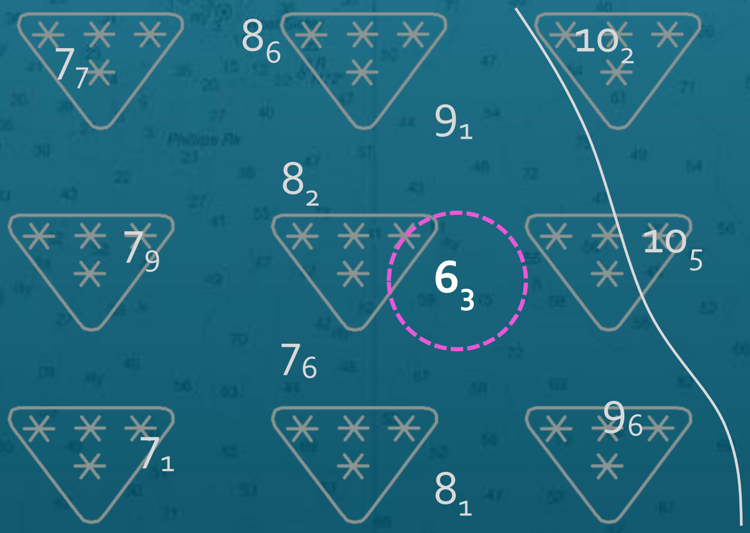
Data Quality
Working Group
Feb. 4-7, 2020

IHO Data Quality Working Group

Monaco, Feb. 4-7, 2020

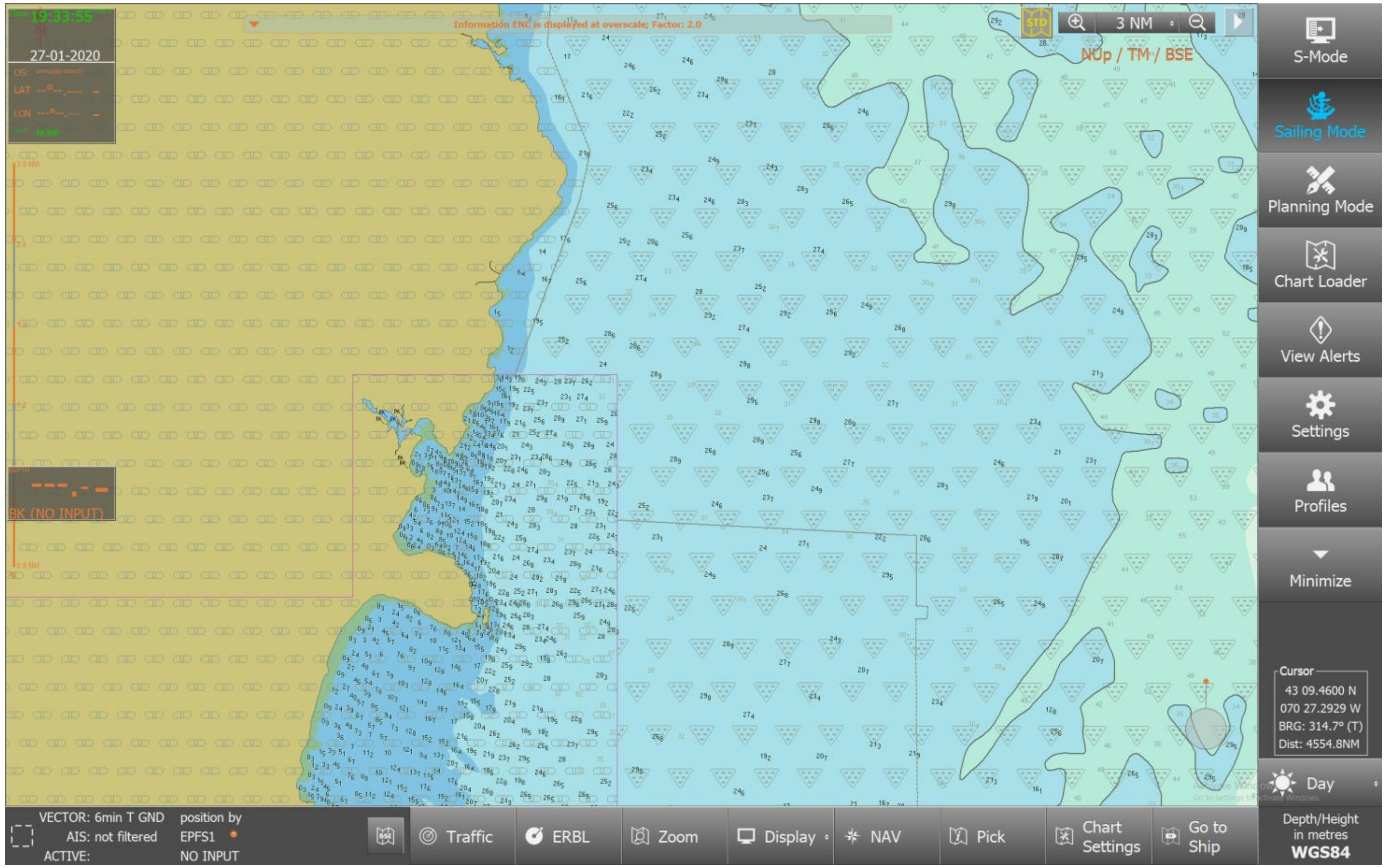
An Alternative Methodology *(to the star symbols)*


7_7
8_6
10_2
9_1
8_2
7_9
6_3
10_5
7_6
7_1
9_6
8_1

Christos Kastrisios
February 7, 2020

Data Quality
Working Group
Feb. 4-7, 2020

SCOPE


19:33:55
27-01-2020
Information ENC is displayed at overscale; Factor: 2.0
3 NM
NUp / TM / BSE
S-Mode
Sailing Mode
Planning Mode
Chart Loader
View Alerts
Settings
Profiles
Minimize
Cursor
43 09.4600 N
070 27.2929 W
BRG: 314.7° (T)
Dist: 4554.8NM
Day
Depth/Height
in metres
WGS84
BK (NO INPUT)
VECTOR: 6min T GND
AIS: not filtered
ACTIVE:
position by
EPFS1
NO INPUT
Traffic
ERBL
Zoom
Display
NAV
Pick
Chart
Settings
Go to
Ship

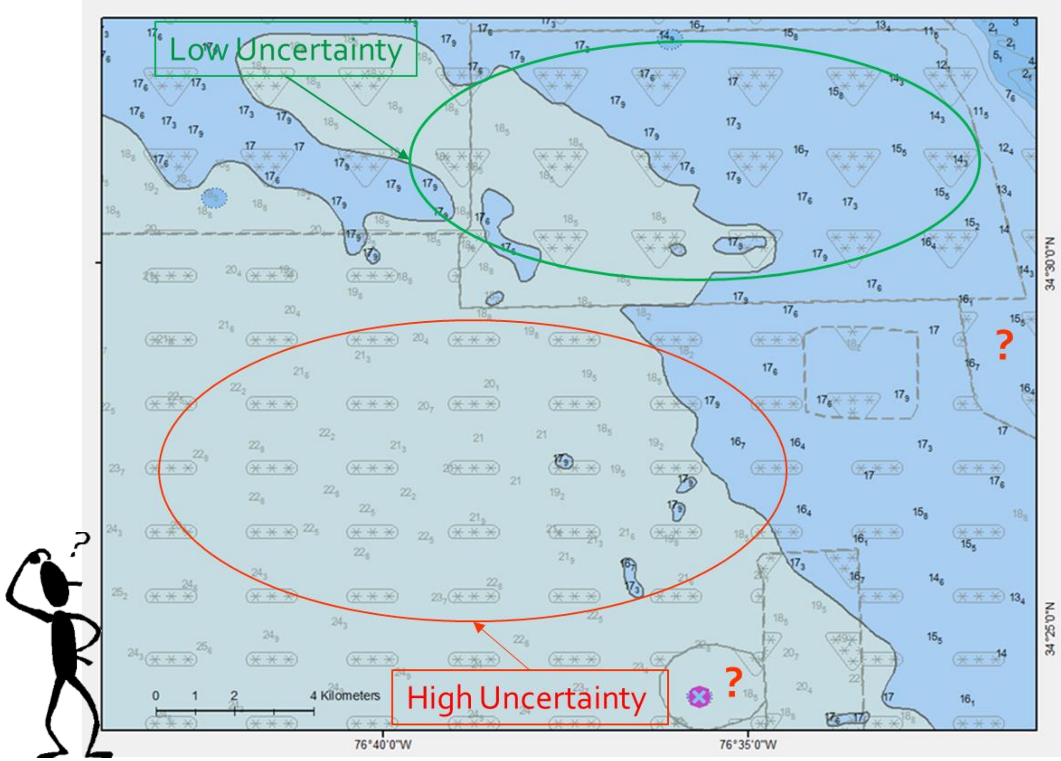
- ☐ *Better communicate data quality on charts.*
- ☐ *Help mariners to make informed decisions.*

NOAA
CCOM
JHC

STAR SYMBOLS

PROBLEMS

- **CLUTTER**
- Obscure high-quality more than low-quality data
- Not intuitive
- May not fit in small areas
- Dominate the screen


Low Uncertainty
High Uncertainty
?
?
?
0 1 2 4 Kilometers
76°40'0"W
76°35'0"W
34°30'0"N
34°25'0"N

STAR SYMBOLS

PROBLEMS

- **CLUTTER**
- Obscure high-quality more than low-quality data
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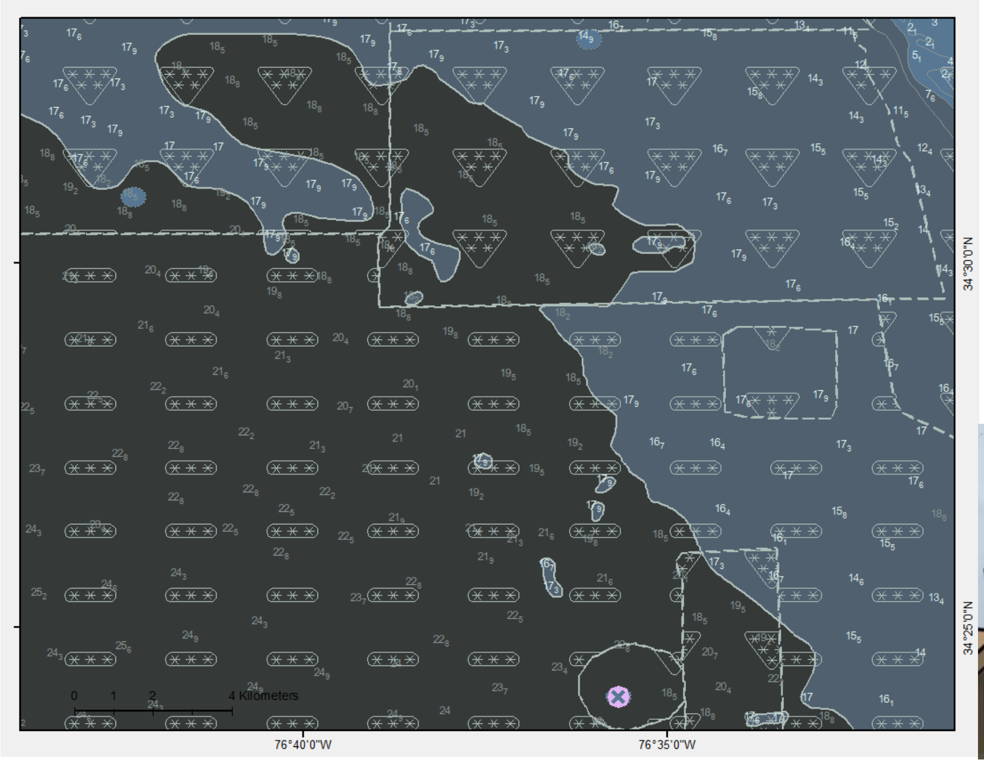
- Dominate the screen

ECDIS Day Blackback Mode


0 1 2 4 Kilometers
76°40'0"W
76°35'0"W
34°30'0"N
34°25'0"N

STAR SYMBOLS

PROBLEMS

- **CLUTTER**
- Obscure high-quality more than low-quality data
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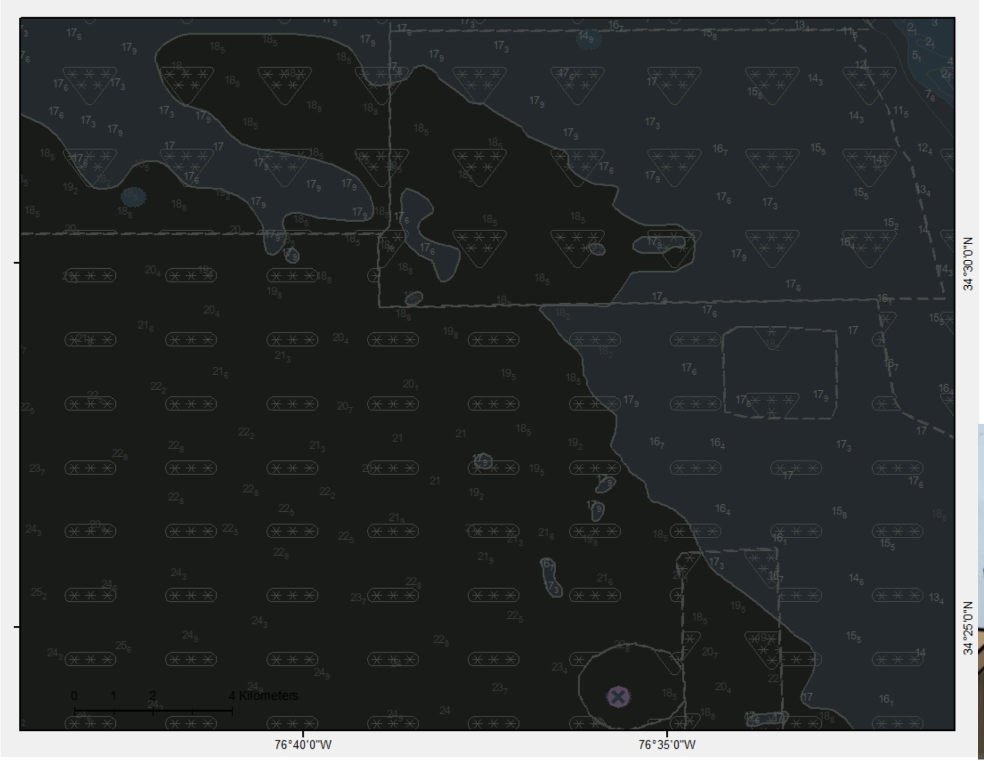
- Dominate the screen

> ***"The current staggered pattern symbology of CATZOC should not be used in S-101"***
>
> DQWG14-08A

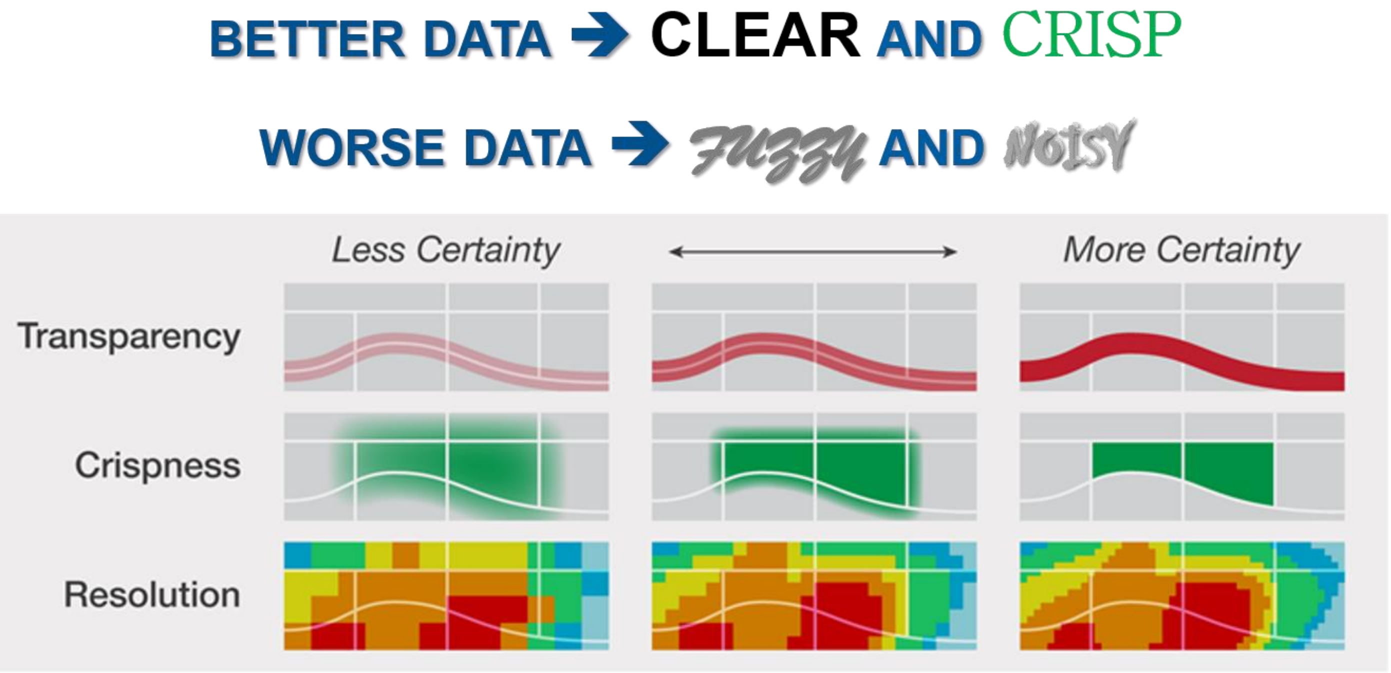
ECDIS Dusk Mode


0
1
2
4 Kilometers
76°40'0"W
76°35'0"W
34°30'0"N
34°25'0"N

Data Quality Working Group
Feb. 4-7, 2020

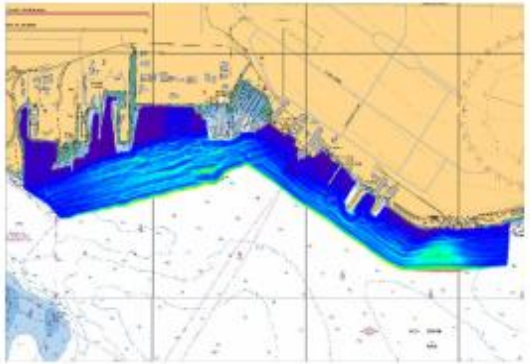
UNCERTAINTY VISUALIZATION

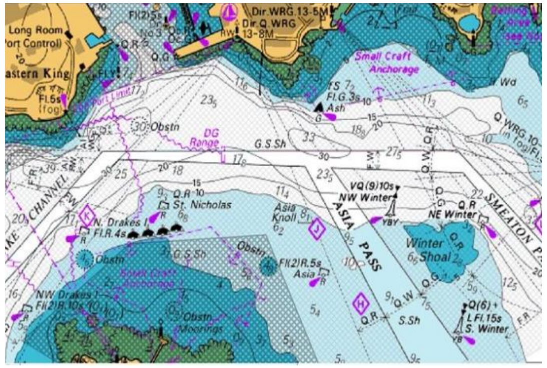
- Cartographic techniques:
  - Visual Variable
    - color value,
    - color saturation,
    - crispness
    - resolution,
    - texture,
    - location
  - Intrinsic / extrinsic

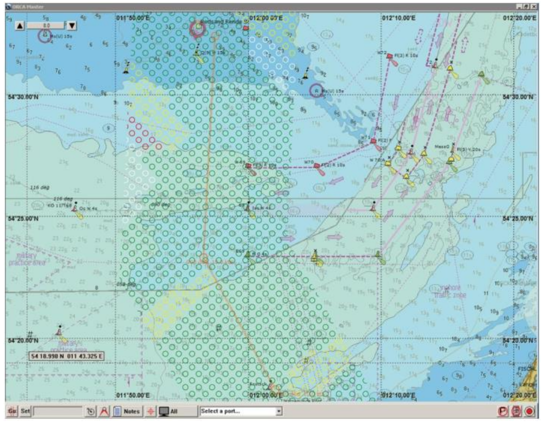

BETTER DATA → CLEAR AND CRISP
WORSE DATA → FUZZY AND NOISY
Less Certainty
More Certainty
Transparency
Crispness
Resolution

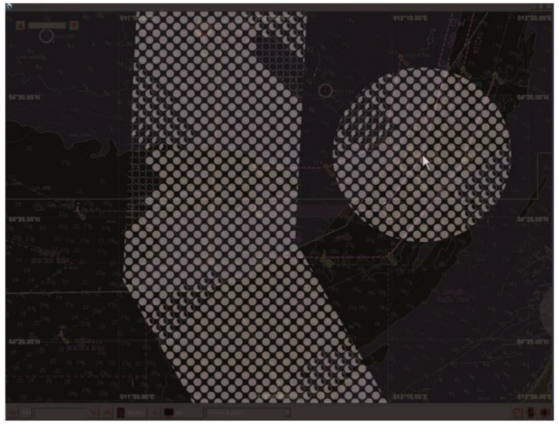
UCGIS (2020). CV-08- Symbolization and Visualization variables. University Consortium for Geographic Information Science. Accessed on Jan. 29, 2020 at https://gistbok.ucgis.org/bok-topics/symbolization-and-visual-variables.

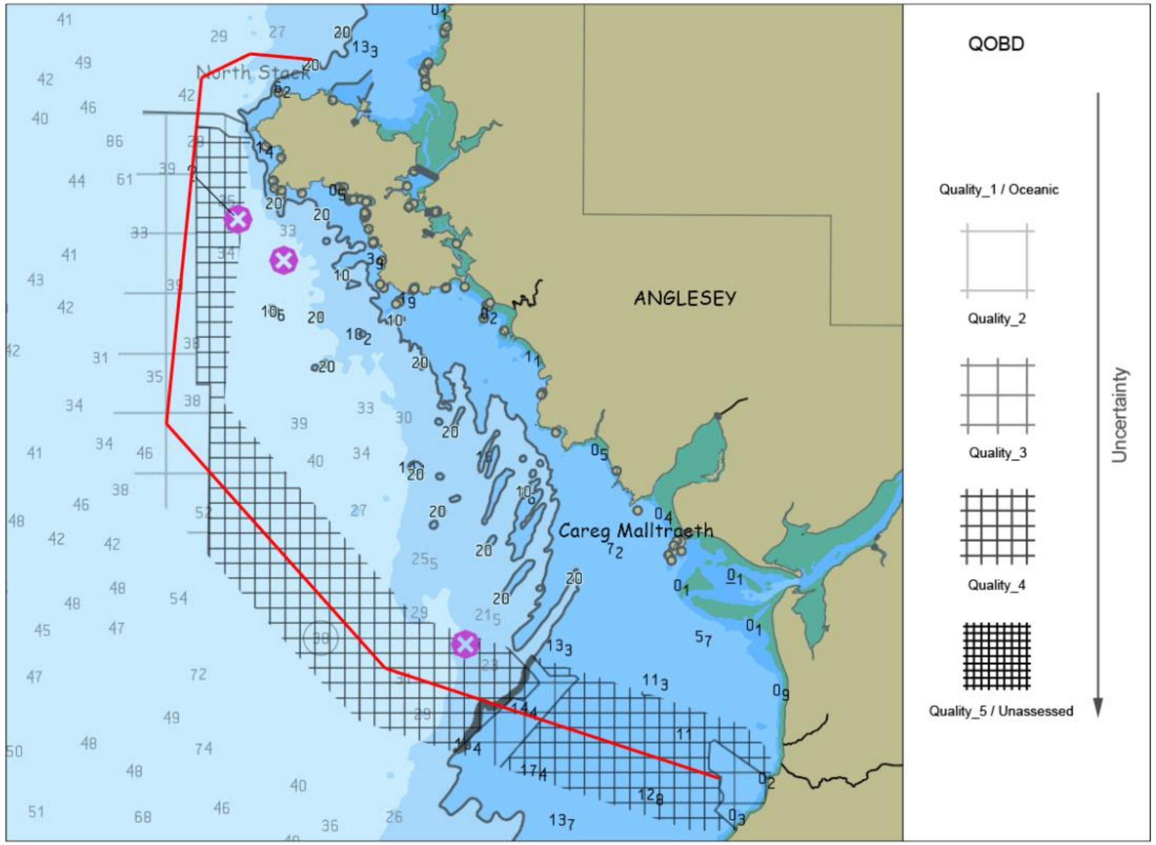
RELEVANT WORK







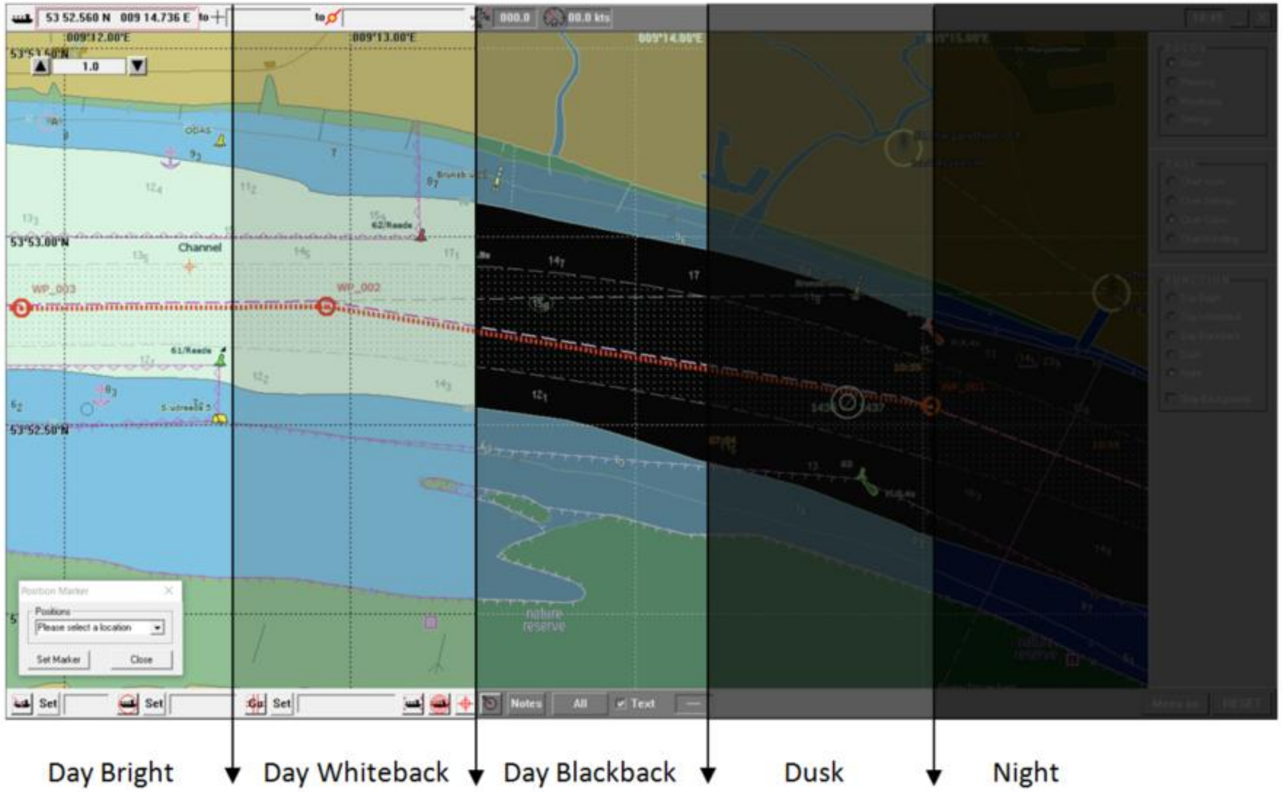



QOBD
Quality_1 / Oceanic
Quality_2
Quality_3
Quality_4
Quality_5 / Unassessed
Uncertainty
North Stack
ANGLESEY
Careg Malltraeth

Hare, R., B. Eakins, and C. Amante (2011). “Modeling bathymetric uncertainty”. In: Proceedings of US Hydro. Tampa, Florida.
DQWG (2014). TSMAD29-DIPWG7-CSPCWG11-TWLWG7-INFxx DQWG9-Outcome- New ways of representing quality of bathymetric data for surface navigation. Tech. rep. IHO.
Gladisch, S. and T. Ruth (2016). DQV - Data Quality Visualization Recommendations for Visualizing Uncertainty in Electronic Nautical Charts. Rostock, Germany.

REQUIREMENTS

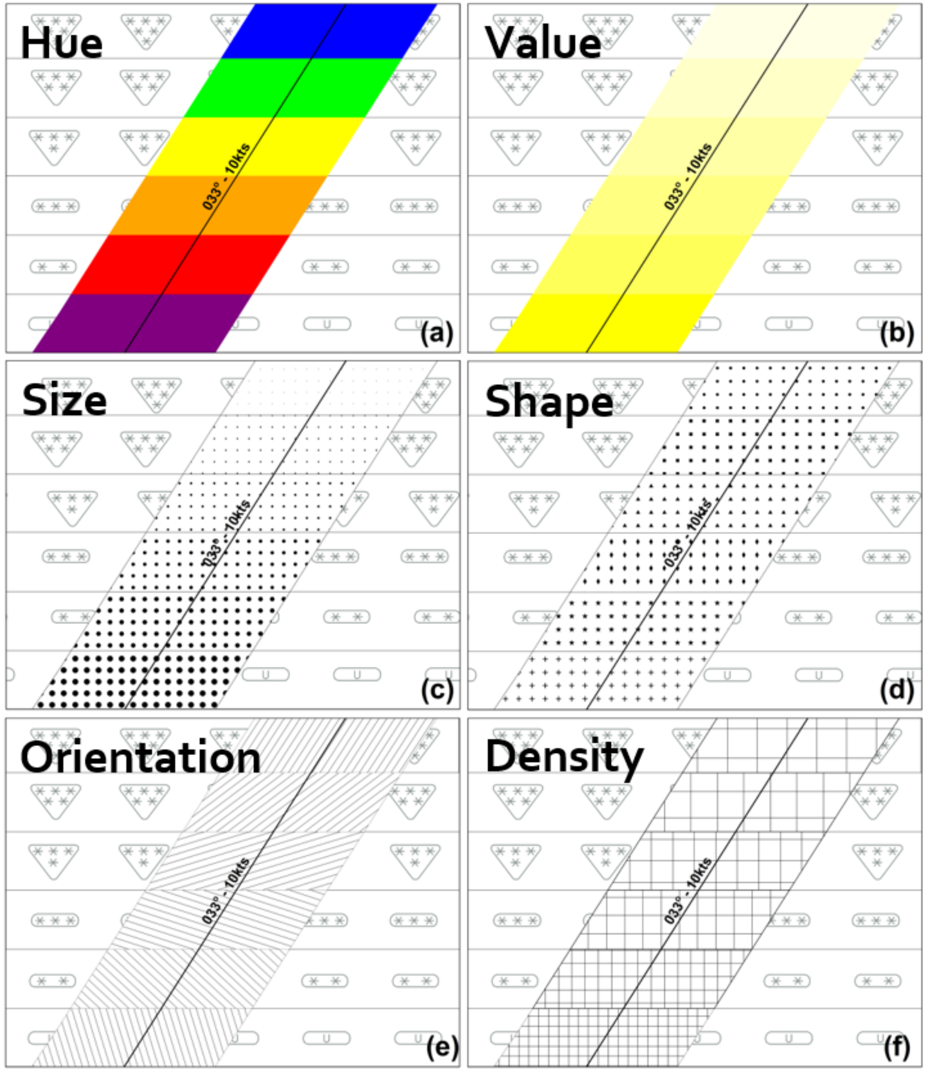
- Unambiguously visualize the different uncertainty levels.
- Minimize the occlusion of navigational information.
- Increase visual weight with the increase of data uncertainty.
- Maintain effectiveness in all ECDIS modes
- Be easy to memorize



Kastrisios, C. and L. Tsoulos. 2016. "Electronic Chart Display and Information Systems as Systems of Dynamic and Interactive Cartography." Paper presented at the 14th HCC - Hellenic Cartographic Conference, 2 – 4 November 2016, Thessaloniki, Greece.

METHODS

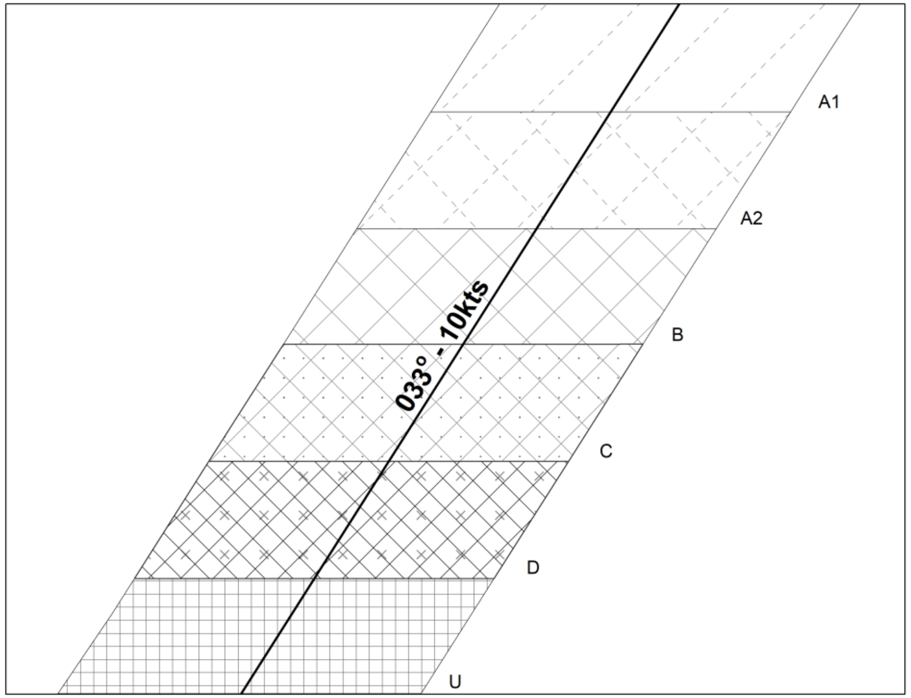
- Color Hue
  - Most primary and secondary colors are already reserved for other uses in the ENC/ECDIS or are not suitable for all ECDIS modes.
- Color value and saturation
  - Both interact with base information and may alter the perception of the underlying chart features.
  - The portrayed layer can obscure ENC information.
  - The portrayed layer of data quality can become dominant in dusk and night modes.
- Size
  - The identification of the different CATZOC levels becomes ambiguous whenever only a few of the levels are displayed.
- Shape
  - Arbitrary shapes are not intuitive and require a legend.
- Orientation, and density
  - They can create an ambiguous visualization of the different CATZOC levels.

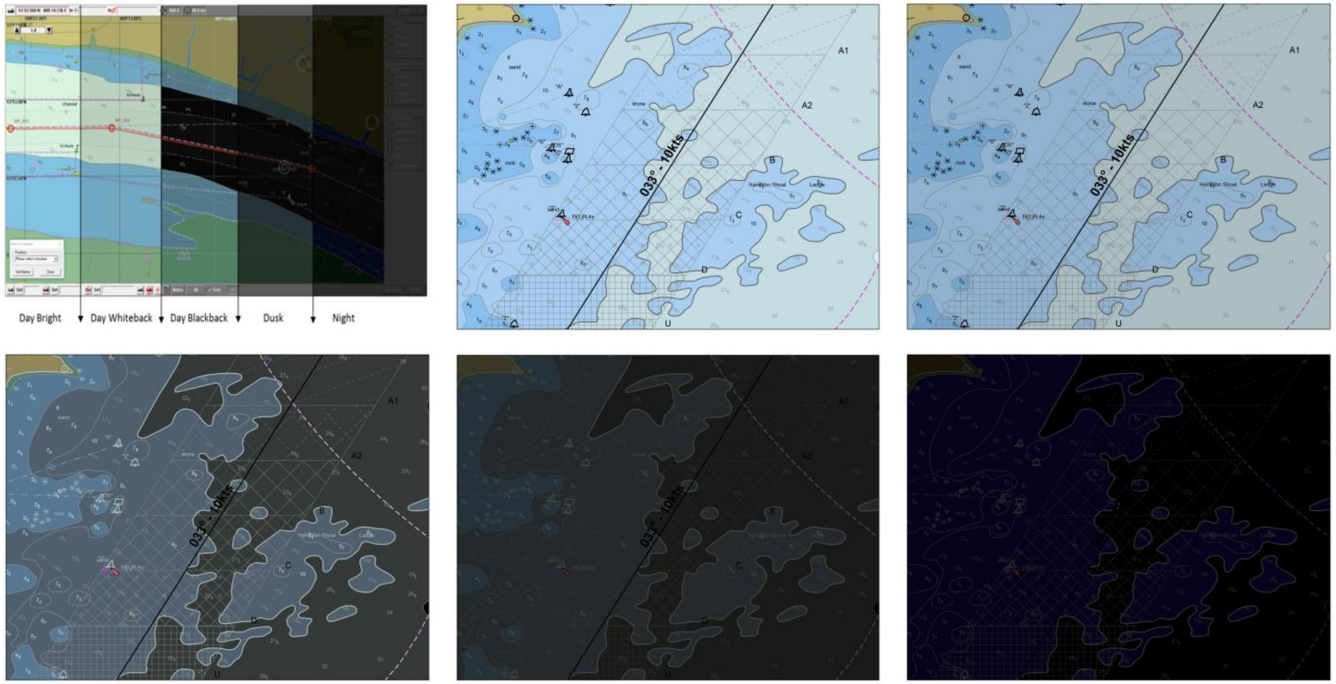


Kastrisios, C., Ware, C., Calder, B., Butkiewicz, T., Alexander, A. L., & Hauser, O. (2020). Nautical chart data uncertainty visualization as the means for integrating bathymetric, meteorological, and oceanographic information in support of coastal navigation. 100th American Meteorological Society Annual Meeting, 18th Symposium on the Coastal Environment, Boston, MA.

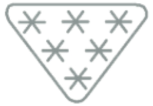
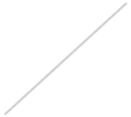
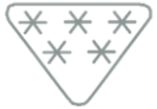
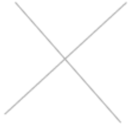
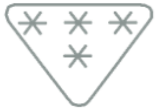
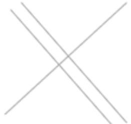
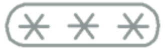
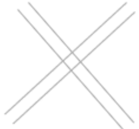
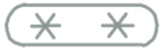
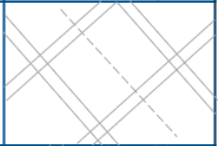
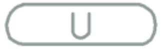
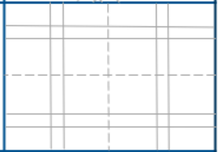
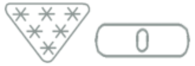
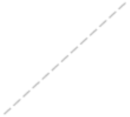
METHODS

Sequence of textures,
created by combining two or more visual variables


A1
A2
B
C
D
U
033° - 10kts


Day Bright
Day Whiteback
Day Blackback
Dusk
Night
A1
A2
B
C
D
U
033° - 10kts

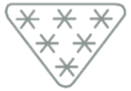
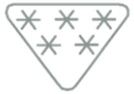
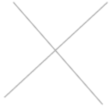
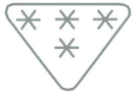
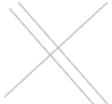
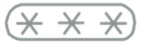
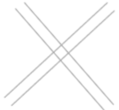
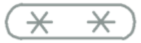
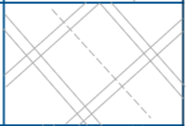
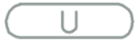
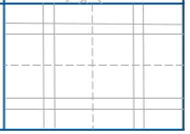
PROPOSED SOLUTION

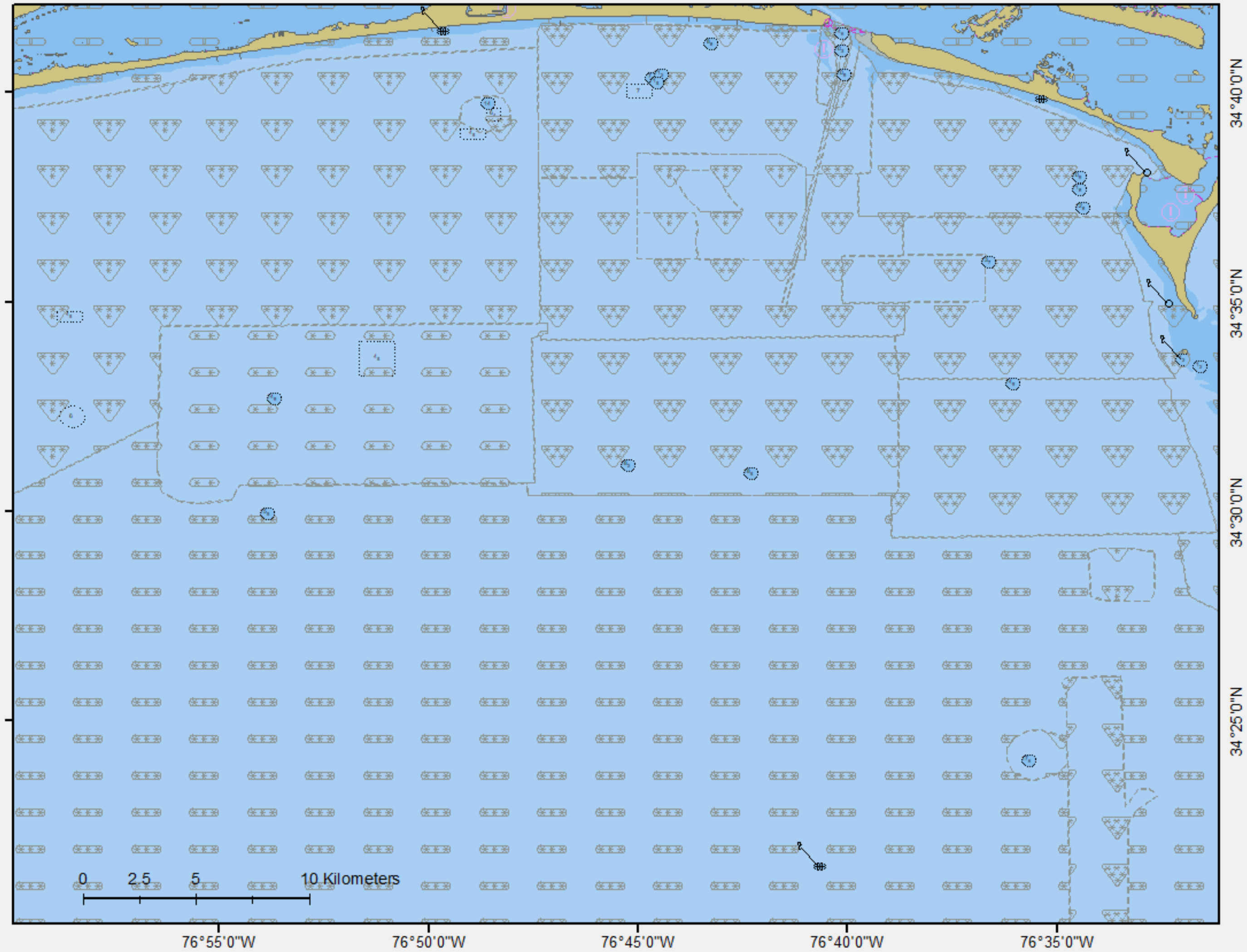
ZOC	QoBD	Symbol	Texture
A1	1		
A2	2		
B	3		
C	4		
D	5		
U	U		
	O	 ???	

Textures of lines:

- # of Lines ➔ Quality of Bathymetric Data (QoBD)
- Angled vs Vertical ➔ Assessed vs Unassessed
- Single vs Double ➔ Full vs Not Full Seafloor coverage
- Solid vs Dash ➔ Quantified vs Not Quantified Uncertainty

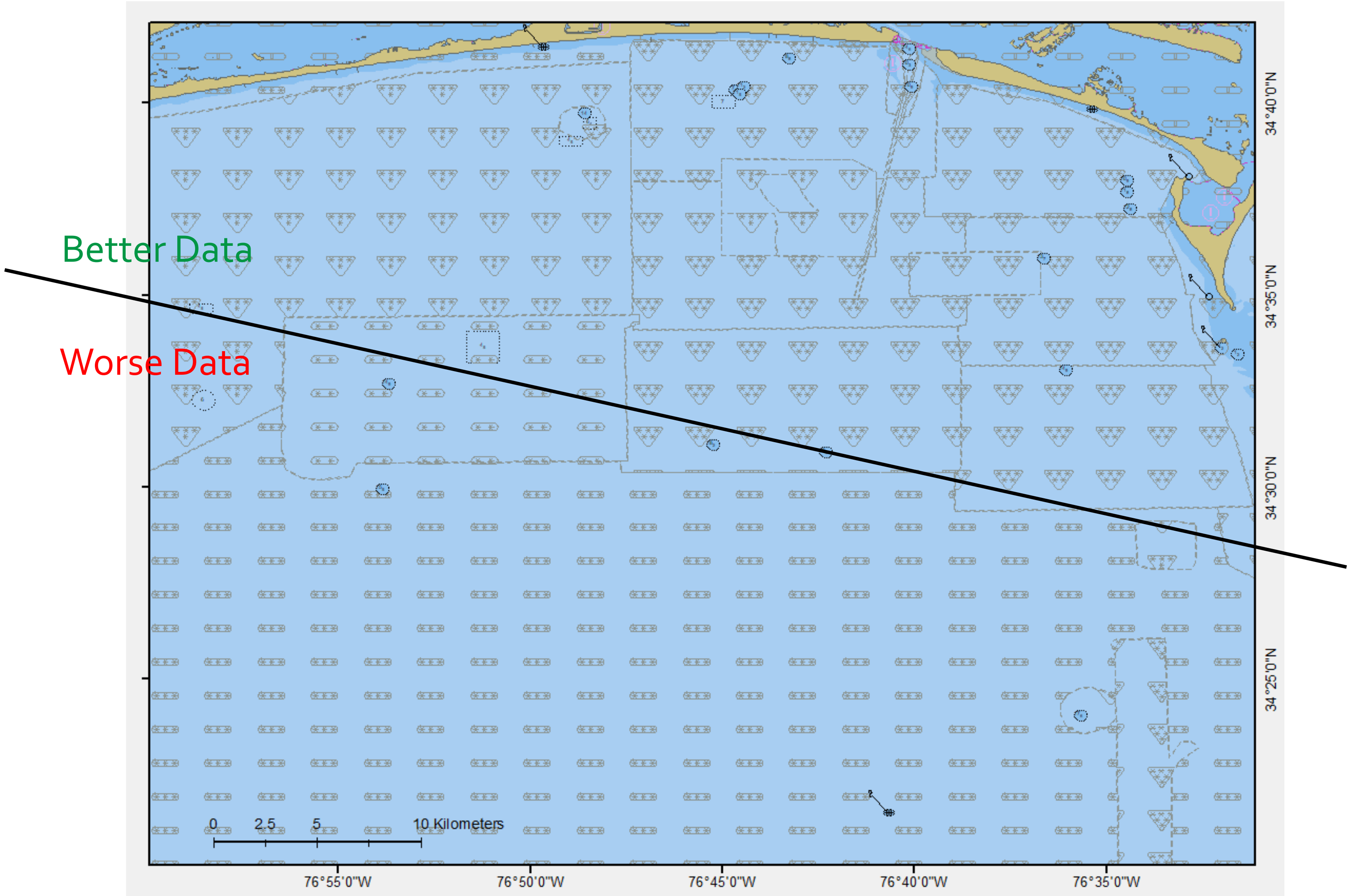
RESULTS

ZOC	QoBD	Symbol	Texture
A1	1		
A2	2		
B	3		
C	4		
D	5		
U	U		

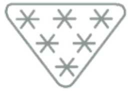
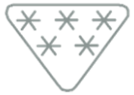
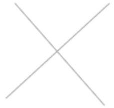
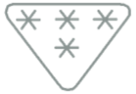
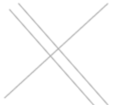
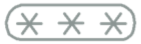
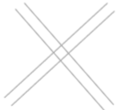
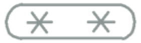
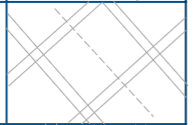
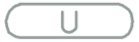
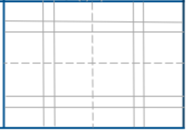

0
2.5
5
10 Kilometers
34°40'0"N
34°35'0"N
34°30'0"N
34°25'0"N
76°55'0"W
76°50'0"W
76°45'0"W
76°40'0"W
76°35'0"W

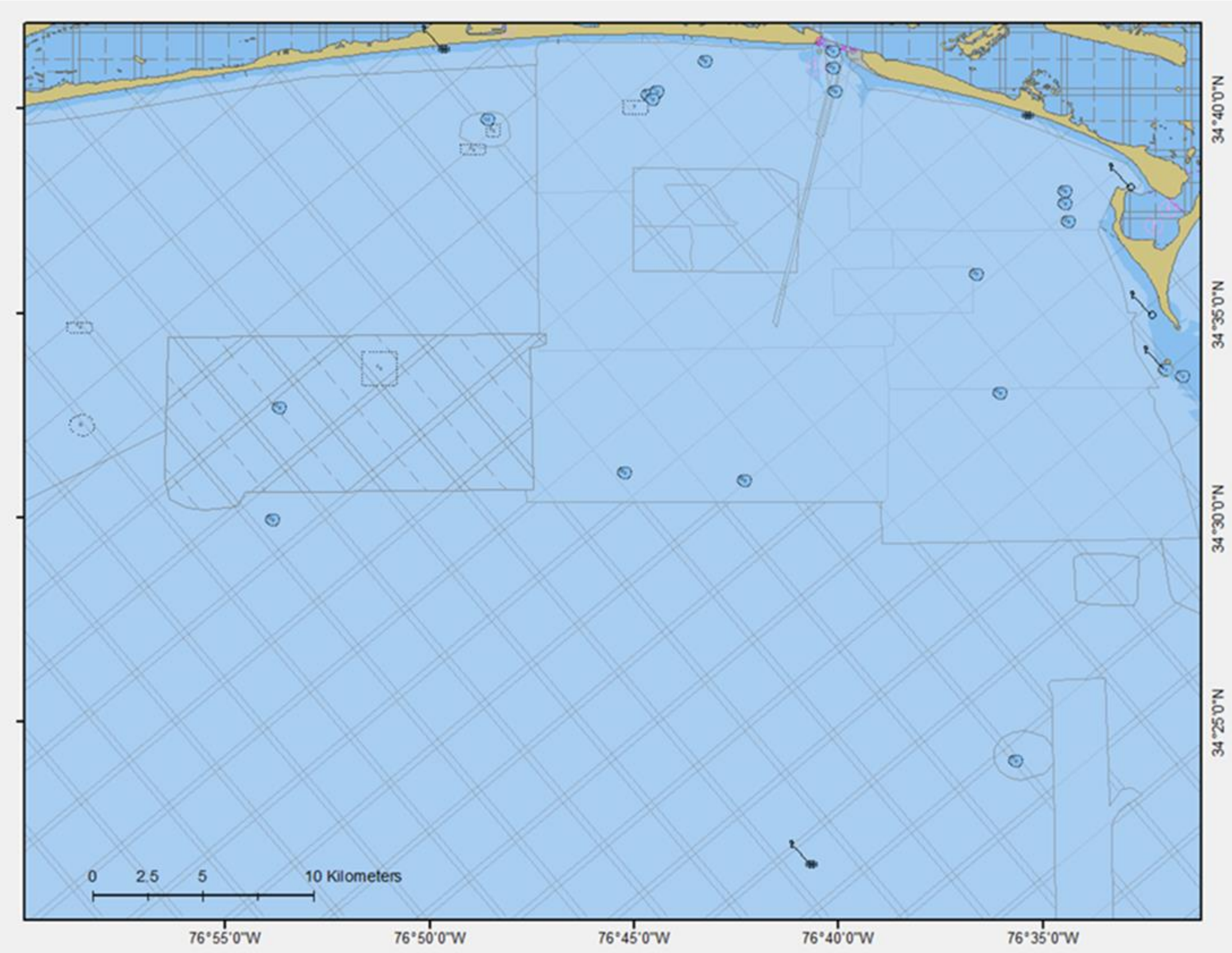
RESULTS

ZOC	QoBD	Symbol	Texture
A1	1	* * * * * *	╱
A2	2	* * * * *	╳
B	3	* * * *	╳
C	4	* * *	╳
D	5	* *	▨
U	U	U	▦

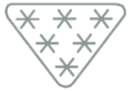
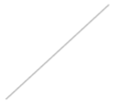
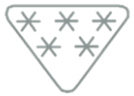
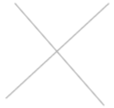
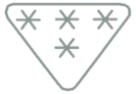
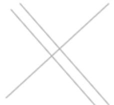
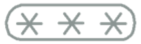
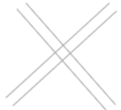
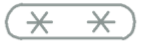
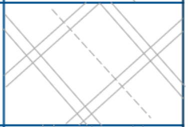
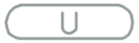
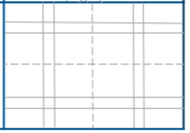

Better Data
Worse Data
0
2.5
5
10 Kilometers
76°55'0"W
76°50'0"W
76°45'0"W
76°40'0"W
76°35'0"W
34°40'0"N
34°35'0"N
34°30'0"N
34°25'0"N

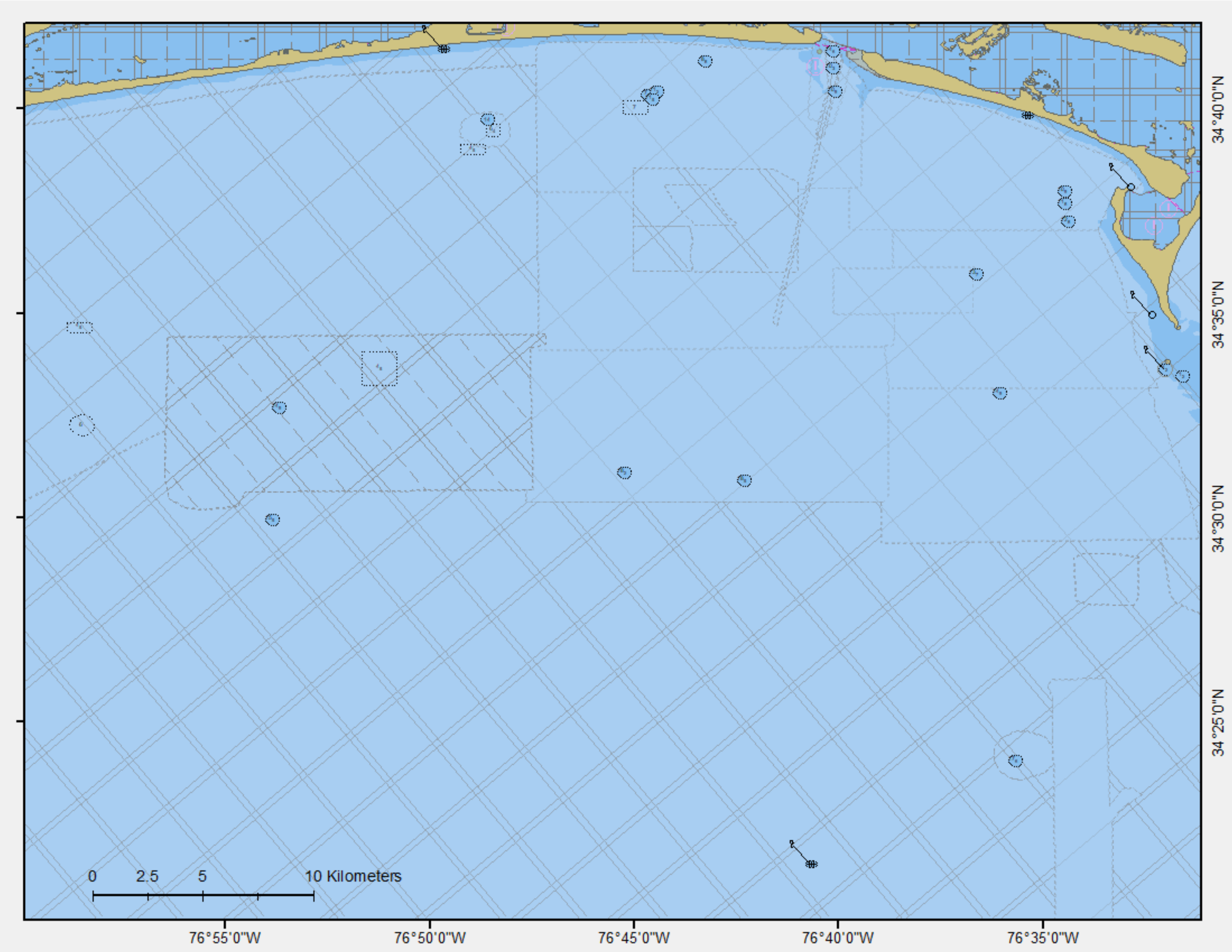
RESULTS

ZOC	QoBD	Symbol	Texture
A1	1		
A2	2		
B	3		
C	4		
D	5		
U	U		

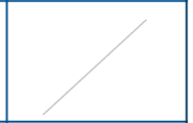
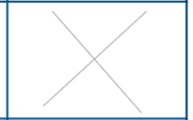
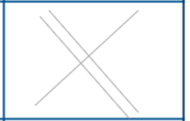
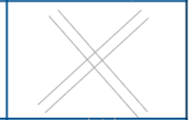
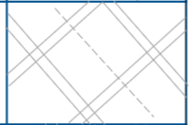
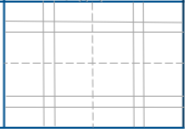

0
2.5
5
10 Kilometers
76°55'0"W
76°50'0"W
76°45'0"W
76°40'0"W
76°35'0"W
34°40'0"N
34°35'0"N
34°30'0"N
34°25'0"N

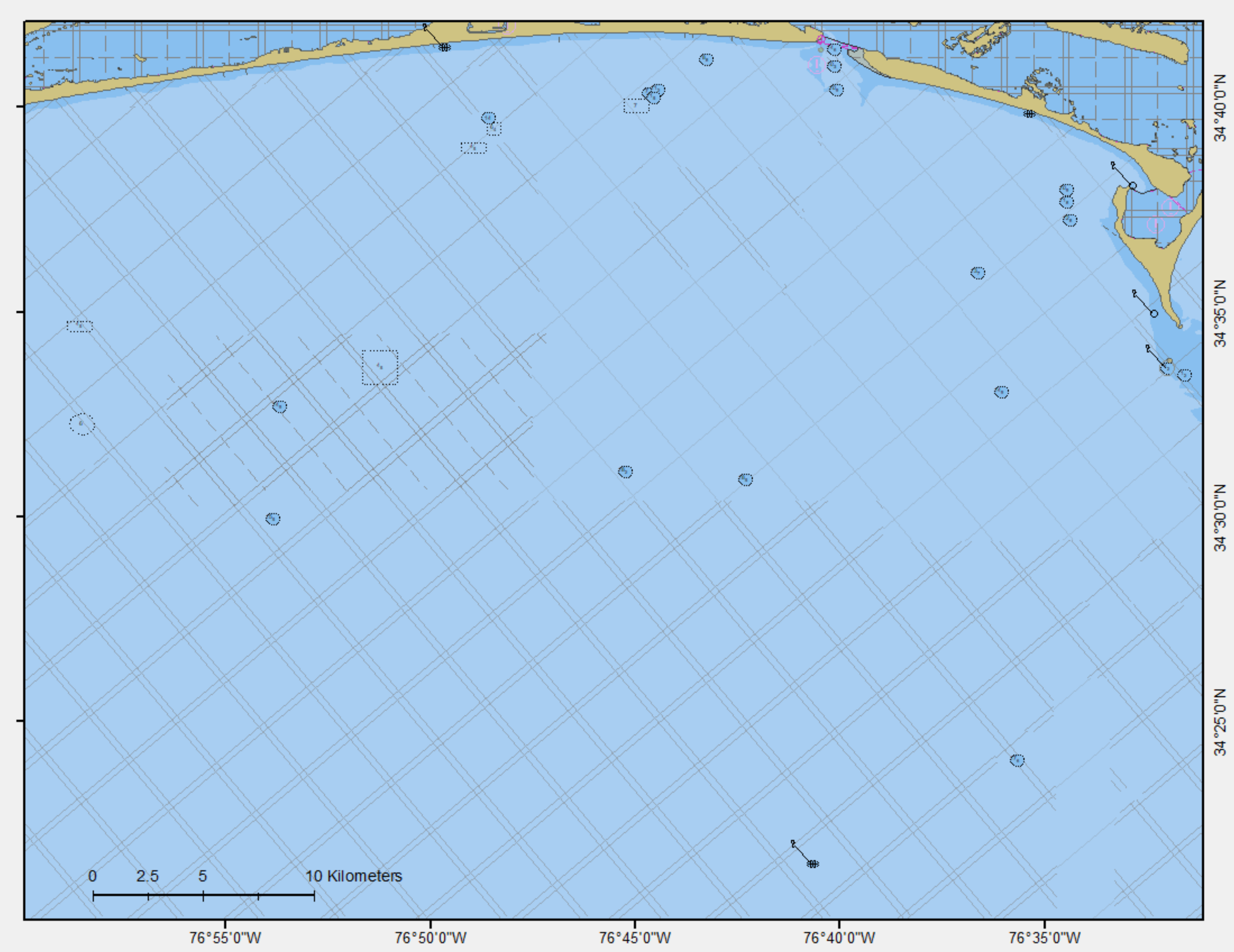
Results

ZOC	QoBD	Symbol	Texture
A1	1		
A2	2		
B	3		
C	4		
D	5		
U	U	 U	

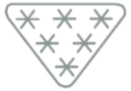
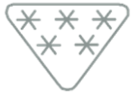
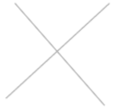
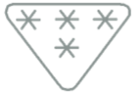
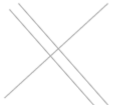
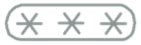
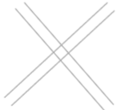
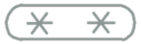
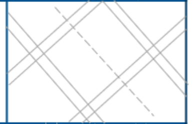
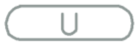
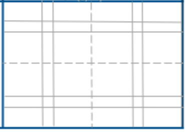

0
2.5
5
10 Kilometers
34°40'0"N
34°35'0"N
34°30'0"N
34°25'0"N
76°55'0"W
76°50'0"W
76°45'0"W
76°40'0"W
76°35'0"W

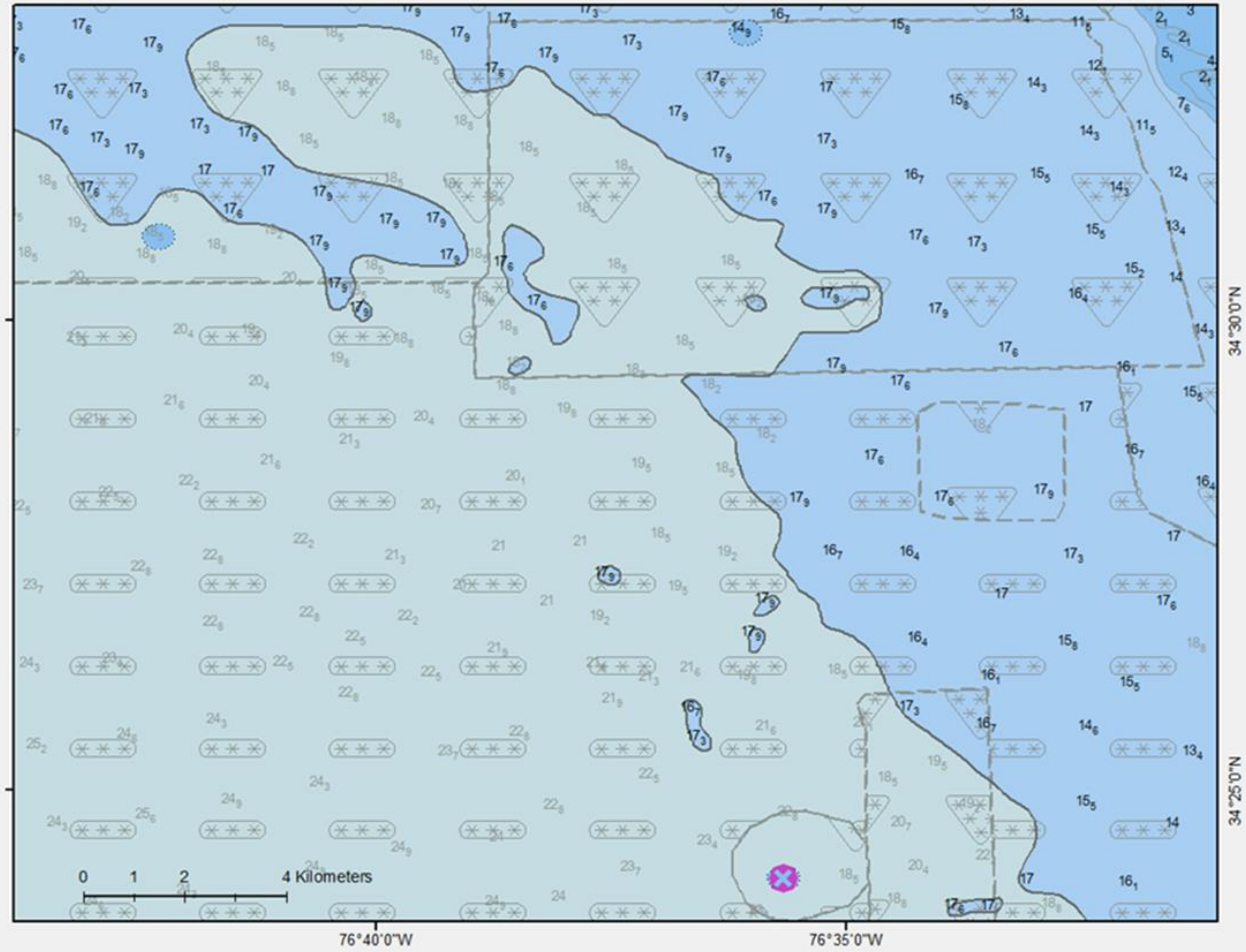
RESULTS

ZOC	QoBD	Symbol	Texture
A1	1	✳✳✳✳✳✳	
A2	2	✳✳✳✳✳	
B	3	✳✳✳✳	
C	4	✳✳✳	
D	5	✳✳	
U	U	U	

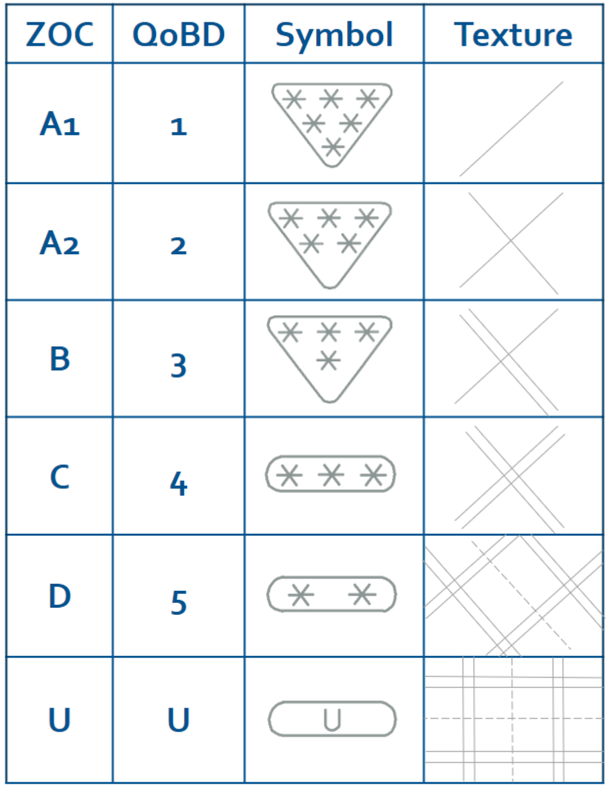

0
2.5
5
10 Kilometers
76°55'0"W
76°50'0"W
76°45'0"W
76°40'0"W
76°35'0"W
34°40'0"N
34°35'0"N
34°30'0"N
34°25'0"N

Results

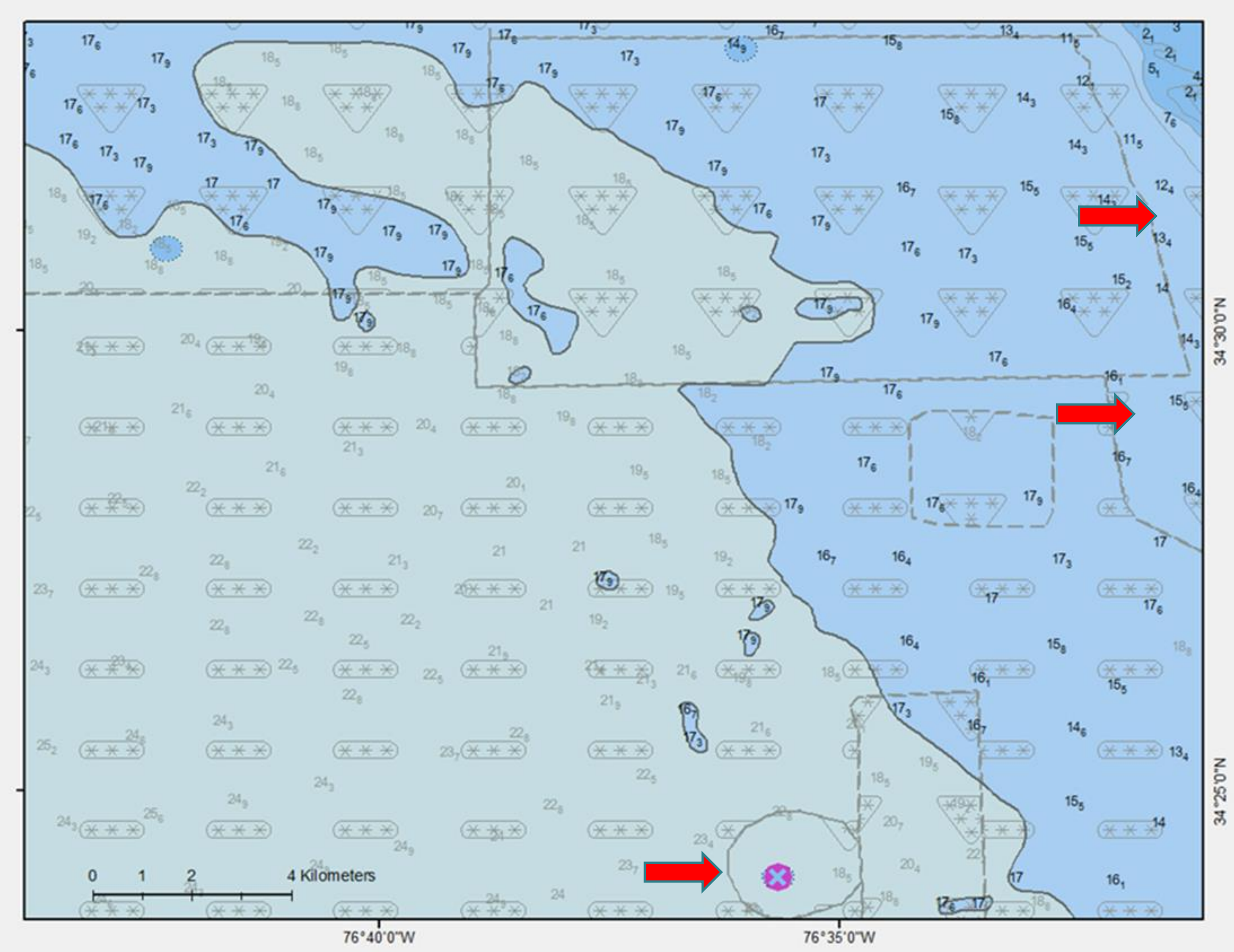
ZOC	QoBD	Symbol	Texture
A1	1		
A2	2		
B	3		
C	4		
D	5		
U	U		


0 1 2 4 Kilometers
76°40'0"W
76°35'0"W
34°30'0"N
34°25'0"N

RESULTS

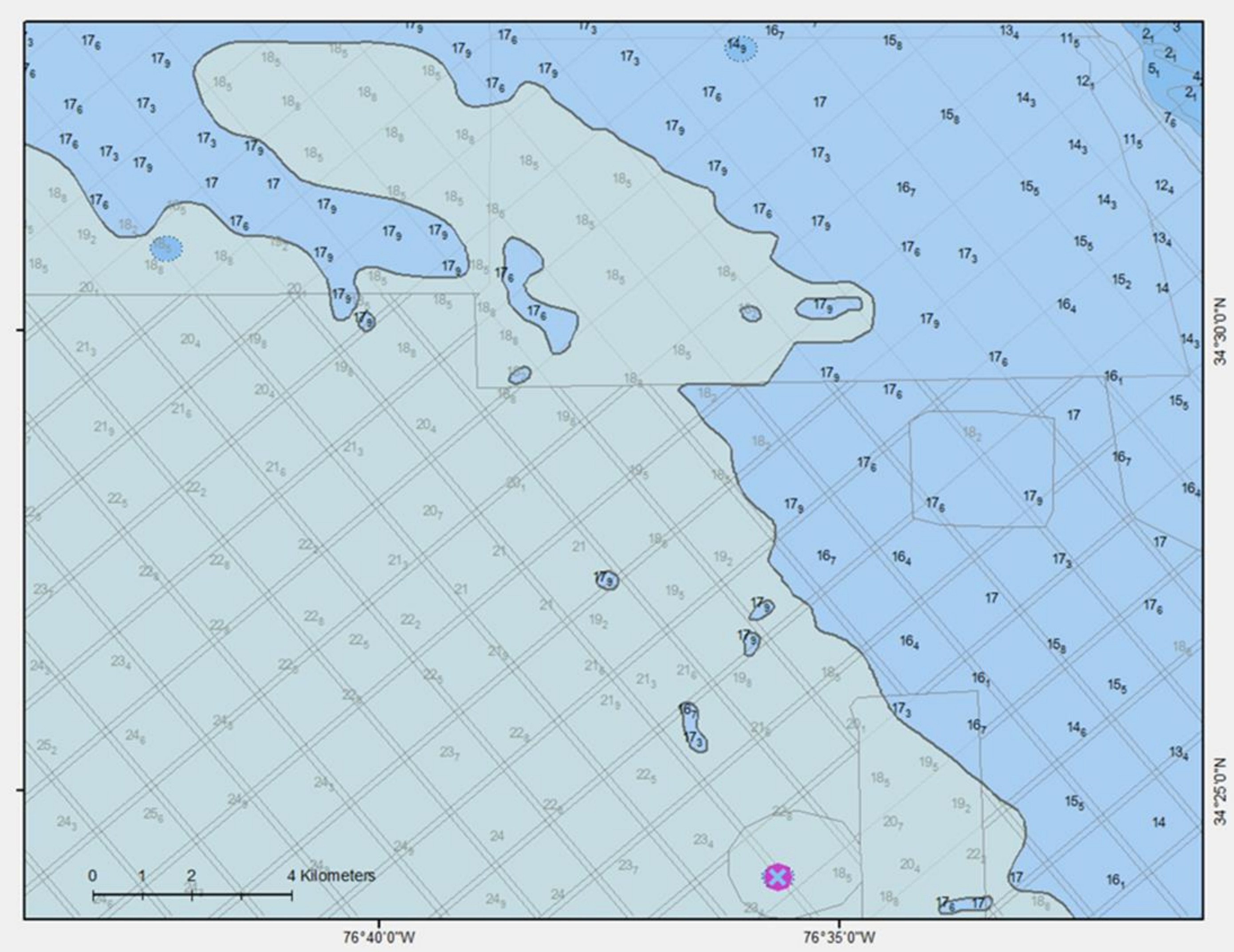


ZOC	QoBD	Symbol	Texture
A1	1		
A2	2		
B	3		
C	4		
D	5		
U	U	U	

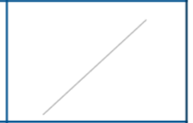
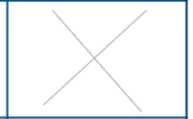
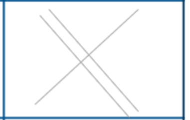
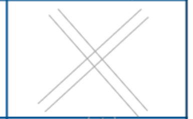
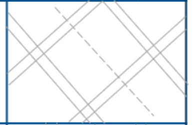
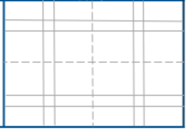

0
1
2
4 Kilometers
76°40'0"W
76°35'0"W
34°30'0"N
34°25'0"N

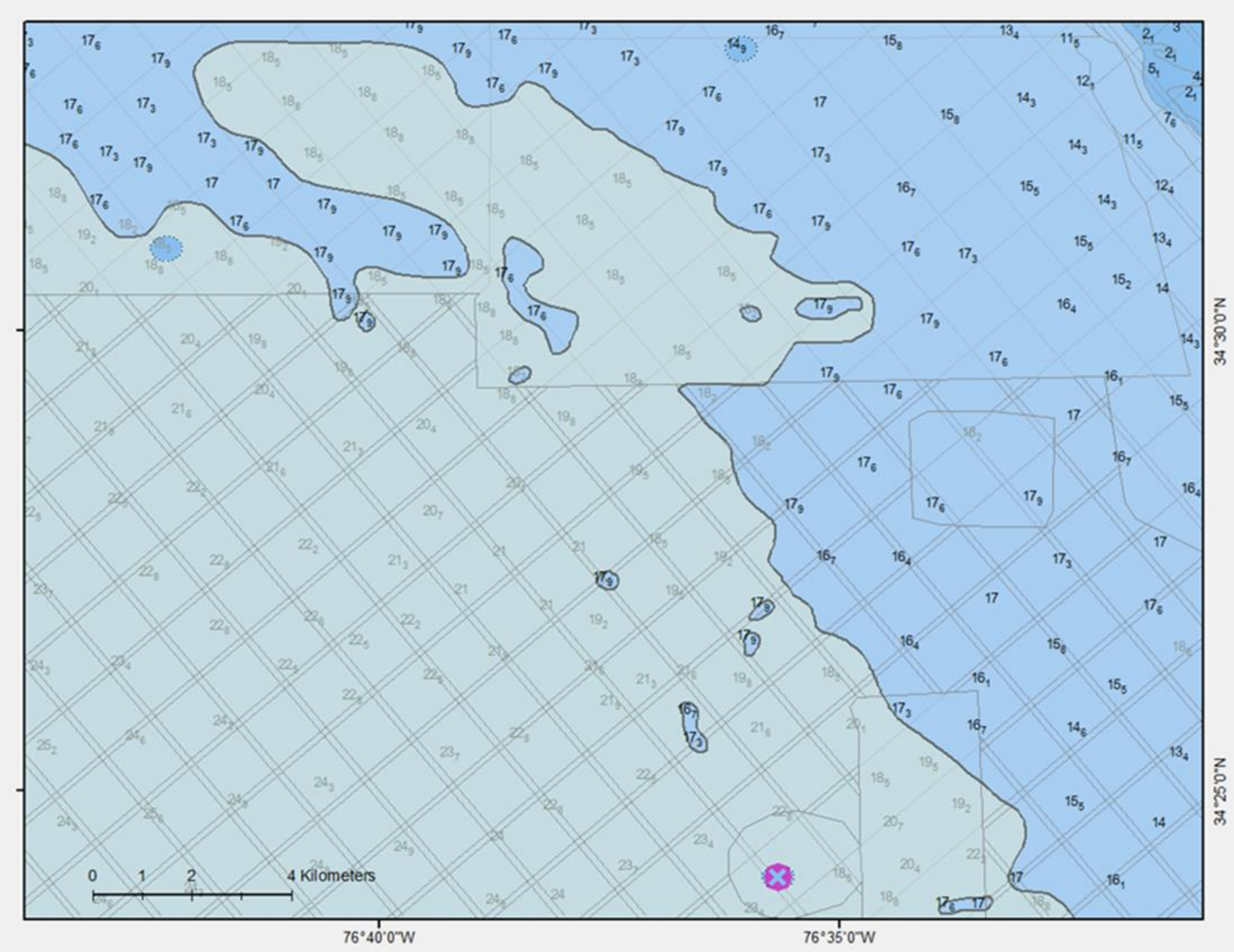
RESULTS

ZOC	QoBD	Symbol	Texture
A1	1	✳✳✳✳✳✳	▨
A2	2	✳✳✳✳✳	▨
B	3	✳✳✳✳	▨
C	4	✳✳✳	▨
D	5	✳✳	▨
U	U	U	▨

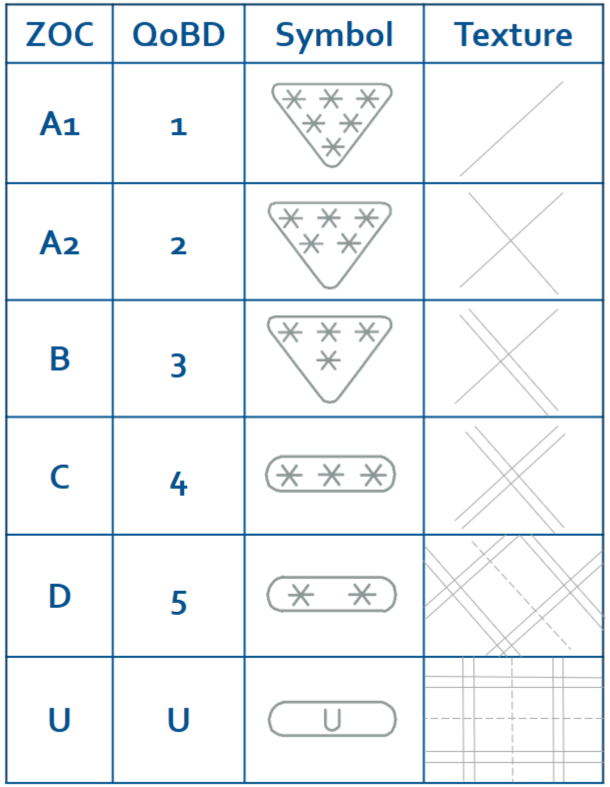

0
1
2
4 Kilometers
76°40'0"W
76°35'0"W
34°30'0"N
34°25'0"N

RESULTS

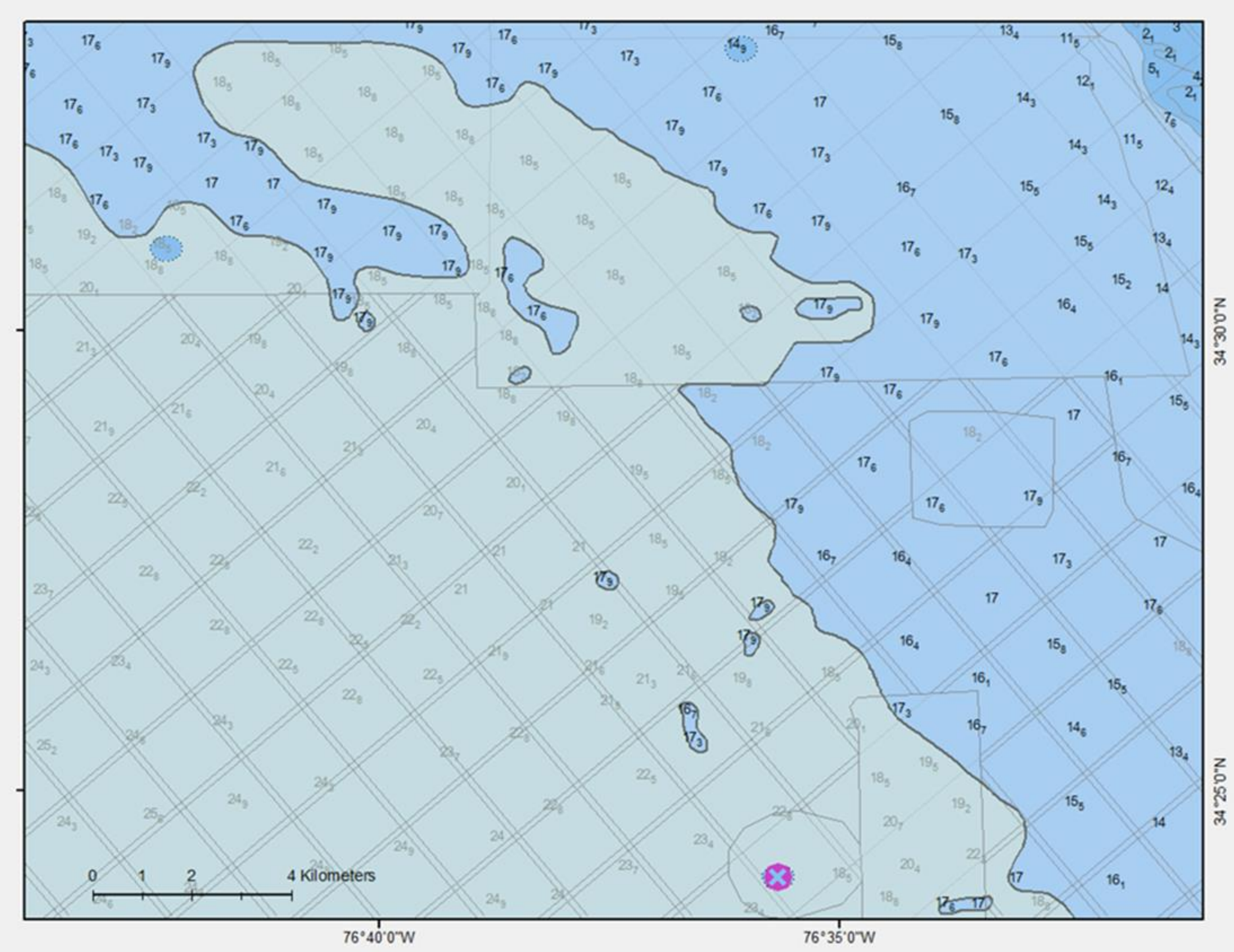
ZOC	QoBD	Symbol	Texture
A1	1	✳✳✳✳✳✳	
A2	2	✳✳✳✳✳	
B	3	✳✳✳✳	
C	4	✳✳✳	
D	5	✳✳	
U	U	U	


0
1
2
4 Kilometers
76°40'0"W
76°35'0"W
34°30'0"N
34°25'0"N

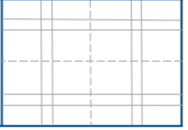
RESULTS

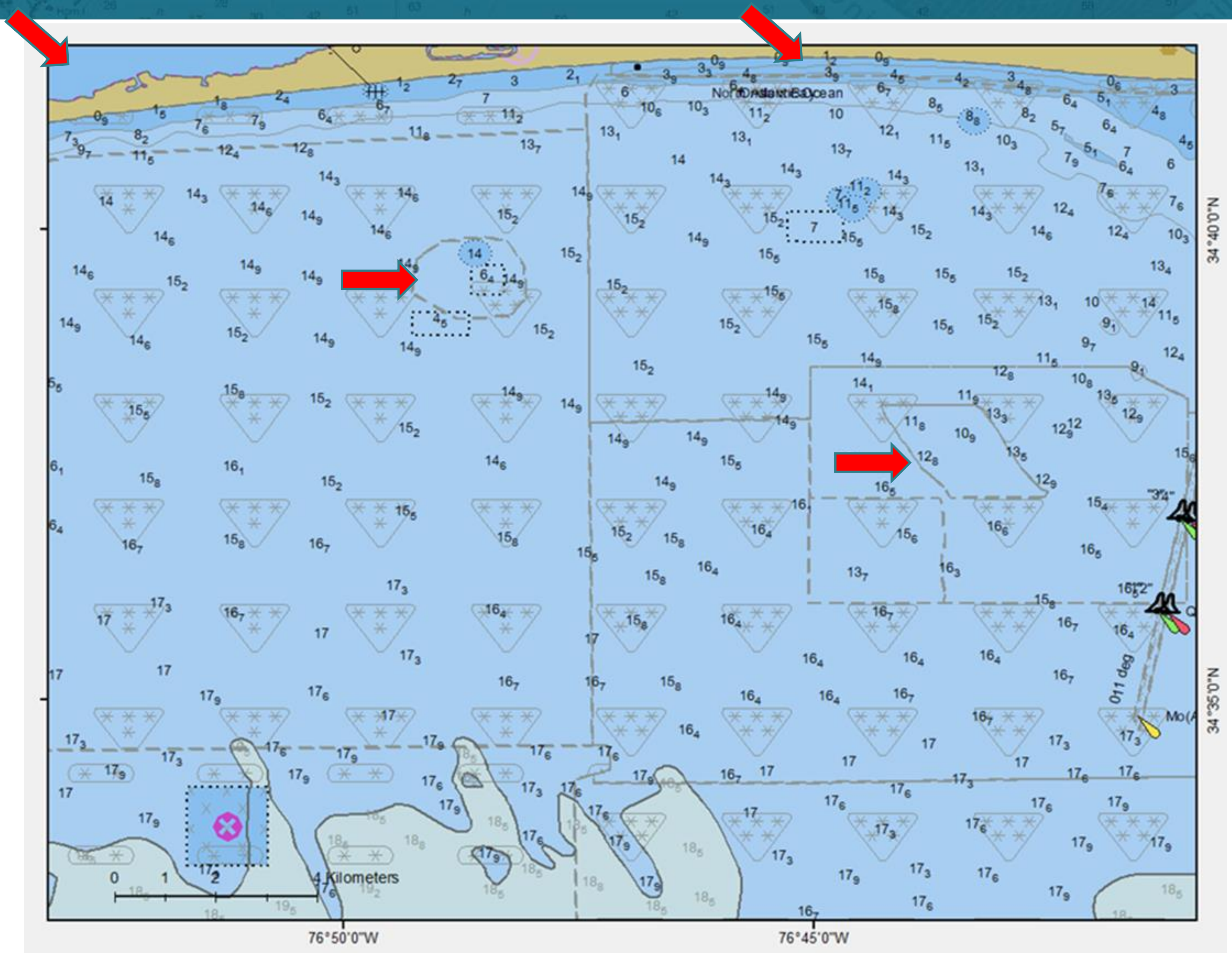


ZOC	QoBD	Symbol	Texture
A1	1	✳✳✳ ✳✳ ✳	╱
A2	2	✳✳✳ ✳✳	╳
B	3	✳✳✳ ✳	╳
C	4	✳✳✳	╳
D	5	✳ ✳	▨
U	U	U	▦

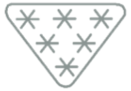
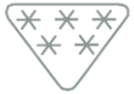
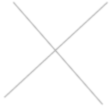
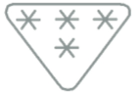
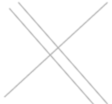
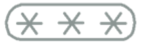
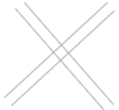
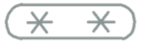
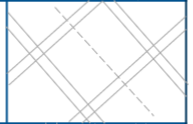
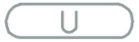
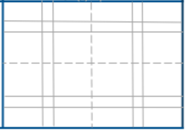

0
1
2
4 Kilometers
76°40'0"W
76°35'0"W
34°30'0"N
34°25'0"N

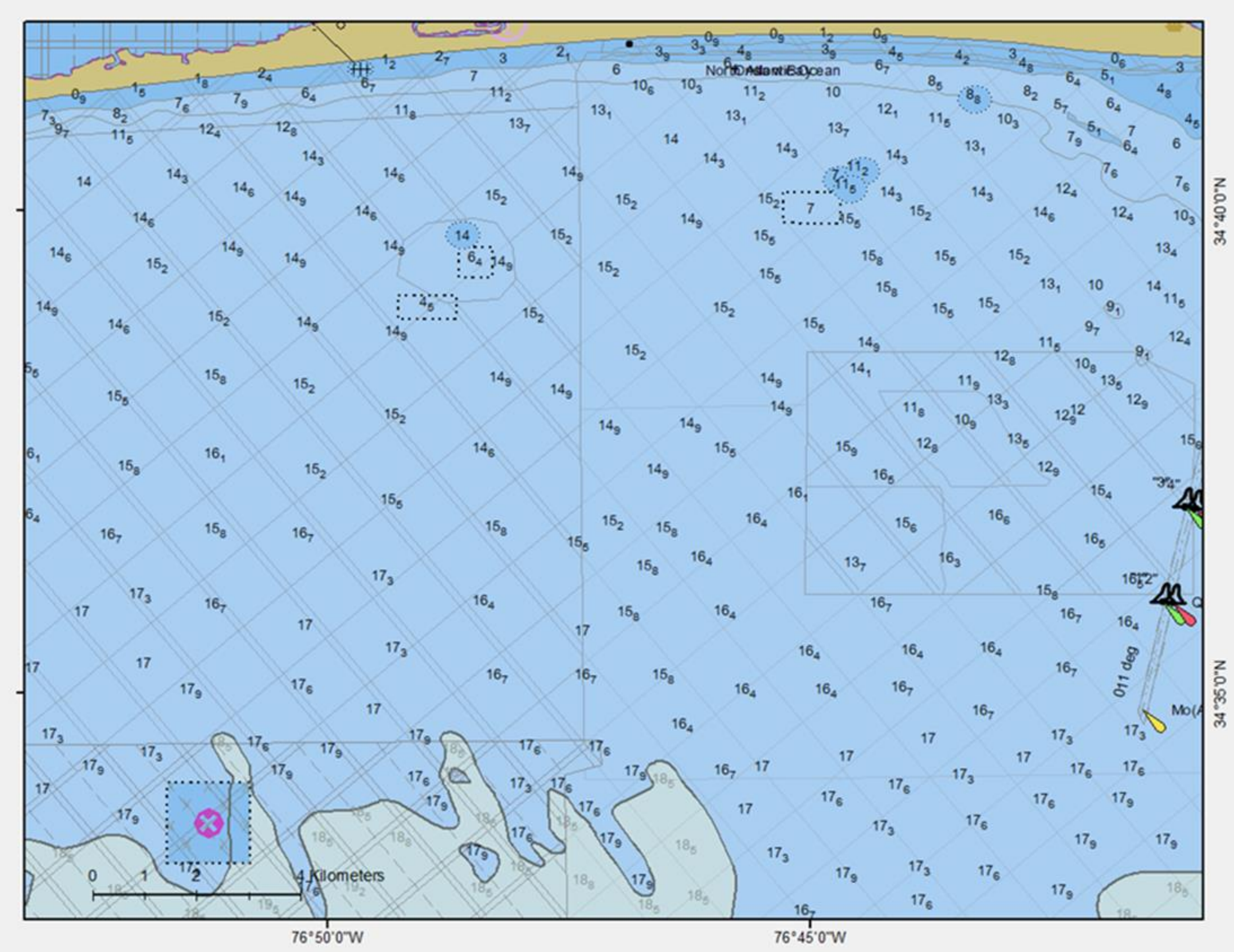
RESULTS

ZOC	QoBD	Symbol	Texture
A1	1	* * * * * *	
A2	2	* * * * *	
B	3	* * * *	
C	4	* * *	
D	5	* *	
U	U	U	

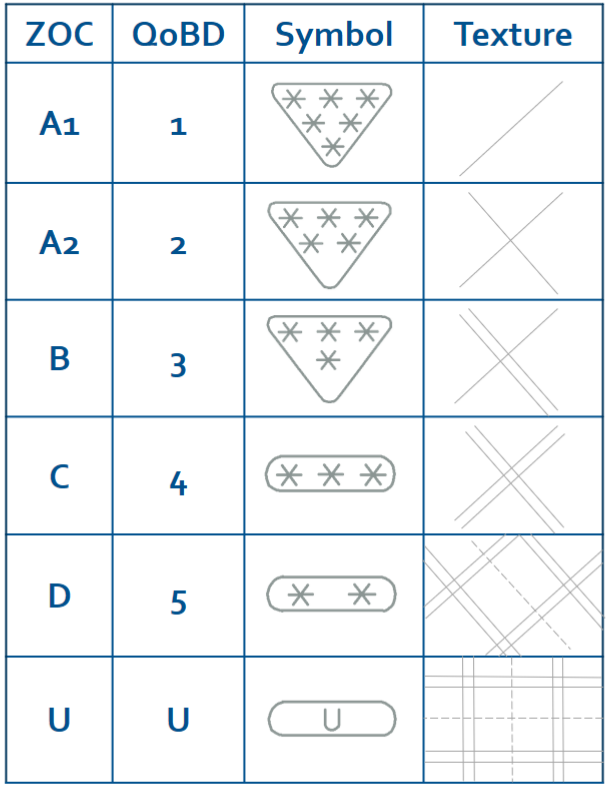

North Atlantic Ocean
0
1
4 Kilometers
76°50'0"W
76°45'0"W
34°40'0"N
34°35'0"N
011 deg

RESULTS

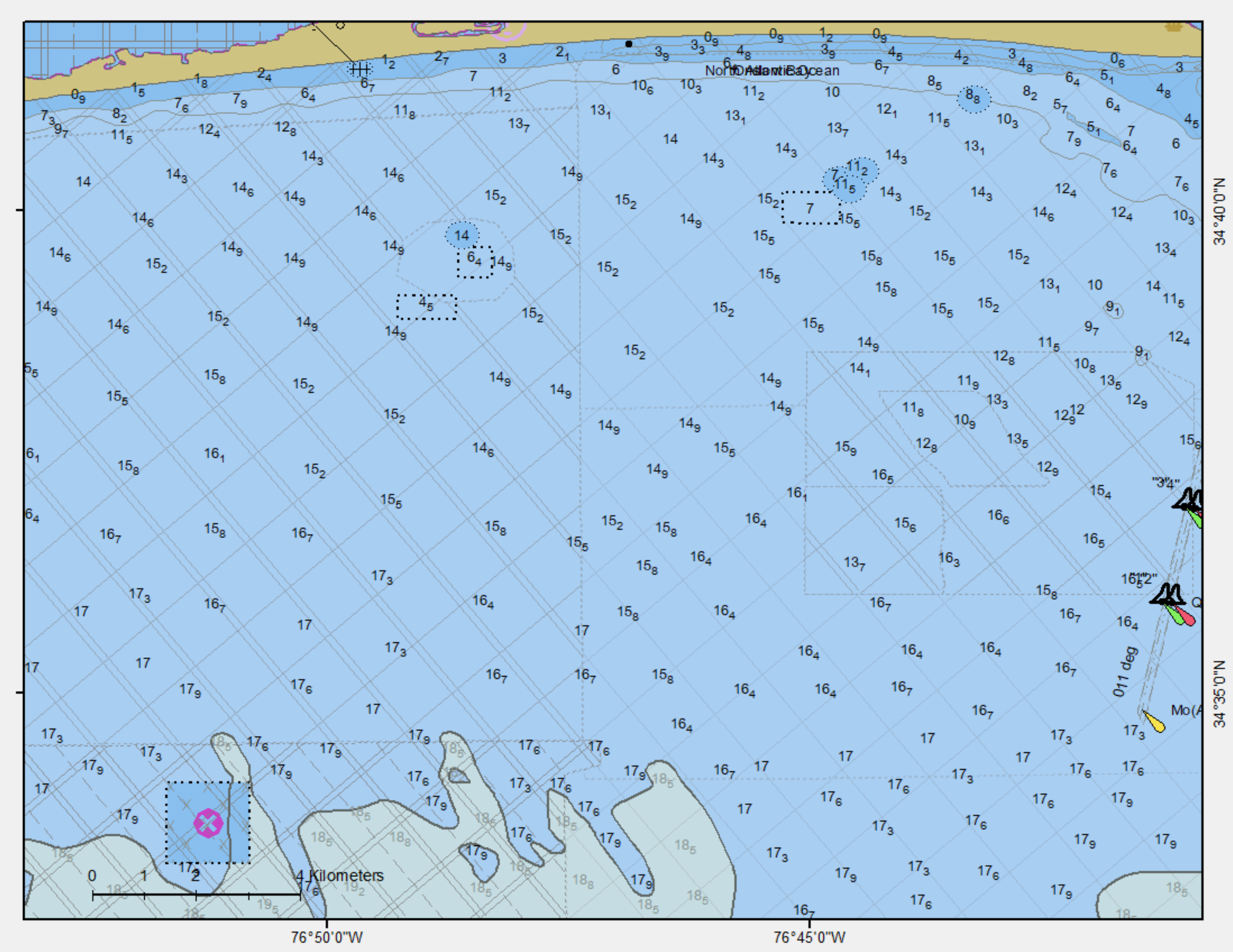
ZOC	QoBD	Symbol	Texture
A1	1		
A2	2		
B	3		
C	4		
D	5		
U	U		


North Atlantic Ocean
0
1
2
4 Kilometers
76°50'0"W
76°45'0"W
34°40'0"N
34°35'0"N
011 deg

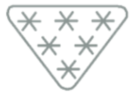
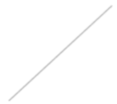
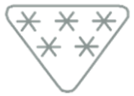
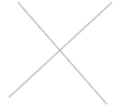
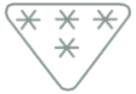
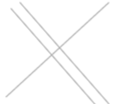
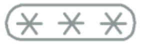
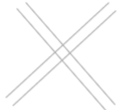
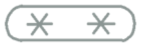
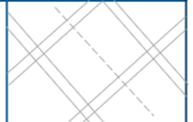
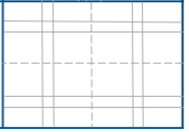
RESULTS

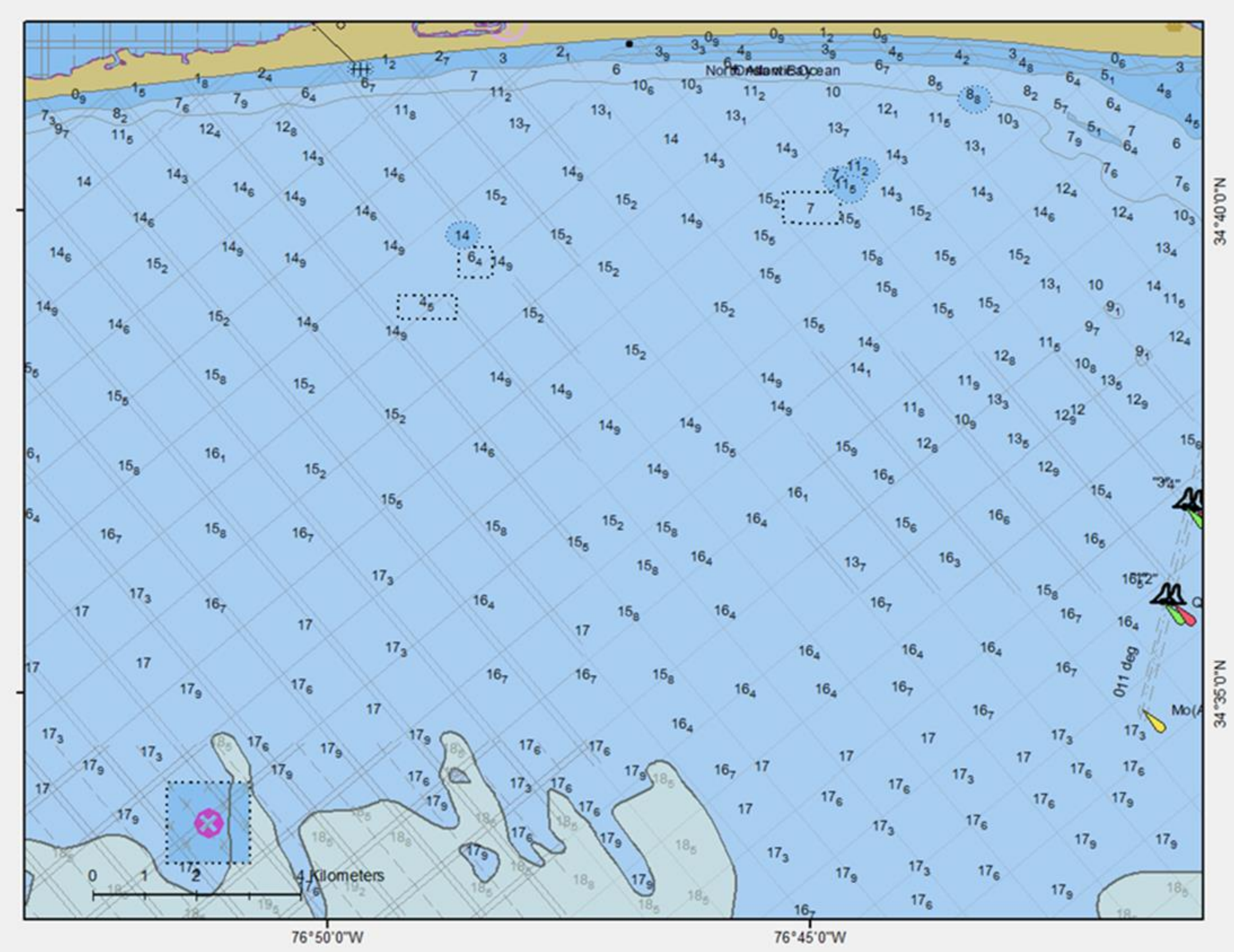


ZOC	QoBD	Symbol	Texture
A1	1	✳✳✳ ✳✳ ✳	
A2	2	✳✳✳ ✳✳	
B	3	✳✳✳ ✳	
C	4	✳✳✳	
D	5	✳ ✳	
U	U	U	


North Atlantic Ocean
0
1
2
4 Kilometers
76°50'0"W
76°45'0"W
34°40'0"N
34°35'0"N
011 deg

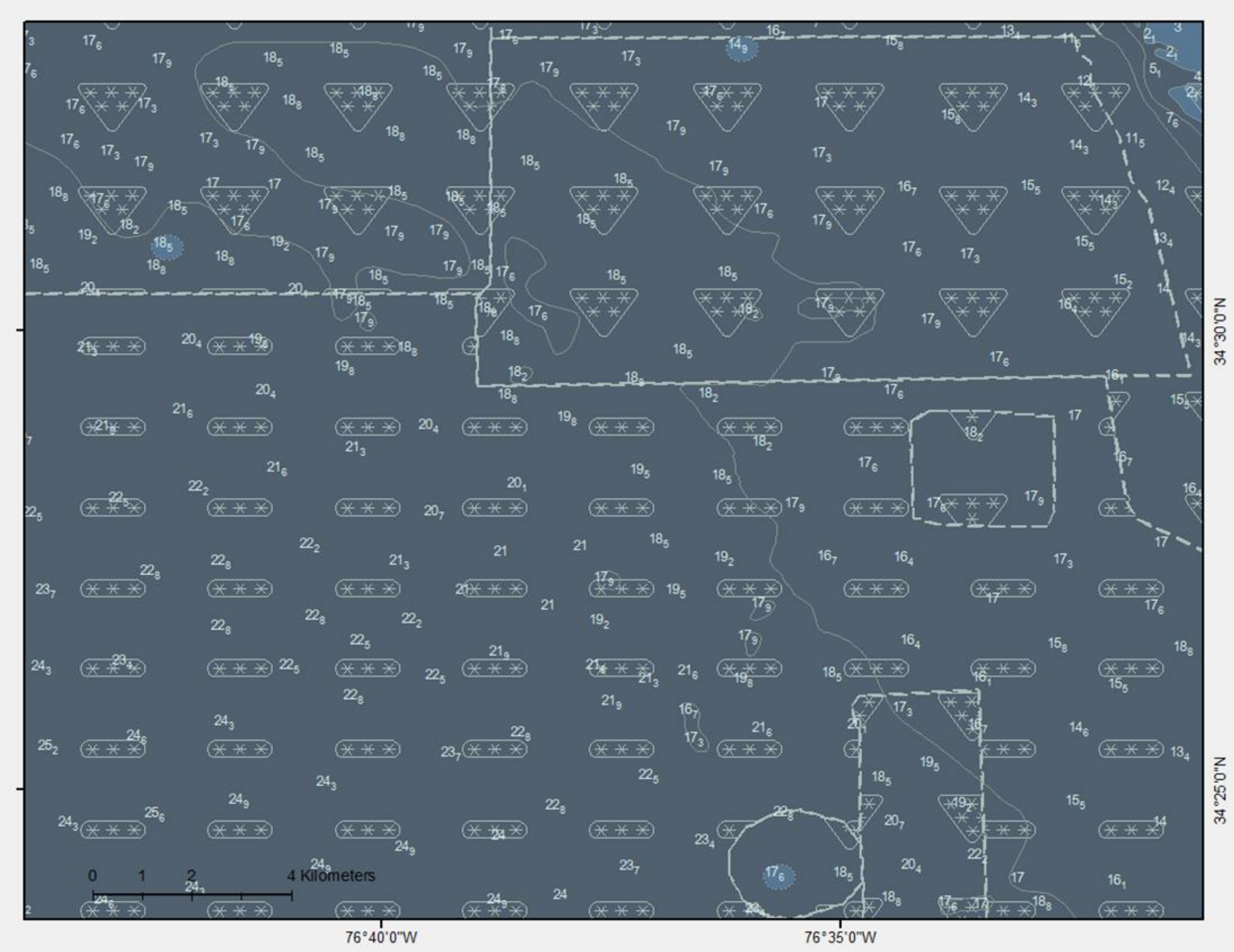
RESULTS

ZOC	QoBD	Symbol	Texture
A1	1		
A2	2		
B	3		
C	4		
D	5		
U	U		

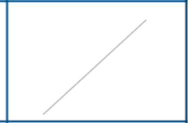
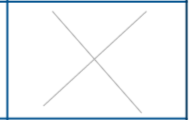
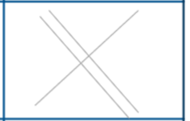
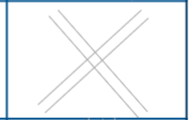
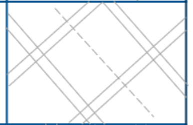
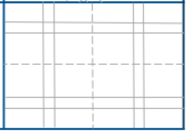

North Atlantic Ocean
0
1
2
4 Kilometers
011 deg
34°40'0"N
34°35'0"N
76°50'0"W
76°45'0"W

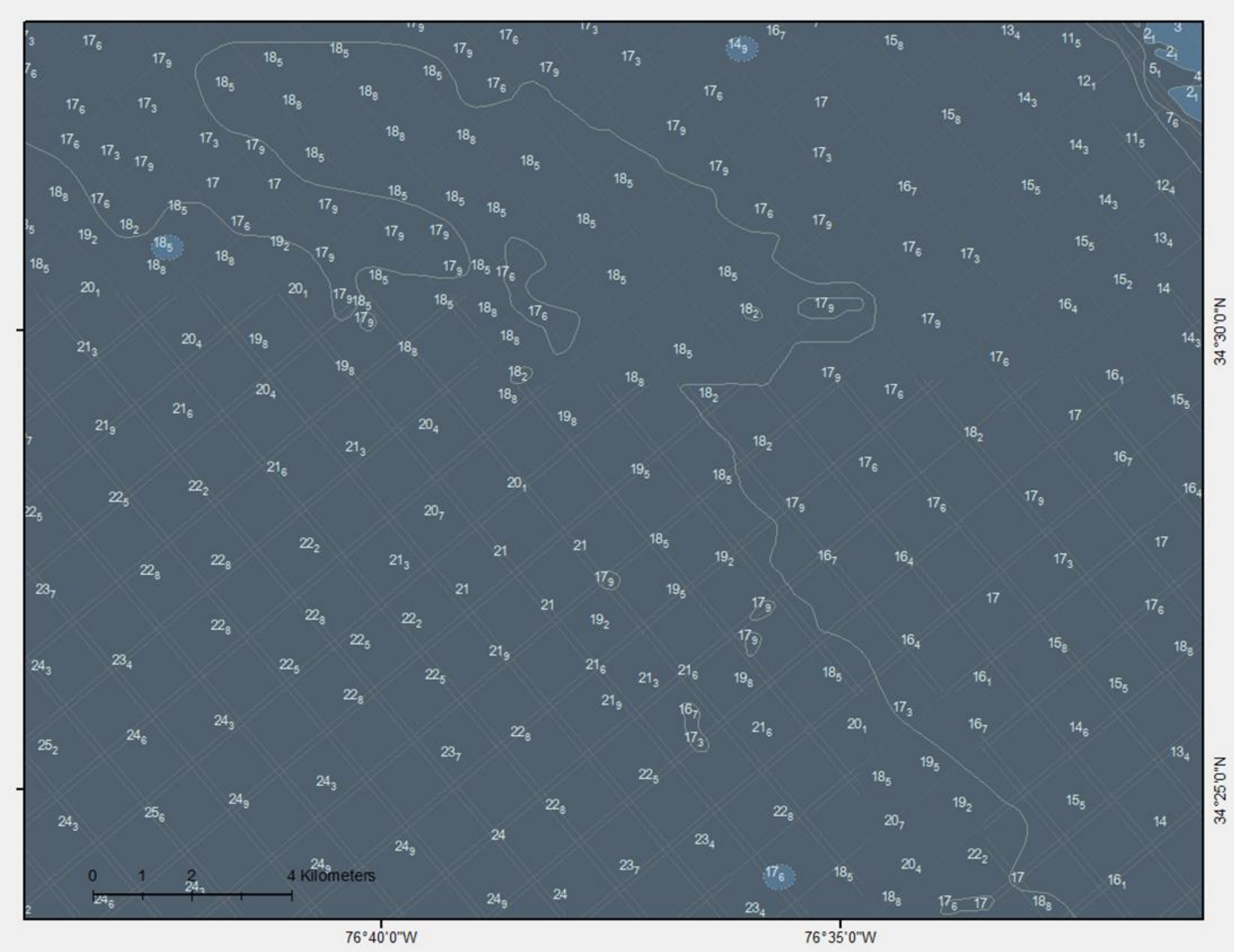
RESULTS

ZOC	QoBD	Symbol	Texture
A1	1	✳ ✳ ✳ ✳ ✳ ✳	╱
A2	2	✳ ✳ ✳ ✳ ✳	╳
B	3	✳ ✳ ✳ ✳	╳
C	4	✳ ✳ ✳	╳
D	5	✳ ✳	╳
U	U	U	╬


0
1
2
4 Kilometers
76°40'0"W
76°35'0"W
34°30'0"N
34°25'0"N

RESULTS

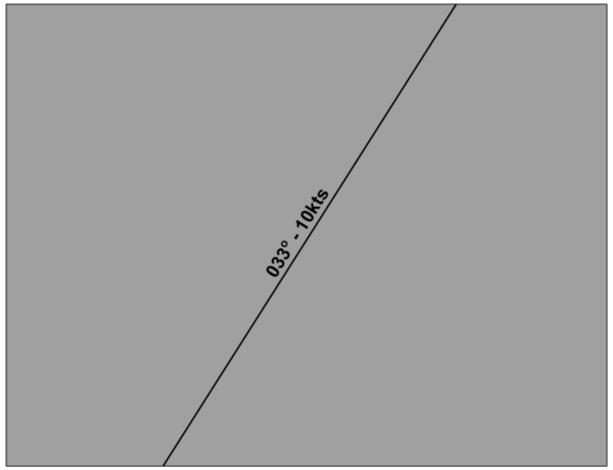
ZOC	QoBD	Symbol	Texture
A1	1	✳✳✳ ✳✳ ✳	
A2	2	✳✳✳ ✳✳	
B	3	✳✳✳ ✳	
C	4	✳✳✳	
D	5	✳ ✳	
U	U	U	

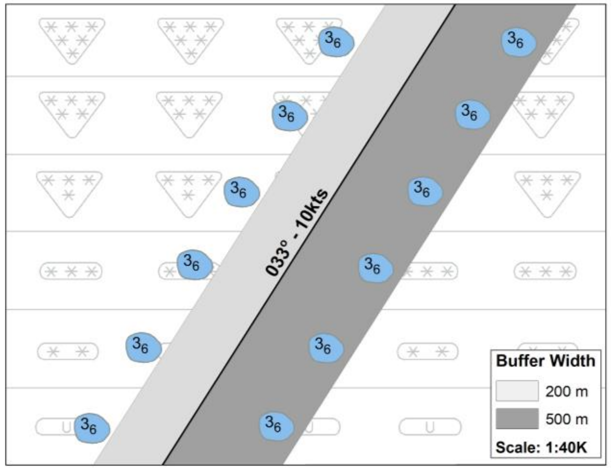

0
1
2
4 Kilometers
76°40'0"W
76°35'0"W
34°30'0"N
34°25'0"N

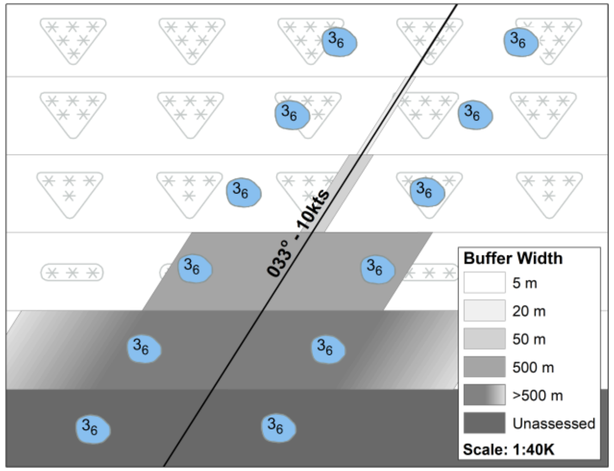
VISUALIZATION EXTENT

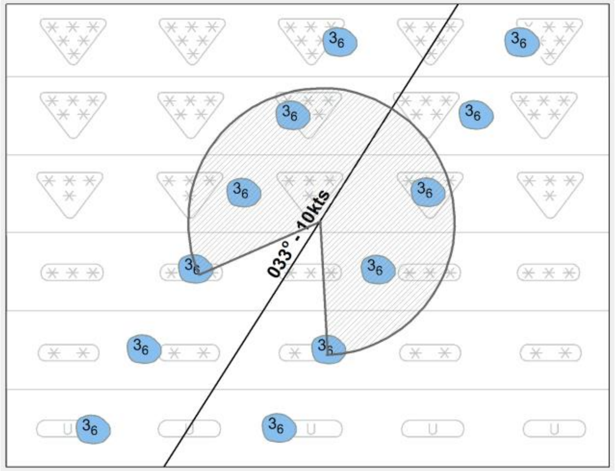
Four step integration in ECDIS:

- Overview
- Safety Zone
- Safe Course
- Watch Area




3_6
033° - 10kts
Buffer Width
200 m
500 m
Scale: 1:40K


3_6
033° - 10kts
Buffer Width
5 m
20 m
50 m
500 m
>500 m
Unassessed
Scale: 1:40K

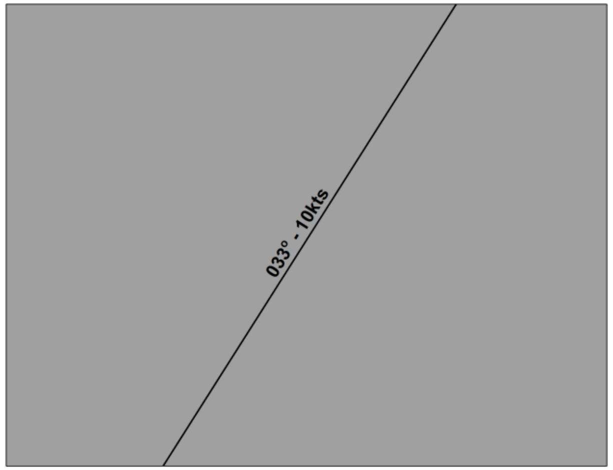

3_6
033° - 10kts

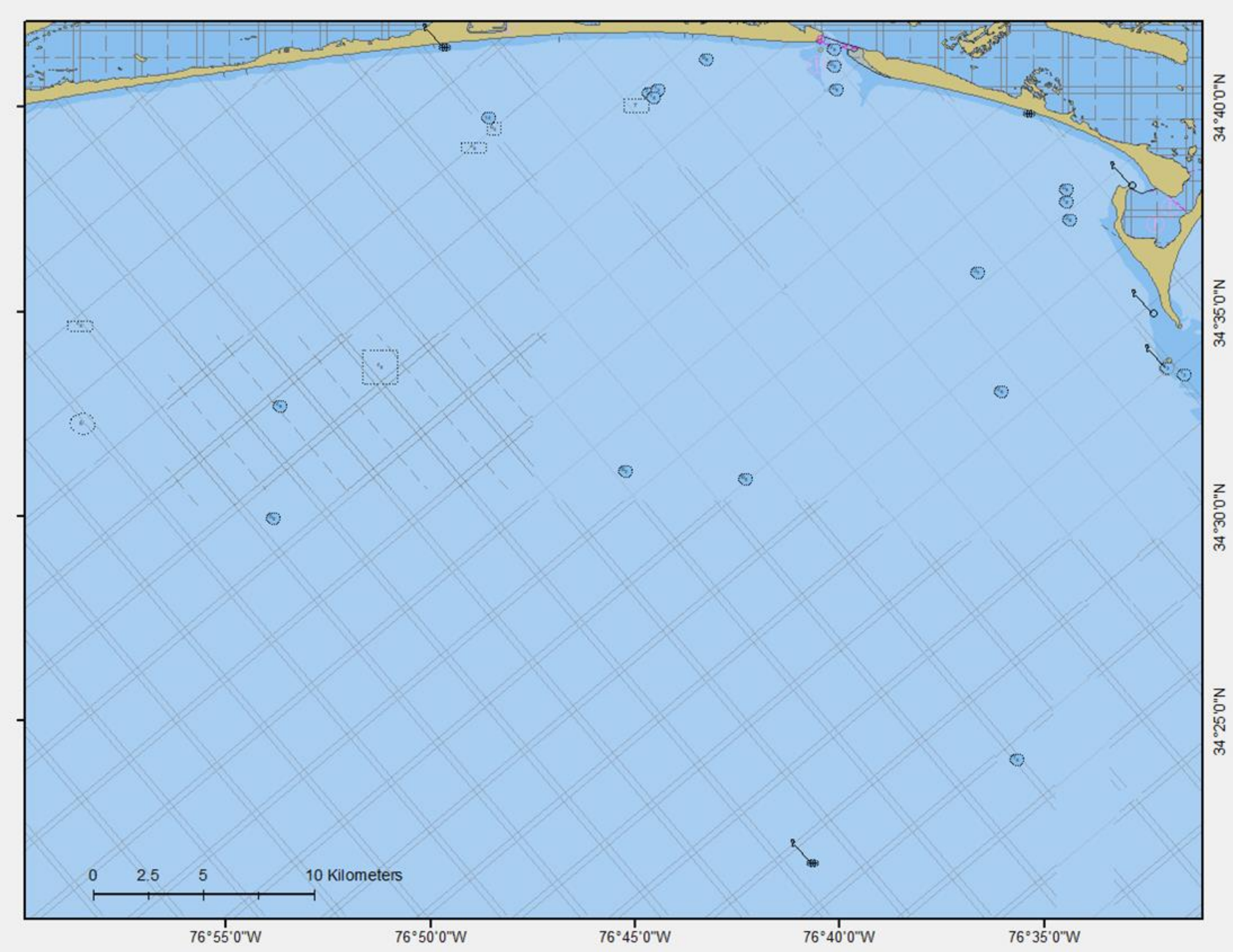
Kastrisios, C., Ware, C., Calder, B., Butkiewicz, T., Alexander, A. L., & Hauser, O. (2020). Nautical chart data uncertainty visualization as the means for integrating bathymetric, meteorological, and oceanographic information in support of coastal navigation. 100th American Meteorological Society Annual Meeting, 18th Symposium on the Coastal Environment, Boston, MA.

VISUALIZATION EXTENT

Four step integration in ECDIS:

- **Overview**
- Safety Zone
- Safe Course
- Watch Area

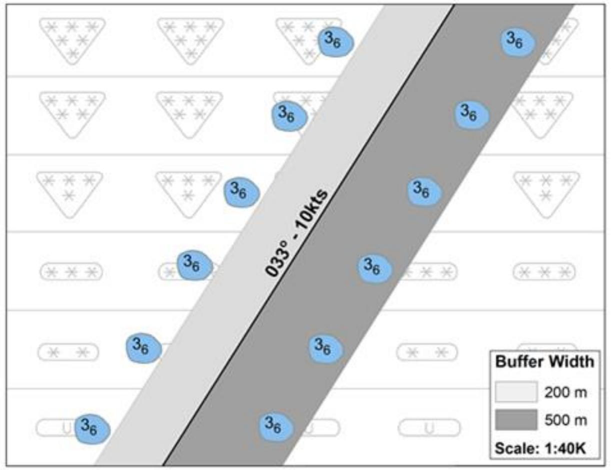


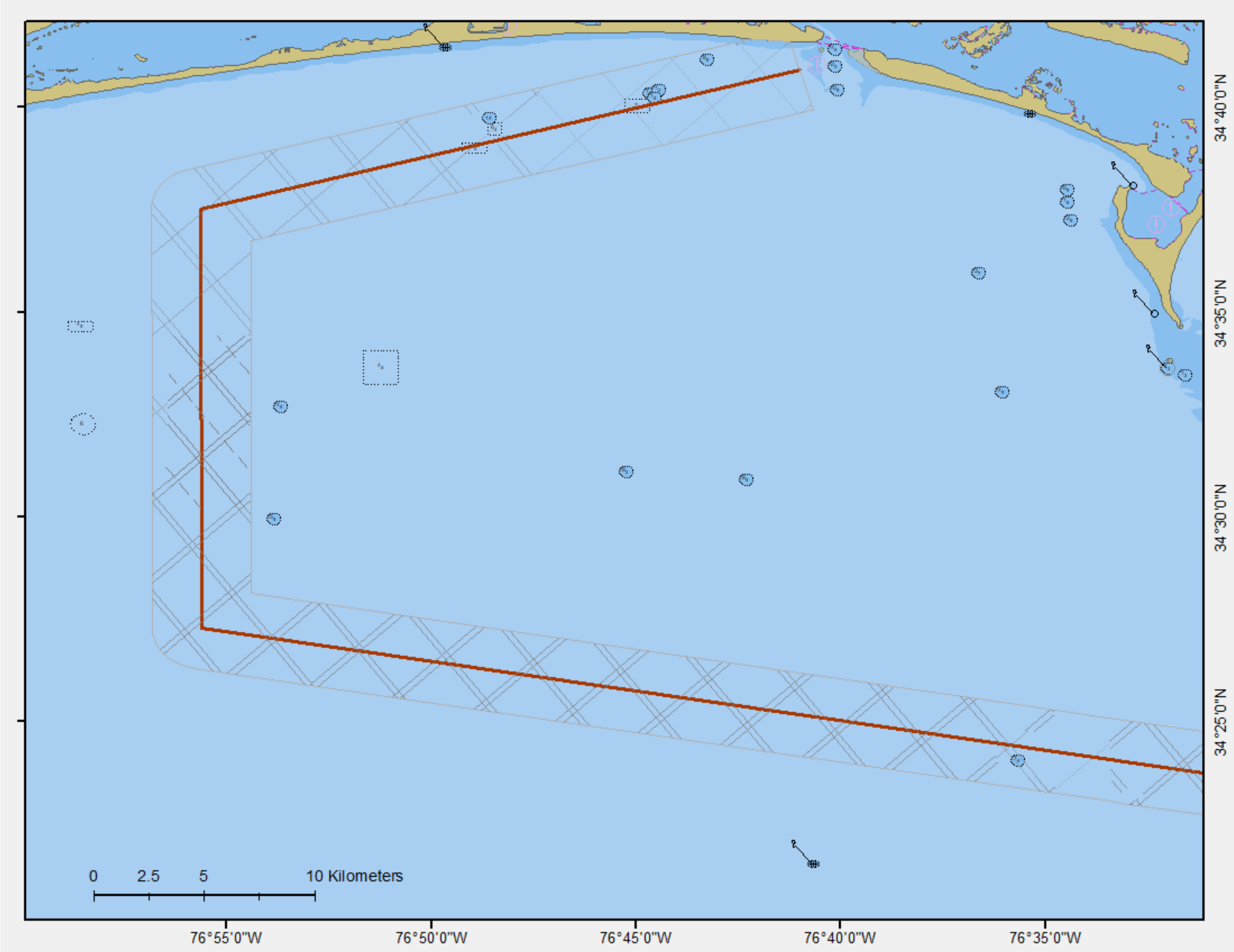

0
2.5
5
10 Kilometers
34°40'0"N
34°35'0"N
34°30'0"N
34°25'0"N
76°55'0"W
76°50'0"W
76°45'0"W
76°40'0"W
76°35'0"W

VISUALIZATION EXTENT

Four step integration in ECDIS:

- Overview
- **Safety Zone**
- Safe Course
- Watch Area

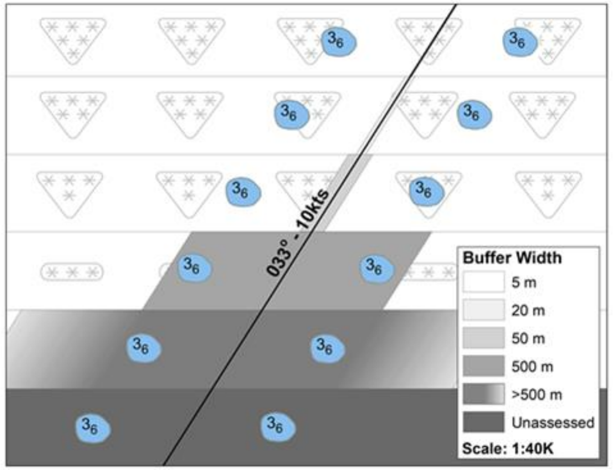

36
033° - 10kts
Buffer Width
200 m
500 m
Scale: 1:40K

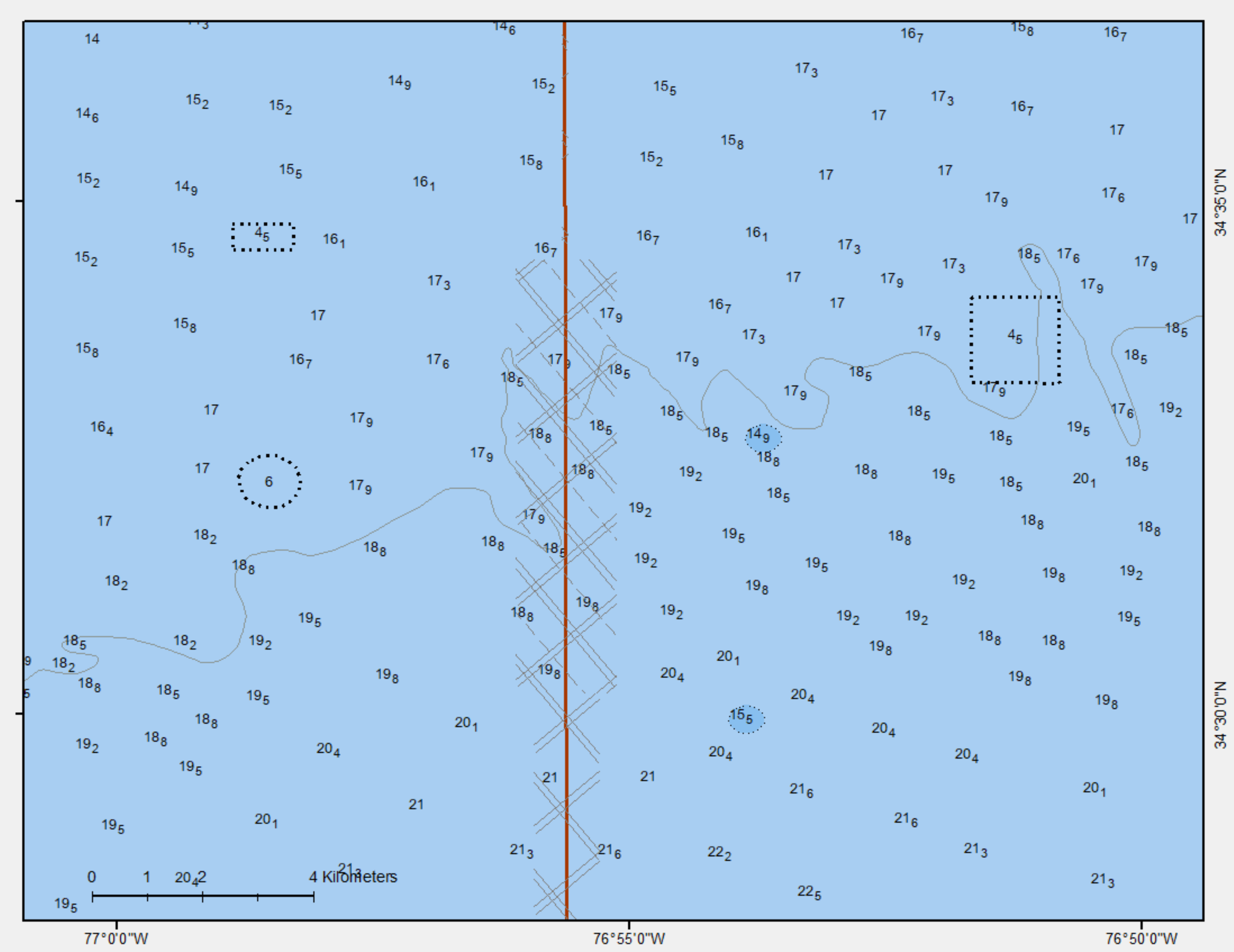

0
2.5
5
10 Kilometers
34°40'0"N
34°35'0"N
34°30'0"N
34°25'0"N
76°55'0"W
76°50'0"W
76°45'0"W
76°40'0"W
76°35'0"W

VISUALIZATION EXTENT

Four step integration in ECDIS:

- Overview
- Safety Zone
- **Safe Course**
- Watch Area

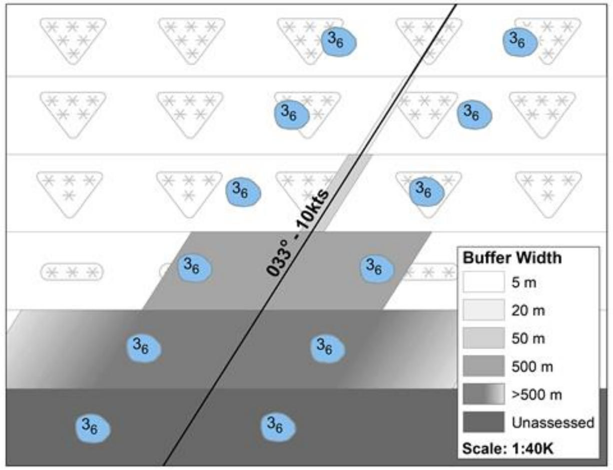

3₆
033° - 10kts
Buffer Width
5 m
20 m
50 m
500 m
>500 m
Unassessed
Scale: 1:40K

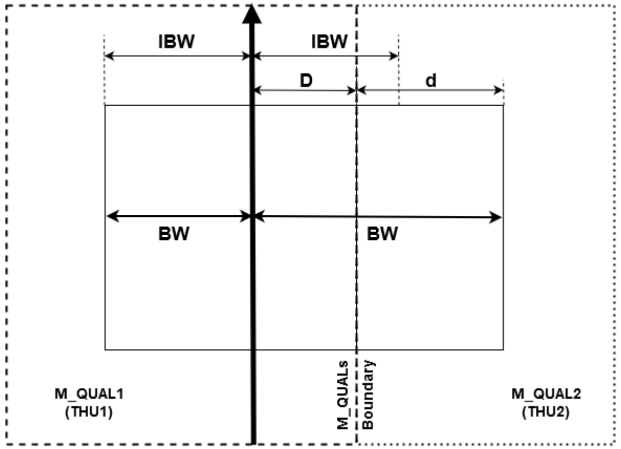

0
1
2
4 Kilometers
77°0'0"W
76°55'0"W
76°50'0"W
34°35'0"N
34°30'0"N

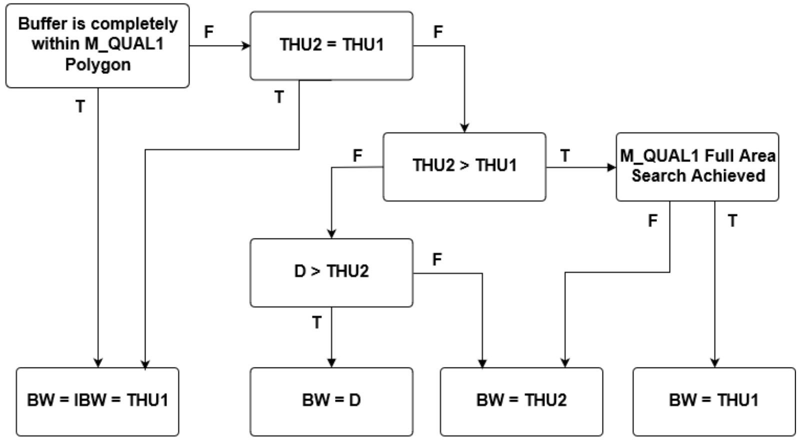
EXTENT

Decision tree

for Safe Course


033° - 10kts
Buffer Width
5 m
20 m
50 m
500 m
>500 m
Unassessed
Scale: 1:40K

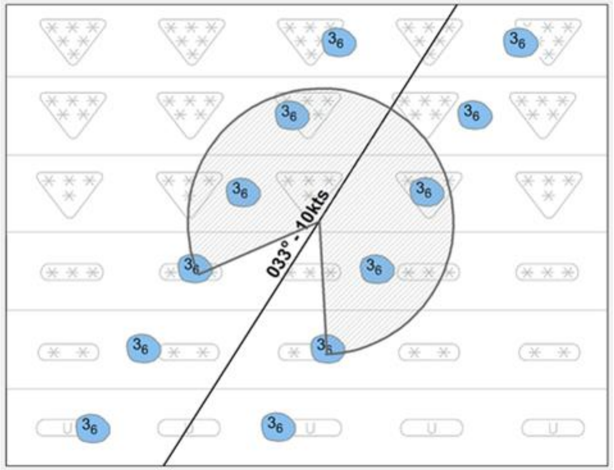

IBW
IBW
D
d
BW
BW
M_QUAL1
(THU1)
M_QUALs
Boundary
M_QUAL2
(THU2)

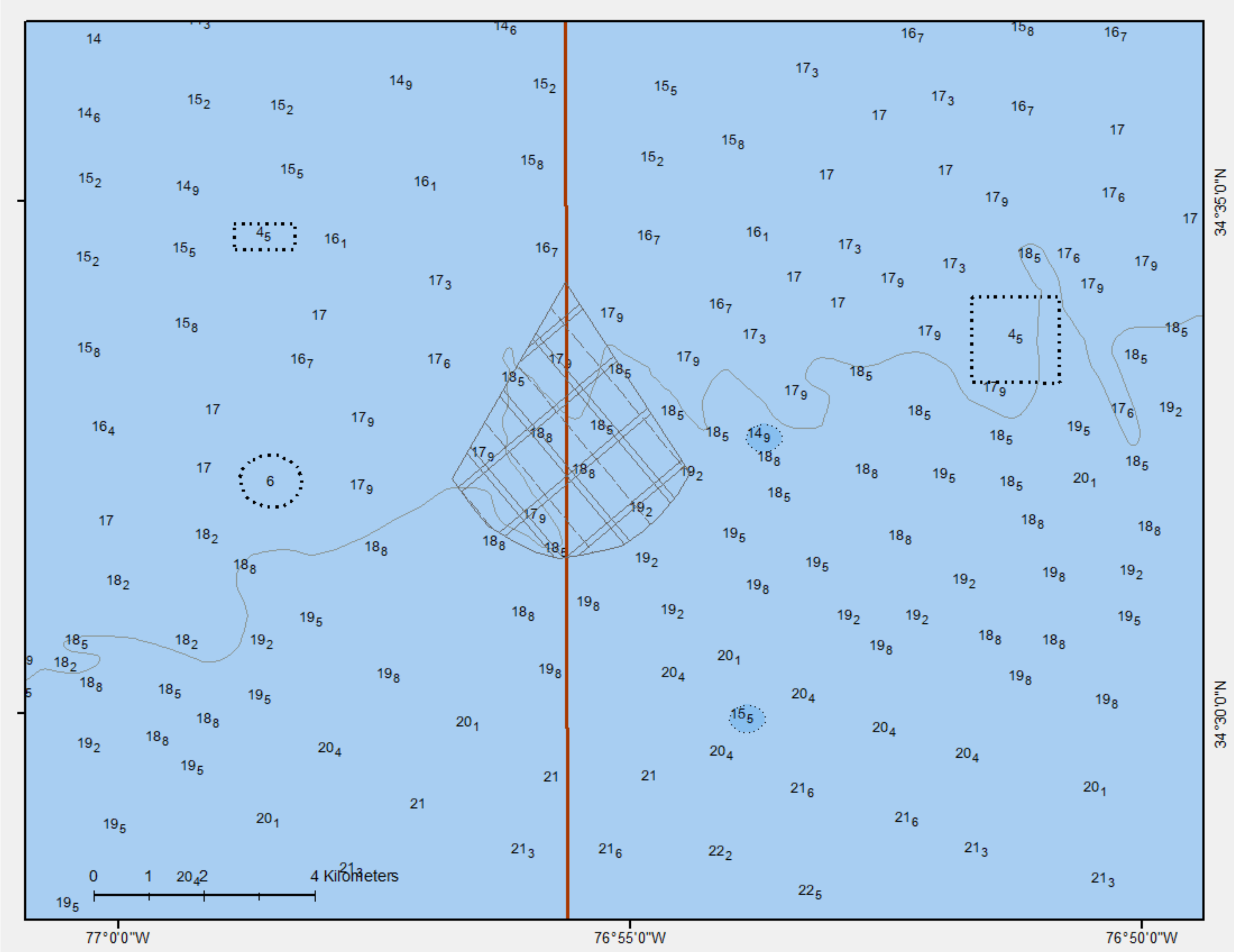

Buffer is completely within M_QUAL1 Polygon
F
T
THU2 = THU1
F
T
THU2 > THU1
F
T
M_QUAL1 Full Area Search Achieved
F
T
D > THU2
F
T
BW = IBW = THU1
BW = D
BW = THU2
BW = THU1

VISUALIZATION EXTENT

Four step integration in ECDIS:

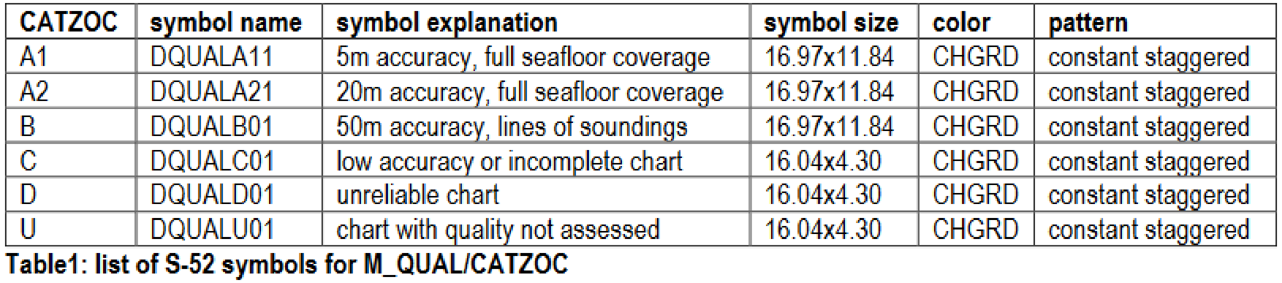
- Overview
- Safety Zone
- Safe Course
- **Watch Area**


033° - 10kts
36


0
1
2
4 Kilometers
77°0'0"W
76°55'0"W
76°50'0"W
34°35'0"N
34°30'0"N

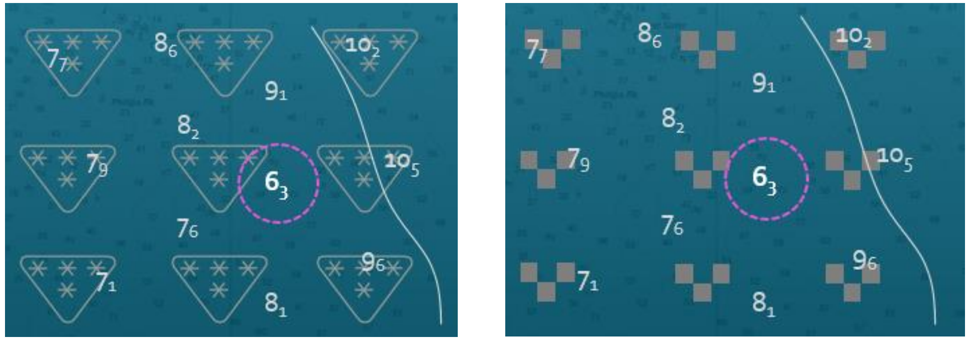
FUTURE WORK

- Investigate:
  - Spacing
  - Color
  - Line transparency
  - Line weight
  - Values for QoBD 5
- Seek feedback
- Develop SVGs

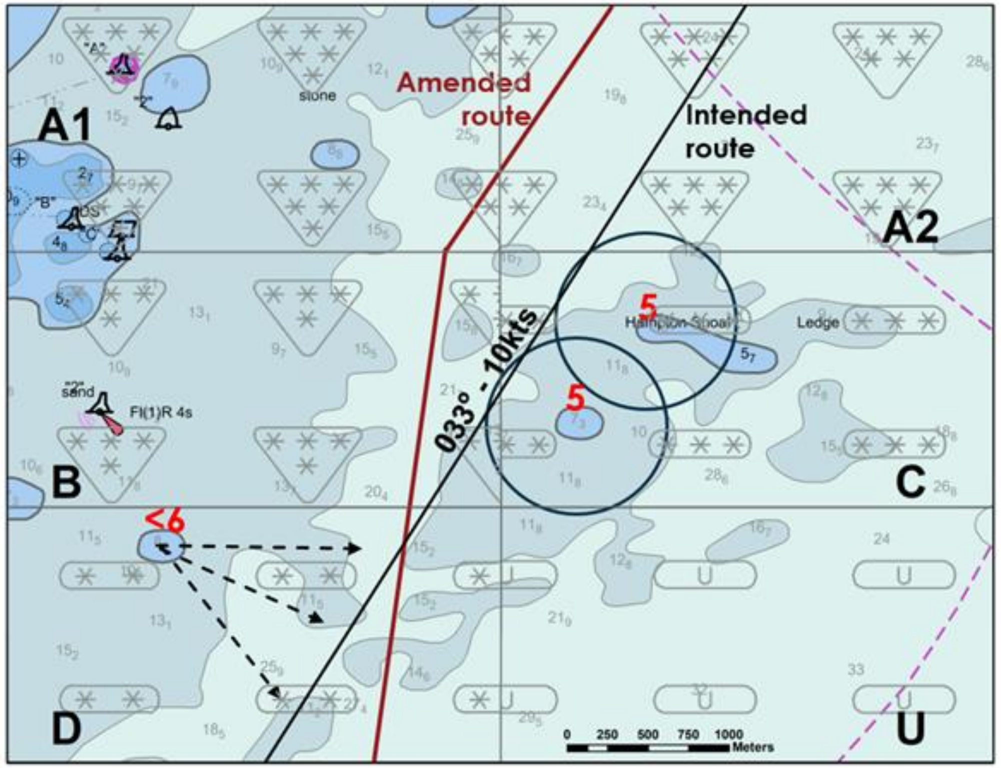


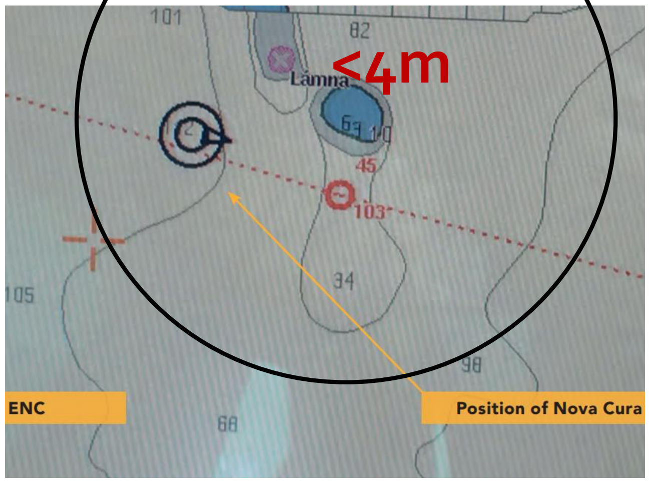
CATZOC	symbol name	symbol explanation	symbol size	color	pattern
A1	DQUALA11	5m accuracy, full seafloor coverage	16.97x11.84	CHGRD	constant staggered
A2	DQUALA21	20m accuracy, full seafloor coverage	16.97x11.84	CHGRD	constant staggered
B	DQUALB01	50m accuracy, lines of soundings	16.97x11.84	CHGRD	constant staggered
C	DQUALC01	low accuracy or incomplete chart	16.04x4.30	CHGRD	constant staggered
D	DQUALD01	unreliable chart	16.04x4.30	CHGRD	constant staggered
U	DQUALU01	chart with quality not assessed	16.04x4.30	CHGRD	constant staggered

Table1: list of S-52 symbols for M_QUAL/CATZOC



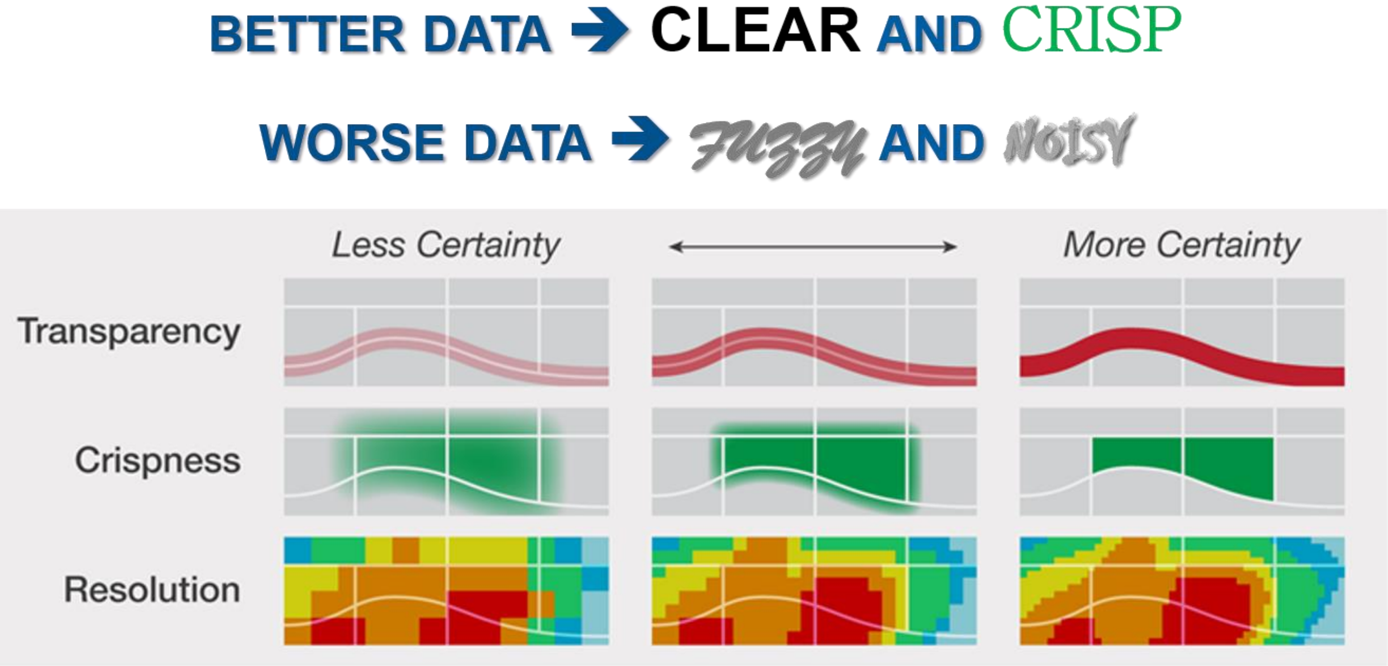
INDIVIDUAL FEATURES


A1
A2
B
C
D
U
stone
sand
Fl(1)R 4s
Amended route
Intended route
033° - 10kts
5
5
Hampton Shoal
Ledge
<6
0 250 500 750 1000 Meters


<4m
Lämna
101
82
45
103
105
34
98
68
ENC
Position of Nova Cura

UNCERTAINTY VISUALIZATION

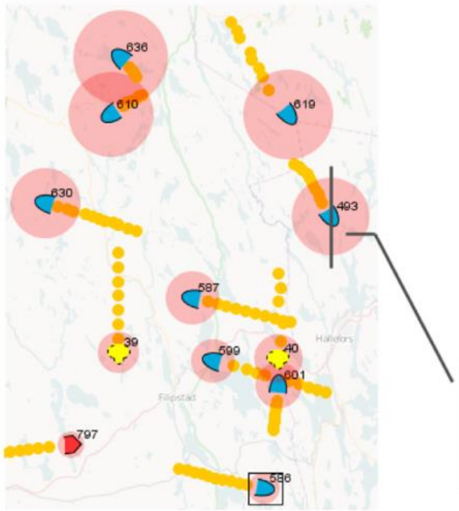
- Cartographic techniques:
  - Visual Variable
    - color value,
    - color saturation,
    - crispness
    - resolution,
    - texture,
    - location
  - Intrinsic / extrinsic

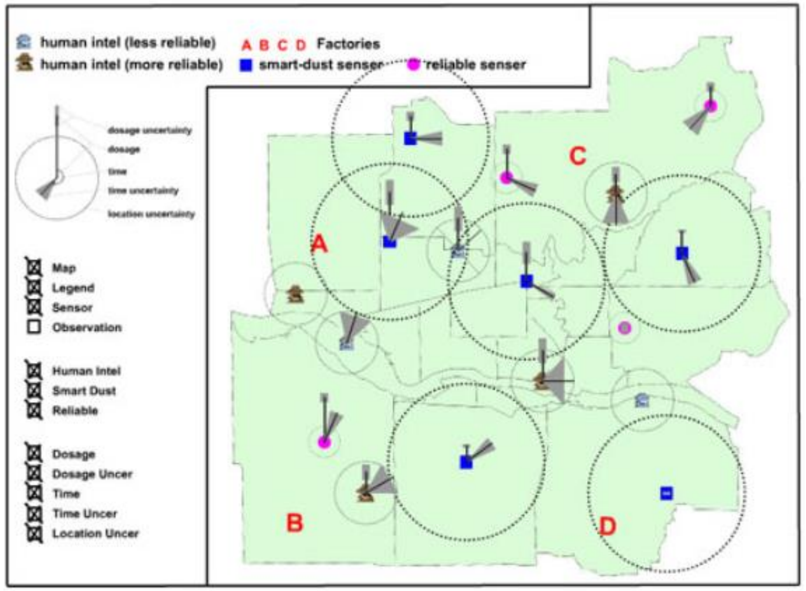

BETTER DATA → CLEAR AND CRISP
WORSE DATA → FUZZY AND NOISY
Less Certainty
More Certainty
Transparency
Crispness
Resolution

UCGIS (2020). CV-08- Symbolization and Visualization variables. University Consortium for Geographic Information Science. Accessed on Jan. 29, 2020 at https://gistbok.ucgis.org/bok-topics/symbolization-and-visual-variables.

UNCERTAINTY VISUALIZATION

- Cartographic techniques:
  - Visual Variable
    - color value,
    - color saturation,
    - crispness
    - resolution,
    - texture,
    - location
  - Intrinsic / extrinsic

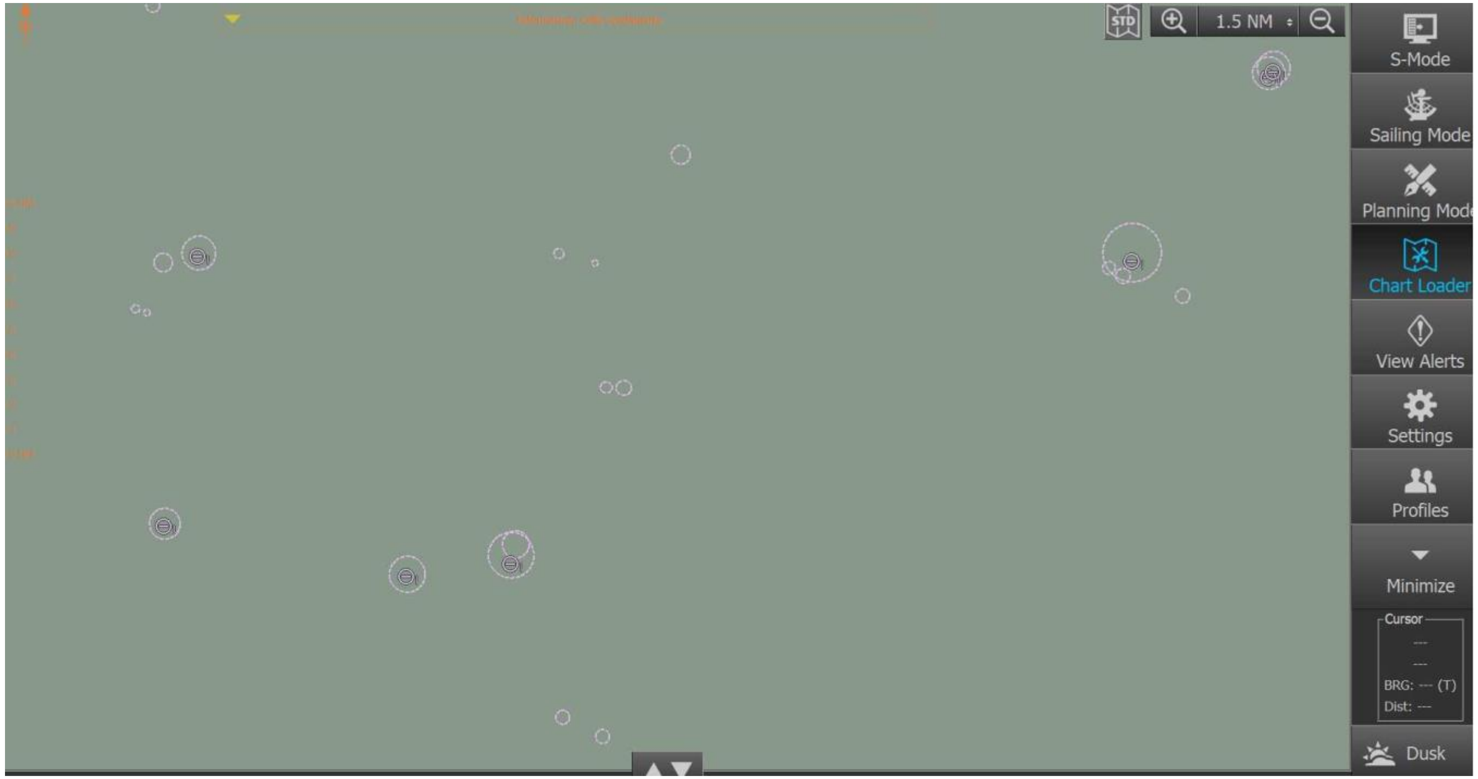

636
610
619
630
493
587
39
599
40
601
797
586

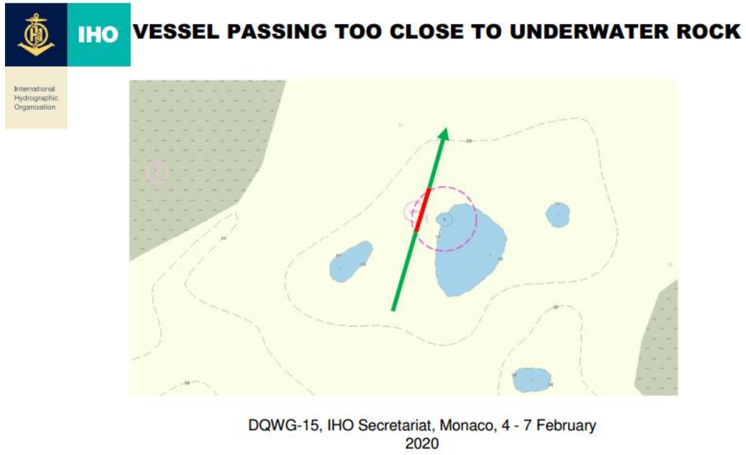

human intel (less reliable)
human intel (more reliable)
A B C D Factories
smart-dust senser
reliable senser
dosage uncertainty
dosage
time
time uncertainty
location uncertainty
☒ Map
☒ Legend
☒ Sensor
☐ Observation
☒ Human Intel
☒ Smart Dust
☒ Reliable
☒ Dosage
☒ Dosage Uncer
☒ Time
☒ Time Uncer
☒ Location Uncer
A
B
C
D

Uncertainty associated with position

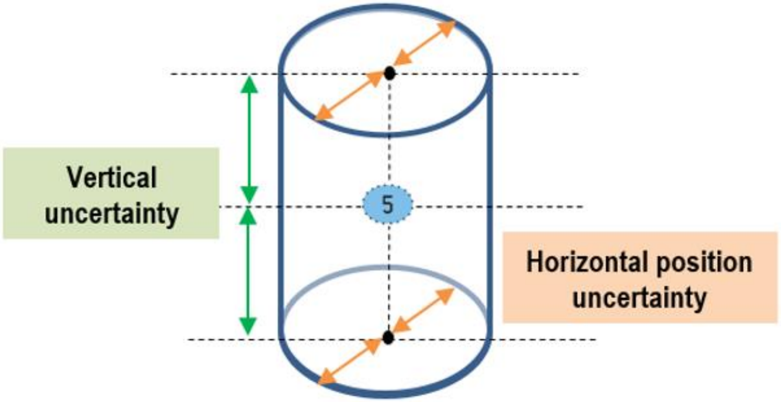
A. Gruver and J. Dutton. Visual Representations of Data Uncertainty. Available at https://courseware.e-education.psu.edu/courses/geog486/graphics/three-uncertainty.jpg
Riveiro et al.(2014) Effects of Visualizing Uncertainty on Decision-making in a Target Identification Scenario. Computers & Graphics. Elsevier. http://dx.doi.org/10.1016/j.cag.2014.02.006

RELEVANT WORK


STD
1.5 NM
S-Mode
Sailing Mode
Planning Mode
Chart Loader
View Alerts
Settings
Profiles
Minimize
Cursor
BRG: --- (T)
Dist: ---
Dusk


IHO VESSEL PASSING TOO CLOSE TO UNDERWATER ROCK

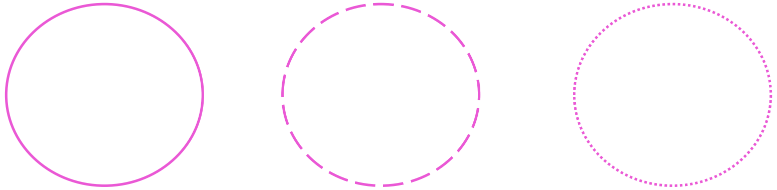
DQWG-15, IHO Secretariat, Monaco, 4 - 7 February 2020

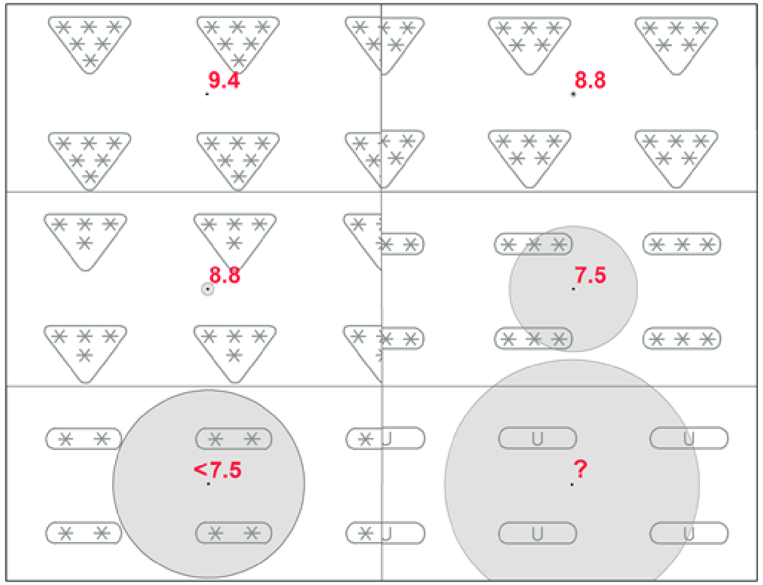

Vertical uncertainty
5
Horizontal position uncertainty

DQWG (2020) Using data quality for safe navigation. 15th meeting of the DQWG. 4-7 February 2020. Monaco.
DQWG (2020) Uncertainty of measurements and ECDIS performance. 4-7 February 2020. Monaco.

UNCERTAINTY VISUALIZATION

- Features to visualize:
  - What?
  - Where?
  - When?
  - How?



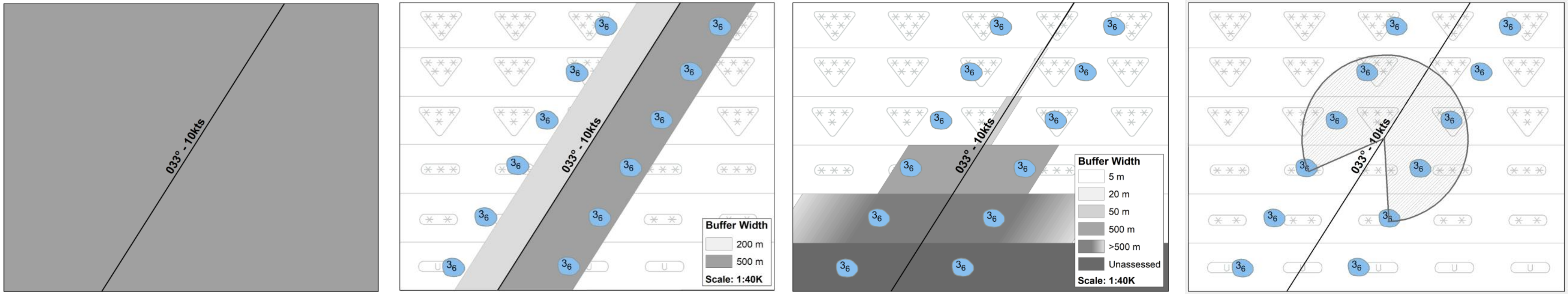


		Scale					
		1:5K	1:10K	1:20K	1:40K	1:80K	1:160K
Buffer	5 m	1	0.5	0.25	0.125	0.0625	0.03125
	20 m	4	2	1	0.5	0.25	0.125
	50 m	10	5	2.5	1.25	0.625	0.3125
	500 m	100	50	25	12.5	6.25	3.125

EXTENT

Four step integration in ECDIS:

- Overview
- Safety Zone
- Safe Course
- Watch Area

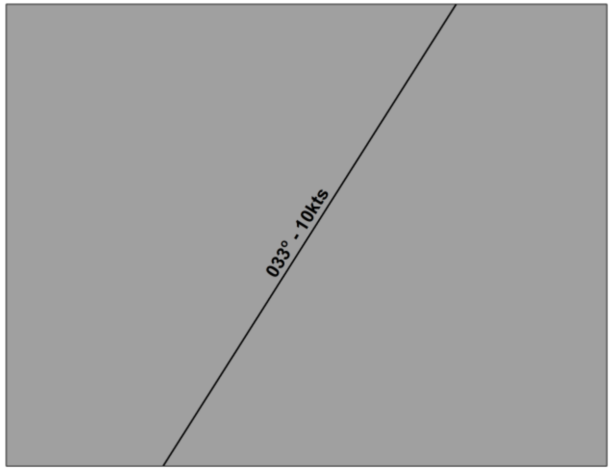

033° - 10kts
Buffer Width
200 m
500 m
Scale: 1:40K
033° - 10kts
Buffer Width
5 m
20 m
50 m
500 m
>500 m
Unassessed
Scale: 1:40K
033° - 10kts
3_6
U

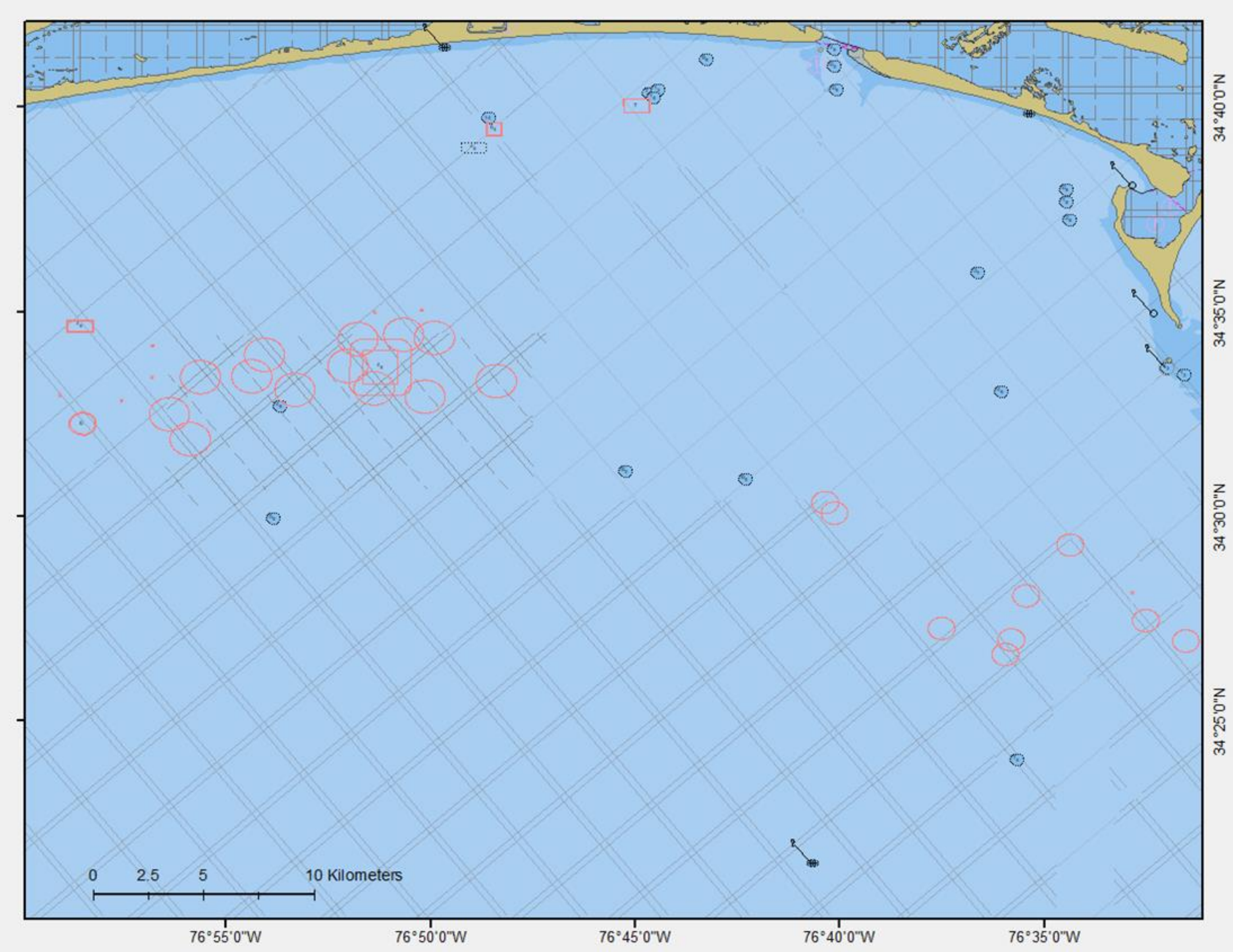
Kastrisios, C., Ware, C., Calder, B., Butkiewicz, T., Alexander, A. L., & Hauser, O. (2020). Nautical chart data uncertainty visualization as the means for integrating bathymetric, meteorological, and oceanographic information in support of coastal navigation. 100th American Meteorological Society Annual Meeting, 18th Symposium on the Coastal Environment, Boston, MA.

EXTENT

Four step integration in ECDIS:

- **Overview**
- Safety Zone
- Safe Course
- Watch Area

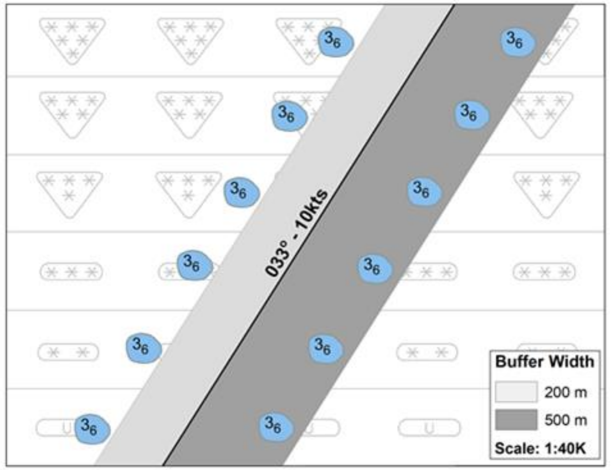


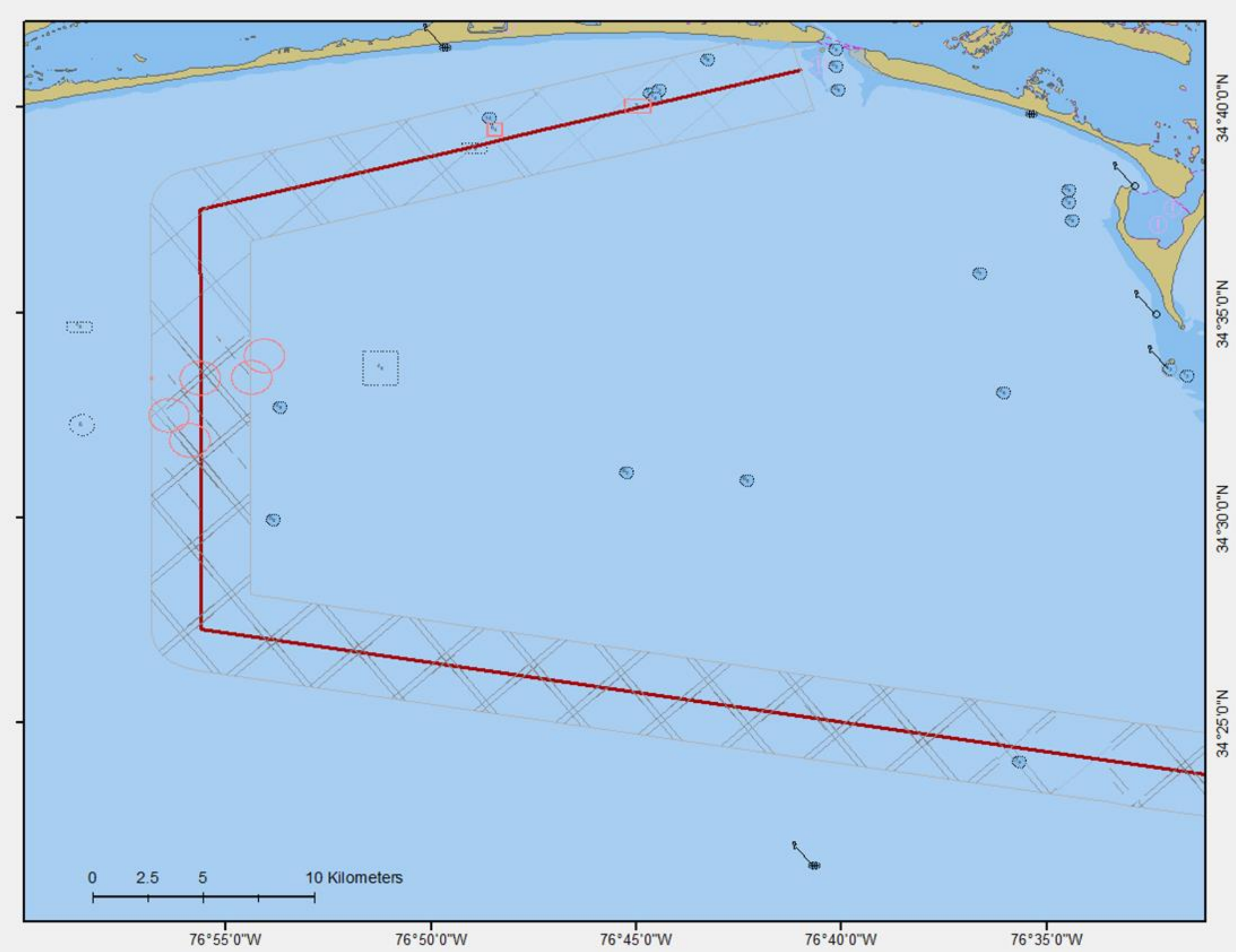

0
2.5
5
10 Kilometers
76°55'0"W
76°50'0"W
76°45'0"W
76°40'0"W
76°35'0"W
34°40'0"N
34°35'0"N
34°30'0"N
34°25'0"N

EXTENT

Four step integration in ECDIS:

- Overview
- **Safety Zone**
- Safe Course
- Watch Area

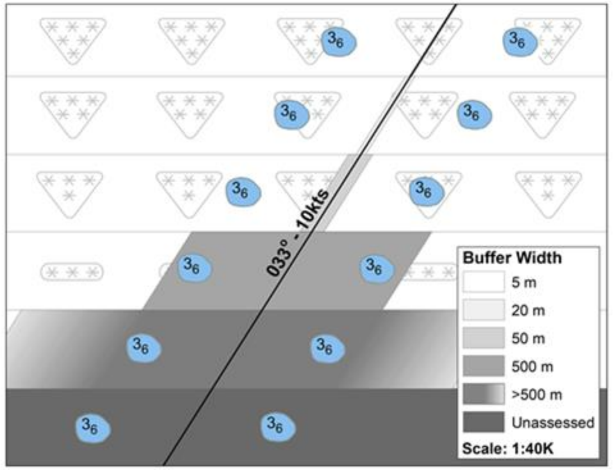

033° - 10kts
36
Buffer Width
200 m
500 m
Scale: 1:40K

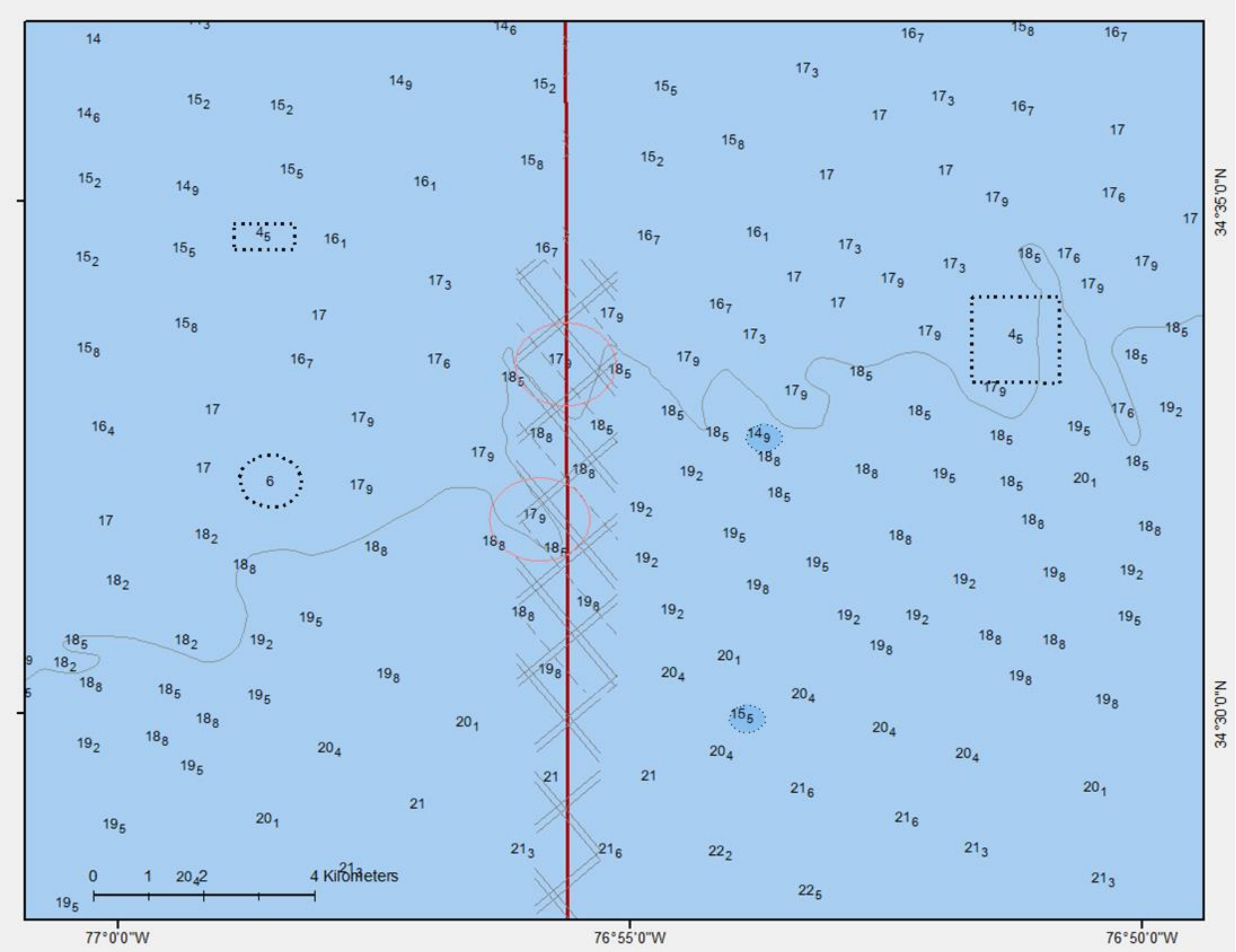

0
2.5
5
10 Kilometers
34°40'0"N
34°35'0"N
34°30'0"N
34°25'0"N
76°55'0"W
76°50'0"W
76°45'0"W
76°40'0"W
76°35'0"W

EXTENT

Four step integration in ECDIS:

- Overview
- Safety Zone
- **Safe Course**
- Watch Area

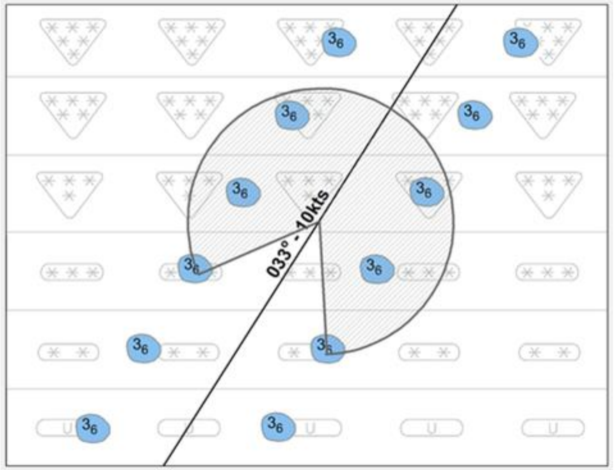

033° - 10kts
Buffer Width
5 m
20 m
50 m
500 m
>500 m
Unassessed
Scale: 1:40K

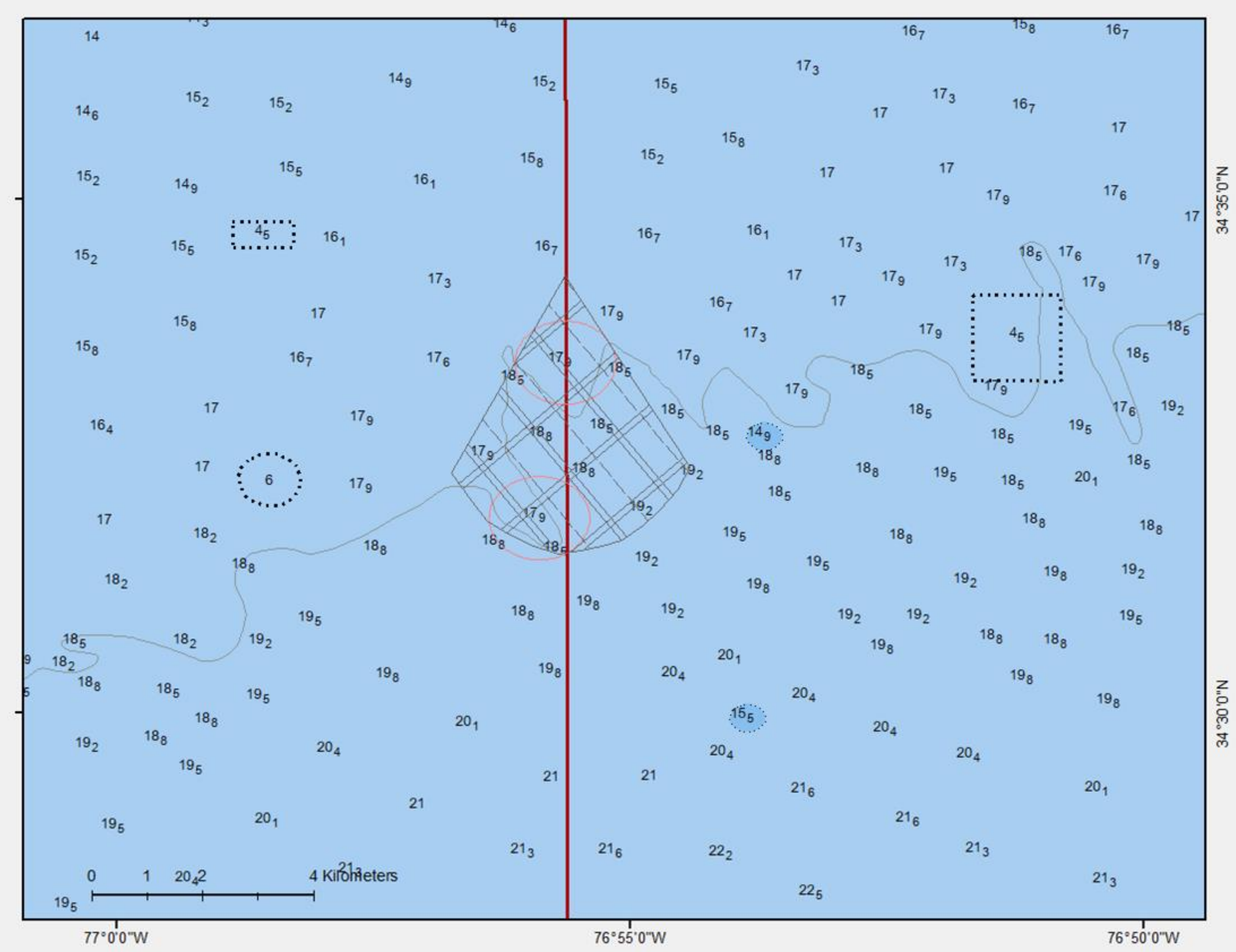

0
1
2
4 Kilometers
77°0'0"W
76°55'0"W
76°50'0"W
34°35'0"N
34°30'0"N

EXTENT

Four step integration in ECDIS:

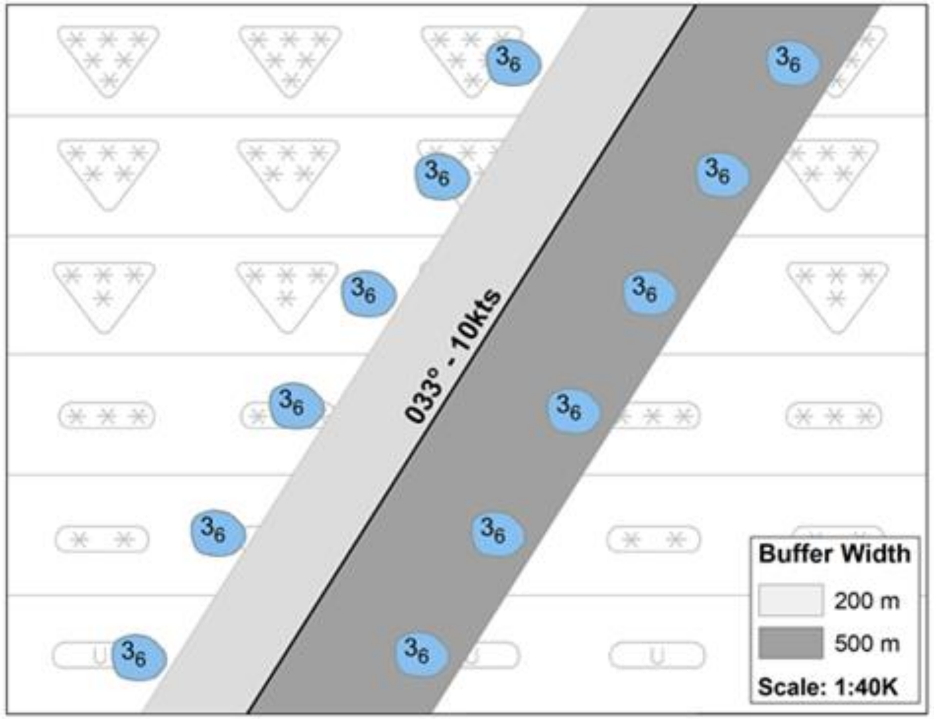
- Overview
- Safety Zone
- Safe Course
- **Watch Area**

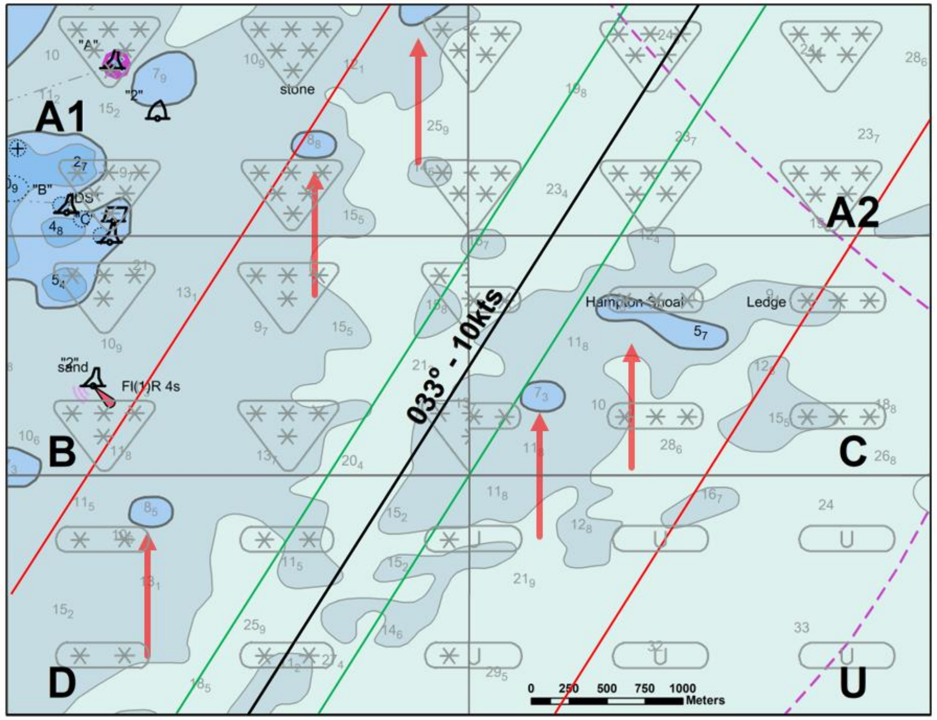

3₆
033° - 10kts


0 1 2 4 Kilometers
77°0'0"W
76°55'0"W
76°50'0"W
34°35'0"N
34°30'0"N

EXTENT

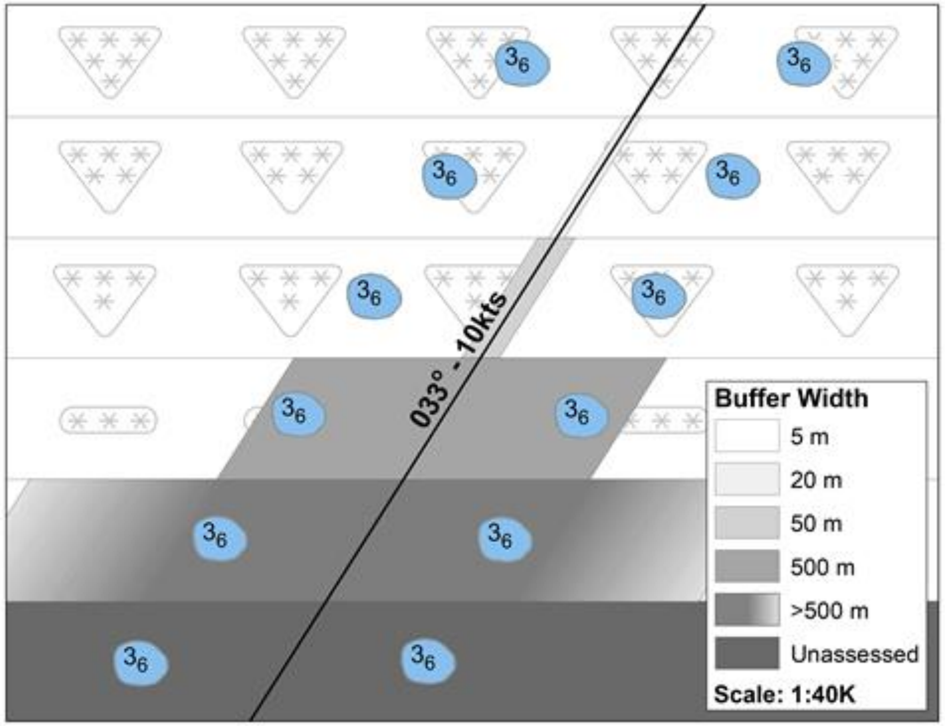
Why Safe Course?

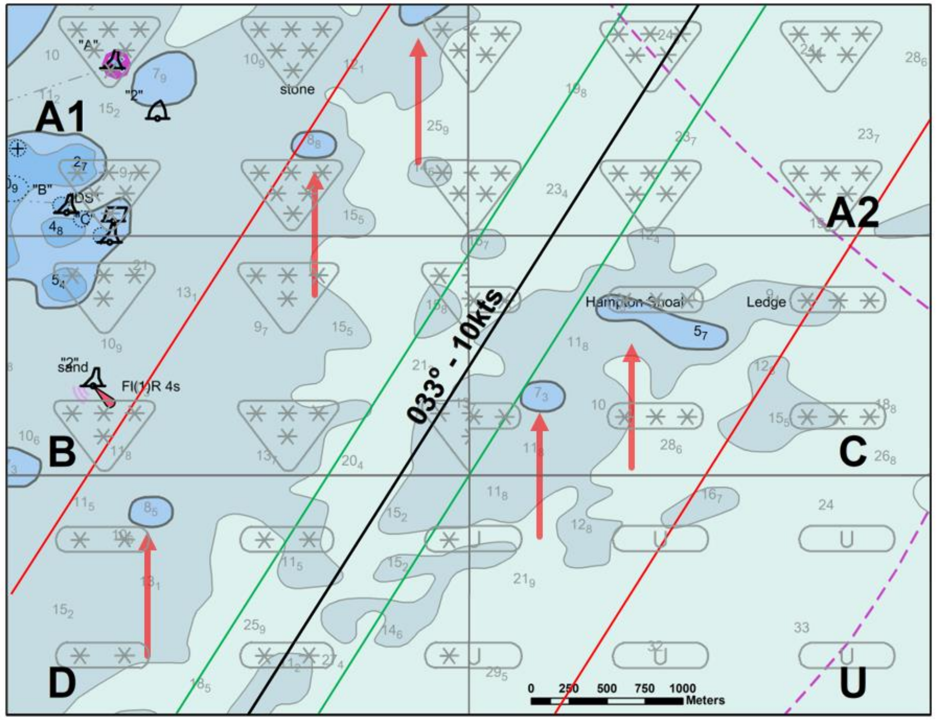

3₆
033° - 10kts
Buffer Width
200 m
500 m
Scale: 1:40K


A1
A2
B
C
D
U
"A"
"2"
"B"
stone
sand
Fl(1)R 4s
Hampton Shoal
Ledge
033° - 10kts
0 250 500 750 1000
Meters

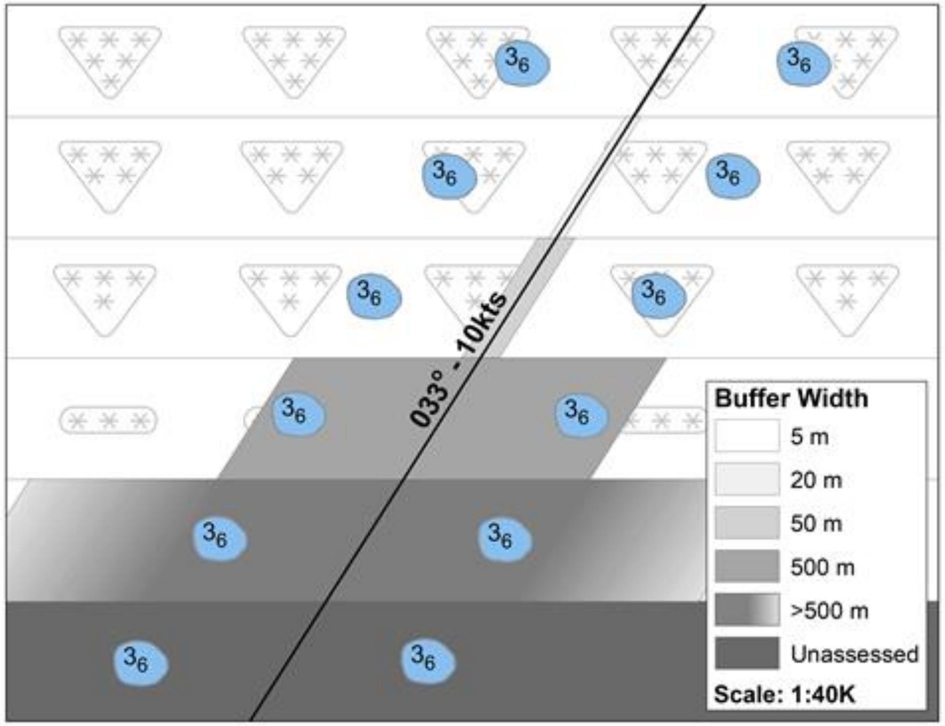
EXTENT

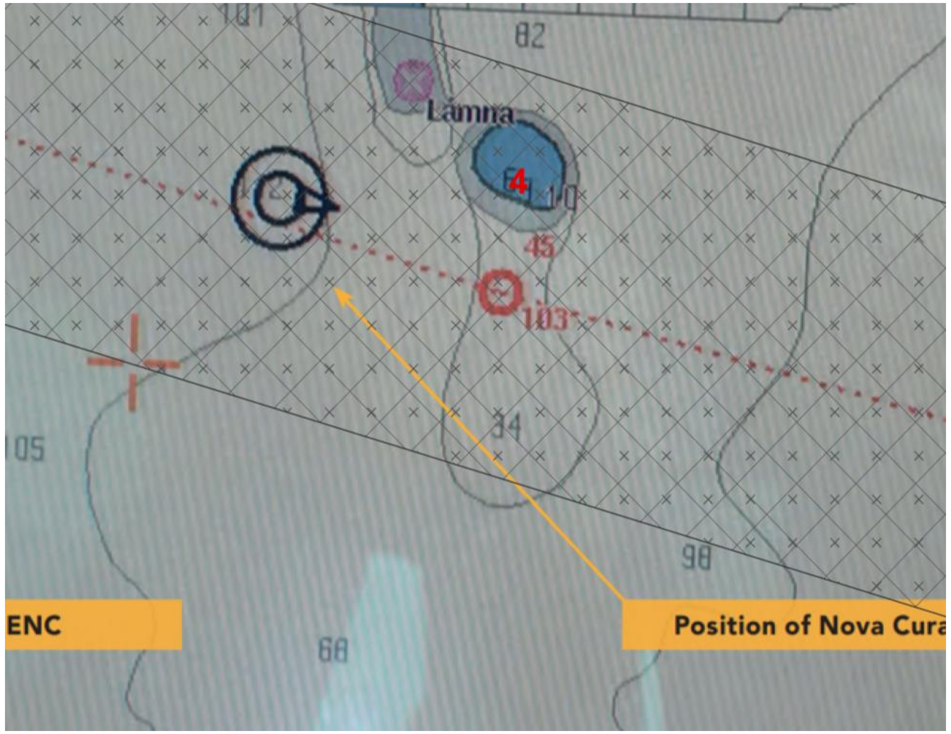
Why Safe Course?


3₆
033° - 10kts
Buffer Width
5 m
20 m
50 m
500 m
>500 m
Unassessed
Scale: 1:40K


A1
A2
B
C
D
U
"A"
"B"
"2"
stone
sand
Fl(1)R 4s
Hampton Shoal
Ledge
033° - 10kts
0 250 500 750 1000 Meters

EXTENT

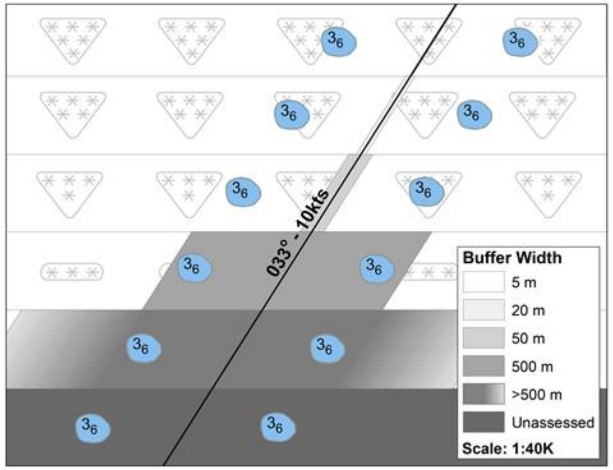

033° - 10kts
36
Buffer Width
5 m
20 m
50 m
500 m
>500 m
Unassessed
Scale: 1:40K

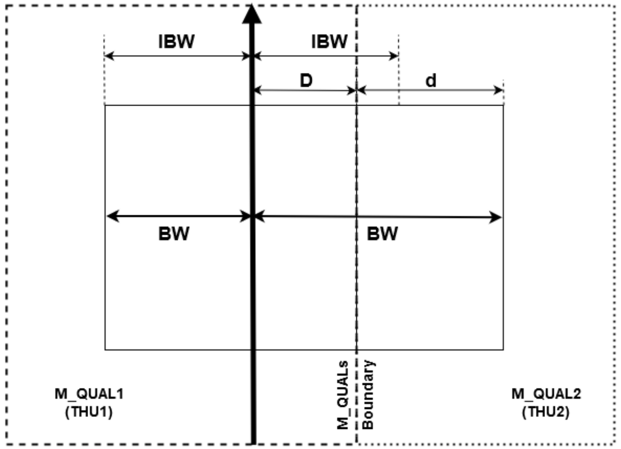

101
82
Lämna
4
10
45
103
105
34
98
68
ENC
Position of Nova Cura

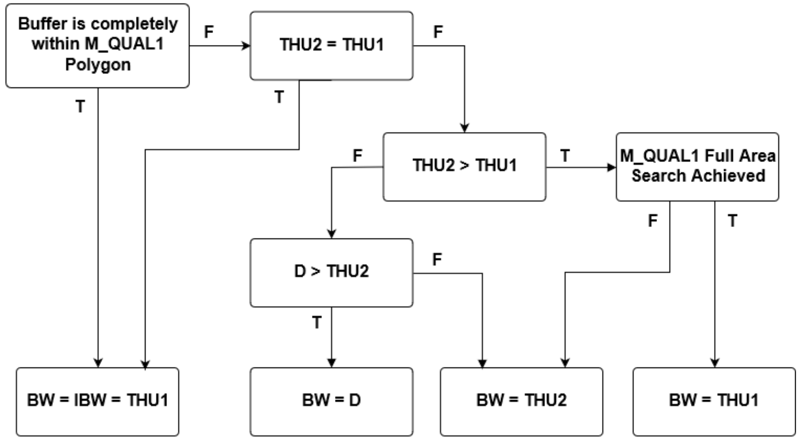
EXTENT

Decision tree

for Safe Course


36
033° - 10kts
Buffer Width
5 m
20 m
50 m
500 m
>500 m
Unassessed
Scale: 1:40K

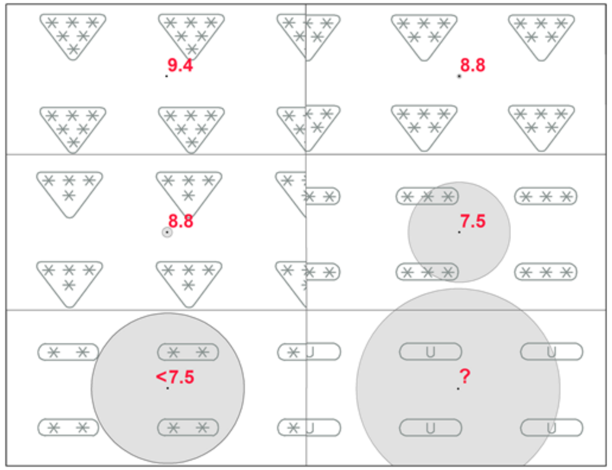

IBW
IBW
D
d
BW
BW
M_QUAL1
(THU1)
M_QUALs
Boundary
M_QUAL2
(THU2)

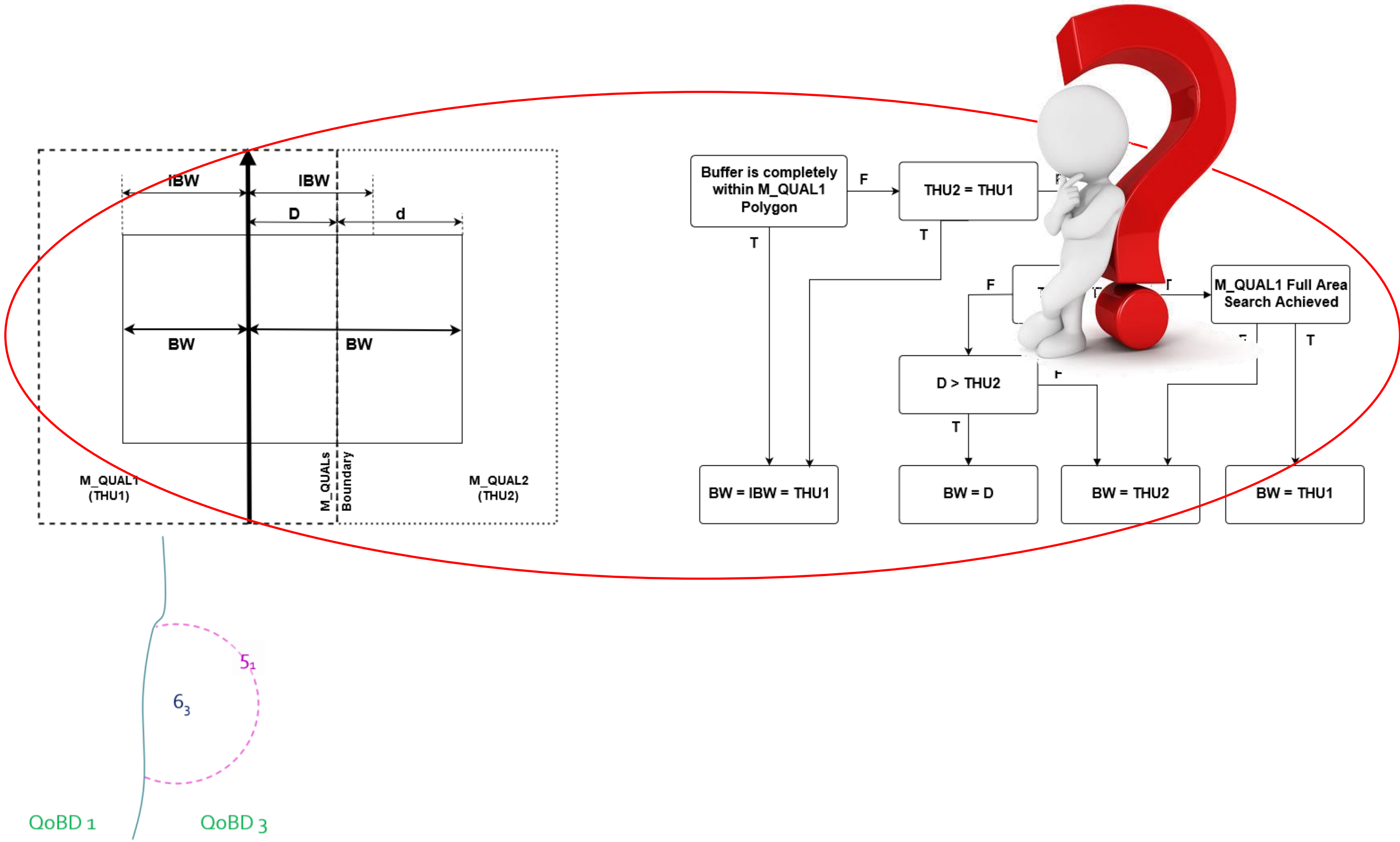

Buffer is completely within M_QUAL1 Polygon
F
T
THU2 = THU1
F
T
THU2 > THU1
F
T
M_QUAL1 Full Area Search Achieved
F
T
D > THU2
F
T
BW = IBW = THU1
BW = D
BW = THU2
BW = THU1

UTILIZATION

Decision tree

for uncertainty circles


9.4
8.8
8.8
7.5
<7.5
?
U


IBW
IBW
D
d
BW
BW
M_QUAL1
(THU1)
M_QUALs
Boundary
M_QUAL2
(THU2)
6₃
5₁
QoBD 1
QoBD 3
Buffer is completely within M_QUAL1 Polygon
F
T
THU2 = THU1
T
F
T
M_QUAL1 Full Area Search Achieved
T
D > THU2
T
BW = IBW = THU1
BW = D
BW = THU2
BW = THU1

FUTURE WORK

- Investigate:
    - Line type
    - Adjusted depth location
    - Acuities
    - Temporal variation
- Implementation
- Seek feedback

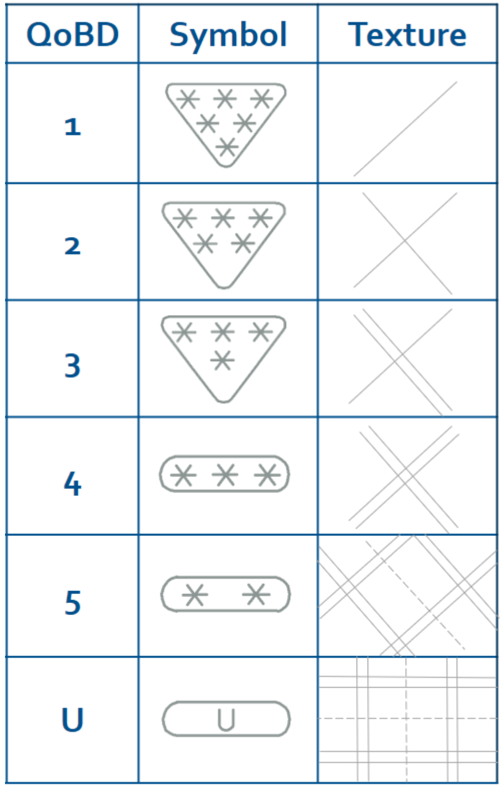
> ***"Any functionality in order to succeed must be fully embraced and accepted by the users".***
>
> AHO

Mariners' Workshop

MITAGS
MARITIME INSTITUTE OF TECHNOLOGY AND GRADUATE STUDIES

CSEM MSRC
CENTRE DE SIMULATION ET D'EXPERTISE MARITIME
MARITIME SIMULATION AND RESOURCE CENTRE

THANK YOU!



QoBD	Symbol	Texture
1	✳✳✳✳✳✳	
2	✳✳✳✳✳	
3	✳✳✳✳	
4	✳✳✳	
5	✳✳	
U	U	

This work is supported by the National Oceanic and Atmospheric Administration [grant number NA15NOS4000200]