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Application of Sonar to the Detection of the Underwater Swimmer Threat in Commercial Ports

Presented
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What is SONAR?

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- SoNAR (Sound Navigation And Ranging)

- Essentially an underwater RADAR system using sound waves instead of electromagnetic waves.

- There are essentially two types of Sonar:

  – ACTIVE SONAR: where an acoustic pulse is transmitted and echoes off the environment. The signals are received through a large number of hydrophones (underwater microphones) and processed to create an underwater acoustic image.

  – PASSIVE SONAR: where a large number of hydrophones (underwater microphones) listen to the underwater sounds and through sophisticated processing the different sound signatures may be extracted.

- Swimmer Detection Sonar may use ACTIVE, PASSIVE or a combination of both types of Sonar.
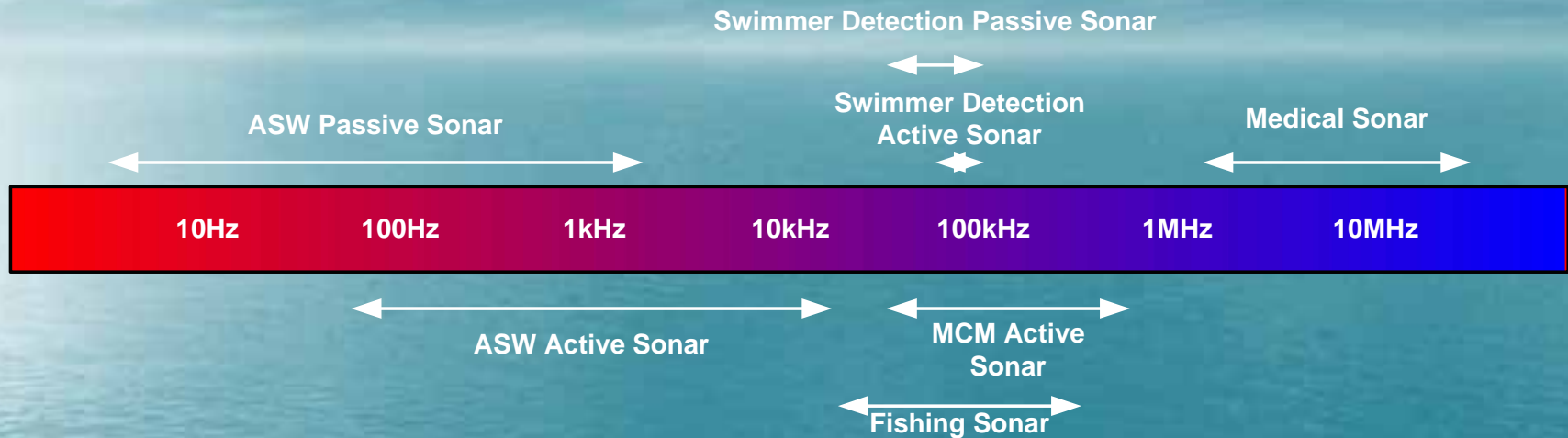
Active Sonar

- Active SONAR:
  - works well in noisy environments.
  - By measuring the time an acoustic signal takes to complete the round trip from the sound source, to the underwater contact, and back to the hydrophone array, an exact determination of range is possible.
  - By processing the data from a large number of hydrophones it is possible to determine the direction for the echo to better than parts of a degree.
  - Precise range and bearing data received from each underwater contact allows the processor to track each contact, and this track information provides major clues into the classification of a contact into threat or non threat categories.

Passive Sonar

- Passive Sonar:
  - Does not do well in noisy environments.
  - Directional properties can be used to reject noise from directions other than those in which the target exists.
  - Mechanical actuation of the breathing apparatus has a signature that separates mechanical noise from the marine mammals.
  - Typically passive SONAR yields lower Ranges than active SONAR of the same frequency.

SONAR Frequency Spectrum

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Swimmer Detection Passive Sonar

Swimmer Detection Active Sonar

Medical Sonar

ASW Passive Sonar

| 10Hz | 100Hz | 1kHz | 10kHz | 100kHz | 1MHz | 10MHz |

ASW Active Sonar

MCM Active Sonar

Fishing Sonar

- Range increases inversely with the acoustic frequency.
- Resolution improves proportionally with frequency.
- Swimmer detection SONAR uses frequency within the band 60 to 120kHz to strike the right compromise.

Performance is not Magic

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- Performance results from a few simple parameters:
  - Active SONAR
    - High source energy
    - Azimuth resolution (Size does matter)
    - Azimuth Coverage
    - Number of beams
    - Bandwidth
    - Receiver Noise
  - Passive SONAR
    - Azimuth resolution (Size does matter)
    - Azimuth Coverage
    - Number of beams
    - Bandwidth
    - Receiver Noise

The Surface Swimmer Threat ^L

- Surface swimmer is generally a nuisance threat as he cannot carry significant ordinance to be much of a threat.

- Difficult to detect in day time because of the surface heating of the water causing the sound rays to bend downwards leaving a shadow zone near the surface.

- At night could pull floating ordinance – Sonar performance is usually very good at night.

The SCUBA Threat

- SCUBA – Self Contained Underwater Breathing Apparatus
- Emits a column of bubbles on exhale:
  - these bubbles are detectable using active sonar as air is a good reflector of underwater sound.
  - Column of bubbles is also detectable using passive sonar.
  - In warm salt waters these bubbles stay in the water for a long time (5 minutes) and leave a long comet tail seen with active sonar.
  - Deep swimming divers provide tall columns of bubbles which are easy to detect.
  - Shallow swimming divers are the most difficult to detect because the bubble column is short and the downward ray bending encountered in the day time shadows the diver.

The CCBA Threat

- CCBA – Closed Circuit Breathing Apparatus
- CCBA's are dangerous to the diver and require considerable training.
  - Generally CCBA's are used by the professional combat diver because of the training required.
  - Commercially available CCBA's are now available for recreational diving where divers want to blend in with the marine life.
  - Some CCBA's use almost pure oxygen. The result is extended endurance from the diver.
- Detectability of the CCBA diver, using SONAR, is lower than the SCUBA diver because there is no air emitted.

Powered Diver Support

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- Divers may use a number of underwater scooters and chariots to enhance their range and payload.

- Even simple Scooters are available in the local Superstores.

Response Time

- Combat divers swim at approximately 1m/sec.
- Powered divers swim at 2 m/sec.
- 500 metres detection range gives only 8 minutes warning for the combat diver and four minutes notice to the powered diver.

Detection Range is your Friend

Factors Affecting Performance

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- Snapping Shrimp produce considerable noise - Lower Eastern Seaboard and into Gulf of Mexico.

- Strong winds in open waters.

- Precipitation

- Surface heating causes downward ray bending (Acoustic Mirages)

- Limitations on Maximum Source Levels necessary to be environmentally friendly to Marine Life.

Impact of Environmental Waters

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- Water Salinity causes absorption of the sound waves.
- Fresh water testing can demonstrate detection ranges in excess of 1.5km against a CCBA diver.
- Areas such a Puget Sound will indicate detection ranges in excess of 800 metres.
- Florida and the Gulf of Mexico yield poor performance because of the high temperatures, snapping shrimp, and the high salinity.
- Estuarine waters form layers of fresh water over the top of salt water resulting is acoustic reflection off the layer. Careful positioning of the sound head is necessary to ensure good performance.
- In poor performance areas more sound heads are required to achieve the necessary area coverage.

Typical Placements

- ## Port Canaveral Scenario
  - Northern High threat area protected by short range limited field of view system. (Green)
  - Southern High Threat Area protected by two long range systems. (Red & Blue)
  - General coverage using Omni System. Would use winch to bring soundhead to sea bed during large ship manoeuvers.
  - Blue coverage protects and provides warning of incoming threats.

Product Liability

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- Product Liability issues are preventing the large companies from using their technologies in the commercial sector.

- Indemnification is required for these companies to move forward in this area.

ACTIVE SONAR

Swimmer Detection Trial
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