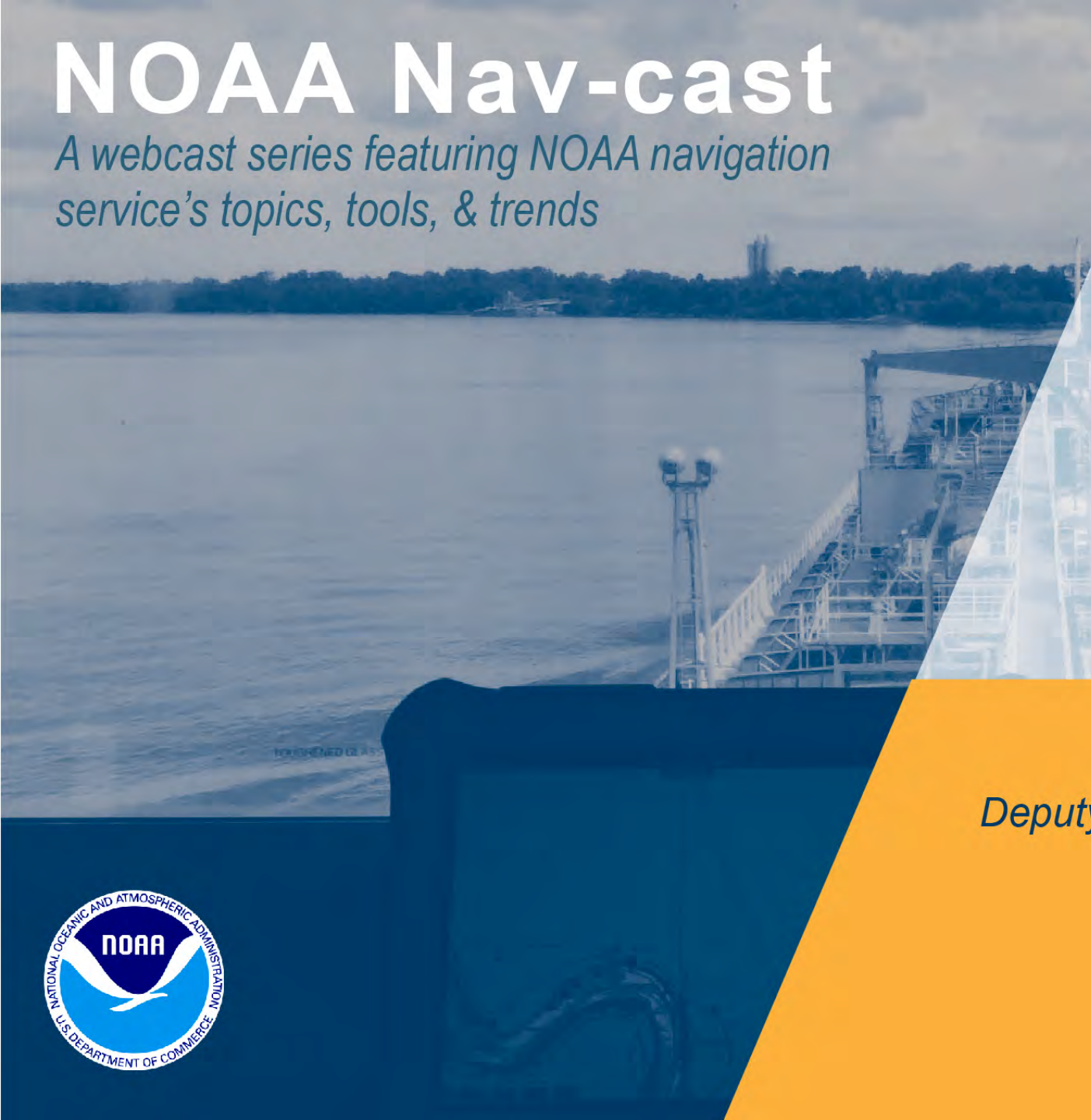
NOAA Nav-cast

A webcast series featuring NOAA navigation service's topics, tools, & trends



S-100 for System Implementers

June 18, 2019 | 11 a.m. (EDT)

Julia Powell
Deputy Division Chief, Coast Survey Development Lab
IHO S-100 Working Group Chair

Neil Weston
Technical Director, Office of Coast Survey

Agenda

- What is S-100
- What do I need from S-100
- Product Specifications
- S-100 Readiness Levels
- Encoding
- Schemas
- S-100 Catalogues
- Discovery Metadata
- Interoperability
- NOAA S-100 Implementations

S-100 – the IHO building blocks

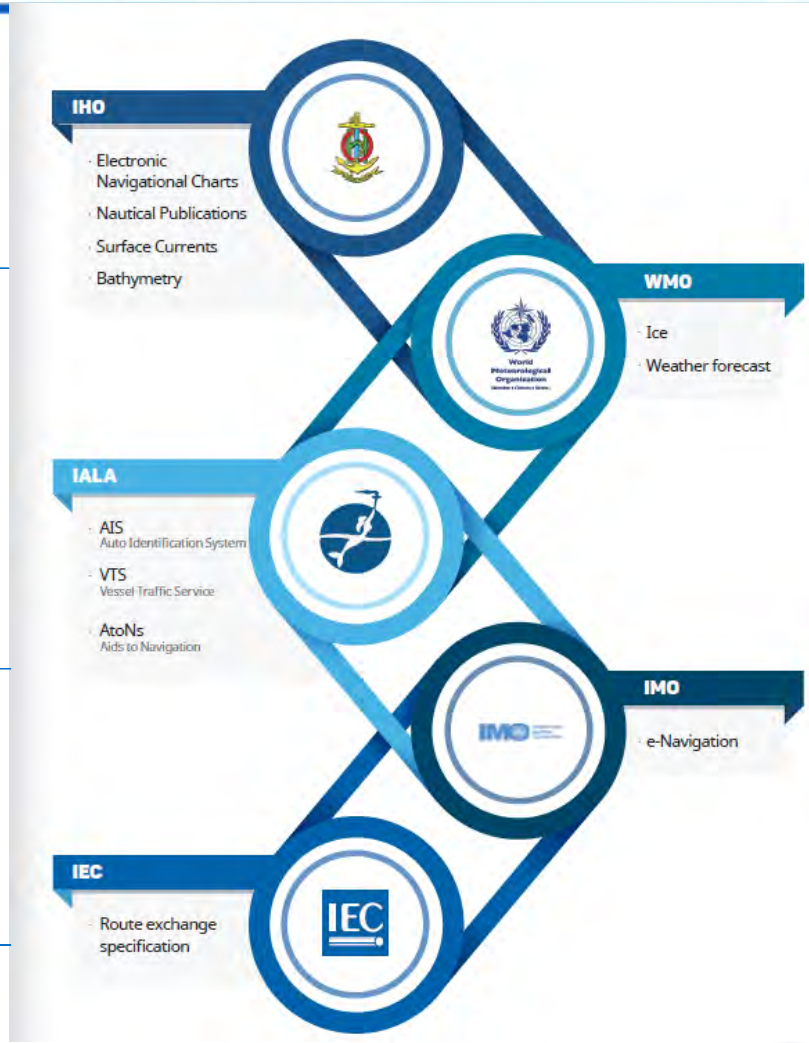
- *Provides the **data framework** for the development of the next generation Electronic Navigational Charting products, as well as other digital products required by the hydrographic, maritime and GIS communities*

Who is developing S-100 product specifications

ENC
Bathymetry
Water Levels
Surface Currents
MPAs
UKC

S-20x

S-421 – Route Exchange



S-411 - Ice
S-412 - Weather

What does S-100 mean for the Maritime Community?

- Leads to a global consistency of products
- Specifies encoding formats based on product type
  - ISO 8211
    - S-101 ENCs
  - HDF5
    - S-102 Bathymetry
    - S-111 Surface Currents
    - S-104 Water Level Information
    - S-412 Gridded Weather Information
  - GML
    - S-412 Vector Weather Information
    - S-122 Marine Protected Areas
- Moves to machine readable catalog mechanism
  - XML Based Catalogues

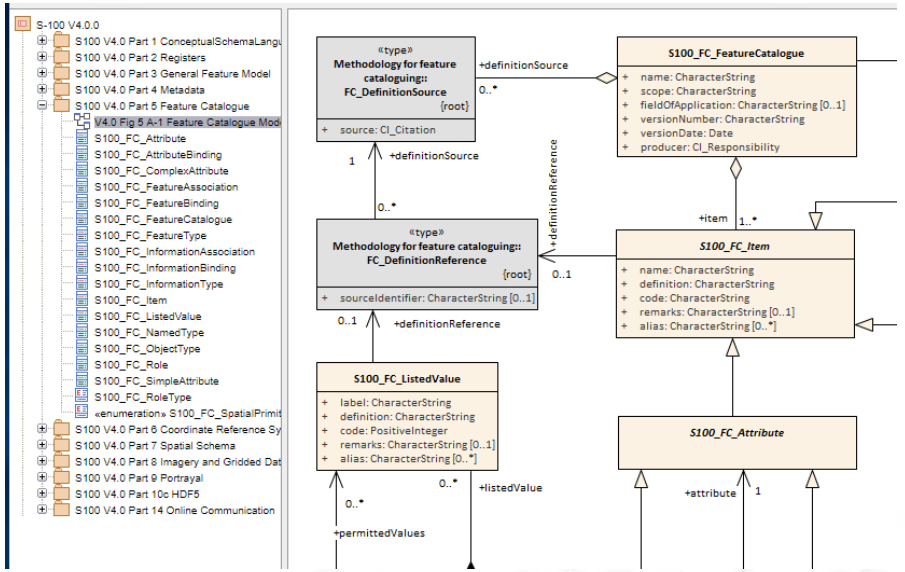
What is contained in S-100

- 15 Different Parts
- Defines
  - Register structure and management
  - Defining the General Feature Model
    - Modelling the real world for machines
  - Metadata
  - Feature Catalogues
  - Coordinate Reference Systems
  - Spatial – otherwise known as geometry
  - Imagery and Gridded Data
  - Portrayal Mechanisms
  - Data Encoding
  - Scripting Language
  - Online Communication
  - Data Protection

Conceptual Schema Language	S-100 Part 1
Management of IHO Geospatial Information Registers	S-100 Part 2
Feature Concept Dictionary Registers	S-100 Part 2a
Portrayal Register	S-100 Part 2b
General Feature Model and Rules for Application Schema	S-100 Part 3
Metadata	S-100 Part 4a
Metadata for Imagery and Gridded Data	S-100 Part 4b
Metadata – Data Quality	S-100 Part 4c
Feature Catalogue	S-100 Part 5
Coordinate Reference Systems	S-100 Part 6
Spatial Schema	S-100 Part 7
Imagery and Gridded Data	S-100 Part 8
Portrayal	S-100 Part 9
Portrayal (Lua)	S-100 Part 9a
Encoding Formats	S-100 Part 10
ISO/IEC 8211 Encoding	S-100 Part 10a
GML Encoding	S-100 Part 10b
HDF5 Encoding	S-100 Part 10c
Product Specifications	S-100 Part 11
S-100 Maintenance Procedures	S-100 Part 12
S-100 Scripting Language	S-100 Part 13
Online Communication Exchange	S-100 Part 14
Encryption and Data Protection	S-100 Part 15

Where do I find information?

- http://s100.iho.int/S100/
  - Links to the latest edition of S-100
  - S-100 Schemas (stored on Github)
  - S-100 UML models
    - Downloadable via Github
    - HTML version



Type	Description/Link	Edition/Date	Comment
	S-100 Edition 4.0.0 Schema packages - Readme	November 2018	See below
	S-100 Edition 4.0.0 Schema packages	November 2018	See Readme - above
	S-100 UML Model	April 2017	S-100 Github - download
	S-100 UML Model - HTML Version	September 2018	HTML version of the UML models
	S-100 Schemas	February 2018	S-100 Github
	S-100 Master Plan Document	(June 2015)	

Product Information	
Product ID	S-101
Title	Electronic Navigational Chart
Scope	Global
Related links	Go to the details ...
Abstract	An Electronic Navigational Chart (ENC) is a vector chart produced on the authority of a government authorized Hydrographic Office or other relevant government institution. Its primary purpose is for use within an Electronic Chart Display and Information Systems (ECDIS) to meet International Maritime Organization (IMO) and Safety of Life at Sea (SOLAS) chart carriage requirements. The ENC contains an extraction of real world information necessary for the safe navigation of vessels
Owner	IHO
Domain	IHO Hydro
Responsible body	IHO (S-100WG)
Contact	IHO Sec. addt@iho.int
Remarks	S-101 Edition 1.0.0 is released for implementation and testing purposes only. The S-101 Edition 1.0.0 Feature and Portrayal Catalogues included are currently being refined and are expected to be completed in February 2019.

Version Information		
Version	1.0.0 ▾ Published	Uploader:Yong BAEK/ S-101 ENC Product Specification Ed. 1.0.0.zip Down
Version Date	2018-12-21	
S-100 Version	4.0.0	
Feature Catalogue		Uploader:Yong BAEK/ S-101FC_1.0.0_20190409.xml Down
Portrayal Catalogue	The portrayal catalogue(XSLT) is based on 0.9.3 version of S-101 feature catalogue.	Uploader:Yong BAEK/ S-101_PC_0.9.3.zip Down

Back to list

Product Specifications under Development

- IHO maintains a testbed registry – password protected
- http://registry.iho.int/beta/testbed/list.do

Domain ALL Status ALL Category product ID

	No	ID	Name	Version	Status	Domain	Date updated
+	1	S-102	Bathymetric Surface	2.0.0	Approval process	IHO Hydro	2019-05-08
+	2	S-104	Water Level Information for Surface Navigation	0.0.6		IHO Hydro	2019-04-09
+	3	S-121	Maritime Limits and Boundaries	1.0.0	Approval process	IHO Hydro	2019-03-26
+	4	S-124	Navigational Warnings	0.2	Testbed	IHO Hydro	2019-04-09
+	5	S-127	Marine Traffic Management	1.0	StakeholderReview	IHO Hydro	2019-05-22
+	6	S-128	Catalogue of Nautical Products	0.1		IHO Hydro	2019-01-03
+	7	S-129	Under Keel Clearance Management Product Specification	1.0.0	Approval process	IHO Hydro	2019-03-26
+	8	S-412	Weather and Wave Hazards	0.1.0		WMO Weather	2018-12-13

Showing 1 to 8 of 8 rows

S-100 Readiness Levels

- Adapted from NASA TRL
- Readiness for operational use
- Allows non-IHO stakeholder organizations to gauge when their development meets an appropriate readiness level for transition to live operation

Required product specification component	(TRL5) Level 1 v1.0.0	(TRL6) Level 2 v1-2.0.0	(TRL7) Level 3 >v2.0.0	(TRL8) Level 4 >v2.0.0	(TRL9) Level 5 >v2.0.0
Main Document (Defines the relevant parts of S-100 that are required for the product specification)	X	X	X	X	X
A Default Encoding	X	X	X	X	X
S-100 Compliant Feature Catalogue	X	X	X	X	X
DCEG	X	X	X	X	X
S-100 Compliant Portrayal Catalogue NOTE: Not every specification will need a portrayal catalogue – this should be determined as part of the development process and stakeholder feedback		X	X	X	X
Data Quality Checks		X	X	X	X
Test Data Sets		X	X	X	X
Data Validation (and test datasets)		*X*	*X*	*X*	*X*
Exchange Catalogue		X	X	X	X
Encryption / Digital Signatures			X	X	X
Interoperability				X	X[1]
Alerts and Indications				X	X[1]
Operational data					X

S-100 Based Feature Catalogues

- Machine Readable .xml catalogue
- Binds features and attributes
- Ties in spatial primitives – Point, Curve and Surface.

```
<S100FC:S100_FC_SimpleAttributes>
  - <S100FC:S100_FC_SimpleAttribute>
        <S100FC:name>Application Profile</S100FC:name>
        <S100FC:definition>name of an application profile that can be used with the online resource (ISO 19115)</S100FC:definition>
        <S100FC:code>applicationProfile</S100FC:code>
        <S100FC:alias>APPPRF</S100FC:alias>
        <S100FC:valueType>text</S100FC:valueType>
    </S100FC:S100_FC_SimpleAttribute>
  - <S100FC:S100_FC_SimpleAttribute>
        <S100FC:name>Beacon shape</S100FC:name>
        <S100FC:definition>The shape a beacon exhibits</S100FC:definition>
        <S100FC:code>beaconShape</S100FC:code>
        <S100FC:alias>BCNSHP</S100FC:alias>
        <S100FC:valueType>enumeration</S100FC:valueType>
      - <S100FC:listedValues>
          - <S100FC:listedValue>
                <S100FC:label>Stake, Pole, Perch, Post</S100FC:label>
                <S100FC:definition>An elongated wood or metal pole, driven into the ground or seabed, which serves as a navigational aid or a
```

S-100 Based Portrayal Catalogues

- Machine Readable set of symbols and portrayal rules
- S-100 defines two types of portrayal mechanisms
  - LUA – used for S-101 portrayal and best for portrayal rules that need to use external conditions to generate the portrayal (ship's draft)
  - XSLT – simplified rules based on XML style sheets
- Navigation Systems MUST implement both

S-100 Discovery Metadata

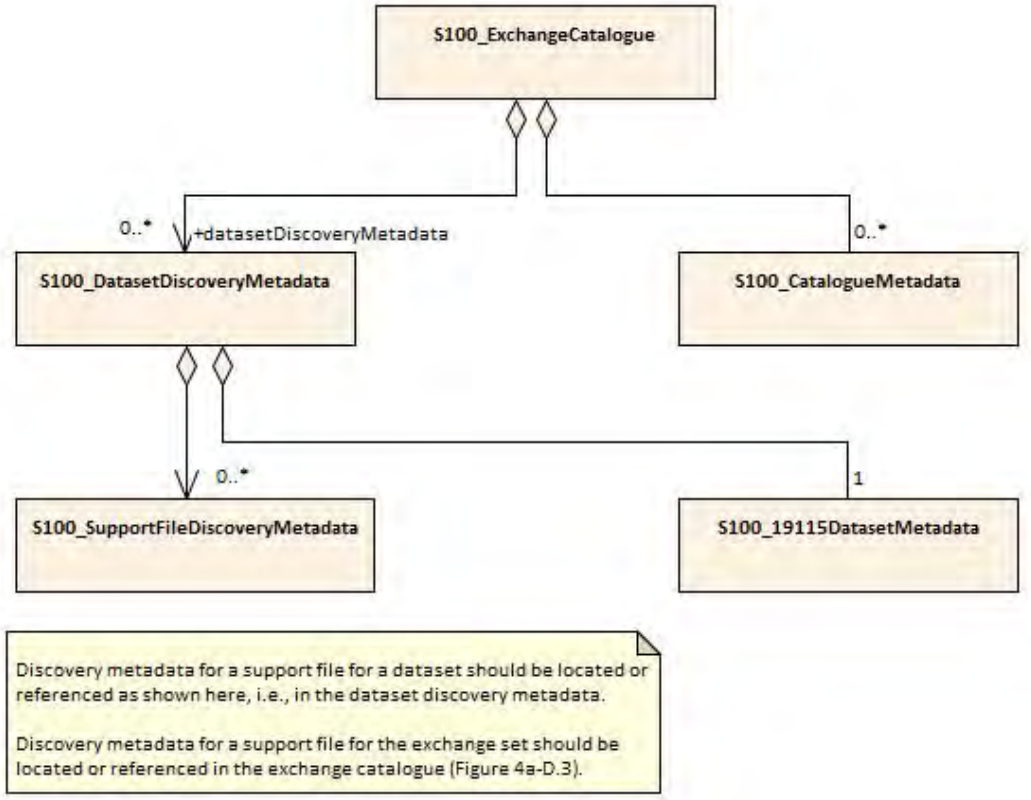
- Discovery metadata allows for automated tools to discover the semantics of the data within the datasets
- S-100 Metadata is a profile of ISO 19115-3:2016
  - S100_Metadata specializes the MD_Metadata class from ISO 19115
    - Makes metadataIdentifier mandatory
- Validated via the S100 XML Schema Definition and the S-100 Schematron Metadata Rules

S-100 Discovery Metadata – Information Exchange

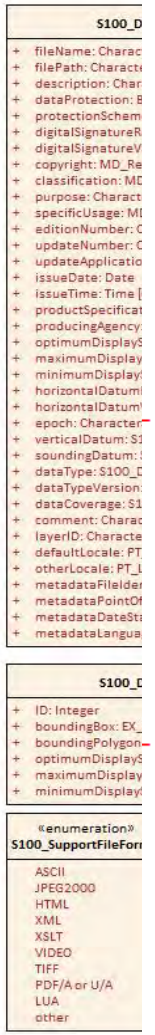
- Implemented utilizing XML exchange catalogues
- Contains:
  - Metadata about the overall exchange catalogue
  - Metadata about the individual datasets
  - Metadata about the support files that make up the package
- At the S-100 level most everything is optional
  - Restrictions may occur at the product specification level
  - Not every specification uses every field

S-100 Exchange Set Catalogue

- How datasets are packaged up and delivered
  - Usually a .zip
- XML Instance
- Sections:
  - Catalogues (Feature, Portrayal)
  - Datasets
- Subsections
  - Support files



S-100 Disc

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      </S100XC:phone>
    - <S100XC:address gco:isoType="gmd:CI_Address">
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            <gco:CharacterString>1315 East West Highway</gco:CharacterString>
          </gmd:deliveryPoint>
        - <gmd:city>
            <gco:CharacterString>Silver Spring</gco:CharacterString>
          </gmd:city>
        - <gmd:postalCode>
            <gco:CharacterString>MD 20910</gco:CharacterString>
          </gmd:postalCode>
      </S100XC:address>
  </S100XC:contact>
  <S100XC:metadataLanguage>English</S100XC:metadataLanguage>
  <S100XC:exchangeCatalogueName>S101ed1.CAT</S100XC:exchangeCatalogueName>
  <S100XC:exchangeCatalogueDescription>S101TestDataXC001 exchange set contains 21 ENC test datasets develop
      and IHO to support S-101 version 1.0 test plan.</S100XC:exchangeCatalogueDescription>
  <S100XC:productSpecification>
      <S100XC:name>S-101</S100XC:name>
      <S100XC:version>1.0</S100XC:version>
      <S100XC:date>2015-07-22</S100XC:date>
  </S100XC:productSpecification>
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  <S100XC:replacedData>false</S100XC:replacedData>
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      <S100XC:filePath>AADLULBD01</S100XC:filePath>
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      <S100XC:dataProtection>false</S100XC:dataProtection>
      <S100XC:digitalSignature>TBD</S100XC:digitalSignature>
      <S100XC:copyright>© Copyright 2015</S100XC:copyright>
      <S100XC:classification>unclassified</S100XC:classification>
      <S100XC:purpose>New Dataset</S100XC:purpose>
      <S100XC:specificUsage>Port Entry</S100XC:specificUsage>
      <S100XC:editionNumber>1</S100XC:editionNumber>
      <S100XC:updateNumber>0</S100XC:updateNumber>
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      <S100XC:issueDate>2015-09-15</S100XC:issueDate>
```

Discovery for Dissemination

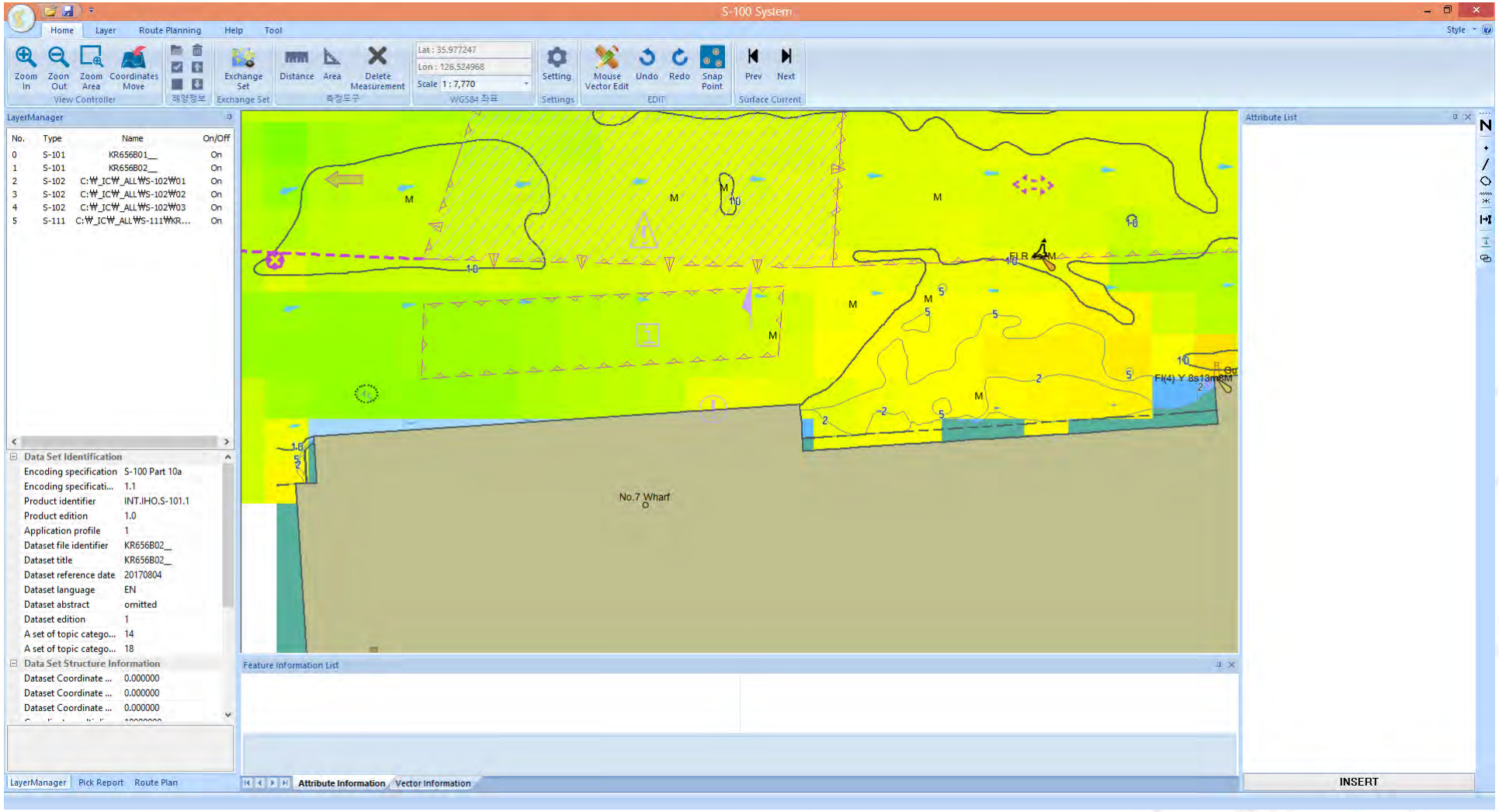
- Building out a central metadata database to handle the dataset metadata
- XML allows for discovery:
  - When new data is released
  - Where the data is stored
  - Where the data is geographically
  - What type of data it is
  - Who produced the data

A little about Data Dissemination

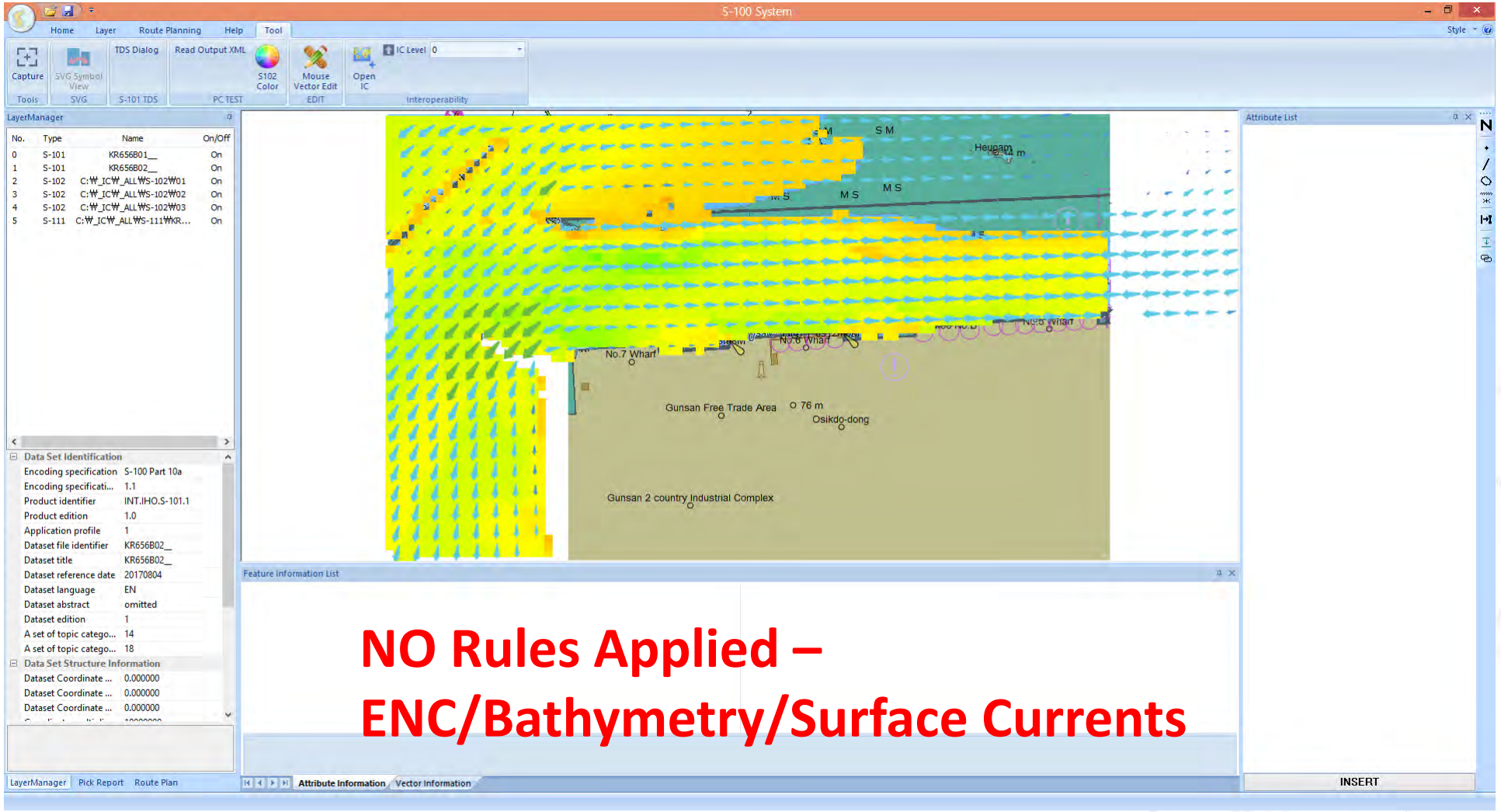
S-98 – S-100 Interoperability for Navigation Systems

- Framework for capturing interoperabity rules for use in ECDIS and “front of bridge” systems
- Machine readable mechanism for rules
- Harmonized graphical presentations of S-100 data products

We want this


S-100 System
Home
Layer
Route Planning
Help
Tool
Zoom In
Zoon Out
Zoom Area
Coordinates Move
View Controller
Exchange Set
Distance
Area
Delete Measurement
Lat : 35.977247
Lon : 126.524968
Scale 1 : 7,770
WGS84 좌표
Setting
Settings
Mouse Vector Edit
Undo
Redo
Snap Point
EDIT
Prev
Next
Surface Current
LayerManager
No. Type Name On/Off
0 S-101 KR656B01__ On
1 S-101 KR656B02__ On
2 S-102 C:₩_IC₩_ALL₩S-102₩01 On
3 S-102 C:₩_IC₩_ALL₩S-102₩02 On
4 S-102 C:₩_IC₩_ALL₩S-102₩03 On
5 S-111 C:₩_IC₩_ALL₩S-111₩KR... On
Data Set Identification
Encoding specification S-100 Part 10a
Encoding specificati... 1.1
Product identifier INT.IHO.S-101.1
Product edition 1.0
Application profile 1
Dataset file identifier KR656B02__
Dataset title KR656B02__
Dataset reference date 20170804
Dataset language EN
Dataset abstract omitted
Dataset edition 1
A set of topic catego... 14
A set of topic catego... 18
Data Set Structure Information
Dataset Coordinate ... 0.000000
Dataset Coordinate ... 0.000000
Dataset Coordinate ... 0.000000
No.7 Wharf
Fl R 4M
Fl(4) Y 8s13m8M
Attribute List
Feature Information List
Attribute Information
Vector Information
INSERT
LayerManager
Pick Report
Route Plan

Not THIS!


S-100 System
Home
Layer
Route Planning
Help
Tool
Capture
TDS Dialog
Read Output XML
S102 Color
Mouse Vector Edit
Open IC
IC Level
LayerManager
No. Type Name On/Off
0 S-101 KR656B01__ On
1 S-101 KR656B02__ On
2 S-102 C:₩IC₩ALL₩S-102₩01 On
3 S-102 C:₩IC₩ALL₩S-102₩02 On
4 S-102 C:₩IC₩ALL₩S-102₩03 On
5 S-111 C:₩IC₩ALL₩S-111₩KR... On
Data Set Identification
Encoding specification S-100 Part 10a
Encoding specificati... 1.1
Product identifier INT.IHO.S-101.1
Product edition 1.0
Application profile 1
Dataset file identifier KR656B02__
Dataset title KR656B02__
Dataset reference date 20170804
Dataset language EN
Dataset abstract omitted
Dataset edition 1
A set of topic catego... 14
A set of topic catego... 18
Data Set Structure Information
Dataset Coordinate ... 0.000000
Dataset Coordinate ... 0.000000
Dataset Coordinate ... 0.000000
No.7 Wharf
Gunsan Free Trade Area
76 m
Osikdo-dong
Gunsan 2 country Industrial Complex
Attribute List
Feature Information List
NO Rules Applied –
ENC/Bathymetry/Surface Currents
LayerManager
Pick Report
Route Plan
Attribute Information
Vector Information
INSERT

Key Takeaways for Implementation

- Implement at the S-100 Level to ensure optimal plug and play
  - Harmonization of data
  - Improved interoperability
- If data producers move to leveraging consensus based standards it can lead to lower implementation costs for the manufacturer
  - Can lead to lower cost for the consumer
  - Can lead to increased uptake of the product

Operationalization of S-100 at NOAA

Surface Currents - Operationalize S-111 Data

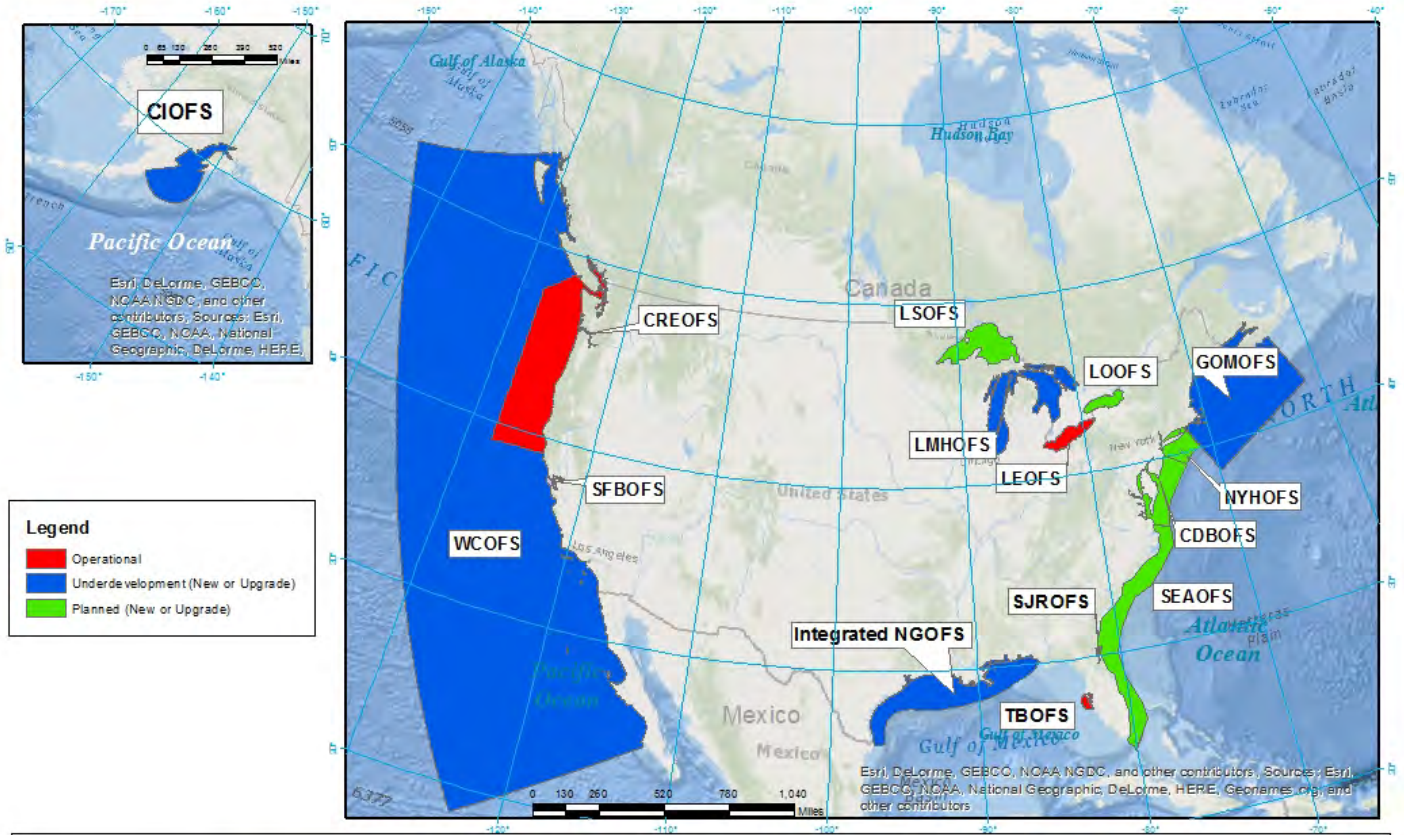
- Develop a service to disseminate OFS surface current data in the IHO's S-111 format
- For use in Electronic Navigation Systems (ENC)
- S-111 data is designed for interoperability
- IHO product specifications based on S-100 Framework
- S-111 Surface Currents Product Specification adopted by IHO on February 13, 2019

Operational Forecast Systems - OFS

- NOAA operational nowcast and forecast models
- Run 24 hours per day; output every 6 hours
- Support NOAA mission goals and priorities
- Operational Forecast System - Data

- Operational Forecast System - Components
  - Hydrodynamic model predictions
  - Product dissemination
  - Quality control monitoring

NOAA Operational Forecast Systems - OFS



Plan for NOAA/National Ocean Service's Operational Oceanographic Forecast Modeling Systems through FY21

June 2016

JGW Kelley, NOS/CSDL/CMMB

Operational Forecast System – Lower Chesapeake Bay

Model Inputs

Winds

Water Levels

Currents

Model Outputs

Water Levels

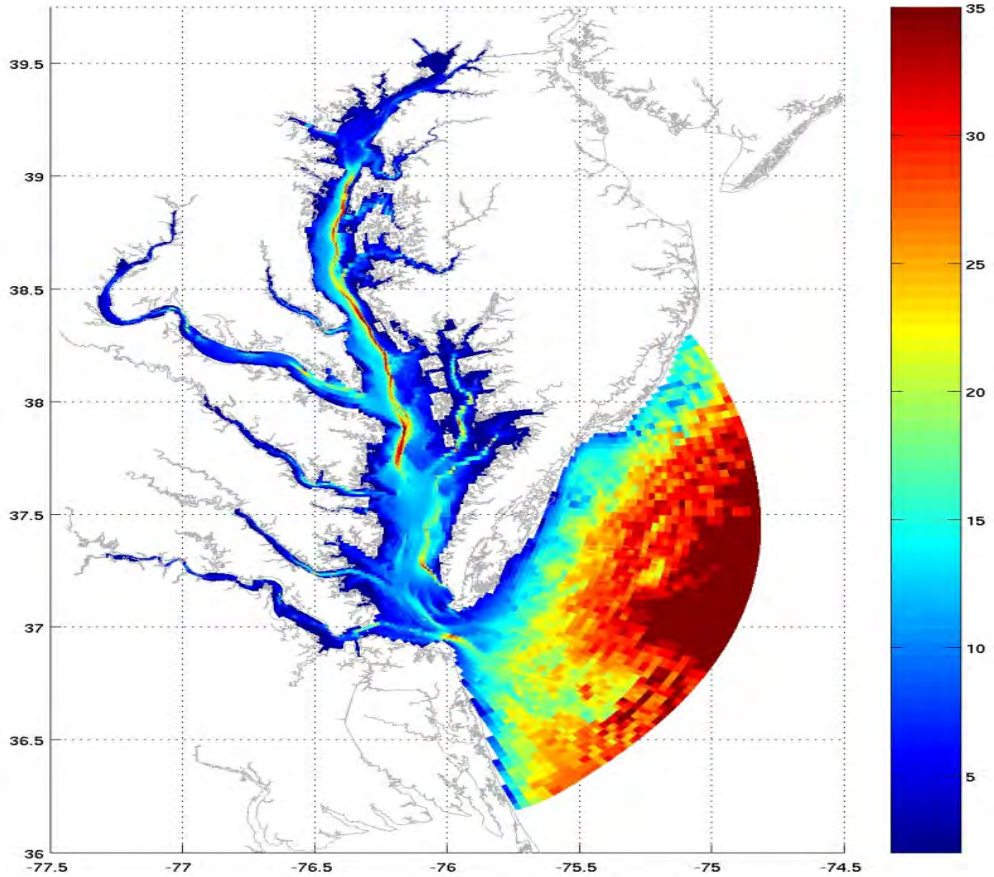
Currents

Water Temperature

Water Salinity

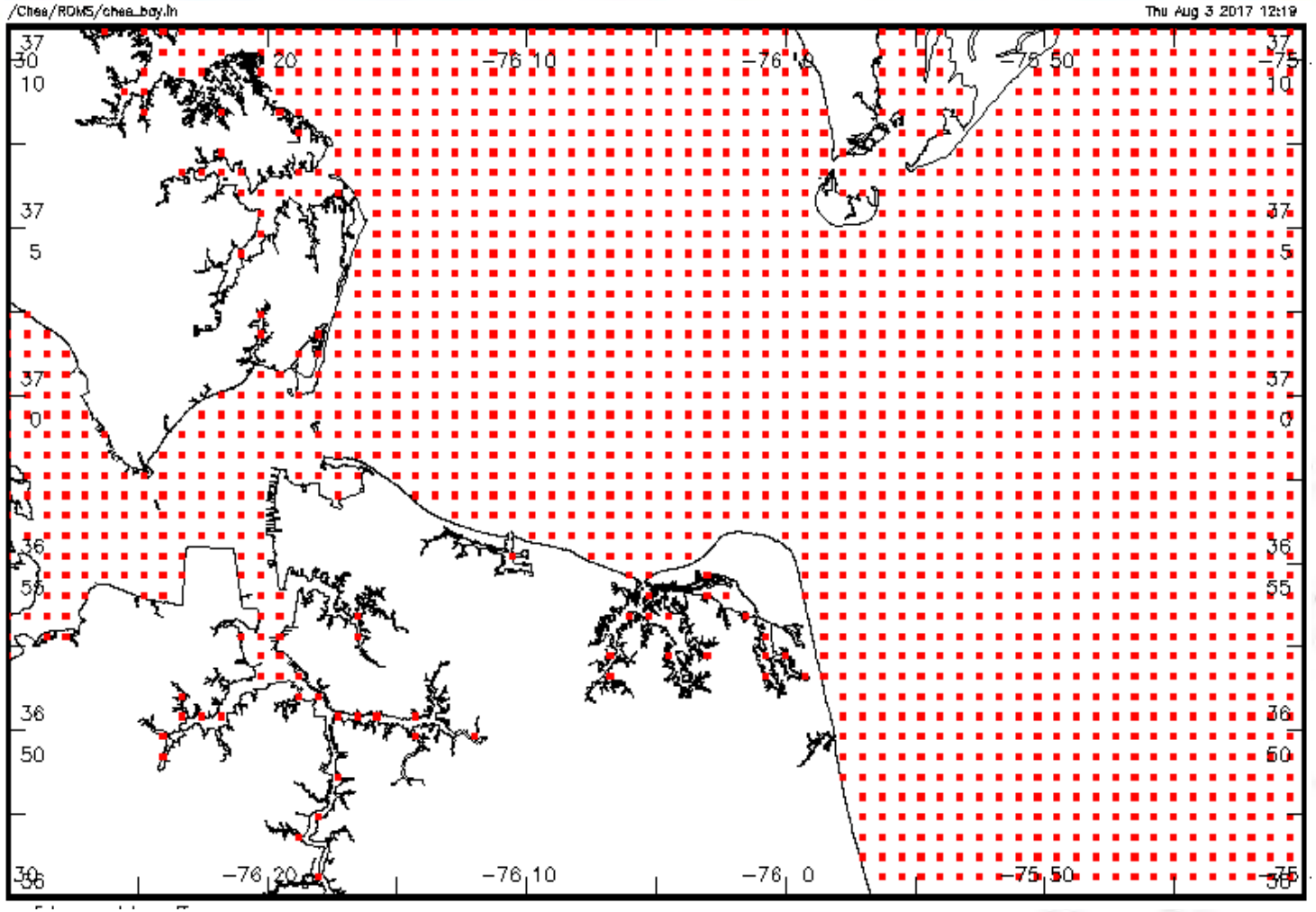
Chesapeake Bay OFS

Irregular node spacing – 78,480 pts



Water depth - meters

Chesapeake Bay – Regular Node Spacing



dx = 0.010 deg dy = 0.010 deg

Surface Currents S-111 Metadata

Variable	Value
IHO Specifications	S-100 Edition 4.0.0 S-111 Edition 1.0.0
Format	Hierarchical Data Format 5 (HDF5)
Operational Forecast System (OFS) Parameter(s)	Surface Currents
Coordinate System	WGS 84
Frequency	4 times daily cycle (0, 6, 12, 18 UTC)
Time Resolution, Duration	Hourly out to 48 hours
Time Zone	UTC
Resolution	~500 m (regular grid)
Depth	4.5 m below surface
Data Coverage	Chesapeake Bay, VA/MD/DC (CBOFS); Delaware Bay, DE/NJ (DBOFS) (as of Dec '18)
Hydrodynamic Model	Regional Ocean Modeling System (ROMS)

Lower Chesapeake Bay

ENC Band: 4

Format: S-111 w/ HDF5 encoding

Grid Resolution: 0.01 deg

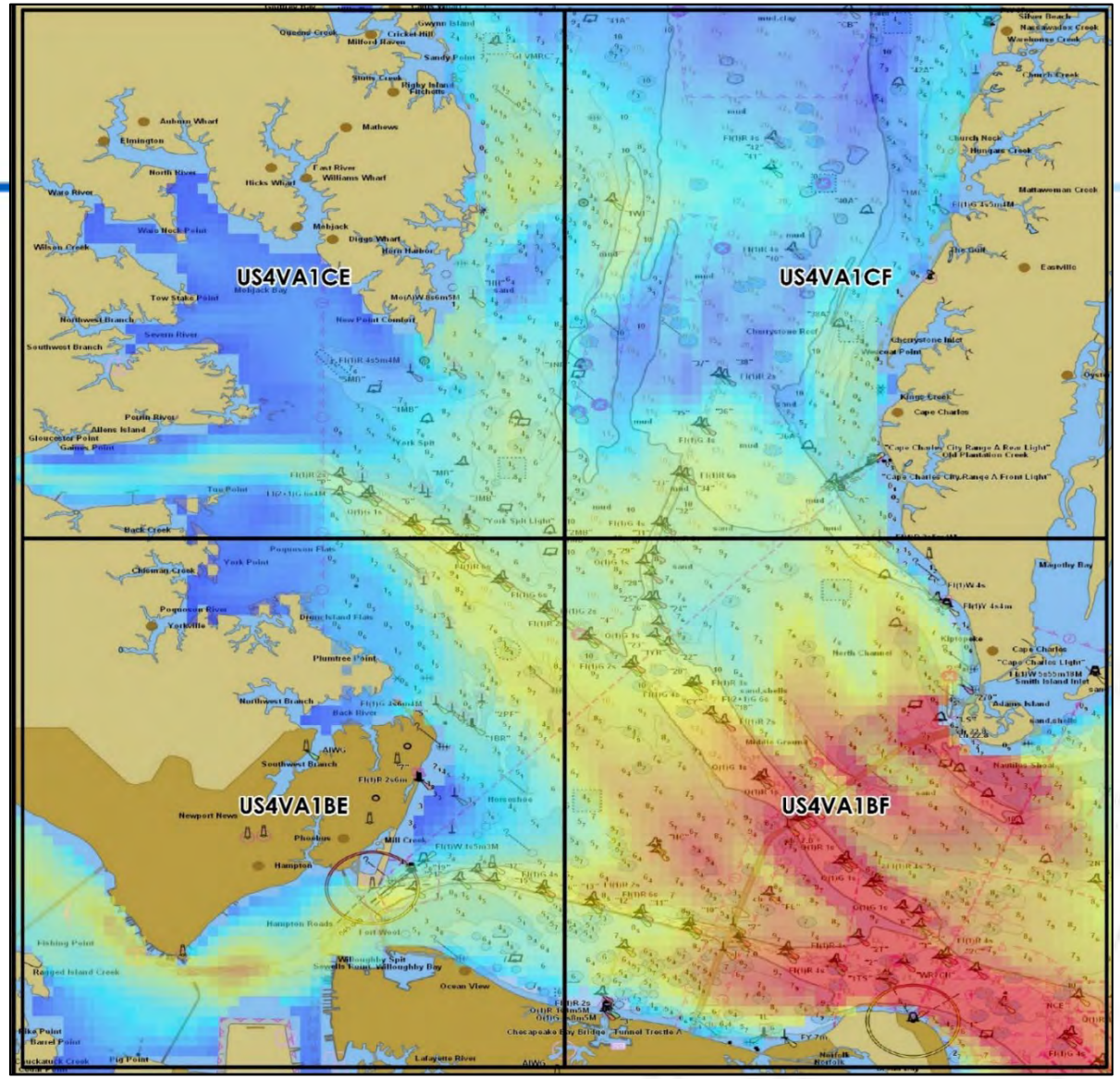
Parameter: Surface currents

Coordinate System: WGS 84

Dataset: 72 hours, 1 hr intervals

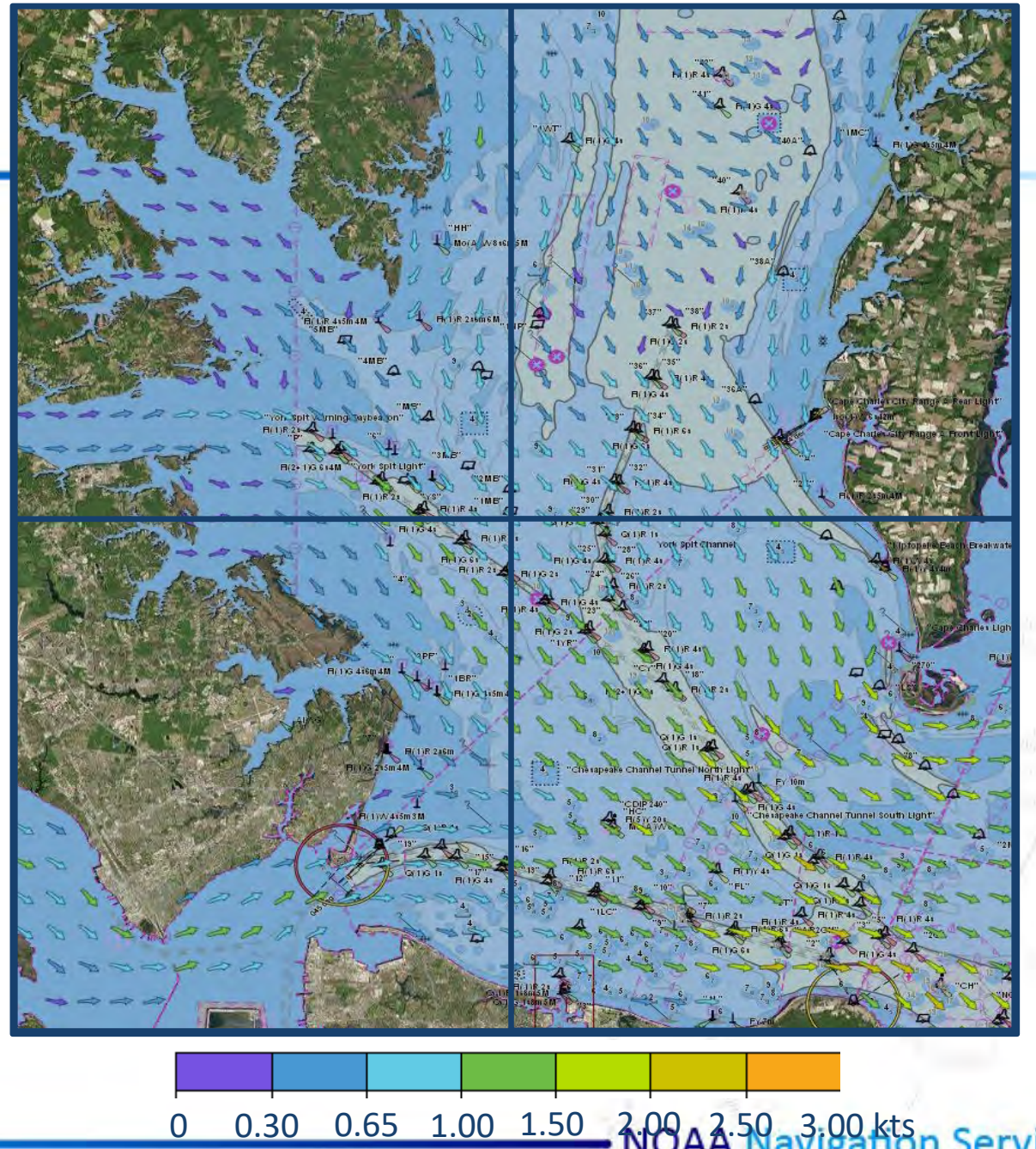
Time Zone: UTC

Date: 19:00 December 3rd, 2018



Lower Chesapeake Bay

ENC Band: 4
Format: S-111 w/ HDF5 encoding
Grid Resolution: 0.01 deg
Parameter: Surface currents
Coordinate System: WGS 84
Dataset: 72 hours, 1 hr intervals
Time Zone: UTC
Date: 19:00 December 3rd, 2018



NOAA Electronic Navigation Charts (ENC)

ENC Band: 4

OFS: Chesapeake Bay, Delaware Bay, New York Harbor

Format: S-111 w/ HDF5 encoding

Grid Resolution: 0.01 deg

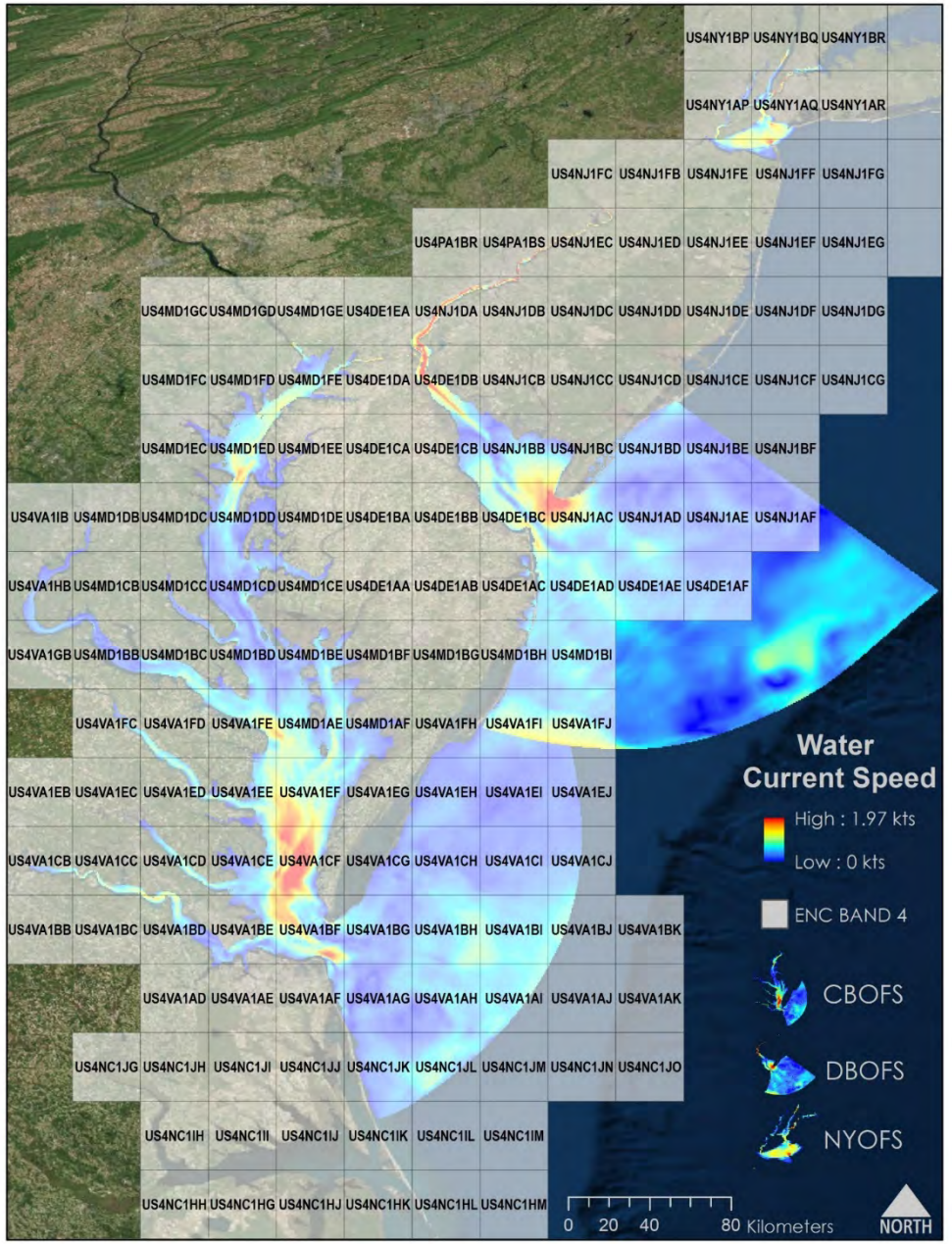
Parameter: Surface currents

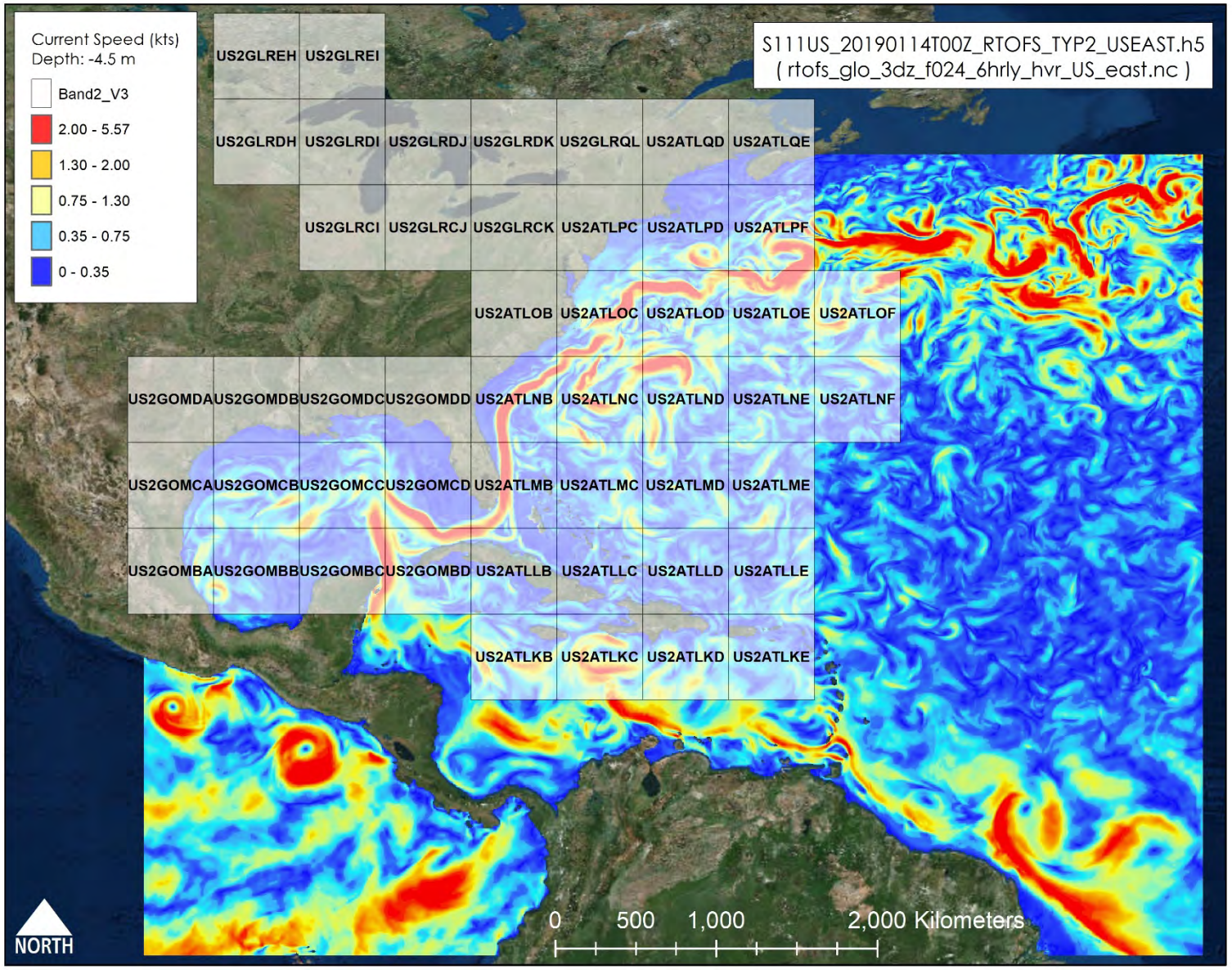
Coordinate System: WGS 84

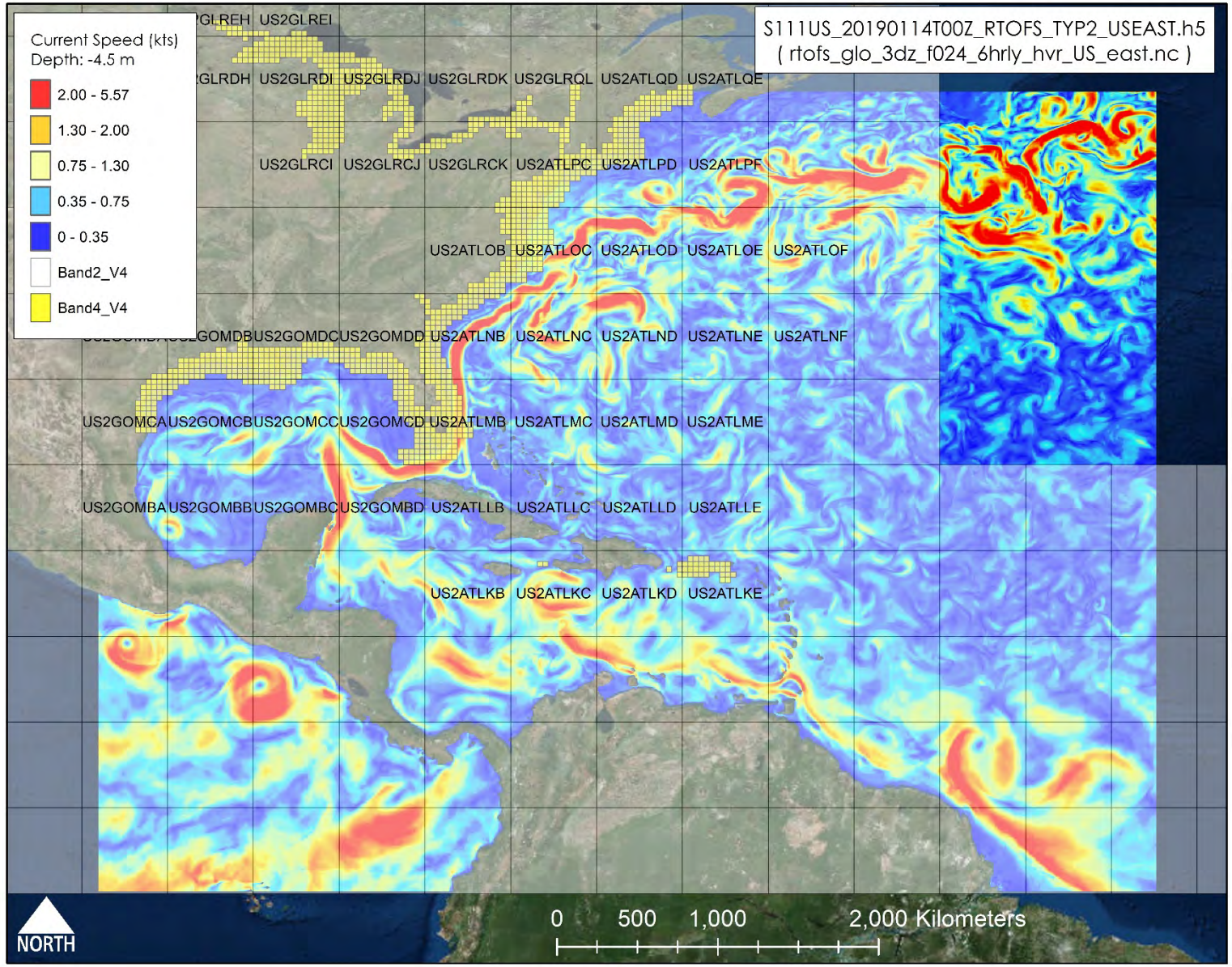
Dataset: 72 hours, 1 hr intervals

Time Zone: UTC

Date: 19:00 December 3rd, 2018




Current Speed (kts)
Depth: -4.5 m
Band2_V3
2.00 - 5.57
1.30 - 2.00
0.75 - 1.30
0.35 - 0.75
0 - 0.35
S111US_20190114T00Z_RTOFS_TYP2_USEAST.h5
(rtofs_glo_3dz_f024_6hrly_hvr_US_east.nc)
US2GLREH US2GLREI
US2GLRDH US2GLRDI US2GLRDJ US2GLRDK US2GLRQL US2ATLQD US2ATLQE
US2GLRCI US2GLRCJ US2GLRCK US2ATLPC US2ATLPD US2ATLPF
US2ATLOB US2ATLOC US2ATLOD US2ATLOE US2ATLOF
US2GOMDA US2GOMDB US2GOMDC US2GOMDD US2ATLNB US2ATLNC US2ATLND US2ATLNE US2ATLNF
US2GOMCA US2GOMCB US2GOMCC US2GOMCD US2ATLMB US2ATLMC US2ATLMD US2ATLME
US2GOMBA US2GOMBB US2GOMBC US2GOMBD US2ATLLB US2ATLLC US2ATLLD US2ATLLE
US2ATLKB US2ATLKC US2ATLKD US2ATLKE
NORTH
0 500 1,000 2,000 Kilometers


S111US_20190114T00Z_RTOFS_TYP2_USEAST.h5
(rtofs_glo_3dz_f024_6hrly_hvr_US_east.nc)
Current Speed (kts)
Depth: -4.5 m
2.00 - 5.57
1.30 - 2.00
0.75 - 1.30
0.35 - 0.75
0 - 0.35
Band2_V4
Band4_V4
US2GLREH US2GLREI
US2GLRDH US2GLRDI US2GLRDJ US2GLRDK US2GLRQL US2ATLQD US2ATLQE
US2GLRCI US2GLRCJ US2GLRCK US2ATLPC US2ATLPD US2ATLPF
US2ATLOB US2ATLOC US2ATLOD US2ATLOE US2ATLOF
GOMDB US2GOMDC US2GOMDD US2ATLNB US2ATLNC US2ATLND US2ATLNE US2ATLNF
US2GOMCA US2GOMCB US2GOMCC US2GOMCD US2ATLMB US2ATLMC US2ATLMD US2ATLME
US2GOMBA US2GOMBB US2GOMBC US2GOMBD US2ATLLB US2ATLLC US2ATLLD US2ATLLE
US2ATLKB US2ATLKC US2ATLKD US2ATLKE
NORTH
0 500 1,000 2,000 Kilometers

Operational Forecast System - Applications

Hydrography

Route survey
Habitat mapping
Deep sea mining
Charting
EEZ survey

Shipping

Precision Navigation *
Baseline environmental assessment
Geophysical survey
Pipeline survey
Debris/clearance survey
Route optimization

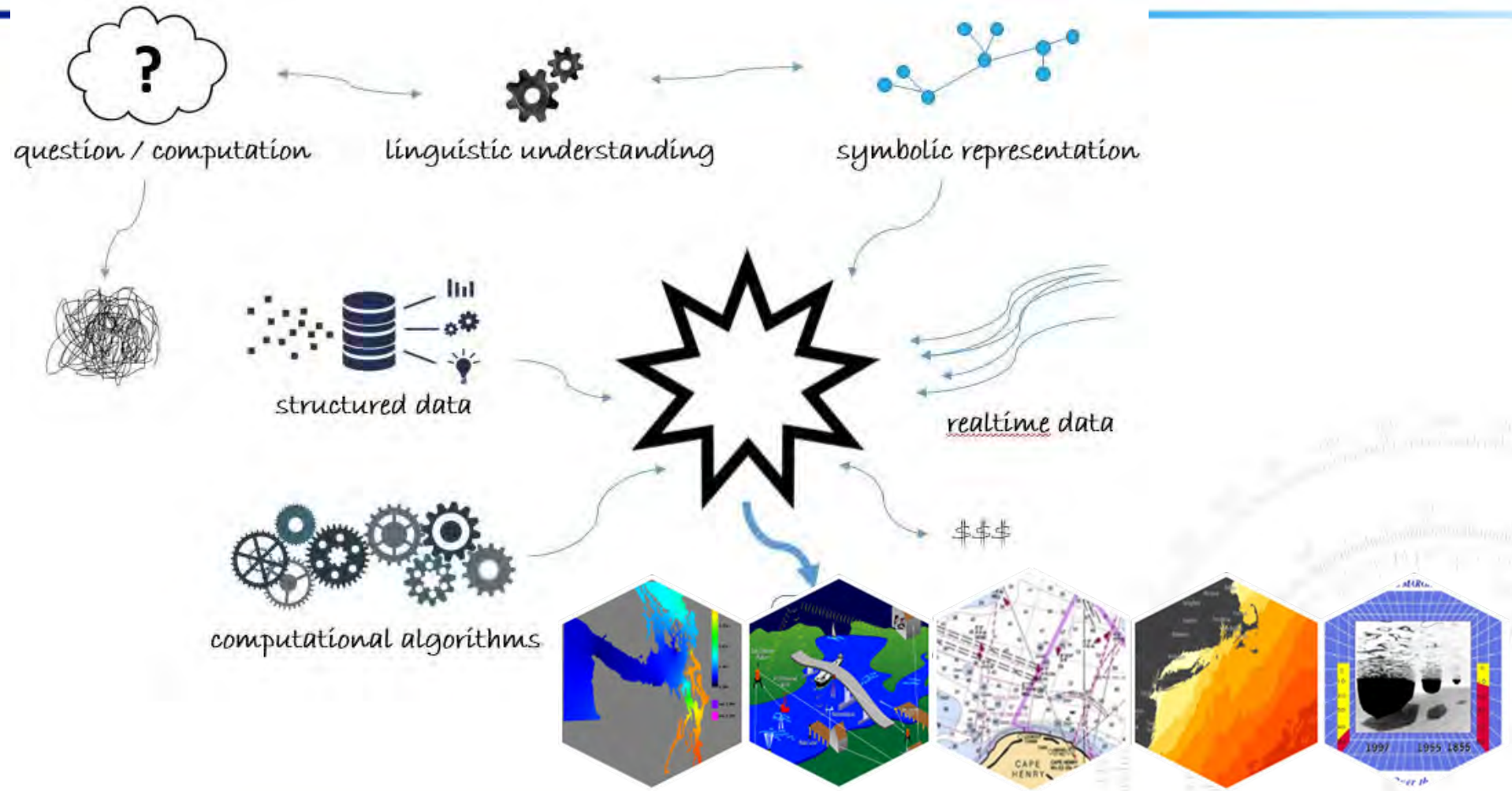
Environmental Monitoring

Emergency response
Water quality
Ecosystem assessment
Spill assessment

Search & Recovery

Asset location
Marine archaeology

Precision Navigation



Precision Navigation – Economic Benefits

- Single streamlined decision support tool to
  - Optimizes the available channel depth
  - Visualize data and environmental conditions
  - Real time data streams (currents, water levels, salinity etc.)
  - IHO standards and specifications (S-100 framework)

- The economic benefits of Precision Navigation will be
  - Increased margins of safety
  - Increased cargo capacity
  - Less delays in port
  - Decreased fuel usage
  - Increase port utilization

Precision Navigation – Challenges

- Today's charts are not meeting the needs of mariners
- Need higher resolution, with real-time information
- Low under-keel clearances on many rivers
- Waves can dominate in many approaches during winter storms
- Air gaps on bridges are tight and getting tighter
- Better water level forecasts are needed
- Fog
- Diverse vertical datums
- Anchorages are crowded
- Discrete versus continuous data

Precision Navigation – Tools and Data

- Enhanced and integrated decision support tools
- Develop/expand risk reduction nowcast/forecast models
- Provide chart information in standard formats
- IHO Standards and Specifications (S-100, S-111, S-412)
- Vessel Traffic Control Systems
- Portable Pilot Units, iPads

Precision Navigation Data Dissemination

- Building out an S-100 based data discovery mechanism for dissemination of data
  - Proof of Concept – S-111 Surface Currents
  - Initial Operating Capability:
    - 2020 – S-111 Surface Currents
    - 2020 – S-102 High Resolution Bathymetry
    - 2021 – S-104 Water Levels
    - 2022 – S-101 Electronic Navigational Charts