Acoustic Issues on Research Vessels

November 18, 2013

Timothy Gates and Marisa Yearta

Why is Acoustic Noise 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

How does noise impact sonar performance

- Active Sonar Equation
- SE = SL – 2(TL) – LN
- SE = Signal Excess (must be at least 10 dB)
- SL = Sonar Source Level
- TL = Sum of absorption and spherical spreading for outgoing and returning signal
- LN = ship background noise
- Every dB of additional LN equates to 1 dB of reduced Signal Excess

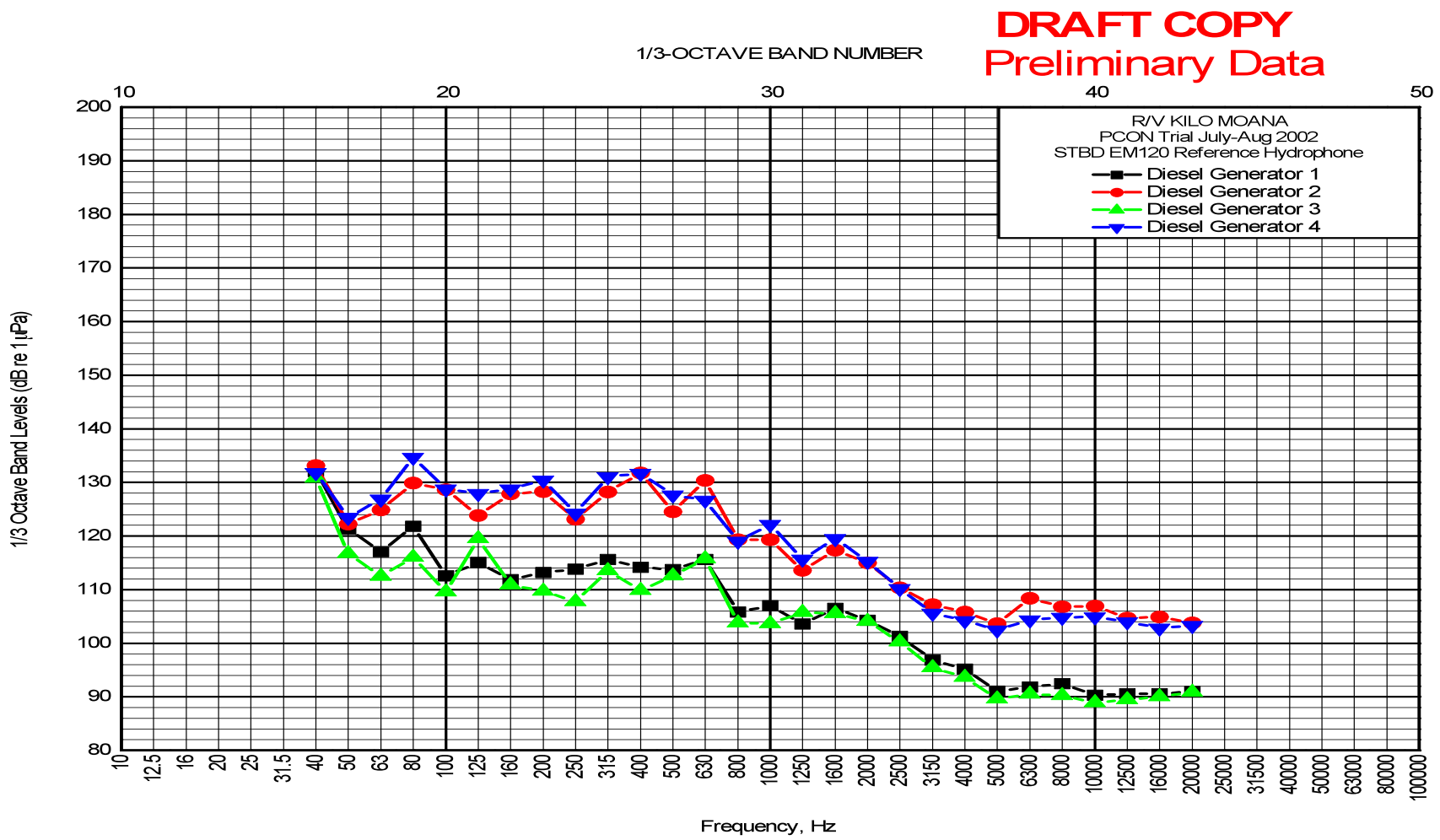
Typical Sources of Ship-Related Noise

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

Machinery Noise

- KILO MOANA – Diesel Engines
- KILO MOANA – Scientific Seawater Pump
- HEALY – Boiler Feed Pump
- REVELLE – Sewage Pump
- MELVILLE – Anti-Roll Tank
- HI'IALAKAI – Air Conditioning

Kilo Moana
Diesel Noise



KM SWATH IMPACT

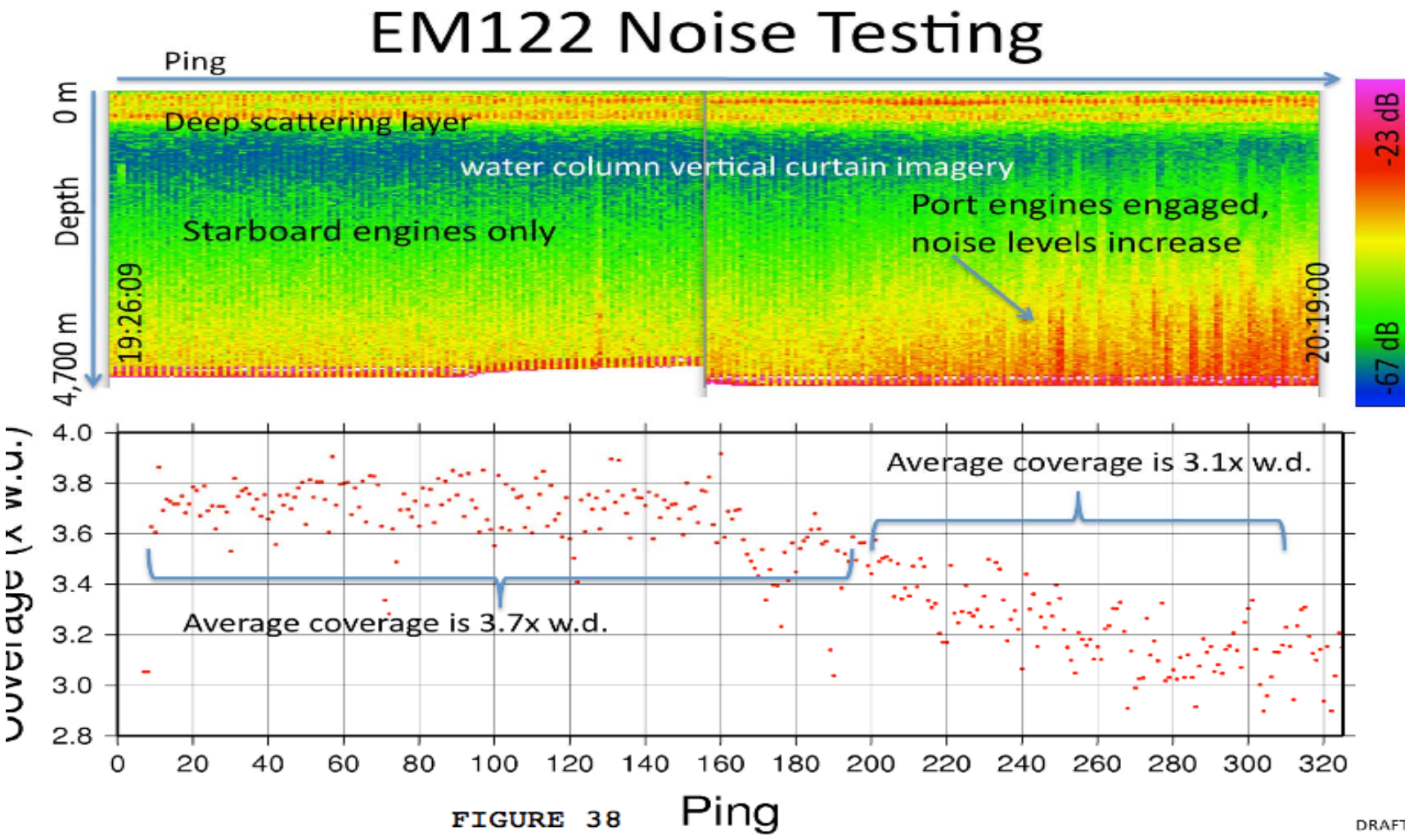
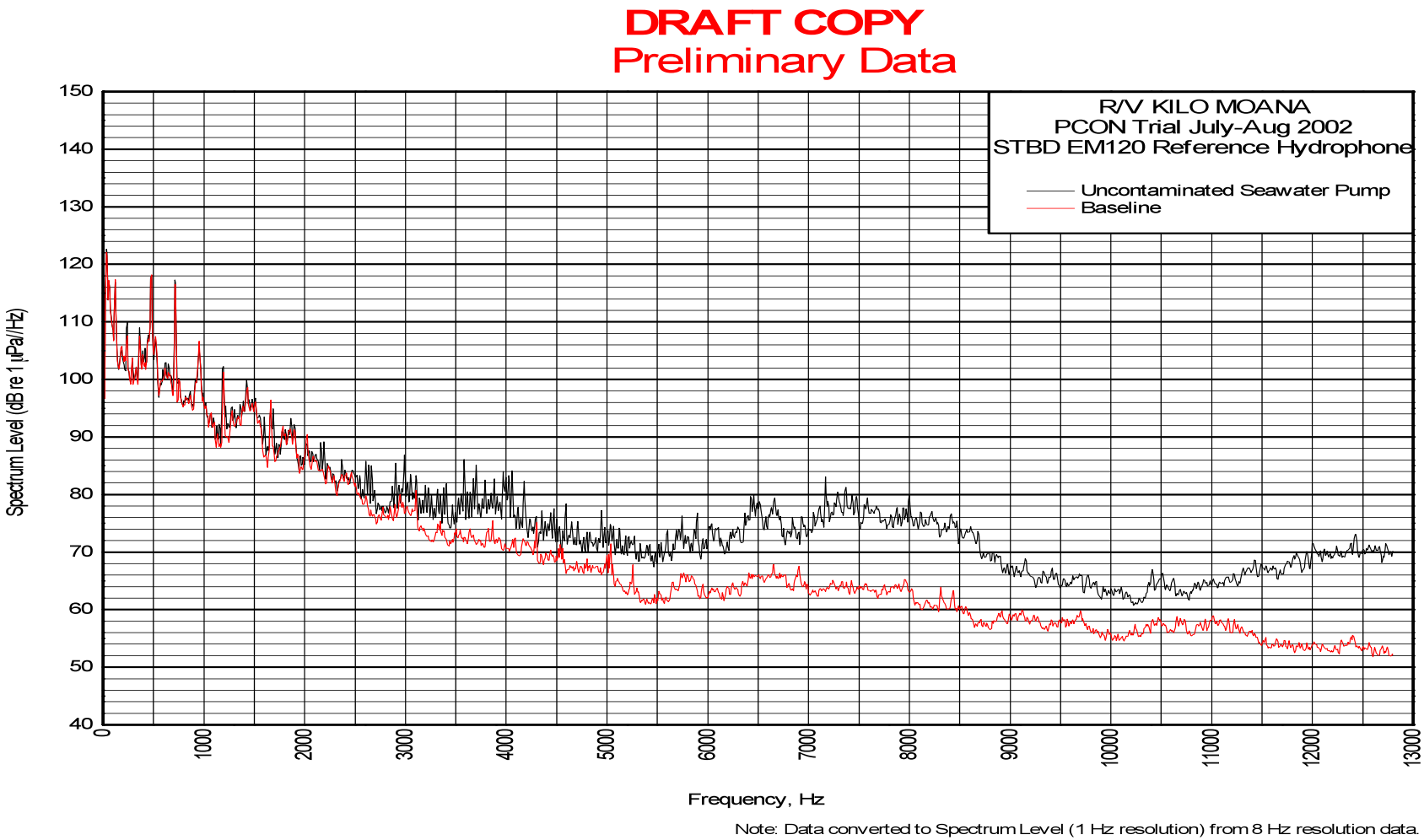


FIGURE 38

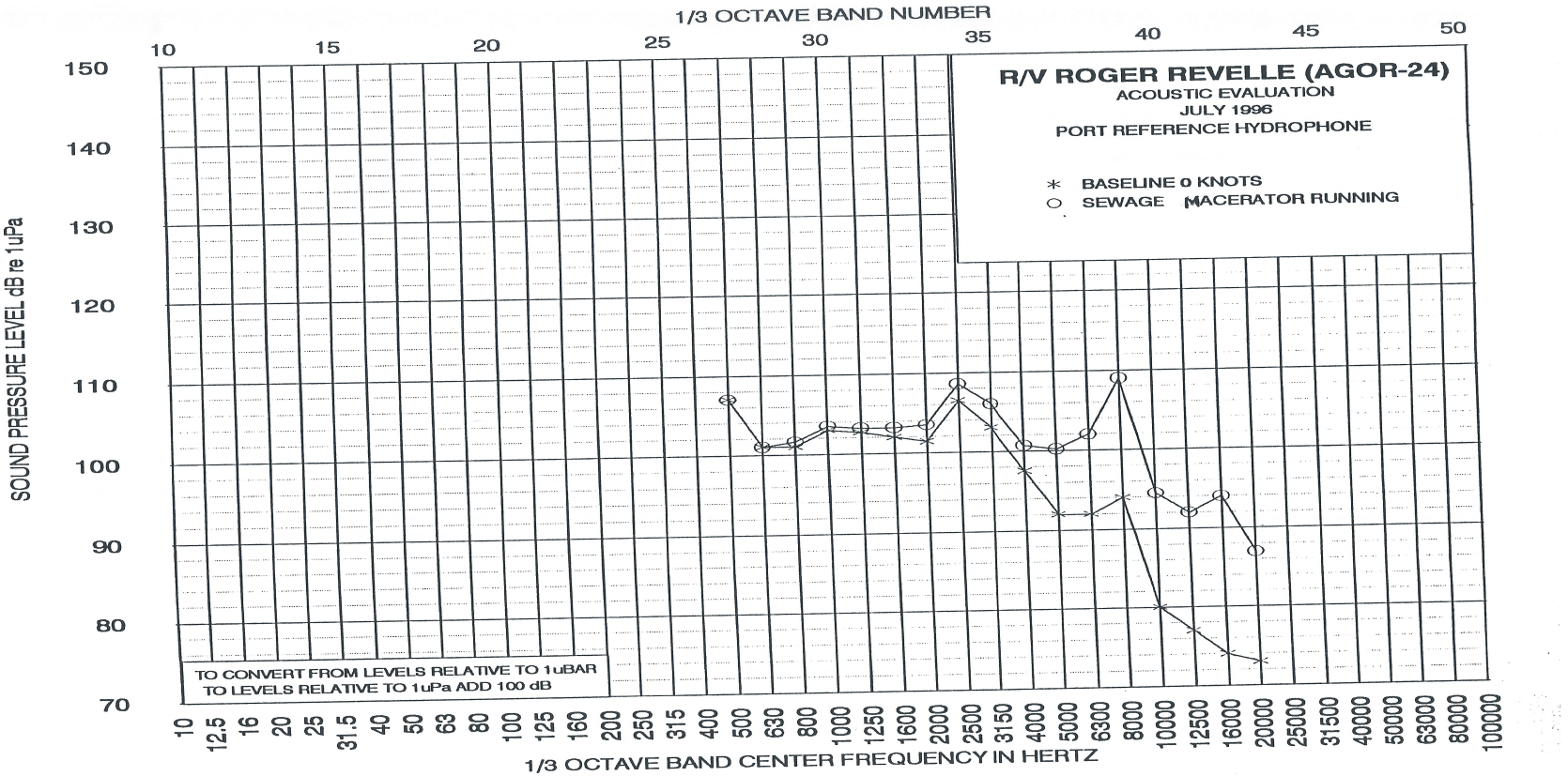
DRAFT

Kilo Moana
Scientific Seawater Pump

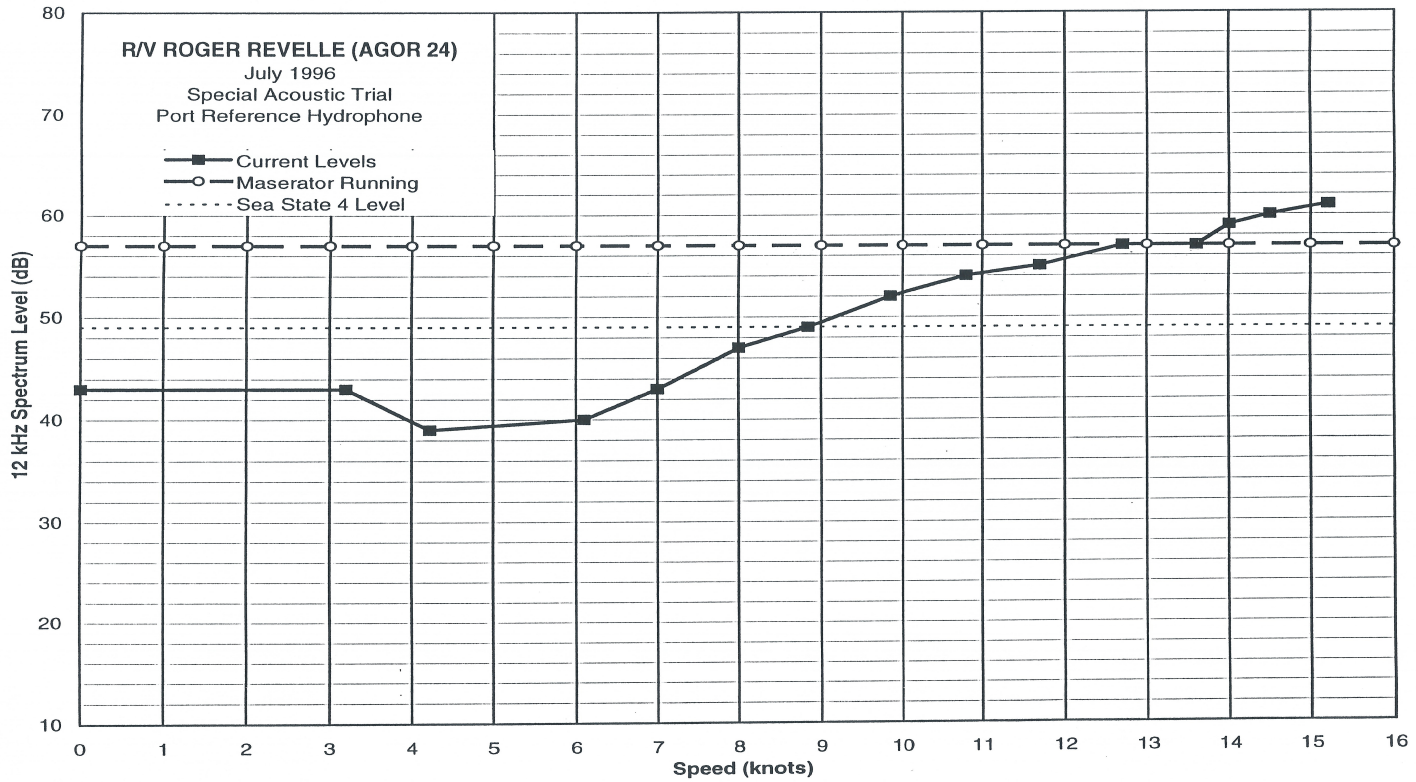


Note: Data converted to Spectrum Level (1 Hz resolution) from 8 Hz resolution data.

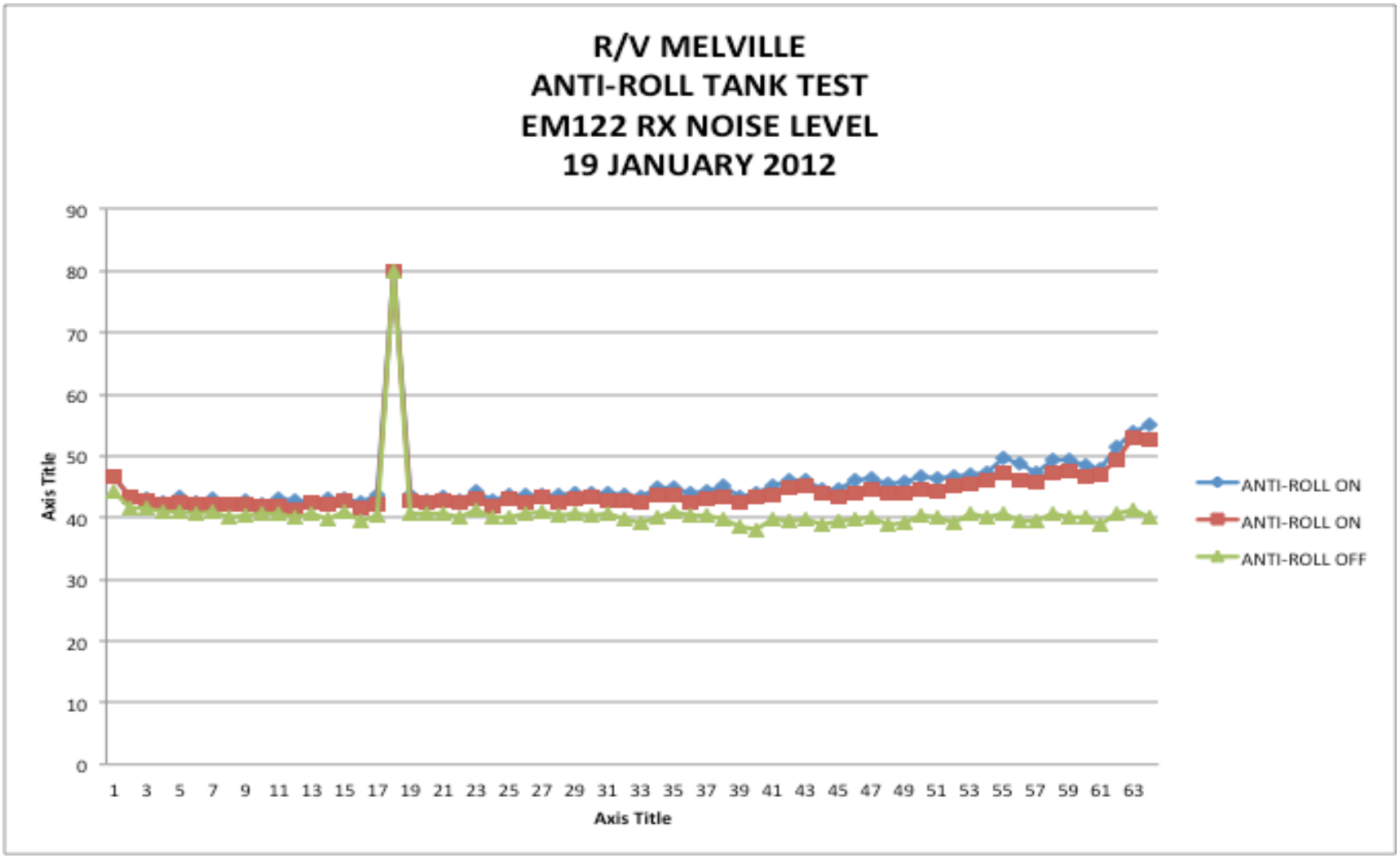
R/V ROGER REVELLE



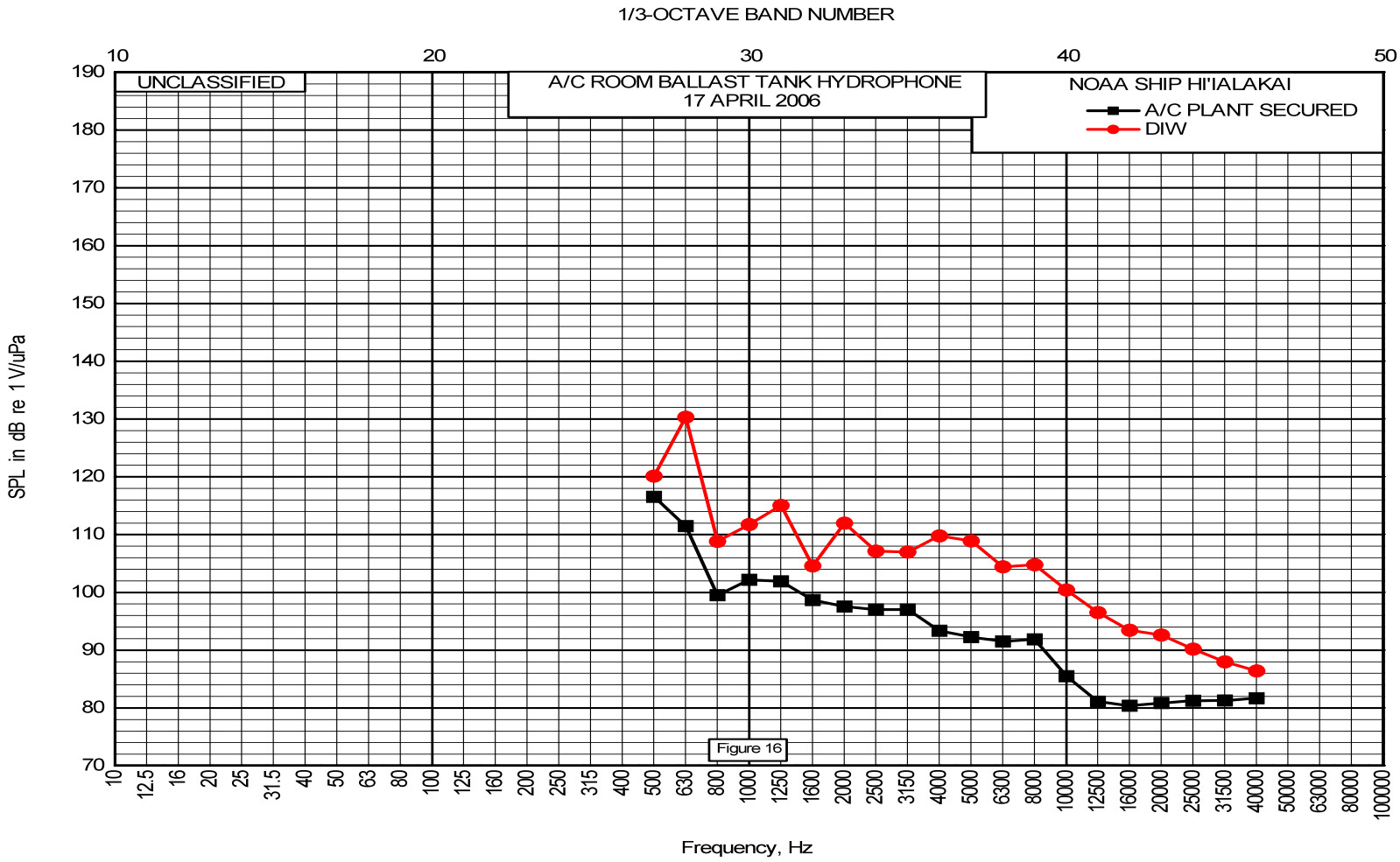
R/V ROGER REVELLE



MELVILLE ANTI-ROLL



HI'IALAKAI
air conditioning problem



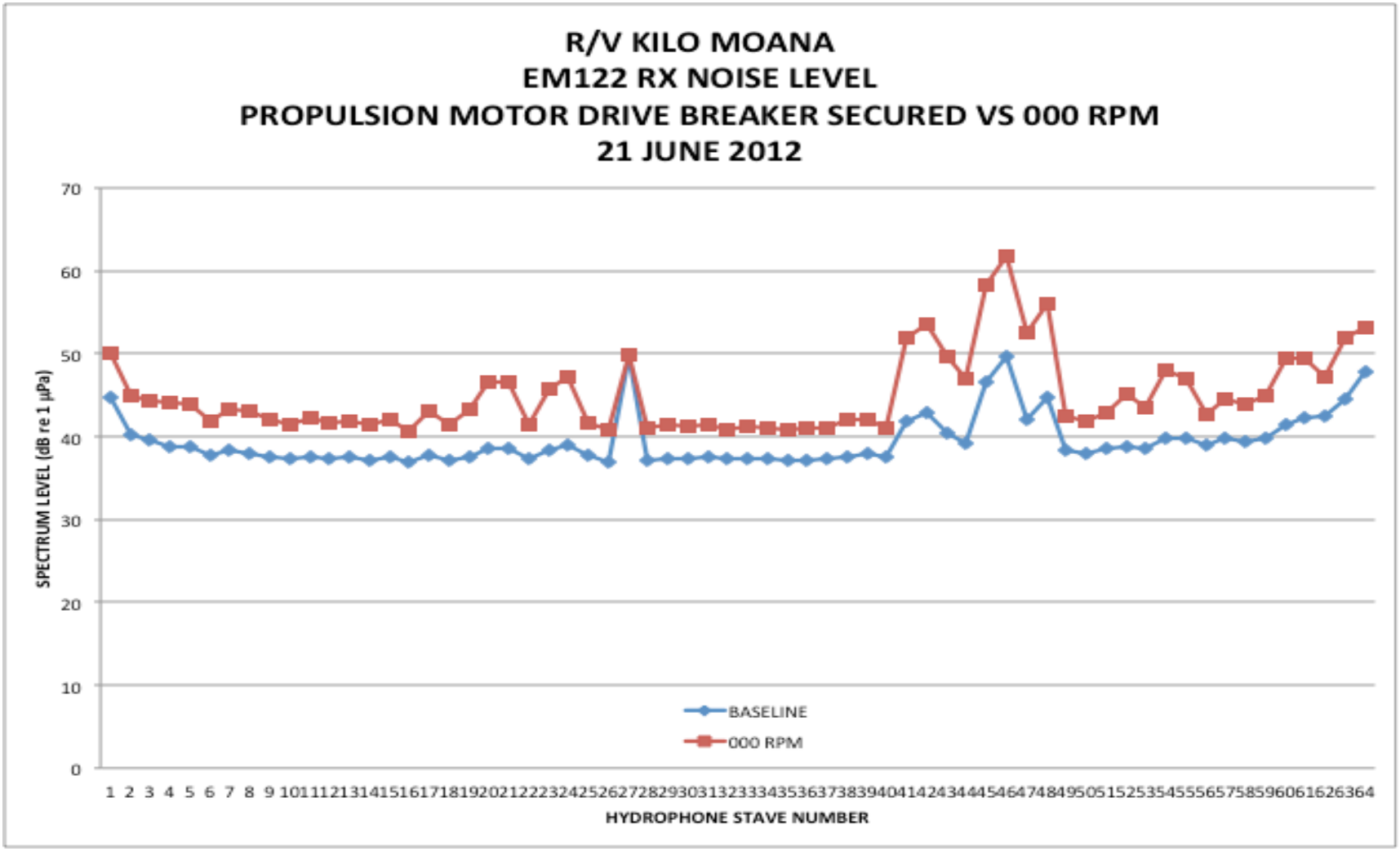
UNCLASSIFIED

UNCLASSIFIED

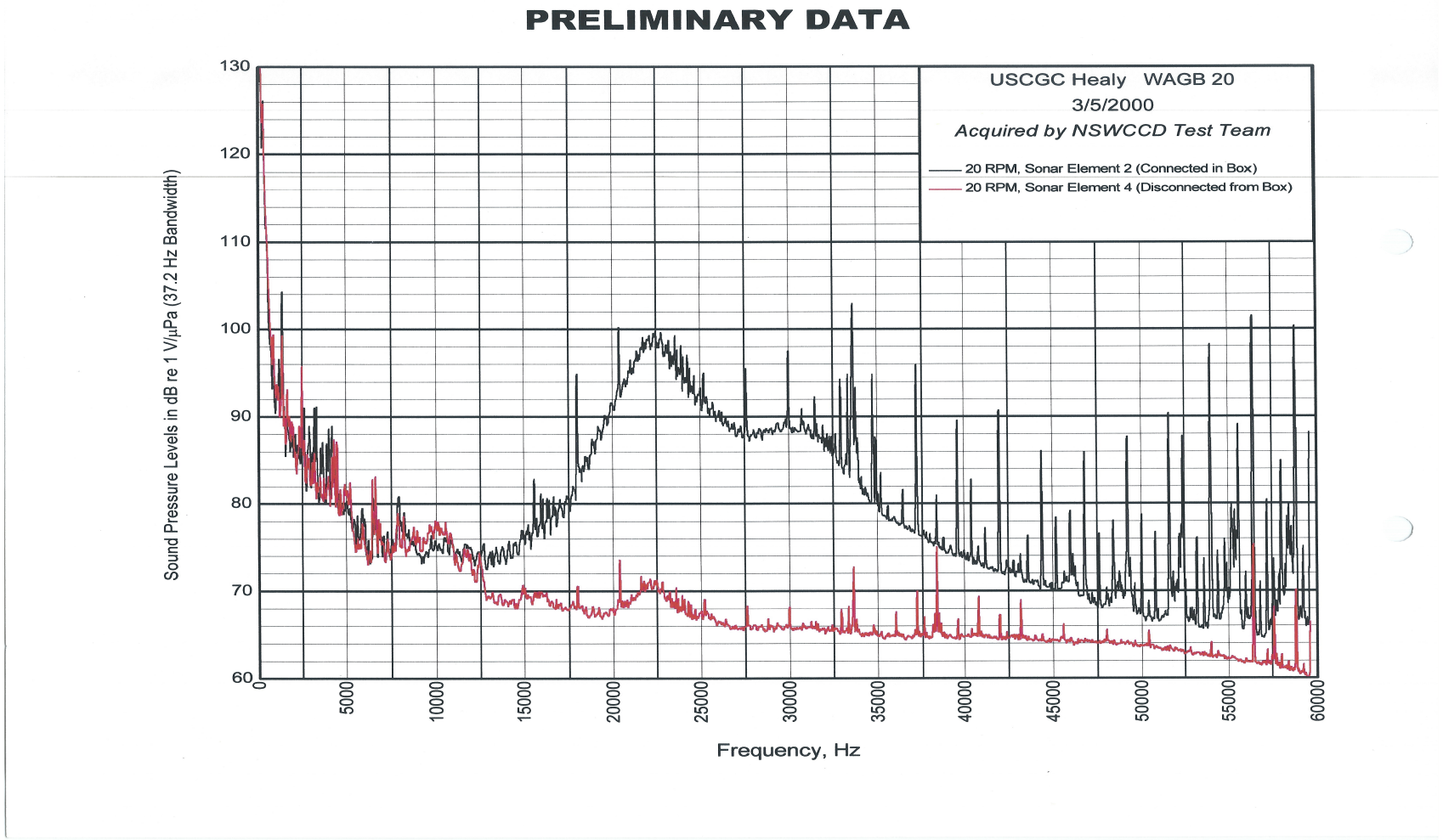
Electronic Noise

- KILO MOANA – Unknown Source
- HEALY – Initial EMI installation
- NAUTILUS – UPS EMI
- REVELLE – Noisy Sonar Rx Array

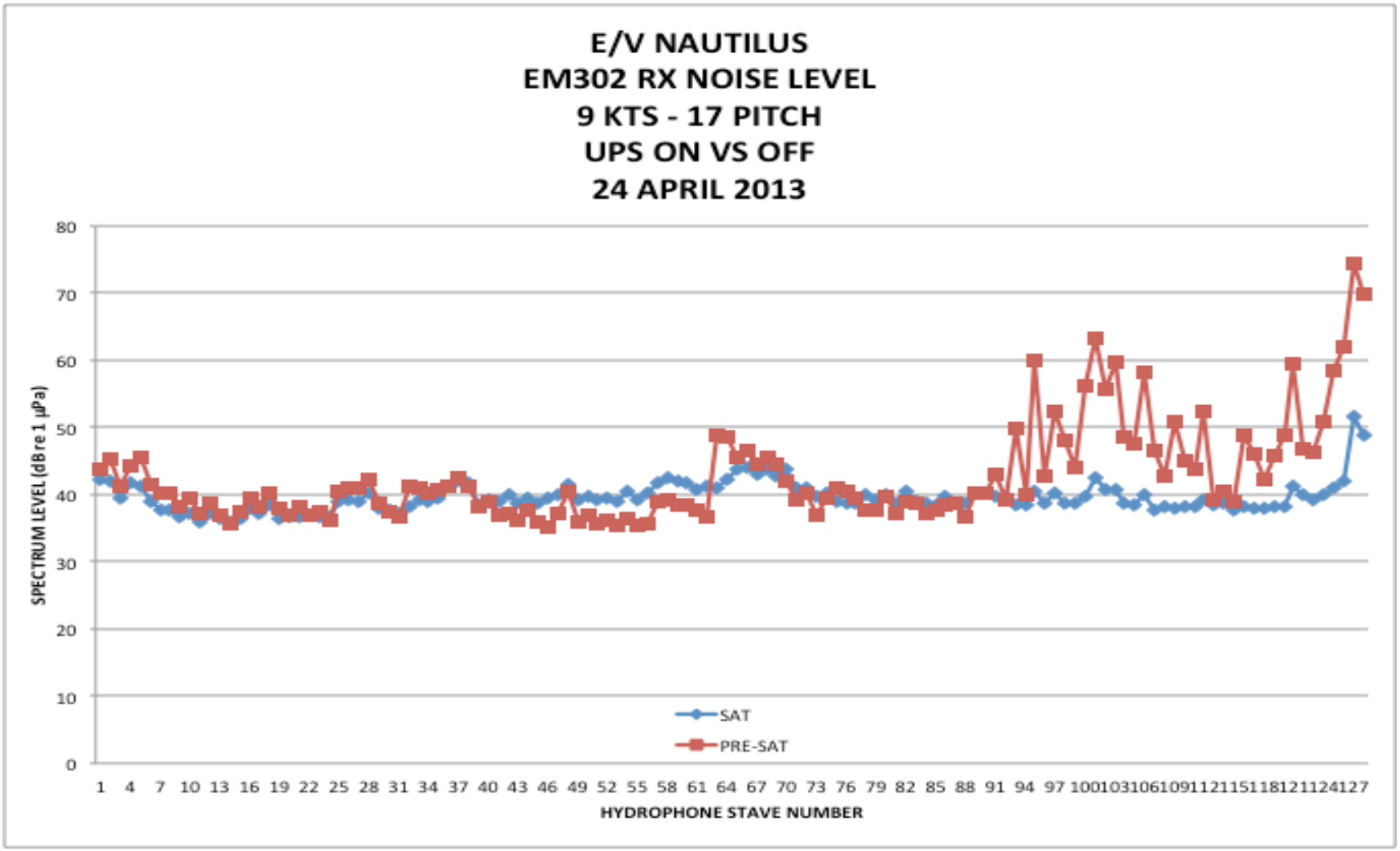
KILO MOANA EMI



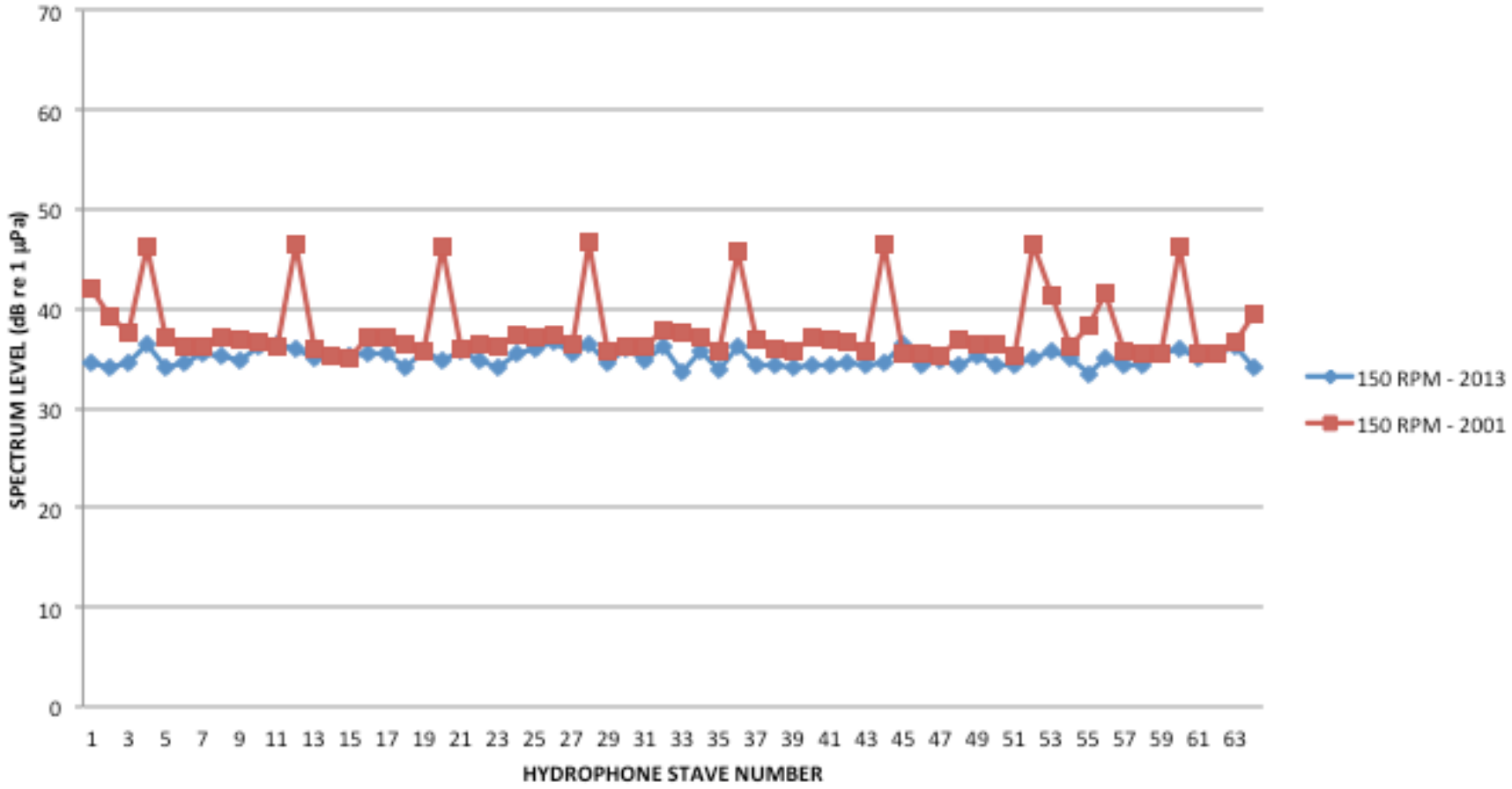
USCGC HEALY EMI



E/V NAUTILUS EMI



R/V ROGER REVELLE
EM 122 RX NOISE LEVEL
150 RPM - 2001 VS 2012
26 JANUARY 2013

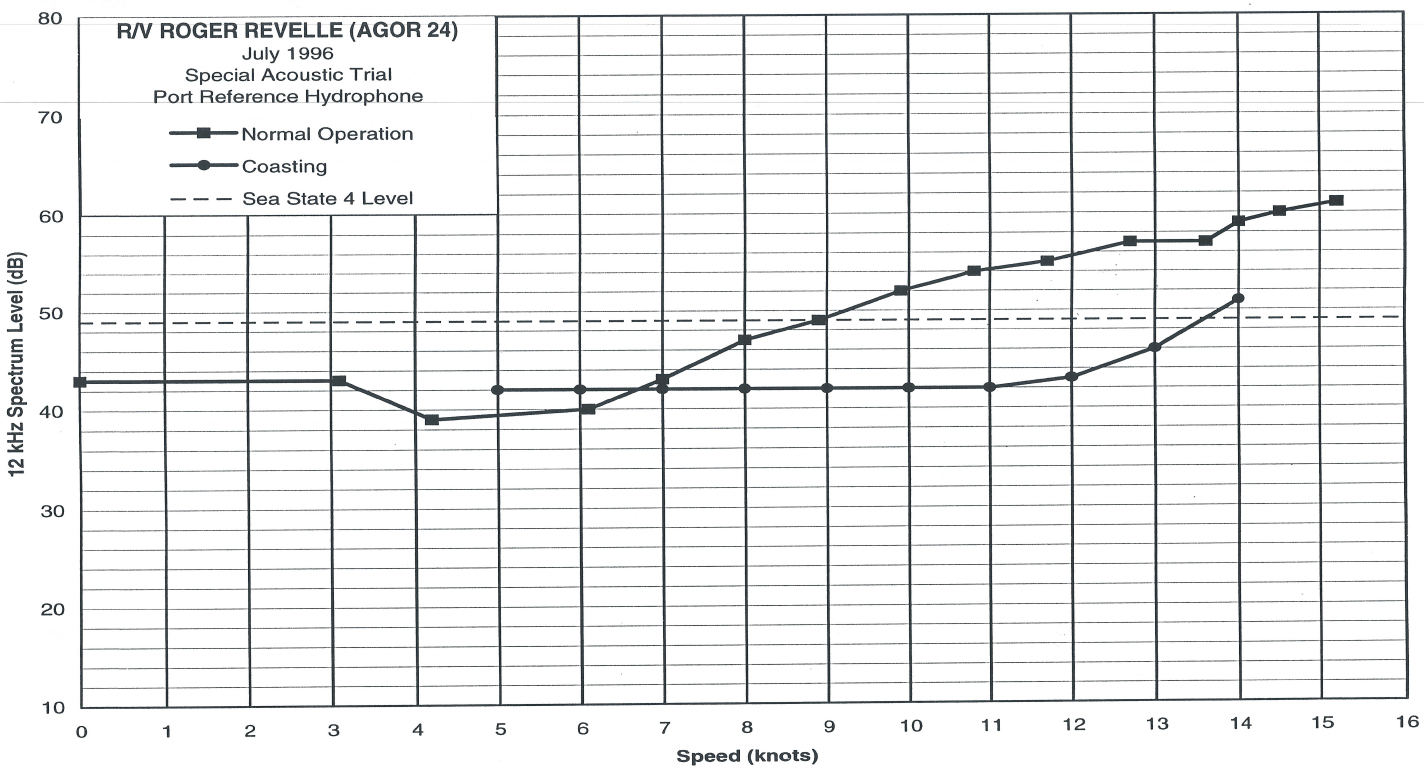


Propeller Noise

- REVELLE – Hub Vortex Cavitation
- TAGS 60 Class – Tip Cavitation
- TAGS 60 – Misalignment picture
- LANGSETH – Tip Cavitation (CPP Propeller)

R/V ROGER REVELLE HUB/TIP CAVITATION

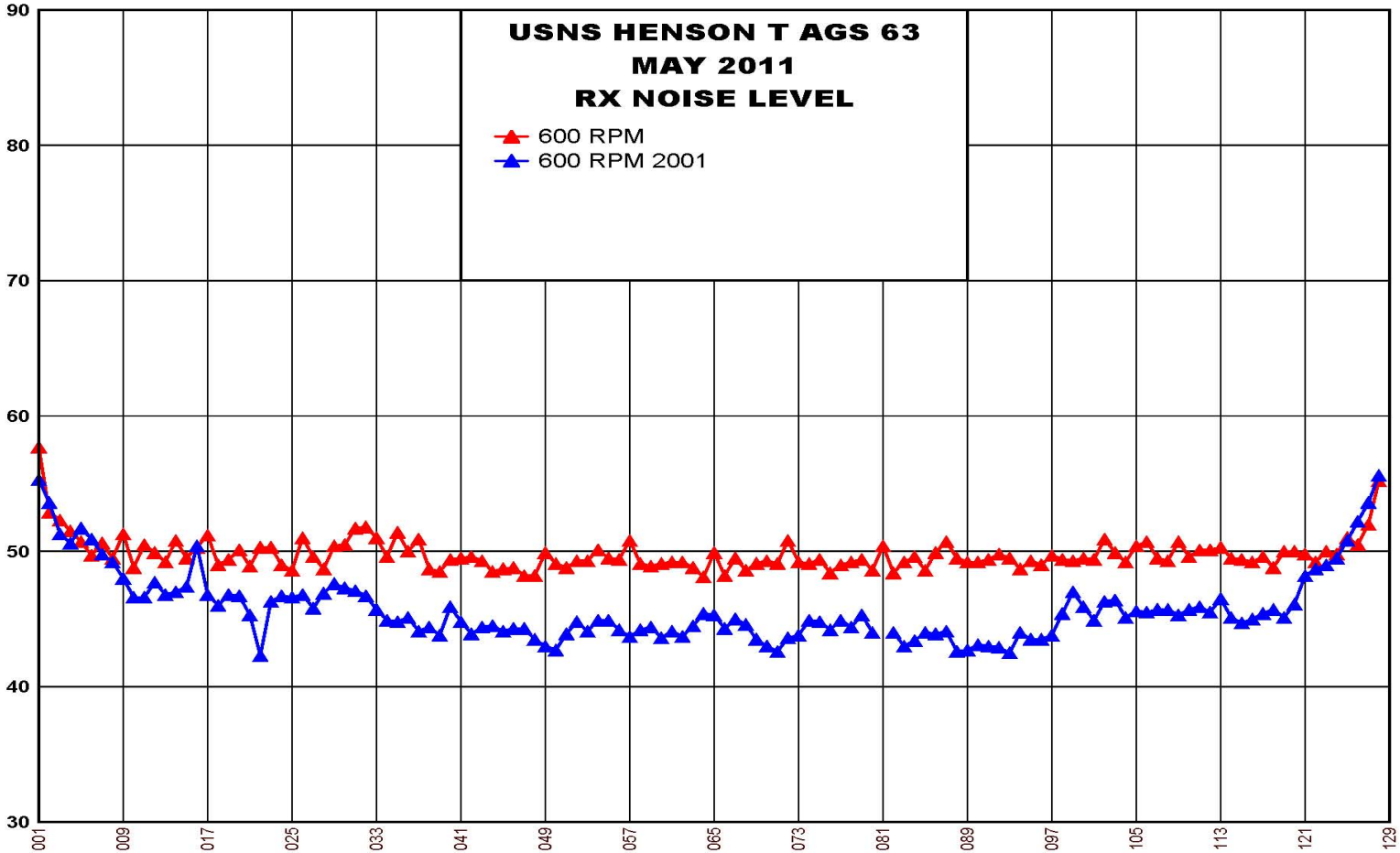
R/V ROGER REVELLE



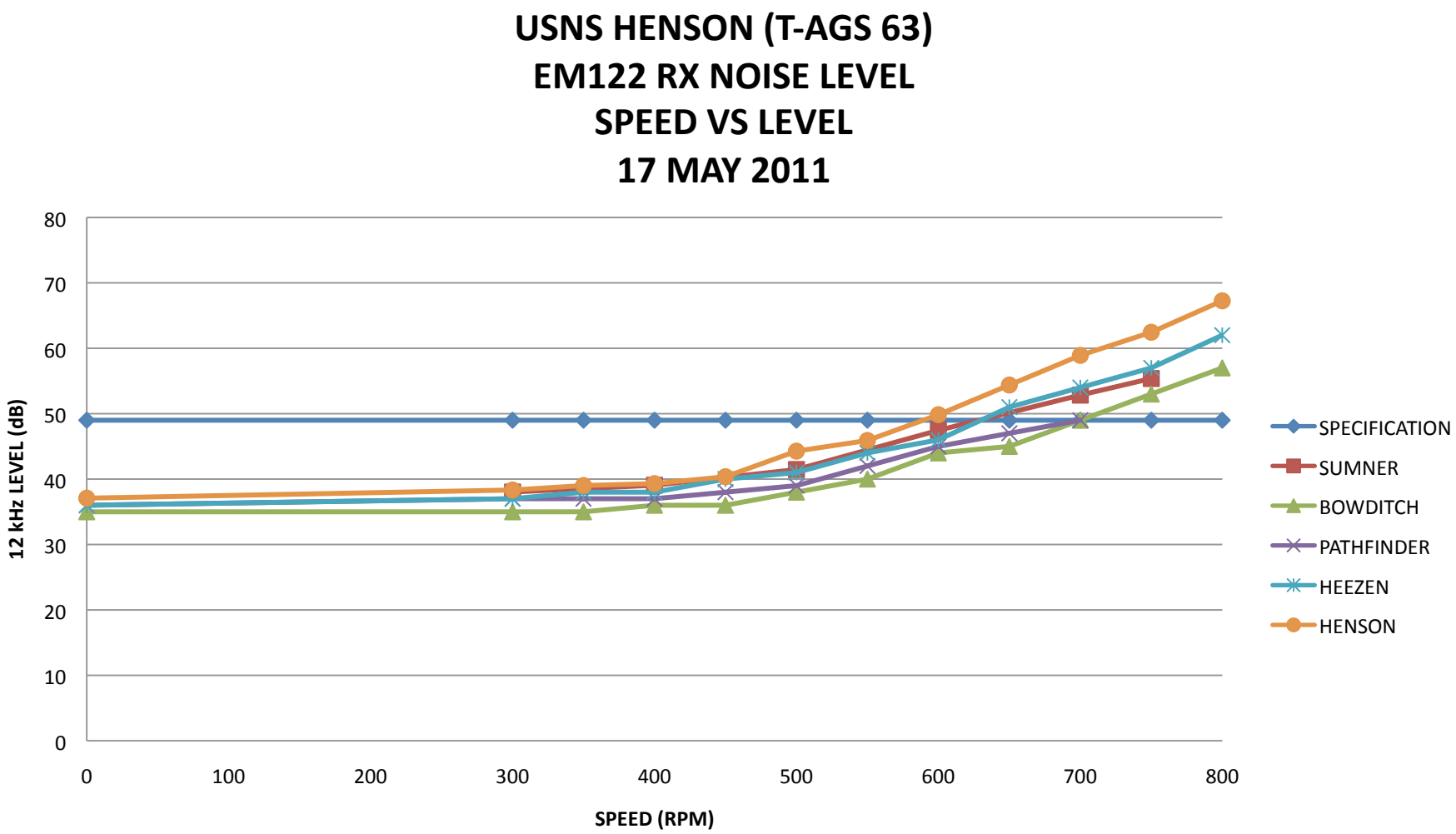
PATHFINDER PROP MISALIGNMENT

USNS PATHFINDER TIP CAVITATION

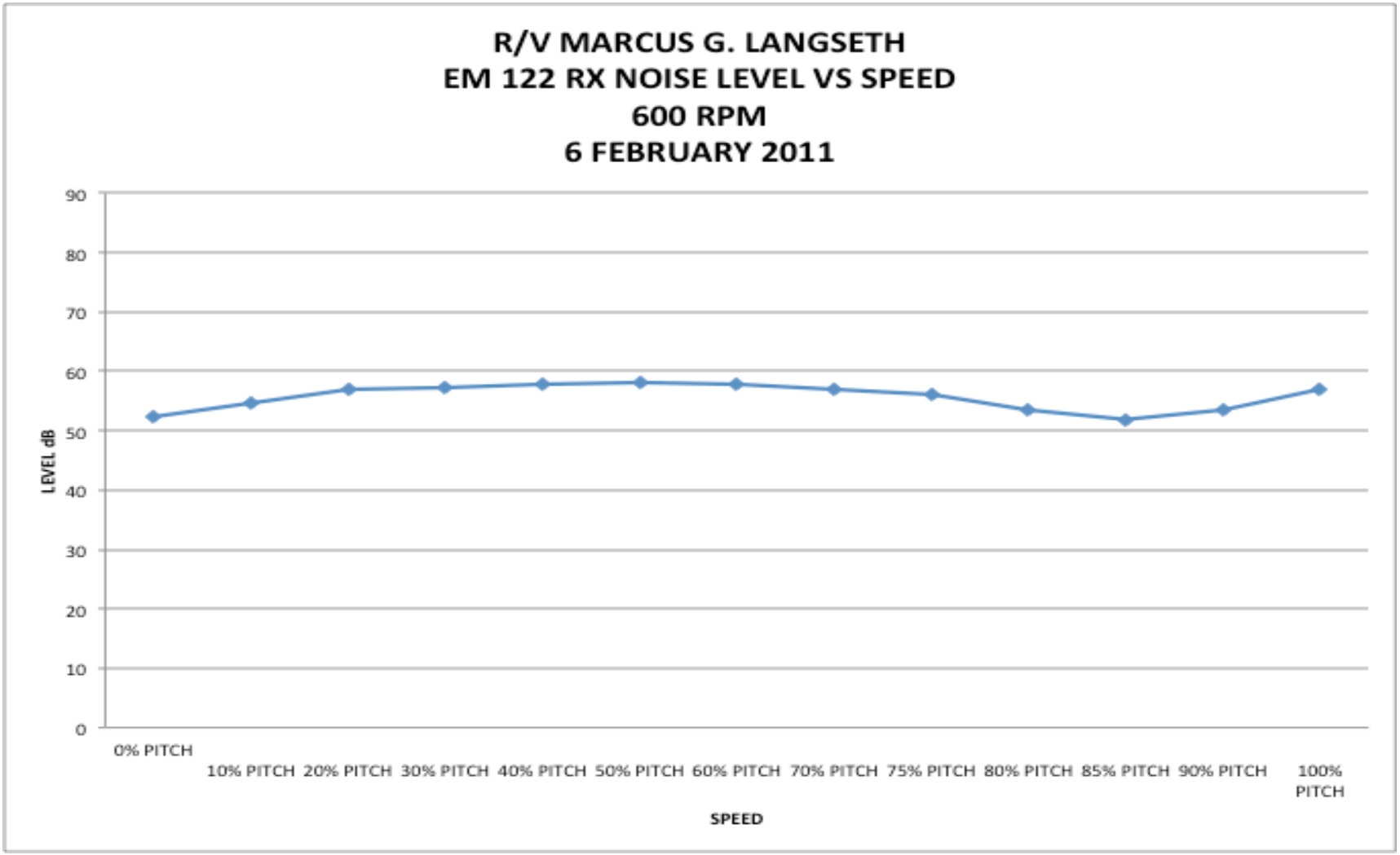
HENSON PROP CAV



HENSON VS T-AGS 60 CLASS



R/V MARCUS G. LANGSETH PROPELLER CAVITATION

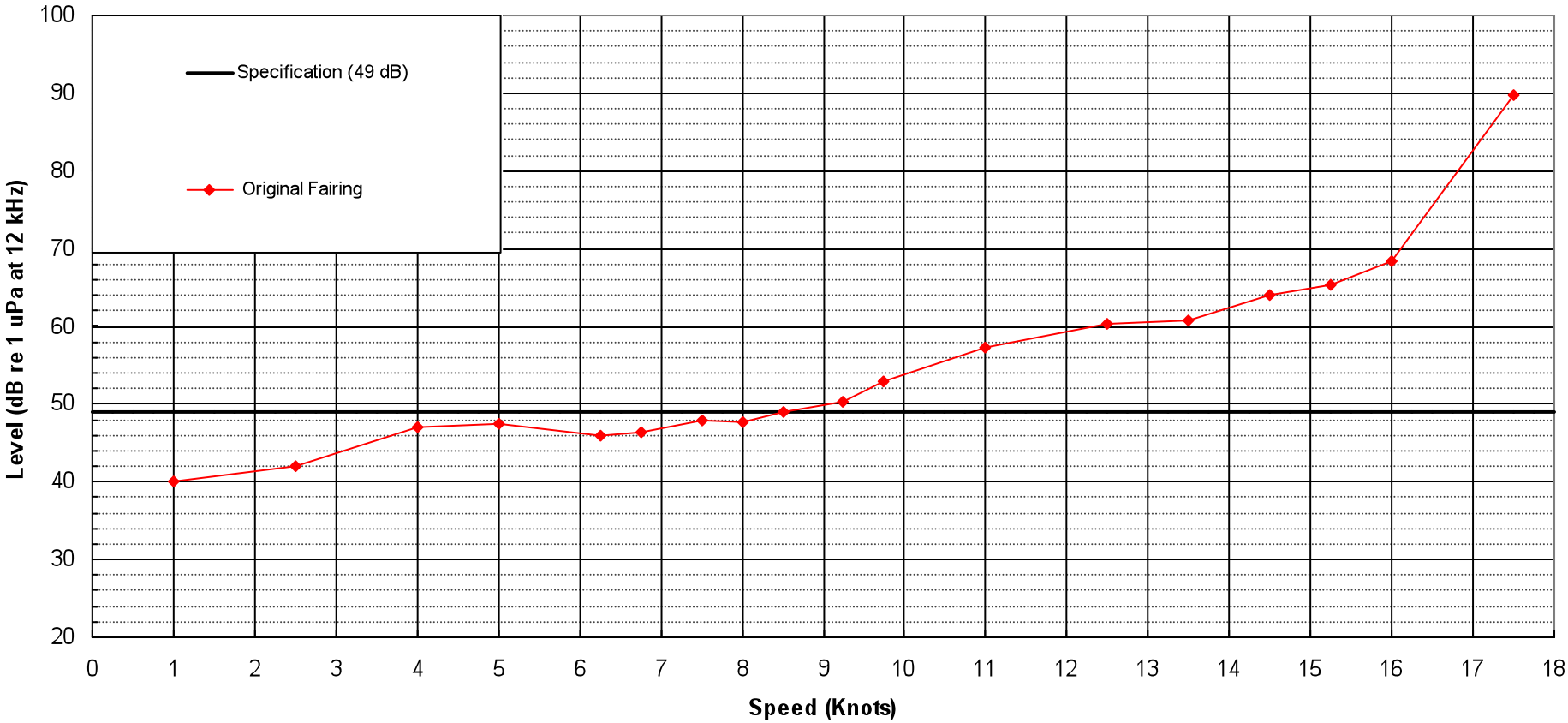


Hydrodynamic Flow Noise

- TAGS 60 Class – Sonar Fairing
- TAGS 60 (HEEZEN) – Biologic Fouling
- TAGS 60 paint

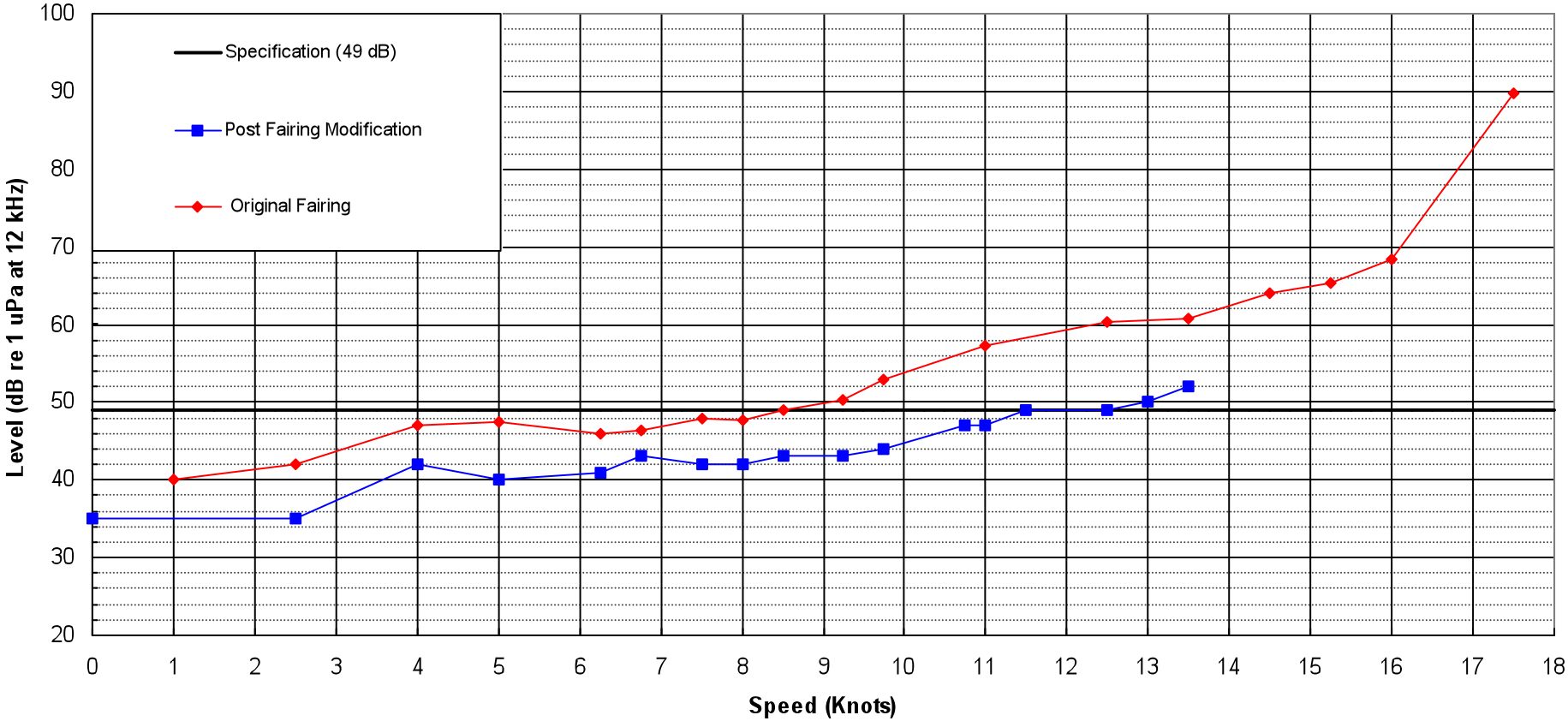
PATHFINDER ORIGINAL SONAR FAIRING

Original PATHFINDER Levels



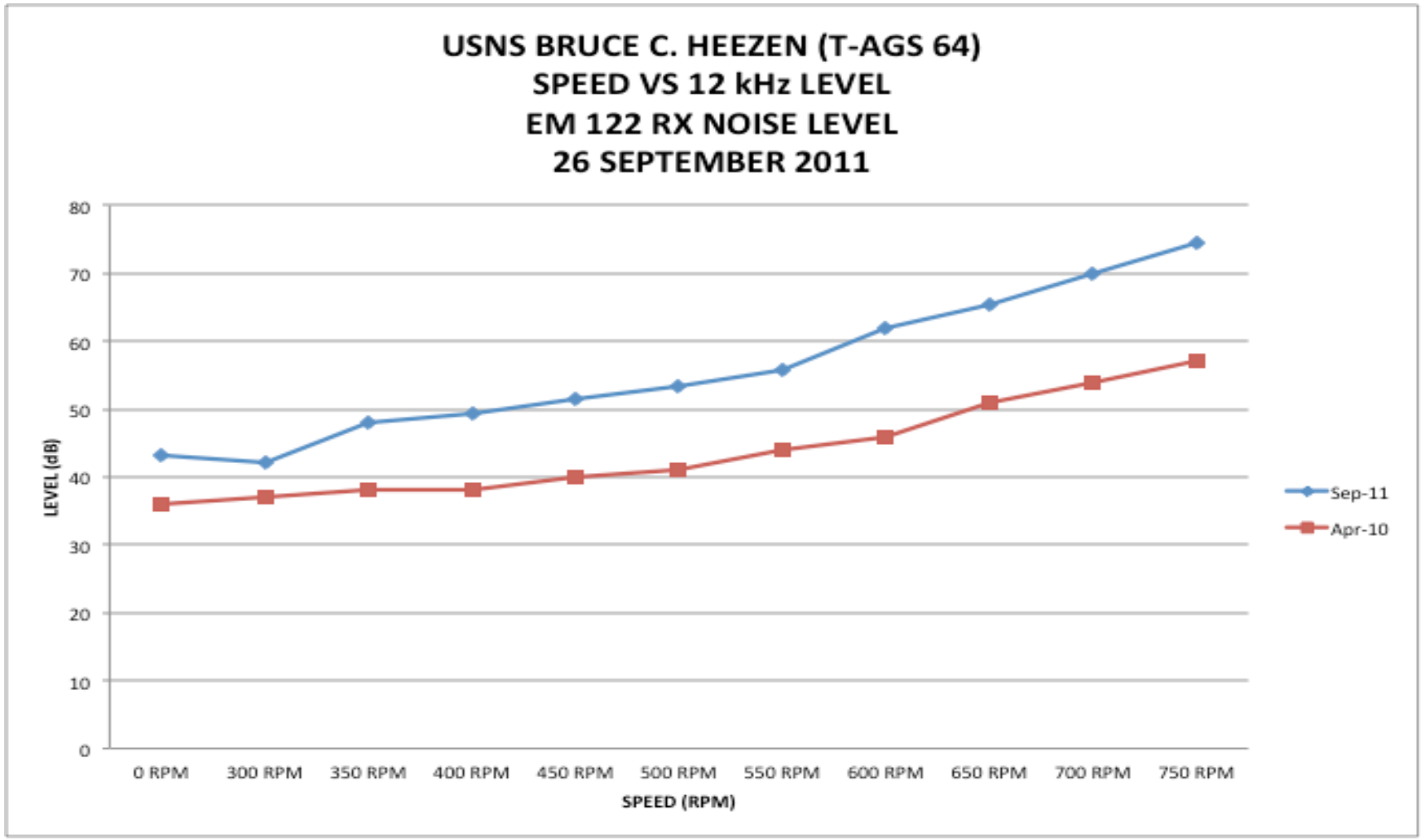
NEW SONAR FAIRING

PATHFINDER
With New Fairing

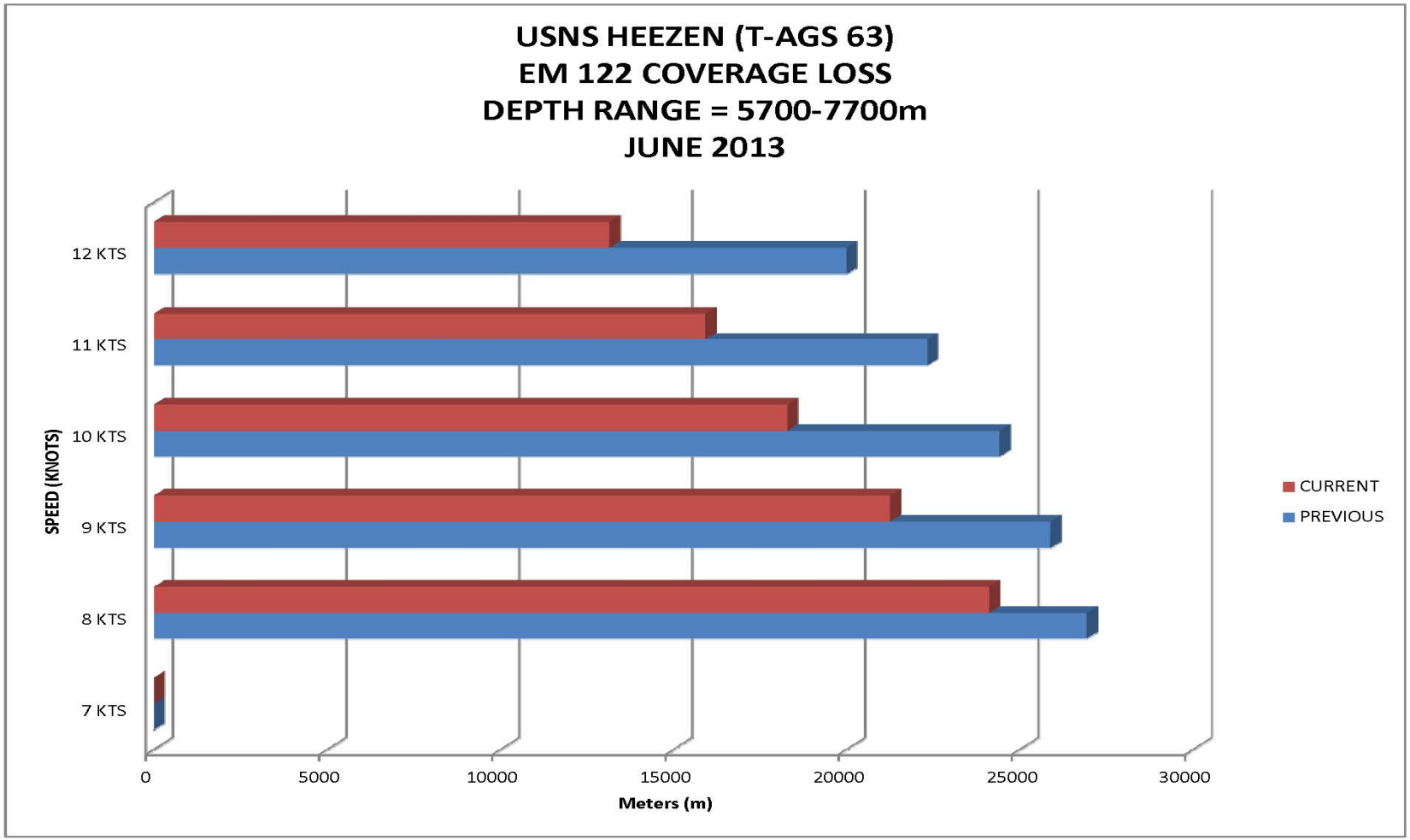


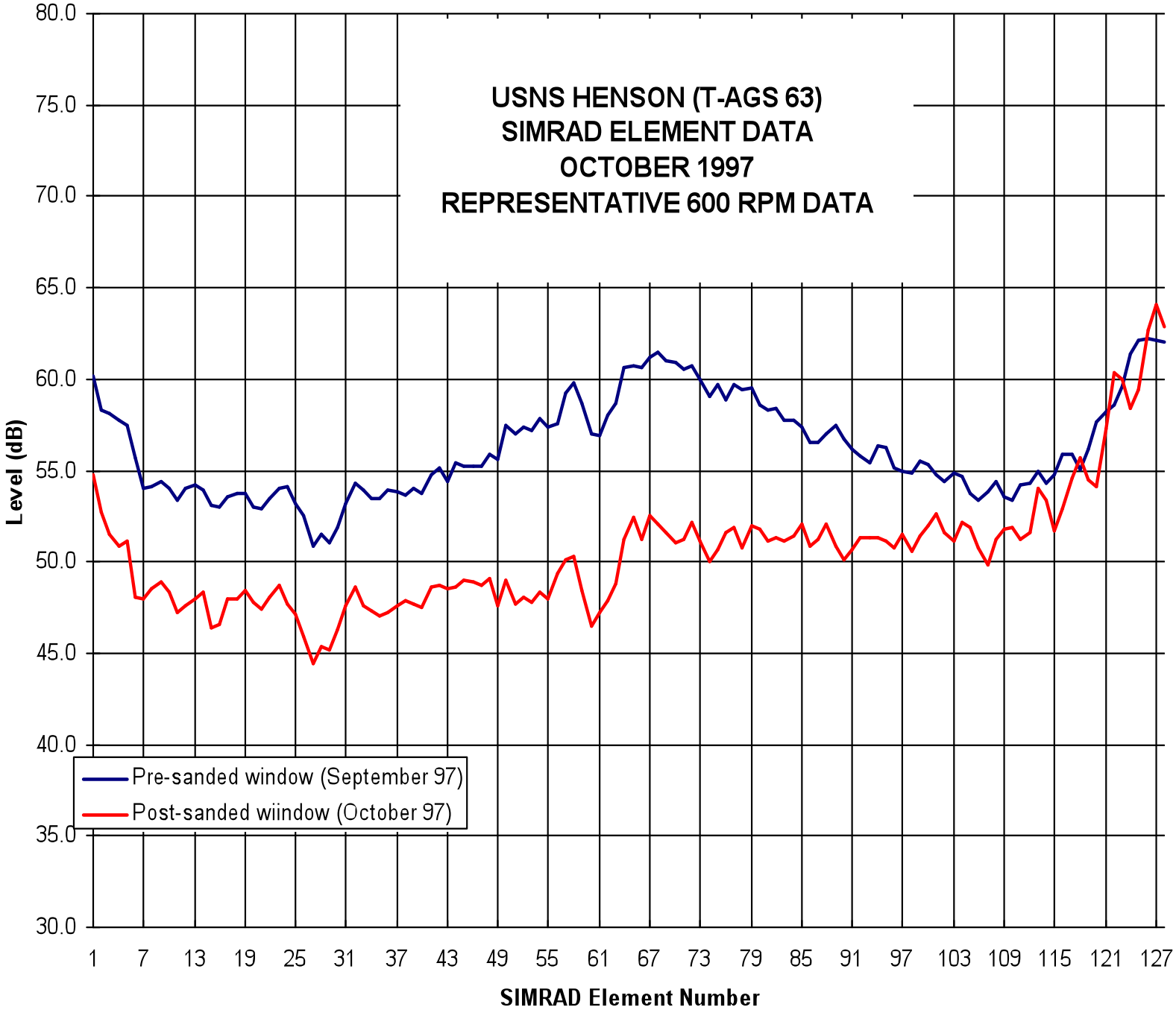
BIOLOGICAL FOULING
MULTIBEAM RECEIVE ARRAY

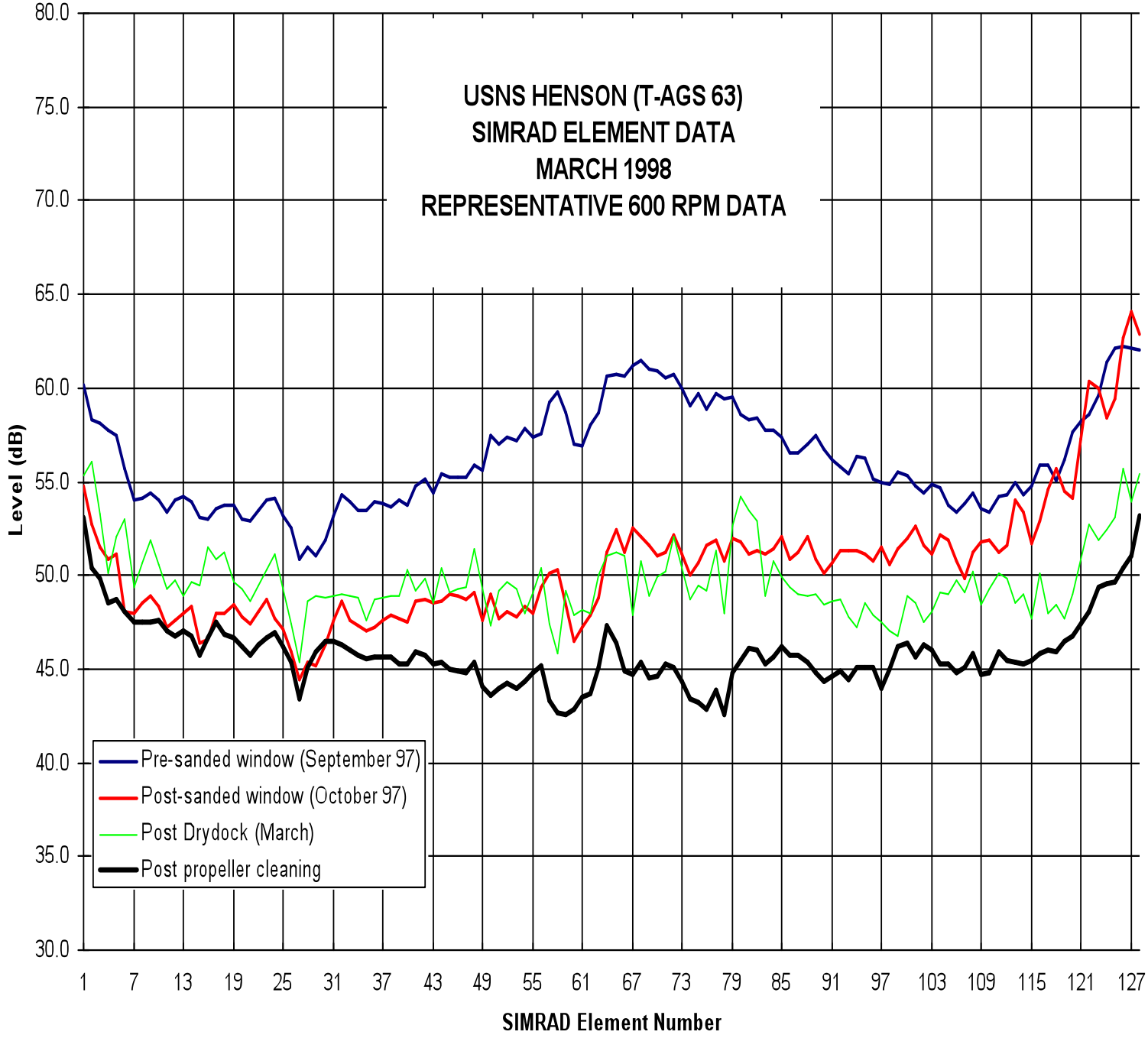
BIOLOGICAL FOULLING TRANSDUCER FACING


USNS BRUCE C. HEEZEN (T-AGS 64)
SPEED VS 12 kHz LEVEL
EM 122 RX NOISE LEVEL
26 SEPTEMBER 2011
LEVEL (dB)
80
70
60
50
40
30
20
10
0
0 RPM
300 RPM
350 RPM
400 RPM
450 RPM
500 RPM
550 RPM
600 RPM
650 RPM
700 RPM
750 RPM
SPEED (RPM)
Sep-11
Apr-10

REDUCTION IN SWATH COVERAGE DUE TO ACOUSTIC NOISE



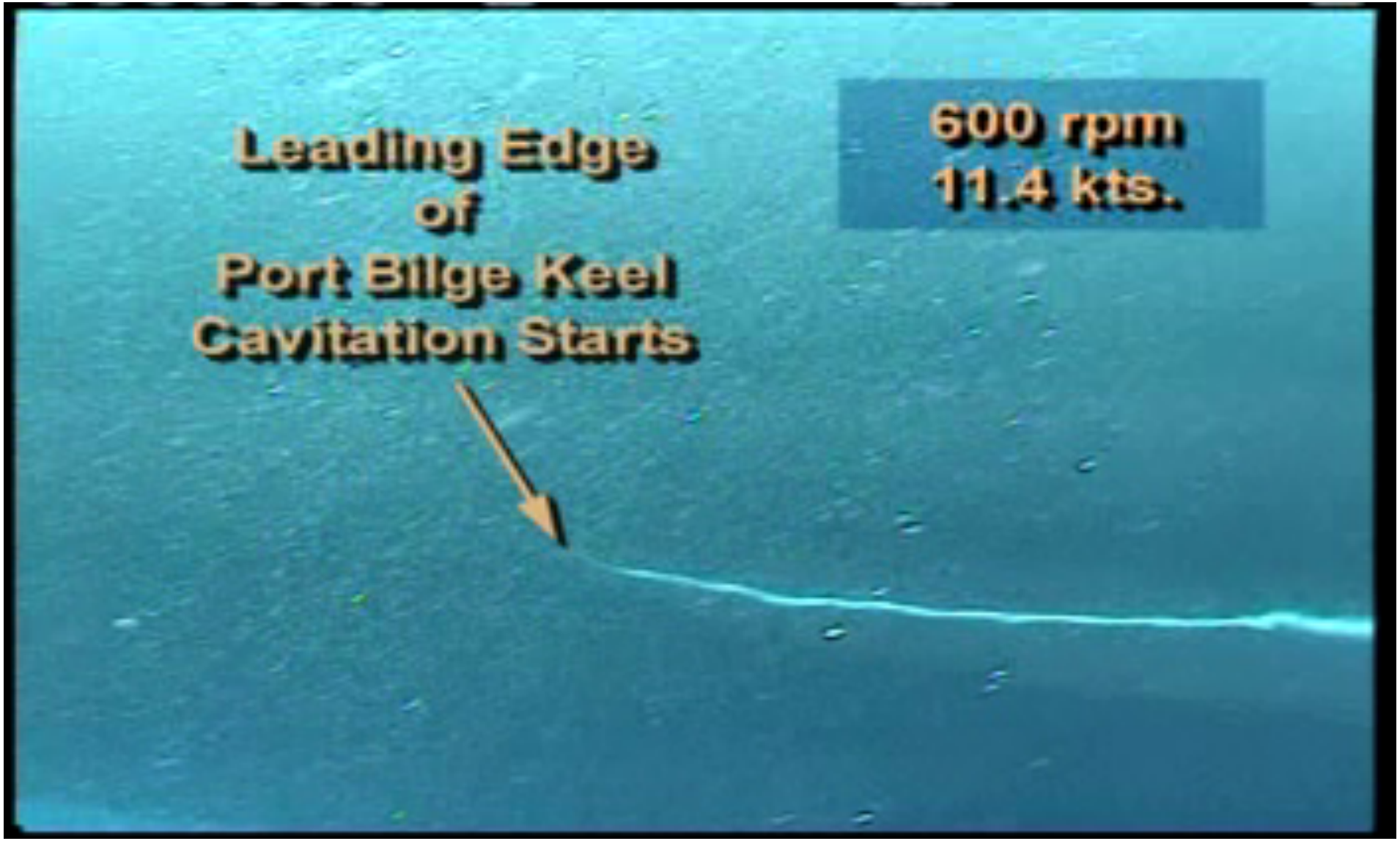

USNS HENSON (T-AGS 63)
SIMRAD ELEMENT DATA
OCTOBER 1997
REPRESENTATIVE 600 RPM DATA
Level (dB)
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
1
7
13
19
25
31
37
43
49
55
61
67
73
79
85
91
97
103
109
115
121
127
SIMRAD Element Number
Pre-sanded window (September 97)
Post-sanded wiindow (October 97)


USNS HENSON (T-AGS 63)
SIMRAD ELEMENT DATA
MARCH 1998
REPRESENTATIVE 600 RPM DATA
Level (dB)
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
1
7
13
19
25
31
37
43
49
55
61
67
73
79
85
91
97
103
109
115
121
127
SIMRAD Element Number
Pre-sanded window (September 97)
Post-sanded window (October 97)
Post Drydock (March)
Post propeller cleaning

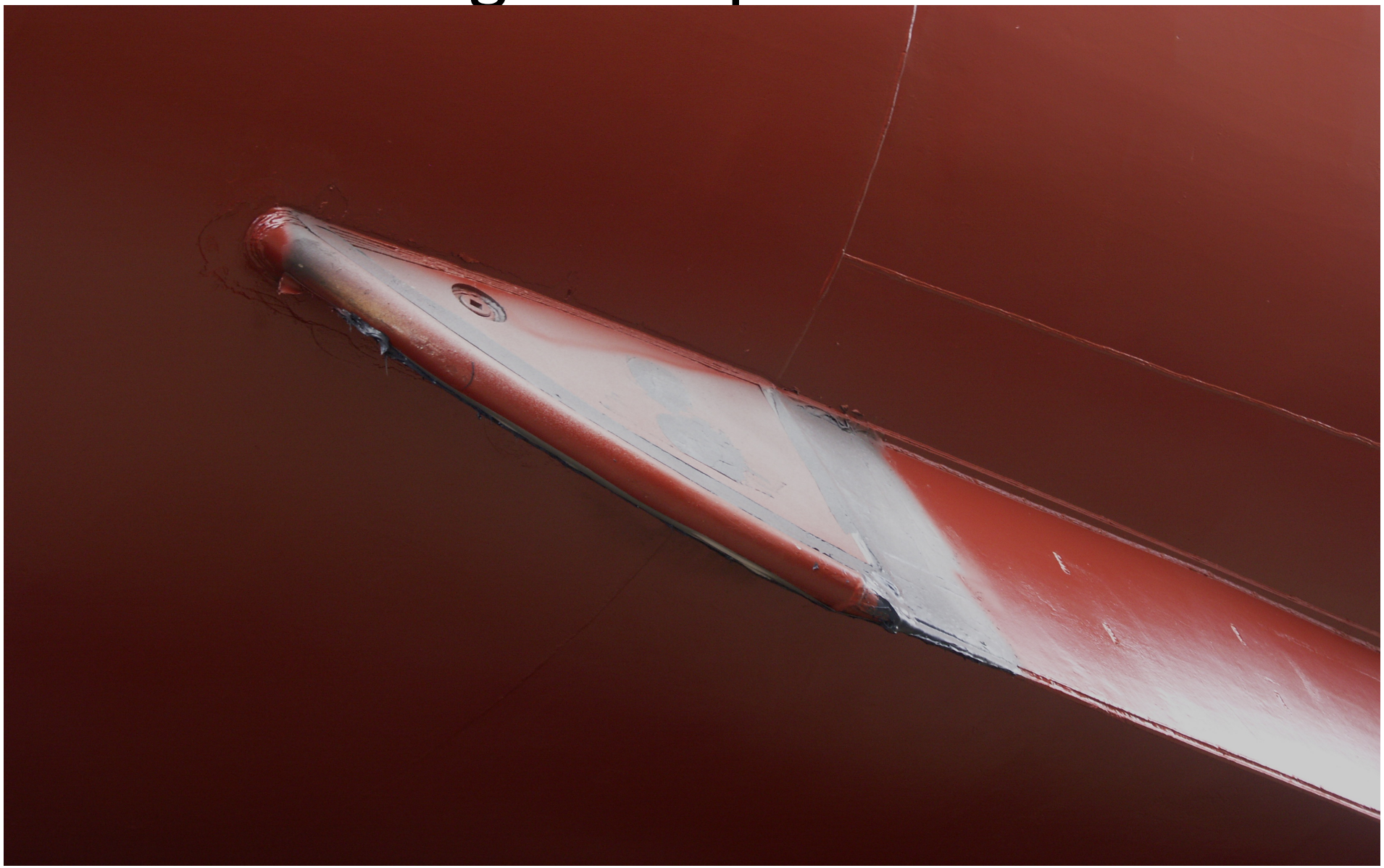
Appendage Cavitation

- TAGS 60 Class – Bilge Keels
- TAGS 60 Class – Auxiliary Sonar Fairing
- ATLANTIS – Multibeam Sonar Fairing
- BEAUTEMPS BEAUPRE – Multibeam Sonar Fairing

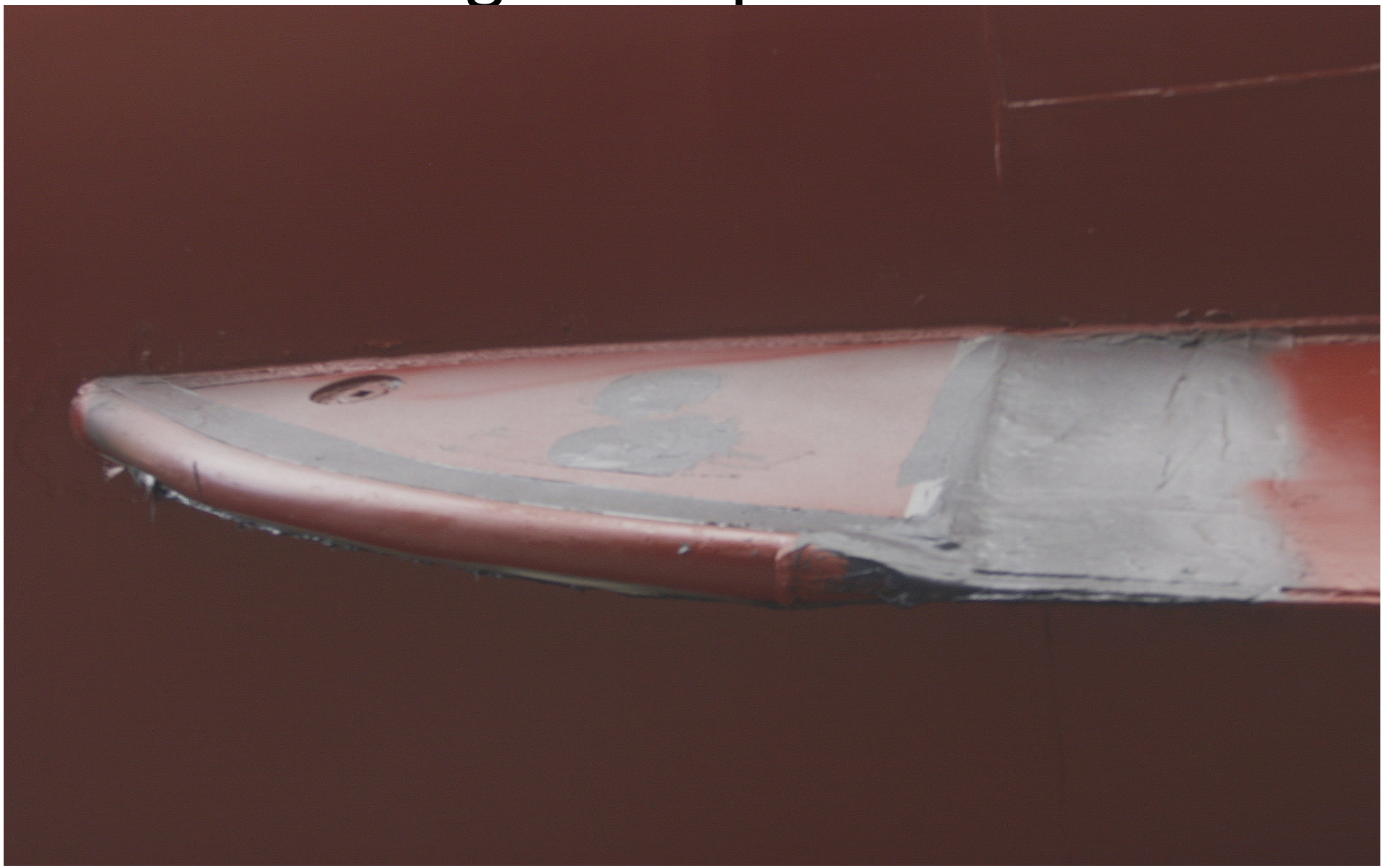
Bilge Keel transient



Bilge keel pictures



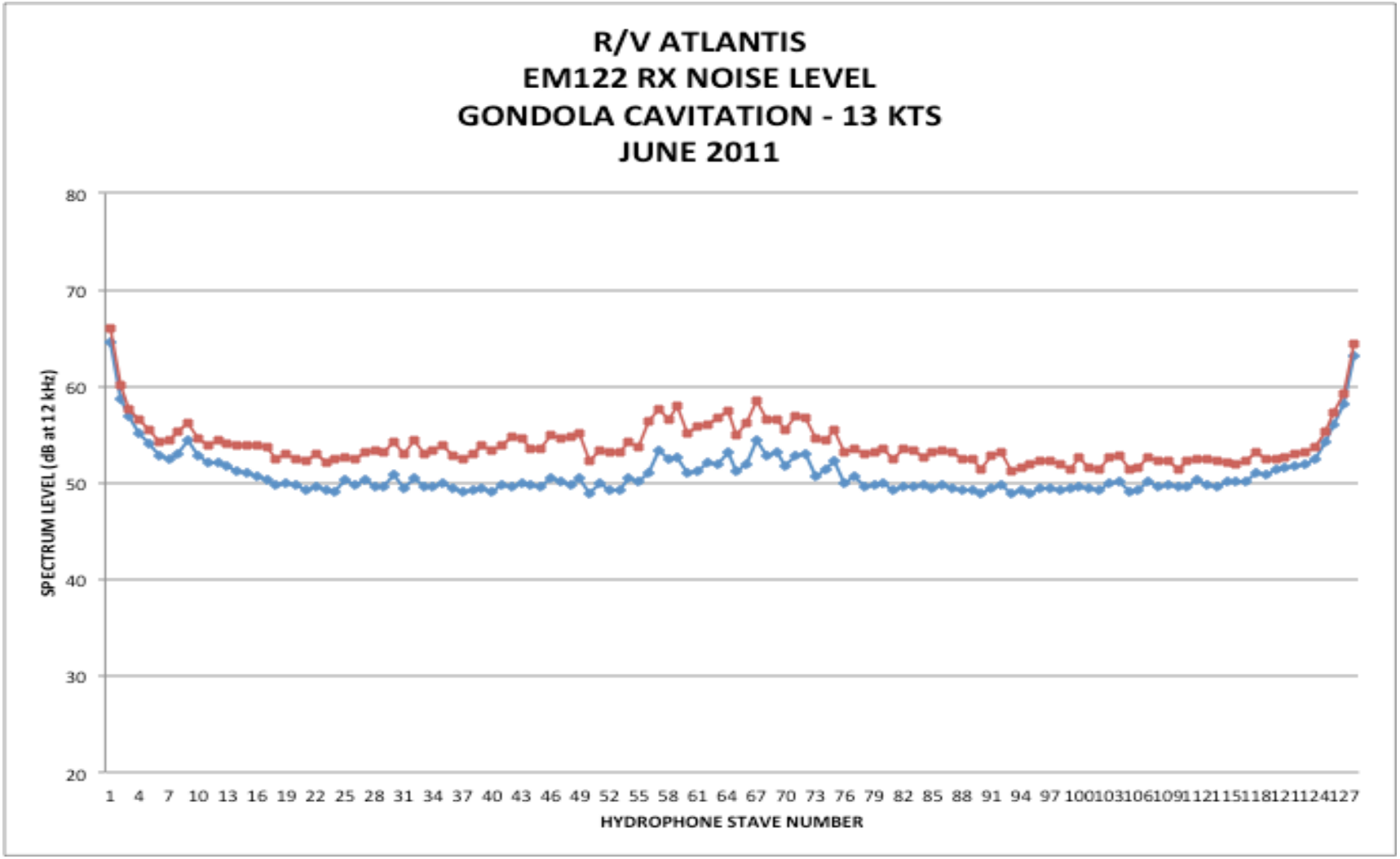
Bilge Keel pictures



Original Transducer Pod

Re-designed Transducer Pod

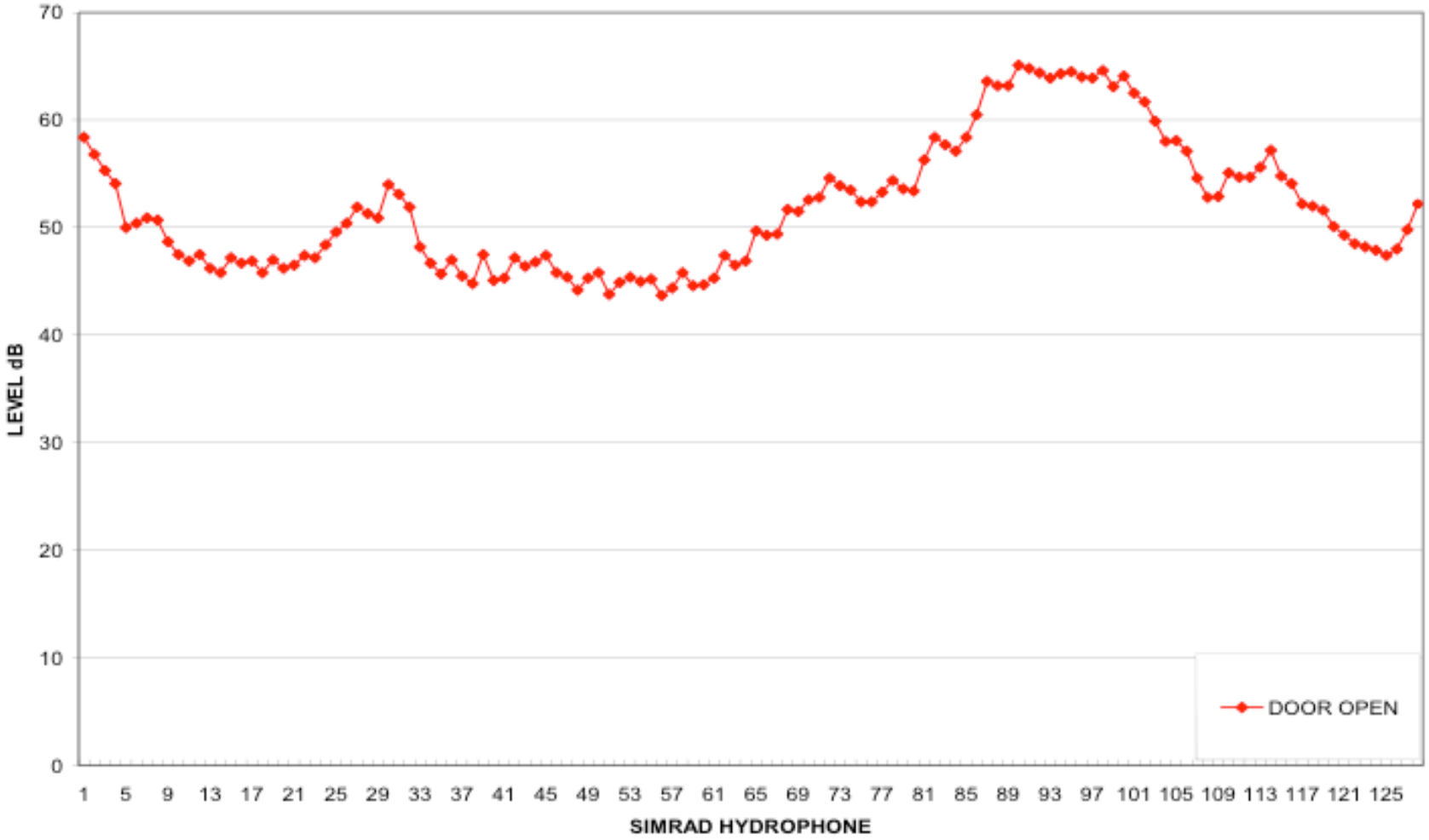
R/V ATLANTIS EM122 RX NOISE LEVEL



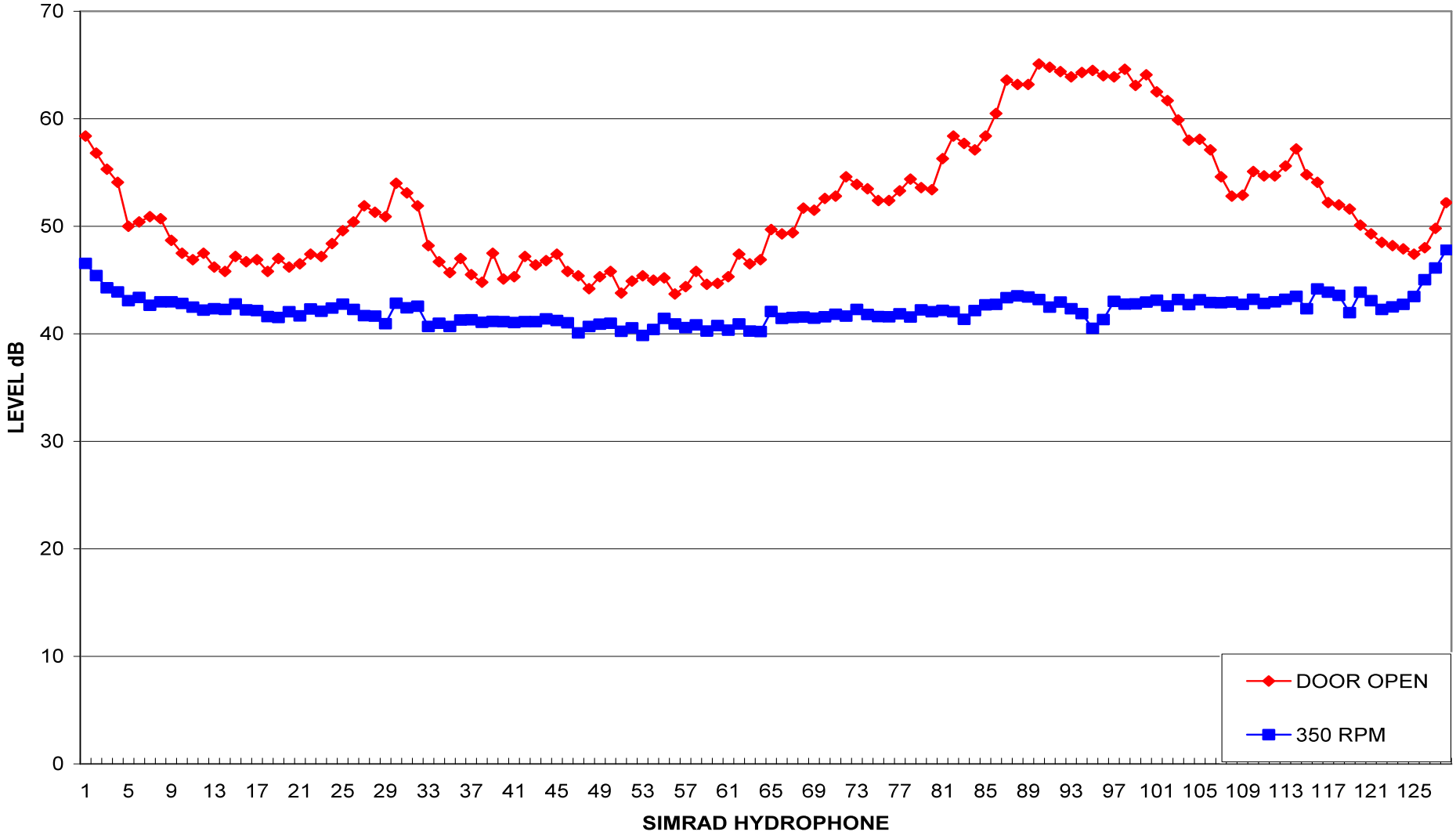
Transients

- TAGS 60 (SEARS) – Unsecured Door
- OKEANOS EXPLORER – Unknown Transient
- T-AGS 60 CLASS – Gondola Rattle

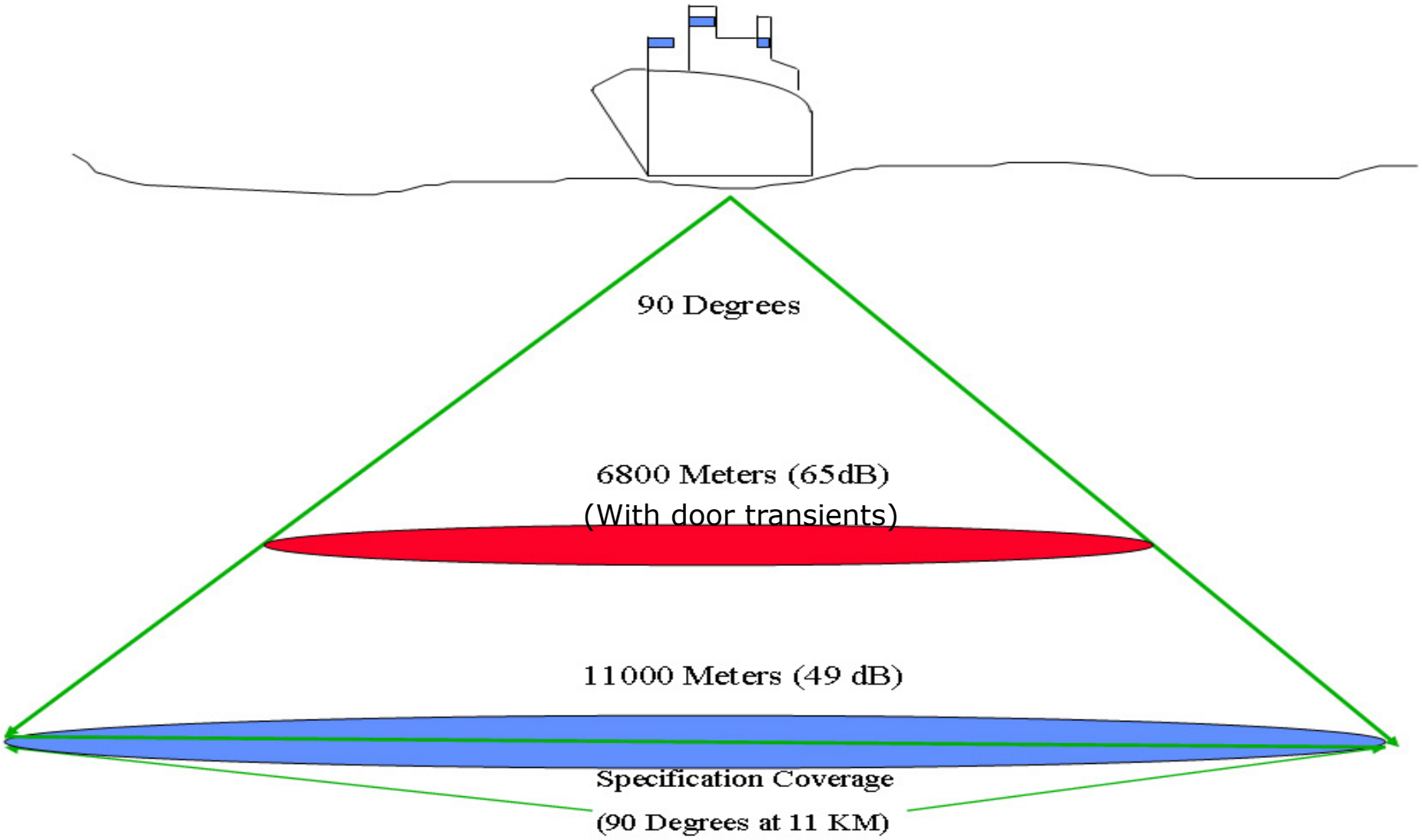
MARY SEARS DOOR



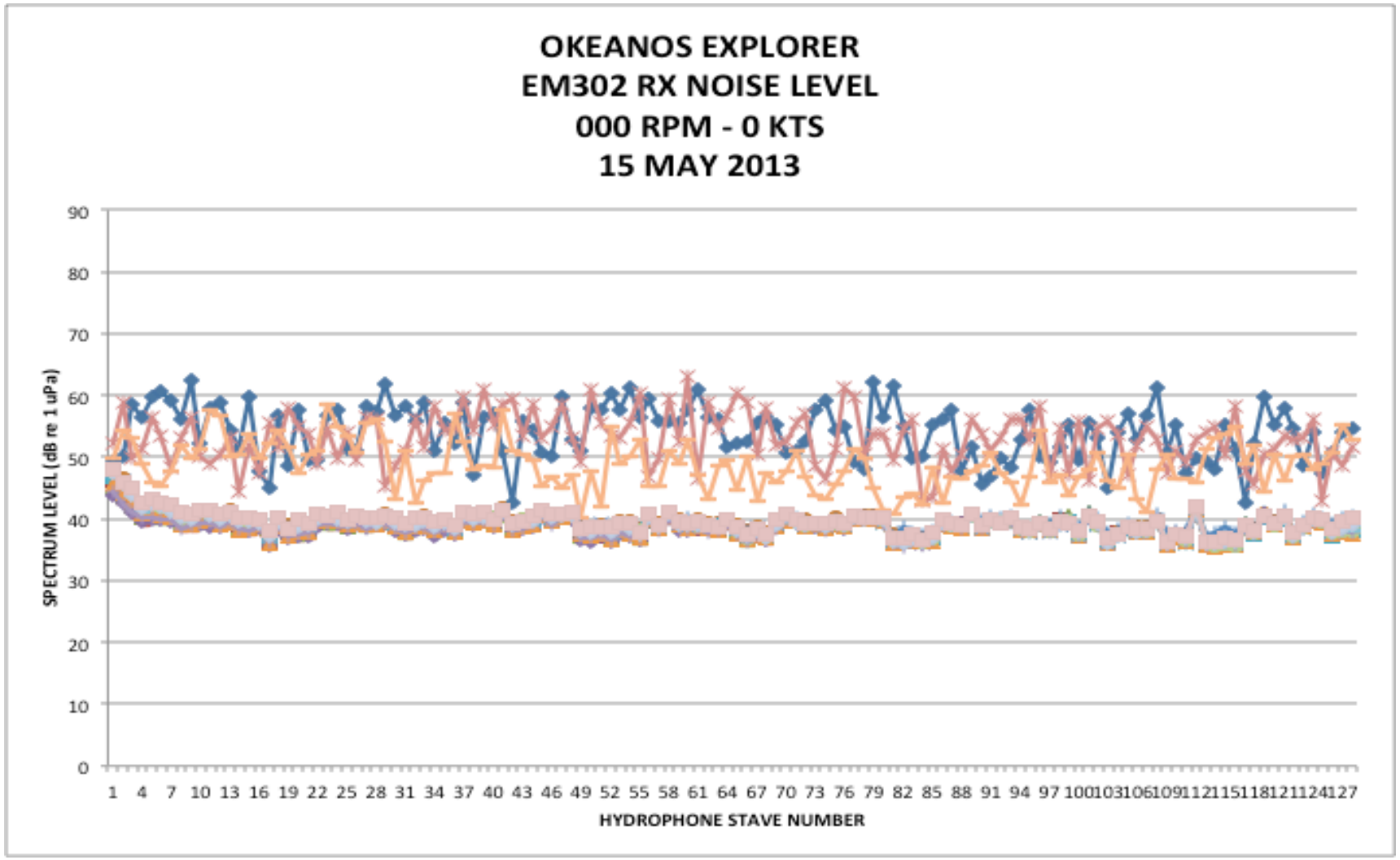
USNS MARY SEARS (T-AGS 65)
IMPACT OF UNSECURED DOOR

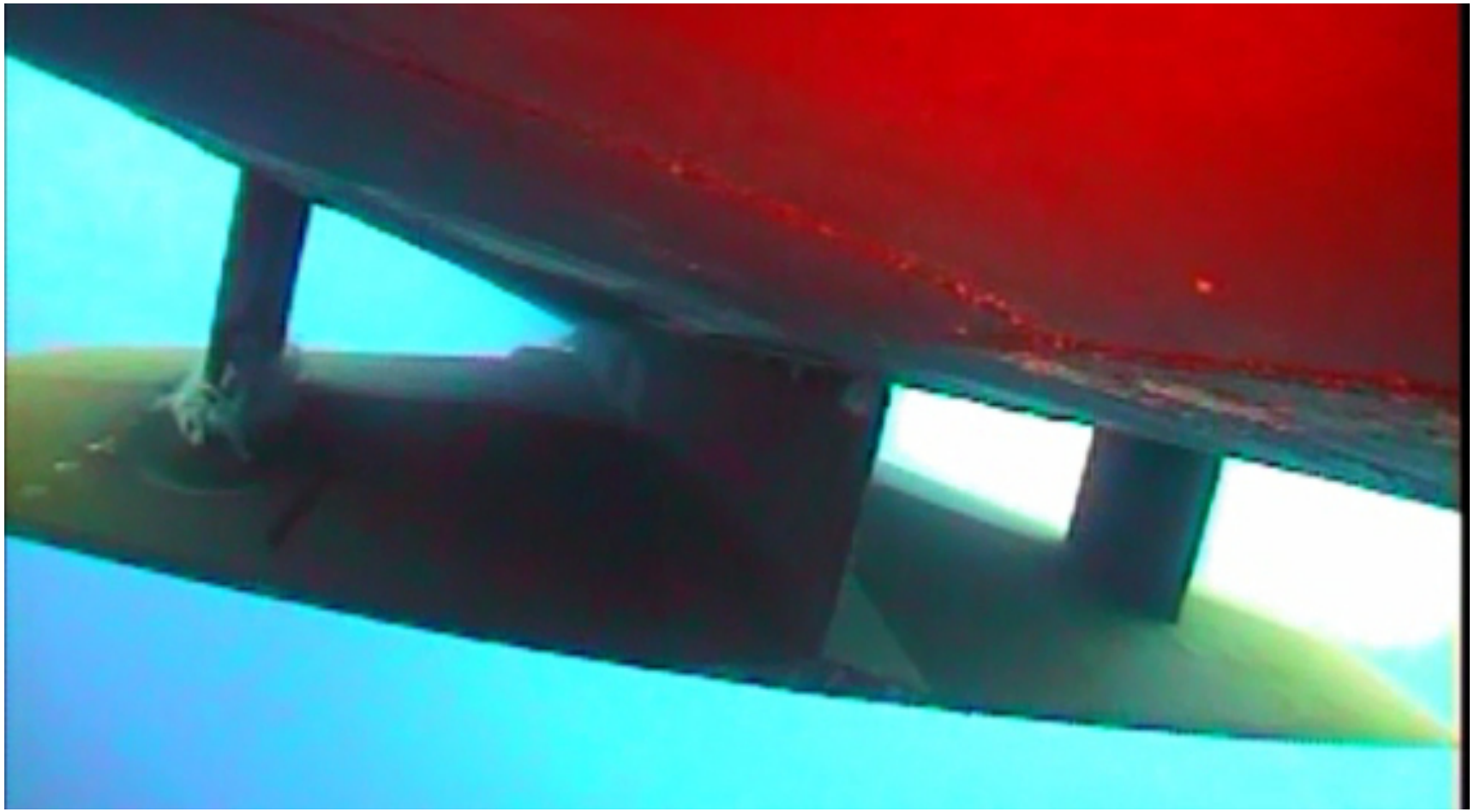


Bottom Swath at Noise Goal

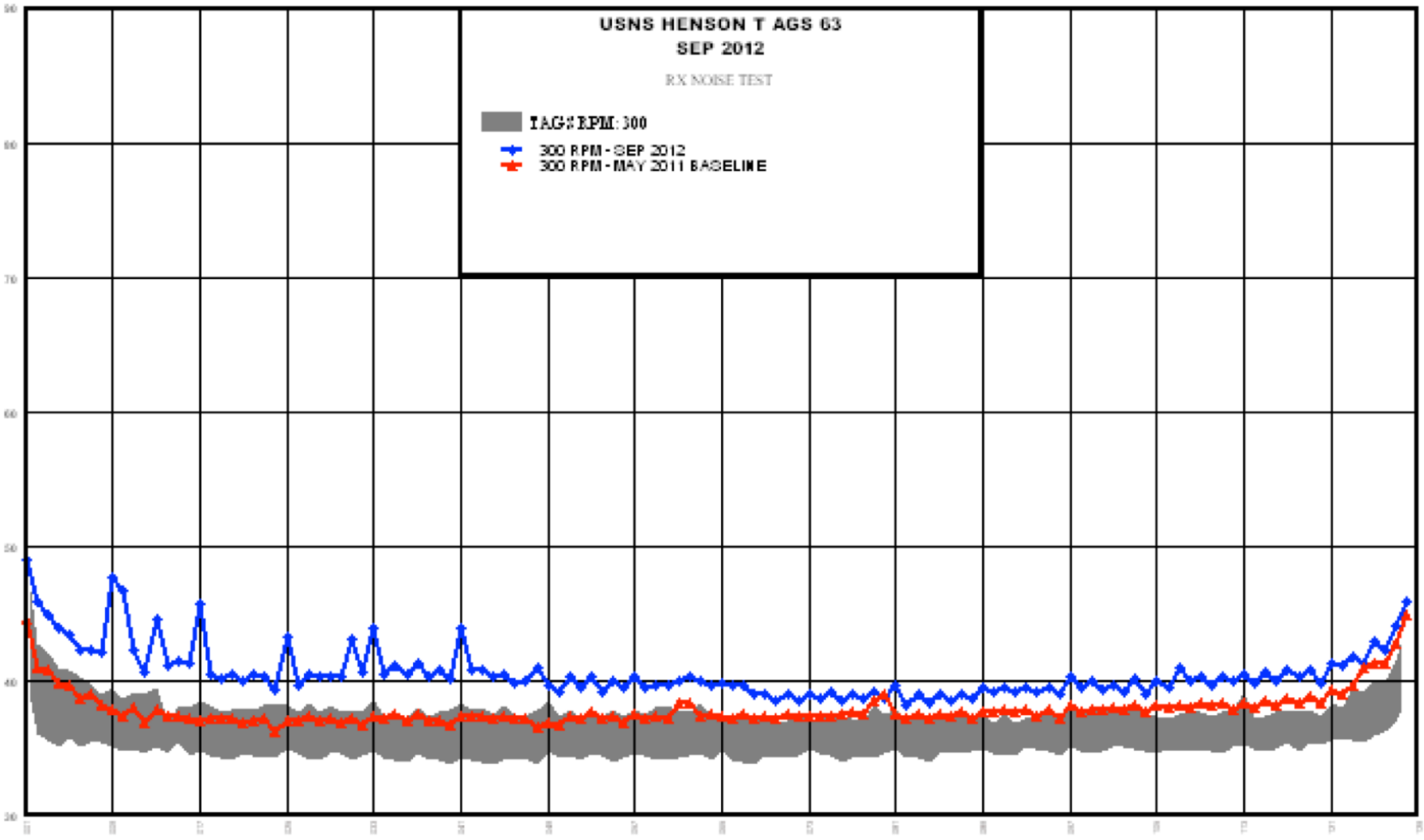


OKEANOS EXPLORER





HENSON RATTLE

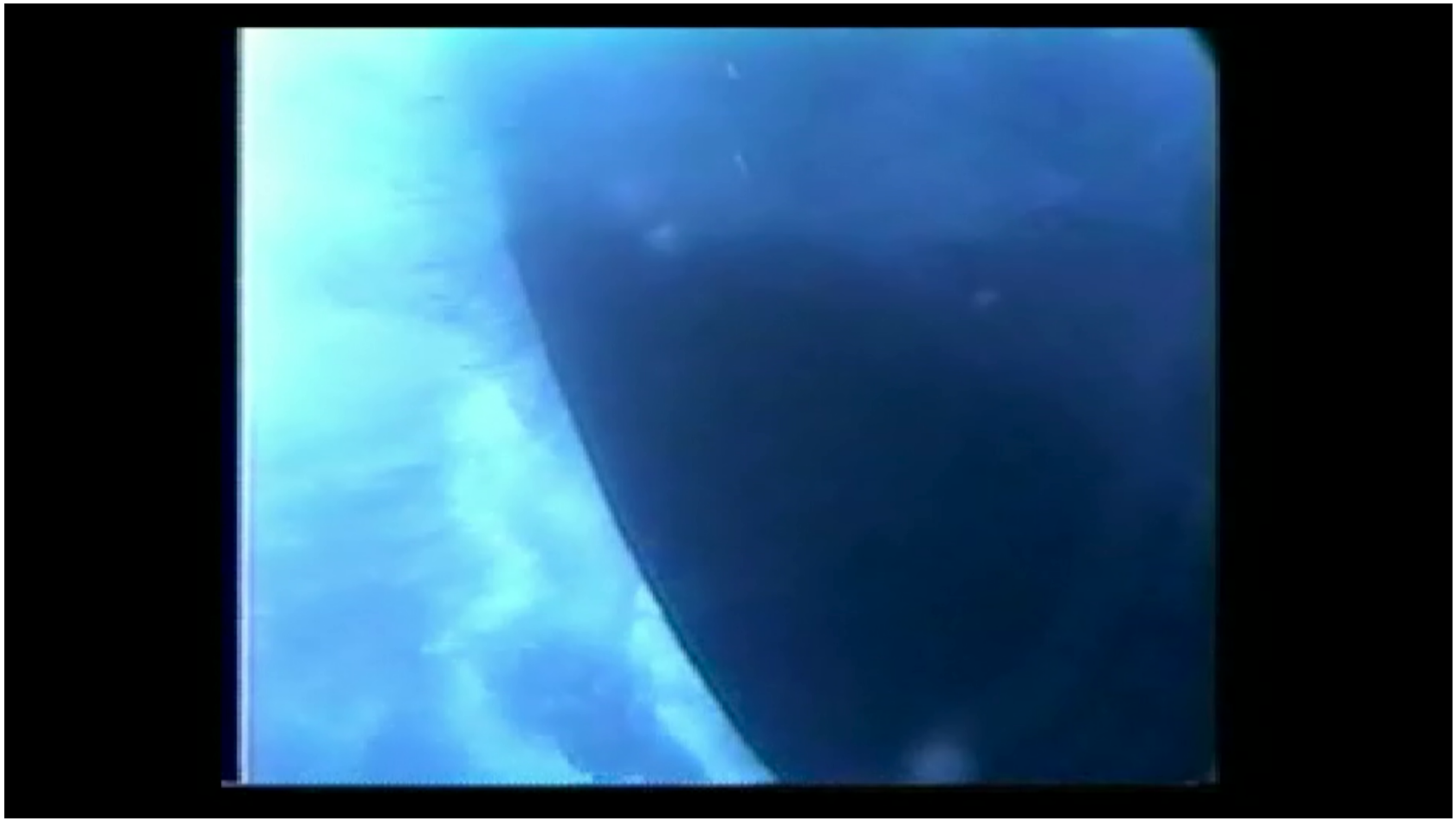


Bubble Sweepdown

- TAGS 60 Class – Bubbles from bow region
- REVELLE – Bubbles from bow region
- SETTE – Bubbles from bow region
- COOK – Bubbles from bulbous bow

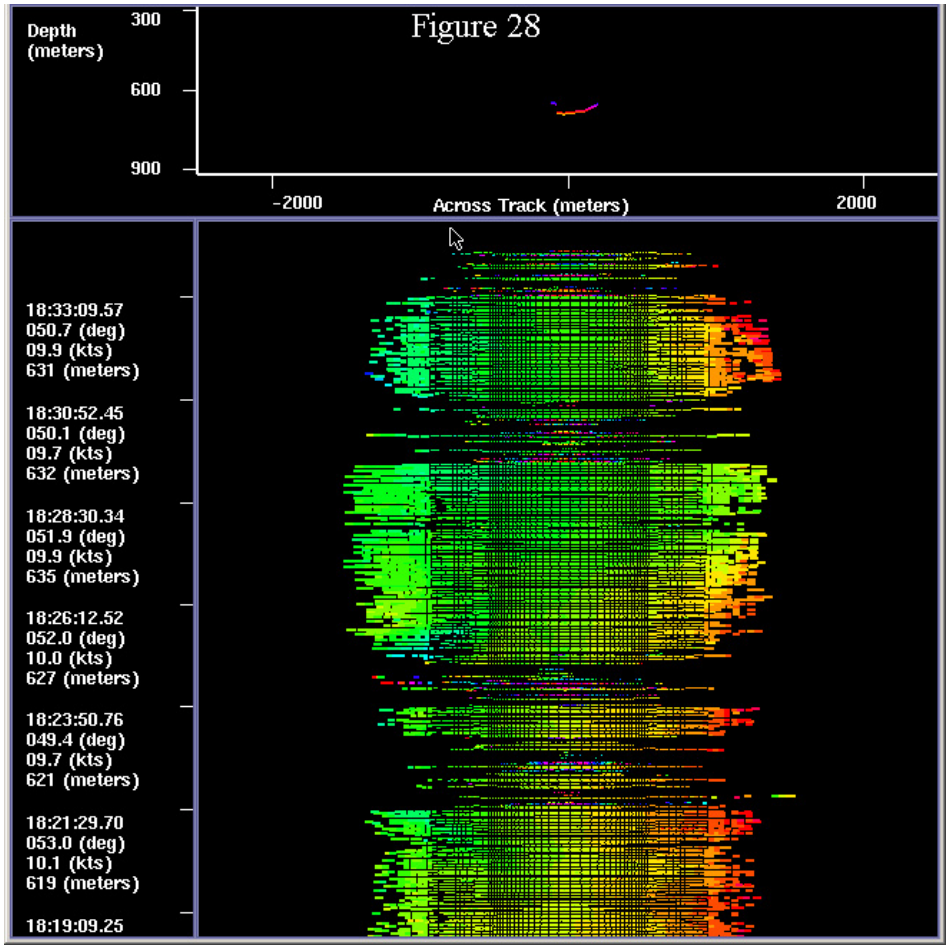
TAGS 60 CLASS BUBBLE SWEEPDOWN VIDEO

REVELLE BUBBLE SWEEPDOWN VIDEO

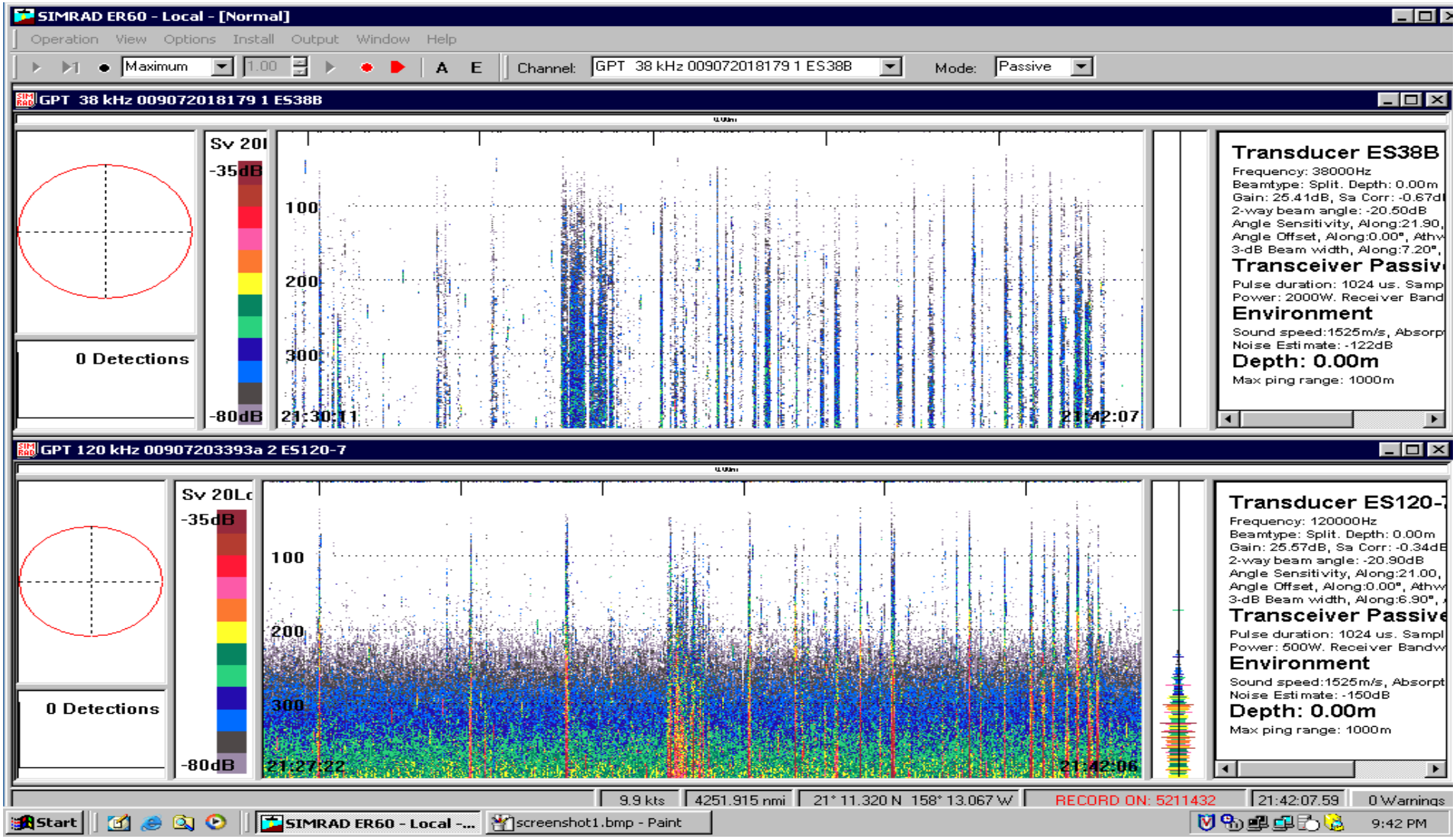


SETTE BUBBLE SWEEPDOWN VIDEO

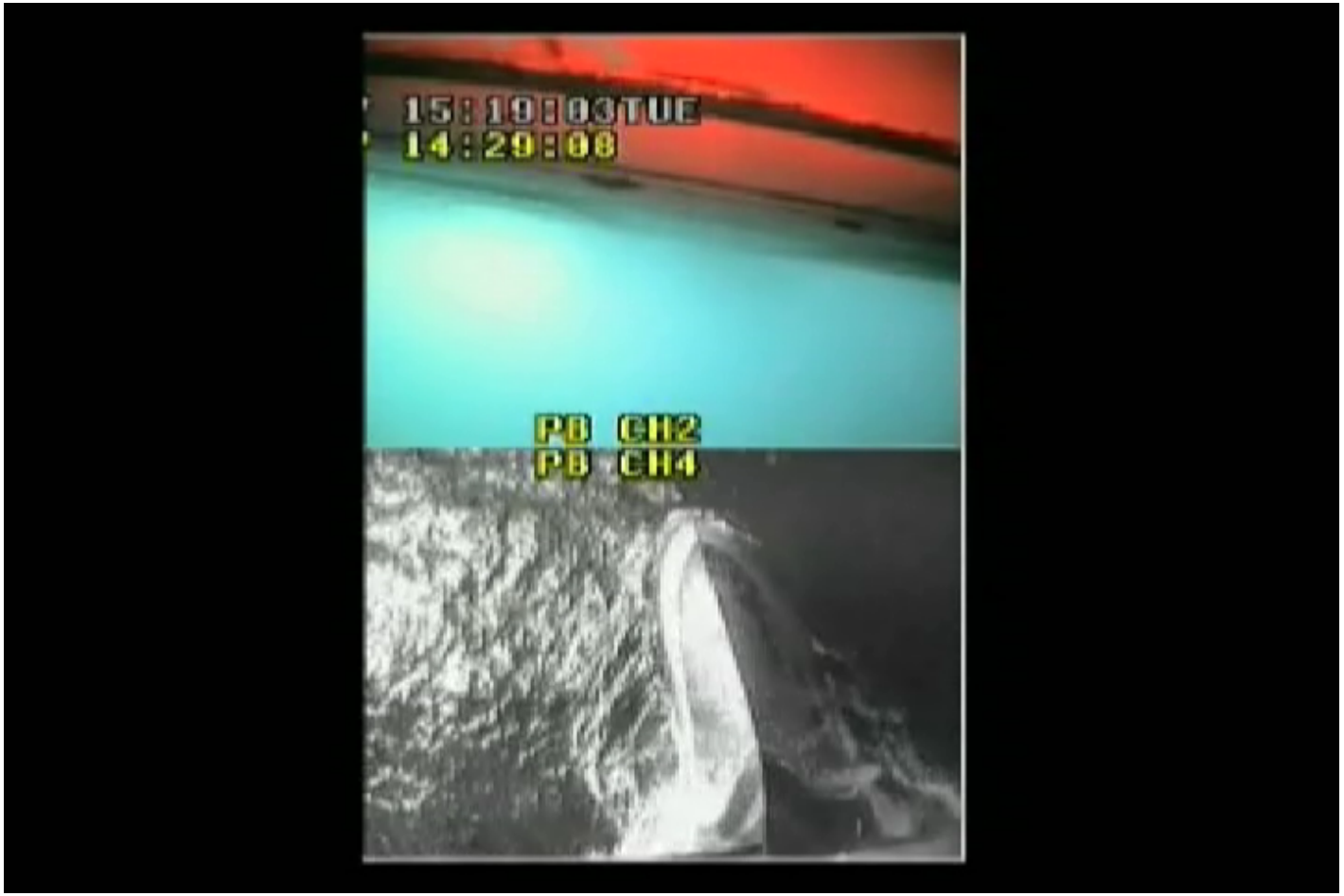
EM 300 Sonar Display on HI'IALAKAI



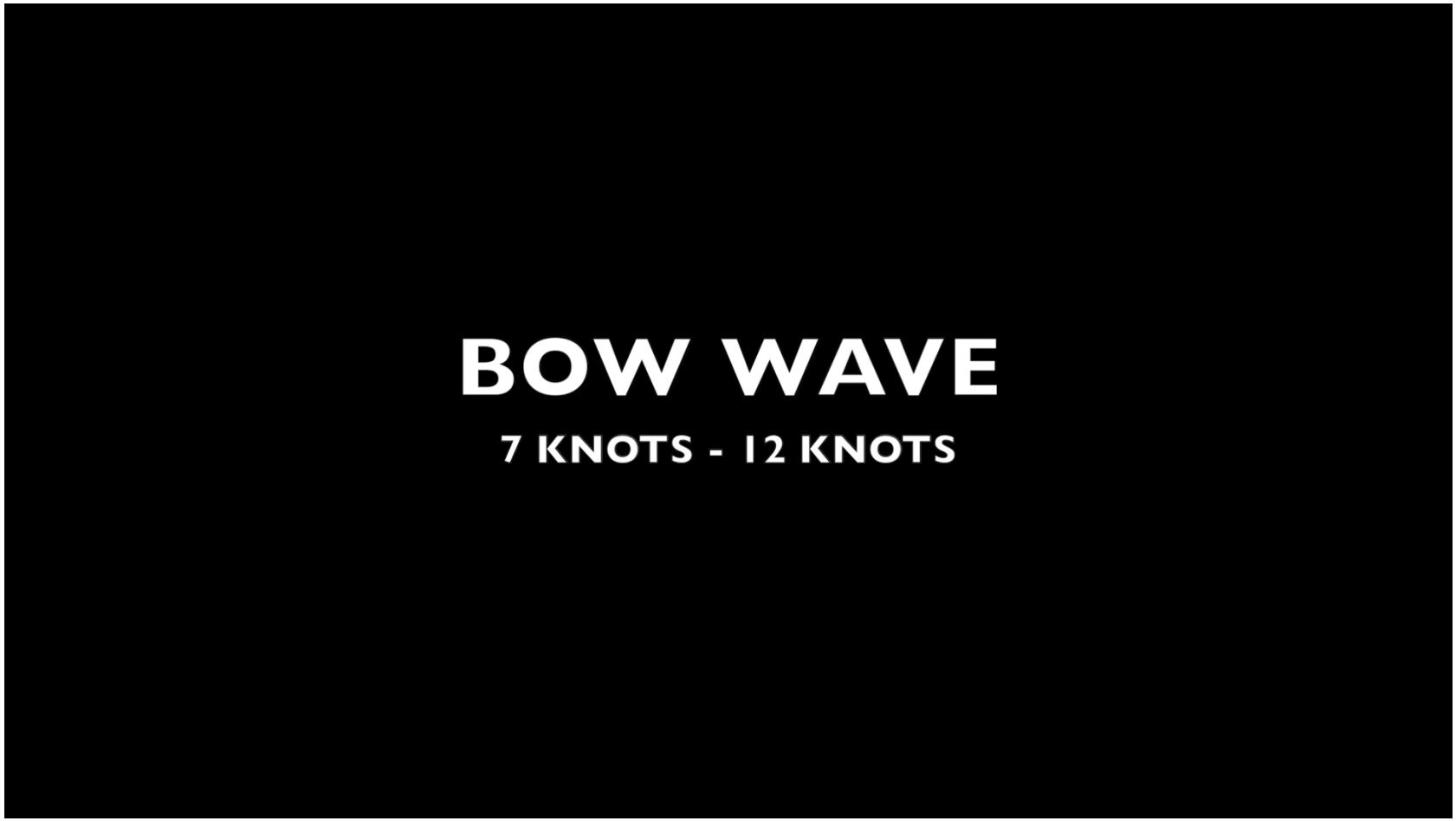
EK 60 Sonar Display on OSCAR ELTON SETTE



COOK BUBBLE SWEEPDOWN VIDEO



EM710 BUBBLE SWEEPDOWN VIDEO



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 that acoustic levels are not degrading sonar performance

Acoustic Monitoring

- Options for Acoustic Monitoring
  - Do nothing and hope for the best
  - Take internal sonar noise levels measurements using built in routines
  - Install hydrophones and do a full assessment
    - Requires special sensors and onboard equipment

Acoustic Monitoring

- Hardware requirements
- Sensors
- Power Supply
- Filter/Amplifier
- Speakers

Acoustic Monitoring

- We believe that acoustic assessments should be performed yearly.
- We also believe that prior to any survey utilizing acoustic mission equipment, that an acoustic snap should be taken to give the "housekeeping seal of approval"
- A snapshot could be accomplished with onboard personnel in 30 minutes

How to take a Snapshot

- Ensure vessel is in deep water (>1000m)
- Acquire sonar levels at 0 knots
- Acquire sonar levels at mission speed
- Compare to historical data
- If levels are within 3 dB of historical/previous data, you are ready to survey!!
- If levels have increased more than 3 dB, it's time to conduct diagnostic testing

What to measure for a Baseline

- Sonar/Hydrophone levels at all speeds of interest
- Determine controlling noise source at each speed
- Propeller Cavitation Inception/performance

What to measure for a periodic assessment

- Hydrophone/Sonar levels at a selected range of speeds
- Propeller Cavitation performance/inception
- Compare data to baseline to determine trends/degradations

SURVEY

- Who takes acoustic measurements on their vessels?
- How do you do it?
- What equipment do you have?
- How often do you do it?