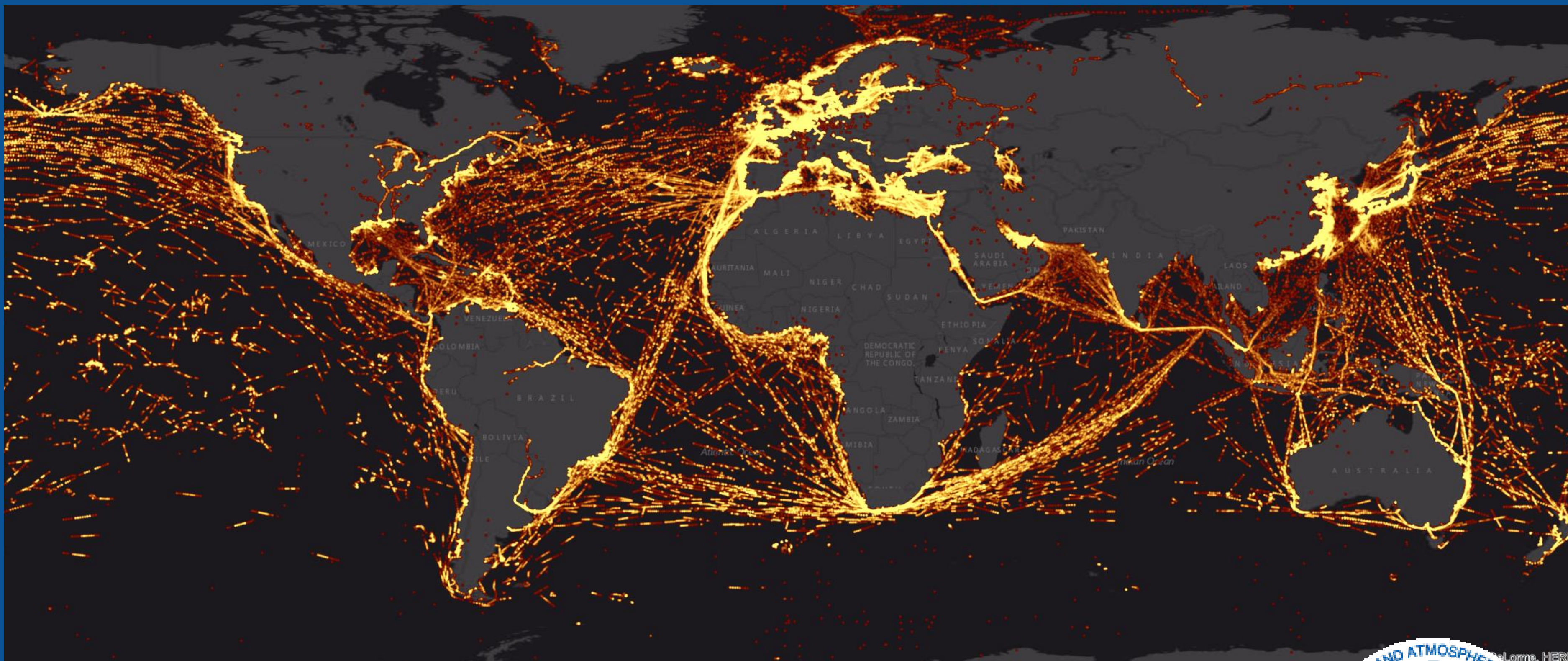
Initiatives in Using Crowdsourcing, Satellite Derived Bathymetry, and Other Non-Traditional Hydrographic/Bathymetric Measurements in the Assessment and Improvement of NOAA Nautical Charts



GEBCO Science Day – Kuala Lumpur, Malaysia – 5 October 2015
LT Anthony Klemm, NOAA – Office of Coast Survey – Marine Chart Division

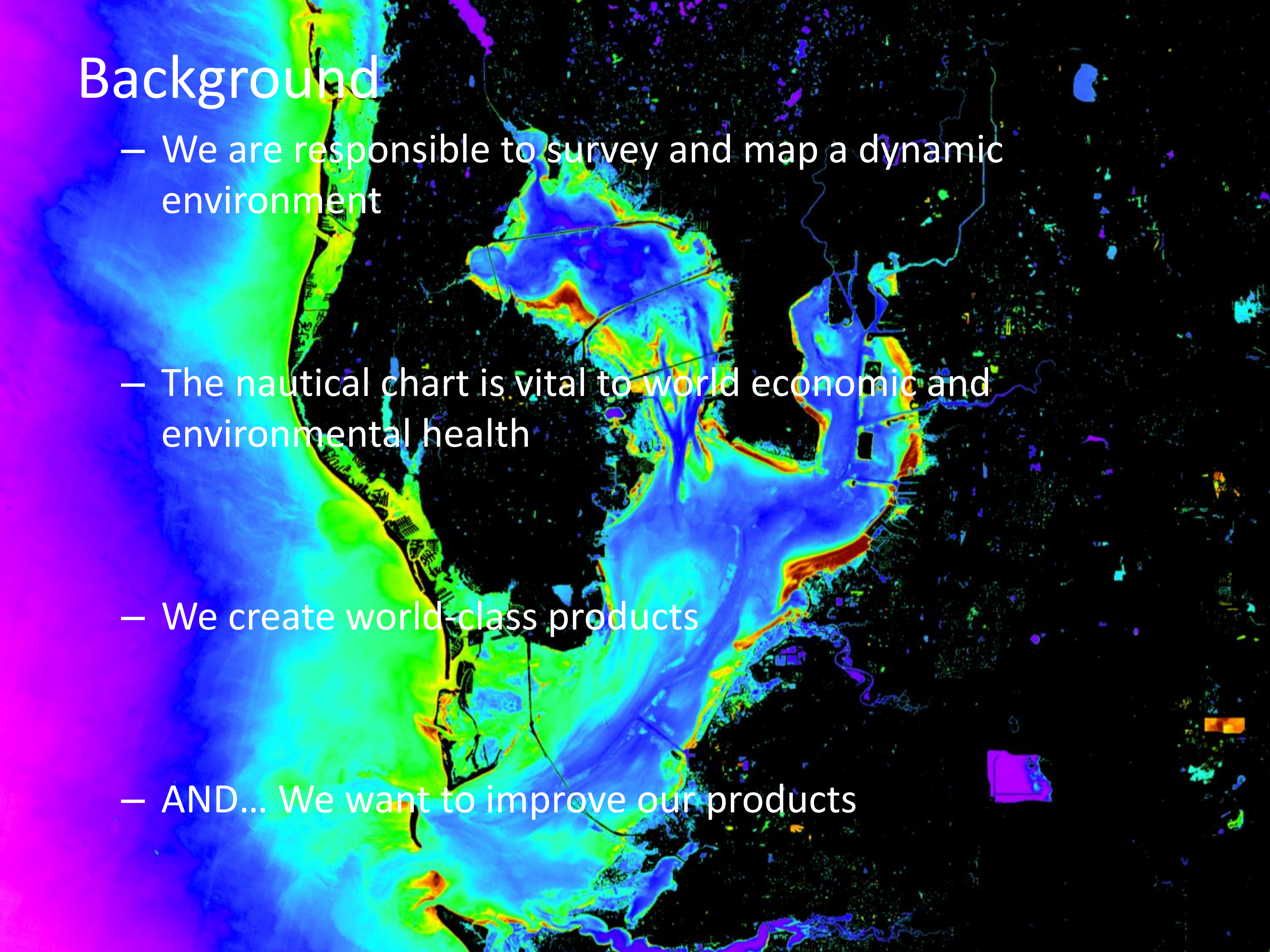
Agenda

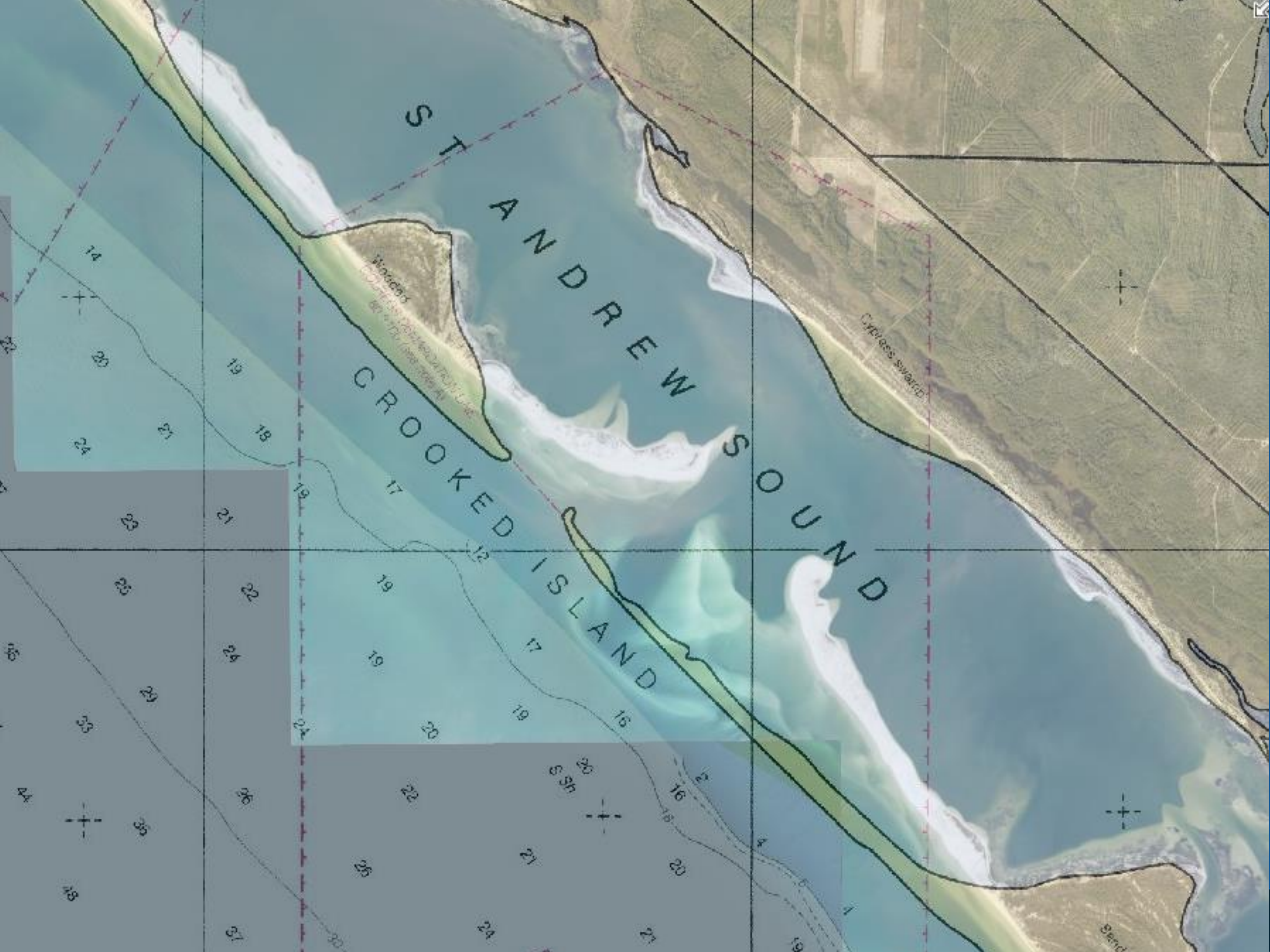
- Chart Adequacy Evaluation Procedure
- 1st NOAA/GEBCO International Chart Adequacy Workshop
- Satellite Derived Bathymetry Applications
- Crowdsourced Bathymetry Initiatives

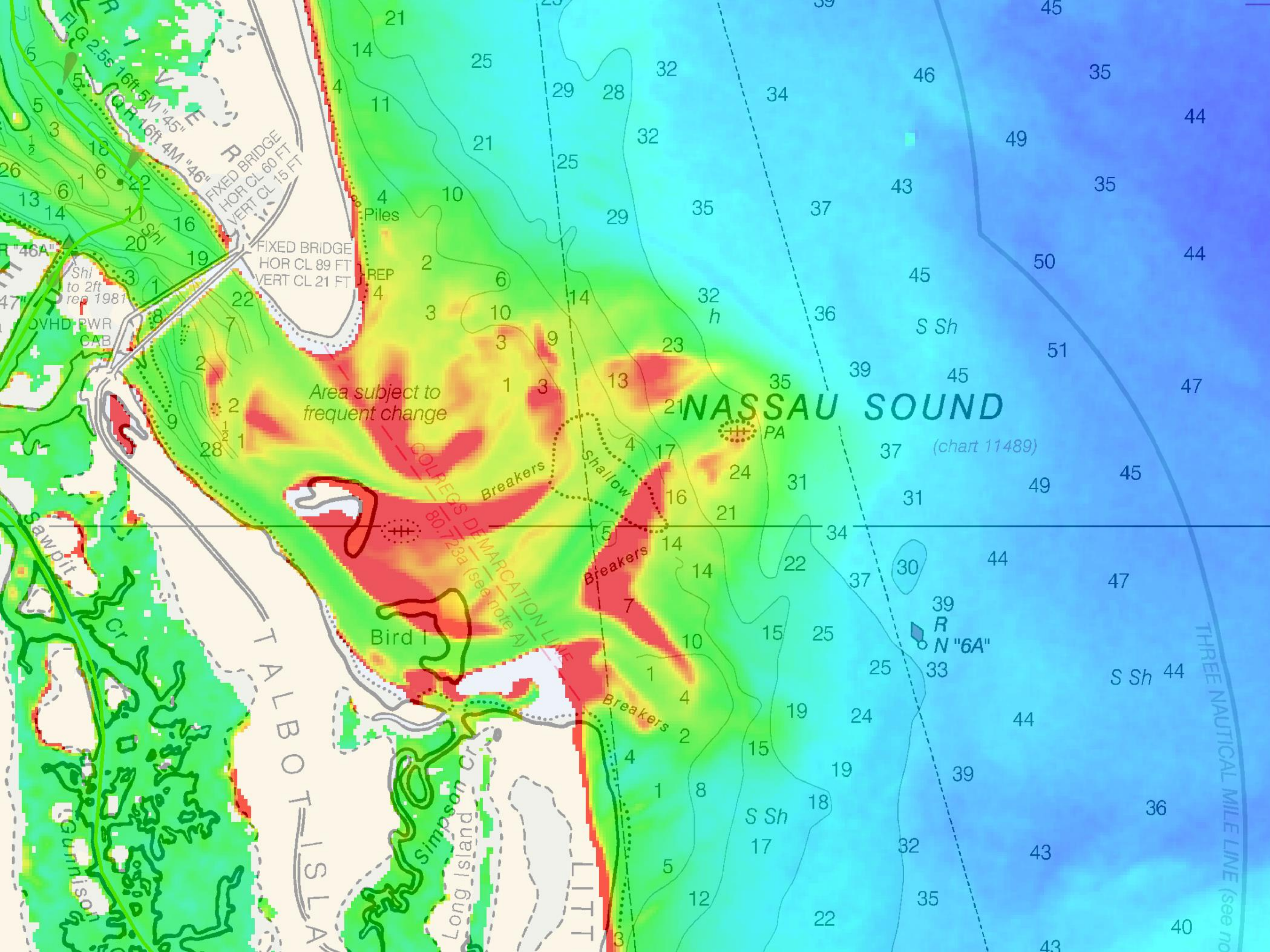
Courtesy: Hydrographische Nachrichten June 2013 (www.dhyg.de)

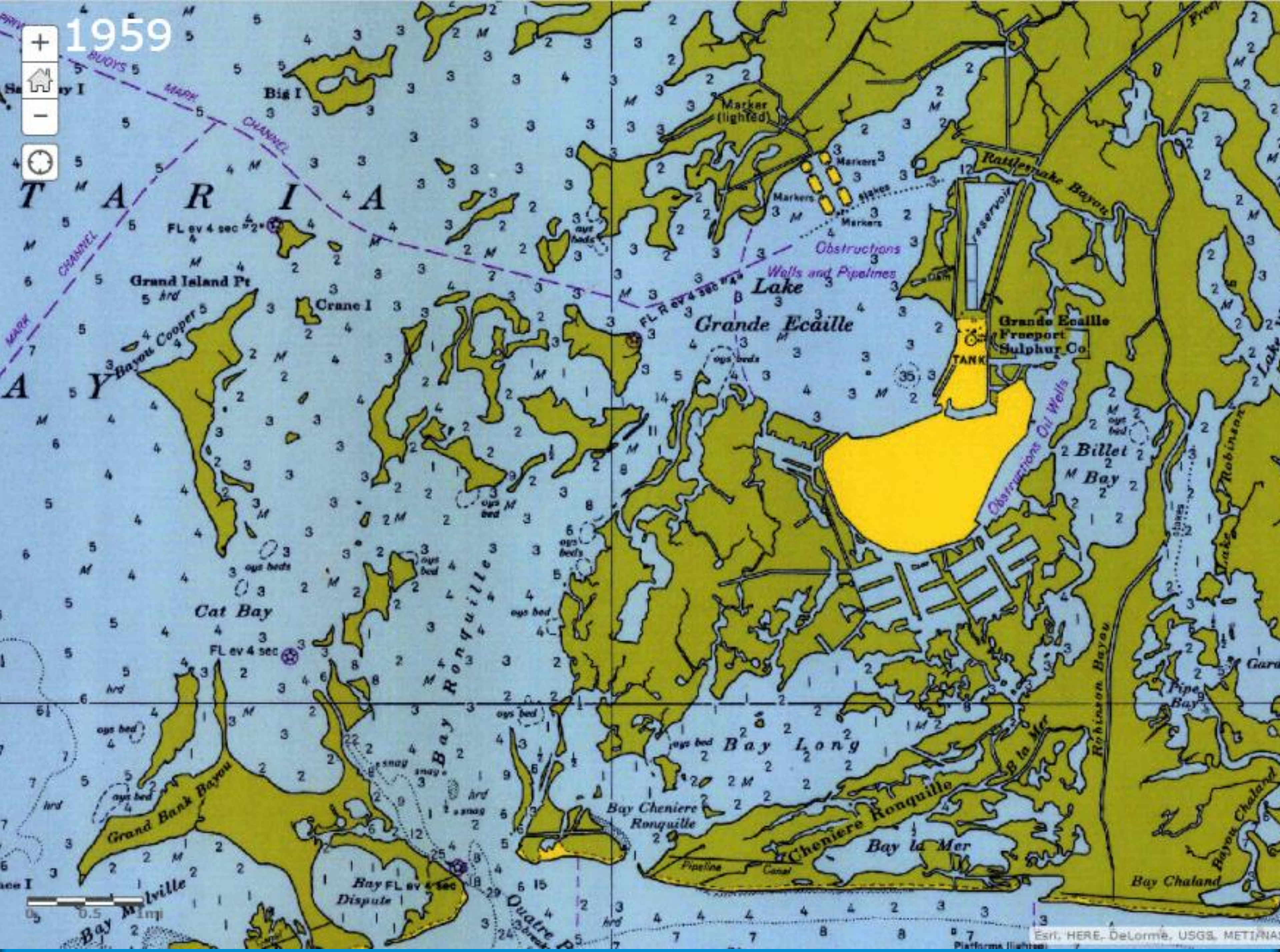
Background

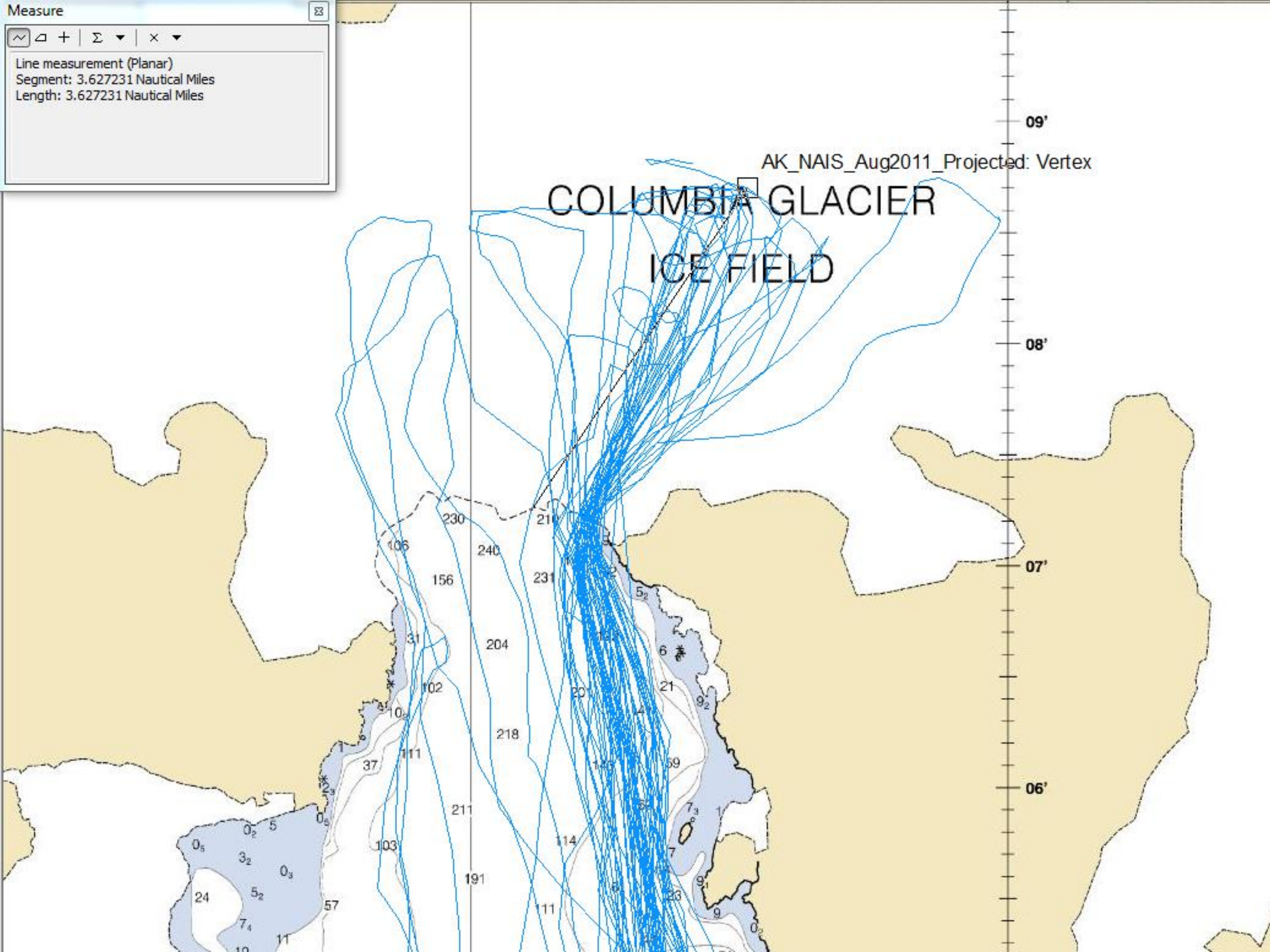
- We are responsible to survey and map a dynamic environment
- The nautical chart is vital to world economic and environmental health
- We create world-class products
- AND… We want to improve our products

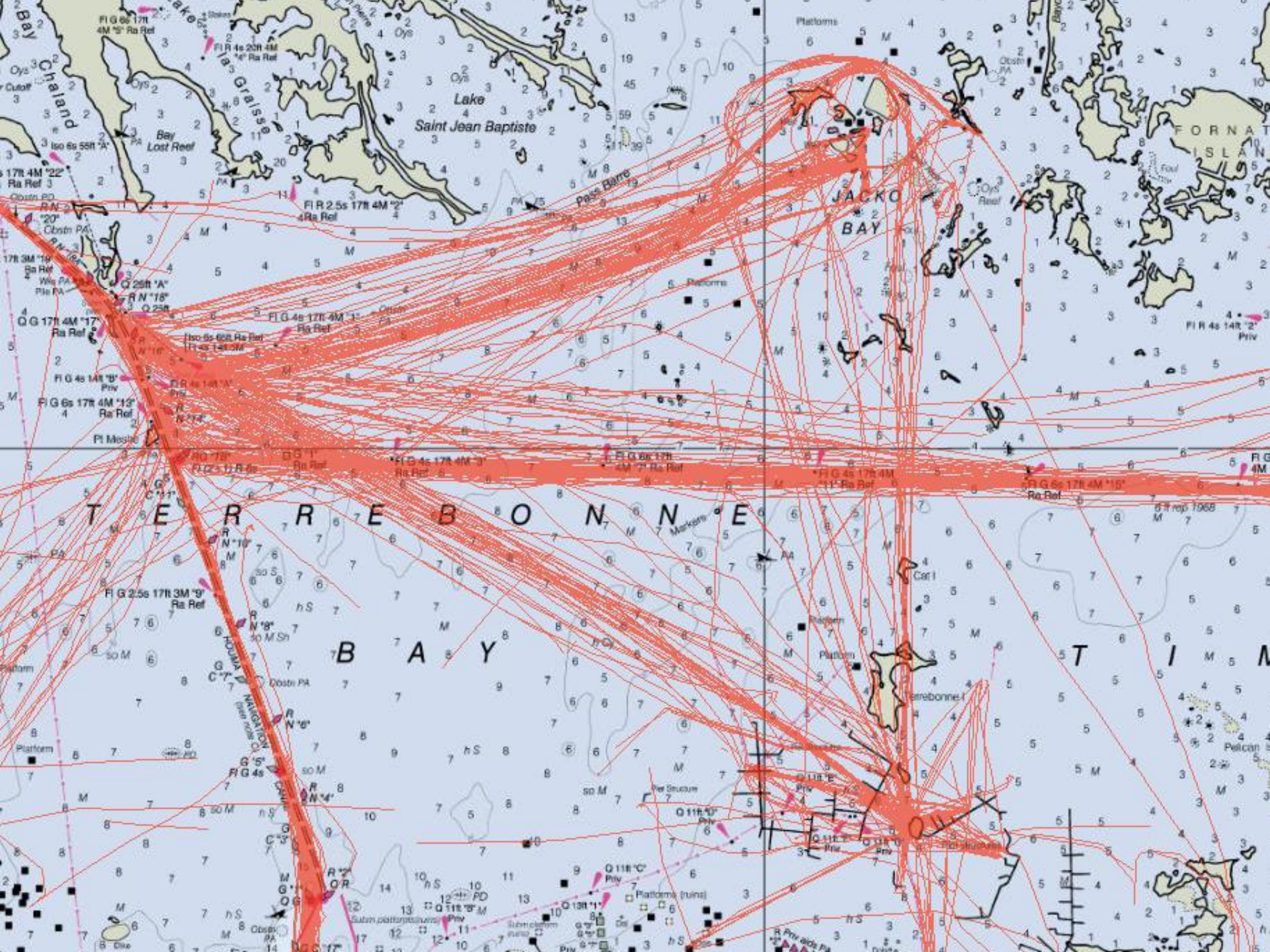



ST ANDREW SOUND
CROOKED ISLAND
Wooded
Cypress swamp

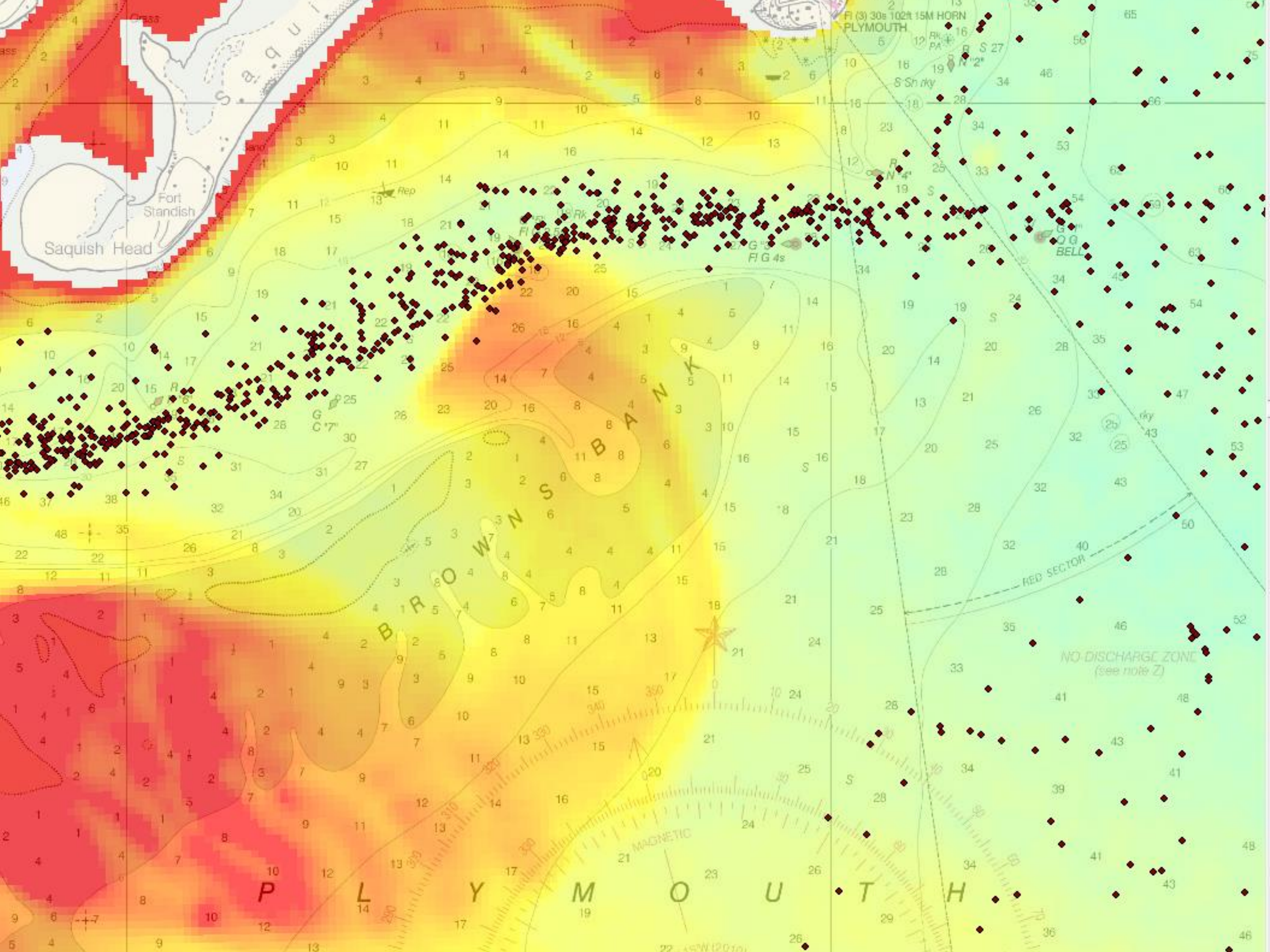

NASSAU SOUND
(chart 11489)
Area subject to
frequent change
FIXED BRIDGE
HOR CL 89 FT
VERT CL 21 FT
FIXED BRIDGE
HOR CL 60 FT
VERT CL 15 FT
OVHD PWR
CAB
Piles
REP
Breakers
Shallow
Breakers
Breakers
COLREGS DEMARCATION LINE
80.723a (see note A)
Bird I
TALBOT ISLA
Sawpit Cr
Simpson Cr
Long Island
Gunnison
PA
S Sh
S Sh
S Sh
R
N "6A"
THREE NAUTICAL MILE LINE (see no


1959
Big I
Grand Island Pt
Crane I
Bayou Cooper
Cat Bay
Marker (lighted)
Markers
Stakes
Obstructions
Wells and Pipelines
Lake
Grande Ecaille
Rattlesnake Bayou
reservoir
Grande Ecaille Freeport Sulphur Co
TANK
Obstructions Oil Wells
Billet Bay
Bay Ronquille
Bay Long
Bay Cheniere Ronquille
Cheniere Ronquille
B la Mer
Bay la Mer
Robinson Bayou
Pipe Bay
Bayou Chaland
Bay Chaland
Grand Bank Bayou
Bay Dispute
Pipeline Canal
FL ev 4 sec
oys bed
CHANNEL
MARK
BUOYS
Esri, HERE, DeLorme, USGS, METI/NASA

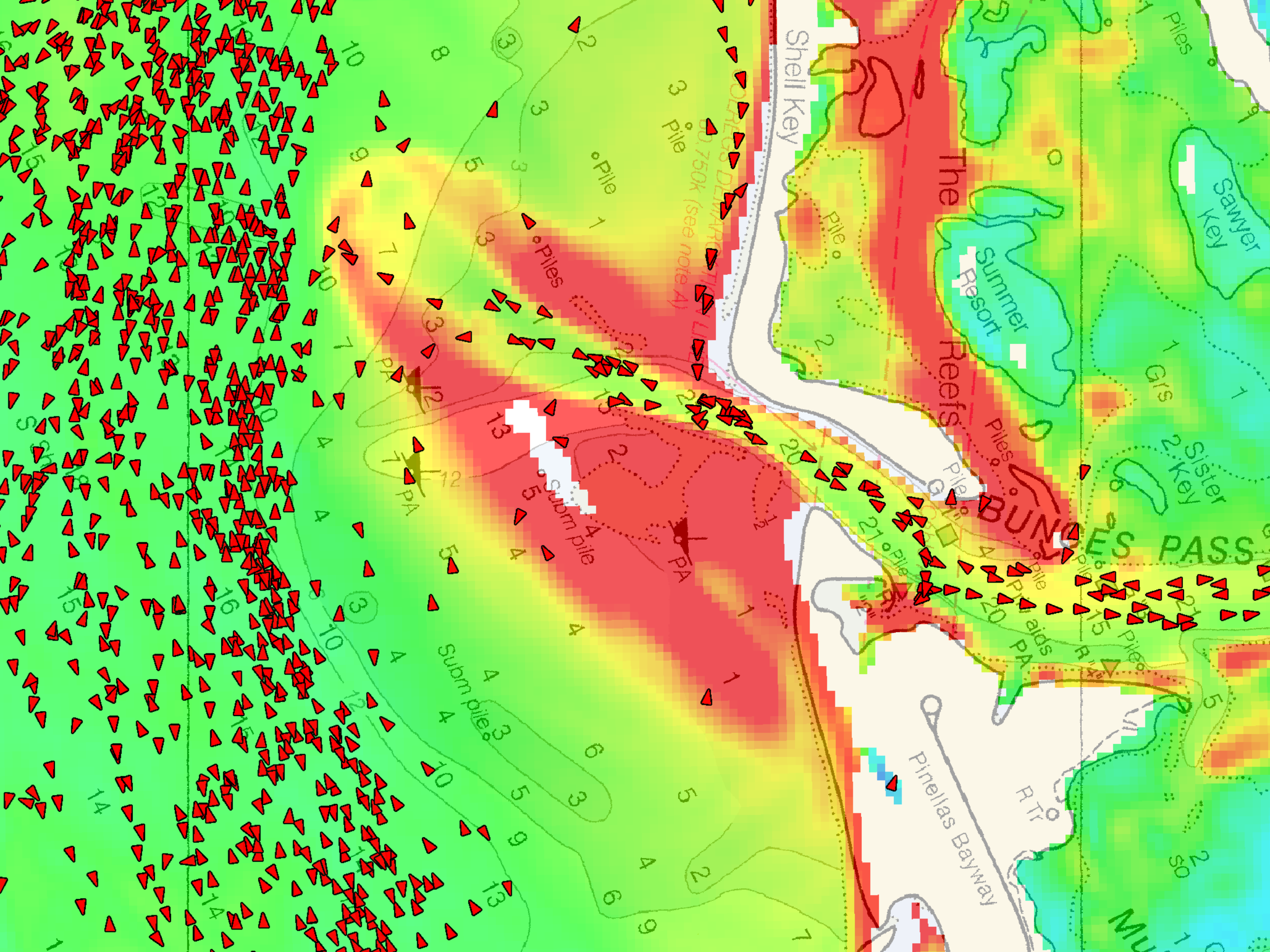

Measure
Line measurement (Planar)
Segment: 3.627231 Nautical Miles
Length: 3.627231 Nautical Miles
09'
AK_NAIS_Aug2011_Projected: Vertex
COLUMBIA GLACIER
ICE FIELD
08'
07'
06'
230
240
210
156
231
204
218
211
191
103
114



Lake Saint Jean Baptiste
Bay Lost Reef
Pass Barre
J A C K O
B A Y
T E R R E B O N N E
B A Y
Platforms
Platform
Terrebonne I
Cat I
Pelican
Fl R 2.5s 17ft 4M "2"
Fl G 4s 17ft 4M "11" Ra Ref
Fl G 6s 17ft 4M "15" Ra Ref
Fl G 2.5s 17ft 3M "9" Ra Ref
Fl R 4s 14ft "2" Priv
Platforms (ruins)
Obstn PA



Fl (3) 30s 102ft 15M HORN
PLYMOUTH
Saquish Head
Fort Standish
BROWNS BANK
Fl G 4s
BELL
RED SECTOR
NO DISCHARGE ZONE
(see note Z)
MAGNETIC
P L Y M O U T H


Shell Key
The Reefs
Summer Resort
Sawyer Key
Sister Key
BUNCES PASS
Pinellas Bayway
Subm pile
Piles
Pile
PA

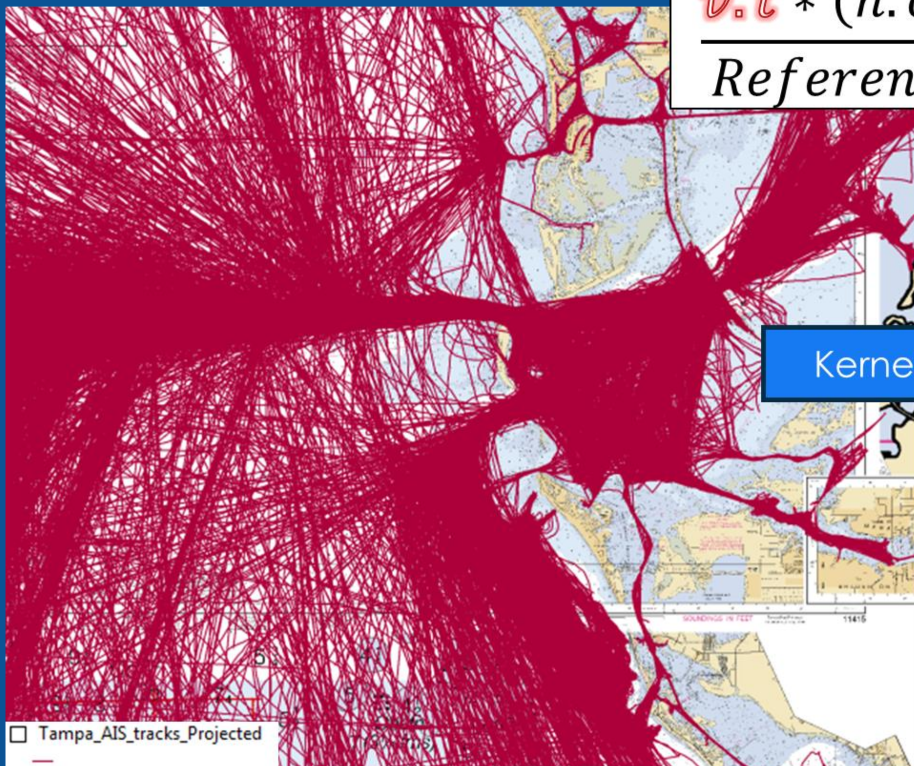
“Why would we ever print a chart we know is wrong?”

-CAPT Shep Smith
Former Chief,
NOAA Marine Chart Division

Chart Adequacy Procedure

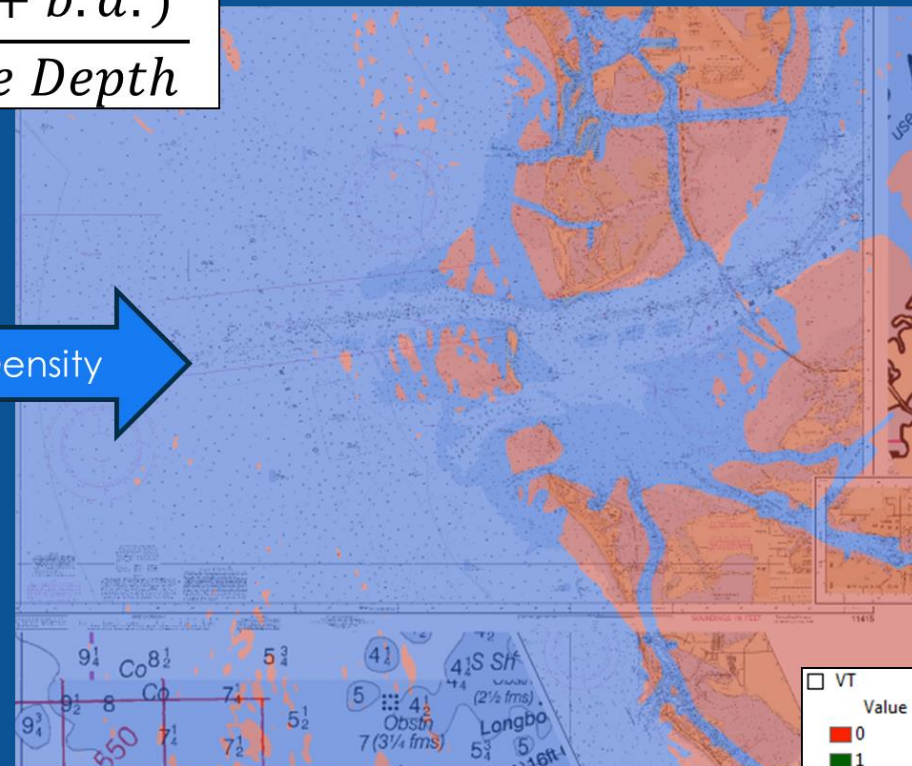
Vessel Traffic Layer – AIS Processing

$$\frac{v.t * (h.c + b.d.)}{Reference\ Depth}$$



One year of historical AIS tracks

Kernel Density

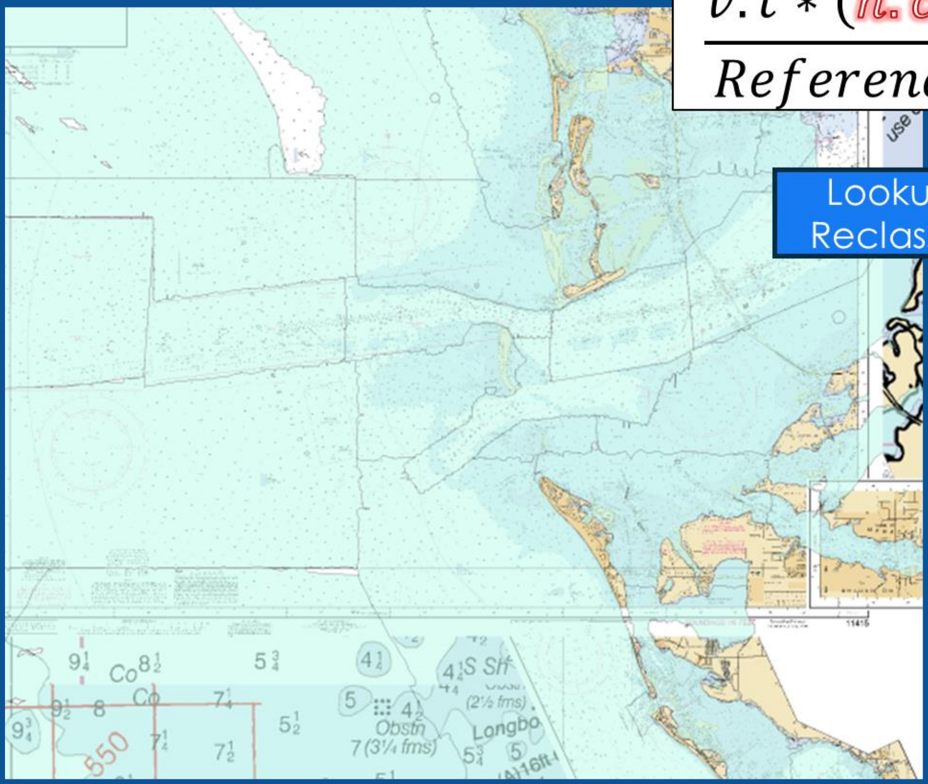


VT Layer – Buffered 300m for 2 or more tracks

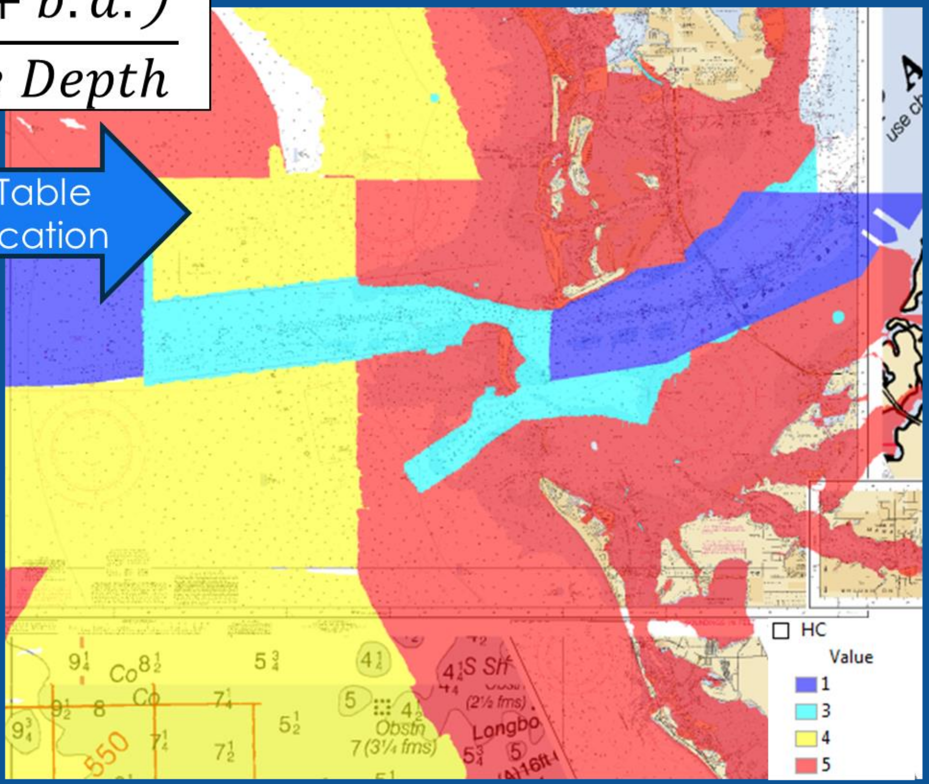
Hydrographic Characteristics Layer

$$\frac{v.t * (h.c + b.d.)}{Reference\ Depth}$$

Lookup Table Reclassification



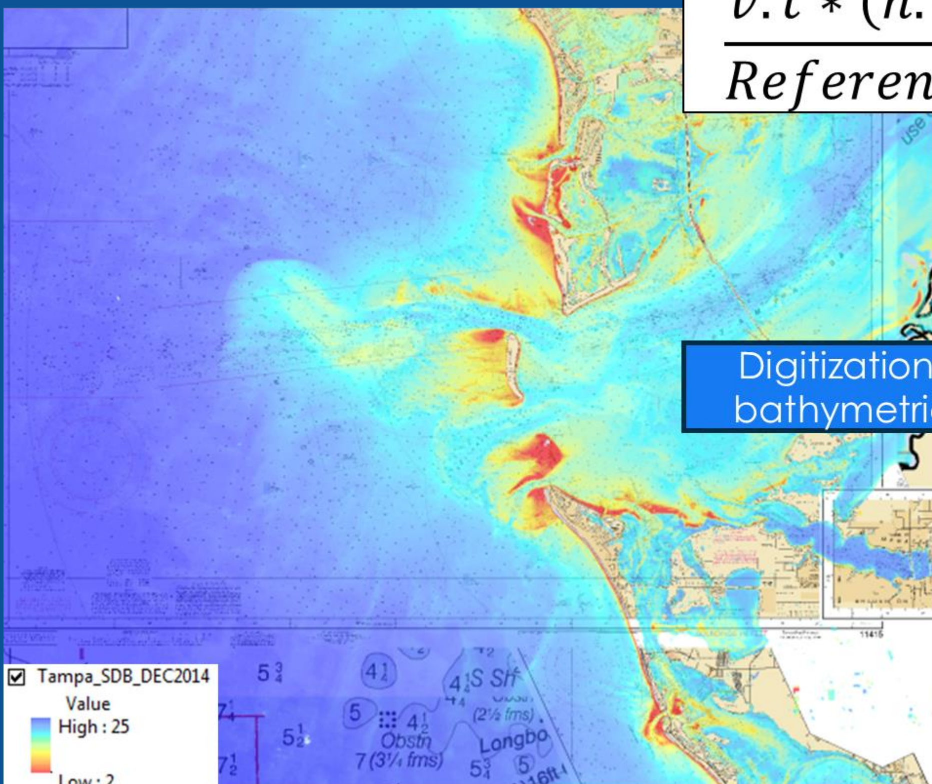
Most recent hydrographic survey outlines



HC Layer – classified based on survey date, technology, and bottom coverage

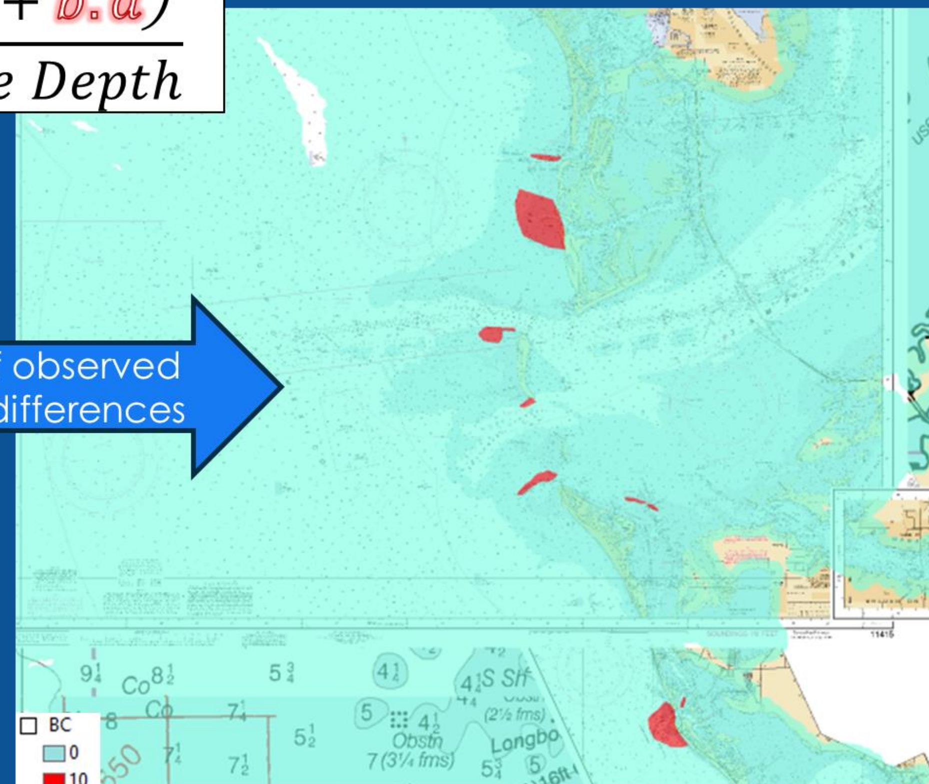
Bathymetric Difference Layer

$$\frac{v.t * (h.c + b.d)}{Reference\ Depth}$$



Satellite-Derived Bathymetry (or survey of opportunity)

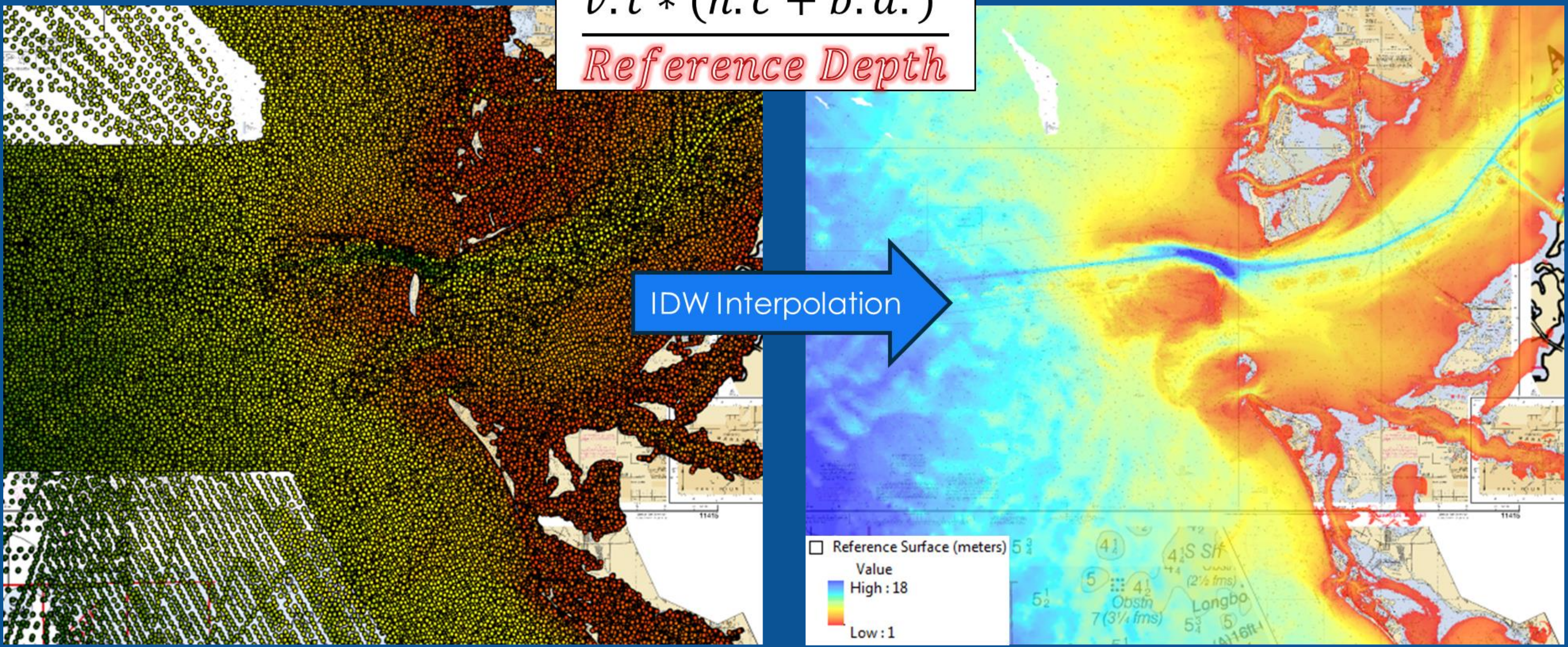
Digitization of observed bathymetric differences



BD Layer – Observed bathymetric chart discrepancies

Charted Depth (Reference Depth)

$$\frac{v.t * (h.c + b.d.)}{\textit{Reference Depth}}$$



Historical Smooth (Fair) Sheet Soundings

Reference Surface

$$\frac{v.t * (h.c + b.d.)}{Reference\ Depth}$$

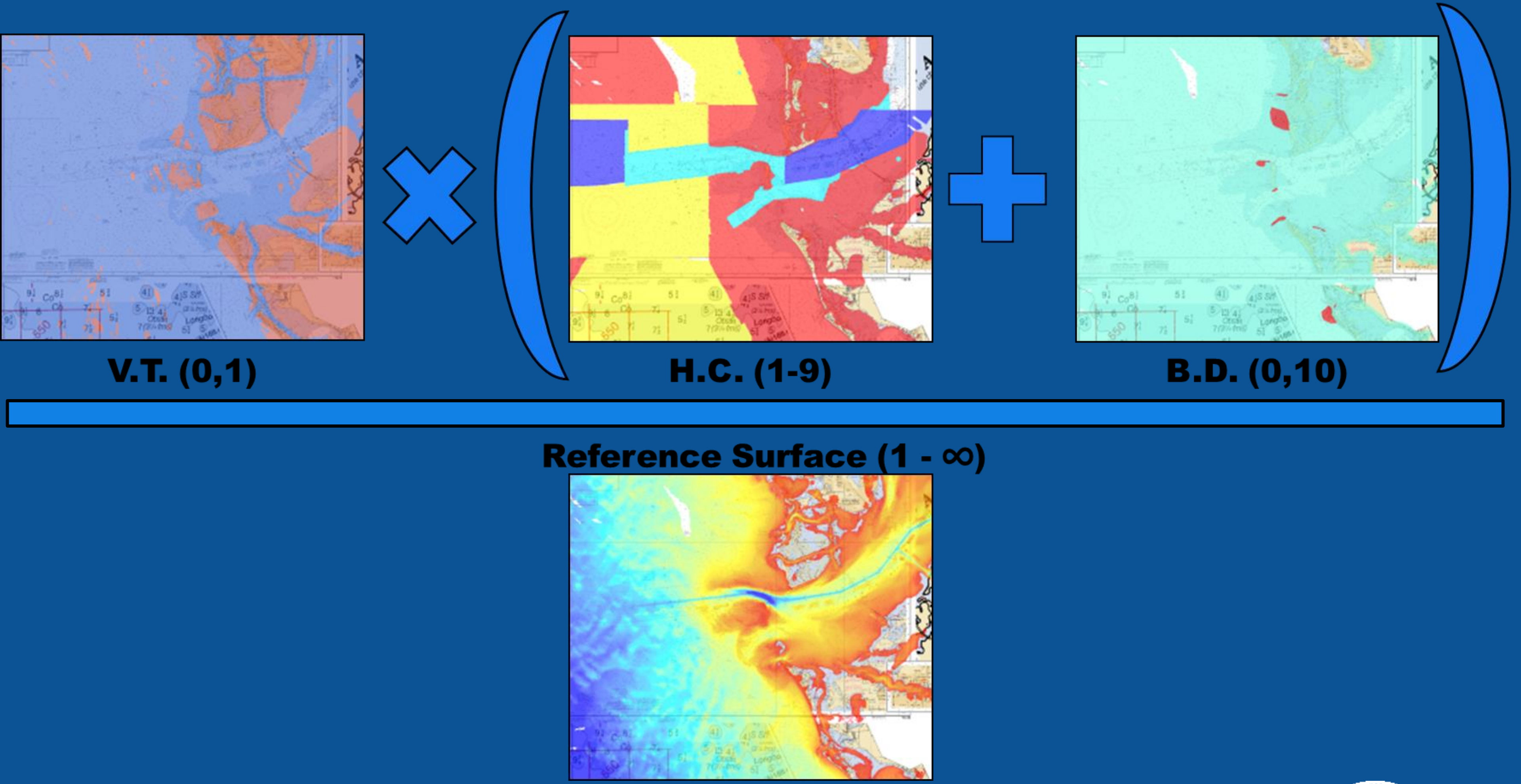


Chart Adequacy Final Product

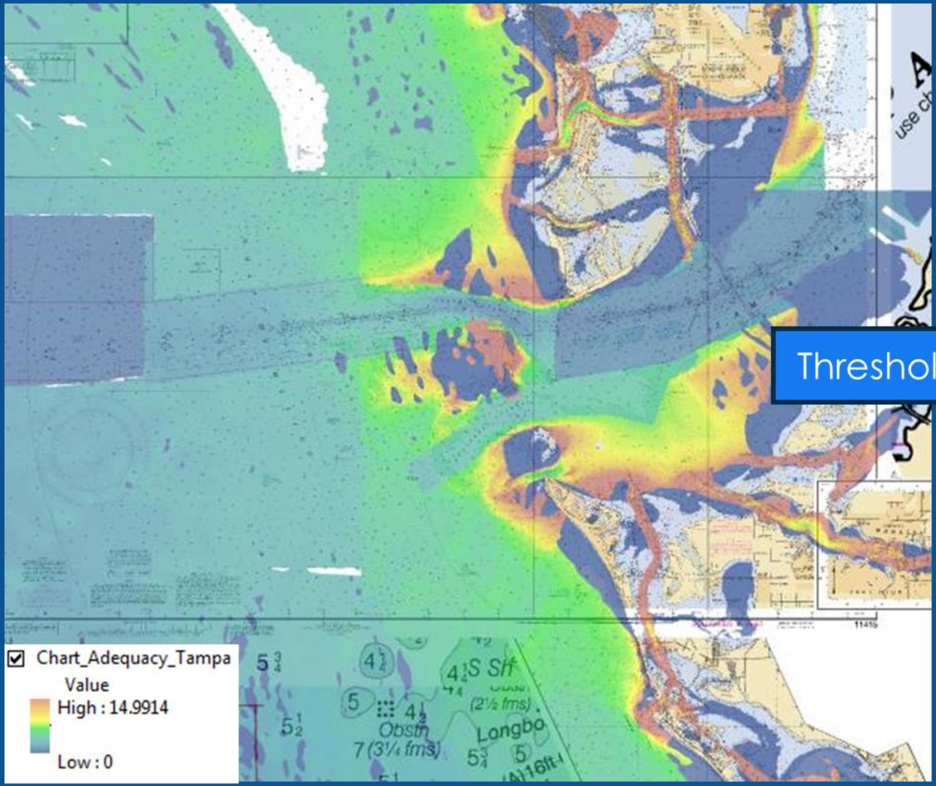
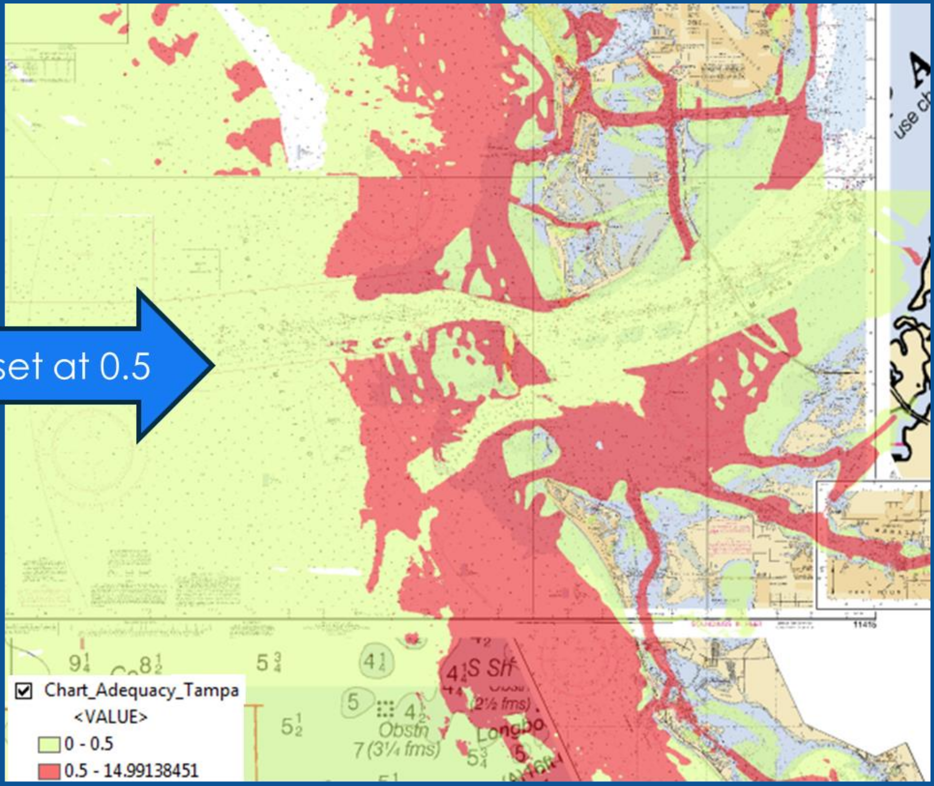


Chart Adequacy Stretched Visualization

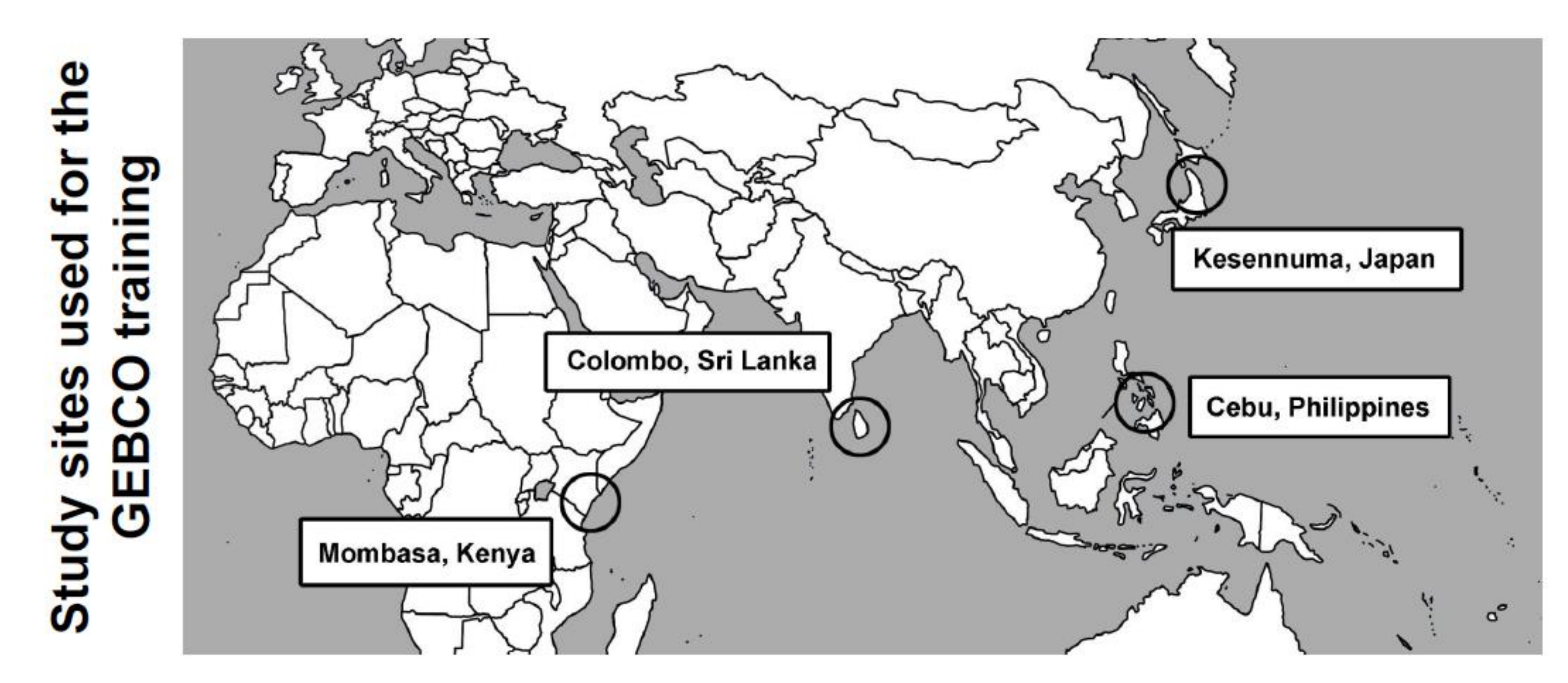
Threshold set at 0.5



0.5 Chart Adequacy Threshold

1st NOAA/GEBCO Chart Adequacy Workshop – Silver Spring, MD – July 2015

1st NOAA/GEBCO Chart Adequacy Workshop – Silver Spring, MD – July 2015



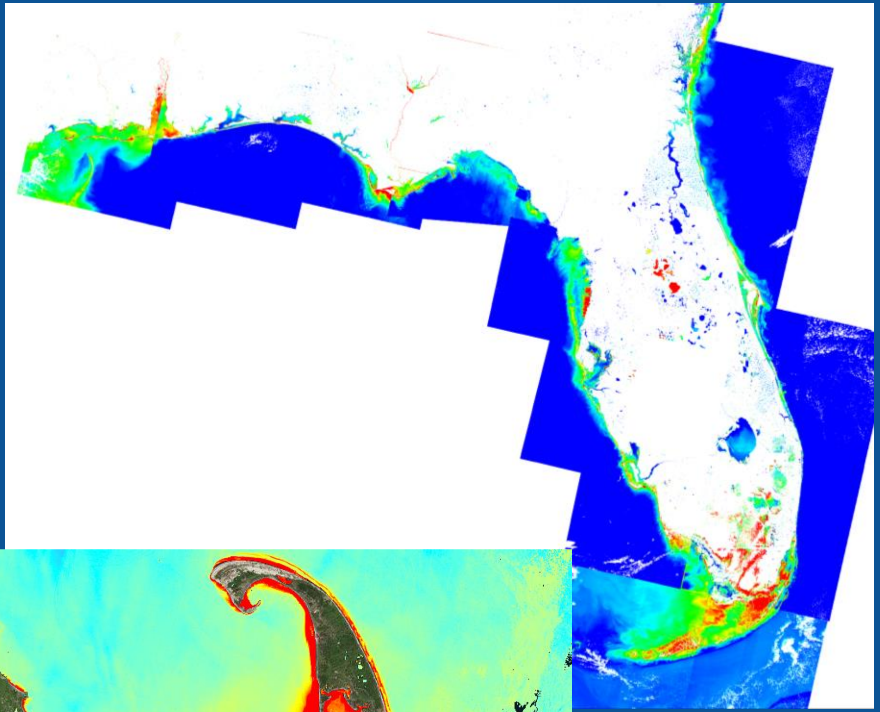
1st NOAA/GEBCO Chart Adequacy Workshop – Silver Spring, MD – July 2015

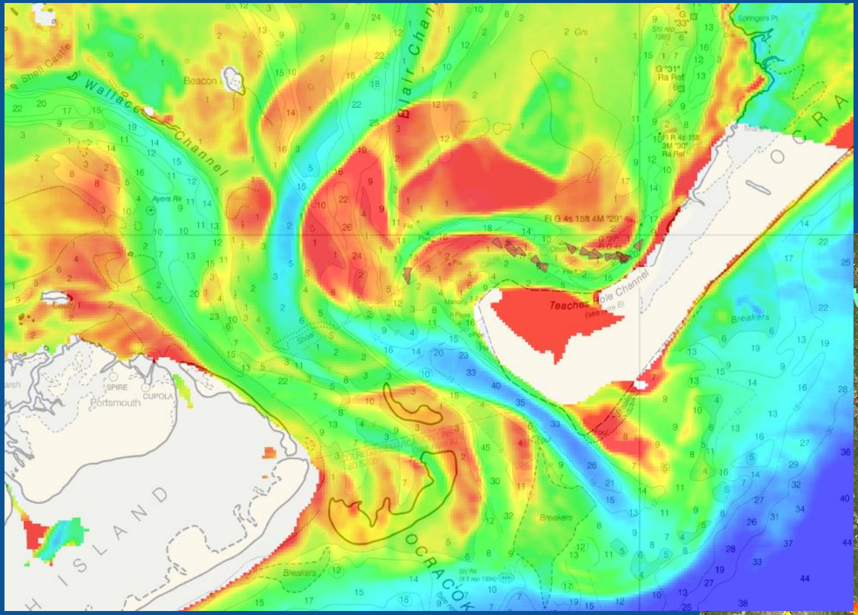
Next Workshop Scheduled for July 2016

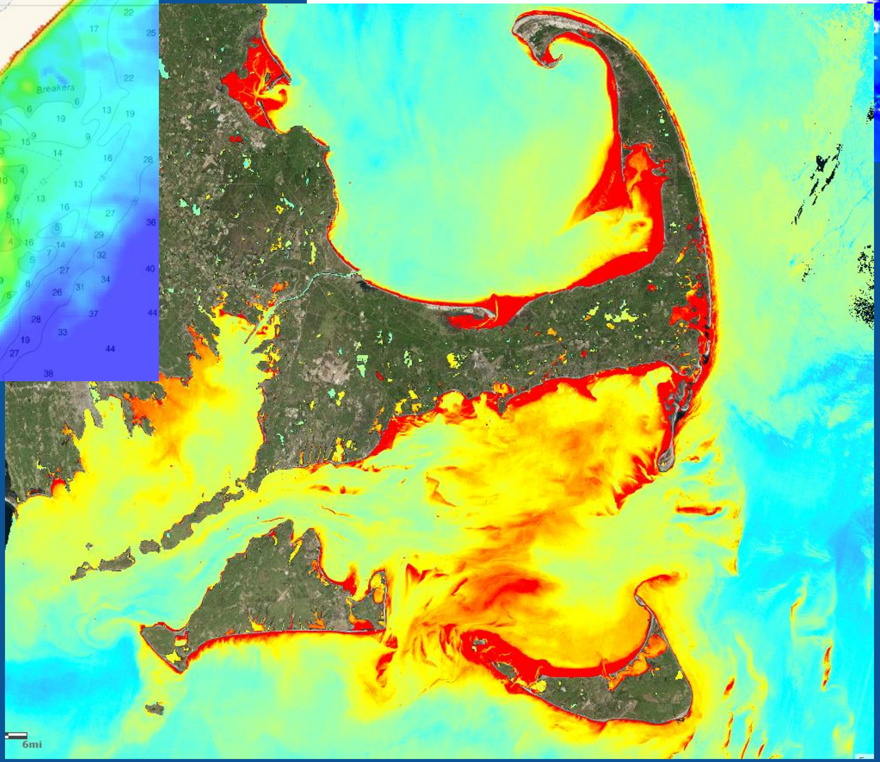
NOAA's vision to use Satellite Derived Bathymetry

- Reconnaissance value
  - Assess chart adequacy
  - Locate possible bathymetric discrepancies
- Selective application to the chart
  - Interim update until traditional survey techniques can be deployed to systematically survey the area
  - Updates are depicted as approximate, with corresponding caveats and notes on the chart

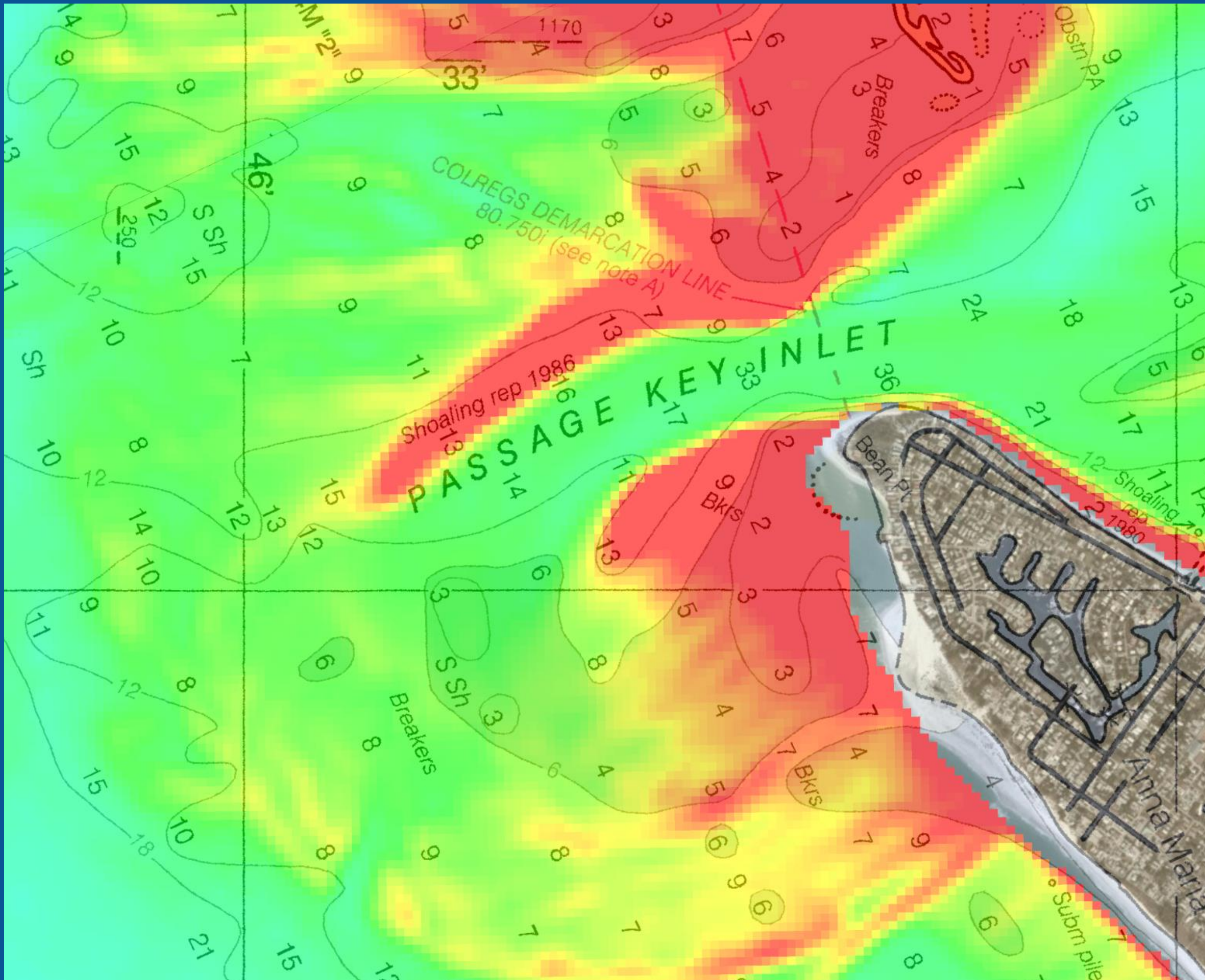
SDB as Reconnaissance

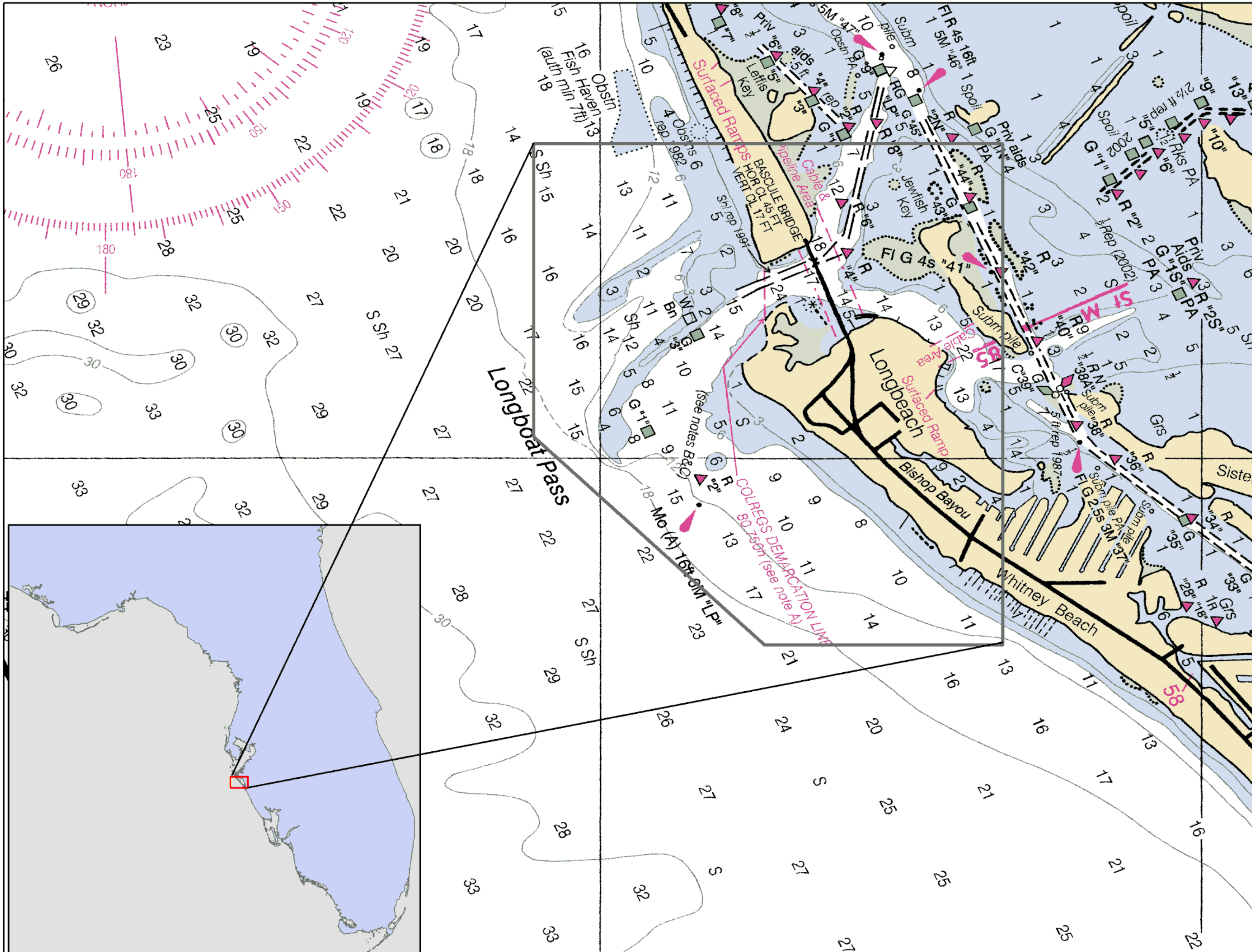




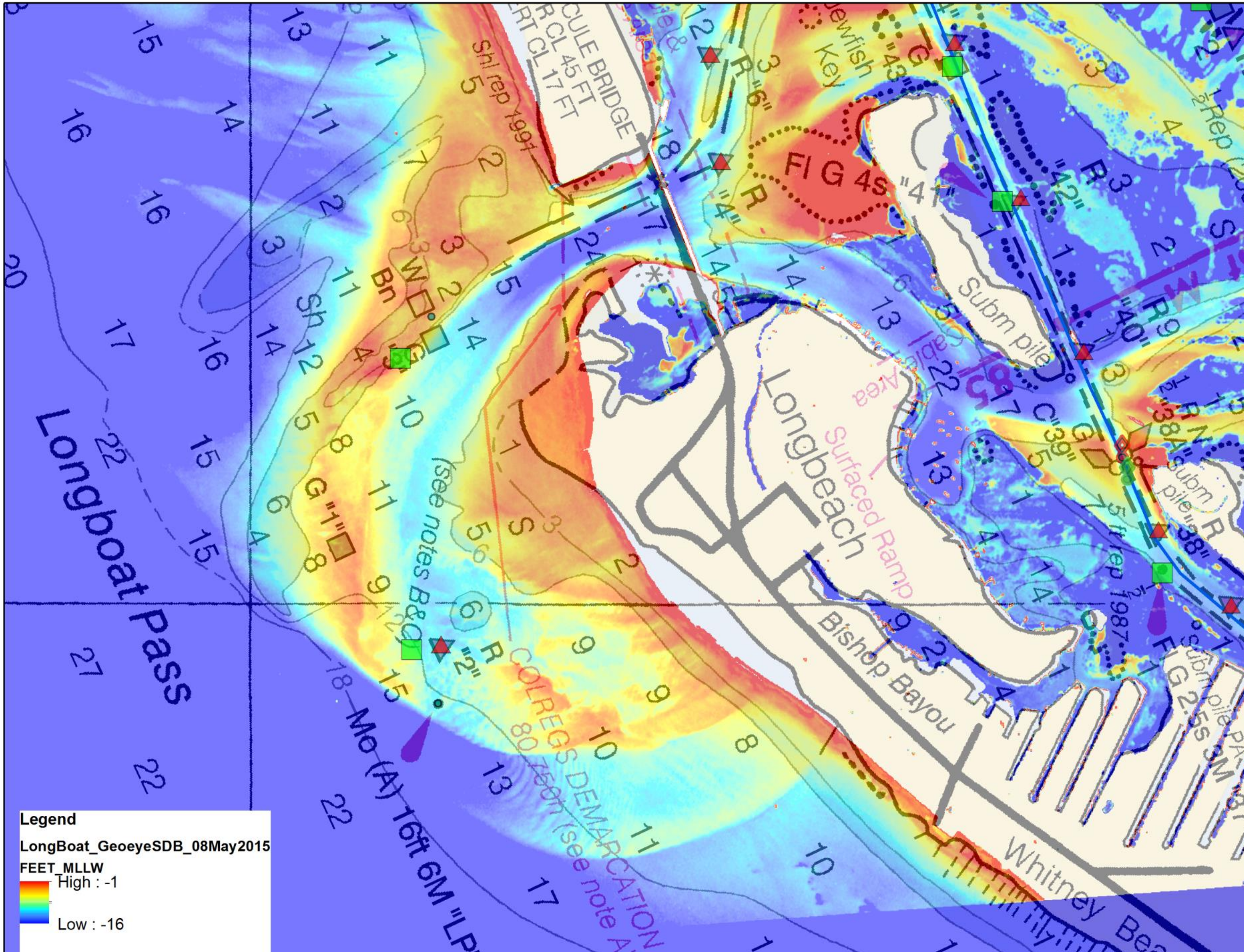


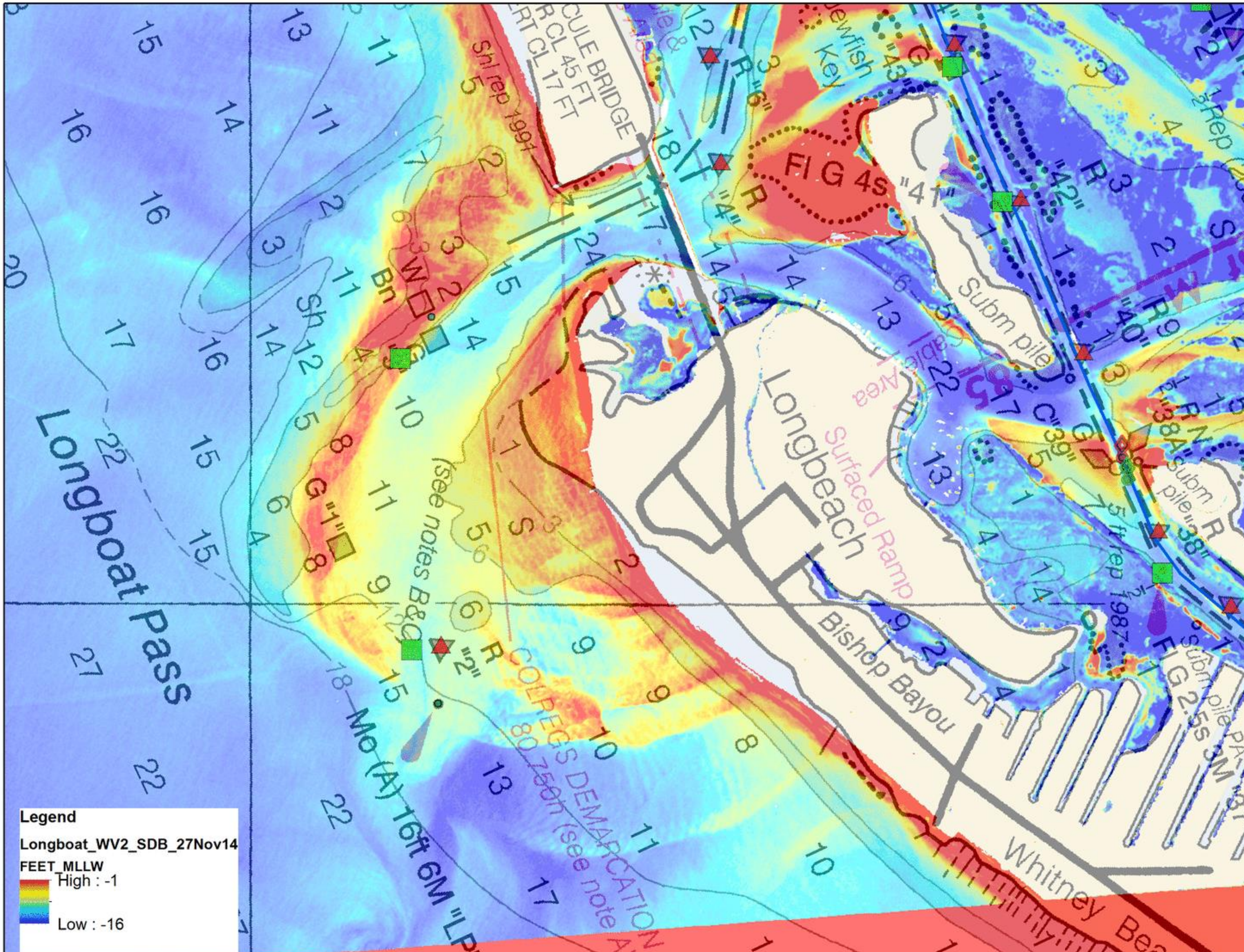
SDB as Reconnaissance



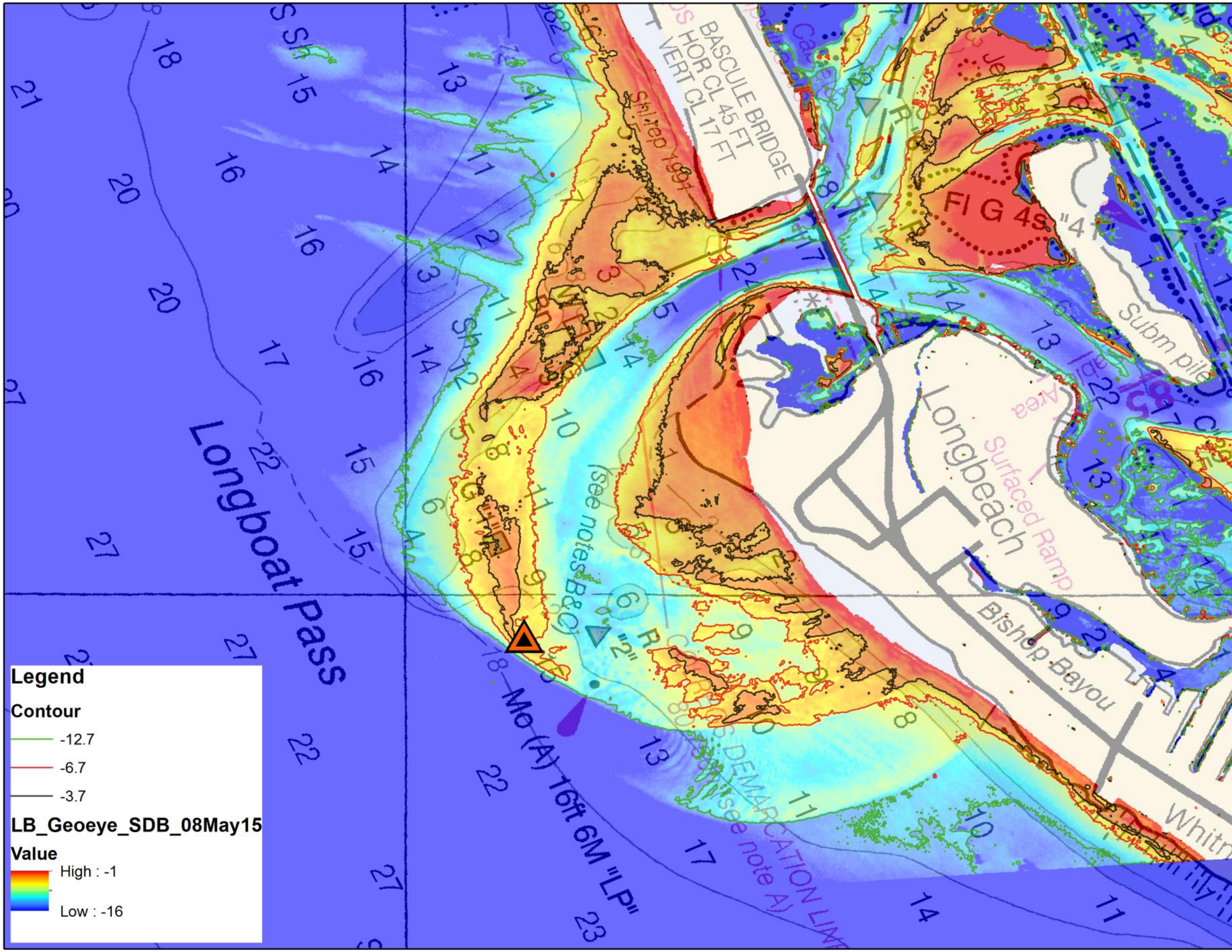


Longboat Pass
Longbeach
Bishop Bayou
Whitney Beach
Sister
Jewfish Key
Leffis Key
Surfaced Ramps
BASCULE BRIDGE HOR CL 45 FT VERT CL 17 FT
Cable & Pipeline Area
Fish Haven (auth min 7ft)
Mo (A) 16ft 6M "LP"
COLREGS DEMARCATION LINE 80.75
(see note A)

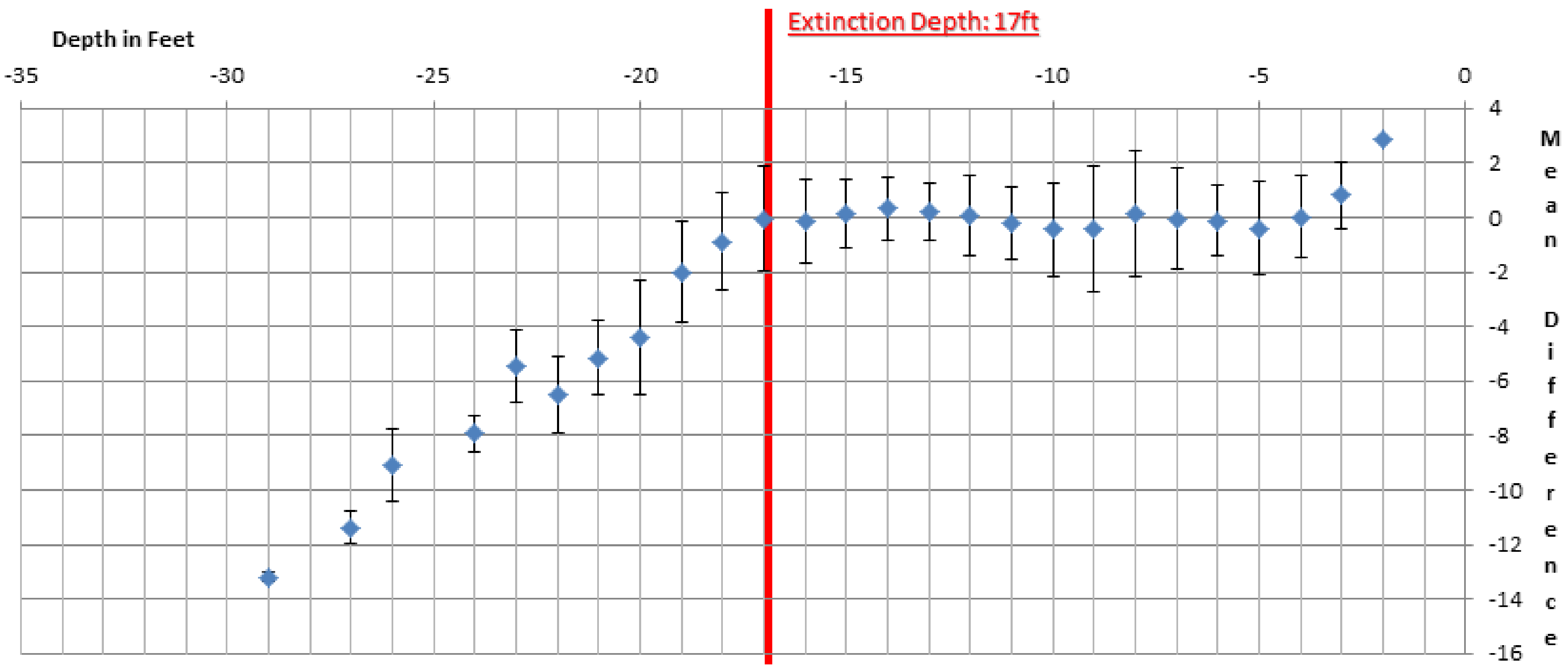

Legend
LongBoat_GeoeyeSDB_08May2015
FEET_MLLW
High : -1
Low : -16
Longboat Pass
Longbeach
Bishop Bayou
Whitney Beach
Surfaced Ramp
Subm pile
Fl G 4s
COLREGS DEMARCATION
(see notes B&C)
Mo (A) 16ft 6M "LP"

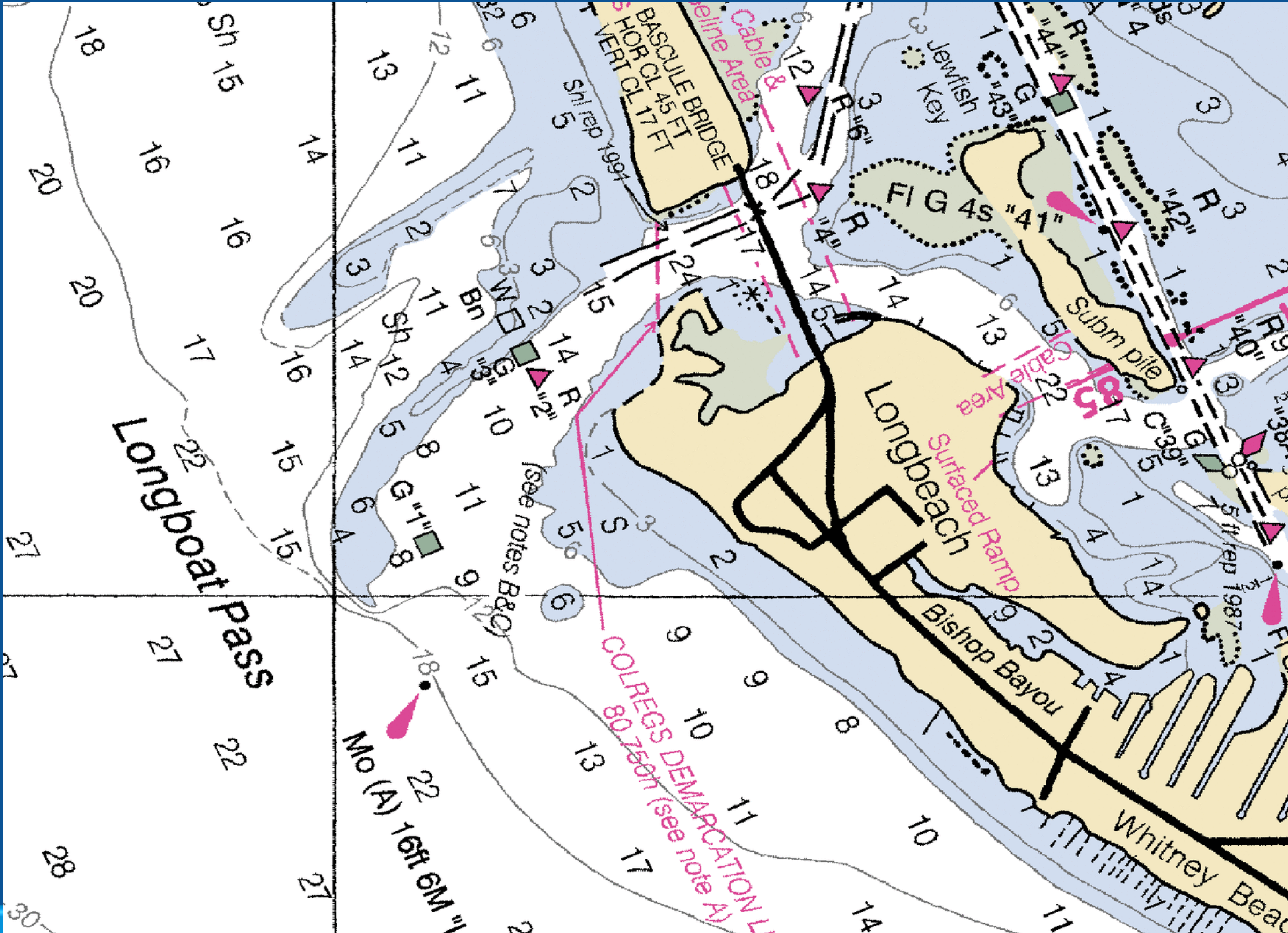


Legend
Longboat_WV2_SDB_27Nov14
FEET_MLLW
High : -1
Low : -16
Longboat Pass
Longbeach
Bishop Bayou
Surfaced Ramp
Whitney Beach
Subm pile
Fl G 4s
Shl rep 1991
(see notes B&C)
COLREGS DEMARCATION
Mo (A) 16ft 6M "LP"


Legend
Contour
-12.7
-6.7
-3.7
LB_Geoeye_SDB_08May15
Value
High : -1
Low : -16
Longboat Pass
Longbeach
Bishop Bayou
Surfaced Ramp
BASCULE BRIDGE
HOR CL 45 FT
VERT CL 17 FT
Fl G 4s "4"
Subm pile
Shl rep 1991
(see notes B&C)
"2"
Mo (A) 16ft 6M "LP"
DEMARCATION LINE
(see note A)

Mean Difference of USACE Survey Reference Data and GeoEye SDB Solution, with Standard Deviation - in Feet

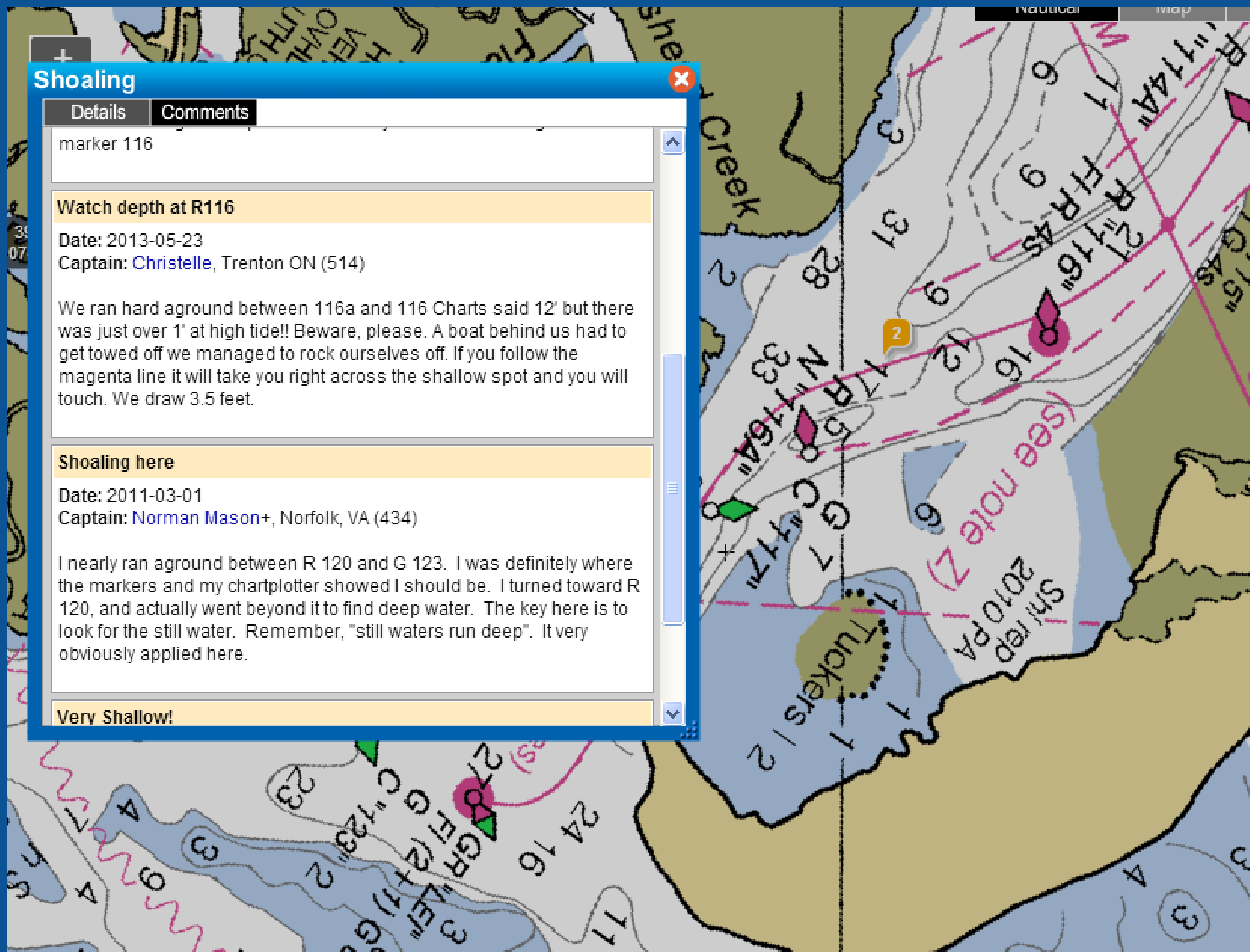



Longboat Pass
Longbeach
Bishop Bayou
Whitney Beach
BASCULE BRIDGE
HOR CL 45 FT
VERT CL 17 FT
Shl rep 1991
Cable Area
Jewfish Key
Fl G 4s "41"
Subm pile
Surfaced Ramp
(see notes B&C)

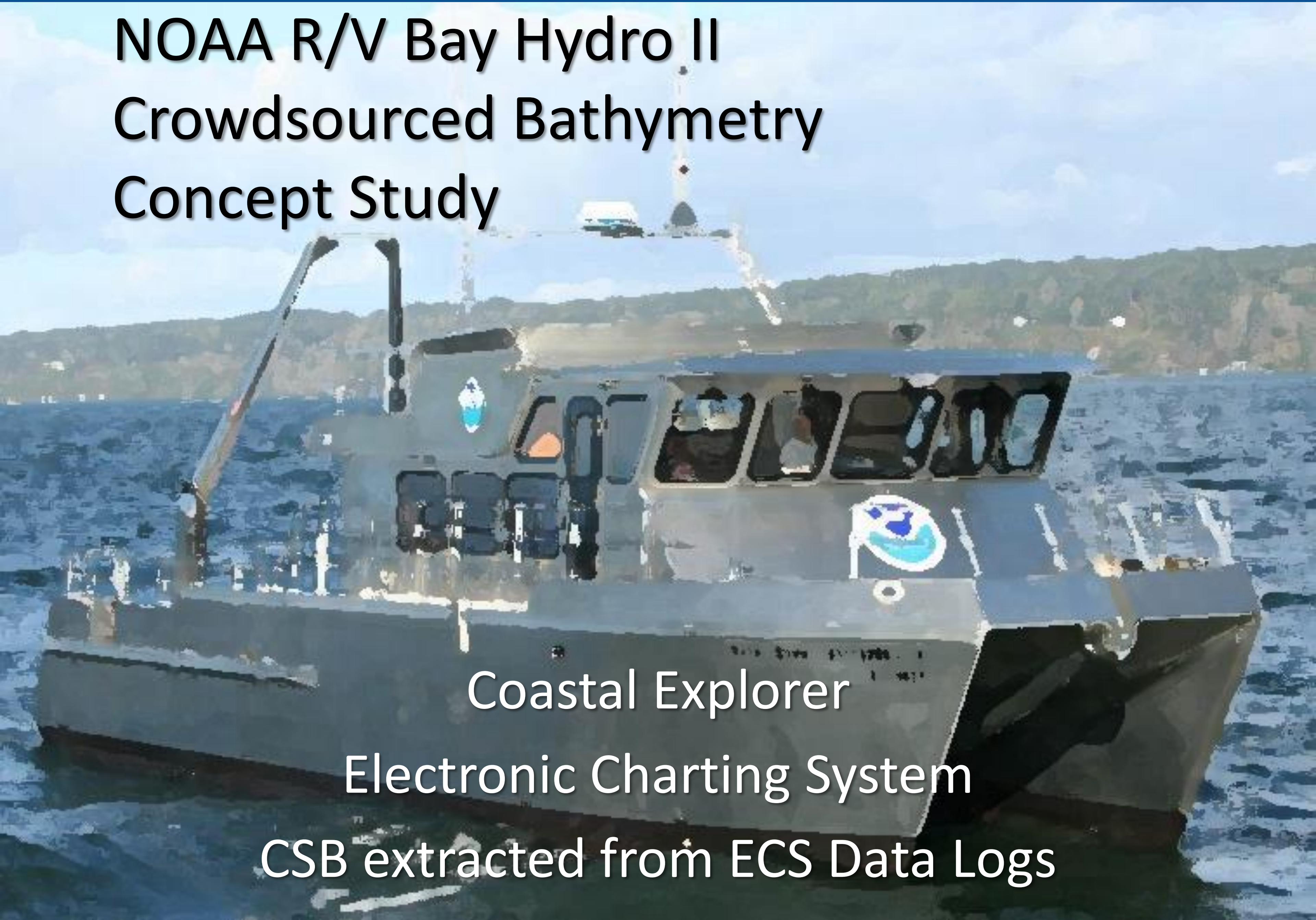
Crowdsourcing Efforts

- ActiveCaptain Navigation Hazards
  - Crowdsourced navigation hazard data
- Crowdsourced Bathymetry (CSB)
  - IHO's Data Centre for Digital Bathymetry
  - Software based solution concept study

ActiveCaptain – Crowdsourced Hazards from social media



NOAA R/V Bay Hydro II Crowdsourced Bathymetry Concept Study



Coastal Explorer

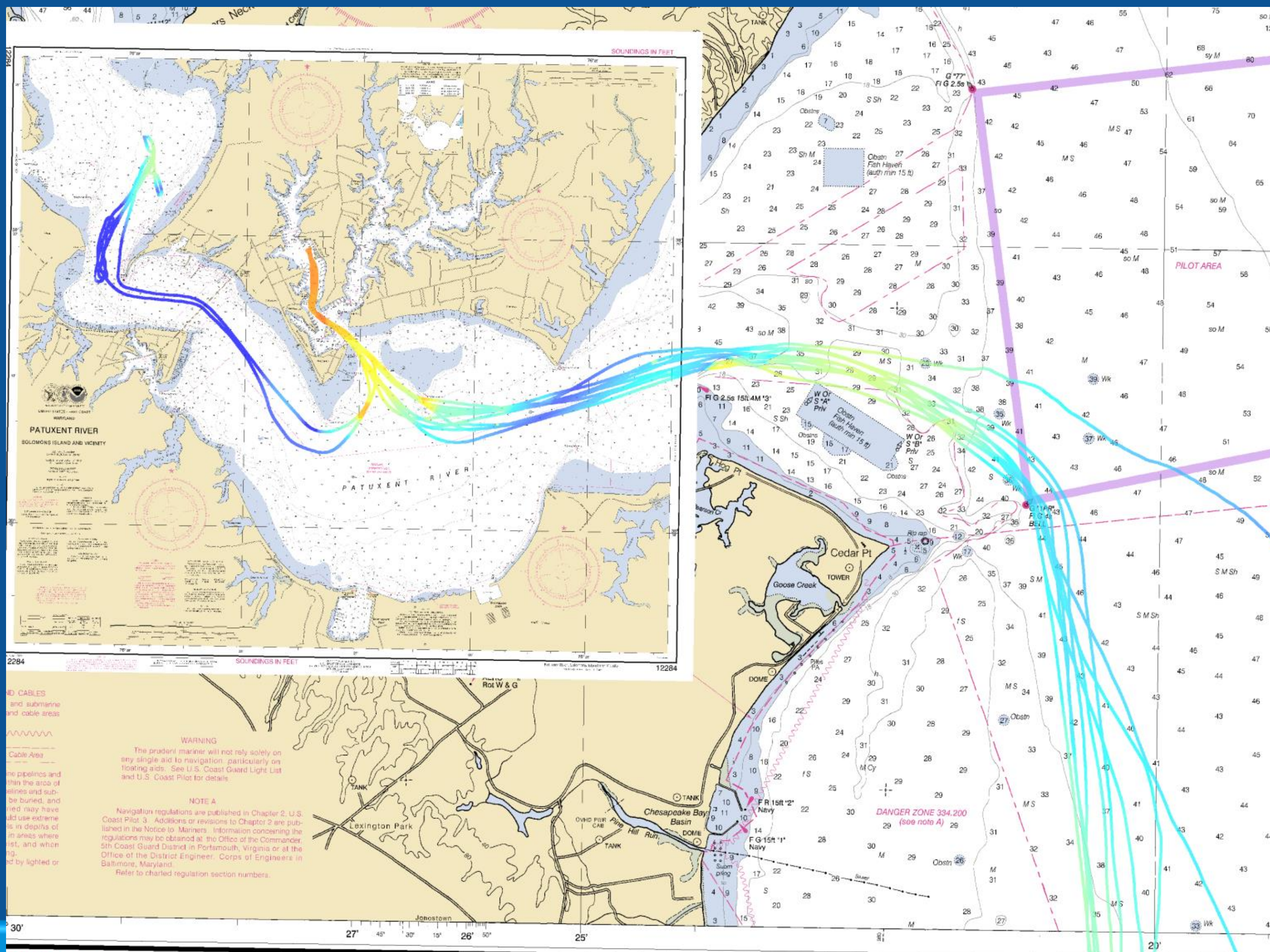
Electronic Charting System

CSB extracted from ECS Data Logs

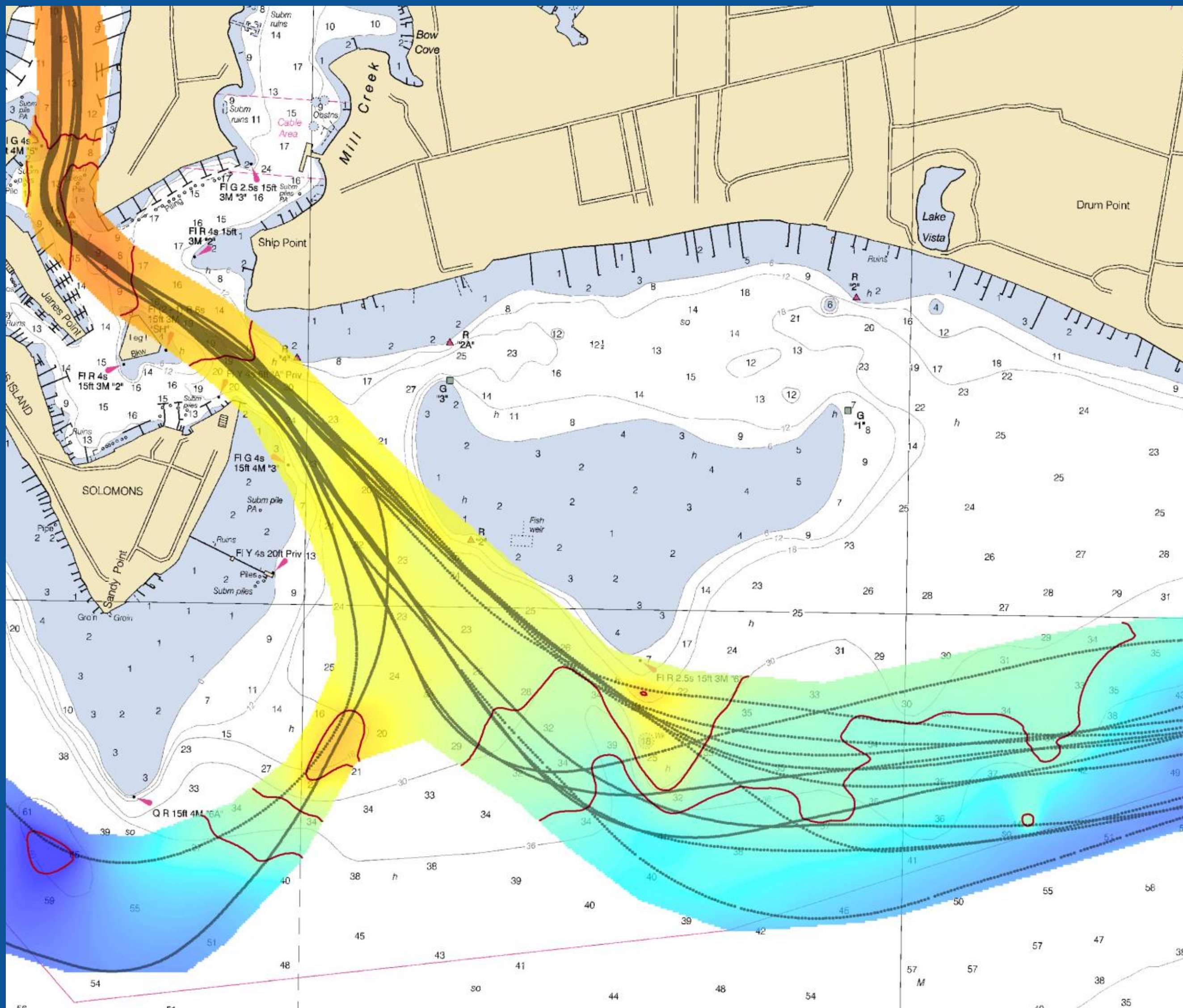
NMEA Data log file is automatically created for developer troubleshooting within Rose Point Coastal Explorer ECS software

```
)00000401000: $GPGGA,115541,3819.9158,N,07627.4480,W,2,9,1.1,4,M,,M,,*61
)00000401889: $GPDPT,3.4,0.0*50
)00000402030: $GPGGA,115542,3819.9158,N,07627.4480,W,2,9,1.1,4,M,,M,,*62
)00000402888: $GPDPT,3.4,0.0*50
)00000403012: $GPGGA,115543,3819.9158,N,07627.4480,W,2,9,1.1,4,M,,M,,*63
)00000403886: $GPDPT,3.5,0.0*51
)00000404011: $GPGGA,115544,3819.9158,N,07627.4481,W,2,9,1.1,4,M,,M,,*65
)00000404058: $PFEC,GPint,ast01*13
)00000404104: $PFEC,idfnc,R,*08
)00000404136: $PAMTC,SIM,Q*4D
)00000404884: $GPDPT,3.5,0.0*51
)00000405009: $GPGGA,115545,3819.9158,N,07627.4480,W,2,9,1.1,4,M,,M,,*65
)00000405883: $GPDPT,3.4,0.0*50
)00000406008: $GPGGA,115546,3819.9158,N,07627.4480,W,2,9,1.1,4,M,,M,,*66
)00000406881: $GPDPT,3.4,0.0*50
)00000407006: $GPGGA,115547,3819.9158,N,07627.4480,W,2,9,1.1,4,M,,M,,*67
)00000407880: $GPDPT,3.4,0.0*50
)00000408005: $GPGGA,115548,3819.9158,N,07627.4481,W,2,9,1.1,4,M,,M,,*69
)00000408878: $GPDPT,3.4,0.0*50
)00000409003: $GPGGA,115549,3819.9158,N,07627.4481,W,2,9,1.1,4,M,,M,,*68
)00000409877: $GPDPT,3.4,0.0*50
)00000410001: $GPGGA,115550,3819.9159,N,07627.4481,W,2,9,1.1,4,M,,M,,*61
)00000410891: $GPDPT,3.4,0.0*50
)00000411015: $GPGGA,115551,3819.9159,N,07627.4481,W,2,9,1.1,4,M,,M,,*60
)00000411889: $GPDPT,3.5,0.0*51
)00000412014: $GPGGA,115552,3819.9159,N,07627.4481,W,2,9,1.1,4,M,,M,,*63
)00000412887: $GPDPT,3.5,0.0*51
)00000413012: $GPGGA,115553,3819.9159,N,07627.4481,W,2,9,1.1,4,M,,M,,*62
)00000413886: $GPDPT,3.4,0.0*50
)00000414011: $GPGGA,115554,3819.9159,N,07627.4481,W,2,9,1.1,4,M,,M,,*65
)00000414073: $PFEC,GPint,ast01*13
)00000414104: $PFEC,idfnc,R,*08
)00000414120: $PAMTC,SIM,Q*4D
)00000414884: $GPDPT,3.4,0.0*50
)00000415009: $GPGGA,115555,3819.9159,N,07627.4481,W,2,9,1.1,4,M,,M,,*64
)00000415883: $GPDPT,3.4,0.0*50
)00000416007: $GPGGA,115556,3819.9158,N,07627.4481,W,2,9,1.1,4,M,,M,,*66
)00000416897: $GPDPT,3.3,0.0*57
```

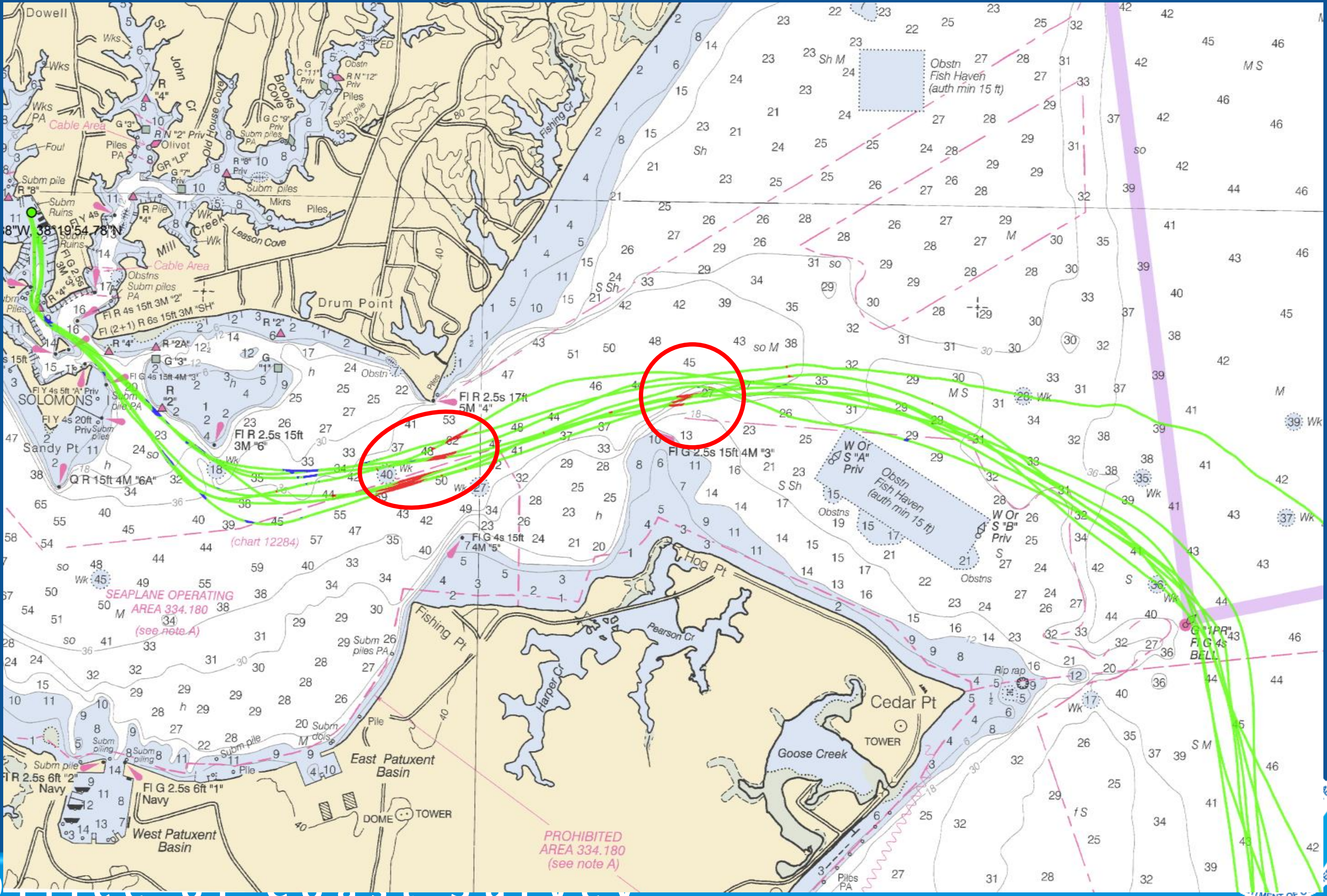
GGA (Time and Position from GPS) and DPT (Depth of water from bridge fathometer) were parsed out and imported into ArcGIS as a point feature class



Six days of data = ~70,000 soundings



Derivative Surface is compared to a reference surface created from Survey Scale (aka fair sheet) Soundings extracted from NOAA's NGDC/NCEI/Coast Survey Bathy Point Store



Derivative Surface is compared to a reference surface created from Survey Scale (aka fair sheet) Soundings extracted from NOAA's NGDC/NCEI/Coast Survey Bathy Point Store

Table

Reclass_diff_25_AUG

Description	Count
CSB deeper than 1 meter of Reference Surface	1633
CSB +/- 1 meter of Reference Surface	104788
CSB shoaler than 1 meter of Reference Surface	717

98% of grid nodes fall within 1 meter of the reference surface

Conclusions and recommended next steps:

- This is a promising potential method to extract Crowdsourced Bathymetry from a typical light-commercial or high-end recreational ECS setup

Next Steps:

- Automate parsing of GGA and DPT strings for input into GIS
- Evaluate solution with cursory tides and transducer offsets applied
- Establish contact with Rose Point Developers
    - Discuss possibility to adopt direct interface with Coastal Explorer and Rose Point ECS software to the IHO DCDB in NCEI – Boulder
- Use this case study to work with other chartplotter software and hardware developers to expand potential crowd contributors

Thank you & terima kasih!

anthony.r.klemm@noaa.gov