

# **Calibration and Integration of Bioluminescence Bathypotometers for REMUS: Phase 1 Transition for FY99**

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Document Number

## **LONG-TERM GOALS**

Bioluminescence is an environmental factor, which may significantly impact the detection of Naval Special Forces. Coastal waters will accumulate large populations of bioluminescent organisms, making transit of personnel and vehicles through this zone susceptible to detection by the unaided eye and light-intensified devices. My long-term goal is to adequately address the problem of detection of swimmers and SEAL Delivery Vehicles (SDVs) by assessing the bioluminescence threat at the planning stage or immediately preceding the mission.

The goal of all previous exercises was to correlate swimming and SDV activities with bathypotometer “sea-truth” measurements. Because all the fieldwork was conducted with the SPAWAR bathypotometer, measurements from this system must be compared to the signal output from the new mini-bathypotometer built at the University of California, Santa Barbara which is being integrated with REMUS.

## **OBJECTIVES**

Both bathypotometer systems must be compared simultaneously to provide some measure of a transfer coefficient from the SPAWAR bathypotometer to the new mini-bathypotometer. This is essential to produce an equivalent Visual Detection Ratio (VDR) product for detection. Secondly, while the SPAWAR bathypotometer has always used a red transmissometer to make water clarity measurements as part of the integral VDR product, the UCSB system will not be using a transmissometer. UCSB will use an OBS (scatterometer) to emulate transmission. There is an undefined amount of “unknown” with respect to this system when compared to the SPAWAR system, which must be tested in bay environment.

## **APPROACH**

We realized that in order to sample a range of water optical types with the scatterometer and compare these data with that collected by our transmissometer, suspending both detectors from our stationary-floating platform within San Diego Bay would be limiting. In fact, not having any experience with the proposed transmissometer replacement, the OBS, was extremely challenging. Little, if any data exists, that compares the signal output from the OBS to a transmissometer. After a series of tank tests with the OBS meter and resultant conflicting and inconsistent test runs, we decided to attach the UCSB bathy to the SPAWAR bathypotometer and conduct a half dozen stations within San Diego Bay. The

# Report Documentation Page

Form Approved  
OMB No. 0704-0188

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1. REPORT DATE <b>30 SEP 1999</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-1999 to 00-00-1999</b>	
4. TITLE AND SUBTITLE <b>Calibration and Integration of Bioluminescence Bathyphotometers for REMUS: Phase 1 Transition for FY99</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Space and Naval Warfare Systems Center, Code D362, 53475 Strothe Road, San Diego, CA, 92152-6310</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

cruise tract would start in the back bay area near Chula Vista marina where bioluminescence is low and water clarity is low. We would then work stations further out the entrance of San Diego Bay where water clarity improves and bioluminescence increases. We would then be able to directly compare signals from the OBS and the UCSB photomultiplier tube to that found on the SPAWAR bathyphotometer.

The second portion of this effort involved our staff (myself, Jaelyn Chock, Andrew Patterson) traveling to Woods Hole, MA in May 1999 to demonstrate our developed VDR software on data collected with the REMUS bathyphotometer. Because no night runs were conducted due to problems with the REMUS navigation, a later data set was collected in New Jersey in July 1999 at the LEO-15 site and processed.

Third portion of this effort was to develop a SIPRNET web home page to illustrate all data collected thus far from all previous and upcoming field exercises. While kept at the classified level, the web page is available to all sponsors and fleet users who may find this information useful for their mission needs.

## **WORK COMPLETED**

An initial calibration tank test exercise was conducted at Case lab at UCSB. The new bathyphotometer and a SPAWAR mini on-board system were compared for responsiveness by adding known concentrations of dinoflagellates to seawater in the tank. The calibration cruise in San Diego Bay took place in April 1999 following initial measurements with the UCSB bathyphotometer from our fixed mooring. The third field exercise was conducted at Woods Hole, MA to integrate the REMUS bathyphotometer to REMUS. A series of day runs were conducted to test the entire system. Due to navigation problems and potential possible confounding effects from the pump motor, all testing was stopped until this problem was further investigated. A daytime Visual Detection Ratio (VDR) product was generated on site from the REMUS bathyphotometer.

A SIPRNET home page was created for viewing of all previous VDR field exercises: Pearl Harbor 1998, Roosevelt Roads 1998, Vieques Island 1998, Bahrain 1998, Bahrain 1999, and South Korea 1999. This web page is linked to a SEAL Team in Coronado, CA.

## **RESULTS**

We were able to compare and relate the offsets of one system to the other for both bioluminescence and backscatter – transmission for 5 stations conducted within San Diego Bay. The SPAWAR bathyphotometer measured more bioluminescence than the UCSB detector, but differences may be due to pump speed, calibration, and turbulence associated with each detector. We did, however, derive a solid correlation coefficient of  $r^2 = 0.924$  between the 2 bioluminescence sensors, so that we could predict the signal output of one detector to the other (Figure 1). We also derived a strong correlation between the SPAWAR transmissometer and the UCSB backscatter meter A/D units for all stations ( $r^2 = 0.938$ ) (Figure 2).

The VDR product which was generated from data collected at Woods Hole, MA showed a “no detection” product which was expected due to water clarity and bioluminescence daylight

photoinhibition. The VDR products generated from the LEO-15 site also showed a “no detect” and “transitional” conditions for the dusk and night runs and is consistent with boat passengers’ visual observations of low bioluminescence.

## **IMPACT/APPLICATIONS**

From these field exercises, the VDR is used to create an operational product that predicts the degree of risk (visual detection). The VDR has been and will continue to be incorporated into a product which depicts “detection probable” (Condition Red), “detection possible” (condition yellow), and “no detection” (Condition Green). The generation of this product requires the measurement of bioluminescence and water clarity. SEAL team operators require this information for planning prior to the execution of an exercise. The VDRs can provide up-to-date data on which depths to transit along the coast without being visually detected. VDRs are constantly being revised and updated this year to validate visual detection.

## **TRANSITIONS**

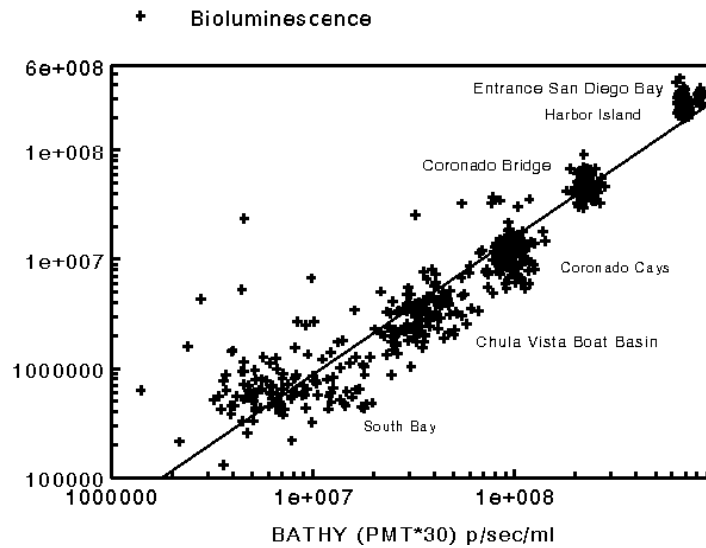
These products are necessary for the final field version of the AUV bathyphotometer being developed at UCSB by taking the collected data and formatting the data to produce a final VDR product. The automated VDR software (funded by NSAP) will access the new AUV bathyphotometer data into a menu-driven and user-friendly contouring program. The program is currently being run from a notebook computer.

## **RELATED PROJECTS**

1 – Development of a new mini bathyphotometer for integration into REMUS (Case, UCSB, ONR funded)

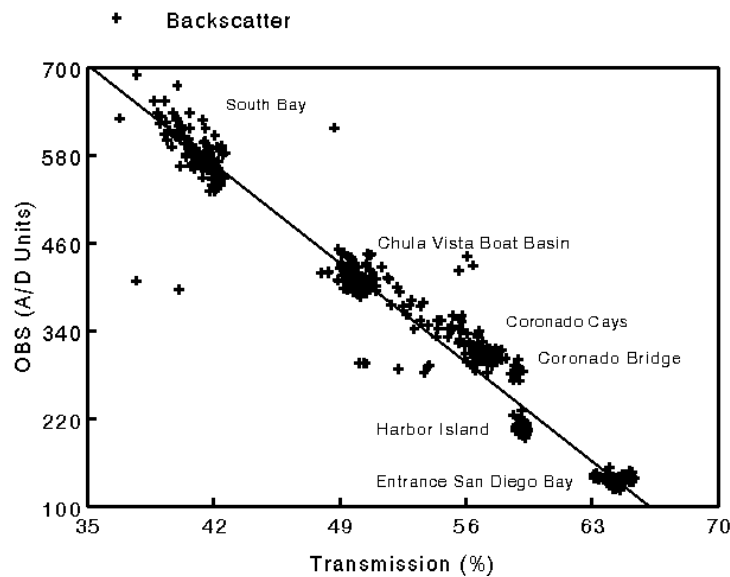
2 – Software development of the Visual Detection Ratio (VDR) product for use with the new bioluminescence-transmissometer detector (Lapota, SPAWAR, San Diego, NSAP funded).

## REMUS Calibration 042099 Bioluminescence (R/V Ecos)



**1. Correlation between bioluminescence sensors (Bathy is the SPAWAR system versus the UCSB REMUS bathyphotometer in San Diego Bay ( $R^2 = 0.924$ )).**

## REMUS Calibration 042099 Transmission vs Backscatter (R/V Ec



**2. Correlation between Sea Tech 0.25 m red LED Transmissometer (SPAWAR Systems Center, San Diego Bathyphotometer) versus the UCSB REMUS Wetlabs backscatter unit in San Diego Bay ( $R^2 = 0.938$ ).**

## **REFERENCES**

Oceanography and Naval Special Warfare, Opportunities and Challenges, Ocean Studies Board, National Research Council, National Academy Press, Washington, D.C. 1997.

## **PUBLICATIONS**

Lapota, D. and Rosenberger, D. 1997: A preliminary method to visually detect swimmers and a SEAL Delivery Vehicle (SDV) at night using bioluminescence (U), U.S. Navy Journal of Underwater Acoustics, 47, No. 3, 1245-1304.

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