Using Passive Sonar for Swimmer Localization: A Feasibility Study

Brian F. Harrison
G. Clifford Carter
Sensors and Sonar Systems Department

Naval Undersea Warfare Center Division
Newport, Rhode Island

Approved for public release; distribution is unlimited.

USING PASSIVE SONAR FOR SWIMMER LOCALIZATION:
A FEASIBILITY STUDY

Dr. Brian F. Harrison and Dr. G. Clifford Carter
Naval Undersea Warfare Center (www.nuwc.navy.mil)
Sensors and Sonar Systems Department
Newport, RI

NAVSEA Homeland and Force Protection Product Area Director: C. E. (Gene) Gallaher
Sponsor: J. Pollock, NUWC Homeland Security Program Office

C.Carter@IEEE.org and harrison_bf@ieee.org
Introduction

• **Objective:** Assess the feasibility of applying passive sonar processing techniques to the detection and localization of scuba swimmers

• **Proposed Solution:** Apply matched-field processing and adaptive interference suppression techniques for the localization (range & depth) of swimmers using vertical array(s)

• **Advantages of Passive over Active Processing Include:**
  1. Passive processing provides covert detection
  2. Active processing known to have difficulty in detecting swimmer near water’s surface
  3. Passive Processing avoids negative environmental issues associated with active acoustic energy transmissions

---

Approach

➢ **Objective of feasibility study is to answer the question:**
*Does a scuba swimmer emit signals of a sufficient level to be detectable at tactically useful ranges in a harbor environment?*

*If yes, then matched-field processing which exploits multipath propagation should be a viable solution*

➢ **Approach:**
  1. Determine radiated pressure spectrum level (PSL) and frequency signature of diver inhale breaths from experimental data
  2. Use PSL in conjunction with a very shallow water propagation model to estimate maximum detection range of swimmers

---

C.Carter@IEEE.org and harrison_bf@ieee.org
Measuring Diver Radiated Signal Power

**Swimmer Acoustic Measurements**

- Swimmer suspended motionless in acoustic tank
- Hydrophone nearby collected radiated noise from scuba gear
- Inhale breaths provide highest signal levels
- Inhale breaths produces broadband frequency signature

Courtesy Roy Manstan and NUWC Dive Team

C.Carter@IEEE.org and harrison_bf@ieee.org
Hot Spot at Depth and Range where (Deep) Swimmer is present

With the “right stuff” (sensors and processing) swimmers are detectable

C.Carter@IEEE.org and harrison_pf@ieee.org

Hot Spot at Depth and Range where (Shallow) Swimmer is present

With the “right stuff” (sensors and processing) swimmers are detectable, even at shallow depths where active fails

C.Carter@IEEE.org and harrison_pf@ieee.org
Detection Region Estimates

- Use normal mode propagation model to model multipath in very shallow-water harbor channels (i.e., 10 – 15 meters)

- Use calibrated PSL measurements and transmission loss computed from model to estimate detection regions of swimmers in range-depth space

- Assumptions:
  1. Vertical spanning array with 22 equally spaced sensors
  2. SVP measured in Narragansett Bay
  3. Sea state 1 (plus 15 dB)
  4. SNR of 0 dB required at array for localization

- Results suggest swimmers detectable to ranges beyond 500 m

SVP Data provided by R. Manstan, NUWC C.carter@IEEE.org and harrison_bl@ieee.org

Conclusions

- Preliminary analysis using experimental swimmer PSL suggests swimmers detectable to ranges beyond 500 m

- Matched-field processing (MFP) should provide a viable solution to swimmer localization

- MFP software for swimmer localization developed and validated using simulated swimmer data

- Further analysis recommended using swimmer data collected in wide variety of harbor environments to calibrate performance of Detection, Classification & Localization (DCL)

C.carter@IEEE.org and harrison_bl@ieee.org
### INITIAL DISTRIBUTION LIST

<table>
<thead>
<tr>
<th>Addressee</th>
<th>No. of Copies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office of Naval Research (ONR 321—J. Tague, V. DeGiorgi)</td>
<td>2</td>
</tr>
<tr>
<td>Naval Sea Systems Command (PEO-IWS5A4—J. Bishop; PMS 480—CAPT P. Cruz)</td>
<td>2</td>
</tr>
<tr>
<td>Naval Surface Warfare Center, Dahlgren (C. E. Gallaher)</td>
<td>1</td>
</tr>
<tr>
<td>Naval Research Laboratory (CAPT D. Schubert)</td>
<td>1</td>
</tr>
</tbody>
</table>