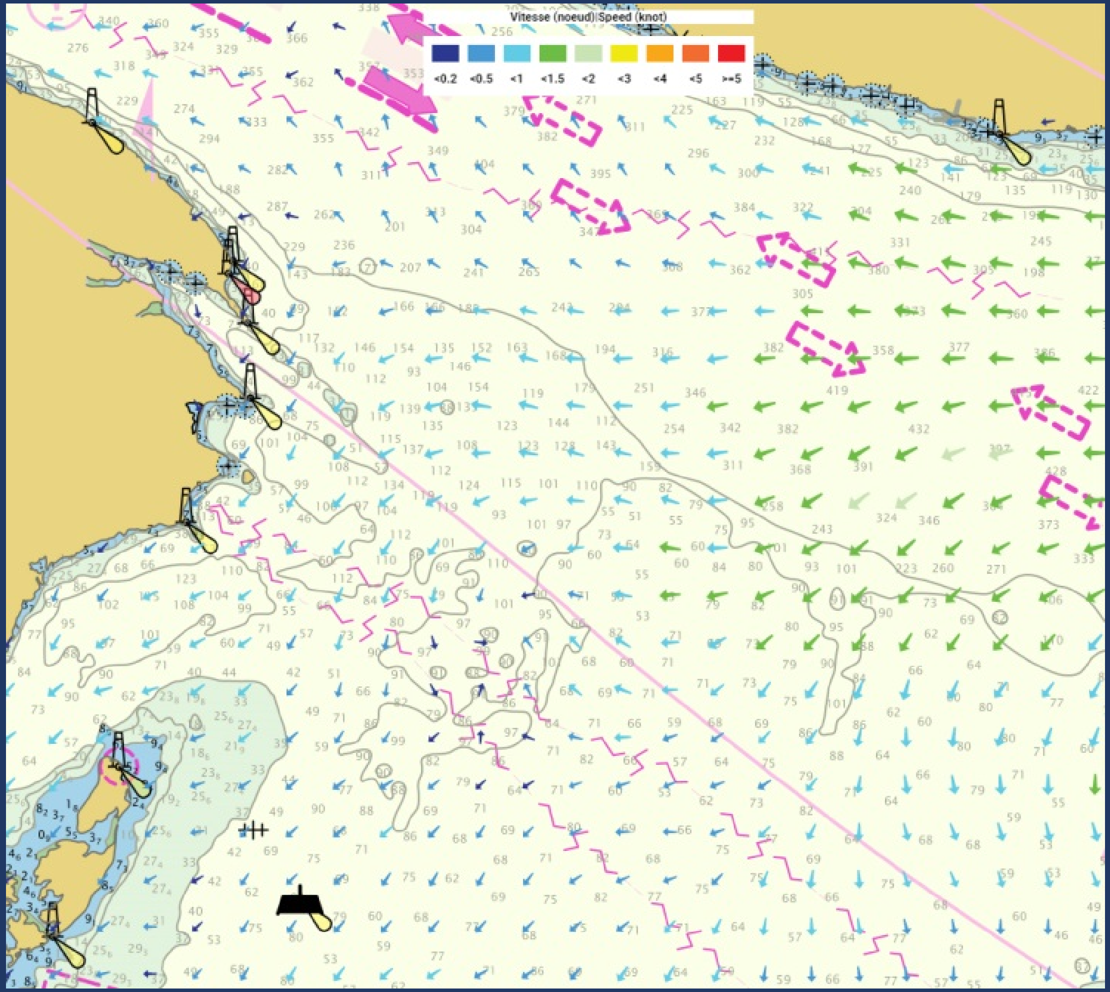
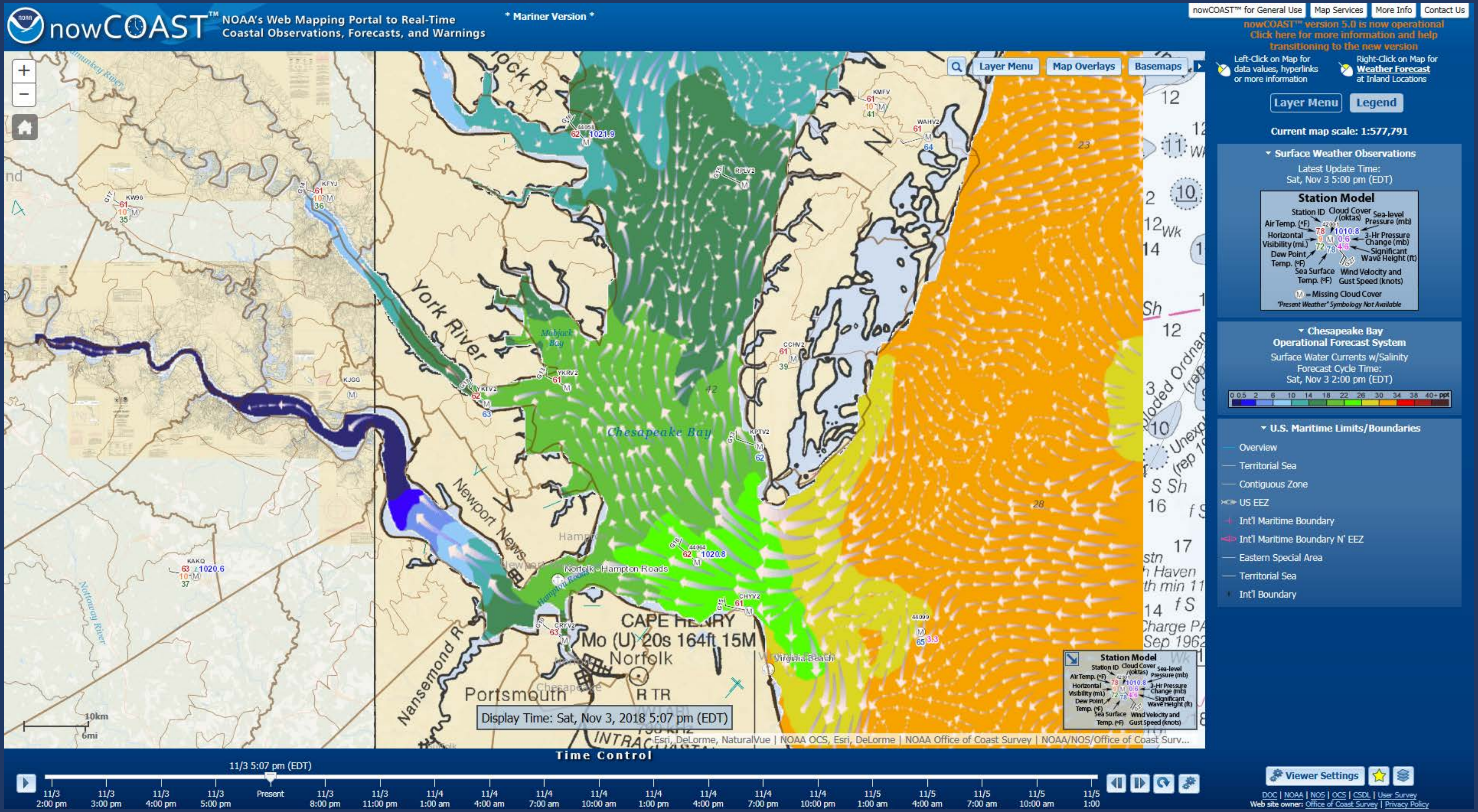
IHO Standard S-111 will permit enhanced portrayal of surface currents on ECDIS…what should that look like?

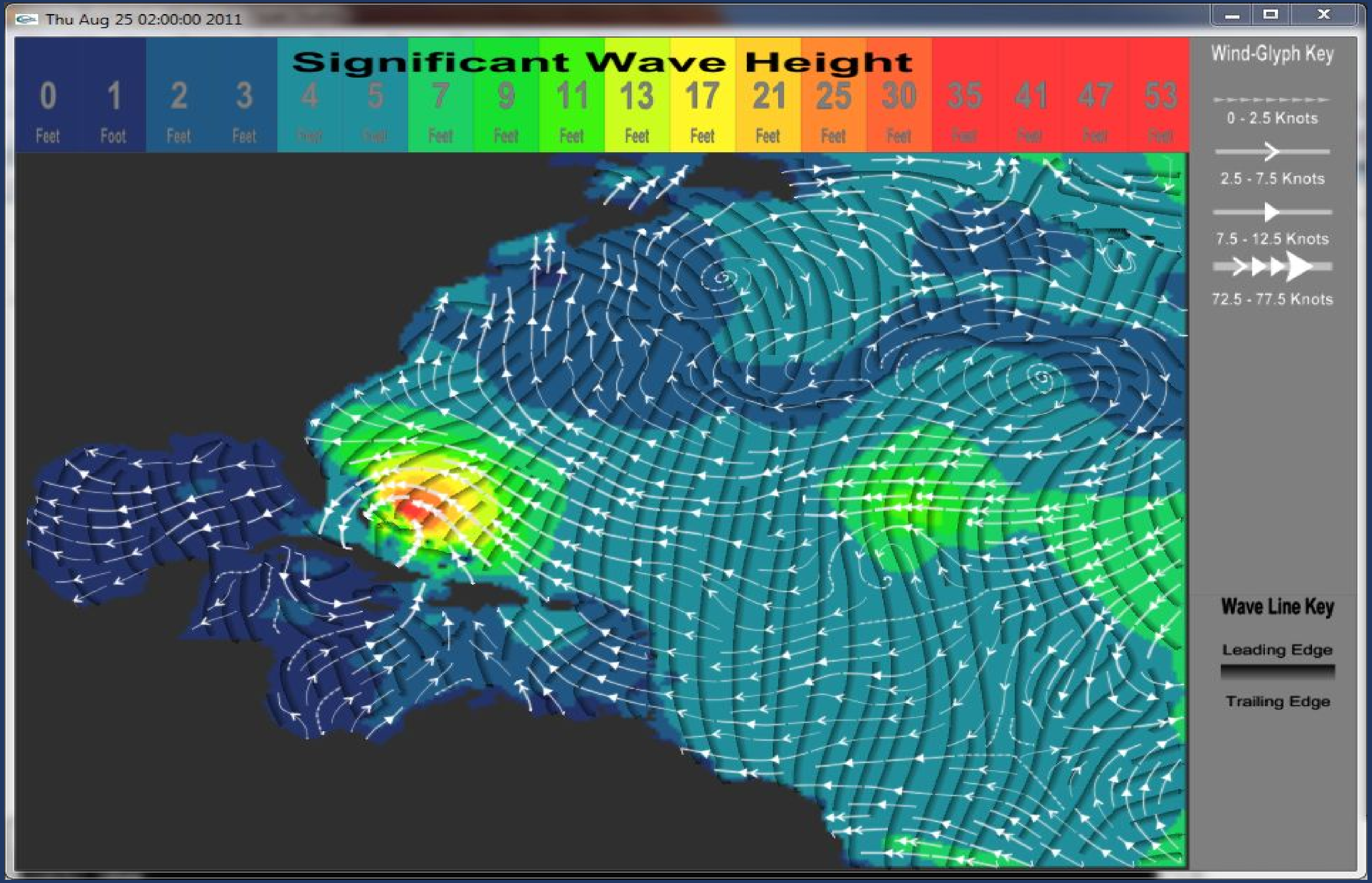




Display of multiple parameters: Current direction and magnitude by arrows and salinity by color



Forecast wind and wave height



- ***Maps of selected wave forecast guidance from NWS/NCEP new Nearshore Wave Prediction Systems or Wave Watch III using new visualization method from CCOM/JHC (NowCoast future product)***

GeoCoastPilot

The GeoCoastPilot was a project started in 2007 to demonstrate a NOAA Coast Pilot™ as an interactive document linked to a 3D map environment. The GeoCoastPilot provides linkages between the written text, 2D and 3D views, web content, and other primary sources such as charts, maps, and related federal regulations.

GeoCoastPilot has a number of innovative features:

- It links NOAA Coast Pilot information with an interactive 3D map and S-57 information, including USCG light list information.

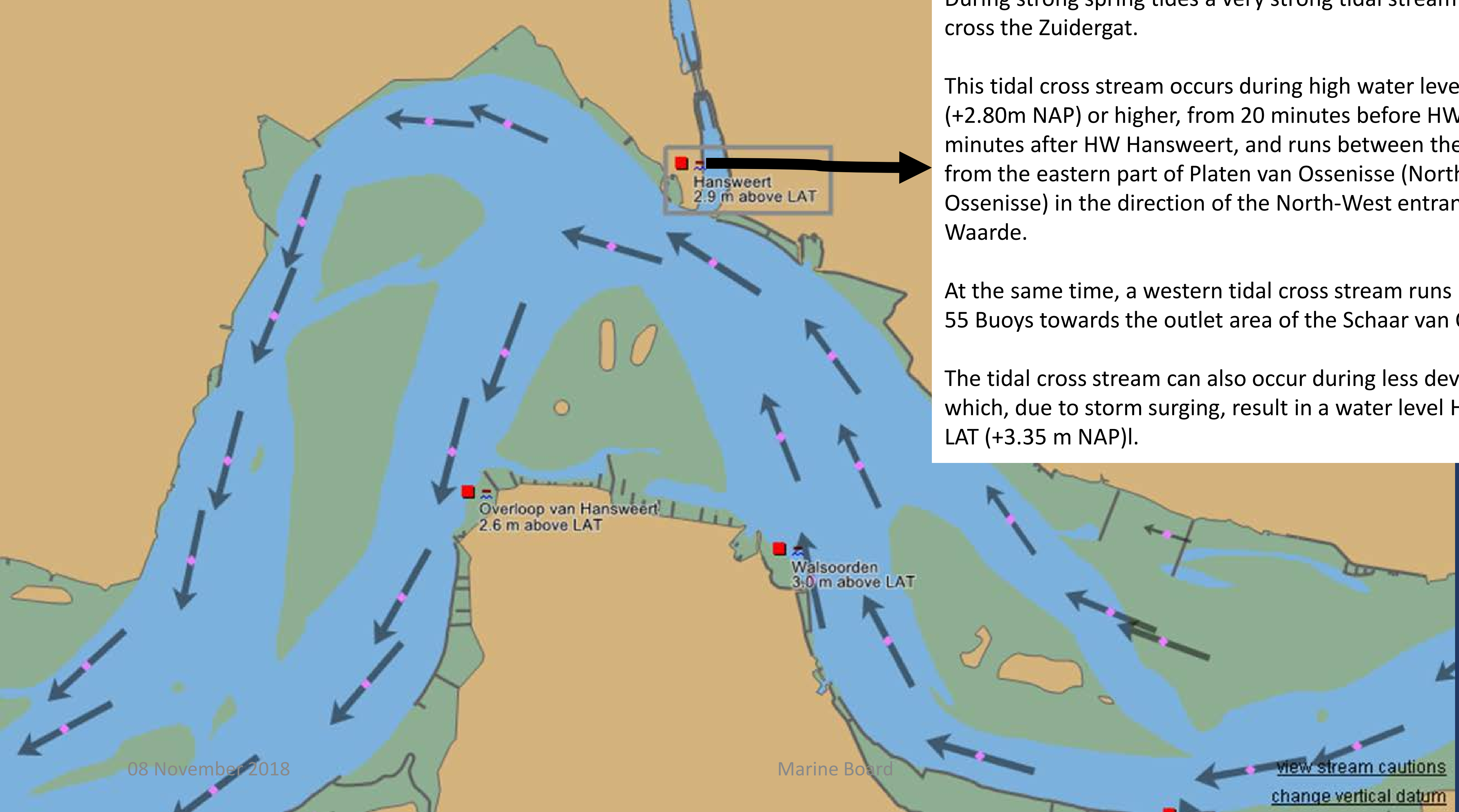
- Wherever some shore feature is mentioned it is linked with a feature on the 3D map. Clicking on the text links center the 3D view on the corresponding feature. Where possible, there is a photo of that feature placed in the correct geographic location.

- Links go both ways: when you click on a photo, buoy, or other navigation mark in the 3D view, you are taken to the first corresponding reference in the Coast Pilot text, and other references are highlighted.

Many of the concepts demonstrated in this project are being incorporated into NOAA's new vision of the Coast Pilot

Platen van Ossenisse (Western Scheldt).

Stream caution:



S-126 Physical Environment (Information from Sailing Directions)

During strong spring tides a very strong tidal stream (2.5 to 5 knots) can cross the Zuidergat.

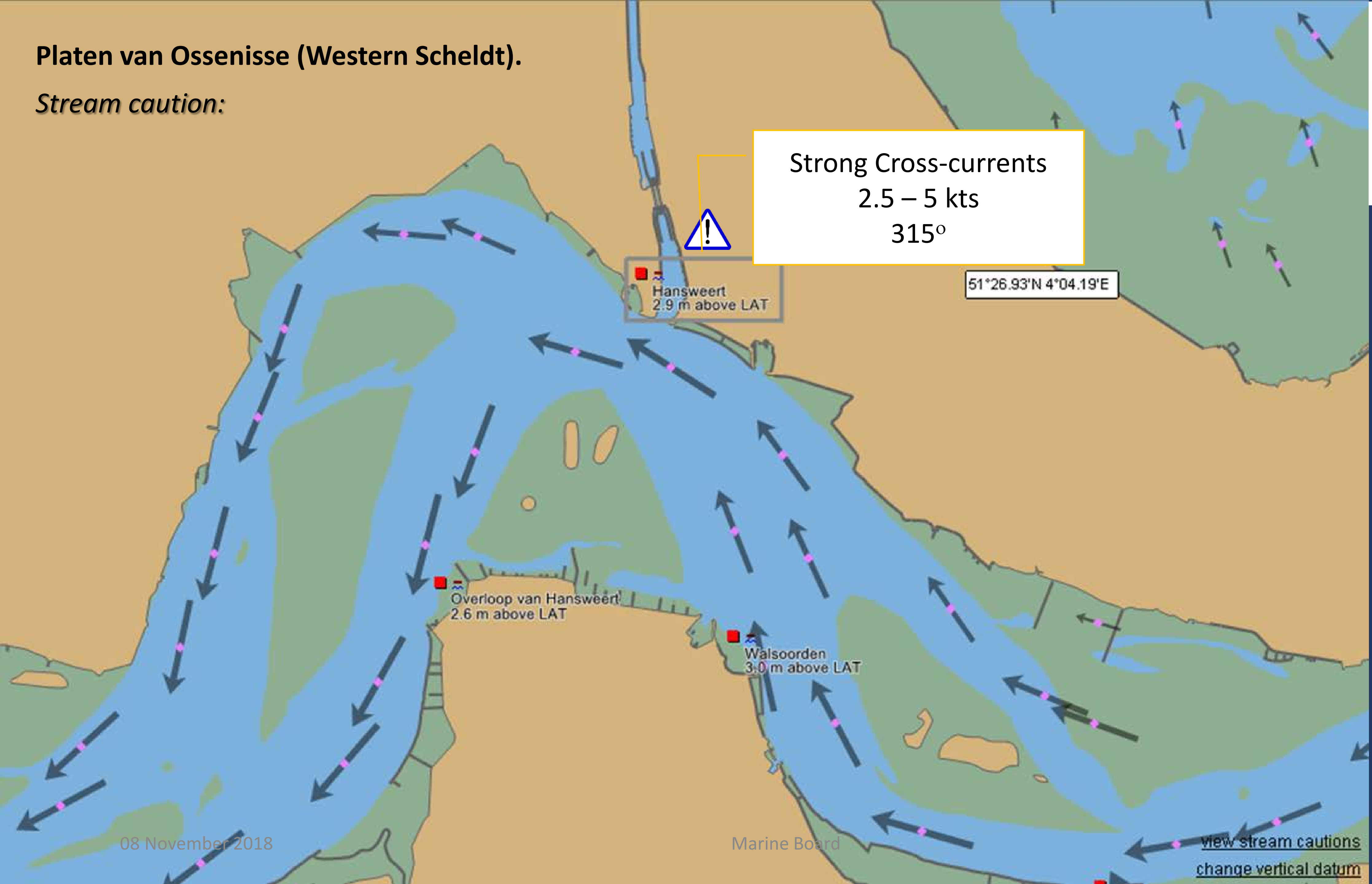
This tidal cross stream occurs during high water levels of 5.60 m LAT (+2.80m NAP) or higher, from 20 minutes before HW Hansweert to 60 minutes after HW Hansweert, and runs between the 51 and 53 Buoys from the eastern part of Platen van Ossenisse (North of Hoek van Ossenisse) in the direction of the North-West entrance of the Schaar van Waarde.

At the same time, a western tidal cross stream runs between the 53 and 55 Buoys towards the outlet area of the Schaar van Ossenisse.

The tidal cross stream can also occur during less developed spring tides which, due to storm surging, result in a water level Hansweert > 6.10 m LAT (+3.35 m NAP)l.

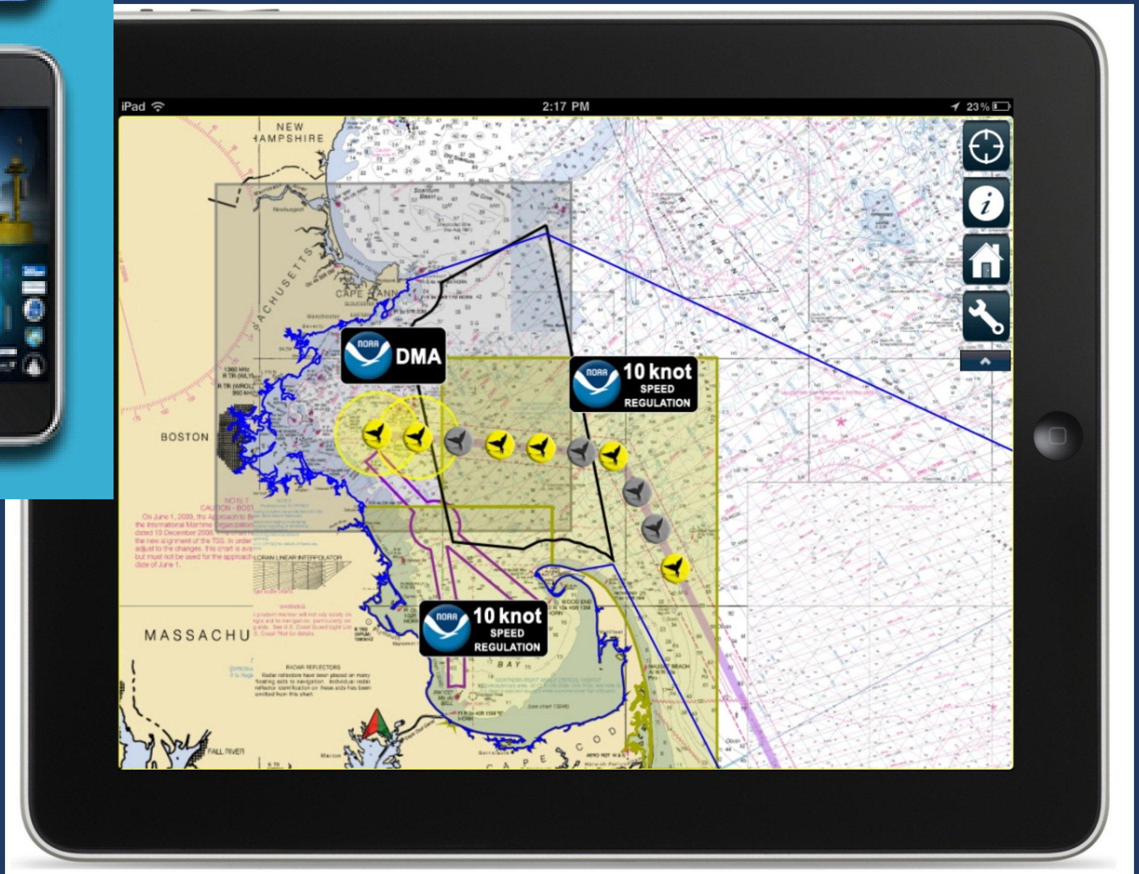
Platen van Ossenisse (Western Scheldt).

Stream caution:



location
date/time
tidal data

Whale ALERT App
Transmitted by Web AIS and deployed on iPhones, iPads, and ECS



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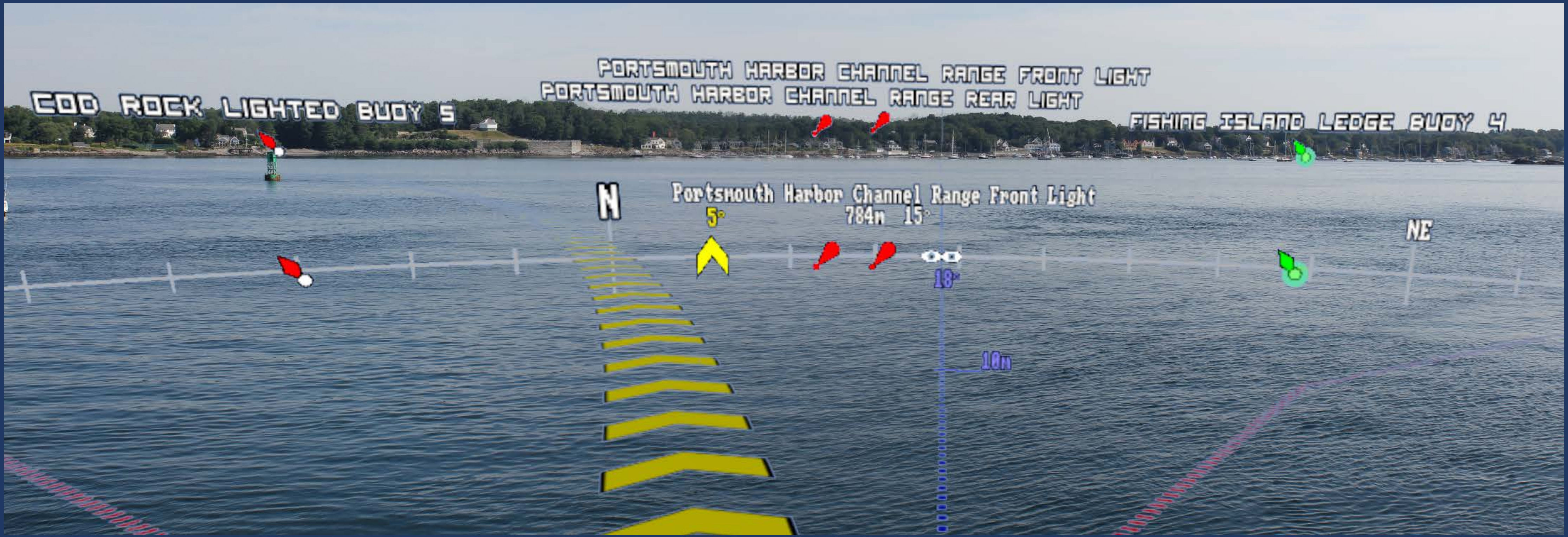
Augmented Reality for Safer Marine Navigation



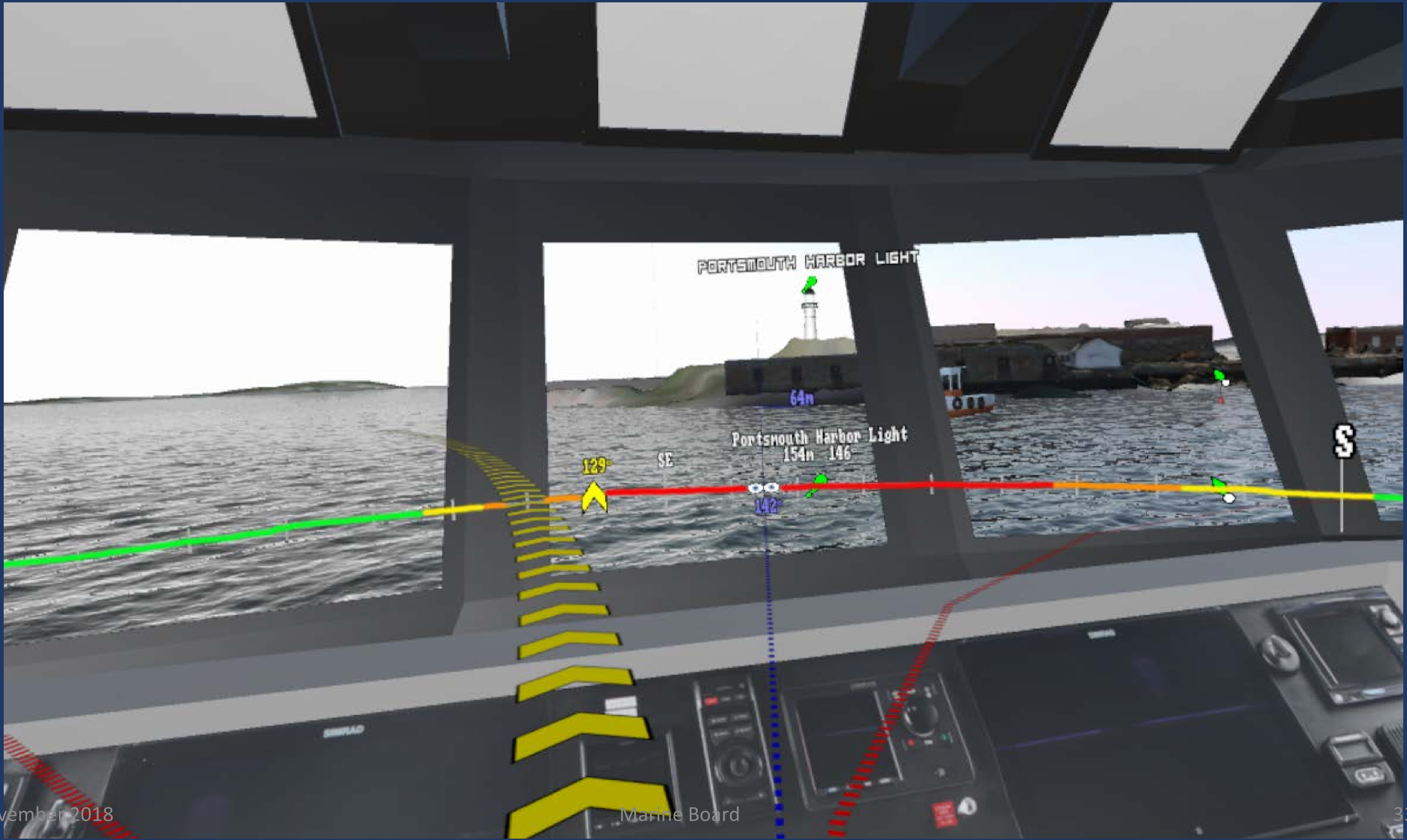
Suitable hardware still a few years away…

But we have already started research by simulating future AR hardware using small inexpensive VR (Bridge simulator)

Goal to identify:

- What's helpful / desired by mariners?
- What do we need from hardware?

Establish best practices early, influence commercial development


PORTSMOUTH HARBOR LIGHT
64m
Portsmouth Harbor Light
154m 146°
129°
SE
142°
S