Optimizing Sonar Performance by Managing Acoustics

November 20, 2014

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WHY ACOUSTIC NOISE IS IMPORTANT

- Excessive ship-related noise can degrade sonar performance
- Degraded sonar performance will impact quality of acquired sonar data
- Reduced sonar performance will increase time required on station to conduct survey operations

WHY ACOUSTIC NOISE IS IMPORTANT

- Once it has been determined a multibeam sonar is functioning properly, the most important factor to consider is contamination with acoustic noise
- Some noise sources are unavoidable, but many sources can be eliminated or mitigated
- Understanding what your noise limiting source is, will greatly enhance your options to improve sonar performance

WHAT IS QUIET?

- Typically 49 dB is used as a quiet ship threshold for 12 kHz systems
- For shallower systems that operate at higher frequencies, the threshold is in the lower 40 dB range
- However, with more information being pulled out of sonar data (water column), the better the signal-to-noise, the better the data quality

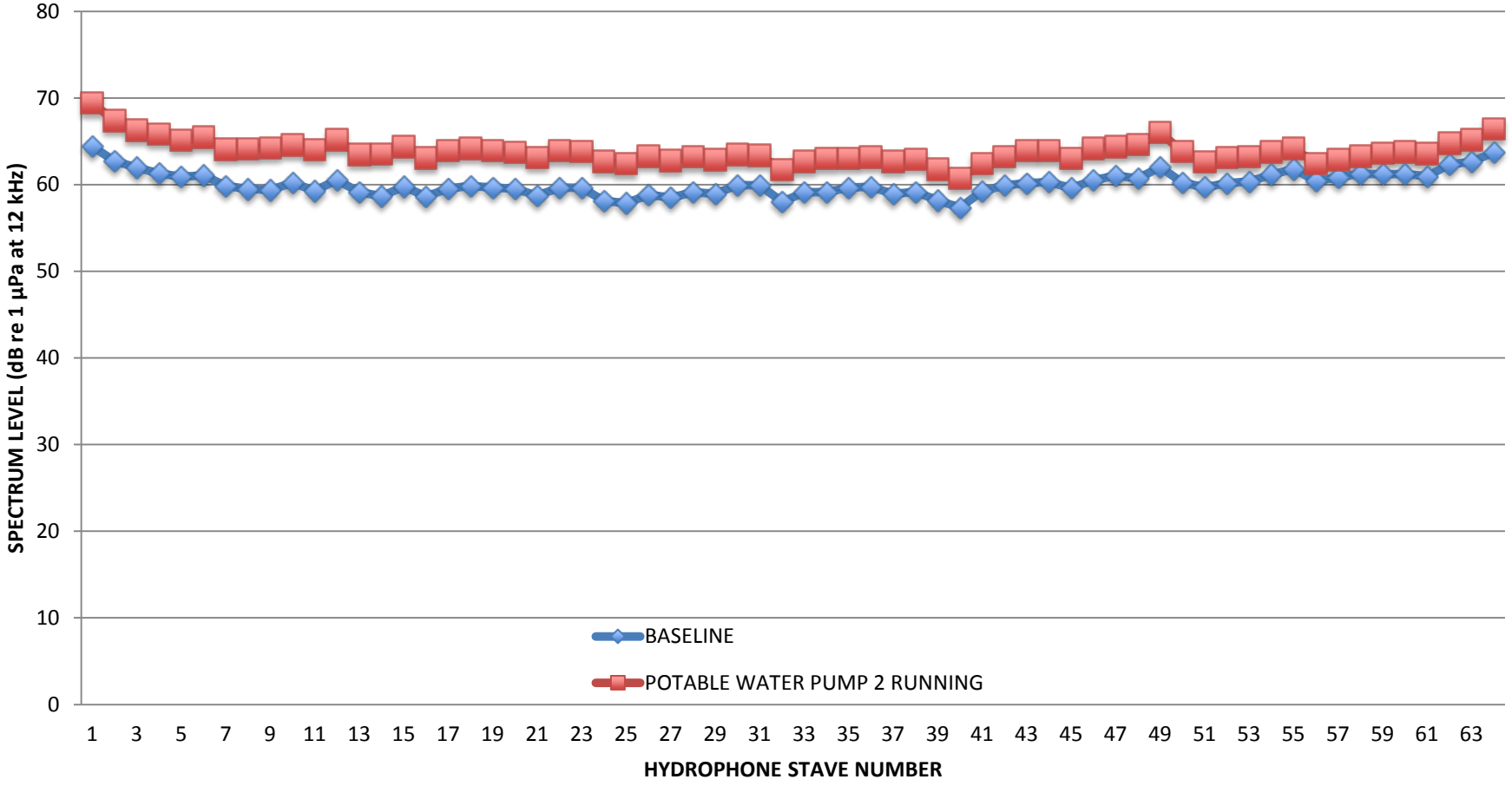
TYPICAL SOURCES OF SHIP-RELATED NOISE

- Machinery Noise
- Sonar Interference
- Electronic Noise
- Propeller Cavitation (Hub and Tip Vortex)
- Hydrodynamic Flow Noise
- Appendage Cavitation
- Transients
- Bubble Sweepdown

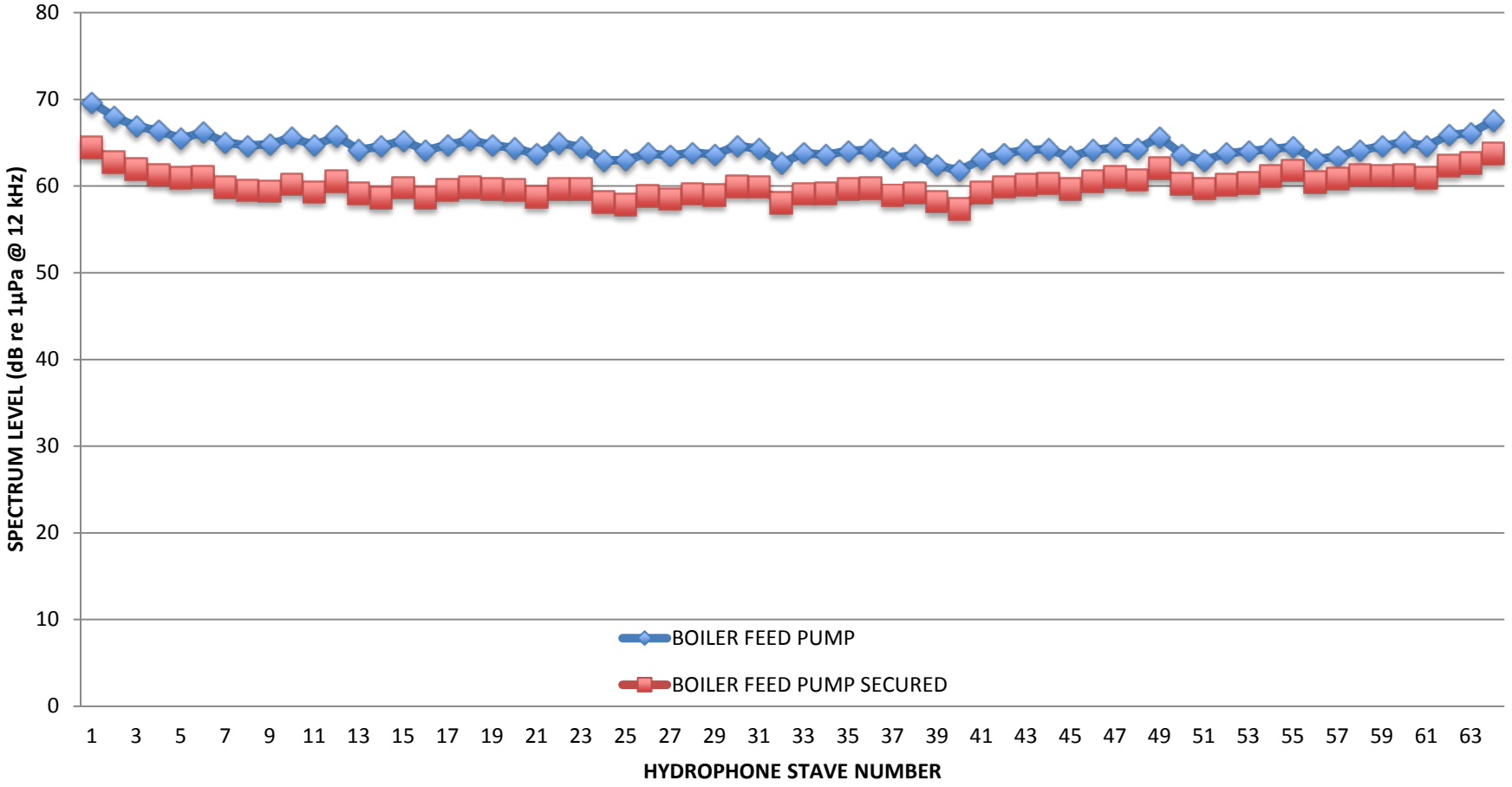
MACHINERY NOISE

- Machinery noise is typically a lower frequency problem
- Occasionally, higher frequency noise does originate from machinery which can degrade oceanographic sonar background noise levels

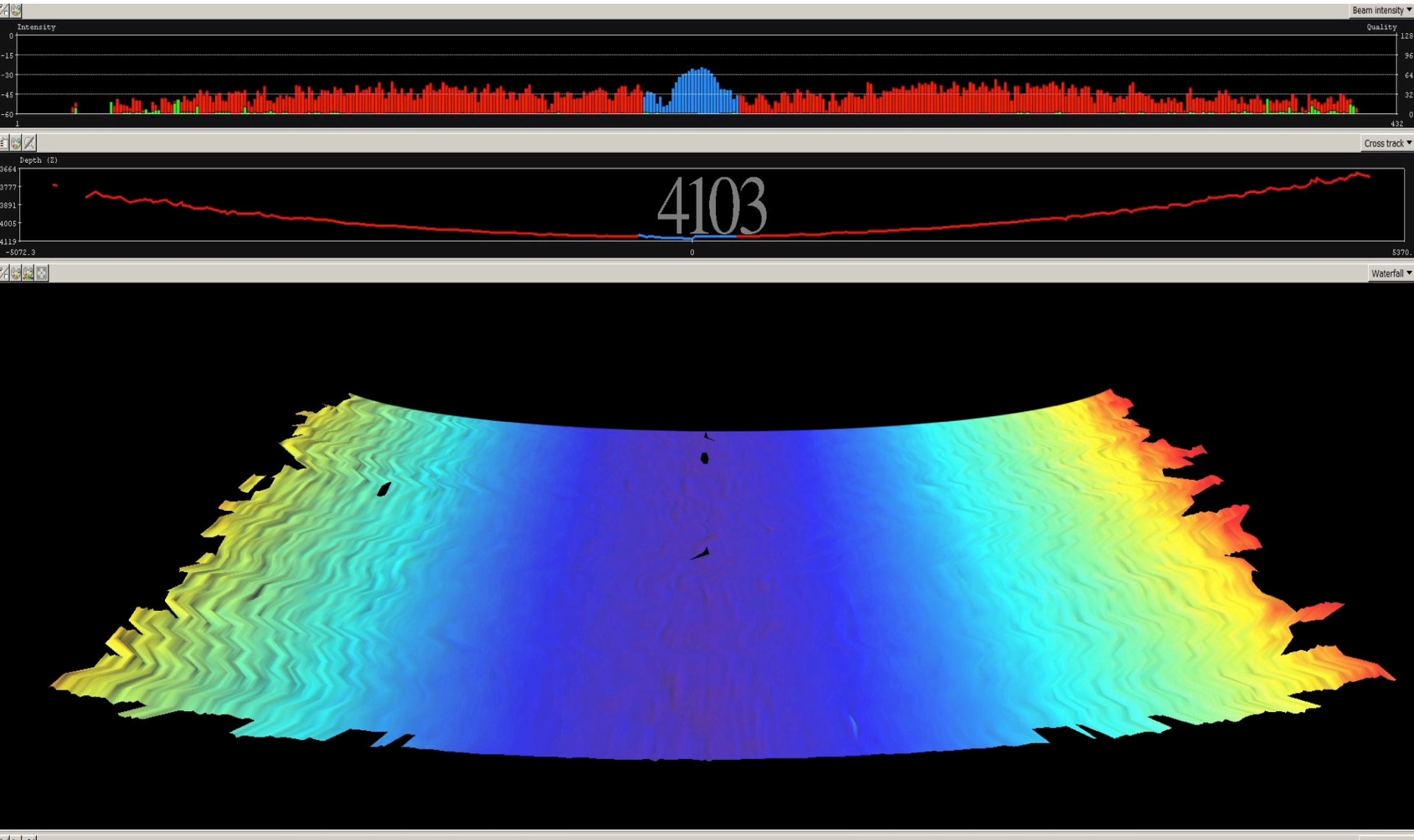
USCGC HEALY (WAGB 20)
EM 122 RX NOISE LEVEL
POTABLE WATER PUMP 2 RUNNING
16 AUGUST 2014



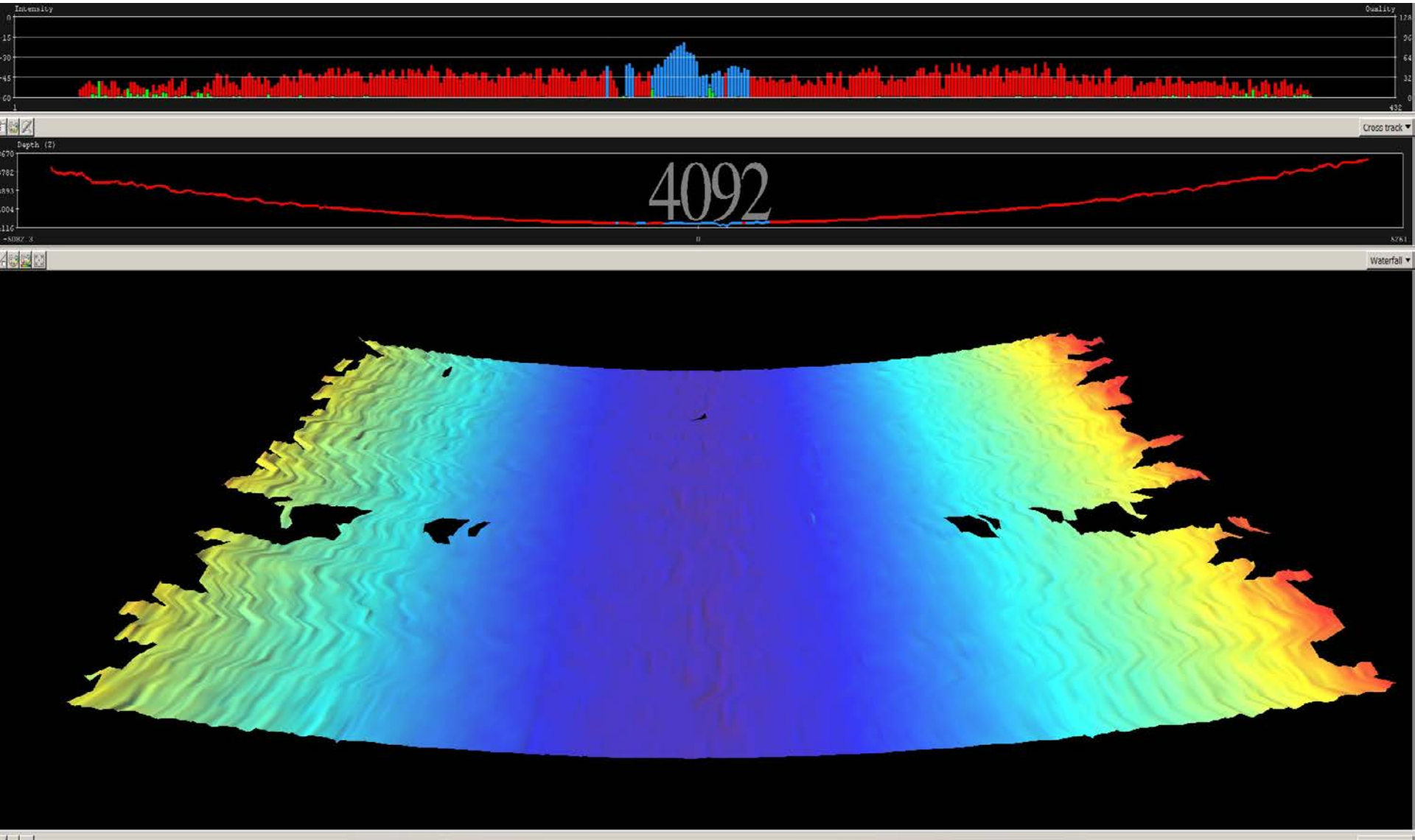
USCGC HEALY (WAGB-20)
BOILER FEED PUMP ON VS OFF
EM122 RX NOISE LEVEL
17 AUGUST 2014



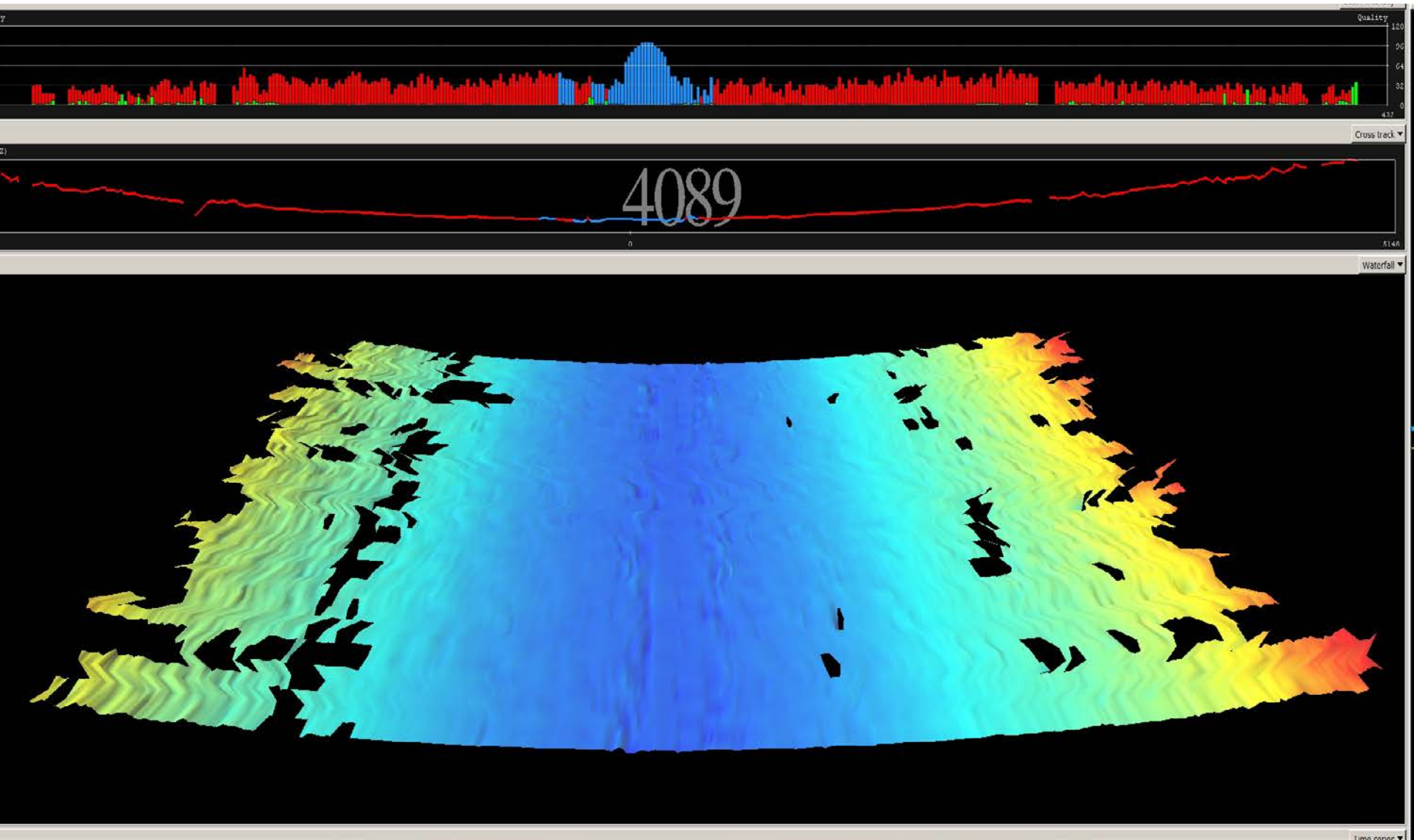
USCGC HEALY (WAGB 20) - QUIET



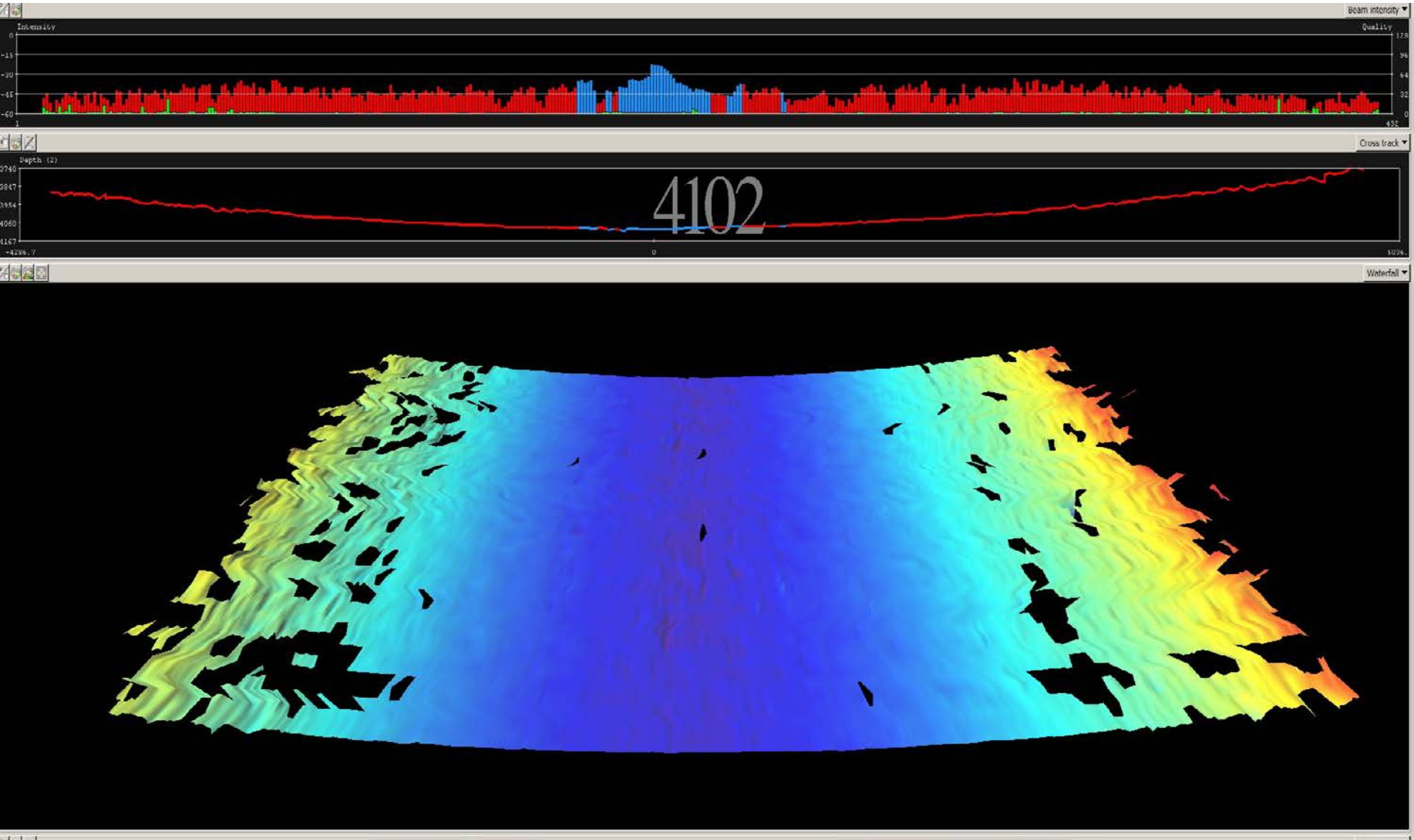
POTABLE WATER PUMP IMPACT



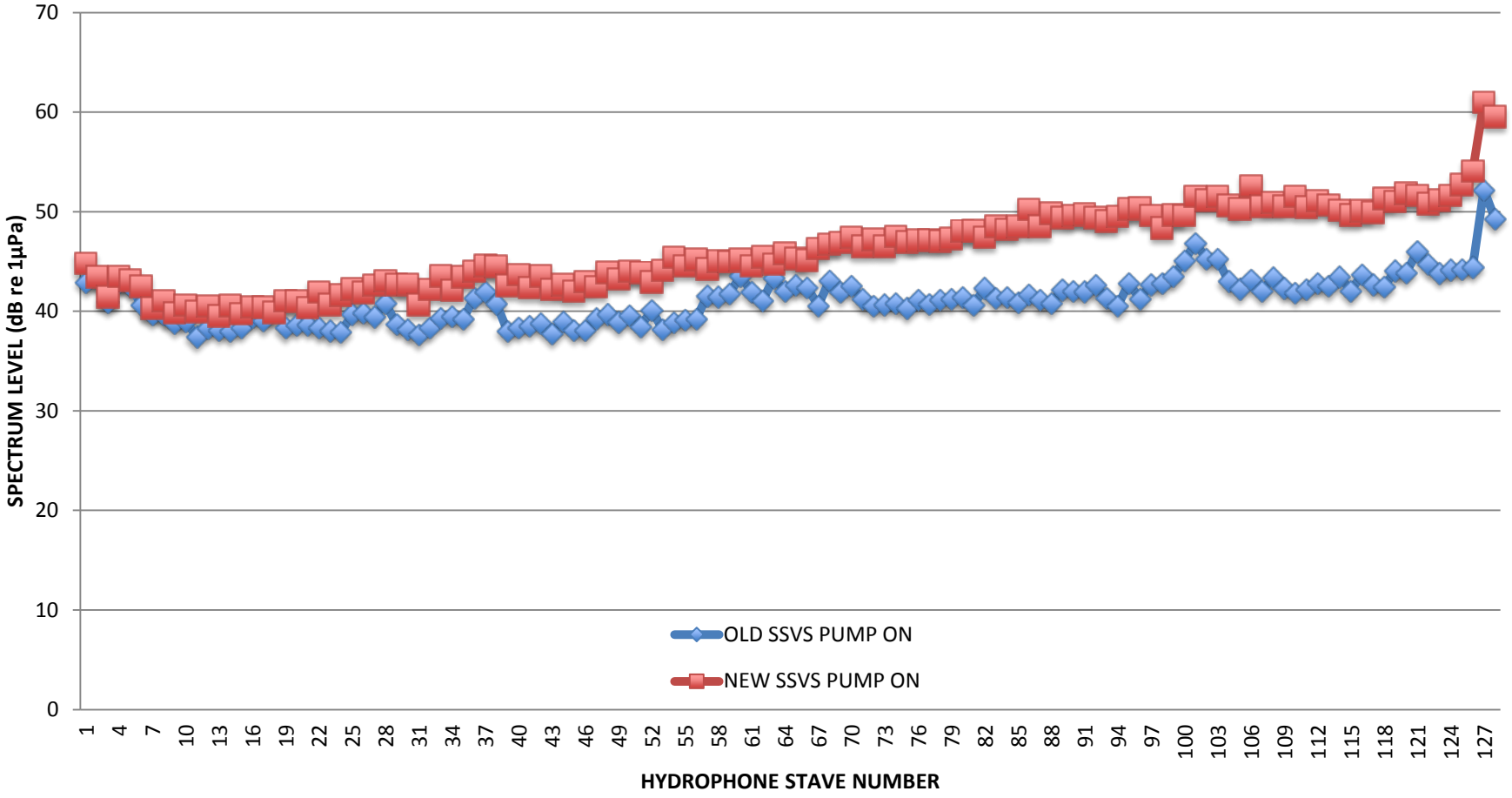
BOILER FEED PUMP 1 IMPACT



BOILER FEED PUMP 2 IMPACT



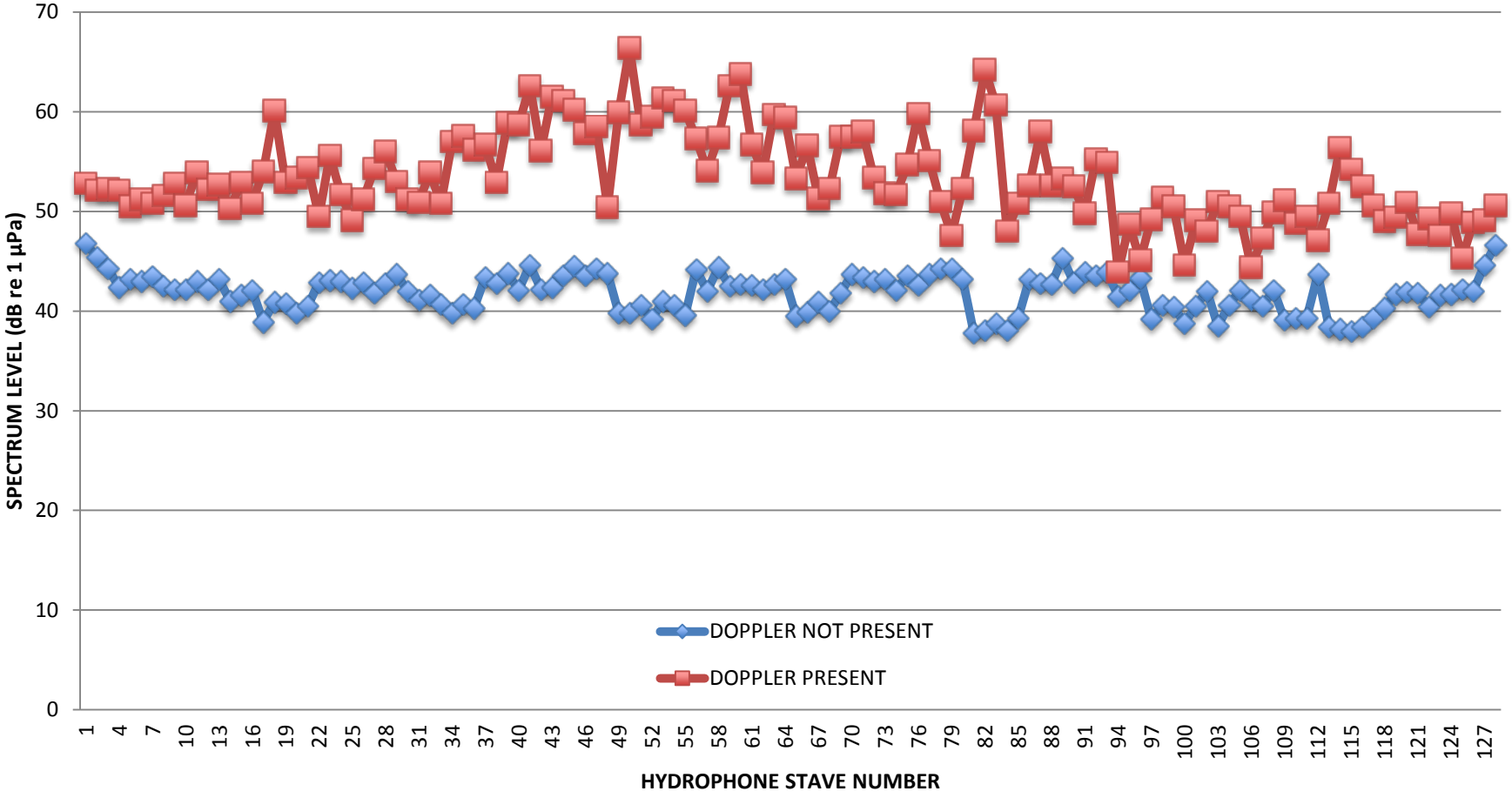
E/V NAUTILUS
EM 302 RX NOISE LEVEL
OLD VS NEW SSVS PUMP COMPARISON
5 MAY 2014



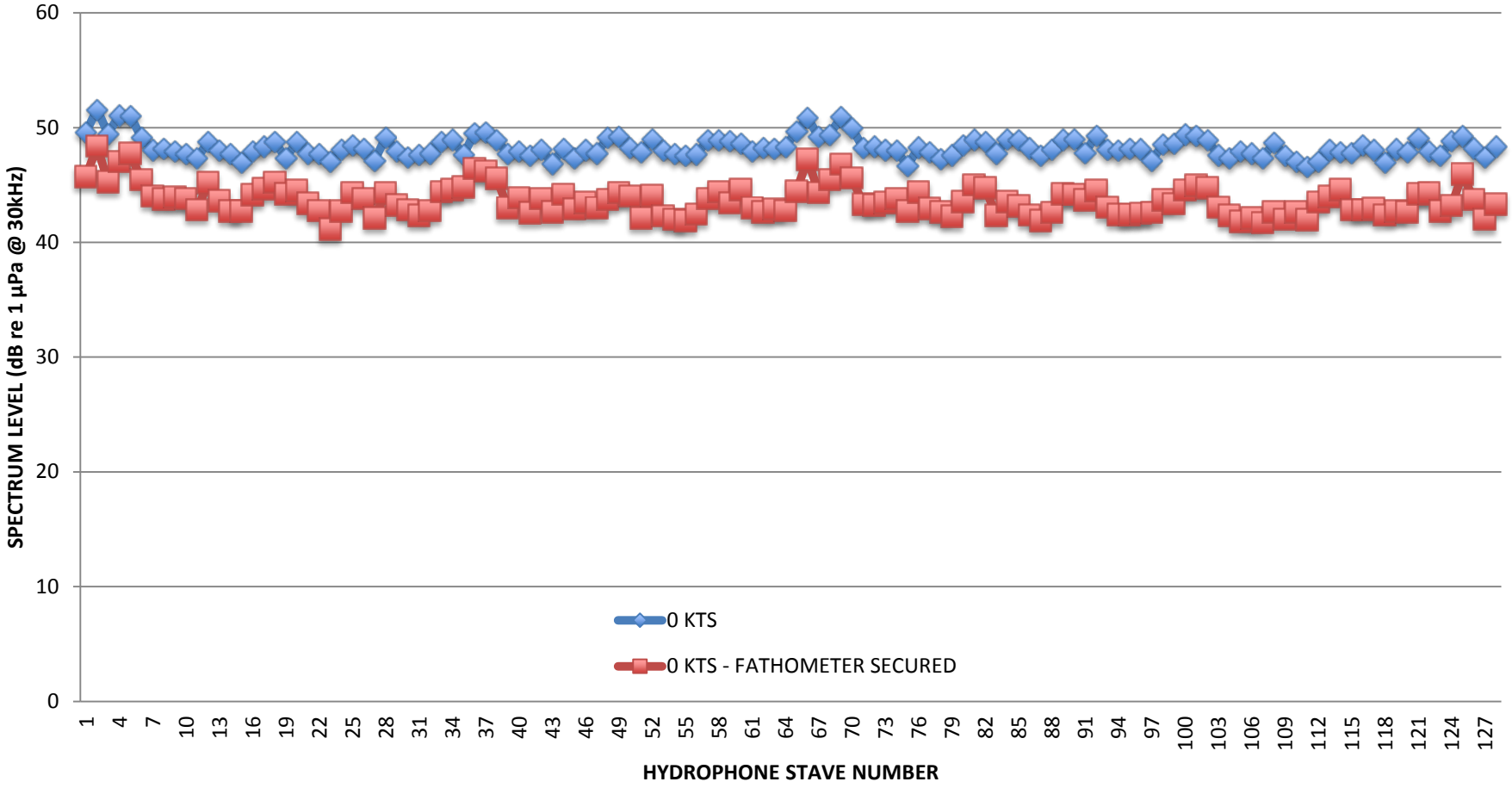
SONAR INTERFERENCE

- Operation of bridge/navigation electronics often degrades sonar performance

NOAA Ship *OKEANOS EXPLORER* (R-337)
DOPPLER SPEED LOG IMPACT - 8 KNOTS
EM 302 RX NOISE LEVEL
7 FEBRUARY 2014



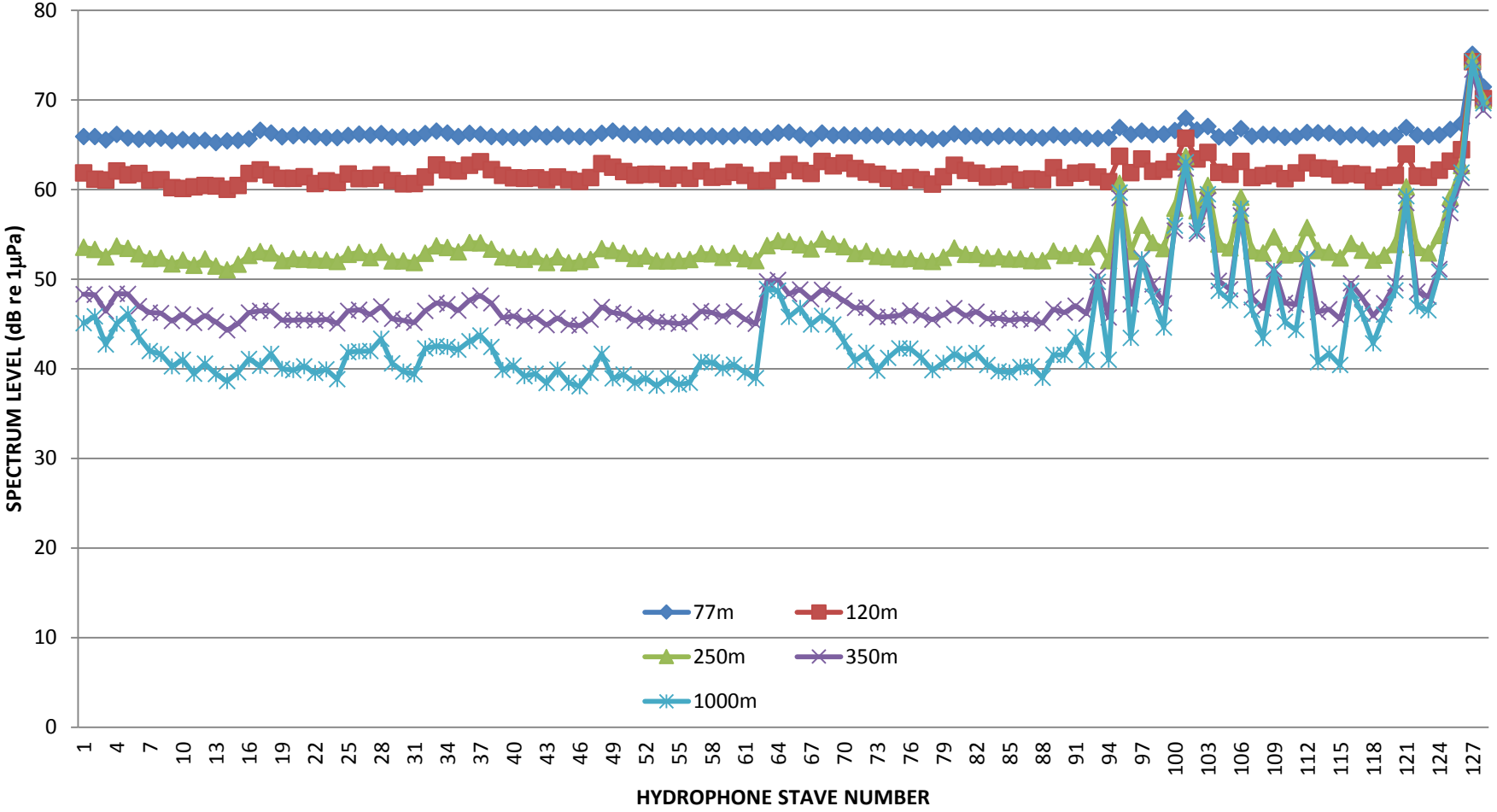
R/V SIKULIAQ
EM302 RX NOISE LEVEL
0 KTS - FATHOMETER ON VS SECURED
16 JULY 2014

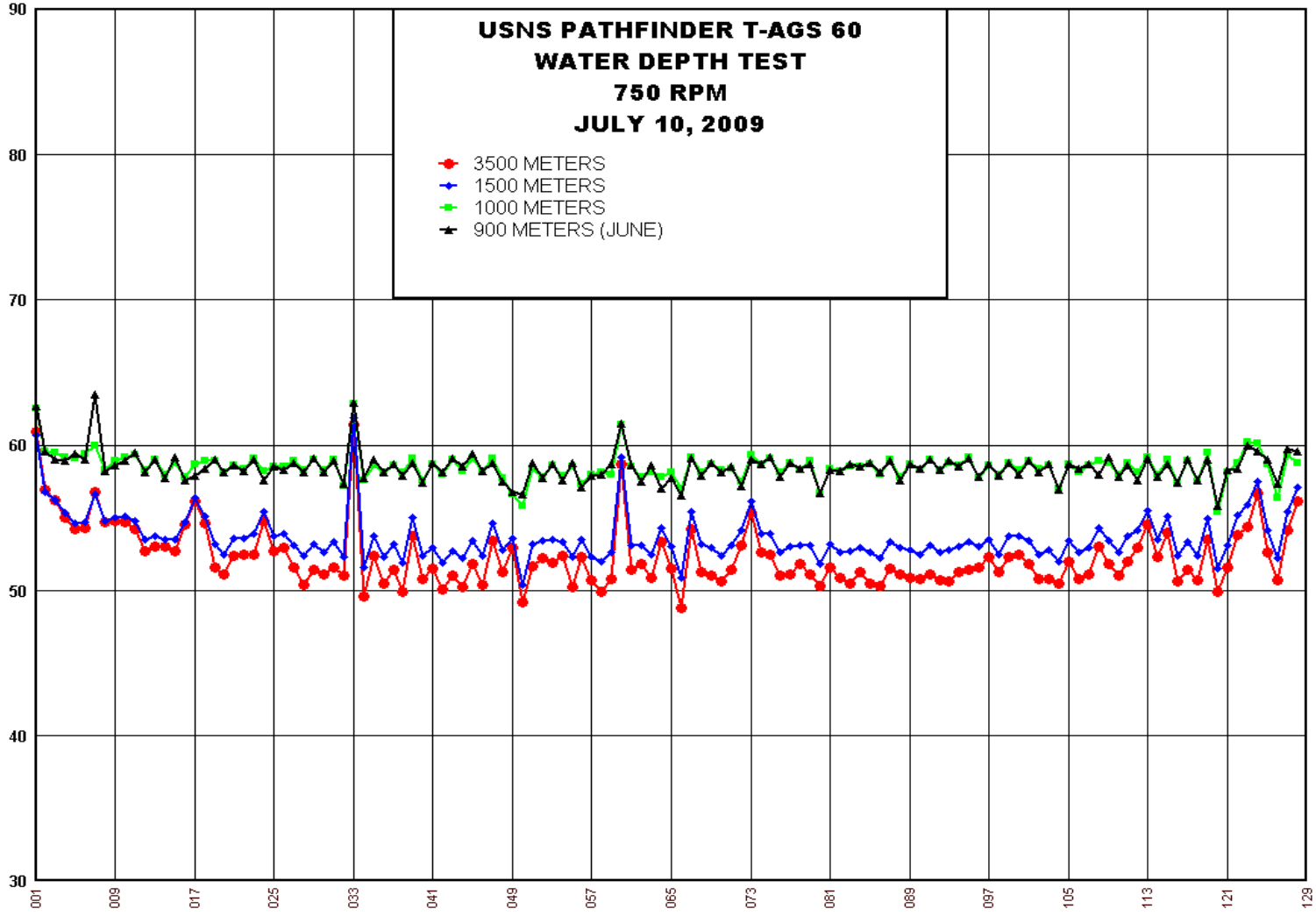


PROPELLER NOISE

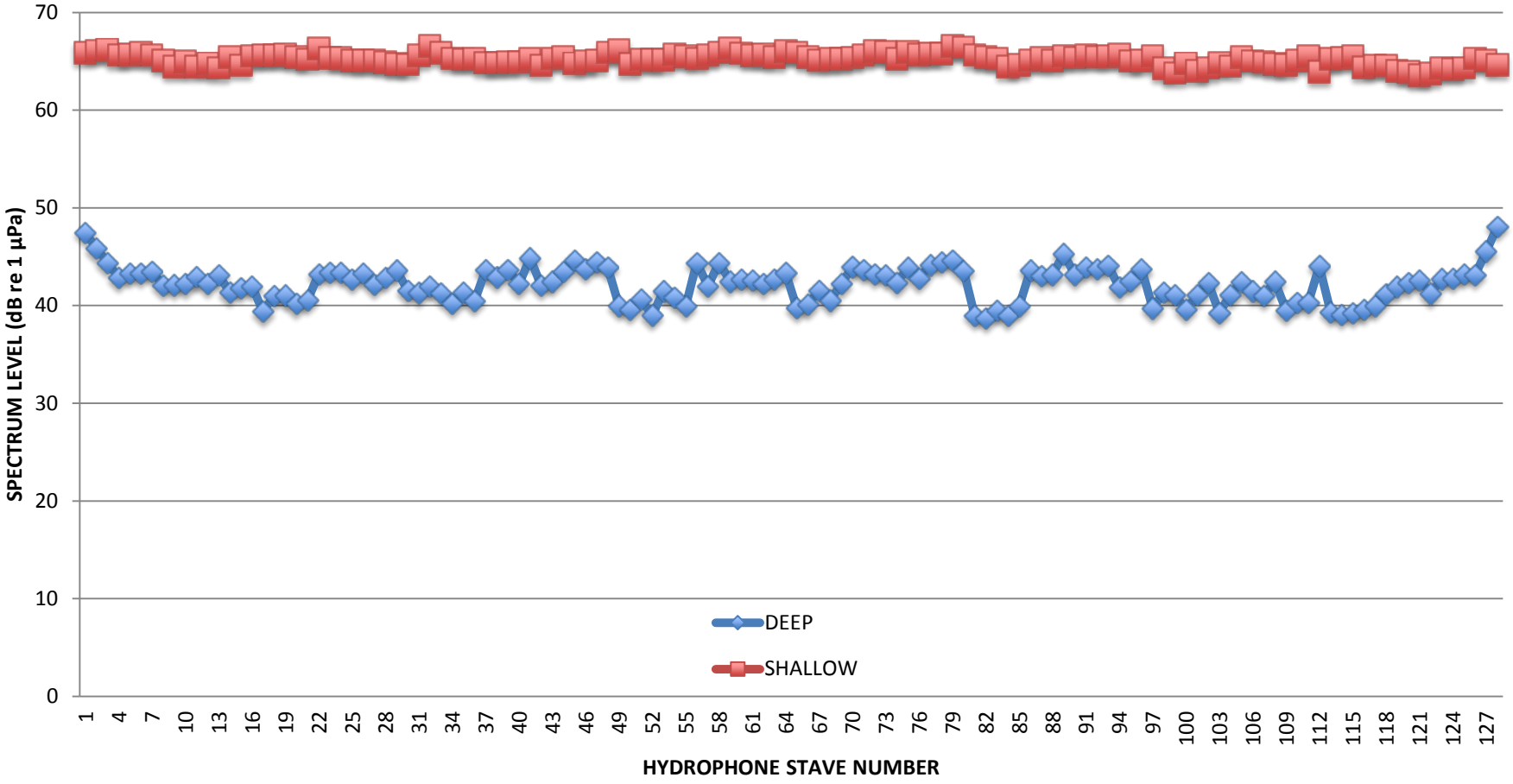
- Propeller cavitation can be loud and is typically present at higher frequencies which can severely impact oceanographic sonars
- Propeller noise is much more prevalent in sonar data in shallow water

E/V NAUTILUS
EM302 RX NOISE LEVEL
DEPTH COMPARE - 25 PITCH
10 APRIL 2013




USNS PATHFINDER T-AGS 60
WATER DEPTH TEST
750 RPM
JULY 10, 2009
3500 METERS
1500 METERS
1000 METERS
900 METERS (JUNE)
90
80
70
60
50
40
30
001
009
017
025
033
041
049
057
065
073
081
089
097
105
113
121
129

NOAA Ship *OKEANOS EXPLORER* (R-337)
8 KNOTS - DEEP VS SHALLOW WATER
EM 302 RX NOISE LEVEL
6 FEBRUARY 2014

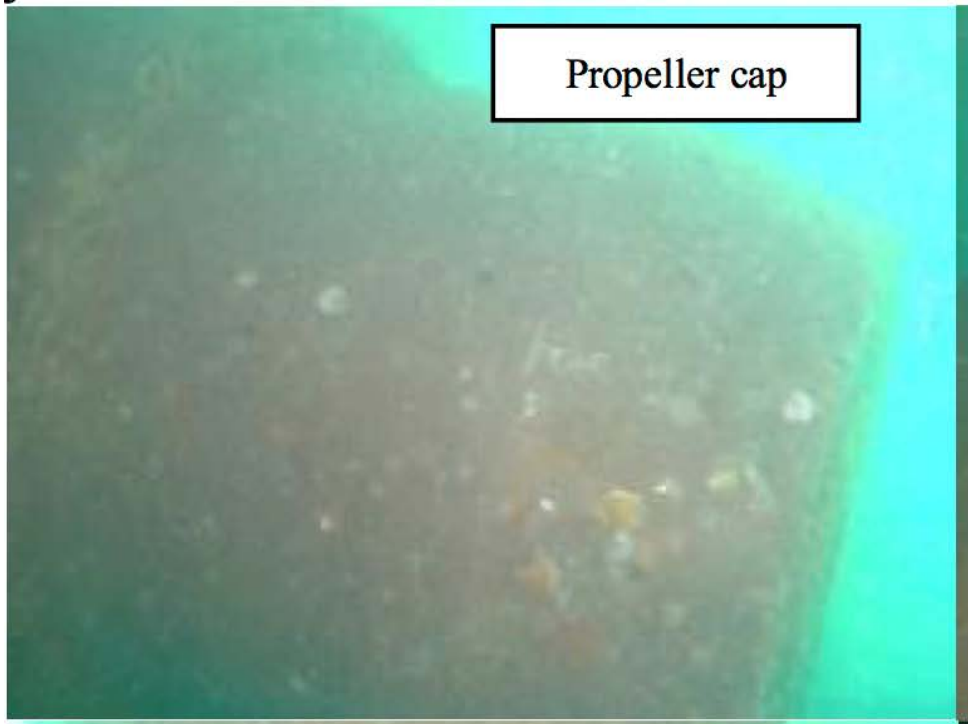


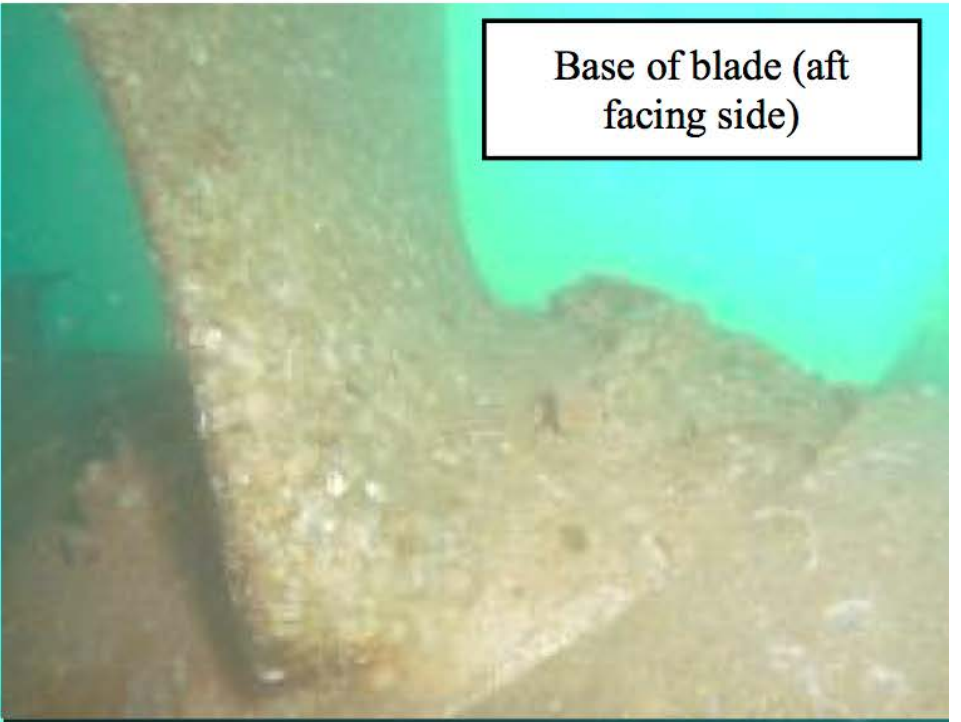
HYDRODYNAMIC FLOW NOISE

- Water flowing over the hull/sonar regions can create noise as the flow becomes turbulent
- Smooth and pristine conditions are ideal
- Biological fouling can be a severe problem

M/V FALKOR

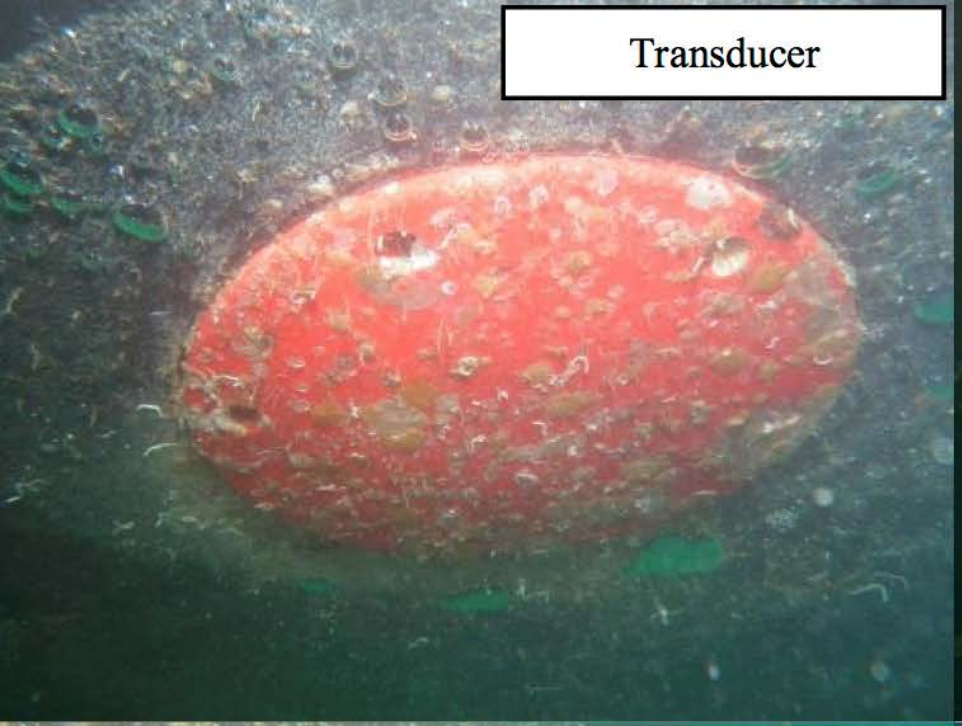
- M/V FALKOR reported significant degradations to sonar performance
- RX Noise levels were significantly increased
- Underhull inspection revealed poor conditions associated with bio-fouling


Propeller cap


Base of blade (aft facing side)


Base of blade (forward facing side)


Shaft junction (aft facing perspective


Transducer

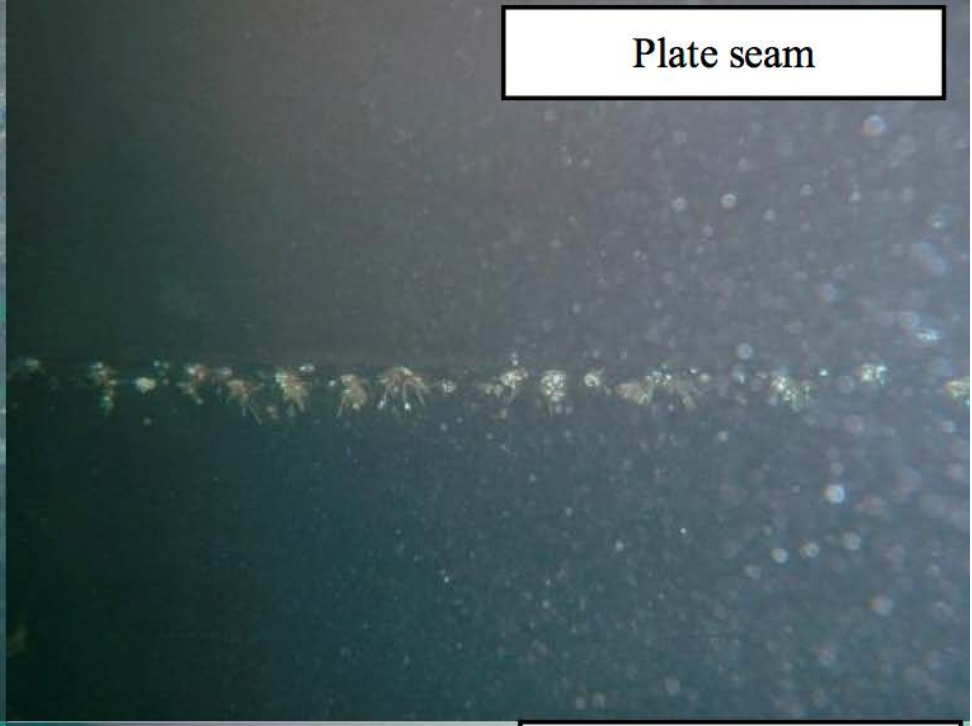


Plate seam


Bulbous bow


Bolt recess on zinc

RVIB NATHANIEL B. PALMER

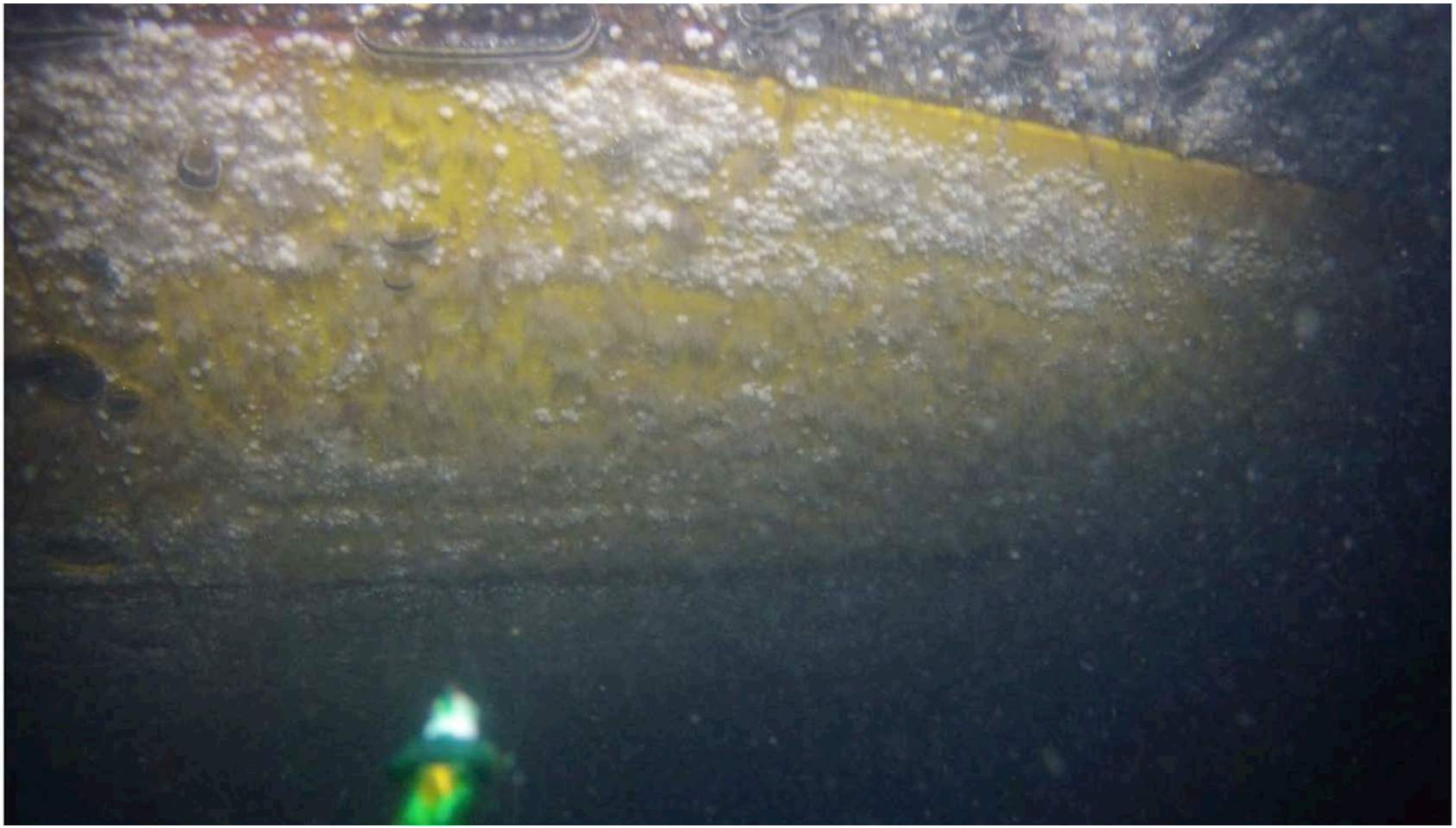
- Drydock inspection revealed extremely poor conditions near sonar transducers
- Gaps were noted between transducer faces and ships hull
- Paint conditions were terrible
- Sonar acoustic windows possessed major cracks
- These conditions will significantly degrade hydrodynamic flow noise levels

R/V SIKULIAQ

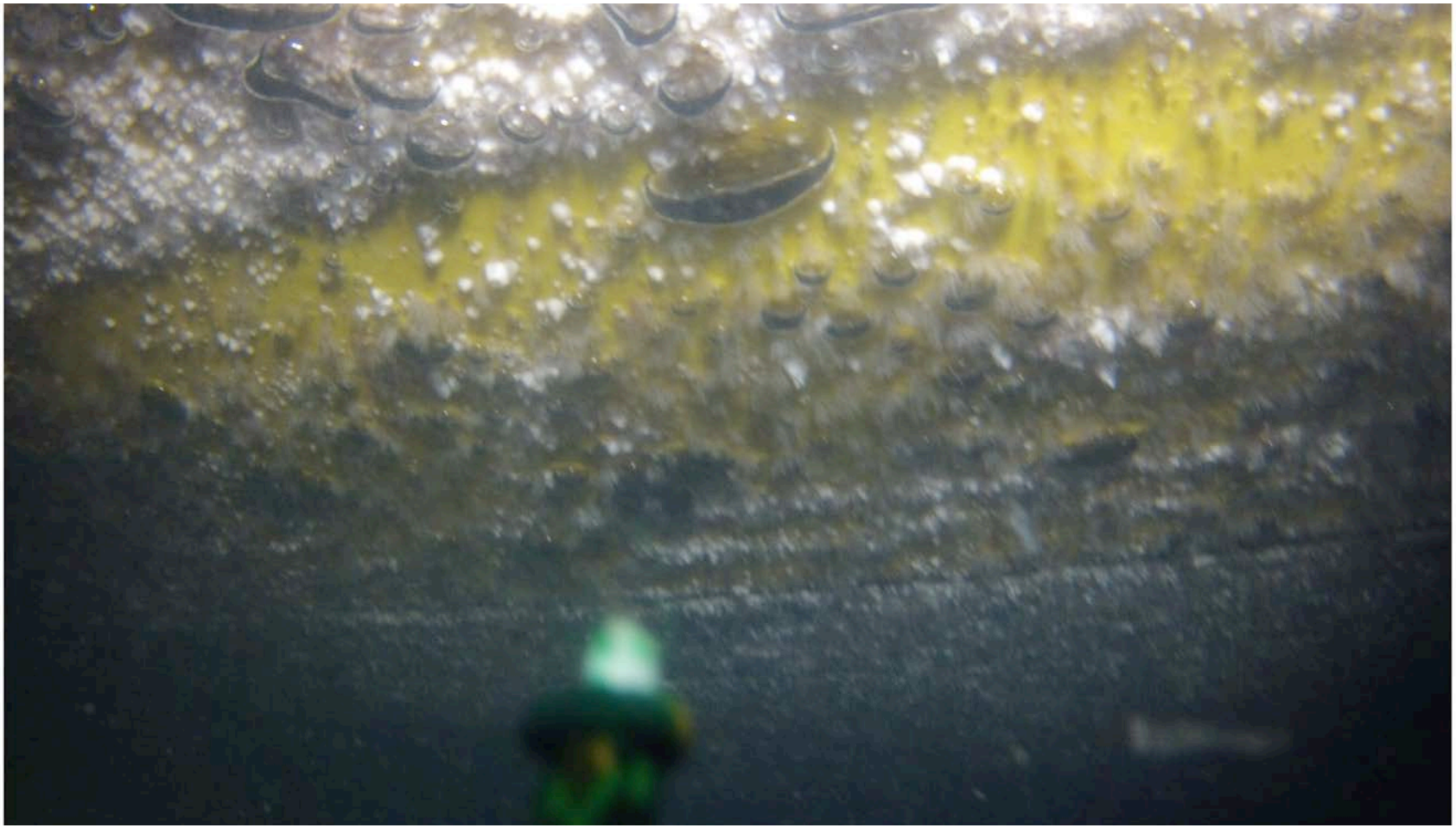
- SIKULIAQ was significantly fouled during baseline acoustic testing
- Sonar levels were completely controlled by hydrodynamic flow noise at vessel of 3 knots and above

R/V SIKULIAQ - ADCP

R/V SIKULIAQ – EM 302



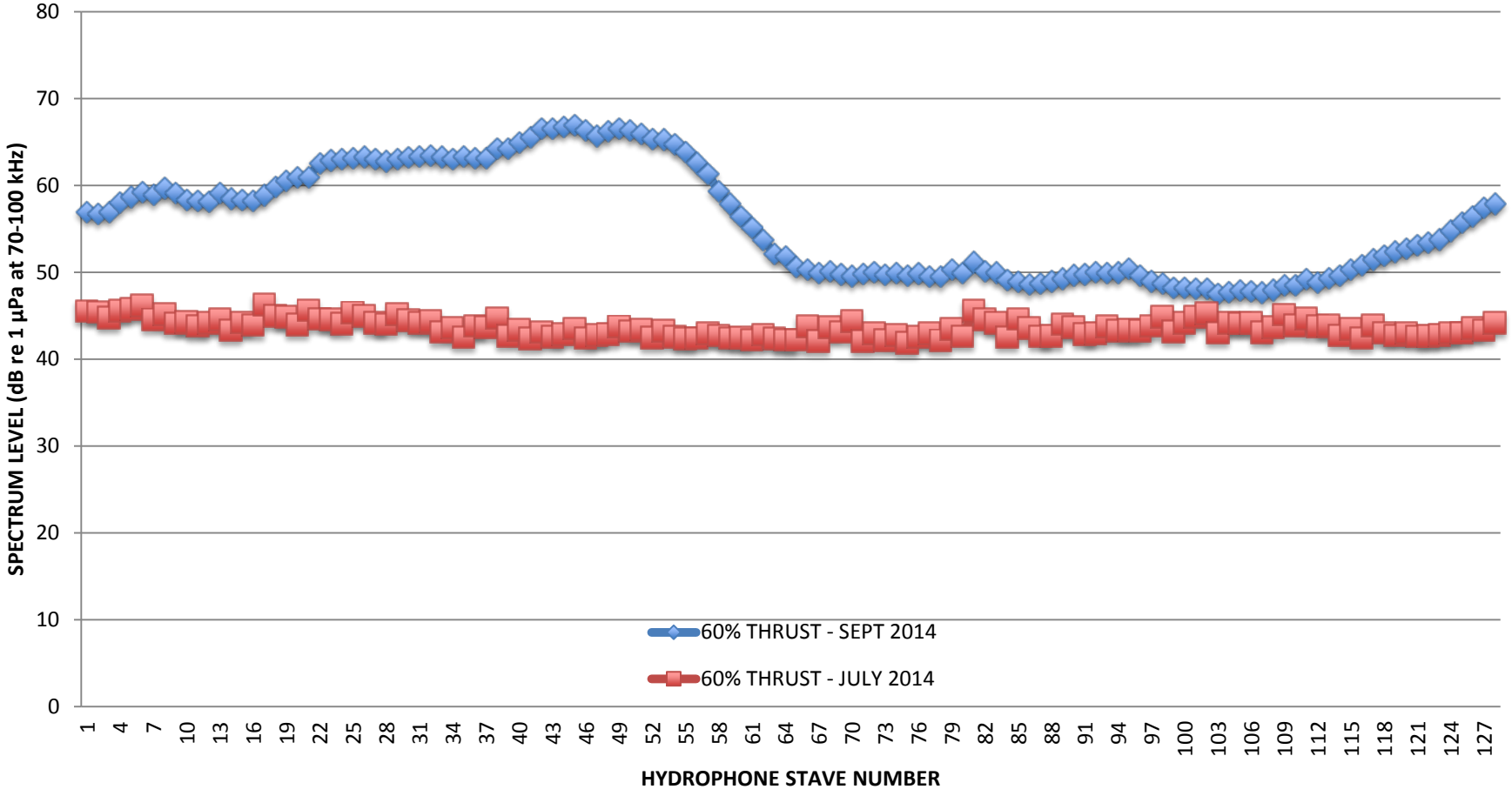
R/V SIKULIAQ – EM 302



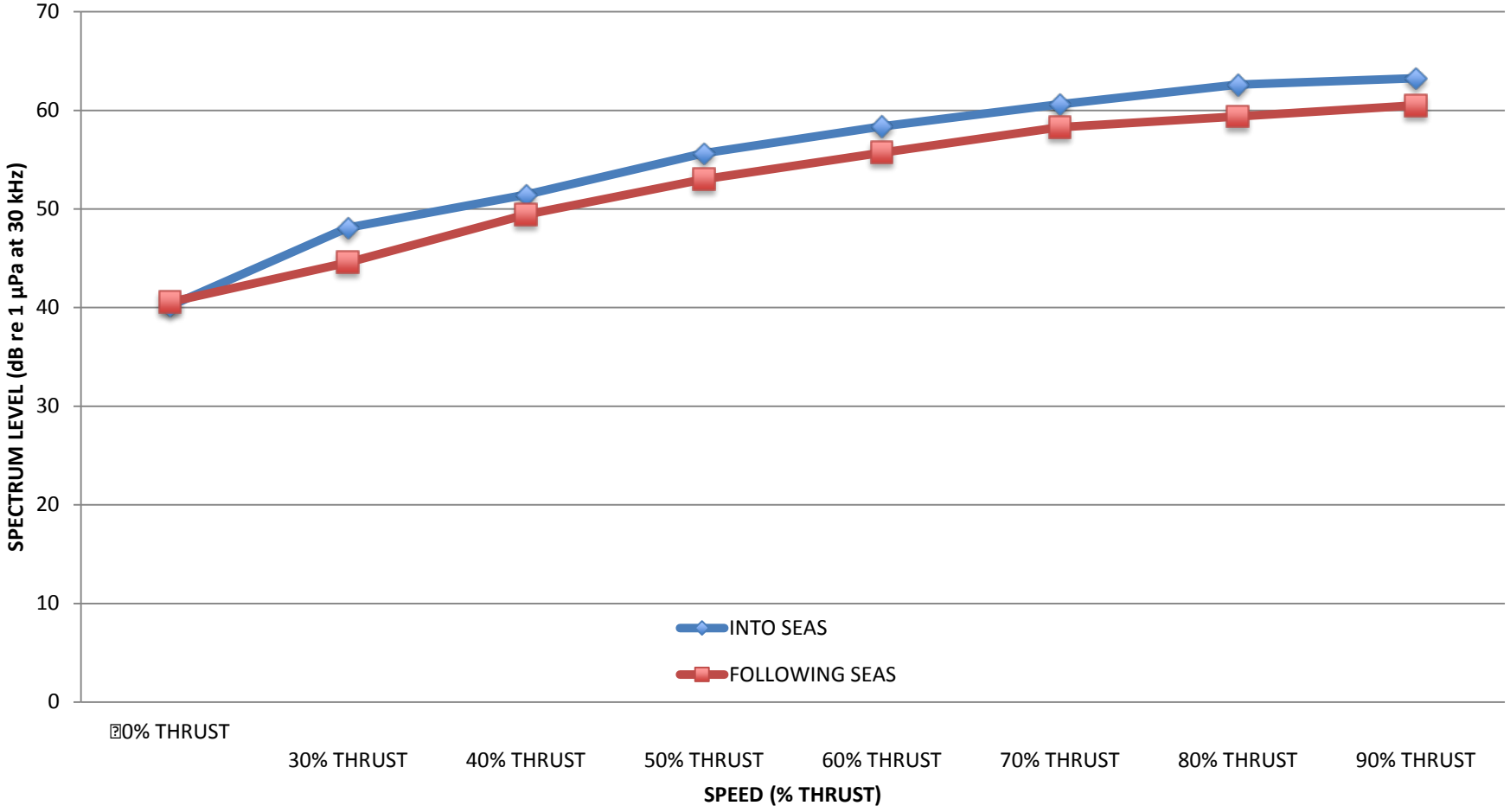
R/V SIKULIAQ – EM 710

R/V SIKULIAQ – EM 710

R/V SIKULIAQ
EM 710 RX NOISE LEVEL
60% THRUST - JULY VERSUS SEPTEMBER 2014
15 SEPTEMBER 2014



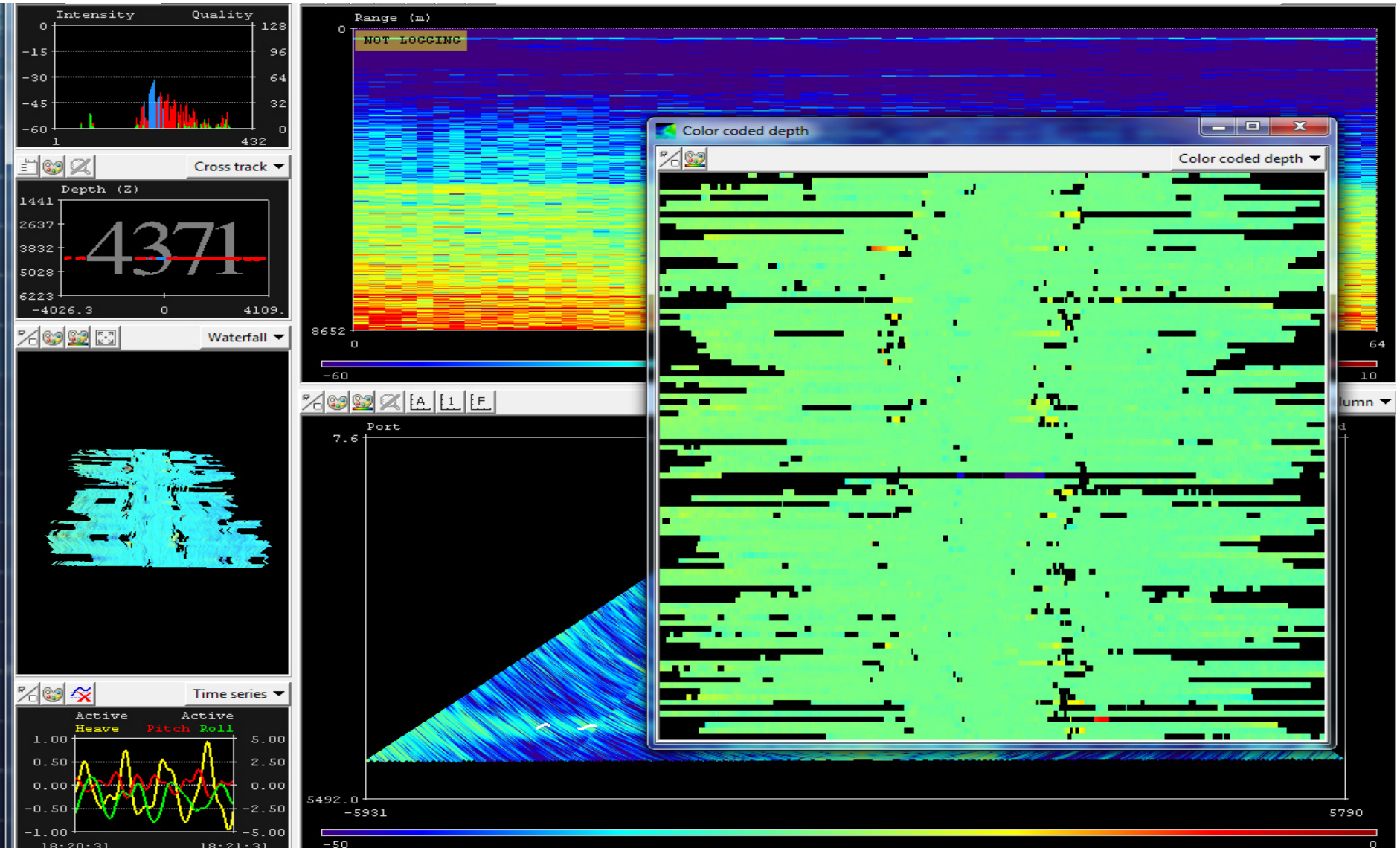
R/V SIKULIAQ
EM 302 RX NOISE LEVEL
SPEED VS 30 kHz LEVEL - INTO VS FOLLOWING SEAS
15 SEPTEMBER 2014



BUBBLE SWEEPDOWN

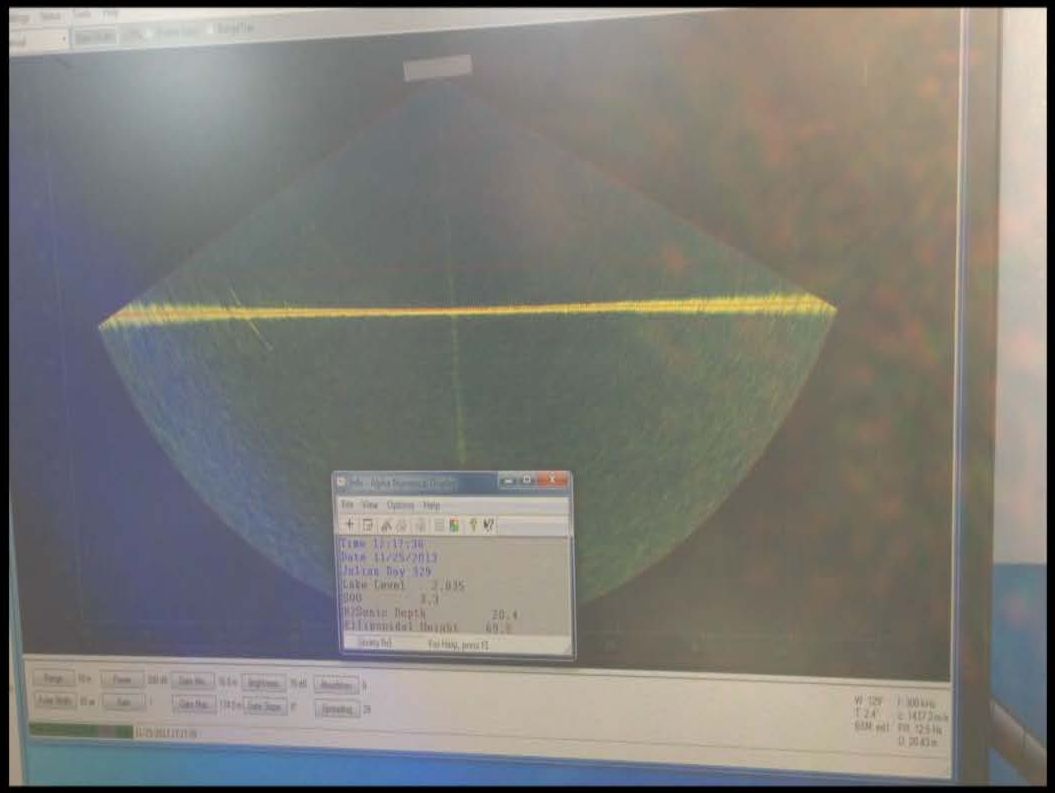
- Bubble sweepdown is created when air from the bow region is sucked under the ships hull
- If it gets to the sonar transducer region it can severely degrade sonar performance

PALMER BUBBLE IMPACT



COMMERCIAL SURVEY LAUNCH

- At any underway speed, random transients were degrading sonar performance
- Problem was more prevalent with any port turn
- Underwater photography was collected with a pole mounted GoPro
- Sonar data dropouts were completely correlated with bubbles impacting sonar transducer face


Time 11:17:36
Date 11/25/2013
Julian Day 329
Lake Level 2.035
Sonic Depth 20.4
Ellipsoidal Height 69.0

R/V CELTIC EXPLORER

- Testing conducted on Irish ship R/V CELTIC EXPLORER discovered major bubble sweepdown events
- CELTIC EXPLORER has a bulbous bow (bubble generator)

FIGURE 27

FIGURE 28

FIGURE 29

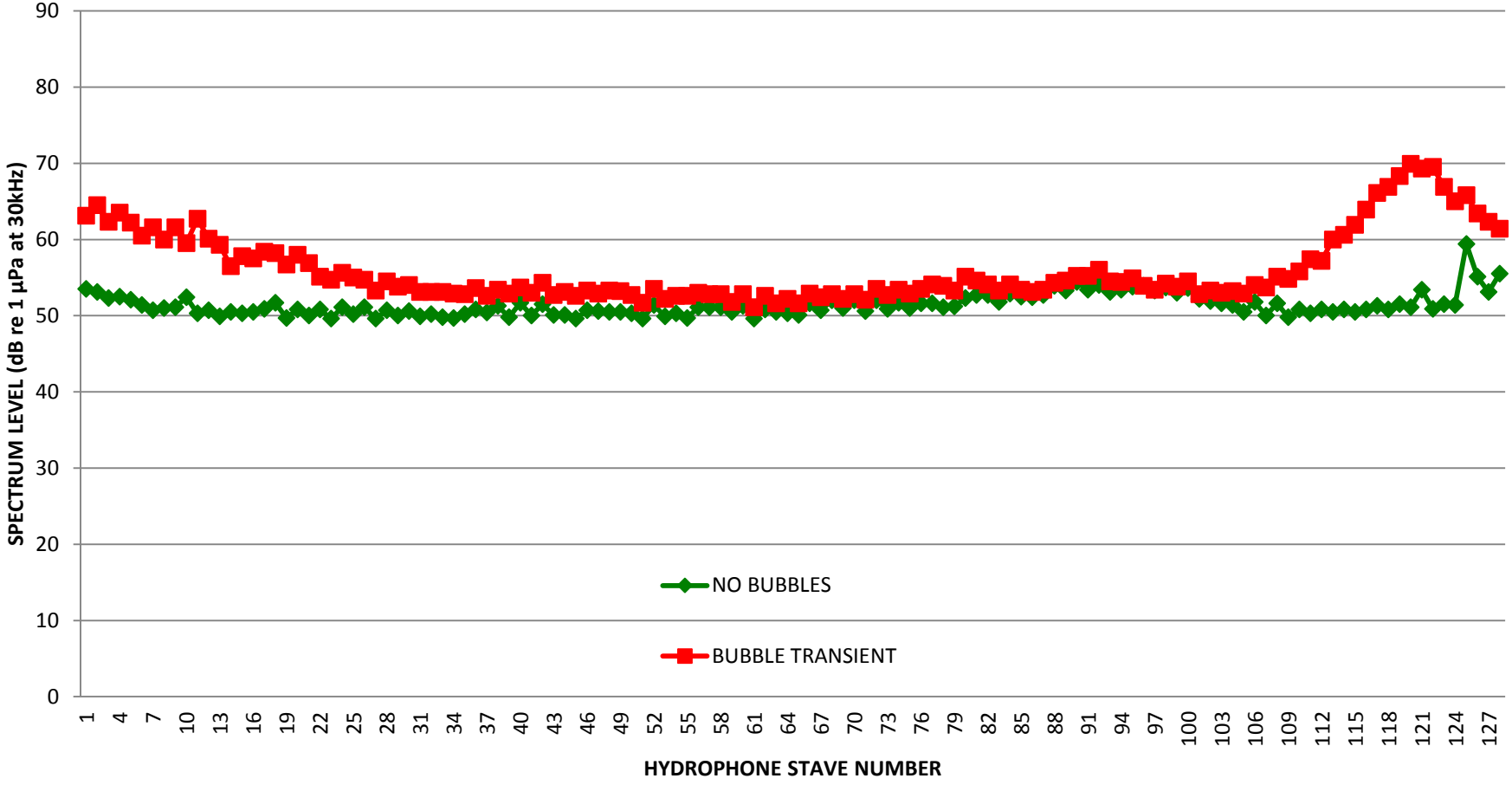
FIGURE 30

FIGURE 31

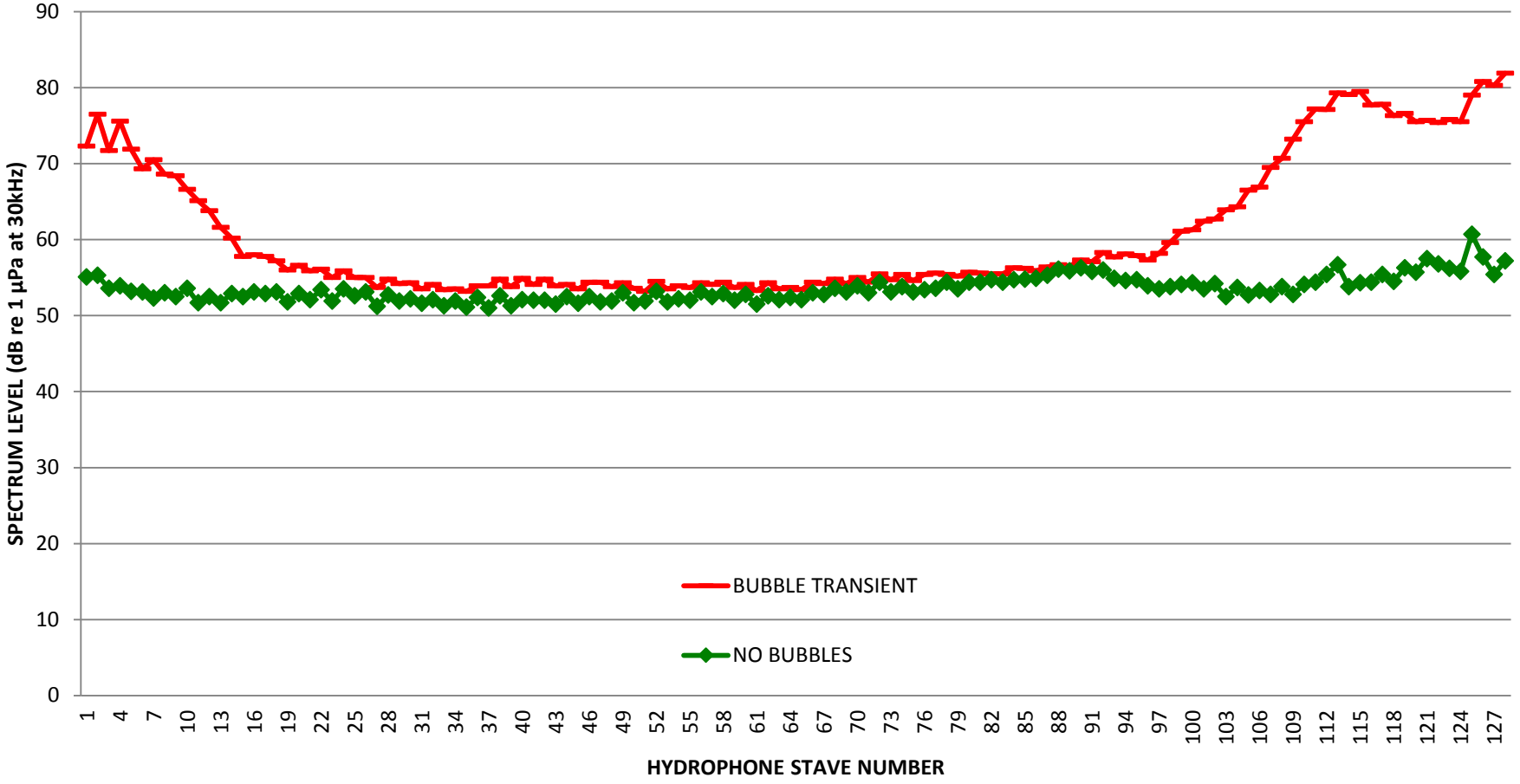
R/V SIKULIAQ BUBBLE SWEEPDOWN

- SIKULIAQ has a lot of bubbles
- SIKULIAQ has an icebreaker hull (notorious for bubbles)
- Bubbles were present at all headings

R/V SIKULIAQ
EM 302 RX NOISE LEVEL
7.5 KTS - 60% THRUST - INTO SEAS
12 SEPTEMBER 2014

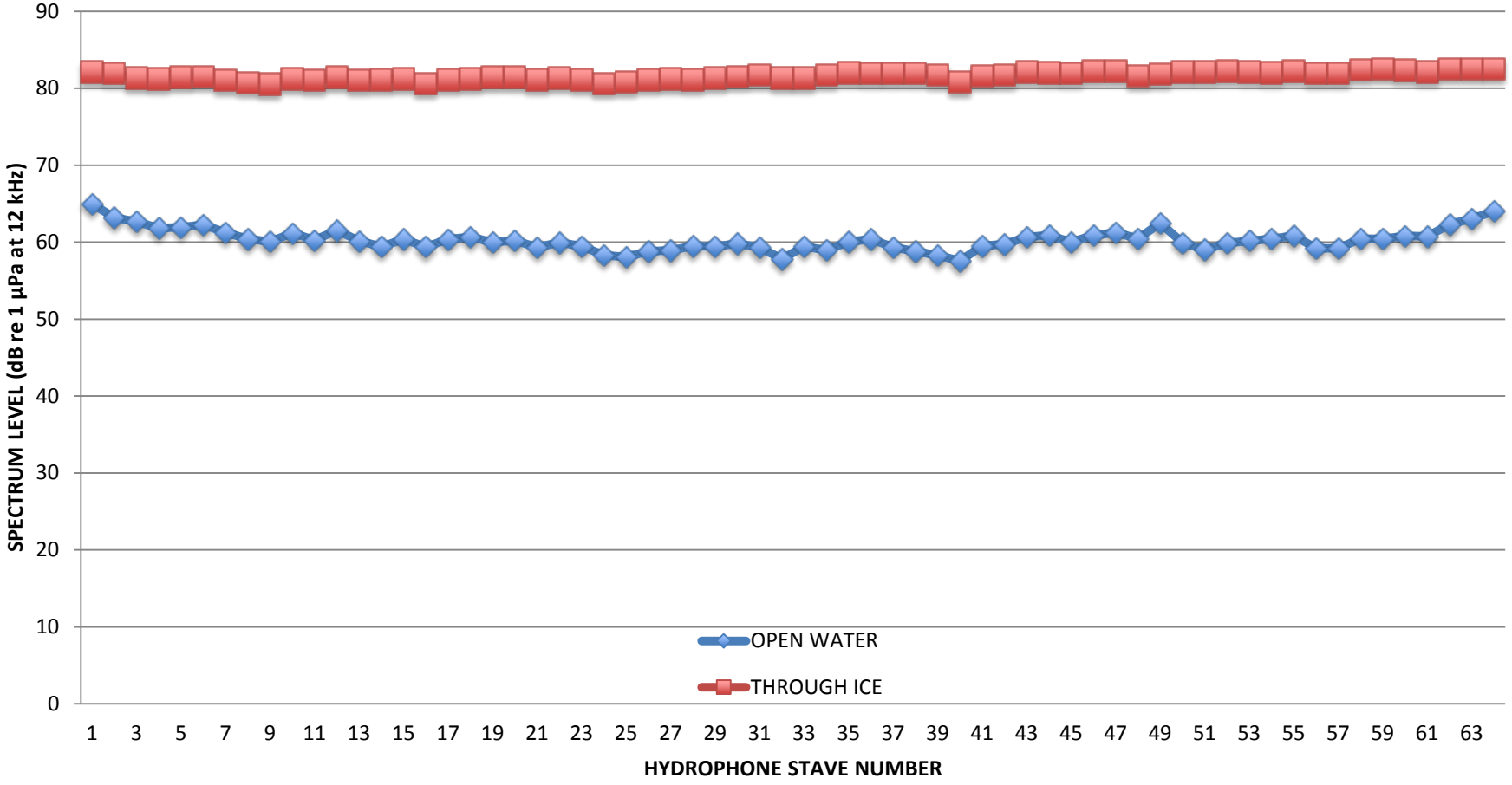


R/V SIKULIAQ
EM 302 RX NOISE LEVEL
8.4 KTS - 60% THRUST - FOLLOWING SEAS
12 SEPTEMBER 2014



TRANSIENTS

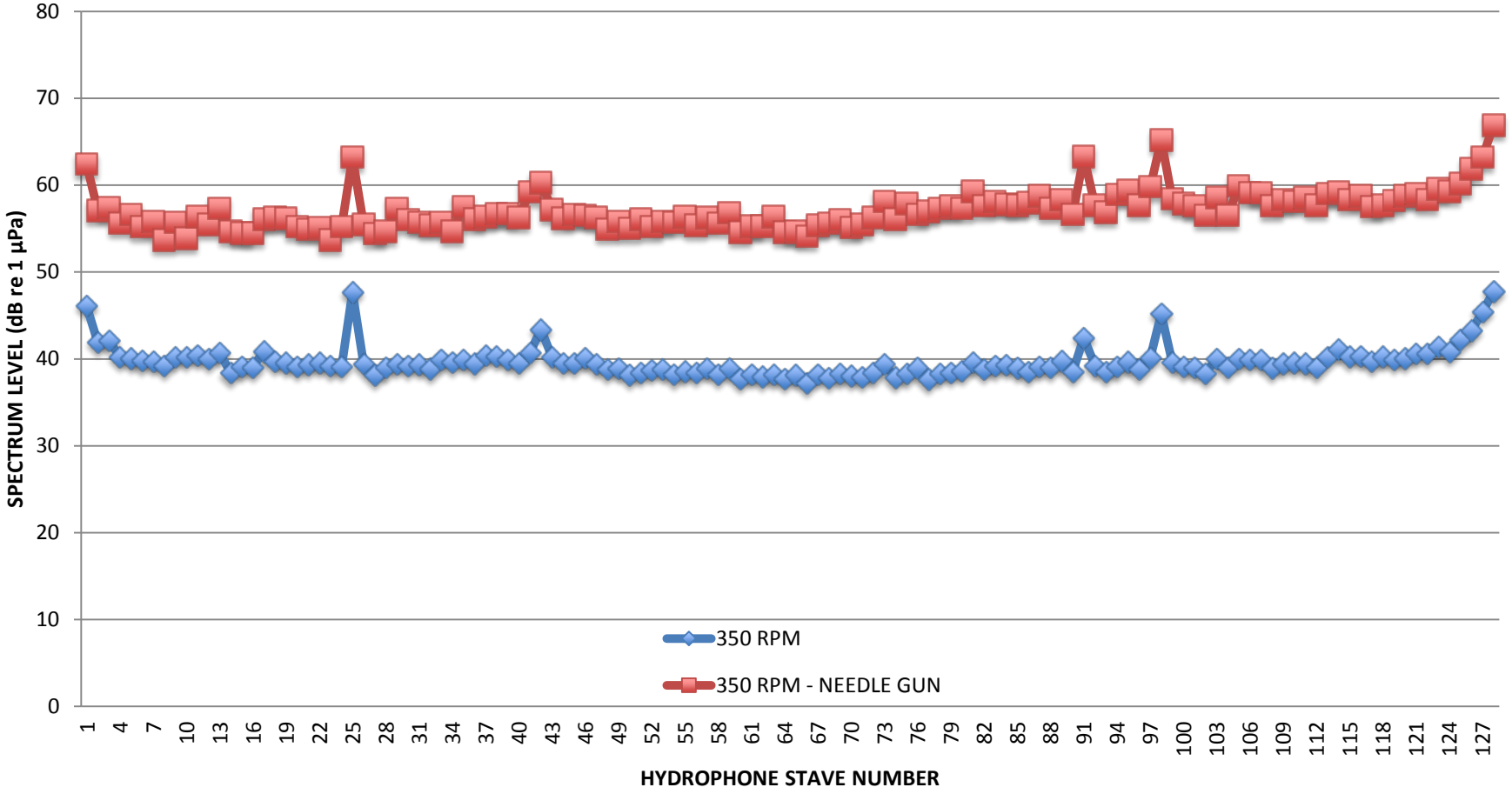
USCGC HEALY (WAGB-20)
EM 122 RX NOISE LEVEL
80 RPM - OPEN WATER VS THROUGH THIN ICE
17 AUGUST 2014



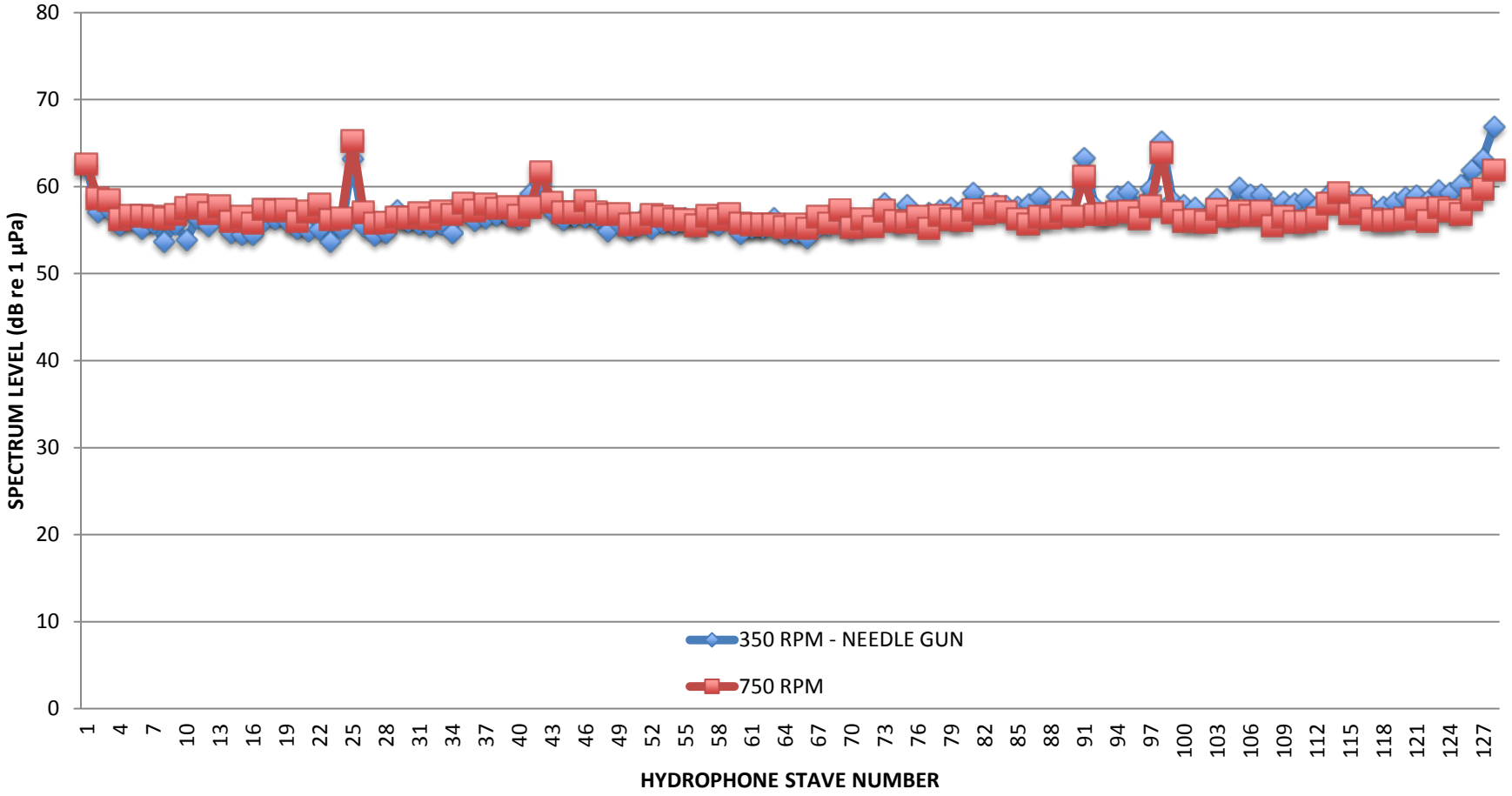
TRANSIENTS

- During an acoustic evaluation of USNS BRUCE C. HEEZEN (T-AGS 64) high levels were noted in the RX Noise Level
- Acoustic monitoring system aurally revealed the presence of deck work being done
- A ship inspection discovered needle gun activity being conducted

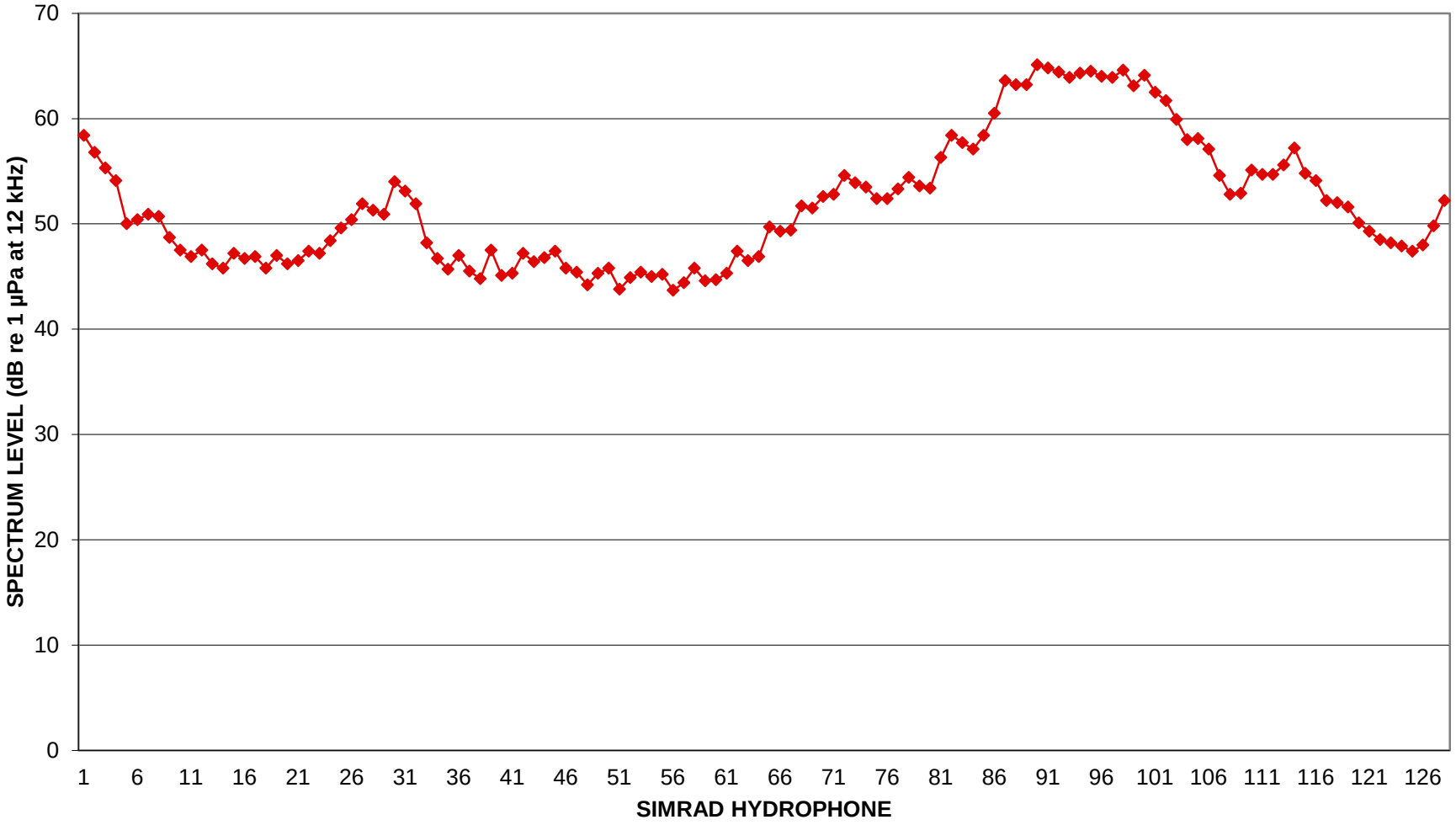
USNS BRUCE C. HEEZEN (T-AGS 64)
EM 122 RX NOISE LEVEL
NEEDLE GUN OPERATION IMPACT
14 APRIL 2014



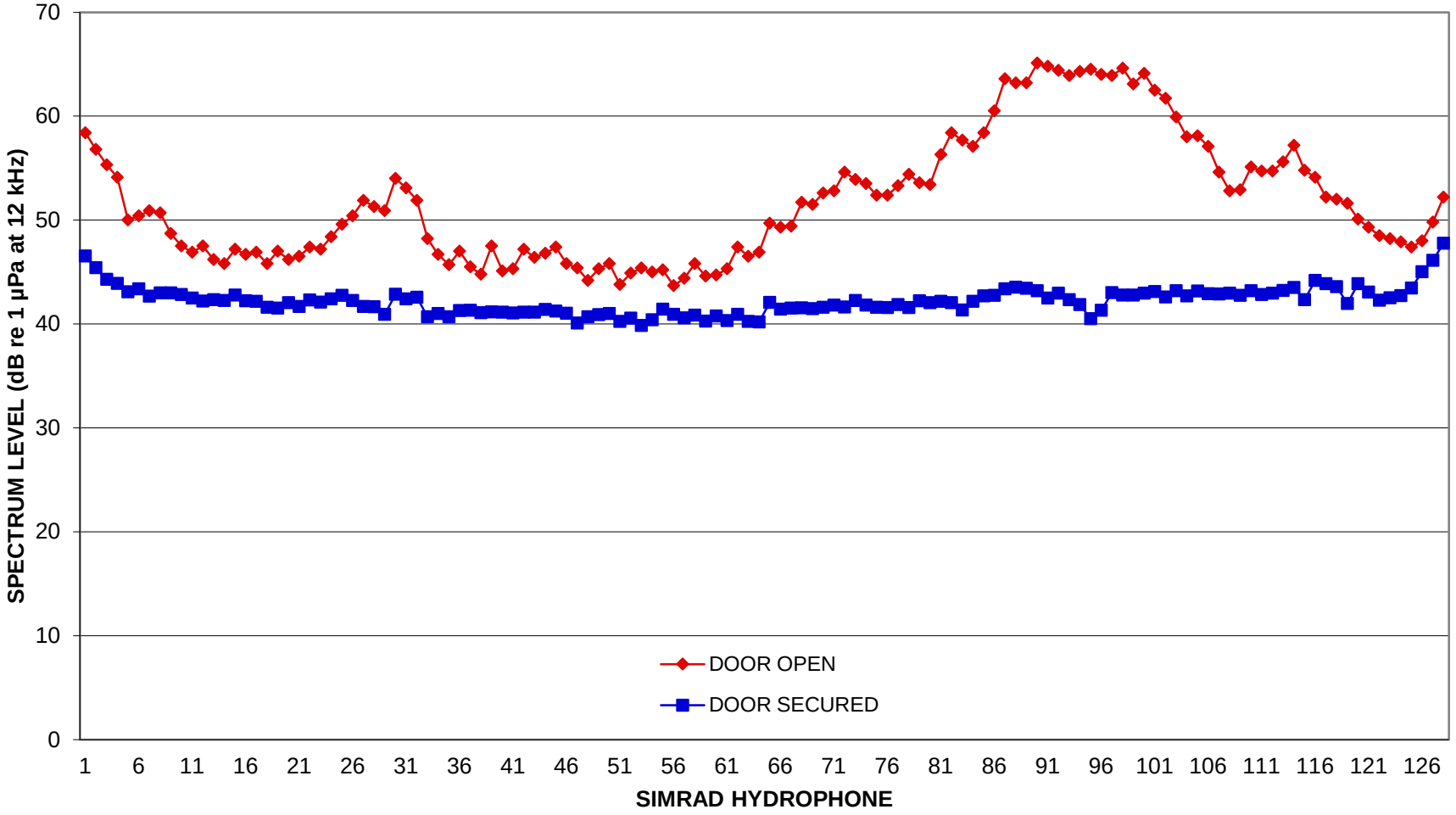
USNS BRUCE C. HEEZEN (T-AGS 64)
EM 122 RX NOISE LEVEL
NEEDLE GUN OPERATION IMPACT
14 APRIL 2014



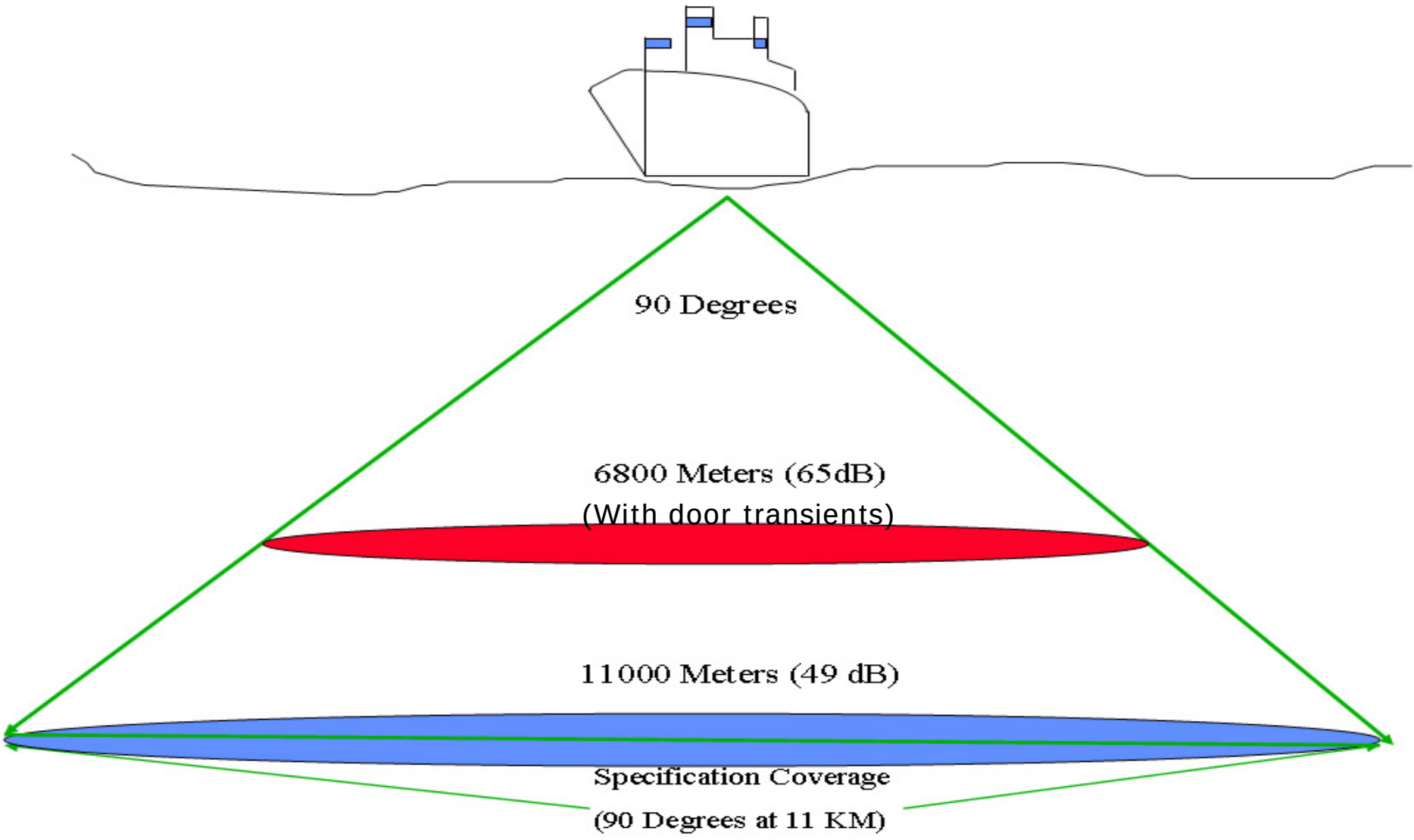
USNS MARY SEARS (T-AGS 65)
RX NOISE LEVEL
TRANSIENT NOISE



USNS MARY SEARS (T-AGS 65)
RX NOISE LEVEL
TRANSIENT NOISE



BOTTOM SWATH AT NOISE GOAL



ACOUSTIC MONITORING

- The acoustic posture of a research vessel should be assessed at critical stages during its life
- An initial baseline at construction should always be obtained
- During major sonar upgrades additional baselines should be acquired
- Additionally, periodic assessments should be conducted to ensure the acoustic levels are not degrading sonar performance

CONCLUSIONS…

BASIC PERFORMANCE TENET

QUIETER IS BETTER!!!