8-2013

Evaluating the USACE's NCMP for NOAA charting operations

Gretchen Imahori
NOAA

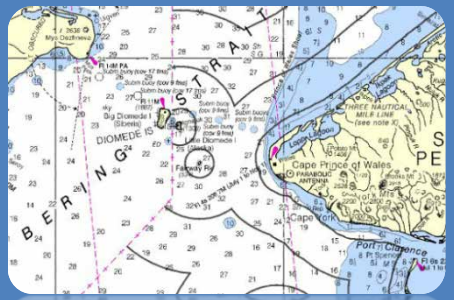
Shachak Pe'eri
University of New Hampshire, Durham, shachak.peeri@unh.edu

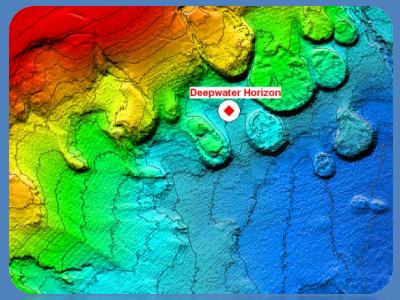
Christopher Parrish
University of New Hampshire, Durham

Toshi Wozumi
NOAA

Stephen A. White
University of New Hampshire, Durham

See next page for additional authors



Evaluating the USACE's NCMP data for NOAA charting operations

JALBTCX Workshop
08/06/13

Gretchen Imahori[1], Shachak Pe'eri[2], Christopher Parrish[1,2], Toshi Wozumi[1], Stephen White[1], Inseong Jeong[1] and Christopher Macon[3]

[1] National Oceanic and Atmospheric Administration, National Ocean Service
[2] University of New Hampshire, Center for Coastal and Ocean Mapping/Joint Hydrographic Center
[3] US Army Corps of Engineers, Joint Airborne Lidar Bathymetry Technical Center of Expertise

Background

The National Oceanic and Atmospheric Administration (NOAA) is mandated to acquire hydrographic data and provide nautical charts.

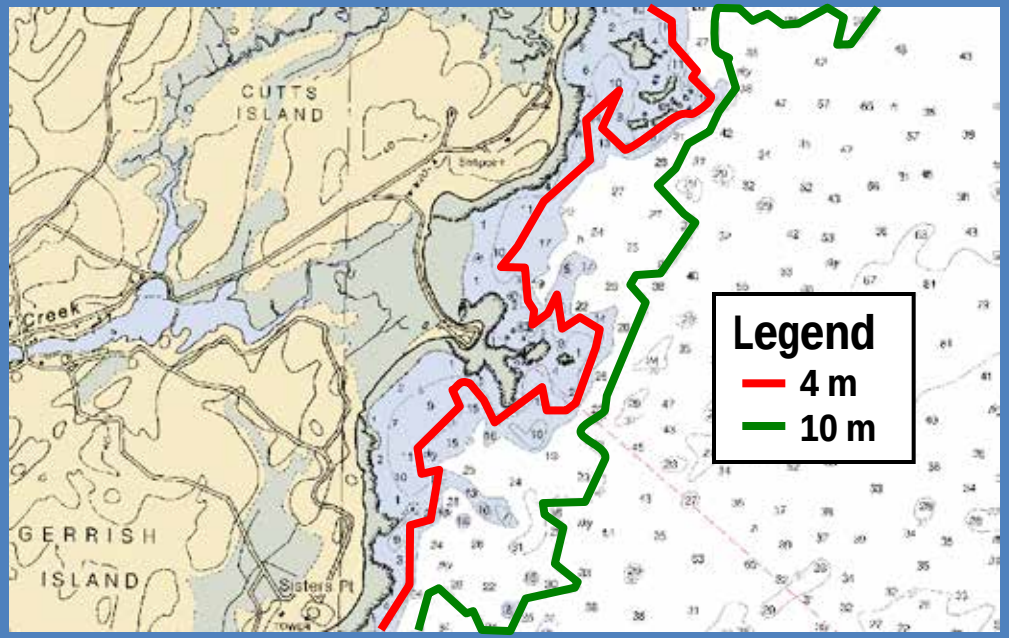
Typically, NOAA uses a combination of in-house and contracting resources to acquire hydrographic data around the coasts of the U.S. and its territories.

NOAA's Hydrographic Surveys Division (HSD) within the Office of Coast Survey (OCS) evaluates outside source data sent to OCS and determines if it can be potentially applied to NOAA Charts.

Shallow water bathymetry gap

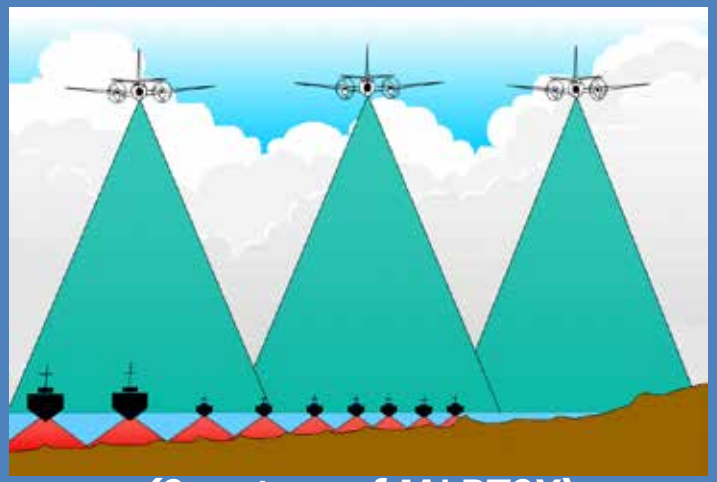
Coastal shallow-water zone

- 0 to 4 m below the MLLW – Depths shallower than the Navigable Area Limit Line (NALL).
- From 4 to 10 m below the MLLW – Junction area with sonar surveys.



NOAA Chart 13283 (subset over Gerrish Island, ME)

Airborne Lidar Bathymetry (ALB)



(Courtesy of JALBTCX)

Goal

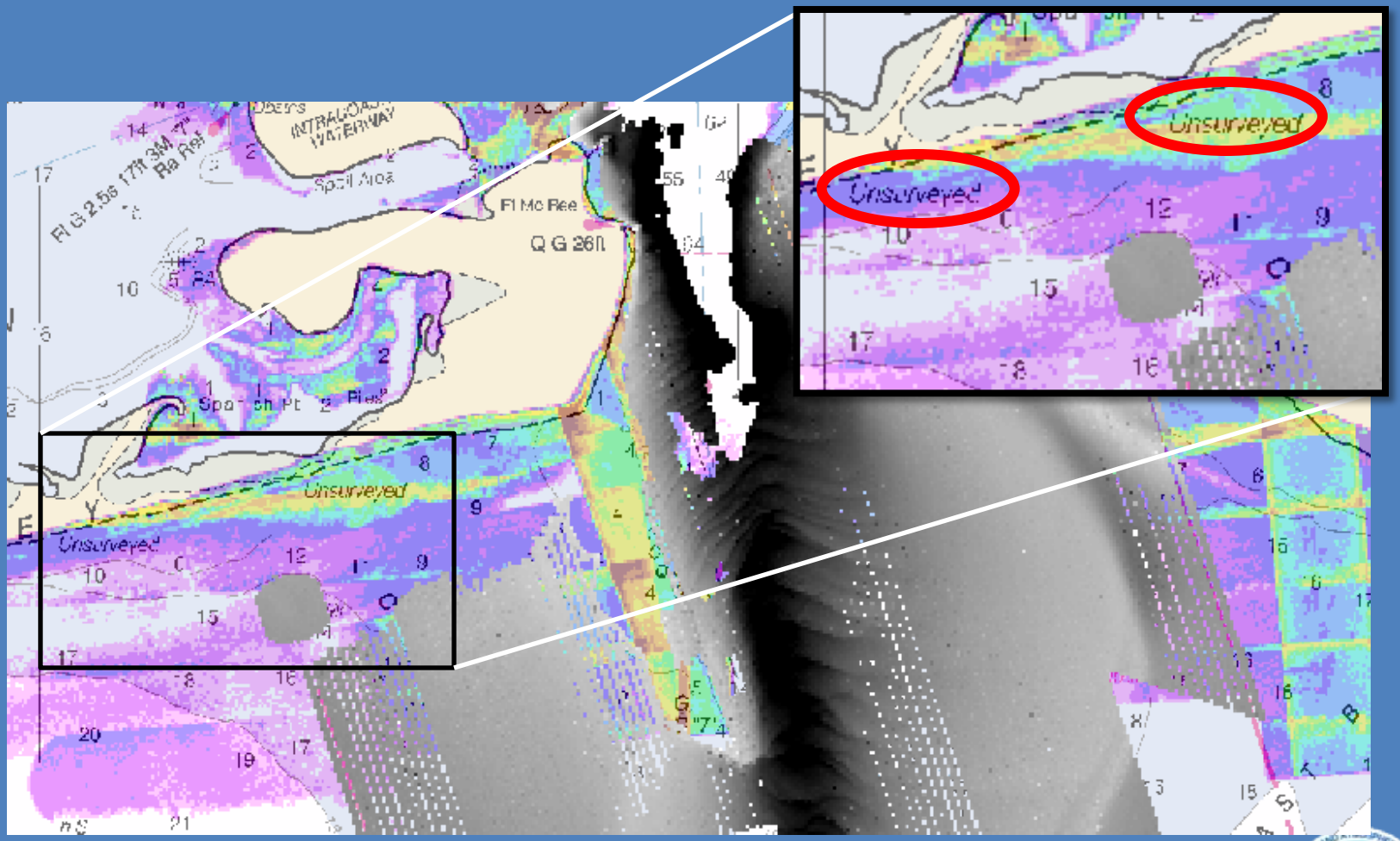
Evaluate the potential use of USACE Airborne Lidar Bathymetry (ALB) data for updating the coastal portion (0-10m) of NOAA charts

Expected contributions

Based on the study results, recommendations will be provided for different site conditions (geology, water clarity and depth).

Also, this will allow the development of future operating procedures with workflows to incorporate the outside source datasets into NOAA's current workflows for updating the Nautical Charts and other products.

Unsurveyed areas



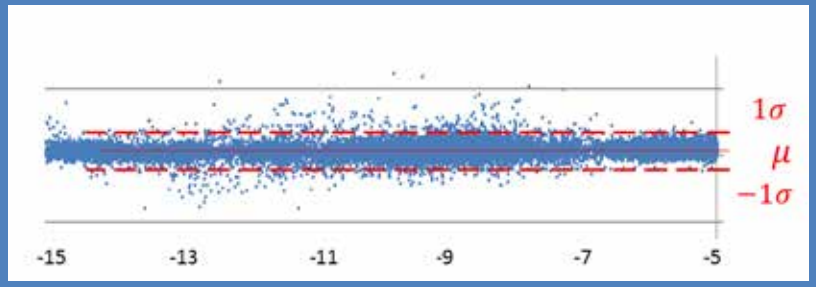
NCMP coverage and density
with OCS MBES overlap

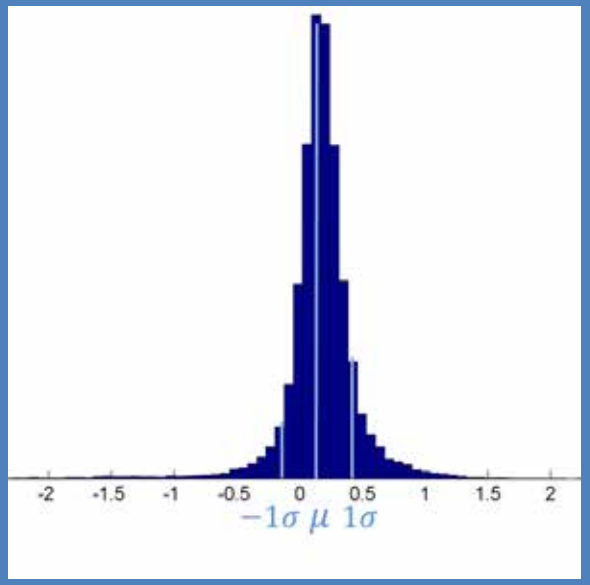
Methodology and Resources

- Statistical analysis between overlapping NOAA multibeam hydro surveys with ALB NCMP surveys.
- ALB datasets collected by SHOALS and Hawkeye systems.
- Software tools: ArcMap (Spatial and 3D-Analyst modules), and LAStools.

Procedure for Statistical Analysis

1. Calculate the point density distribution (ArcMap).
2. Identify the gaps in the dataset (ArcMap).
3. Generate a surface from the ALB and MBES datasets (ArcMap).
4. Statistical Analysis between datasets (MS Excel/Matlab):
   - Spatial difference map
   - Scatter plot
   - Histogram





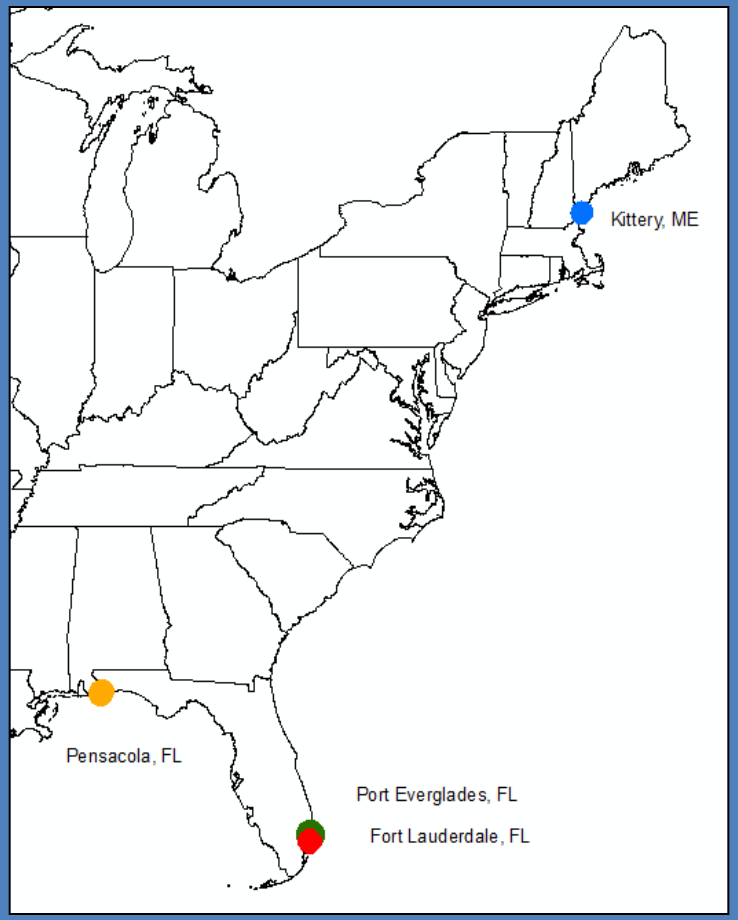
Study sites

Ft. Lauderdale, FL: 2012 NCMP JALBTCX ALB data and 2009 OCS bathy lidar data (H12118)

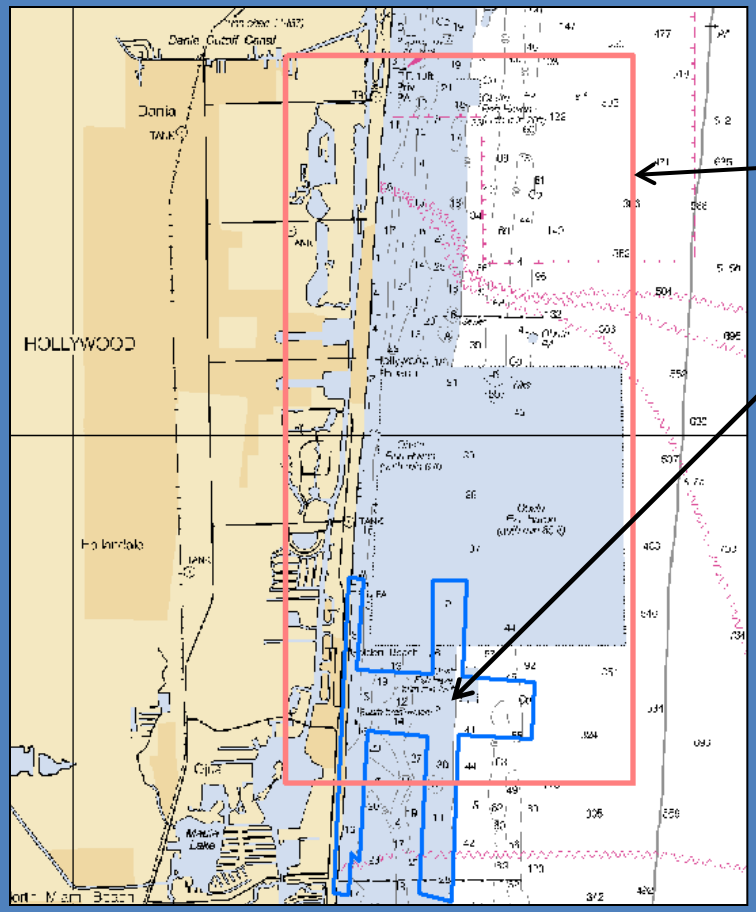
Port Everglades, FL: 2009 NCMP JALBTCX ALB data, 2008 H11896 OCS MB data

Kittery, ME: 2007 NCMP JALBTCX ALB data, 2006 W00178 OCS MB data (CCOM-JHC)

Pensacola, FL: 2004 and 2010 NCMP JALBTCX ALB data, 2009 H12061 OCS MB data

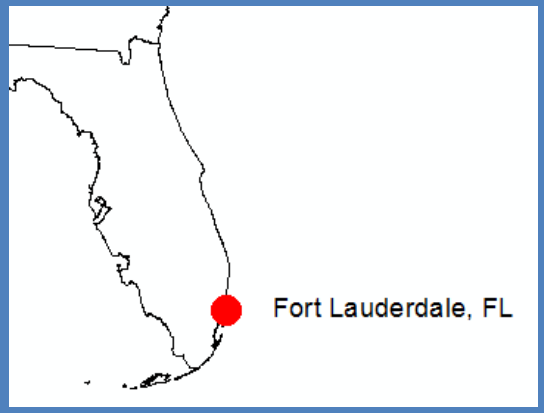


Calibration site: Fort Lauderdale



OCS ALB

USACE NCMP

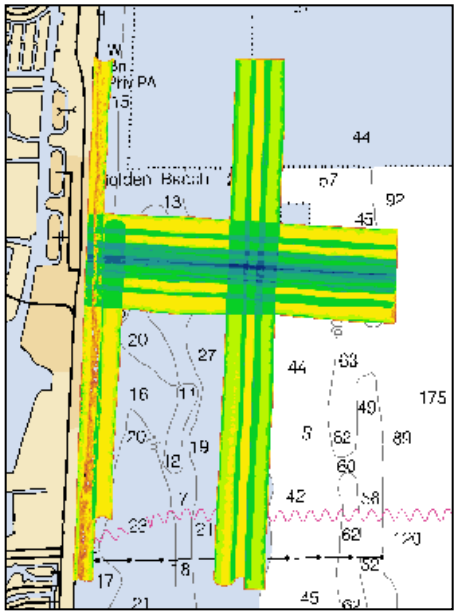


	NCMP ALB	OCS ALB
Date	2012	2009
Spacing	4x4m	2x2m
Overlap	200%	100%

Areas	Mean Difference	Standard Deviation
Fort Lauderdale, FL	0.17m	0.32m

Bottom type: hard bottom and sandy coral.

Statistical Analysis: Fort Lauderdale, FL

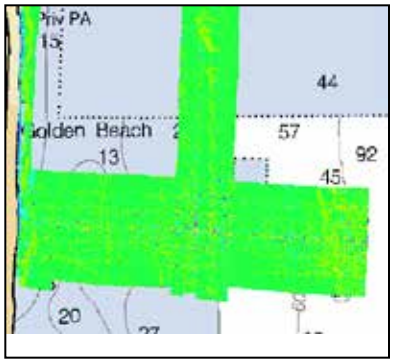


Density Map (#/m²)

- 0 - 0.01
- 0.01 0.03
- 0.03 - 0.05
- 0.05 - 0.07
- 0.07 - 0.09
- 0.09 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6

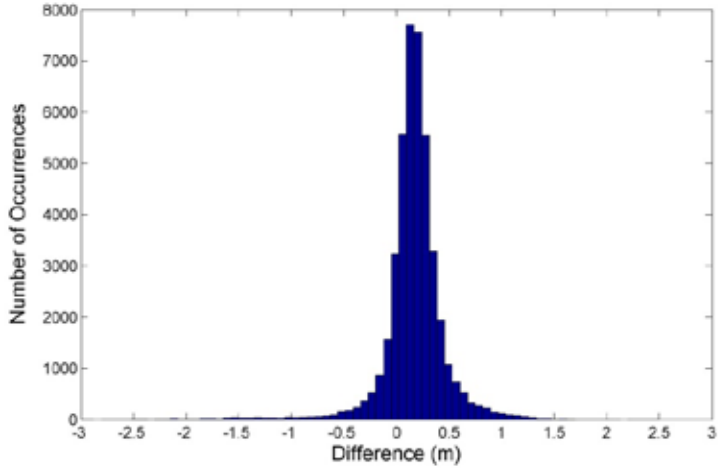
Difference Map (m)

- -4 - -3
- -3 - -2
- -2 - -1
- -1 - 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7

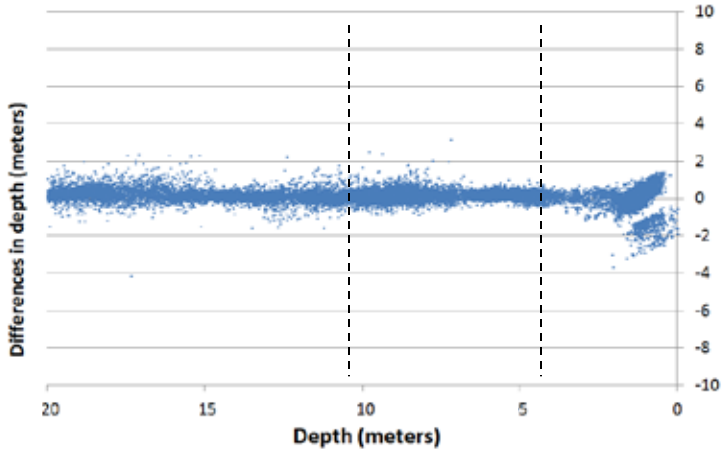


Area	Mean Difference	Standard Deviation
Fort Lauderdale, FL	0.17m	0.32m

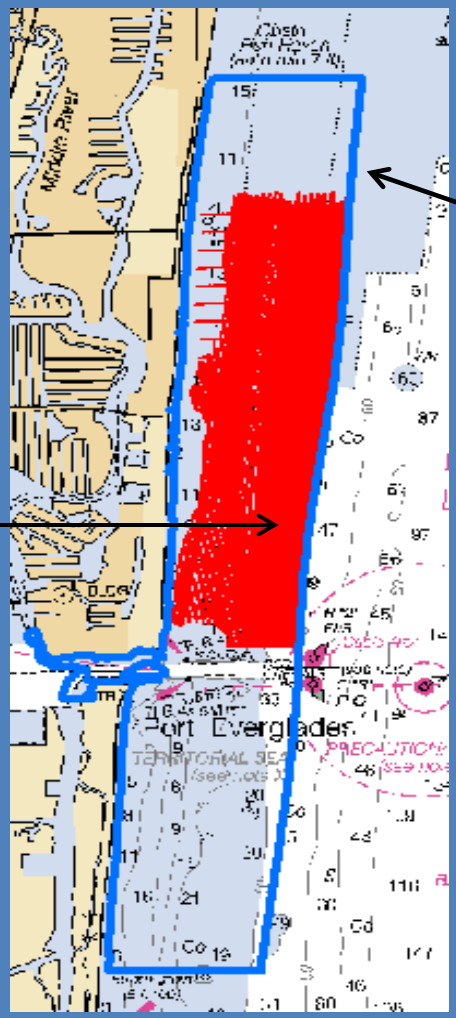
Differences between 2009 OCS lidar and 2012 NCMP lidar

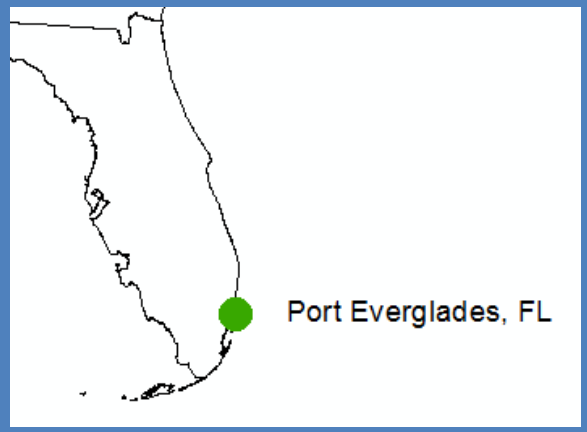


Differences at depth between 2009 OCS lidar and NCMP lidar



Study Site: Port Everglades



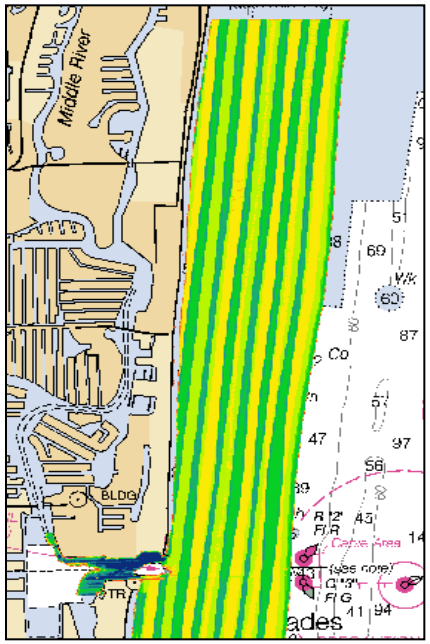


Reported Stats	NCMP ALB	OCS MBES
Date	2009	2008
Spacing	4x4m	50 cm – 1 m
Overlap	100%	100%

Areas	Mean Difference	Standard Deviation
Port Everglades, FL	0.54m	0.27m

Bottom type: hard bottom and sandy coral.

Statistical Analysis: Port Everglades, FL

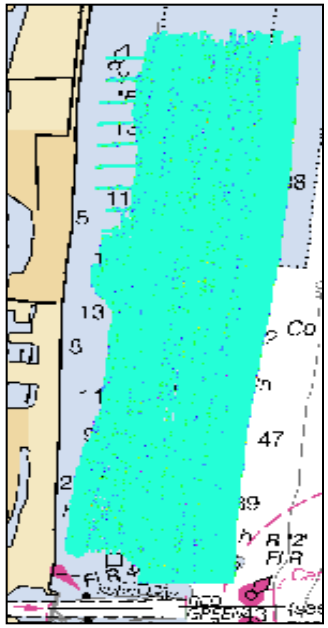


Density Map (#/m²)

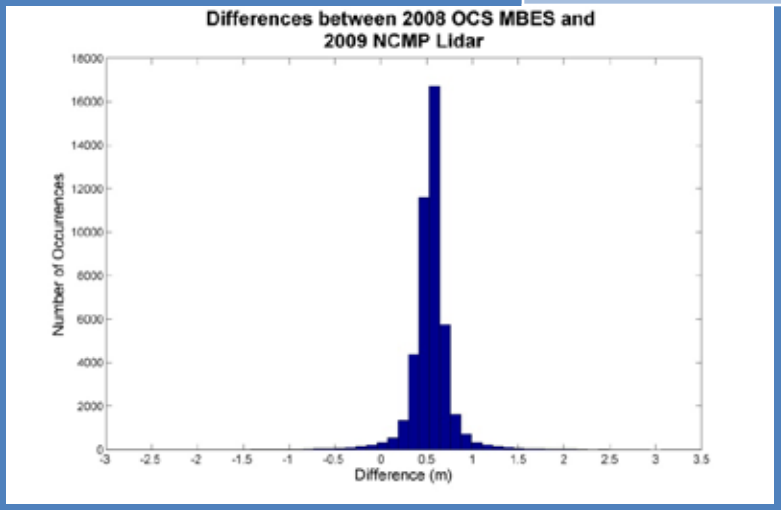
- 0 - 0.01
- 0.01 - 0.03
- 0.03 - 0.05
- 0.05 - 0.07
- 0.07 - 0.09
- 0.09 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6

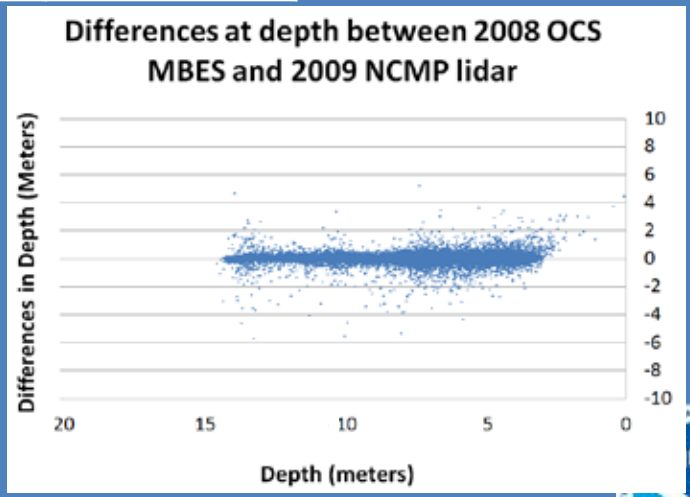
Difference Map (m)

- 4 - -3
- -3 - -2
- -2 - -1
- -1 - 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7



Area	Mean Difference	Standard Deviation
Port Everglades, FL	0.54m	0.27m

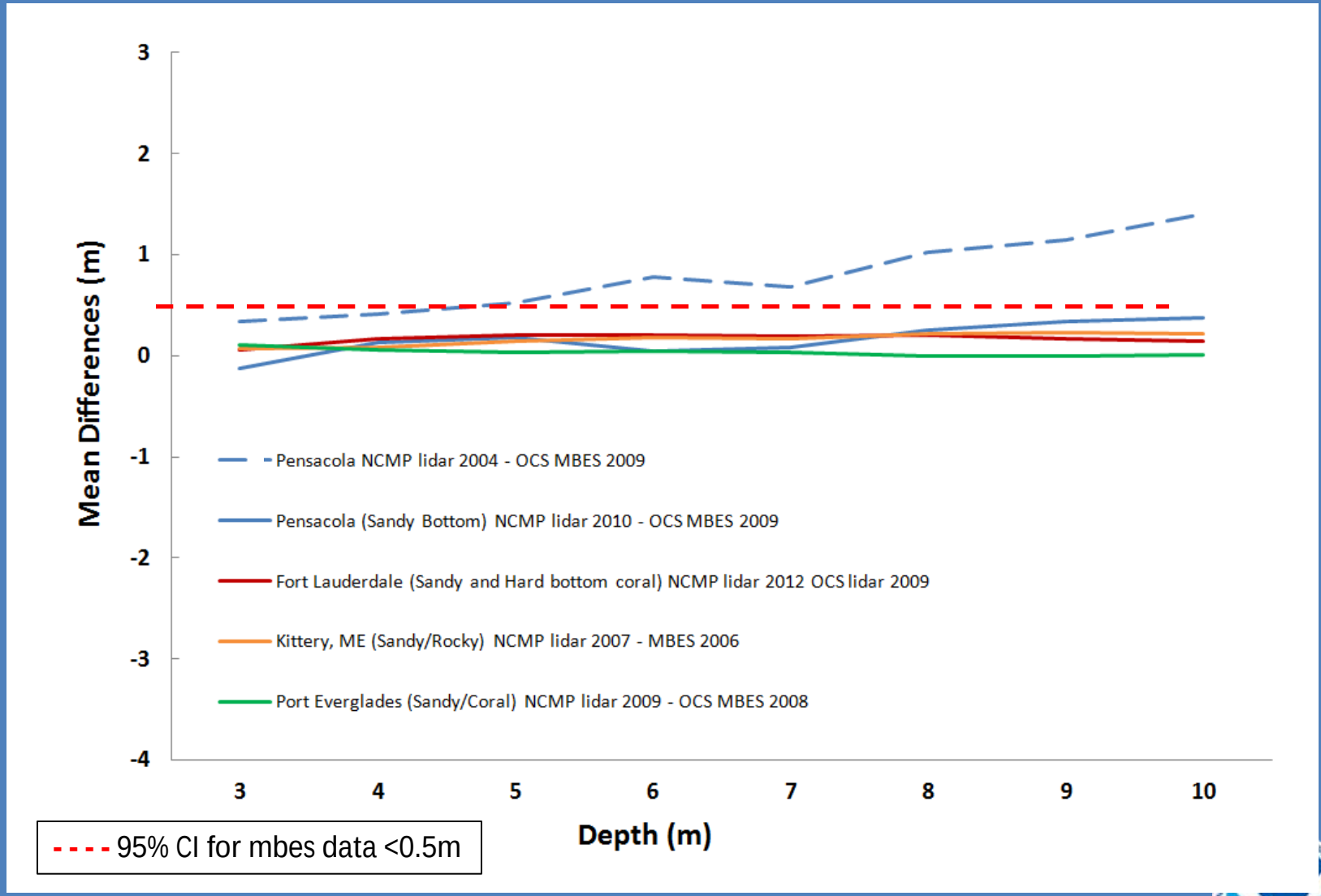




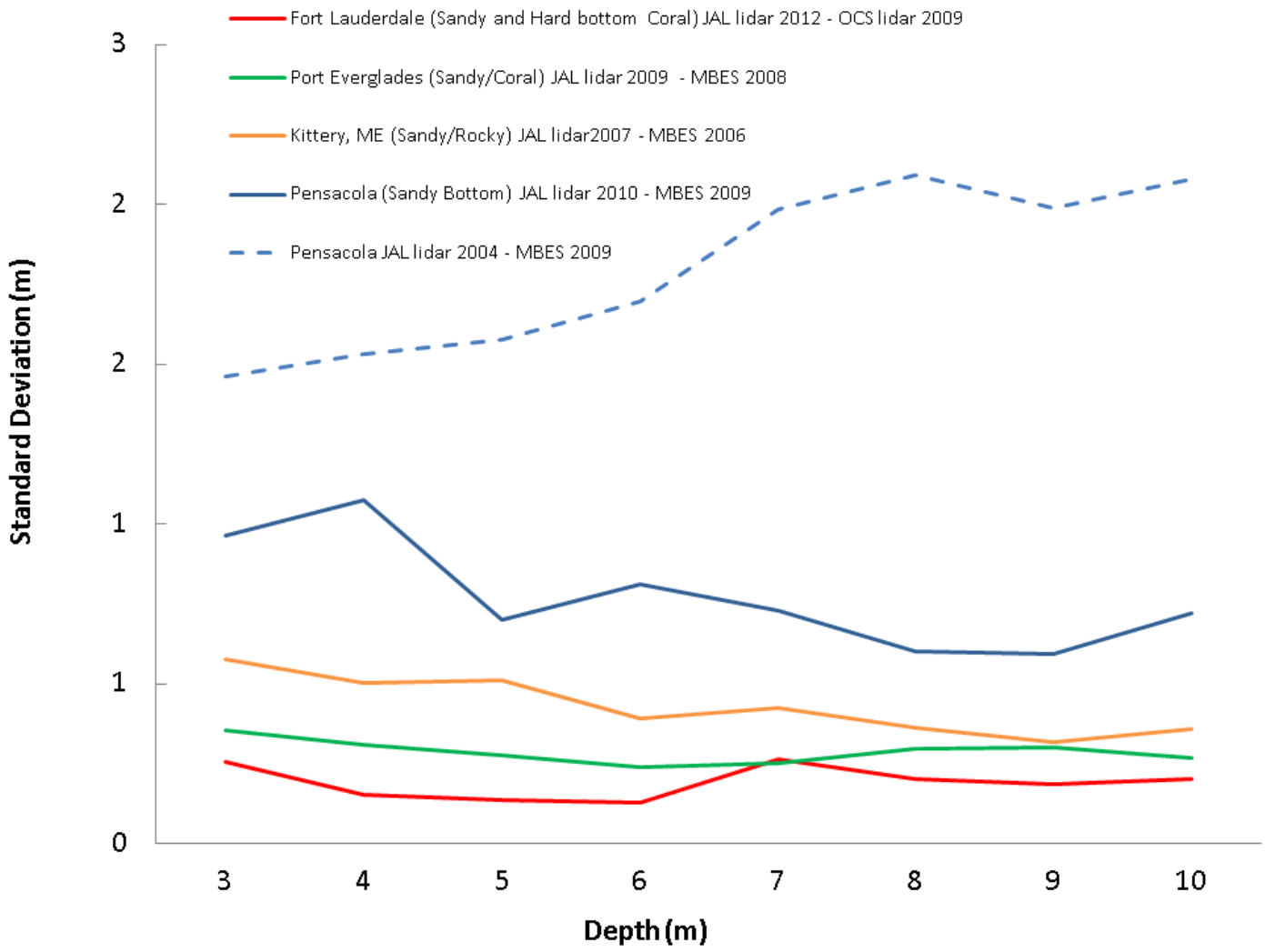
Study Site Summary Table

Study Area	Seafloor Type/Characteristics	NCMP			OCS		
		Spacing (m)	Coverage	Year	Spacing (m)	Coverage	Year
Fort Lauderdale, FL	Sandy and Hard bottom Coral	4x4	200%	2012	4x4	100%	2009
Port Everglades, FL	Sandy and Hard bottom Coral	4x4	100%	2009	0.5x0.5,1x1	100%	2008
Kittery, ME	Fine sand with rock outcrop	5x5	100%	2007	0.5x0.5,1x1	100%	2006
Pensacola, FL	Sand	3x3, 5x5	100%	2010, 2004	1x1,2x2	100%	2009

Mean Differences



Statistical Analysis



Results

The NCMP ALB data were found to correlate well with MBES datasets. Largest differences were between 0-2m.

The NCMP ALB data can be potentially successful for updating OCS nautical charts under the following conditions:

- coastal areas up to 10 m.
- Most seafloor types (e.g., rocky/sandy/coral areas), excluding vegetated and muddy areas.

In general the majority of differences are well within the combined uncertainty of the systems (MBES and lidar) that generated the data being compared

Discussion

- It is important to note that the consistency between the datasets is affected by the seafloor type and the survey period:
  - For example, sandy seafloor near tidal inlets and along-shore bars varies with time.
- The bottom detection success (bathymetry) of NCMP datasets over muddy seafloor is very low.
- The procedure used here is transferable to the NOAA Hydro processing branches and will work within the current workflow.
- This procedure is currently in the process of being expanded to examine other ALB datasets inside (e.g. RSD Sandy ALB) NOAA and can be used for those outside (e.g., CZMIL, EARRL) NOAA

Questions?

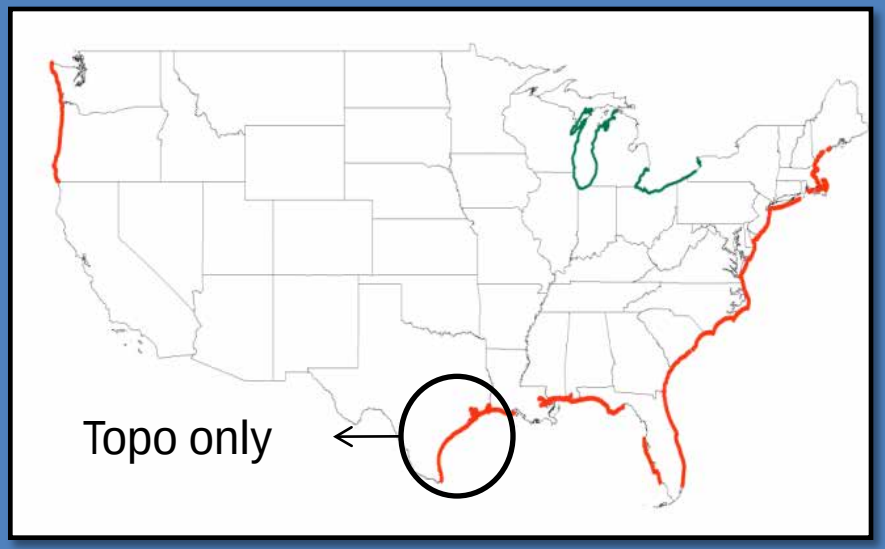
For more info: NOAA Technical Memorandum NOS CS 32
(http://www.nauticalcharts.noaa.gov/hsd/lidar.html)

Thank You!

Background - data

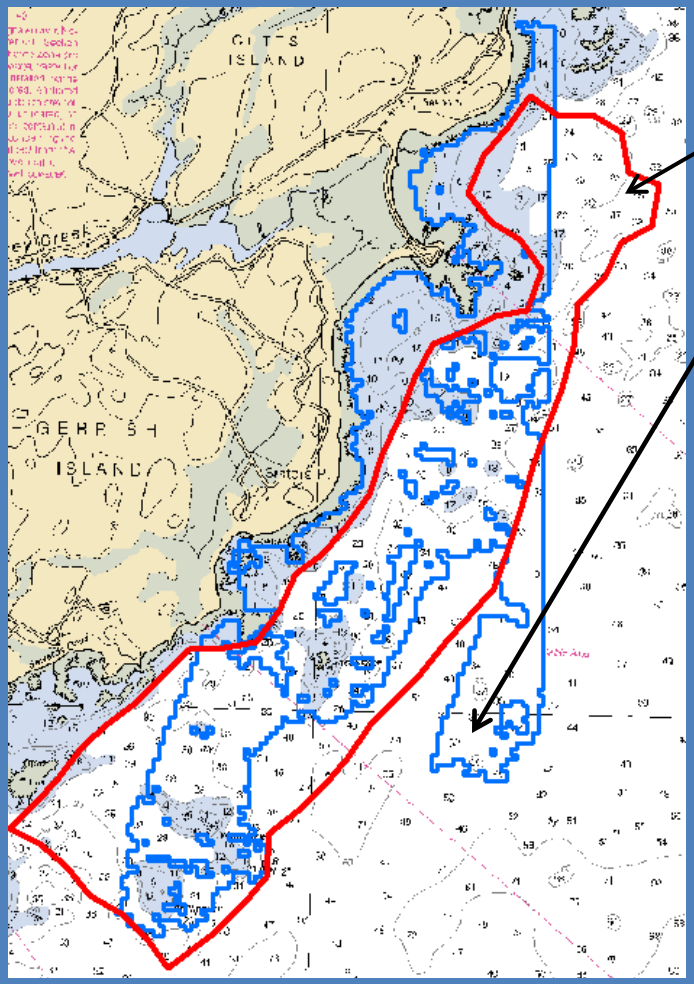
NCMP

- Acquires topo-bathy lidar data every 5-7 years.
- Bathy data exists for many areas along the continental US coastal areas.
- Internal USACE ALB systems: SHOALS and CZMIL.
- External (contractors) USACE ALB systems: Optech SHOALS, LADS MKII and AHAB Hawkeye.
- NCMP Data is publically available.



NCMP coverage map
(JALBTCX, 2012)

Study Site: Kittery, ME



OCS MBES

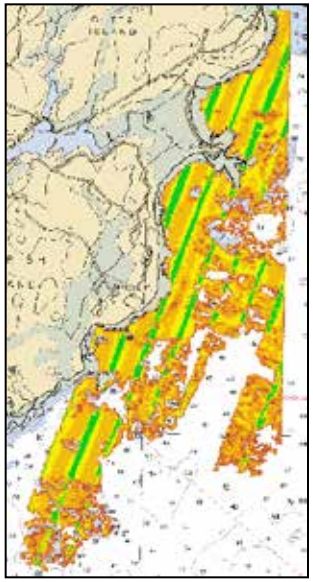
USACE NMCP

Reported Stats	NCMP ALB	OCS MBES
Date	2007	2006
Spacing	5x5	50 cm – 1 m
Overlap	100%	100%

Areas	Mean	Standard Deviation
Kittery, ME	0.17m	0.39m

Seafloor type: fine sand, gravel with rocky outcrop.

Statistical Analysis: Kittery, ME

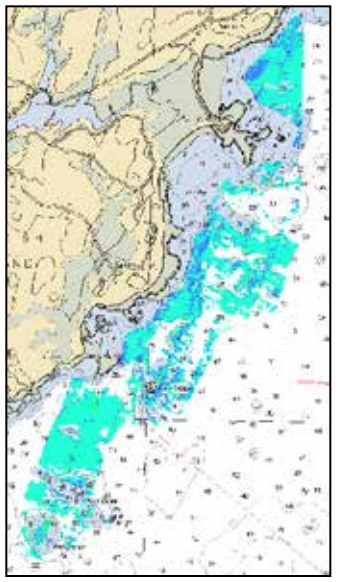


Density Map (#/m^2)

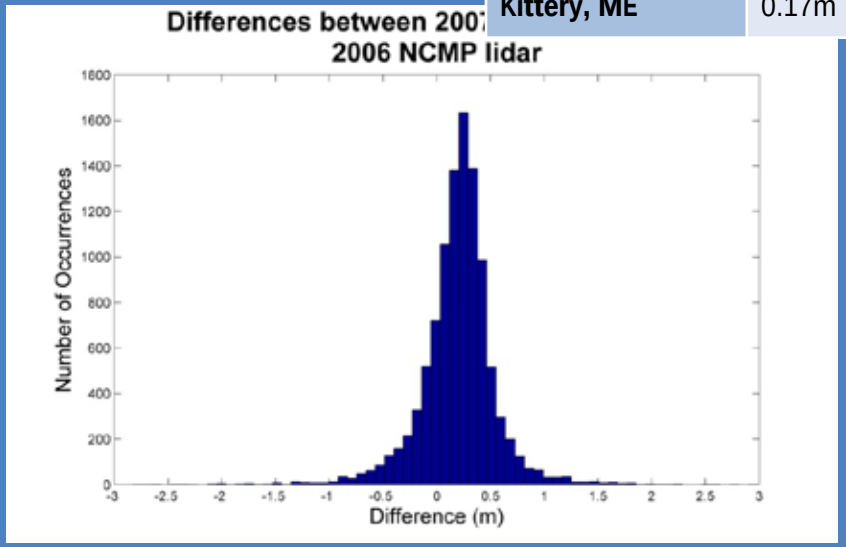
- 0 - 0.01
- 0.01 - 0.03
- 0.03 - 0.05
- 0.05 - 0.07
- 0.07 - 0.09
- 0.09 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6

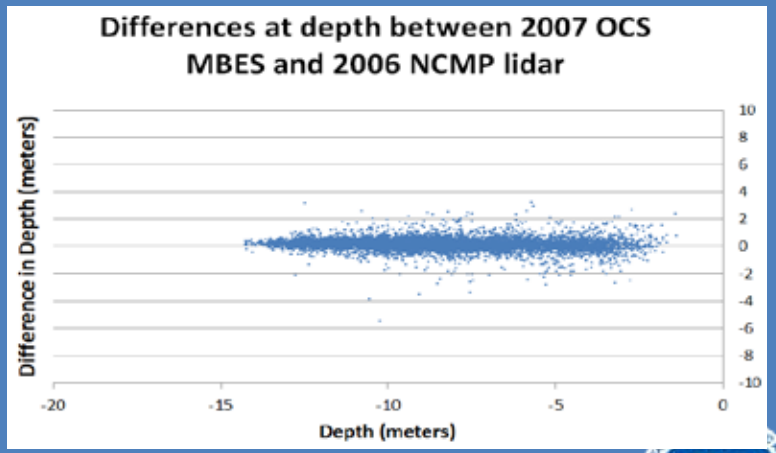
Difference Map (m)

- 4 - -3
- -3 - -2
- -2 - -1
- -1 - 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7

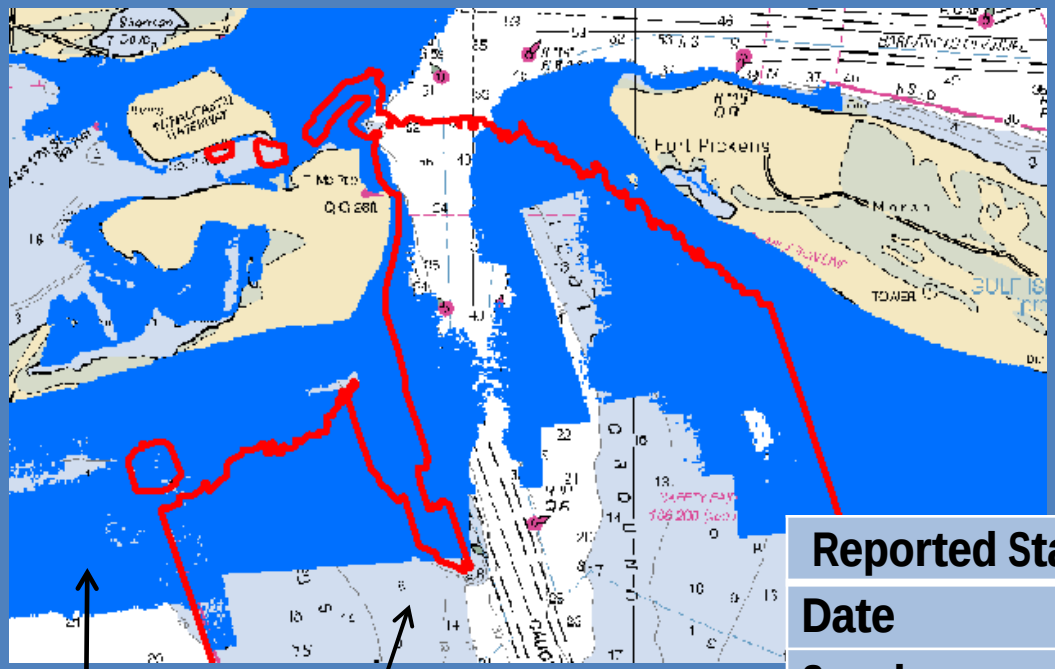


Area	Mean	Standard Deviation
Kittery, ME	0.17m	0.39m



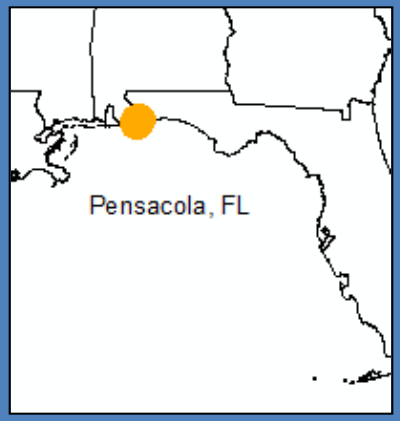


Study Site: Pensacola, FL (2010)



USACE NMCP

OCS MBES

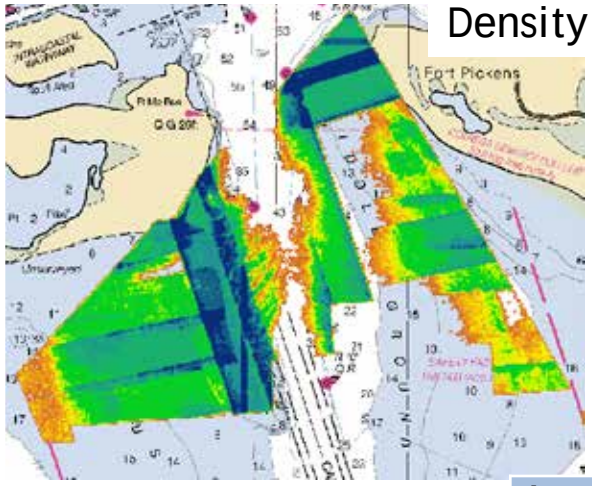


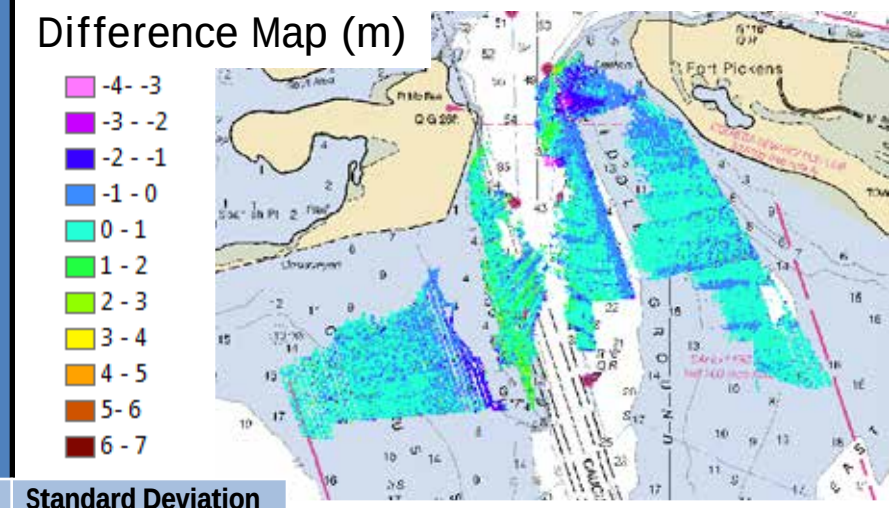
Reported Stats	NCMP ALB	OCS MBES
Date	2010	2009
Spacing	3x3	1x1, 2x2
Overlap	100%	200%

Areas	Mean	Standard Deviation
Pensacola, FL	0.12m	0.94m

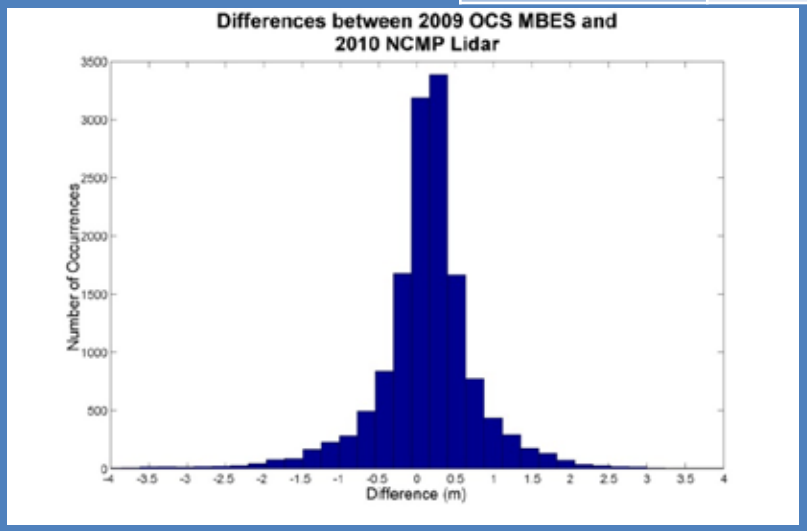
Bottom type: sand

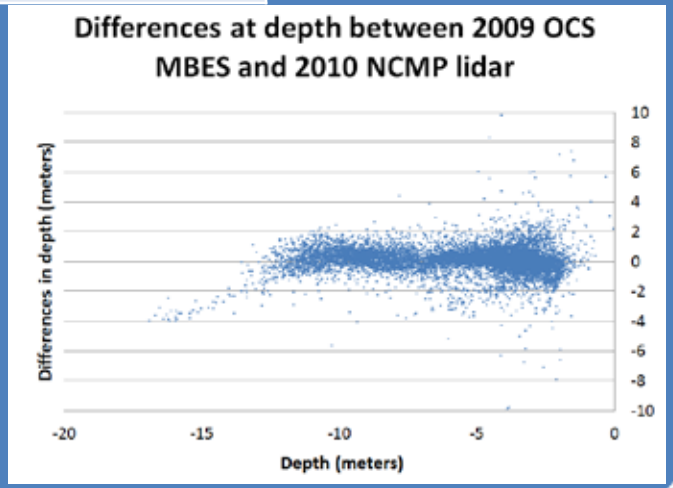
Statistical Analysis: Pensacola, FL (2010)



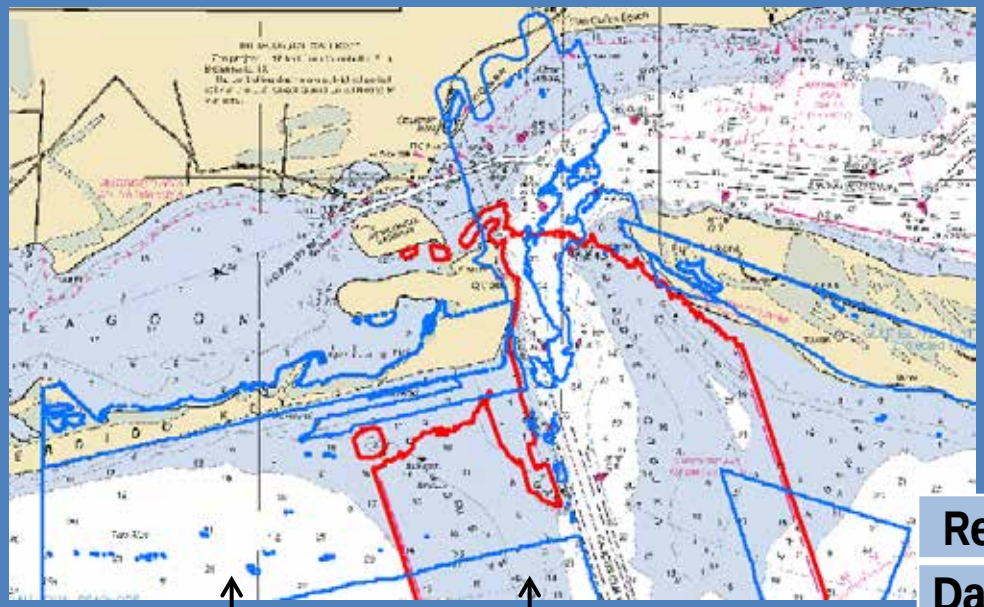


Area	Mean	Standard Deviation
Pensacola, FL	0.12m	0.94m

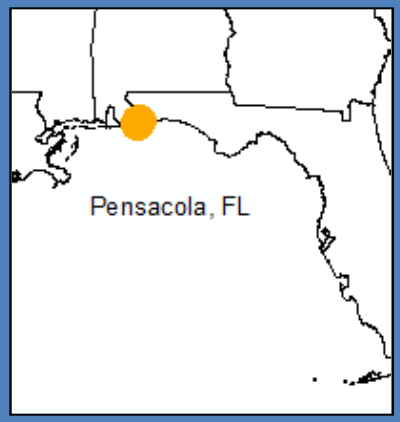




Study Site: Pensacola, FL (2004)



USACE NMCP OCS MBES

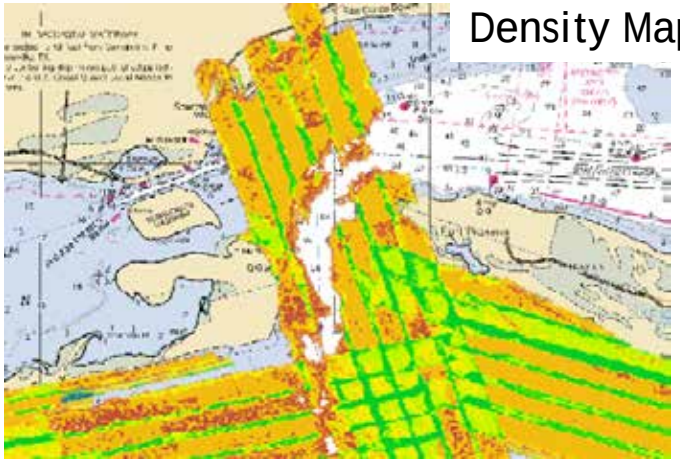


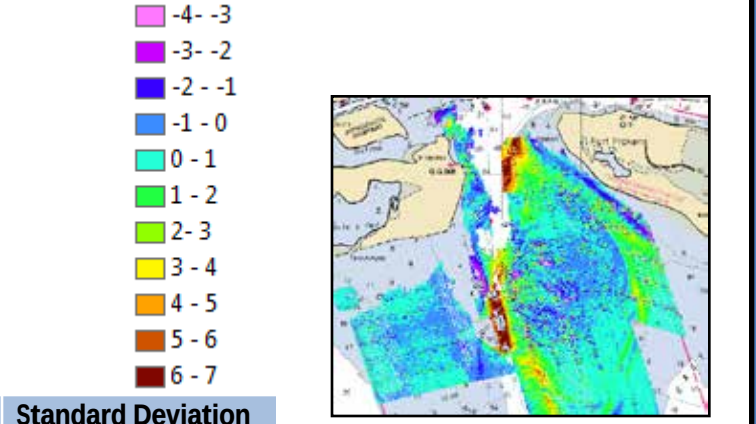
Reported Stats	NCMP ALB	OCS MBES
Date	2004	2009
Spacing	5x5	1x1, 2x2
Overlap	100%	200%

Areas	Mean	Standard Deviation
Pensacola, FL	0.57m	1.72m

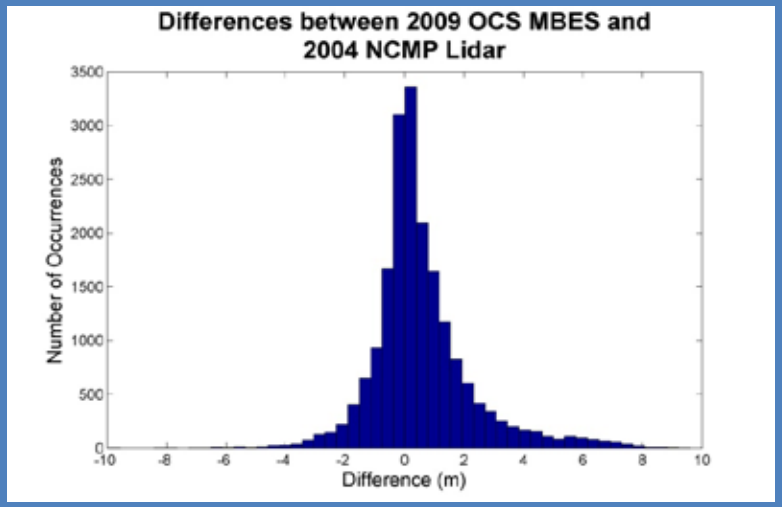
Bottom type: sand

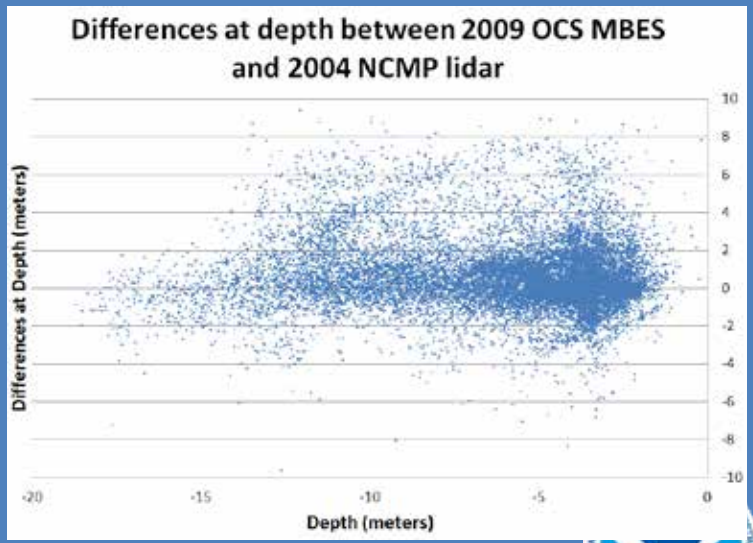
Statistical Analysis: Pensacola, FL (2004)



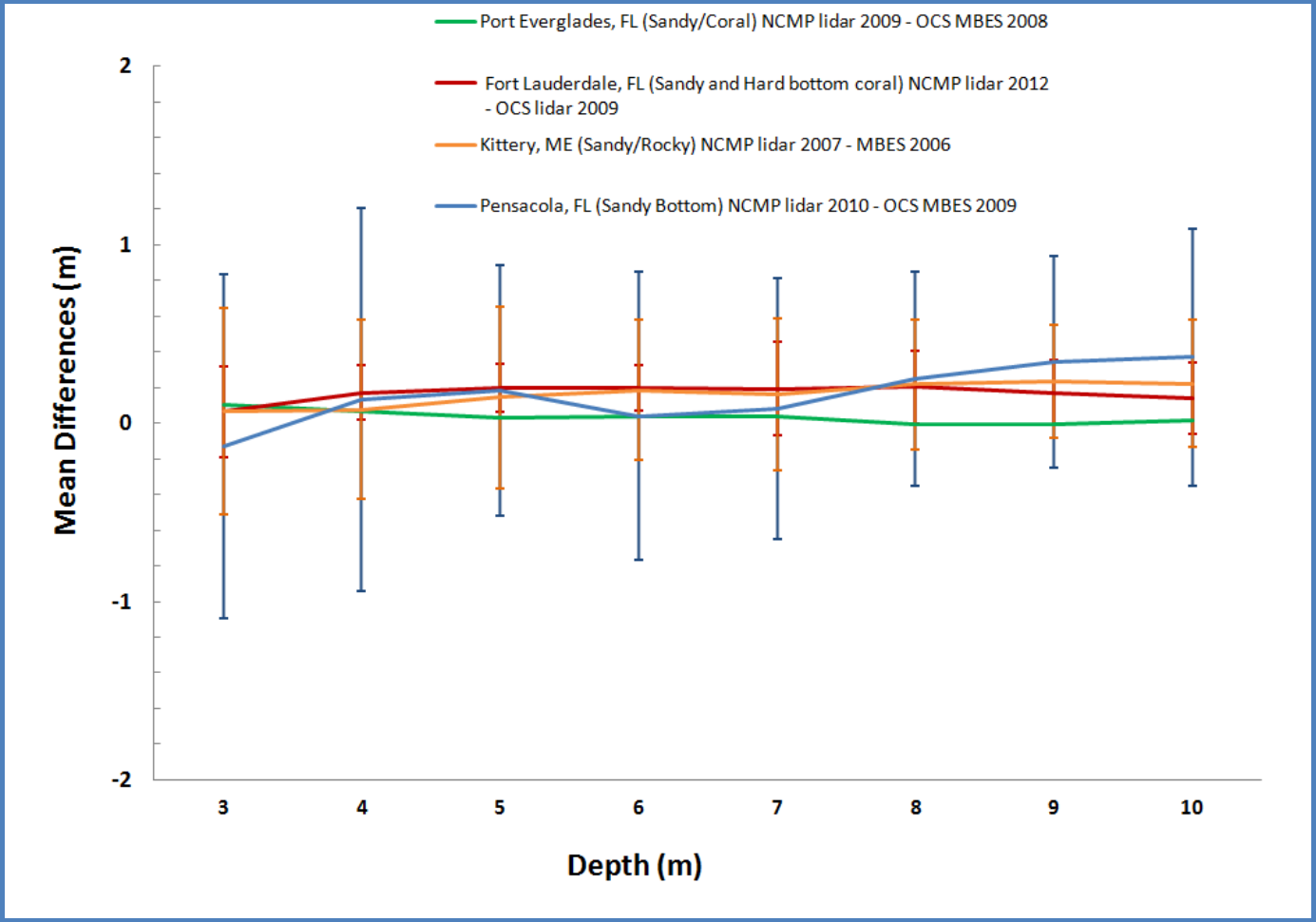


Area	Mean	Standard Deviation
Pensacola, FL	0.57m	1.72m





Summary plot

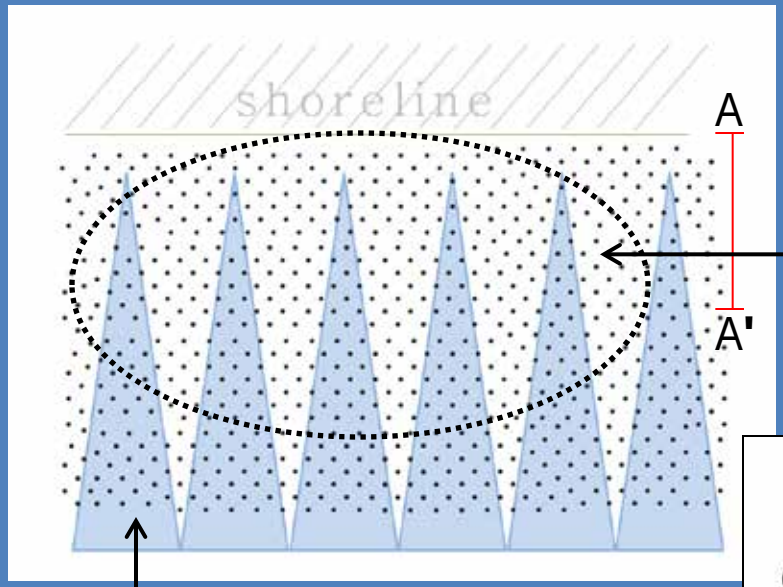


Recommendations for Future Work

- Additional work recommended for new systems:
  - Use QA procedures as a starting point
  - Patch test
  - Comparison/analysis between new and older systems
  - Error uncertainty analysis

Lidar/MBES swath comparison in shallow waters

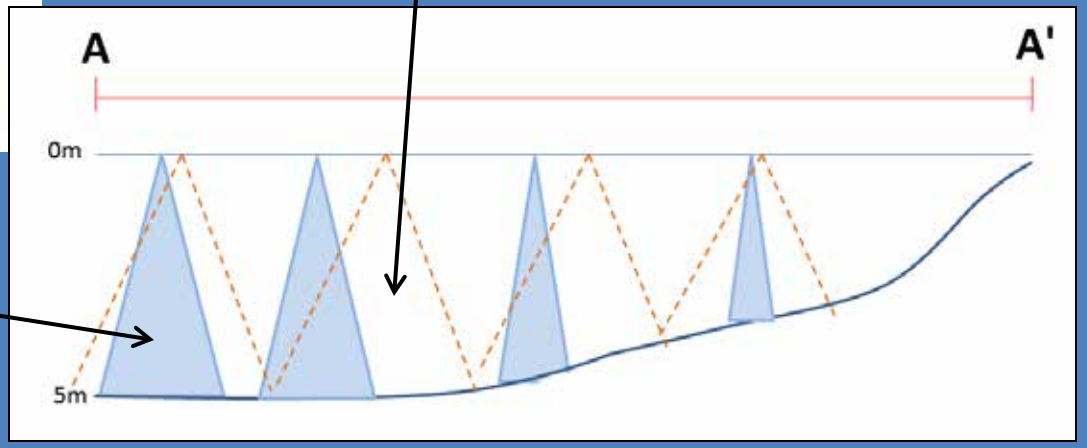
Plan view



Lidar swath/coverage

Multibeam swath

Side profile



IHO S-44 standards

Special Publication N. 44 – 5th Edition, 2008

Order	1b
Description of areas.	Areas shallower than 100 metres where under-keel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.
Maximum allowable THU 95% ***Confidence level***	5 metres + 5% of depth
Maximum allowable TVU 95% ***Confidence level***	a = 0.5 metre b = 0.013
Full Sea floor Search	Not required
Feature Detection	Not Applicable