Optimizing Sonar Performance by Managing Acoustics

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Marisa Yearta and Timothy Gates
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

BOILER FEED PUMP
BOILER FEED PUMP SECURED
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
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)
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
• 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 RX NOISE LEVEL
60% THRUST - JULY VERSUS SEPTEMBER 2014
15 SEPTEMBER 2014

SPECTRUM LEVEL (dB re 1 µPa at 70-100 kHz)

HYDROPHONE STAVE NUMBER

60% THRUST - SEPT 2014
60% THRUST - JULY 2014
R/V SIKULIAQ
EM 302 RX NOISE LEVEL
SPEED VS 30 kHz LEVEL - INTO VS FOLLOWING SEAS
15 SEPTEMBER 2014
• 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
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

INTO SEAS
FIGURE 28
INTO SEAS
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

SPECTRUM LEVEL (dB re 1 µPa at 30kHz)

HYDROPHONE STAVE NUMBER

NO BUBBLES

BUBBLE TRANSIENT
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

SPECTRUM LEVEL (dB re 1 \(\mu\)Pa at 12 kHz)

DOOR OPEN
DOOR SECURED
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!!!