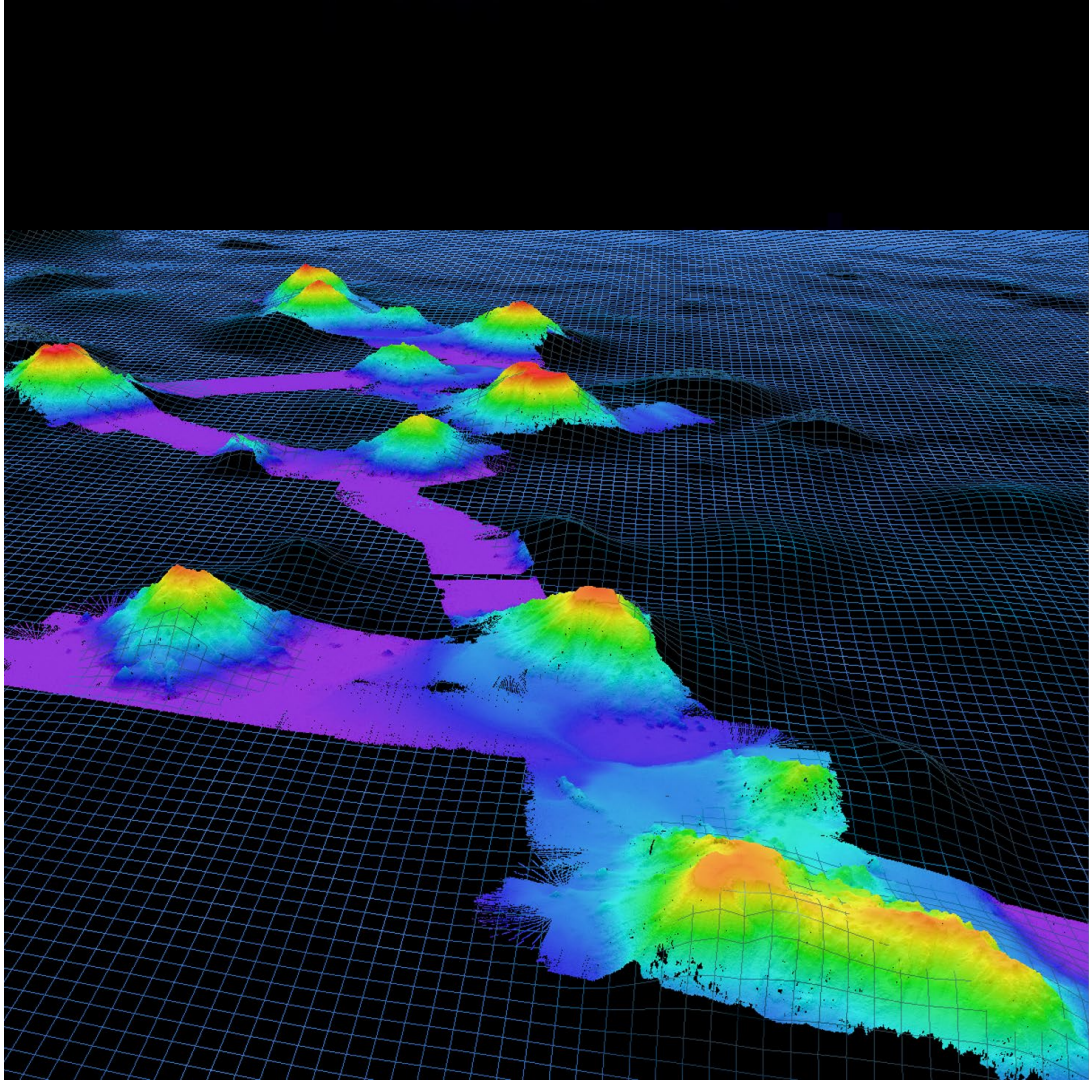
Lessons Learned from a Successful Integration of the EM 304 MKII Variant Multibeam Sonar

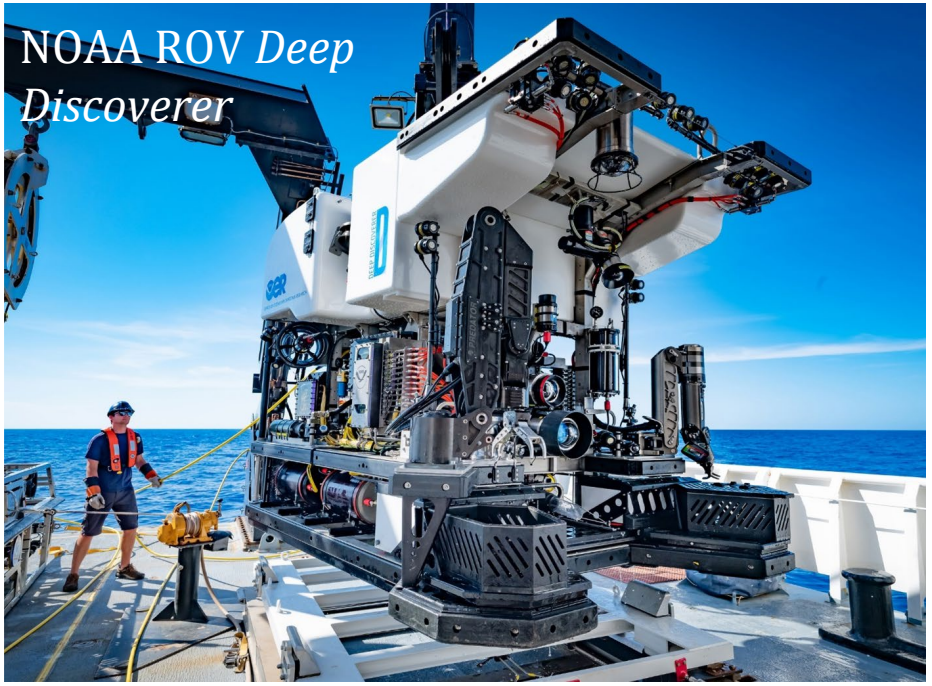
RVTEC 2021

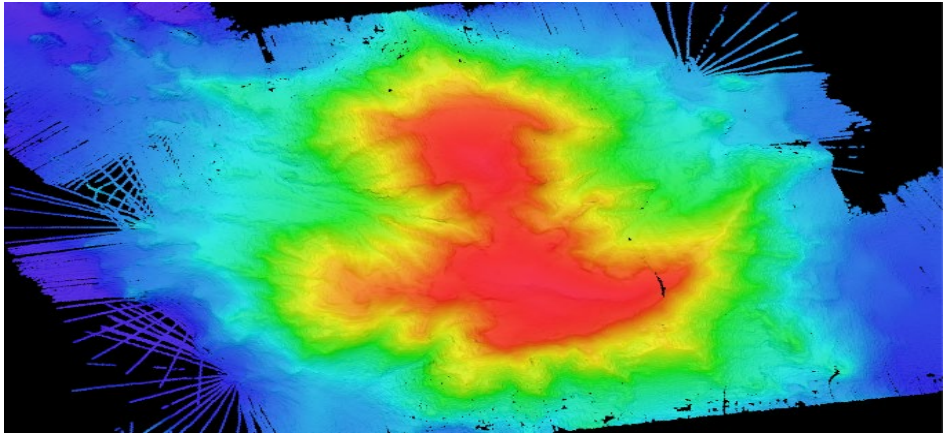
Shannon Hoy and Kevin Jerram
October 26, 2021

NOAA OCEAN EXPLORATION
20 YEARS • 2001-2021

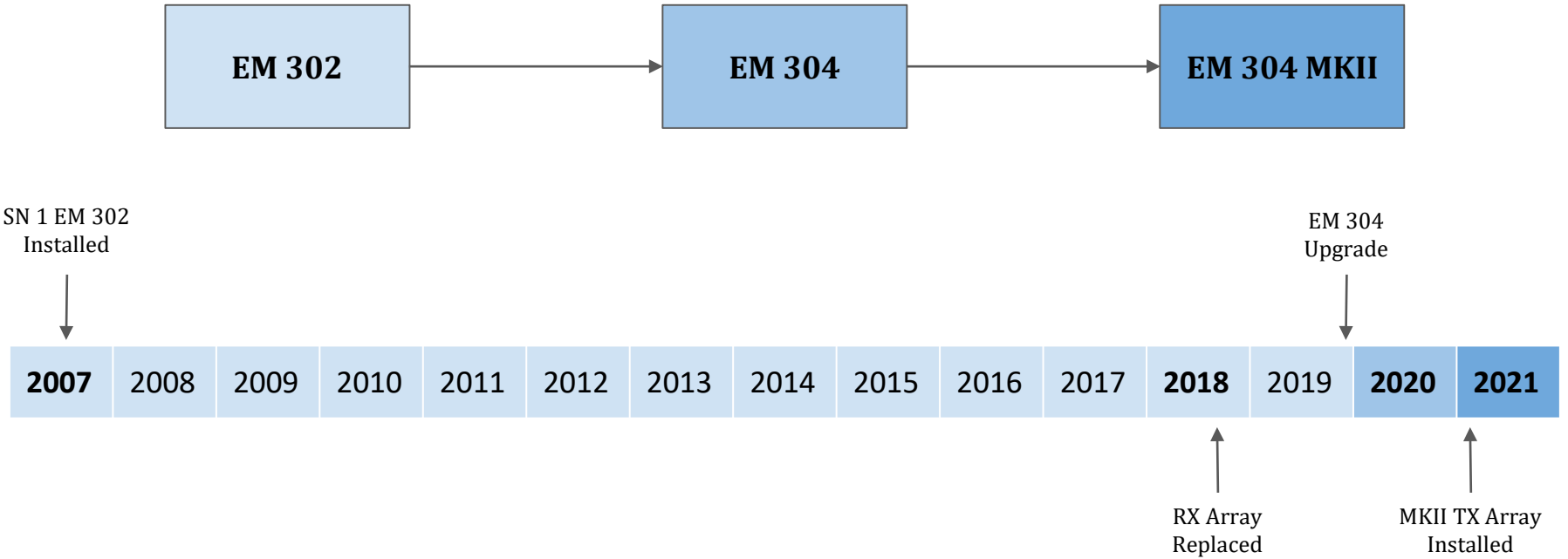


NOAA Ship *Okeanos Explorer*


NOAA ROV *Deep Discoverer*



History of the *Okeanos Explorer's* Multibeam Sonar

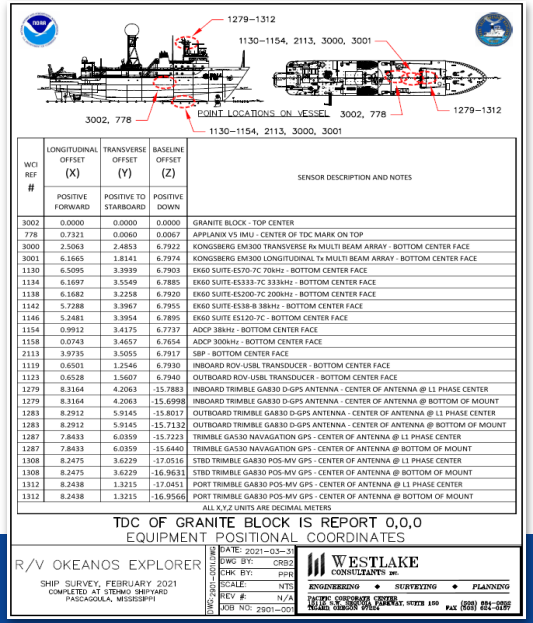


Lessons Learned from Successful Integration

Vessel / Sensor Offset Survey

Proactive reporting following MAC recommendations

POS MV and SIS config ***directly from survey report***



WCI REF #	LONGITUDINAL OFFSET (X) POSITIVE FORWARD	TRANSVERSE OFFSET (Y) POSITIVE TO STARBOARD	BASELINE OFFSET (Z) POSITIVE DOWN	SENSOR DESCRIPTION AND NOTES
3002	0.0000	0.0000	0.0000	GRANITE BLOCK - TOP CENTER
778	0.7321	0.0060	0.0067	APPLANIX V5 IMU - CENTER OF TDC MARK ON TOP
3000	2.5063	2.4853	6.7922	KONGSBERG EM300 TRANSVERSE Rx MULTI BEAM ARRAY - BOTTOM CENTER FACE
3001	6.1665	1.8141	6.7974	KONGSBERG EM300 LONGITUDINAL Tx MULTI BEAM ARRAY - BOTTOM CENTER FACE
1130	6.5095	3.3939	6.7903	EK60 SUITE-ES70-7C 70kHz - BOTTOM CENTER FACE
1134	6.1697	3.5549	6.7885	EK60 SUITE-ES333-7C 333kHz - BOTTOM CENTER FACE
1138	6.1682	3.2258	6.7920	EK60 SUITE-ES200-7C 200kHz - BOTTOM CENTER FACE
1142	5.7288	3.3967	6.7955	EK60 SUITE-ES38-B 38kHz - BOTTOM CENTER FACE
1146	5.2481	3.3954	6.7895	EK60 SUITE ES120-7C - BOTTOM CENTER FACE
1154	0.9912	3.4175	6.7737	ADCP 38kHz - BOTTOM CENTER FACE
1158	0.0743	3.4657	6.7654	ADCP 300kHz - BOTTOM CENTER FACE
2113	3.9735	3.5055	6.7917	SBP - BOTTOM CENTER FACE
1119	0.6501	1.2546	6.7930	INBOARD ROV-USBL TRANSDUCER - BOTTOM CENTER FACE
1123	0.6528	1.5607	6.7940	OUTBOARD ROV-USBL TRANSDUCER - BOTTOM CENTER FACE
1279	8.3164	4.2063	-15.7883	INBOARD TRIMBLE GA830 D-GPS ANTENNA - CENTER OF ANTENNA @ L1 PHASE CENTER
1279	8.3164	4.2063	-15.6998	INBOARD TRIMBLE GA830 D-GPS ANTENNA - CENTER OF ANTENNA @ BOTTOM OF MOUNT
1283	8.2912	5.9145	-15.8017	OUTBOARD TRIMBLE GA830 D-GPS ANTENNA - CENTER OF ANTENNA @ L1 PHASE CENTER
1283	8.2912	5.9145	-15.7132	OUTBOARD TRIMBLE GA830 D-GPS ANTENNA - CENTER OF ANTENNA @ BOTTOM OF MOUNT
1287	7.8433	6.0359	-15.7223	TRIMBLE GAS30 NAVAGATION GPS - CENTER OF ANTENNA @ L1 PHASE CENTER
1287	7.8433	6.0359	-15.6440	TRIMBLE GAS30 NAVAGATION GPS - CENTER OF ANTENNA @ BOTTOM OF MOUNT
1308	8.2475	3.6229	-17.0516	STBD TRIMBLE GA830 POS-MV GPS - CENTER OF ANTENNA @ L1 PHASE CENTER
1308	8.2475	3.6229	-16.9631	STBD TRIMBLE GA830 POS-MV GPS - CENTER OF ANTENNA @ BOTTOM OF MOUNT
1312	8.2438	1.3215	-17.0451	PORT TRIMBLE GA830 POS-MV GPS - CENTER OF ANTENNA @ L1 PHASE CENTER
1312	8.2438	1.3215	-16.9566	PORT TRIMBLE GA830 POS-MV GPS - CENTER OF ANTENNA @ BOTTOM OF MOUNT

ALL X,Y,Z UNITS ARE DECIMAL METERS

TDC OF GRANITE BLOCK IS REPORT 0,0,0
EQUIPMENT POSITIONAL COORDINATES

R/V OKEANOS EXPLORER
SHIP SURVEY, FEBRUARY 2021
COMPLETED AT STEMCO SHIPYARD
PASCAGOULA, MISSISSIPPI

DWG: 2901-001.DWG | DATE: 2021-03-31 | DWG BY: CRB2 | CHK BY: PPR | SCALE: NTS | REV #: N/A | JOB NO: 2901-001

WESTLAKE CONSULTANTS INC.
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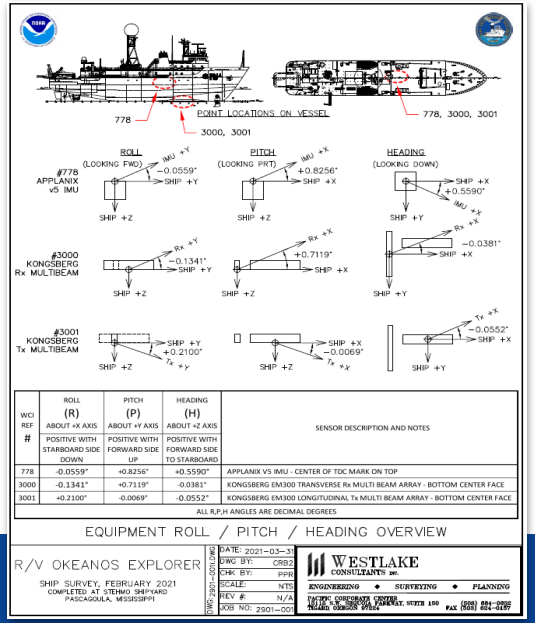

WCI REF #	ROLL (R) ABOUT +X AXIS POSITIVE WITH STARBOARD SIDE DOWN	PITCH (P) ABOUT +Y AXIS POSITIVE WITH FORWARD SIDE UP	HEADING (H) ABOUT +Z AXIS POSITIVE WITH FORWARD SIDE TO STARBOARD	SENSOR DESCRIPTION AND NOTES
778	-0.0559°	+0.8256°	+0.5590°	APPLANIX V5 IMU - CENTER OF TDC MARK ON TOP
3000	-0.1341°	+0.7119°	-0.0381°	KONGSBERG EM300 TRANSVERSE Rx MULTI BEAM ARRAY - BOTTOM CENTER FACE
3001	+0.2100°	-0.0069°	-0.0552°	KONGSBERG EM300 LONGITUDINAL Tx MULTI BEAM ARRAY - BOTTOM CENTER FACE

ALL R,P,H ANGLES ARE DECIMAL DEGREES

EQUIPMENT ROLL / PITCH / HEADING OVERVIEW

R/V OKEANOS EXPLORER
SHIP SURVEY, FEBRUARY 2021
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PASCAGOULA, MISSISSIPPI

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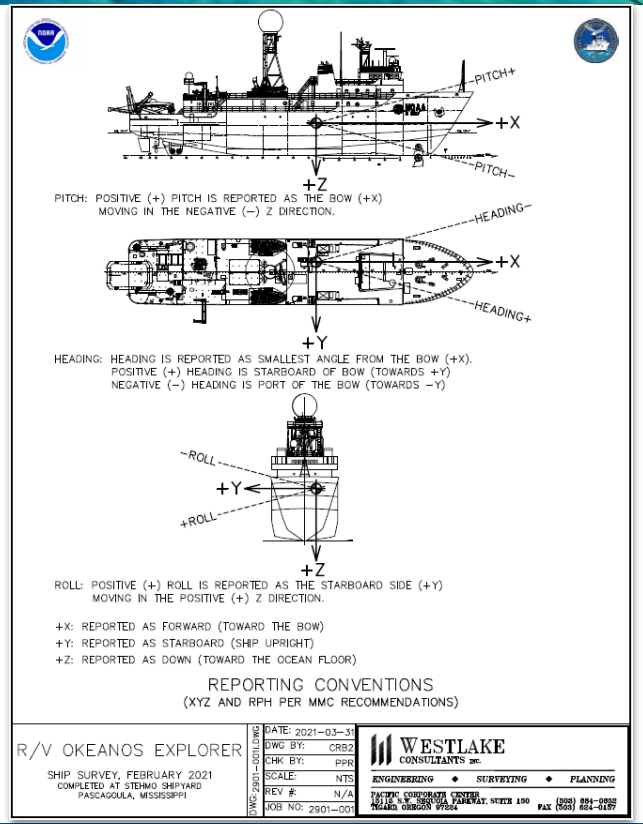

REPORTING CONVENTIONS
(XYZ AND RPH PER MMC RECOMMENDATIONS)

R/V OKEANOS EXPLORER
SHIP SURVEY, FEBRUARY 2021
COMPLETED AT STEMCO SHIPYARD
PASCAGOULA, MISSISSIPPI

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Lessons Learned from Successful Integration

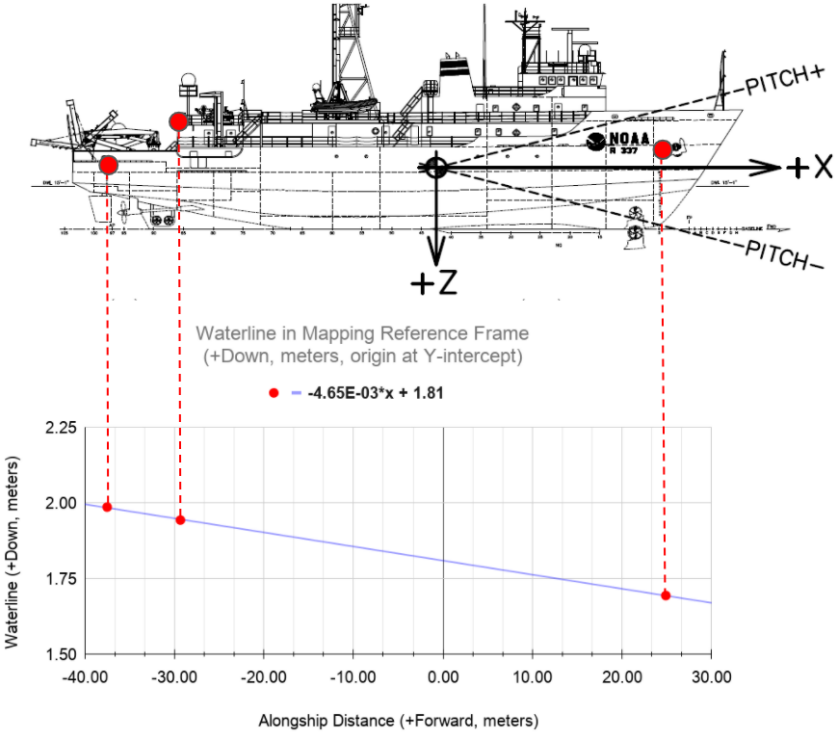
Waterline Assessment

Fresh waterline measurements (dockside).

Repeatable process with variety of benchmarks.

Independent of historic vessel markings.

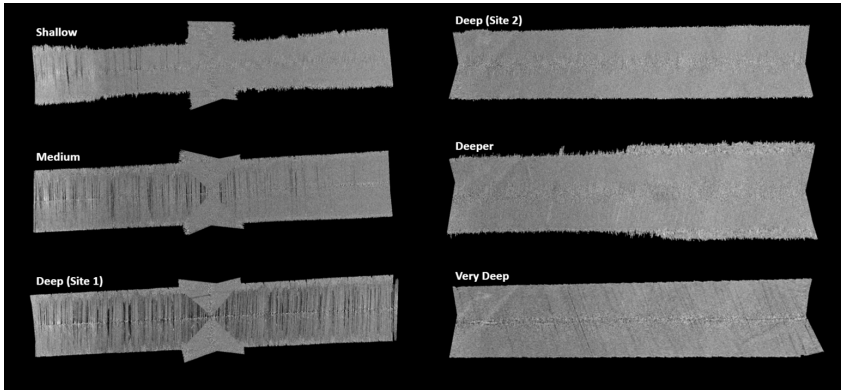
Westlake Benchmark (+X Forward, +Z Down)				Sea Surface	Waterline (+Z Down)		Waterline Along CL (+Z Down)	
Location	ID	X (meters)	Z (meters)	Observed (feet)	Observed (meters)	Westlake (meters)	Mean X (meters)	Mean Z (meters)
Bow Stbd	850	24.9173	-5.4209	23.17	7.06	1.64	24.89	1.69
Bow Port	851	24.8664	-5.4118	23.5	7.16	1.75		
Qtr Deck Above Fantail, Starboard	603	-29.9363	-2.4997	14.17	4.32	1.82	-29.32	1.94
02 Deck, Port Side, Mid Stern	669	-28.7038	-4.8117	22.58	6.88	2.07		
Fantail Starboard Stern	604	-37.1870	-0.9073	8.96	2.73	1.82	-37.50	1.99
Fantail Port Stern	619	-37.8124	-0.8607	9.88	3.01	2.15		
Origin	3002	0.0000	0.0000	-	-	-	-	1.81

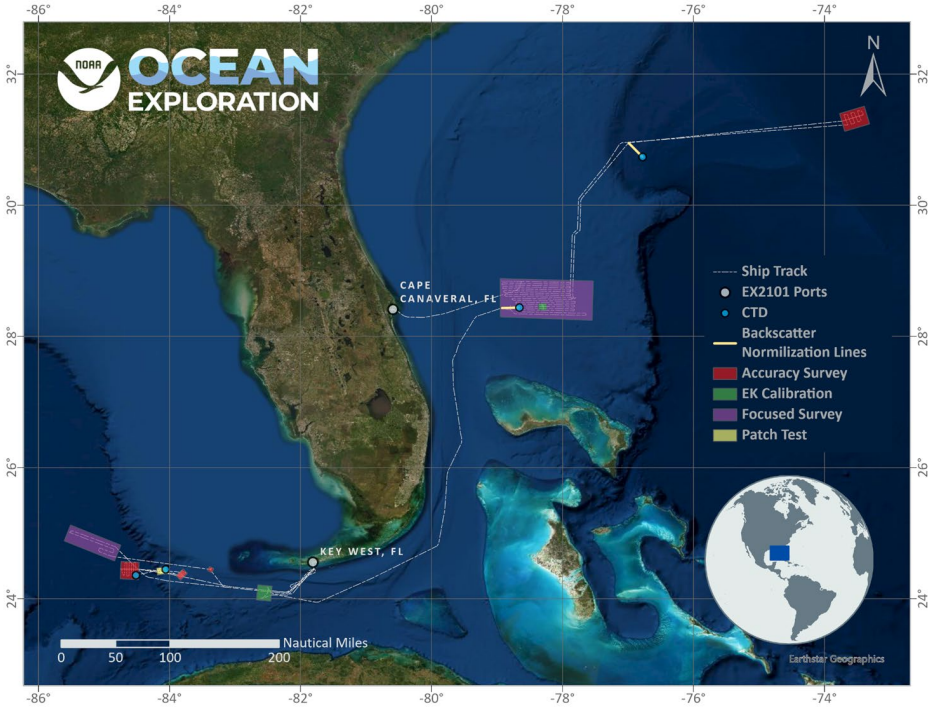


Lessons Learned from Successful Integration

SAT

- Standard SAT checklist with extra testing
- Full characterization and documentation
- Planning + Dockside + Sea Time = Success

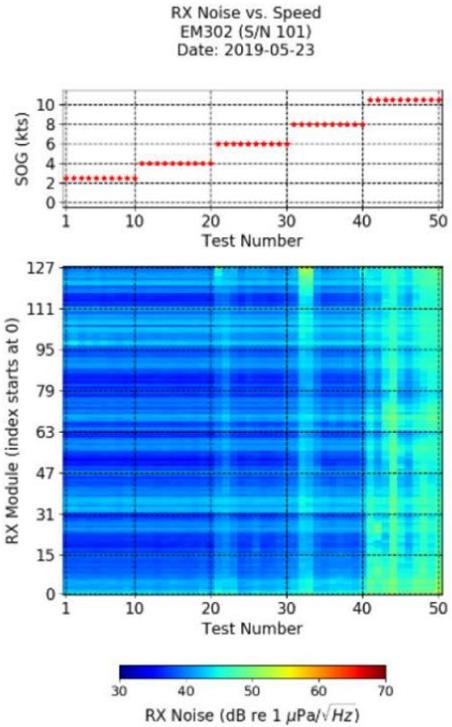




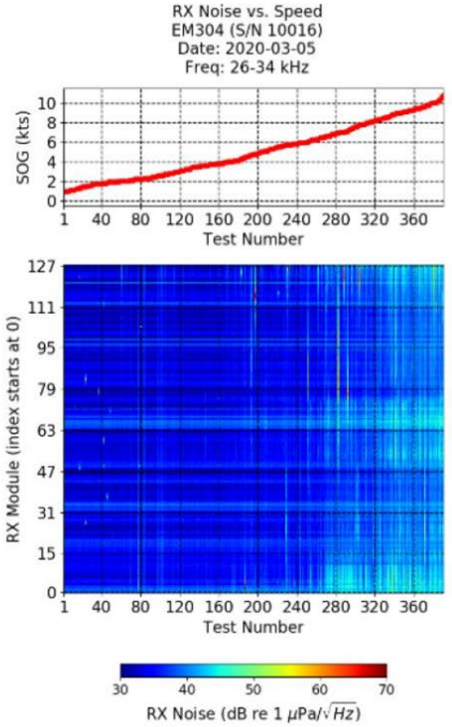
MKII Variant Results

Noise Levels

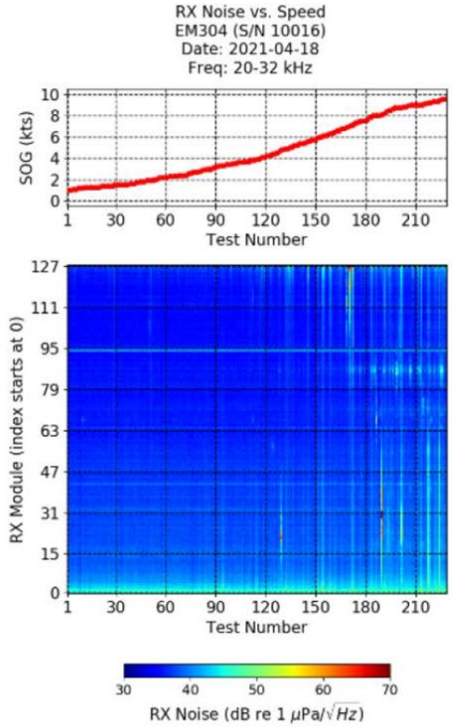
EM302



EM304



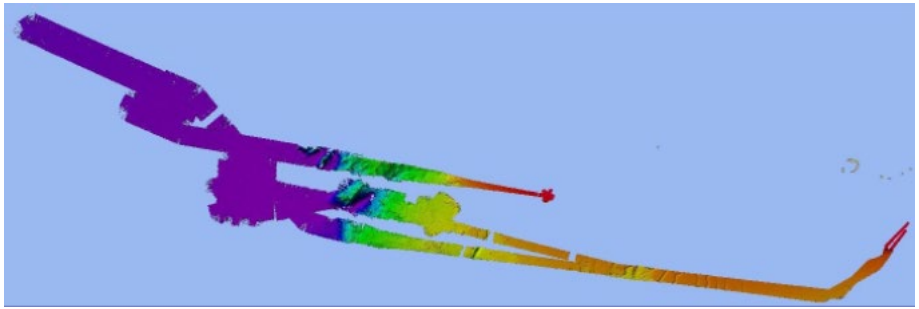
EM304 MKII

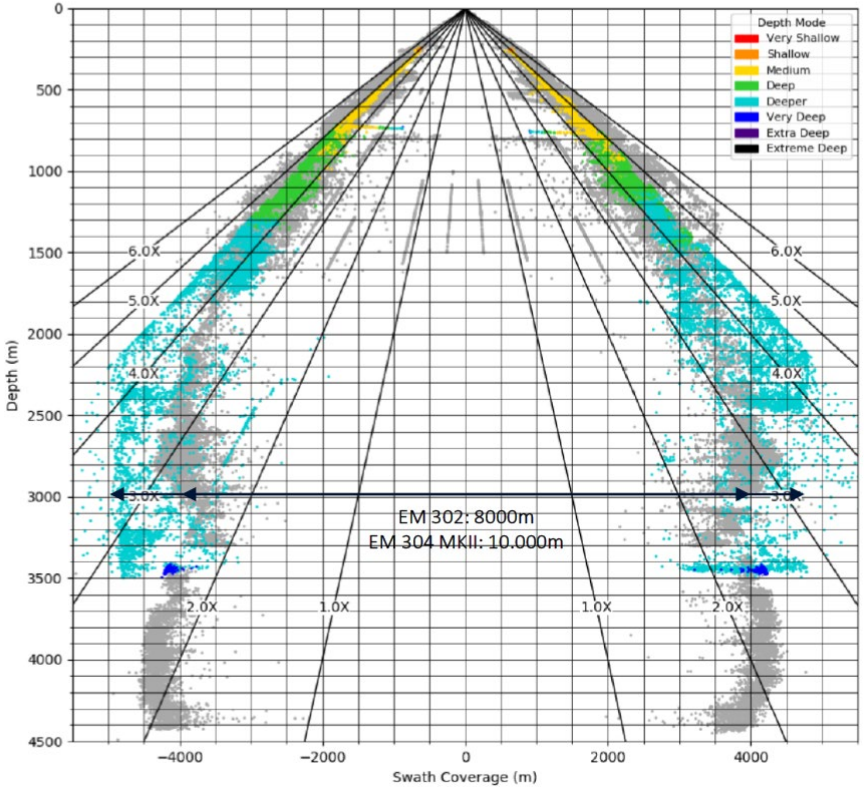


MKII Variant Results

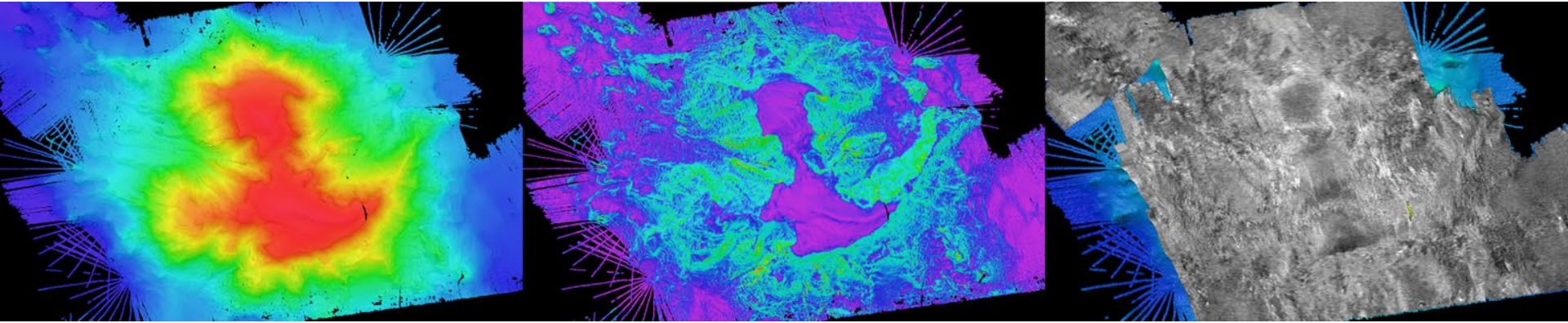
Swath Coverage

- Coverage improvement over EM302
  - Gray: 2018-19 EM302
  - Colored: 2021 EM304 MKII
- Most notable benefit in 1500-3500 m
- SIS coverage limits increased for MKII





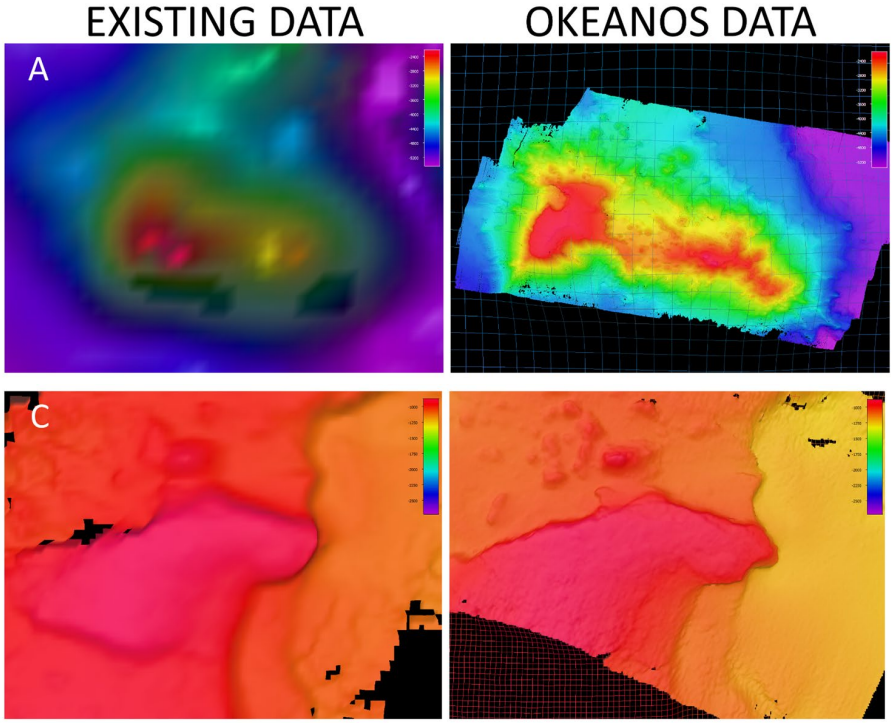
MKII Variant in Use



EM 304 was used to map seamounts prior to ROV dives during EX-21-04:

2021 North Atlantic Stepping Stones: New England and Corner Rise Seamounts Expedition

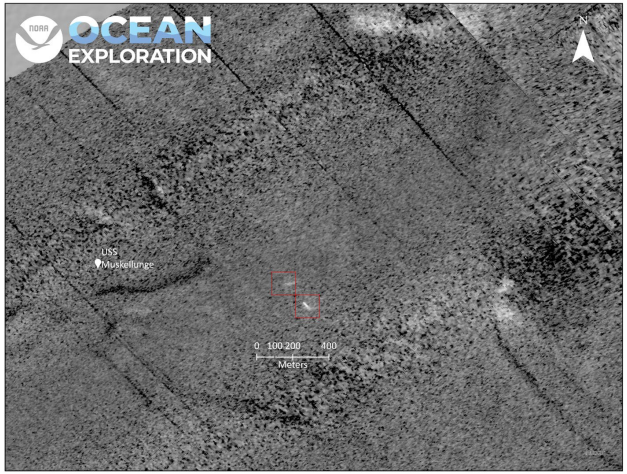
MKII Variant in Use

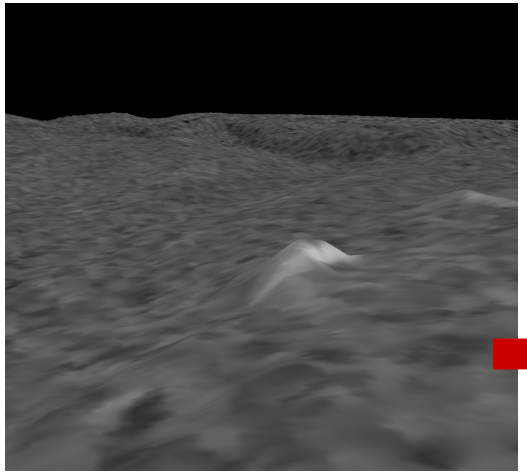


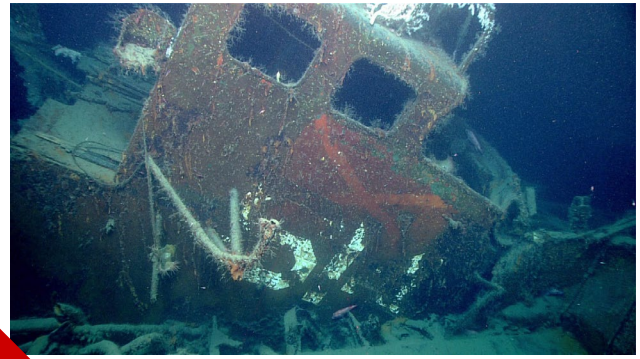
Comparison of existing data to data collected with the EM 304 MKII multibeam sonar during EX-21-04.

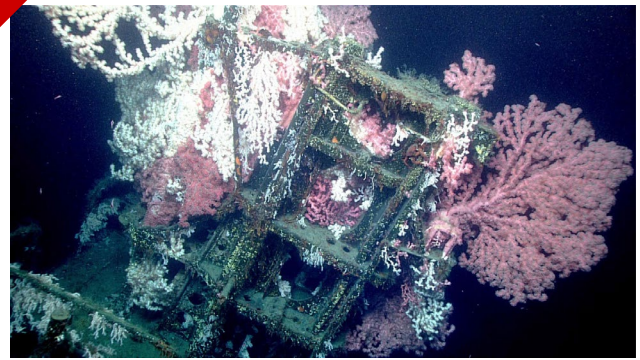
MKII Variant in Use

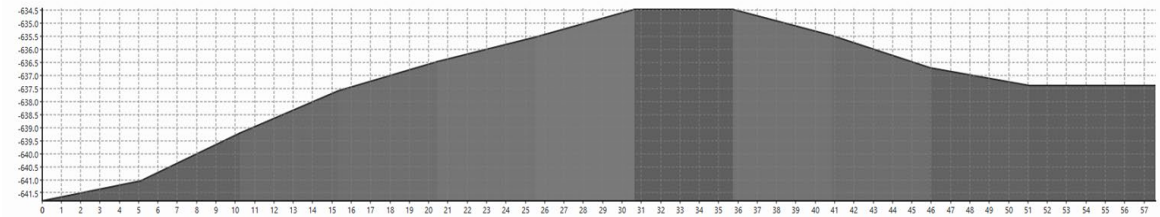
Shipwreck found at 650 m during EX-21-03: ROV Shakedown





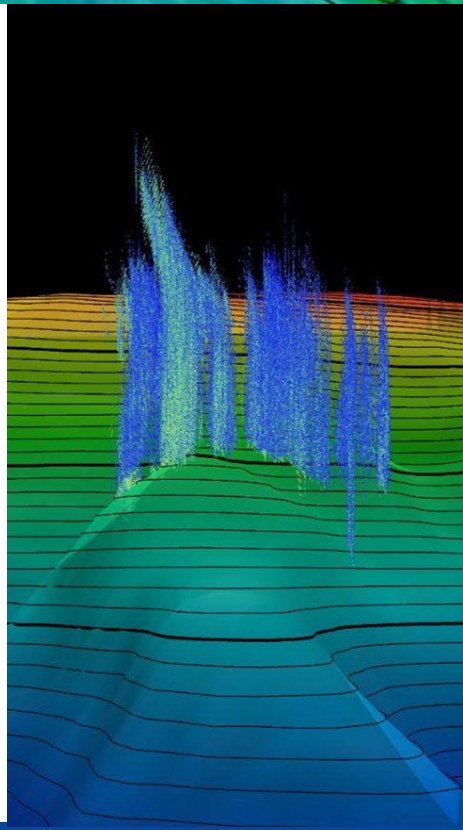






Upcoming

- We will imminently hit **2 million square kilometers** collected from the *Okeanos Explorer!*
- Next year we will operate in the vicinity of the Puerto Rico Trench, allowing **testing of the full coverage achievable** with the MKII.
- We will also operate over Atlantic hydrothermal vents, which will support **further tests of the water column** capabilities.
- We will continue to expand our use of remote and telepresence-enabled systems, including **remote watchstanding and cloud processing.**
- We will continue to **work closely with Kongsberg** to collaborate on the improvement of this system to benefit the broader deep ocean mapping community and industry.



Keep an eye out for the release of the second version of the **Deepwater Exploration Mapping Procedures Manual**!

Useful Reference Material

- EX-20-00 EM 304 SAT Report (slides)
- EX-21-01 EM 304 MKII SAT REPORT
- Deepwater Exploration Mapping Procedures Manual V1
- Standard Operating Procedures (SOP) Table of Contents
- EM and EK Synchronization Presentation
- Target Detection 101 with a 30 kHz Multibeam Sonar
- Establishing and Re-occupying Ship Reference Frame: A case study with EV Nautilus and NOAA Ship Okeanos Explorer - Dr. Anand Hiroji, USM, US Hydro 2021
- An Analysis of Deepwater Multibeam Data from NOAA Ship Okeanos Explorer - Kjetil Jensen, Kongsberg, US Hydro 2021

If you have any questions regarding these references or need access to the google documents, contact shannon.hoy@noaa.gov

Questions?

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