NOAA Integrated Ocean and Coastal Mapping
Using Hurricane Sandy Response Data to Help Build a Bridge Between Lidar Bathymetry and The Chart

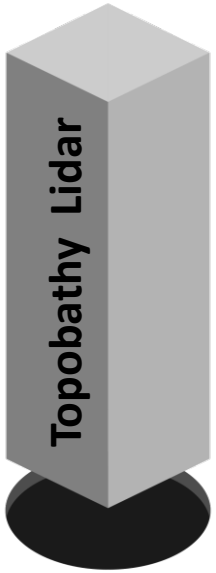
JALBTCX Airborne Coastal Mapping and Charting Workshop

July 19-21 2016

Silver Spring, MD

NOAA IOCM at the Joint Hydrographic Center, Durham, NH
Sarah Wolfskehl, Juliet Kinney, Michael White,
Michael Bogonko, Andy Armstrong

Mission Statement



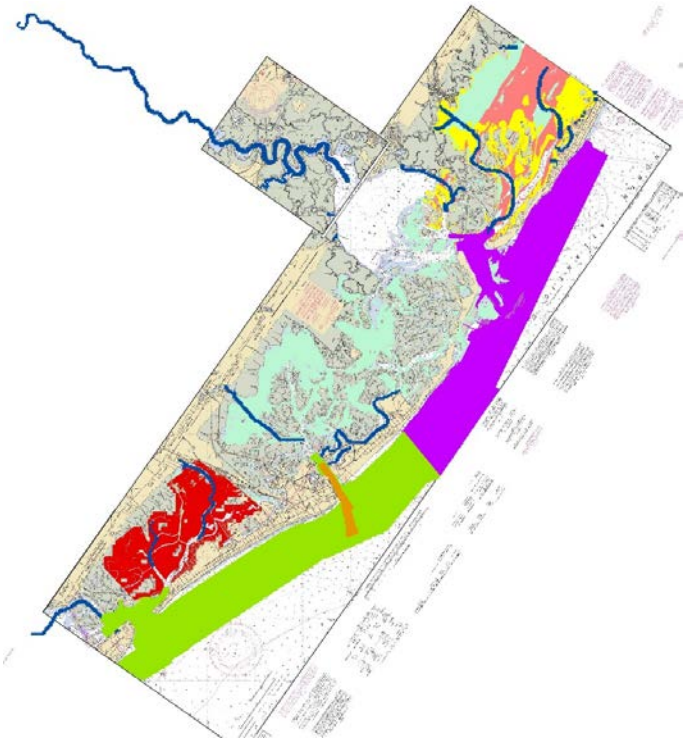
Nautical Chart

- **Integrated Ocean and Coastal Mapping**: the practice of planning, acquiring, integrating, and disseminating ocean and coastal geospatial data and derivative products in a manner that permits **easy access to and use by the greatest range of users.**

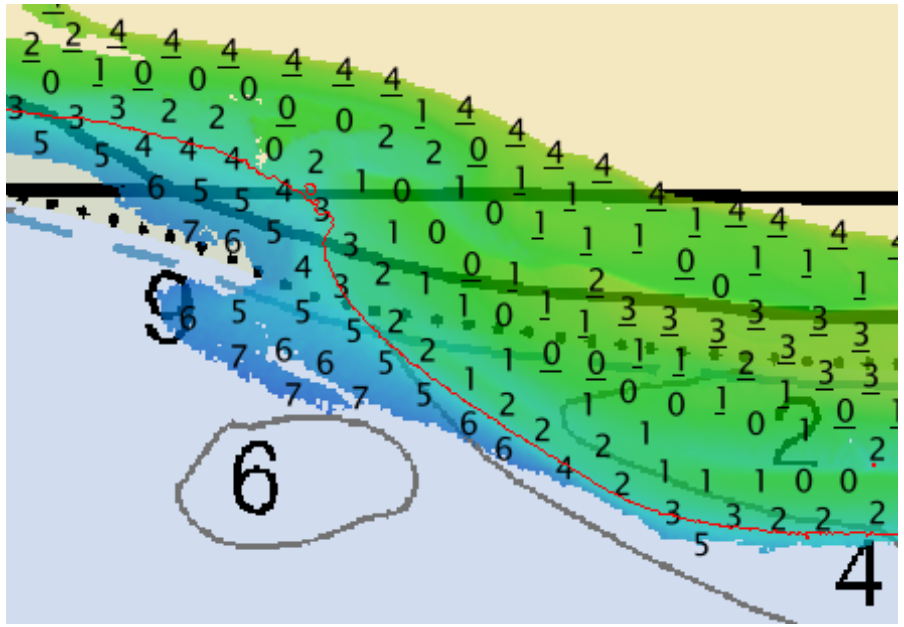
- **GOAL**: utilize terrestrial lidar based software and traditional hydrographic software with bathymetric lidar data to create products for nautical chart application and S-57 attribution.

Two Methods

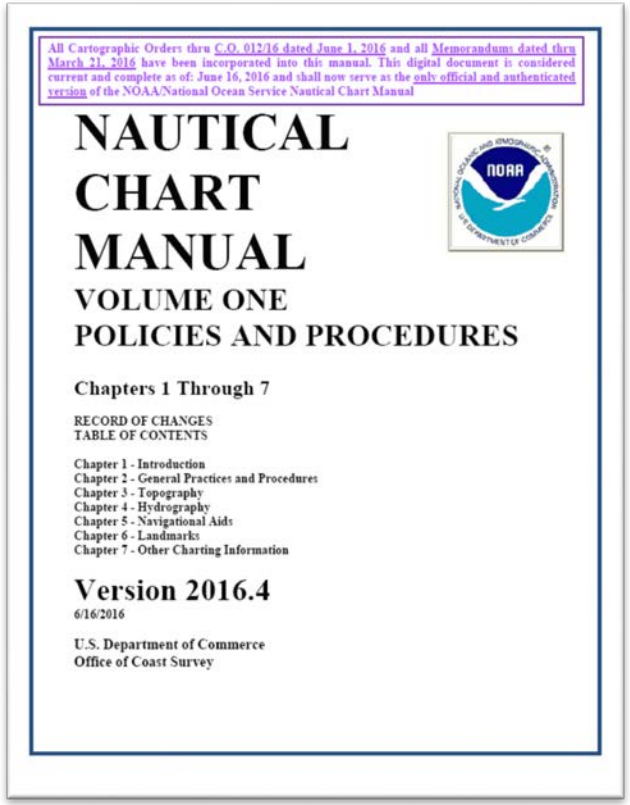
Coastal Composite Bathymetry
Compile grids from lidar and other data sources for general bathymetric interpretation of a region to update contours and soundings where applicable.



Standard Ingestion into Hydrographic Data Pipeline in OCS
Compile data to fit standard procedures as best possible to update soundings and features on the chart.



Office of Coast Survey Chart Data Requirements



All Cartographic Orders thru C.O. 012/16 dated June 1, 2016 and all Memorandums dated thru March 21, 2016 have been incorporated into this manual. This digital document is considered current and complete as of: June 16, 2016 and shall now serve as the only official and authenticated version of the NOAA/National Ocean Service Nautical Chart Manual

NAUTICAL CHART MANUAL

VOLUME ONE
POLICIES AND PROCEDURES

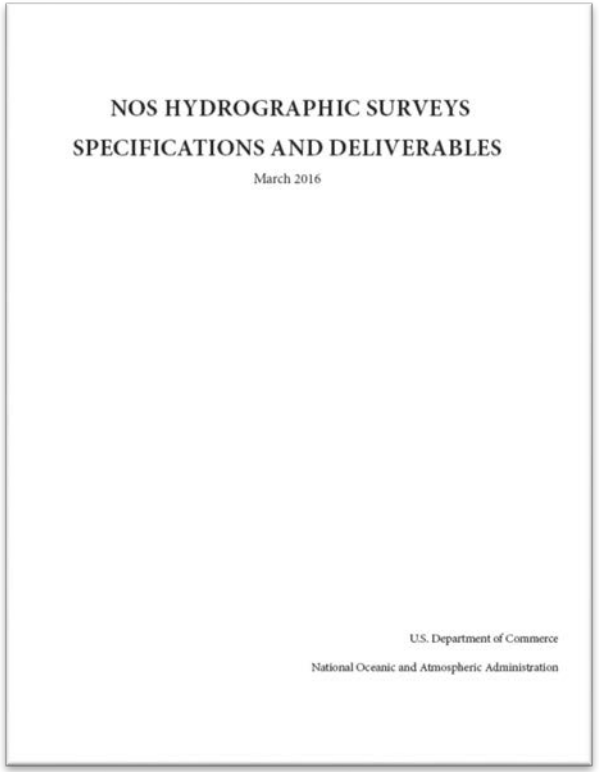
Chapters 1 Through 7

RECORD OF CHANGES
TABLE OF CONTENTS

Chapter 1 - Introduction
Chapter 2 - General Practices and Procedures
Chapter 3 - Topography
Chapter 4 - Hydrography
Chapter 5 - Navigational Aids
Chapter 6 - Landmarks
Chapter 7 - Other Charting Information

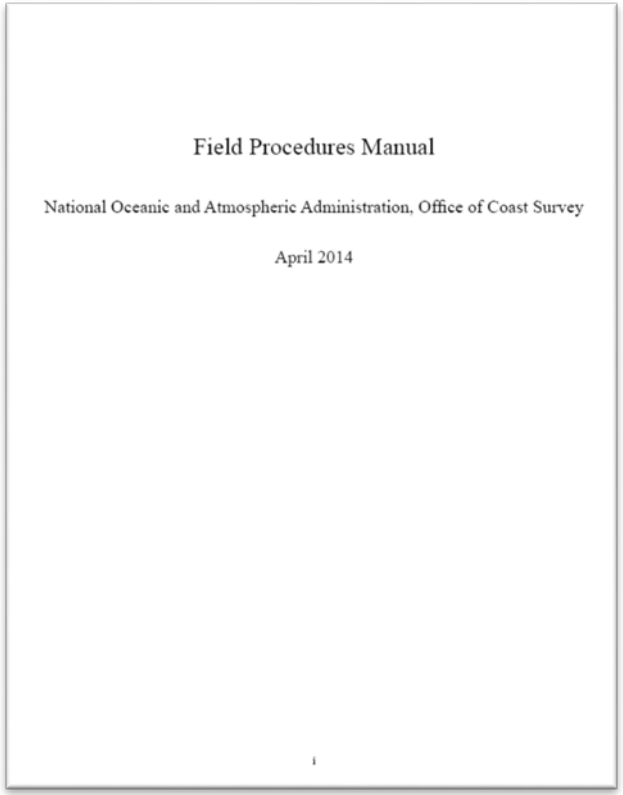
Version 2016.4
6/16/2016

U.S. Department of Commerce
Office of Coast Survey



NOS HYDROGRAPHIC SURVEYS
SPECIFICATIONS AND DELIVERABLES
March 2016

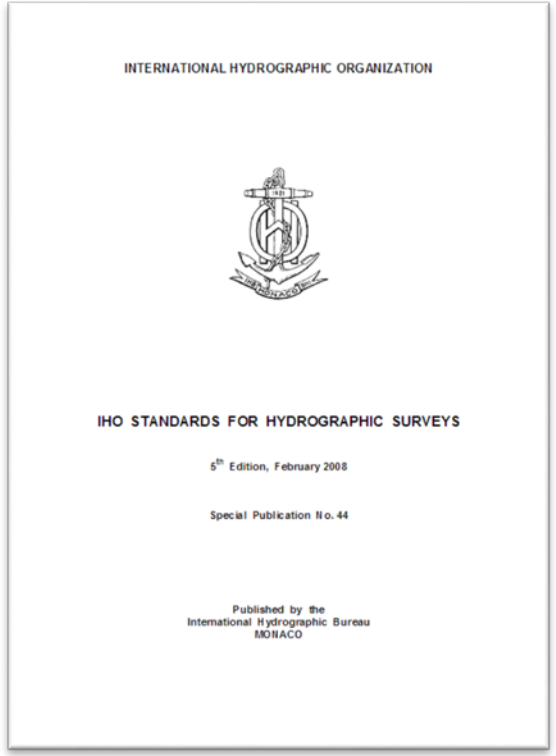
U.S. Department of Commerce
National Oceanic and Atmospheric Administration



Field Procedures Manual

National Oceanic and Atmospheric Administration, Office of Coast Survey

April 2014



INTERNATIONAL HYDROGRAPHIC ORGANIZATION

IHO STANDARDS FOR HYDROGRAPHIC SURVEYS

5th Edition, February 2008

Special Publication No. 44

Published by the
International Hydrographic Bureau
MONACO

Hurricane Sandy Data Timeline

Hurricane Sandy	Start RSD Post Storm Acquisition	End RSD Post Storm Acquisition	RSD Data Available on Digital Coast	RSD chart product submitted to OCS
Oct 2012	**Nov 2013**	**July 2014**	**Sept 2015**	**Feb 2016**

Sept 2014 Contract Starts - aligns with availability of data for post analysis

COASTAL COMPOSITE BATHYMETRY PROJECT

IOCM/MCD Project (with Shachak Pe'eri & Anthony Klemm and others)

Background:

Sandy IOCM Project: Many different agencies and groups collected data in response to Super Storm Sandy.

- How to efficiently organize and ingest to the chart many unconventional data sets of varying size the Sandy team identified?

Many charts of the back bays/ coastal estuaries served by small boat charts often of the 1:40,000 scale or higher resolution are out of date.

- Source data leadline surveys often date to the 1930's

(or even the 1880's as is the case in parts of the DELMARVA)

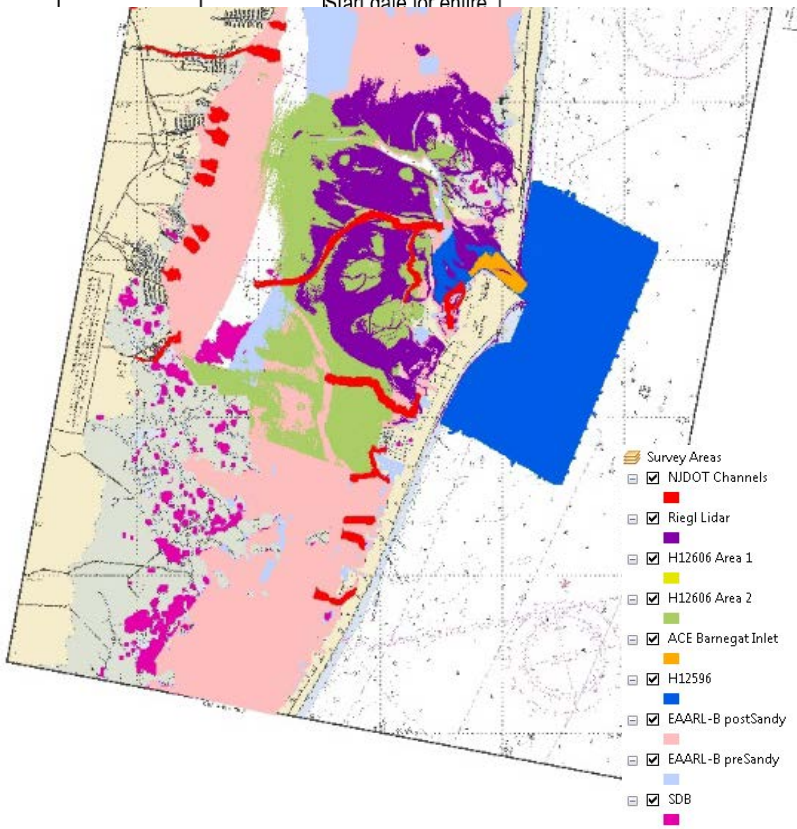
- No source diagrams for many

Goals:

- Update morphology and provide sense of chart quality and adequacy for small charts.
- Use non-traditional and outside data to create composite bathymetric coverage of these shallow areas to show morphology changes.

Products to MCD :

Shapefile Name	CATZOC	DRVAL1	DRVAL2	POSACC	SOUACC	SUREND	SURSTA	TECSOU	VERDAT	INFORM	TXTDSC	SORDAT	SORIND	remarks
H12606_area1	3	-0.14	3.27	1	0.122	20140402	20140401	7	12	H12606, ORP-C308-KRL-13, David Evans and Associates, Inc., Chiroptera Lidar System	OPR-C308-KRL-13_DAPR	20140402	US, US, graph, H12606	Start date for entire H12606 survey was 20140327, end date of entire H12606 survey was 20140403; calibra-
H12606_area2	3	-0.15	12.34	1	0.122	20140402	20140402	7	12	H12606, ORP-C308-KRL-13, David Evans and Associates, Inc., Chiroptera Lidar System	OPR-C KRL-13_			Start date for entire
barnbay_riegl	3	0.01	3.11	1	0.15	20130924	20130923	7	12	W00279, OSD-AHB-14, NOAA RSD, Riegl VQ820G LIDAR	NOAA C Mapping I Project C tion Repor			

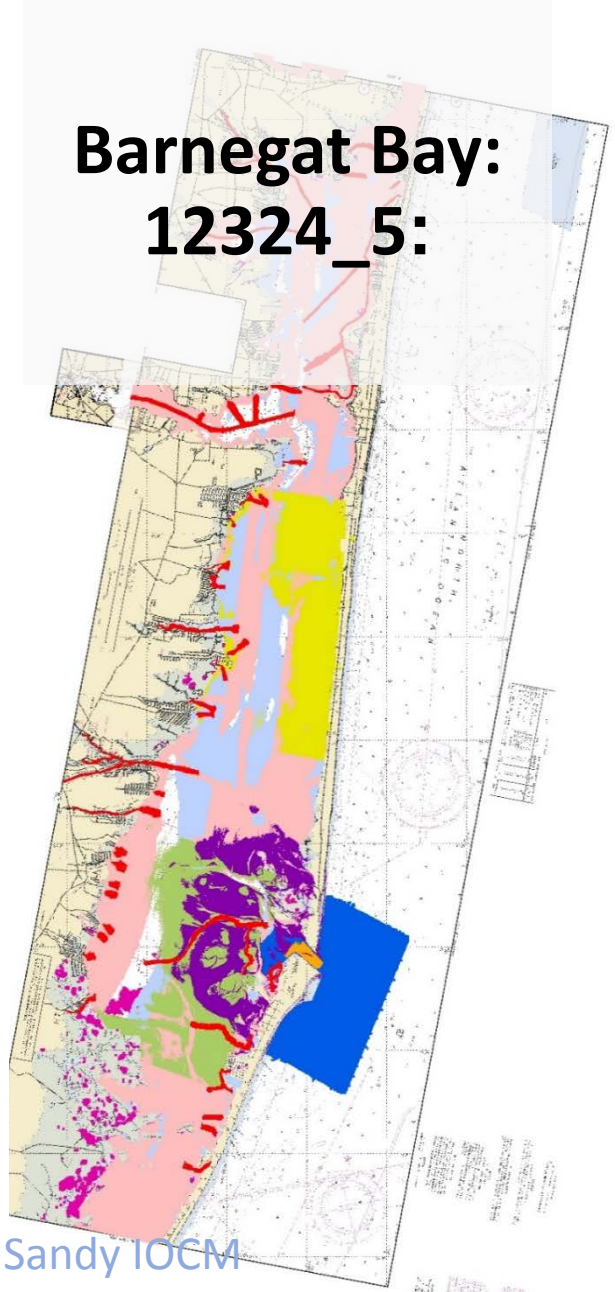


- Source Diagrams: Coverage maps
- MQUAL *(IHO S-57 attribute related to CATZOC)*
- *MQUAL table with CATZOC level and data attributes is associated with the source diagram (shape files)*

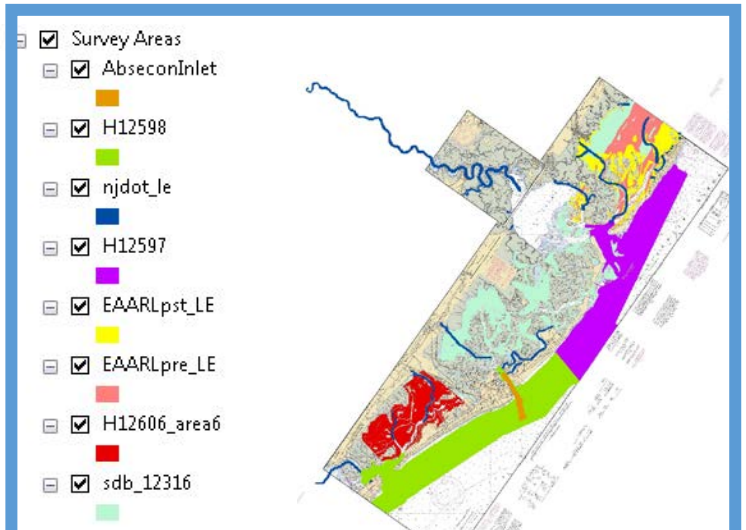
- Prepare system for integration of large amounts of data from Sandy Response

Data Source Coverage (shape files) NJ example

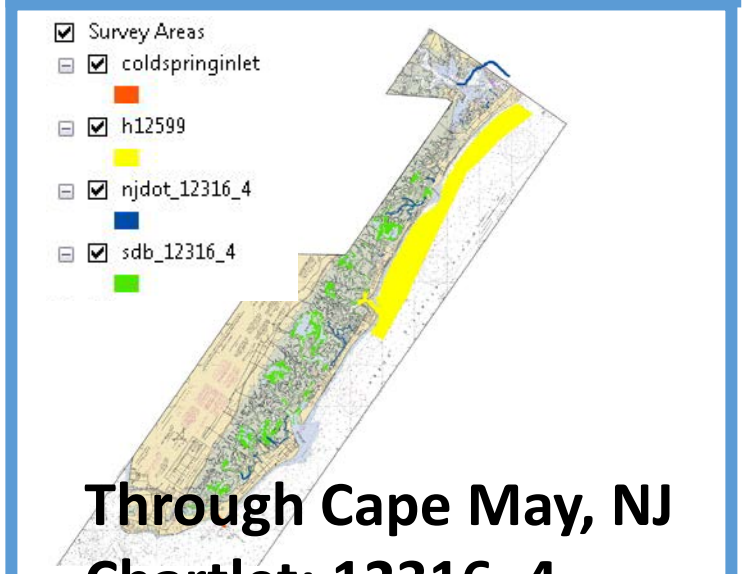
Survey Areas
- NJDOT Channels
- Riegl Lidar
- H12606 Area 1
- H12606 Area 2
- ACE Barnegat Inlet
- H12596
- EAARL-B postSandy
- EAARL-B preSandy
- SDB



Barnegat Bay: 12324_5:

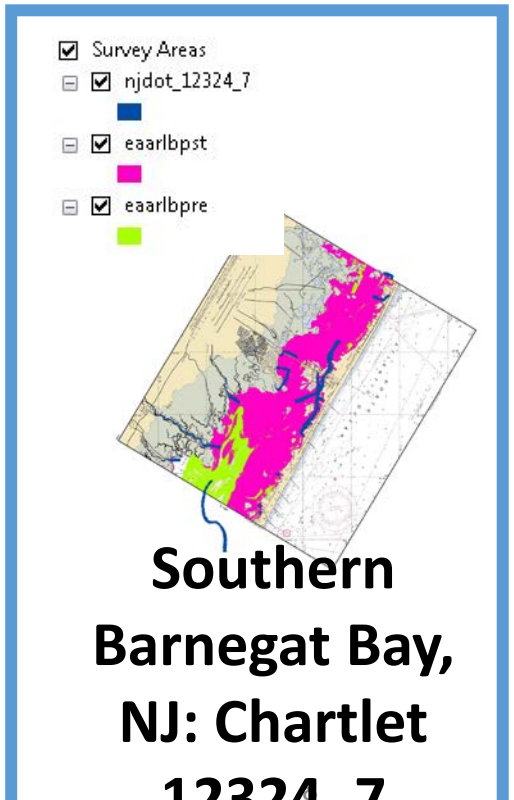


Little Egg: 12316_1 and 12316_3



Through Cape May, NJ Chartlet: 12316_4

**some data sets under analyses not used or shown in initial submission/ prototype*



Southern Barnegat Bay, NJ: Chartlet 12324_7

Products to MCD :

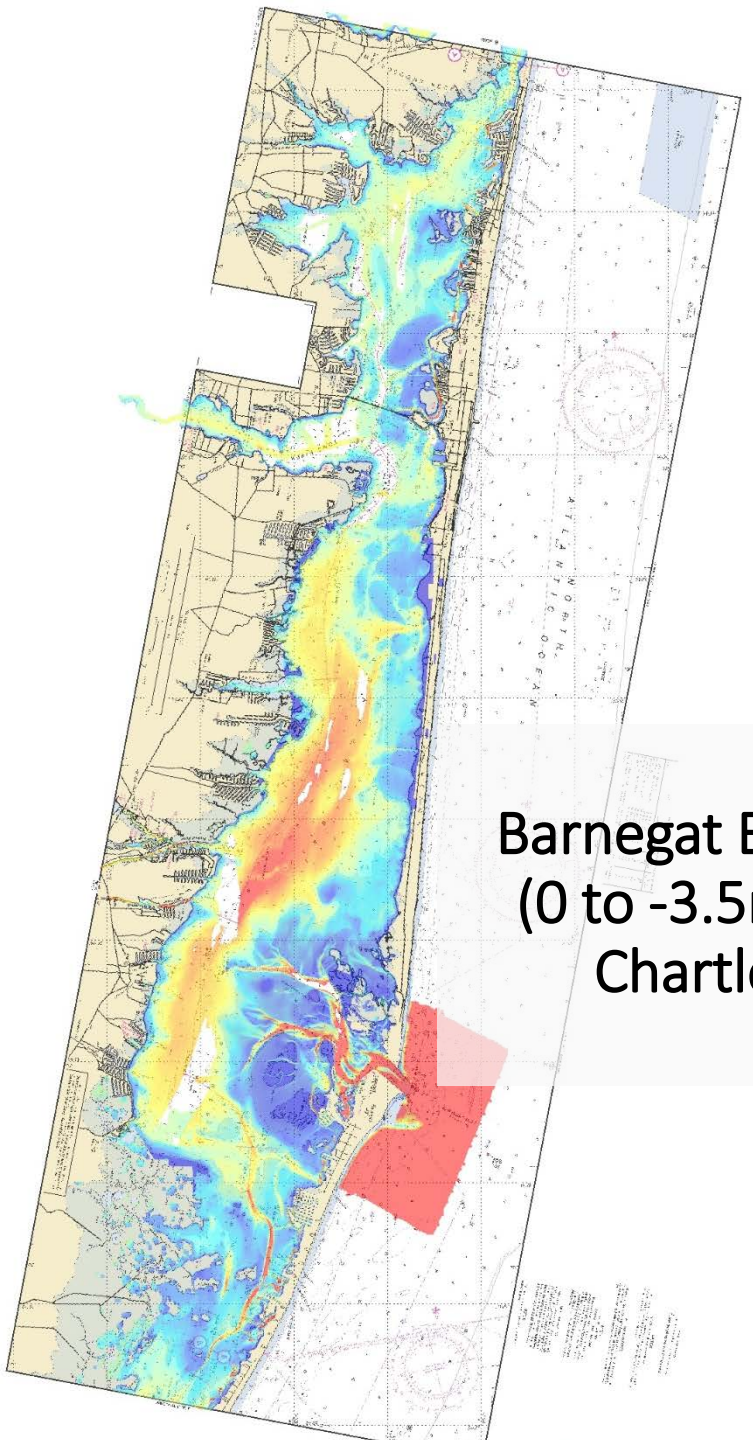
- Contours *(shows morphology changes)*

- Composite coverage maps sorted by CATZOC groupings with newest/ highest quality data prioritized in grid cells.

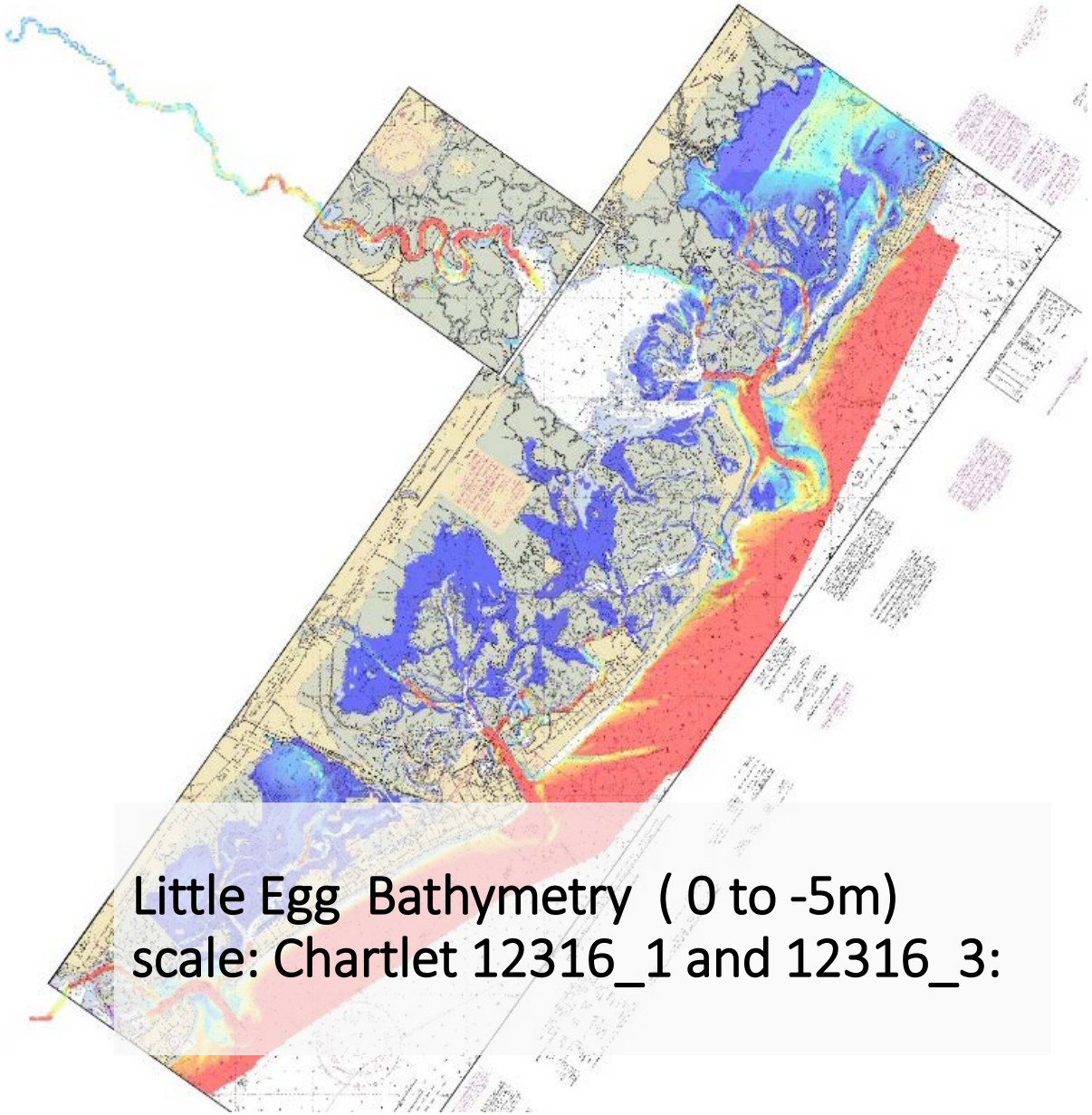
- Create more than one composite:

Sort data of sufficient quality used by MCD to extract soundings vs. data to be used only to show morphology changes/ contours

Composite Bathymetry NJ

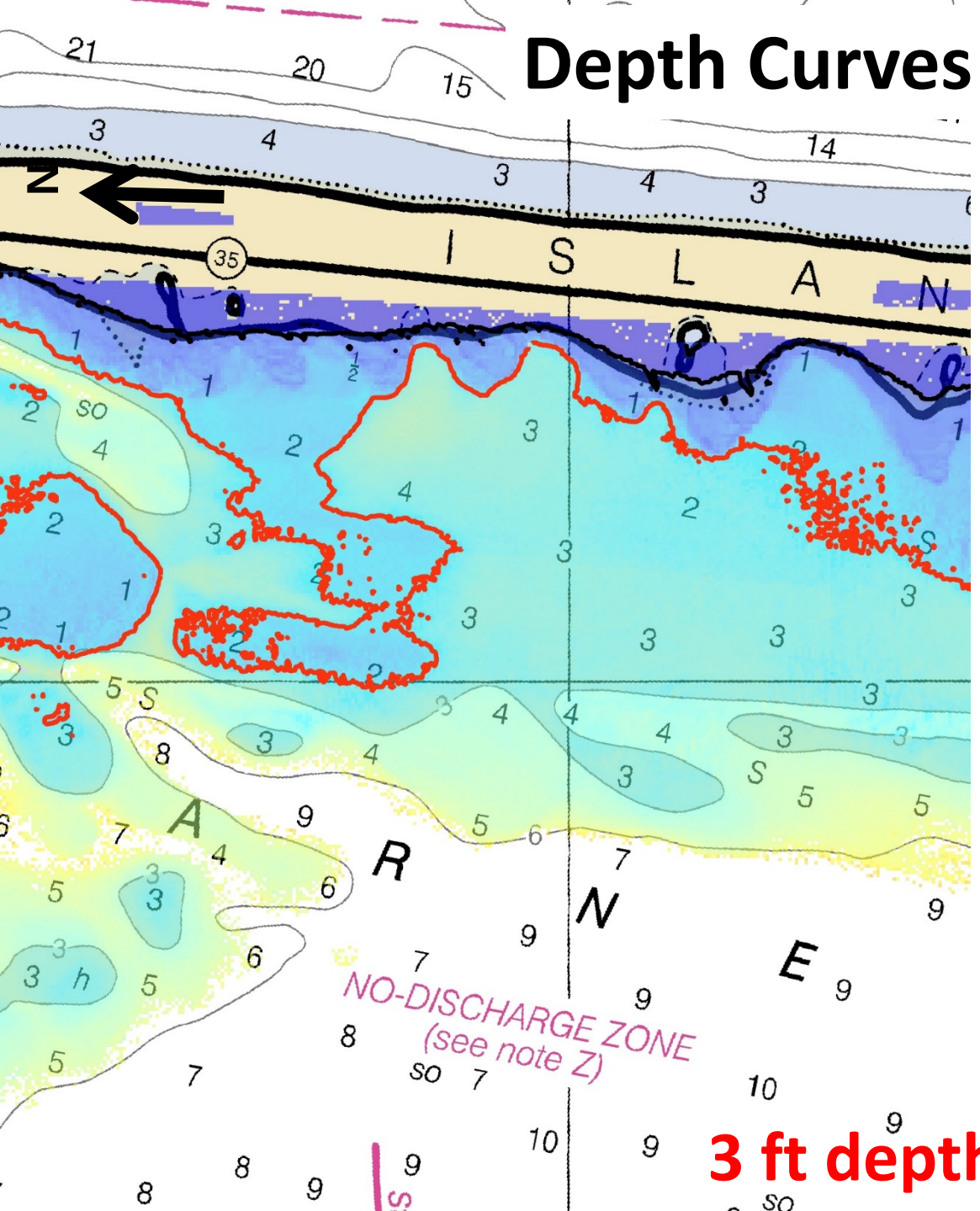


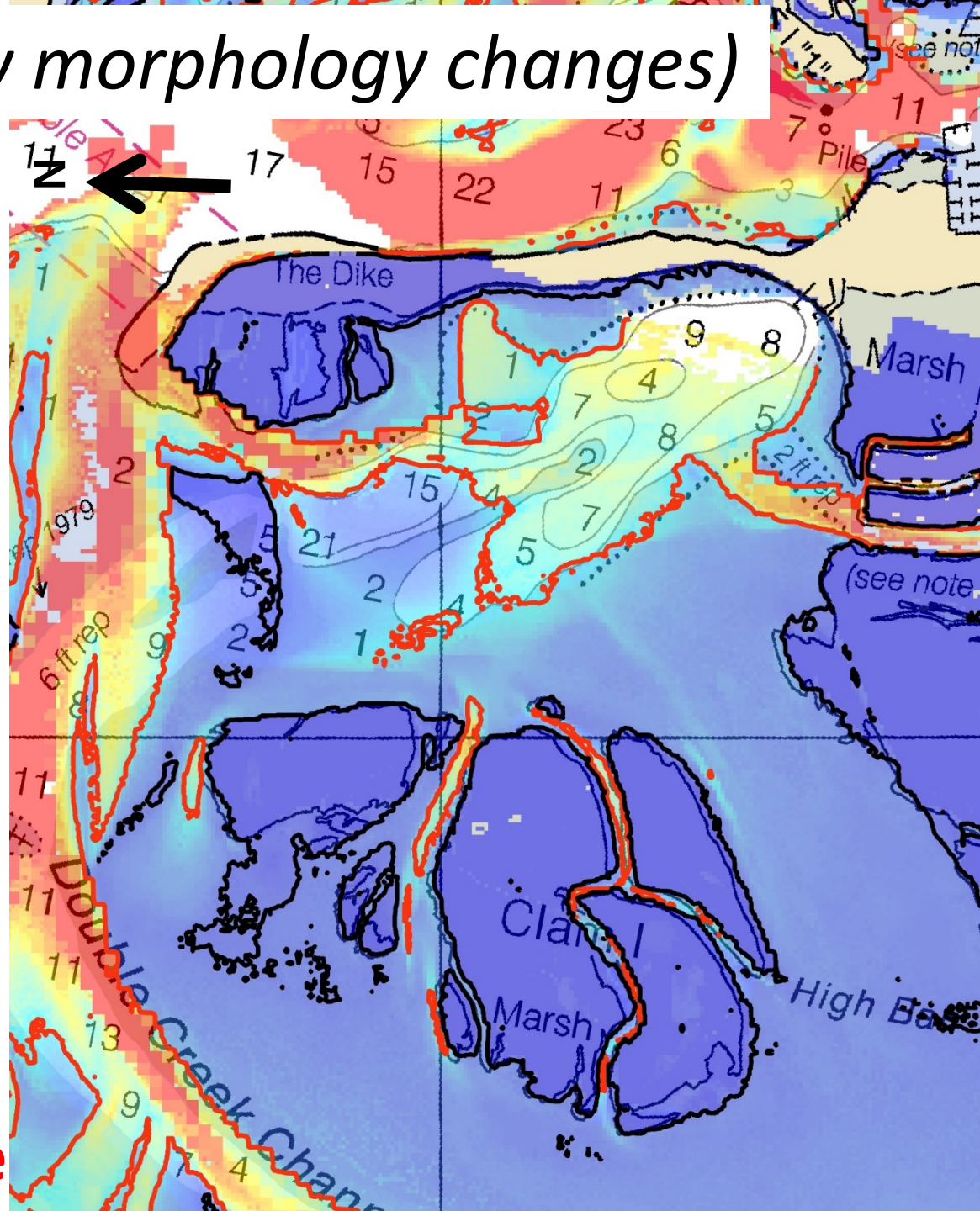
Barnegat Bay Bathymetry
(0 to -3.5m color scale):
Chartlet 12324_5



Little Egg Bathymetry (0 to -5m)
scale: Chartlet 12316_1 and 12316_3:

Depth Curves *(show morphology changes)*

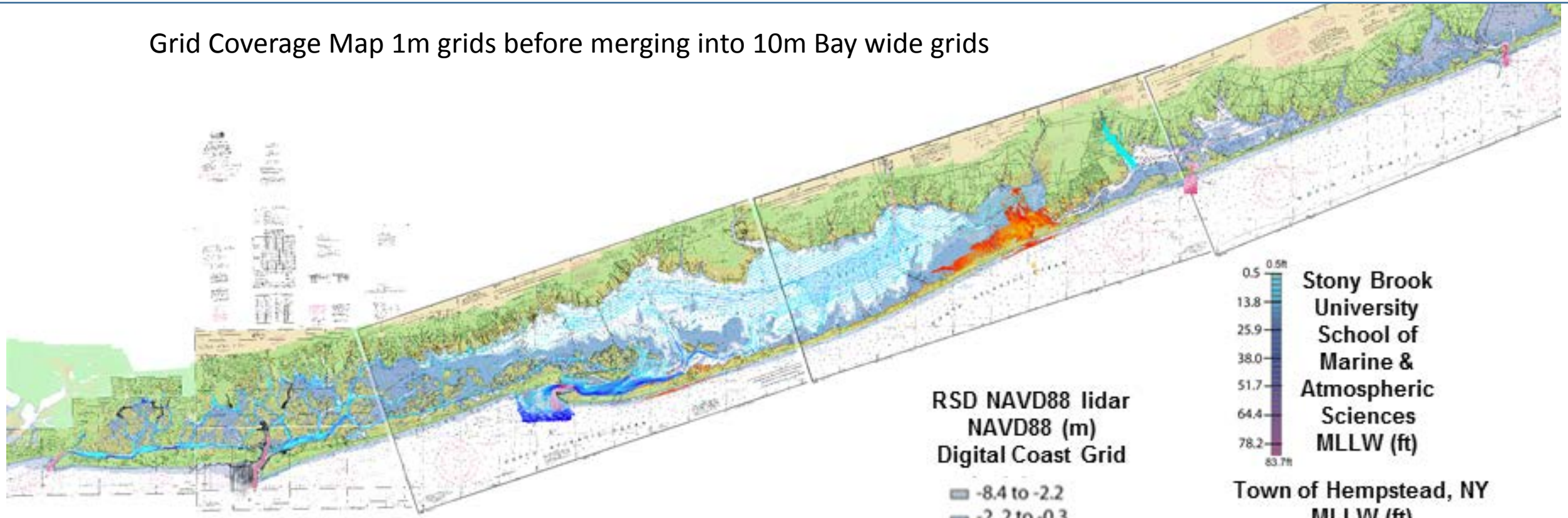




3 ft depth curve

Coastal Composite Bathymetry South Shore Long Island, New York

Grid Coverage Map 1m grids before merging into 10m Bay wide grids



Stony Brook University School of Marine & Atmospheric Sciences MLLW (ft)

0.5 0.5ft
13.8
25.9
38.0
51.7
64.4
78.2
83.7ft

RSD NAVD88 lidar NAVD88 (m) Digital Coast Grid

- -8.4 to -2.2
- -2.2 to -0.3
- -0.3 to 1.7
- 1.7 to 52.8

Town of Hempstead, NY MLLW (ft)

High : 36.8356

Low : -0.37911

USACE CZMIL MLLW (ft)

High : 61.8765

Low : -57.513

USACE NY LI MLLW (ft)

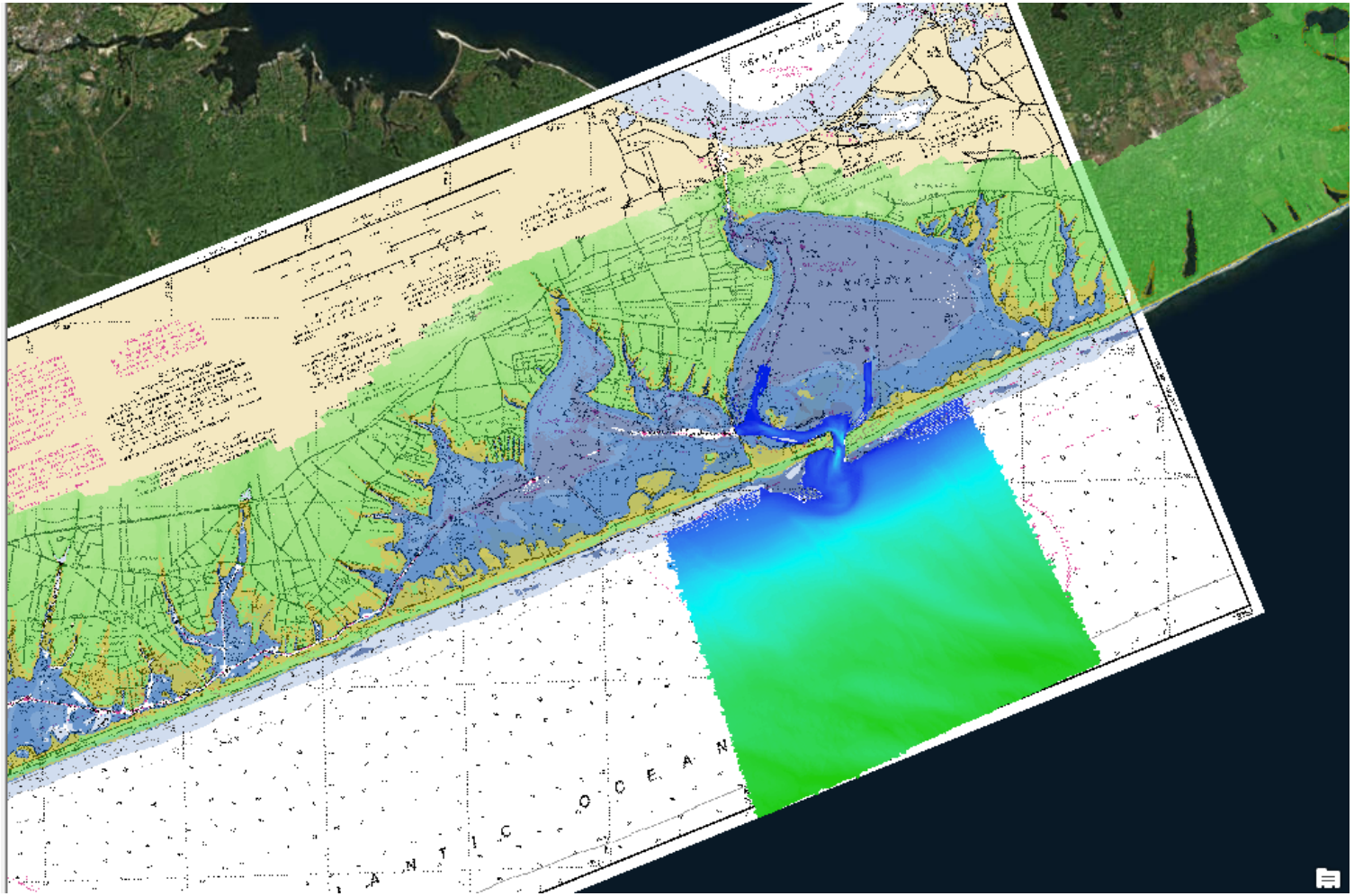
High : 52.16

Low : -0.05

N
W E
S

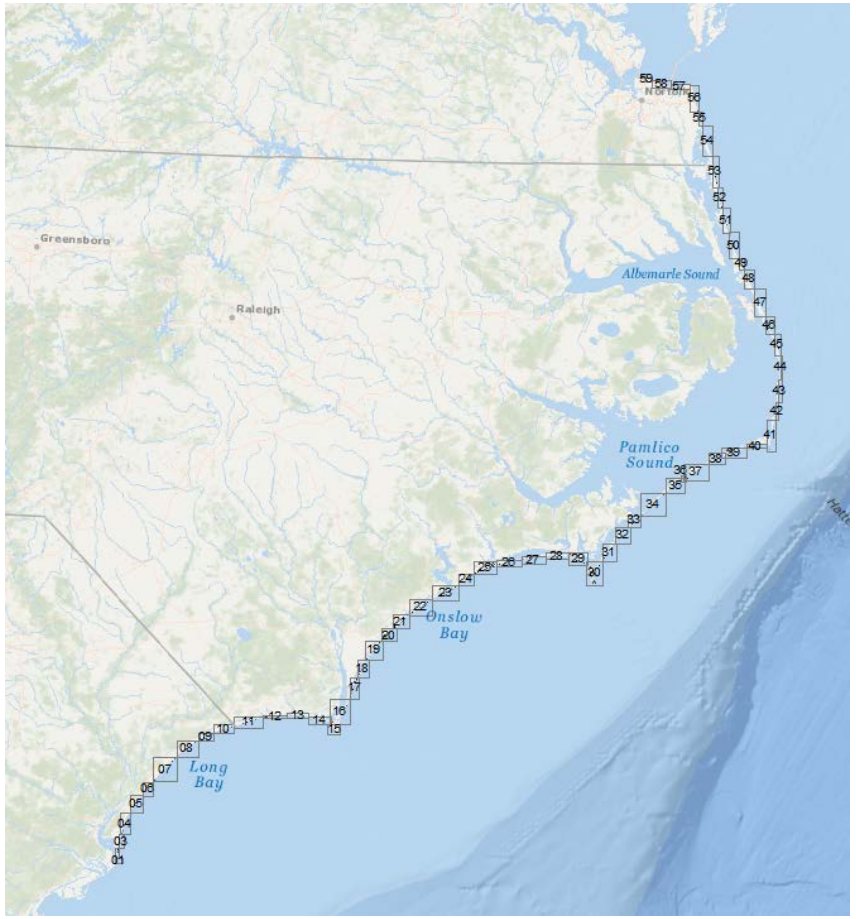
Example of RSD lidar & Acoustic Complimentary match up

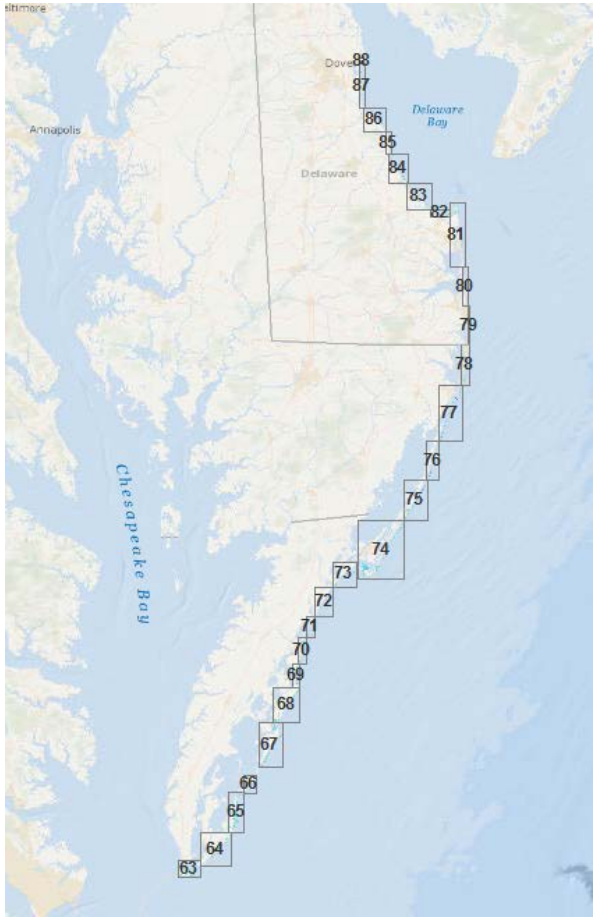
Example: OCS Multibeam & RSD Lidar
Shinnecock Inlet, NY

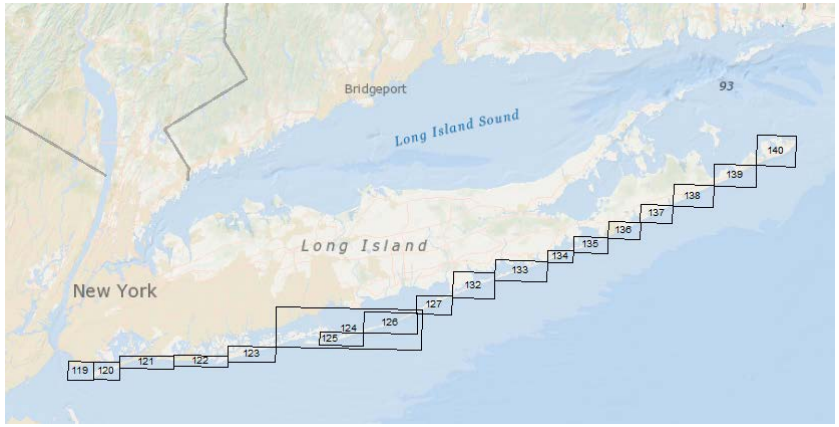


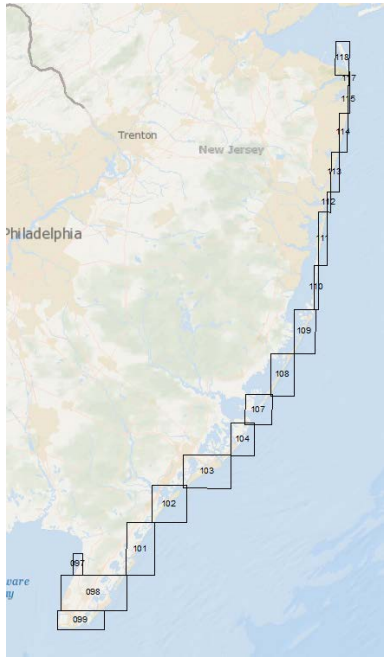
RSD Sandy Data Set – South Carolina to New York

Working with Reigl VQ820G lidar coverage of the OUTER COASTS and INLETS









UNH NOAA Joint Hydrographic Center

OCS Bathymetric Data Requirements Overview

Specification	Acoustic Hydrographic Data (0-20m)	Lidar Data
Vertical Datum	MLLW	MLLW
Feature Detection	0.5m resolution	N/A
Complete Coverage	1m resolution 100% coverage 3.2 beam footprints per3m 4% cross lines	3m resolution or finer 200% coverage laser spot spacing of 4m 8% cross lines
Reconnaissance Coverage	4m	Anything less than complete coverage
Feature Representation	Shoalest sounding be represented in surface for features greater in height then half the allowable TVU	Accurate least depths are obtained on all significant features.
TVU	IHO Order 1. Each sounding have a horizontal and vertical uncertainty estimate	IHO Order 1. Assign a single uncertainty value to all grid nodes that reflect the vertical error budget for a given survey
Archival Surface	BAG	BAG

Deliverables for Hydrographic Surveys Division

- BAG format of grid for public archival on NCEI
- S-57 Feature File
- Chart Comparison
- Aids to Navigation (ATON) investigation
- Sounding layer from grid
- Chart contours

Combination of Software to Achieve Goals

Tools Utilized for Lidar Analysis

- LP360
- QT Modeler
- Las tools
- Vdatum
- Caris Base Editor
- Fledermaus
- ArcMAP

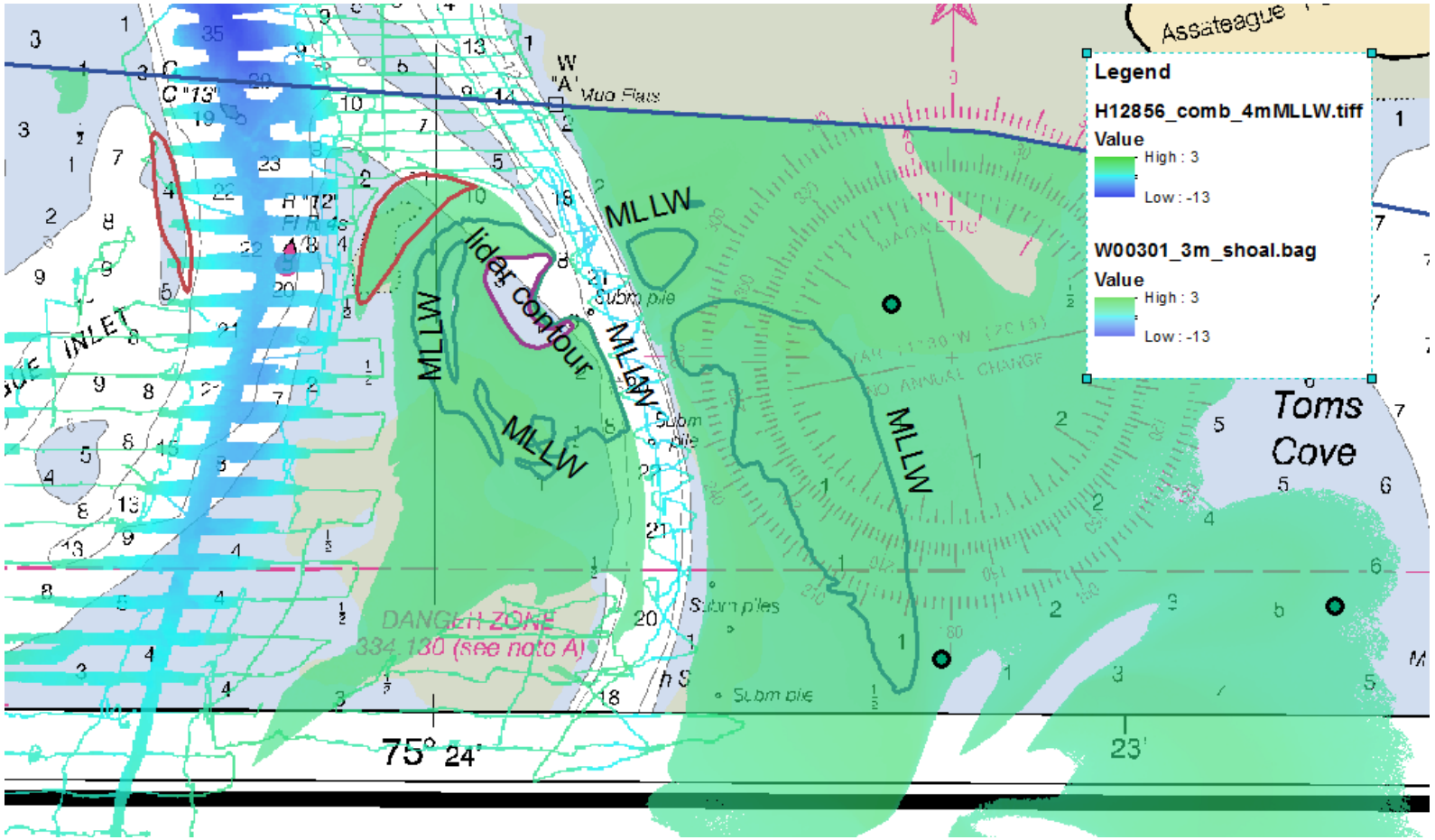
LP360 Primary Lidar Software

- Expertise within NOAA that we could tap into
- Works within ArcMap, software already licensed to NOAA, making learning LP360 more intuitive than other lidar software.
- Tools for visualizing and understanding processed lidar data, that hydro software does not have.

Good Coverage in Hard to Access Locations

RSD Sandy Outer Coasts and Inlets data generated 57.7 square nautical miles of bathymetry (MHW and below) in really hard areas to access by traditional sonar, along approximately 943 miles of coastline.

Chincoteague Inlet, VA



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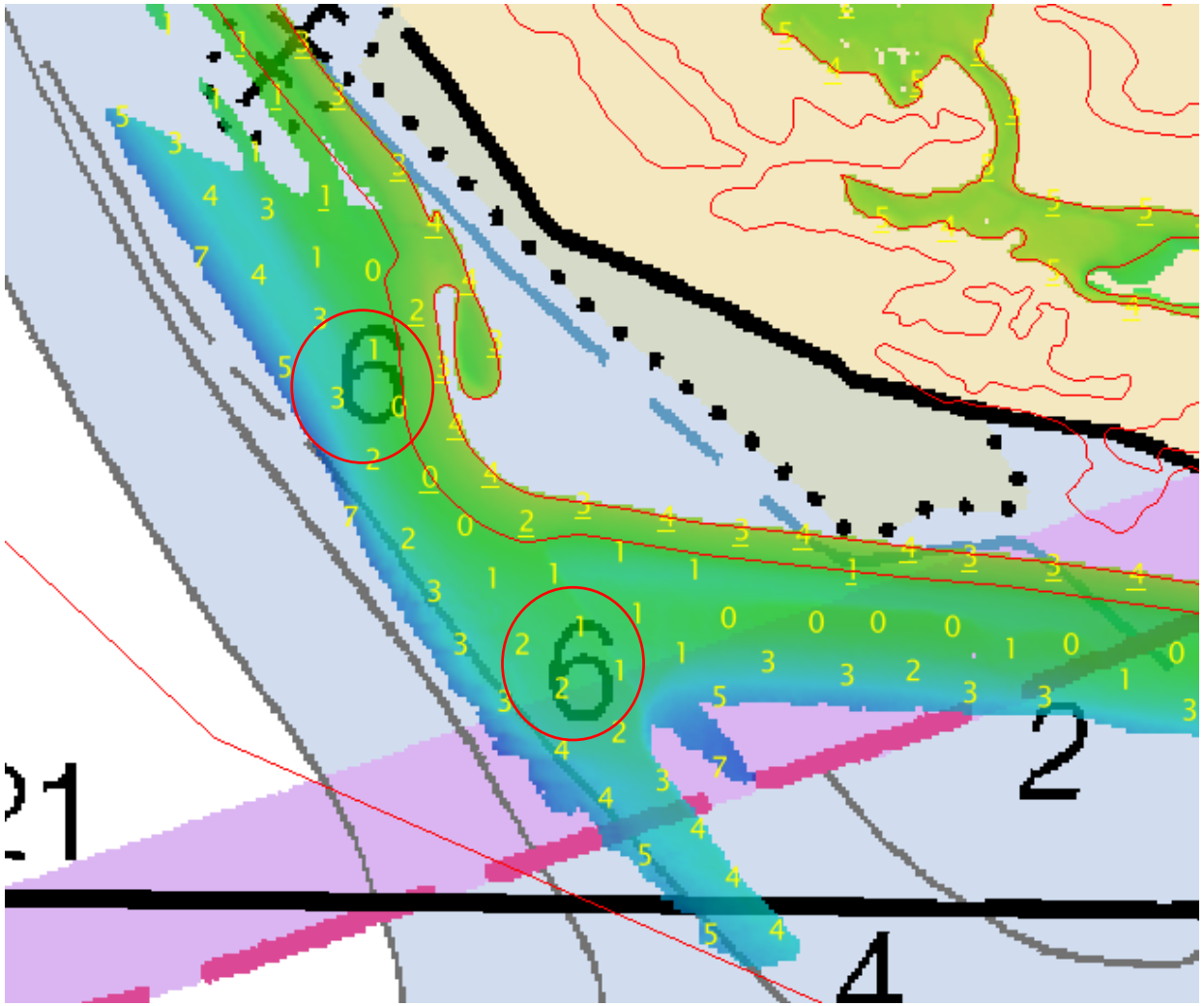
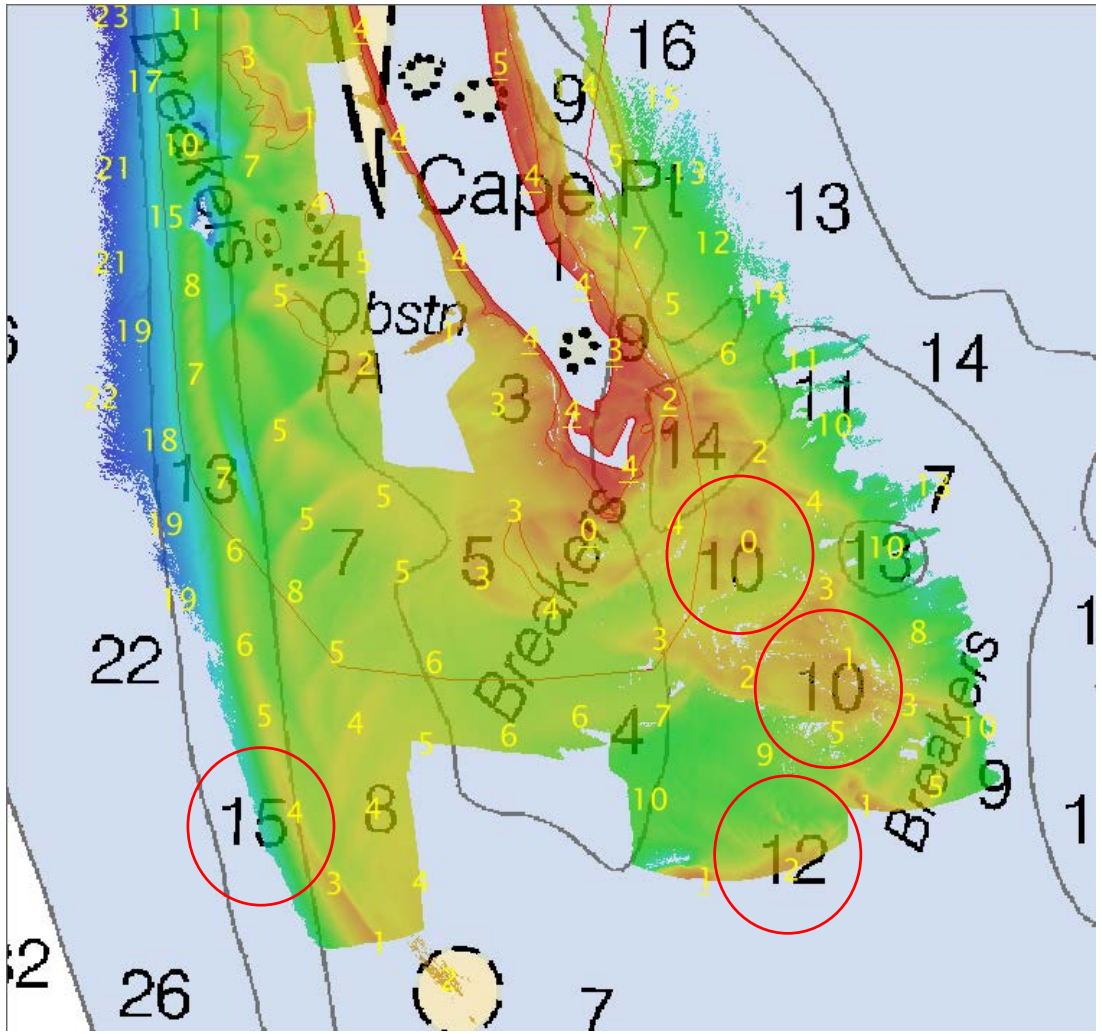
Soundings to Accompany New Shoreline Positions

Fisherman Island, VA

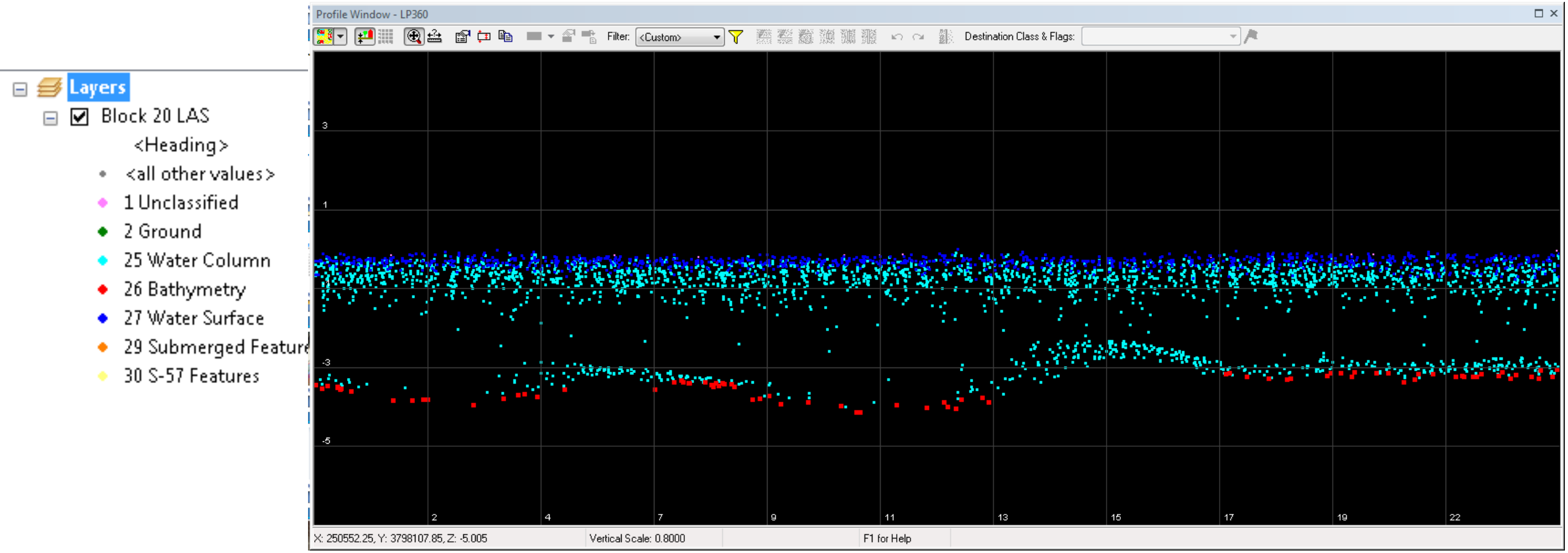


Dangers to Navigation

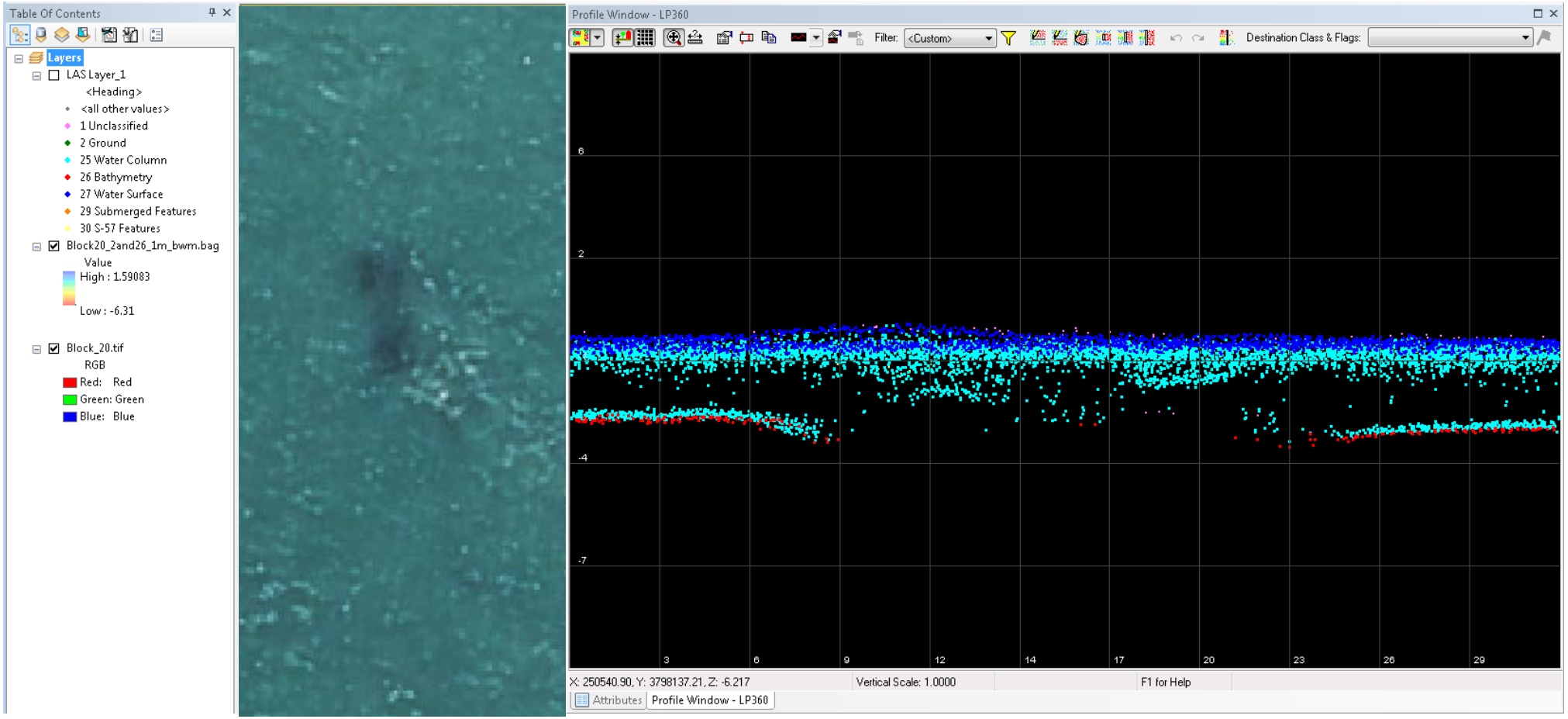
Cape Lookout, NC



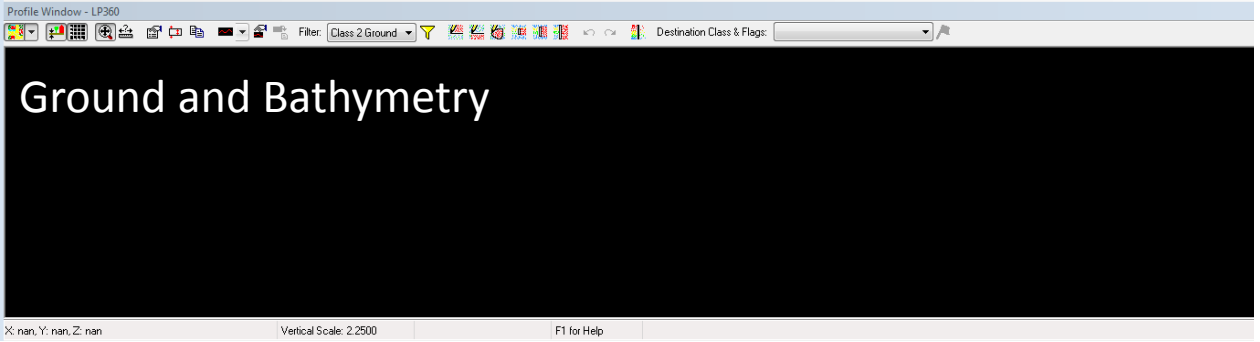
Automated Algorithms Effect Depth Interpretation

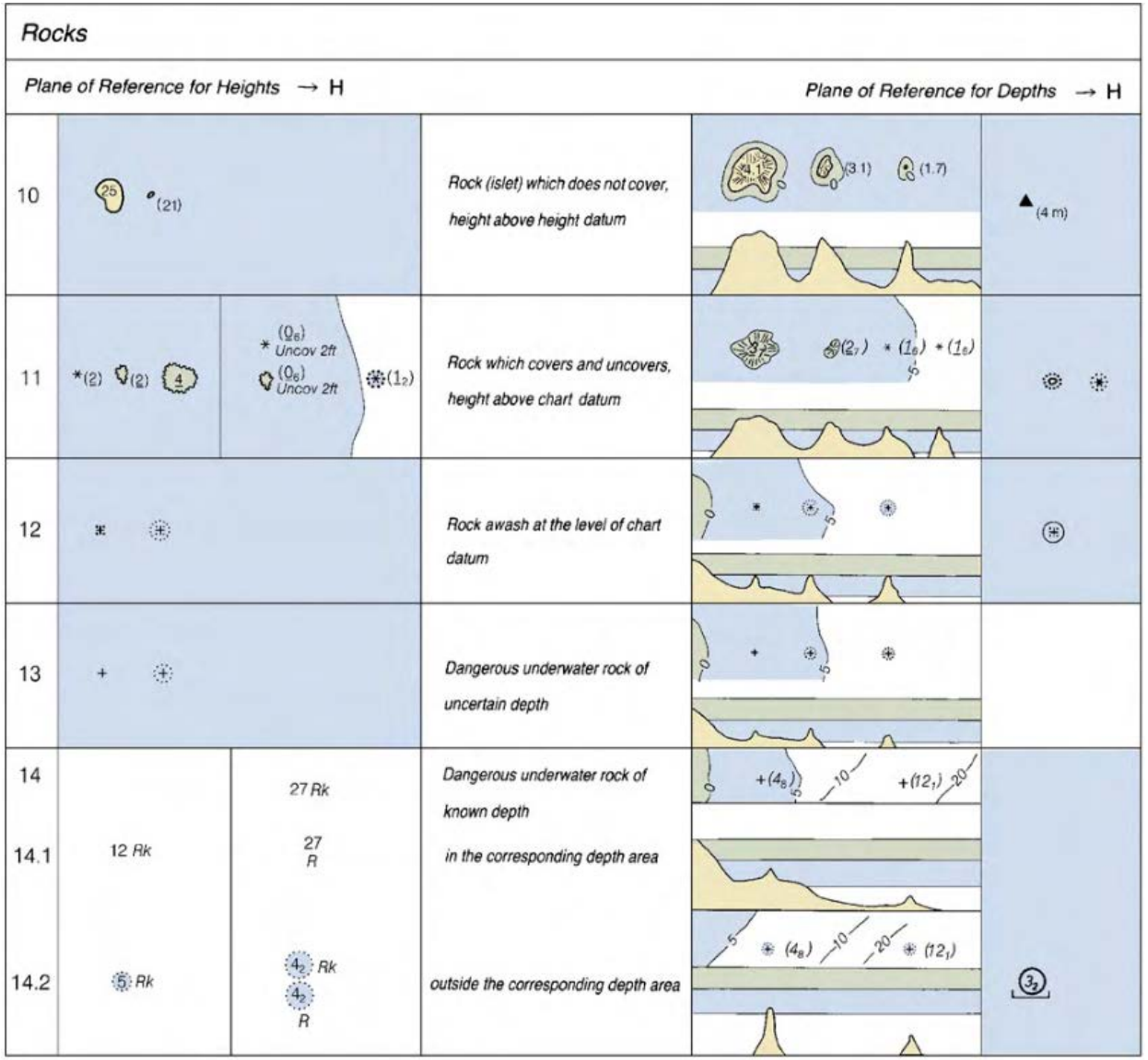


Navigationally Significant Points Excluded From Bare Earth Models

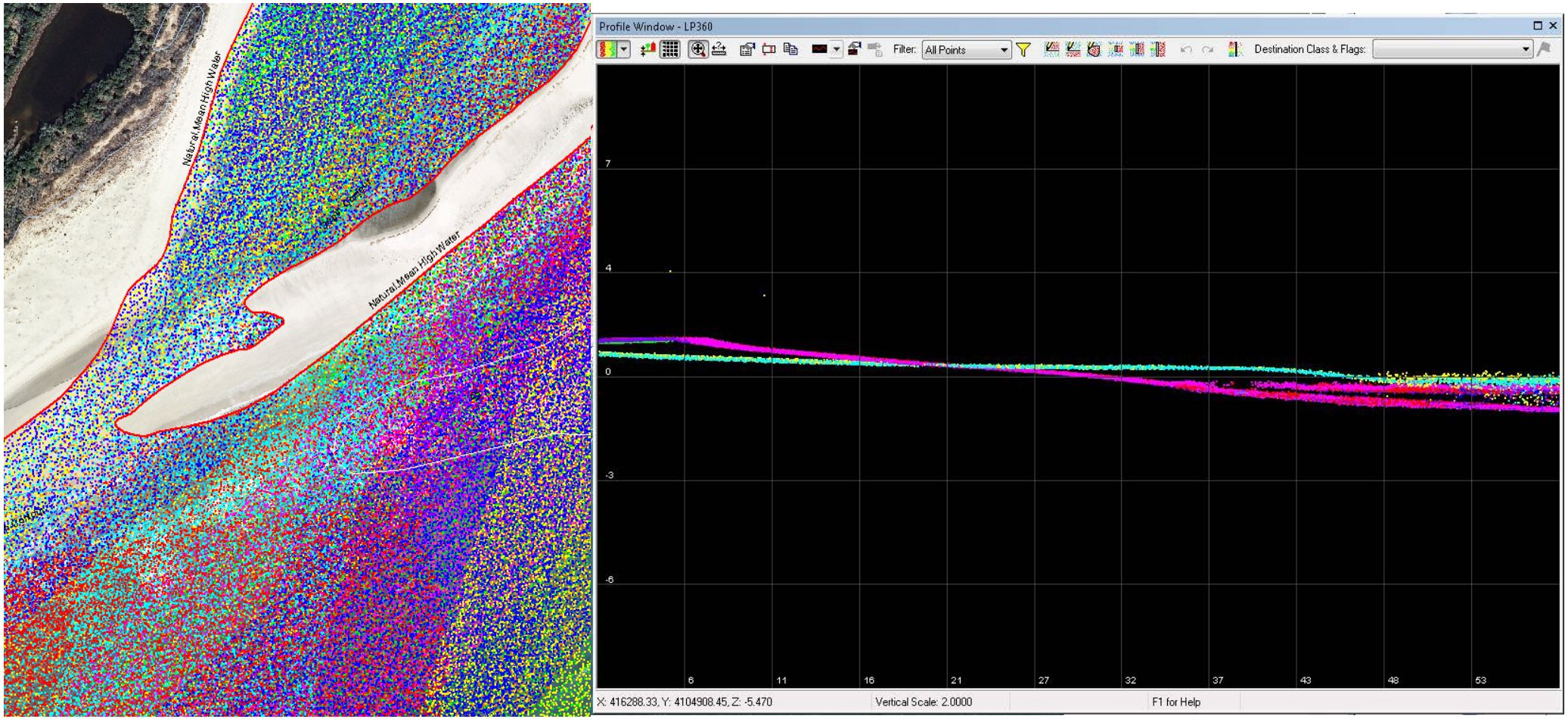


Navigationally Significant Points Exist in Many Classes

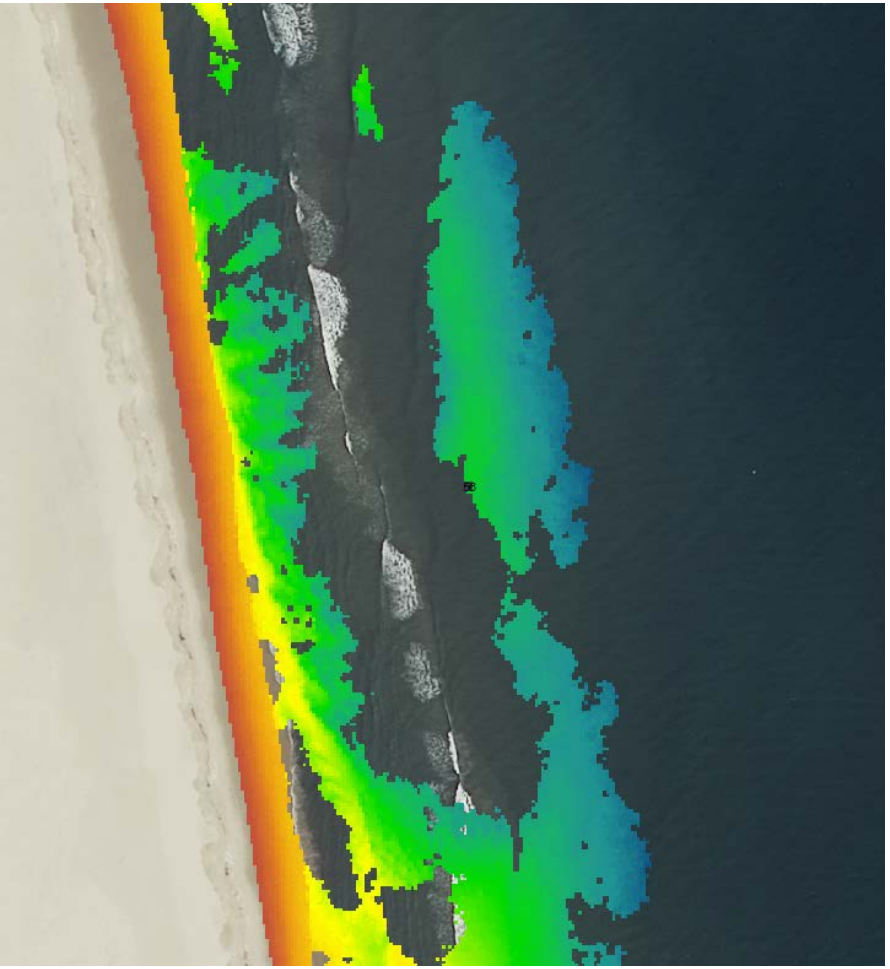


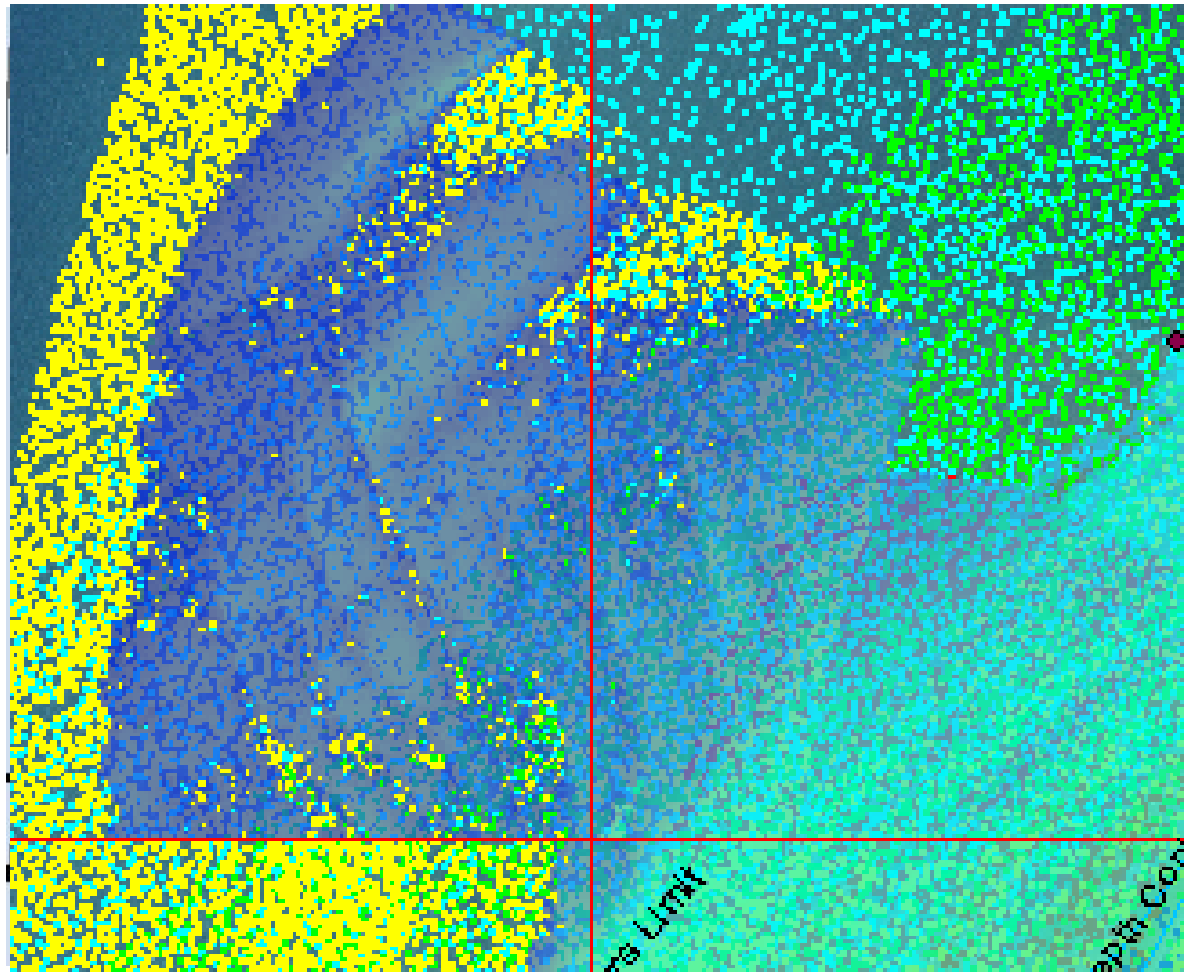


Flight Line Patterns and Time of Data Acquisition

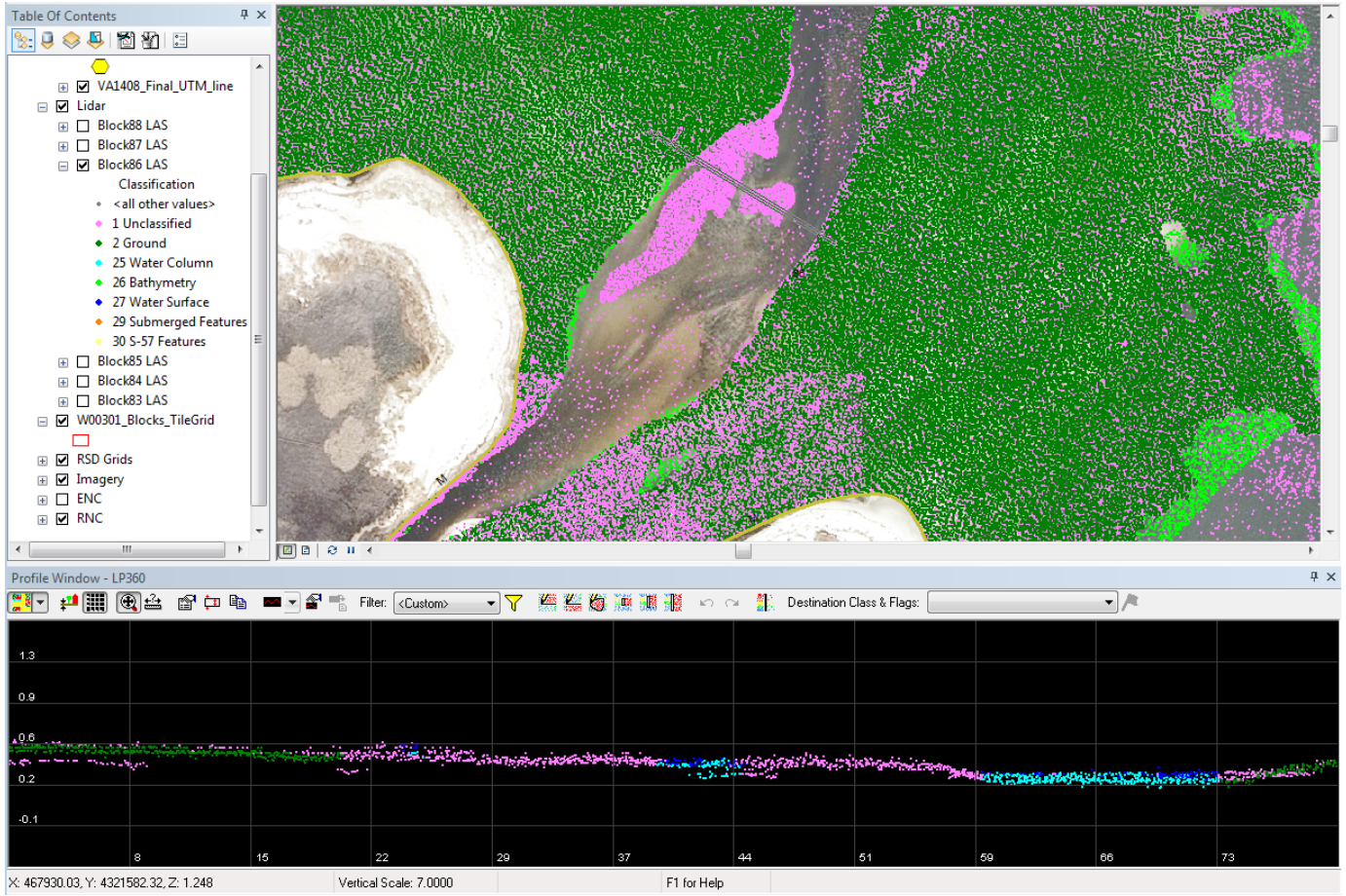


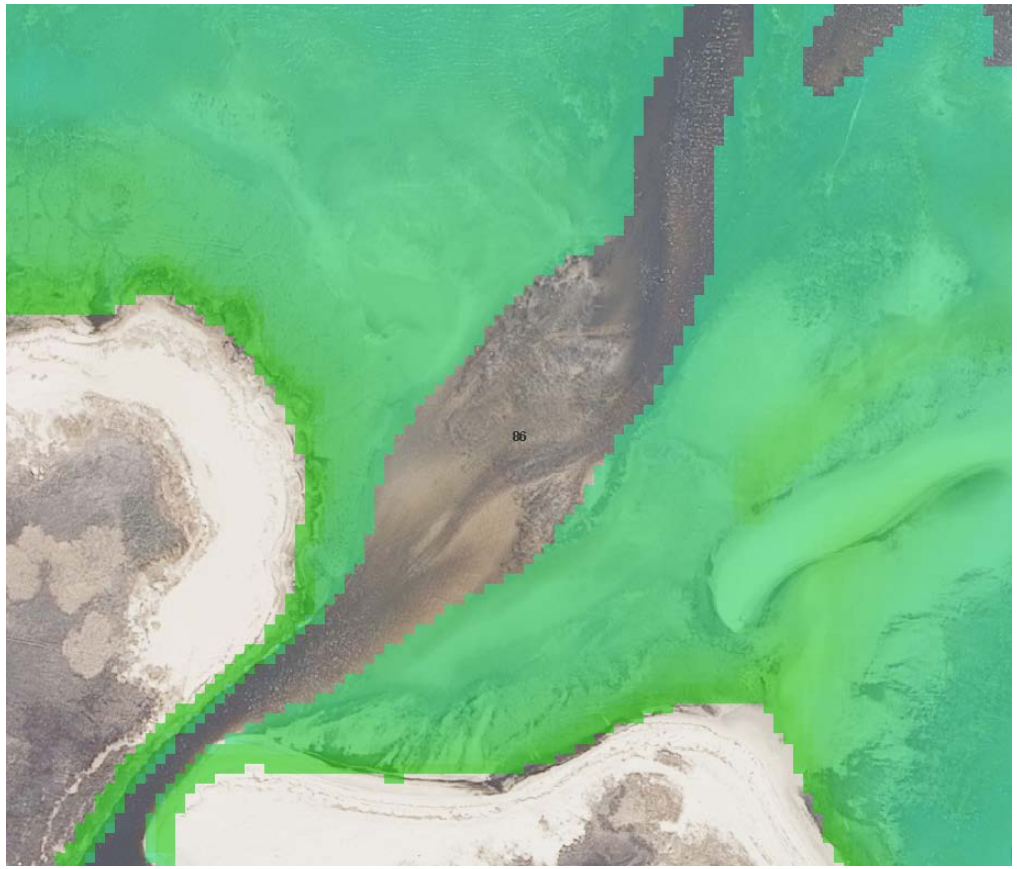
Understanding Missing Data Helps Make Informed Cartographic Decisions



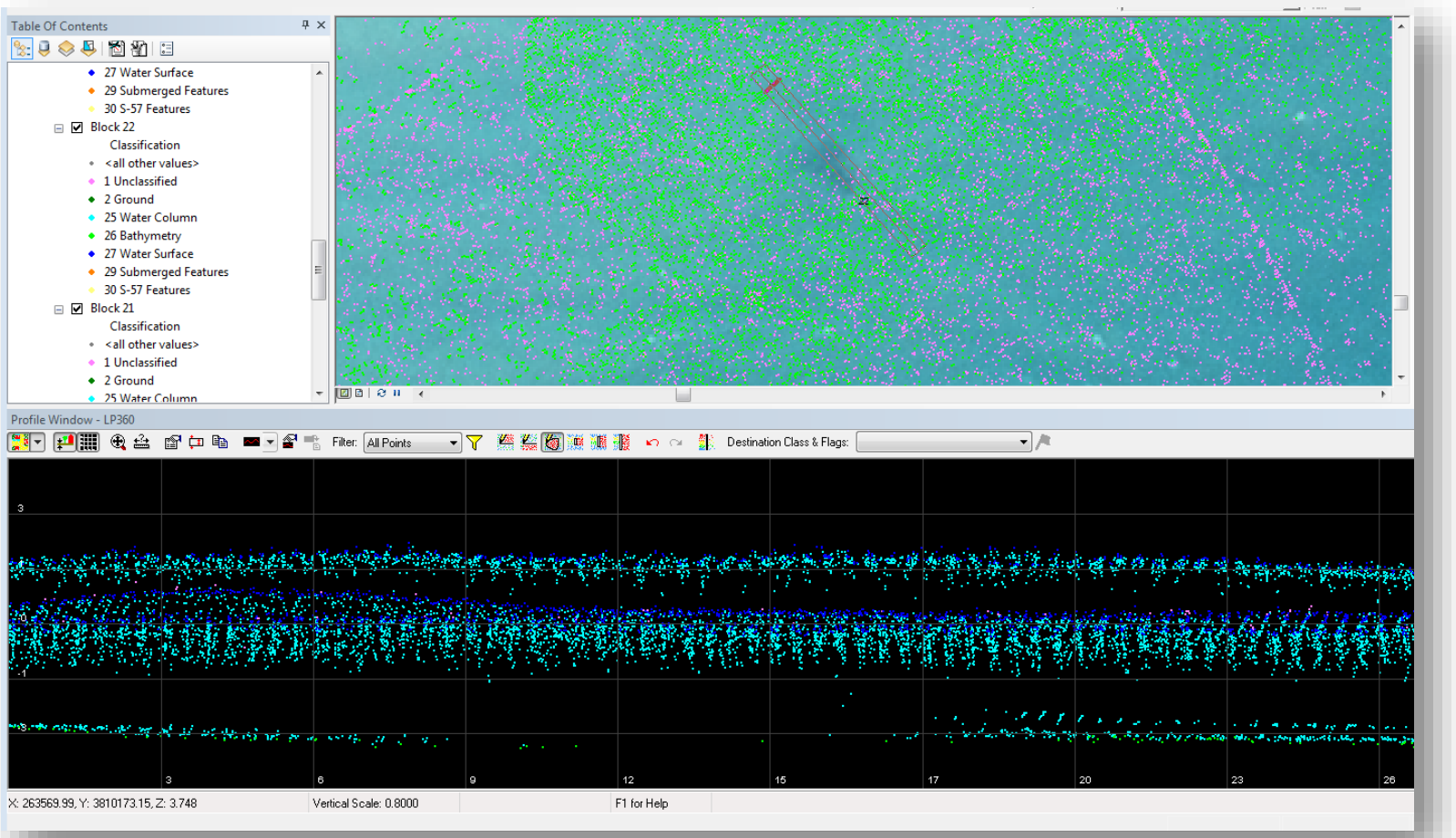


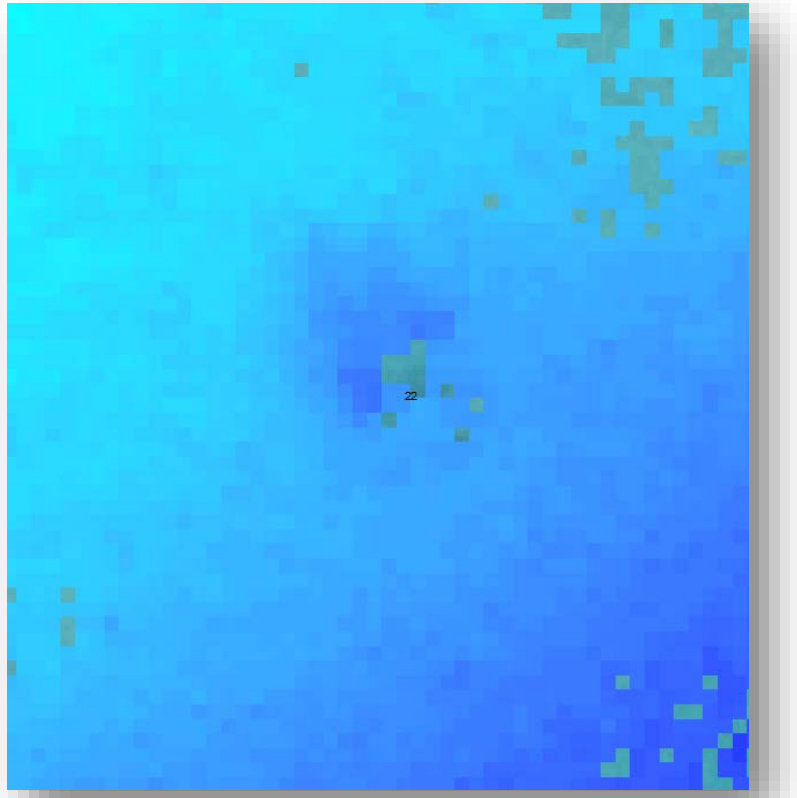
Misclassified Points





Absorption or Extinction?

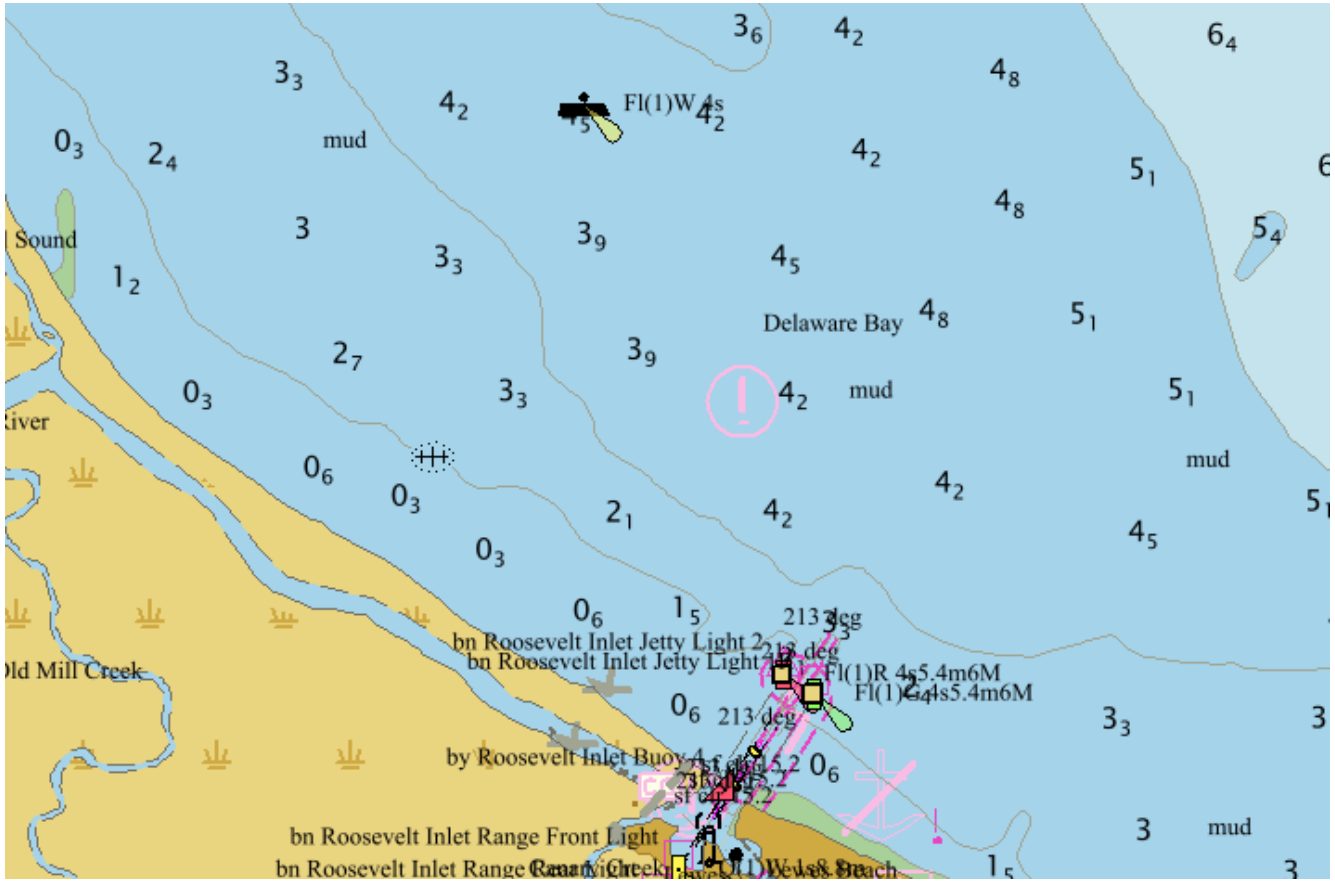
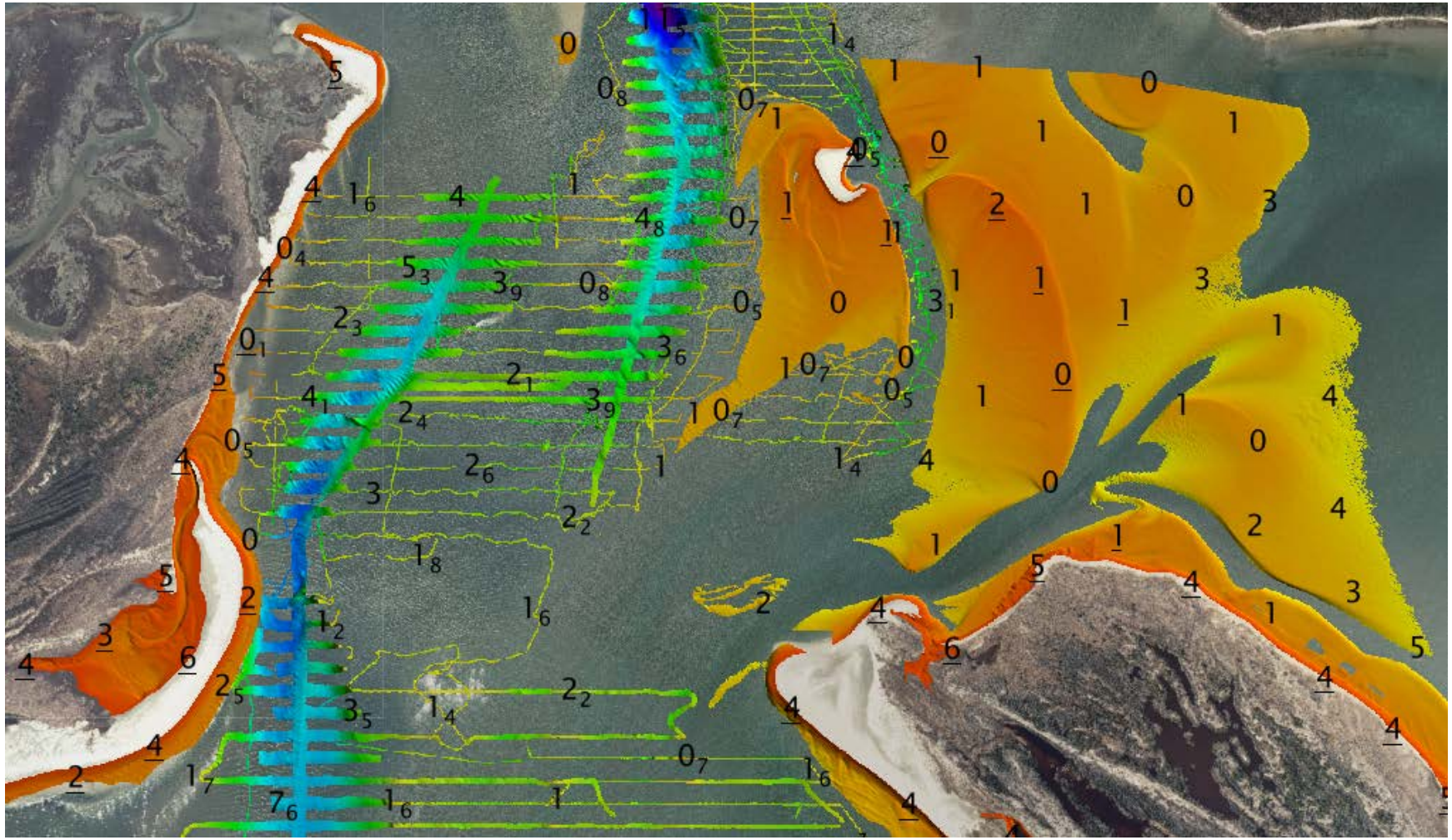




IHO products: S-57 attributed features, contours, depth areas, sounding

Attributes - Obstruction

Acronym	Name	Value
NATSUR	Nature of surface	
NOBJNM	Object name in r	
OBJNAM	Object name	
PRODCT	Product	
QUASOU	Quality of soundi	Value is unknown
SOUACC	Sounding accurac	
STATUS	Status	
TECSOU	Technique of sou	photogrammetry,found by laser
VALSOU	Value of soundin	
VERACC	Vertical accuracy	
VERDAT	Vertical datum	
VERLEN	Vertical length	
WATLEV	Water level effec	always dry
SORDAT	Source date	20140720
SORIND	Source indication	US,US,graph,W00301
INFORM	Information	
NINFOM	Information in na	
NTXTDS	Textual descriptic	
userid	Unique ID	
remrks	Remarks	seen in lidar and imagery, outside rsd sho
recomd	Recommendatior	
descrp	Description	Update
sftype	Special Feature T	
prmsec	Status-Primary/Se	
prkyid	Primary Key ID	
asgnmt	Assignment flag	



Questions?