

A Compact Bathyphotometer

Paul D. Fucile

Woods Hole Oceanographic Institution

phone (508) 289-2622 fax (508) 457-2165 email pfucile@whoi.edu

Dr. Edith Widder

Harbor Branch Oceanographic Institution

phone (561) 465-2400 x315 fax (561) 468-0757 email widder@hboi.edu

Dr. Kenneth Brink, WHOI

Woods Hole Oceanographic Institution

phone (508) 289-2535 fax (508) 457-2181 email kbrink@whoi.edu

Award Number: N00014-99-1-0346 (Fucile/Brink)

Award Number: N00014-99-1-0319 (Widder)

<http://matisse.whoi.edu/biolumhome.html>

<http://www.hboi.edu/marine/biolum1.html>

LONG-TERM GOALS

To develop, test, and deploy a compact and low cost Bioluminescence (BL) measuring Bathyphotometer. This real time system will lend itself to ship mounted, towed, and underway over the side measurements. The economy and simple application of this instrument will allow investigators who are not familiar with bioluminescence to perform fundamental BL field measurements.

OBJECTIVES

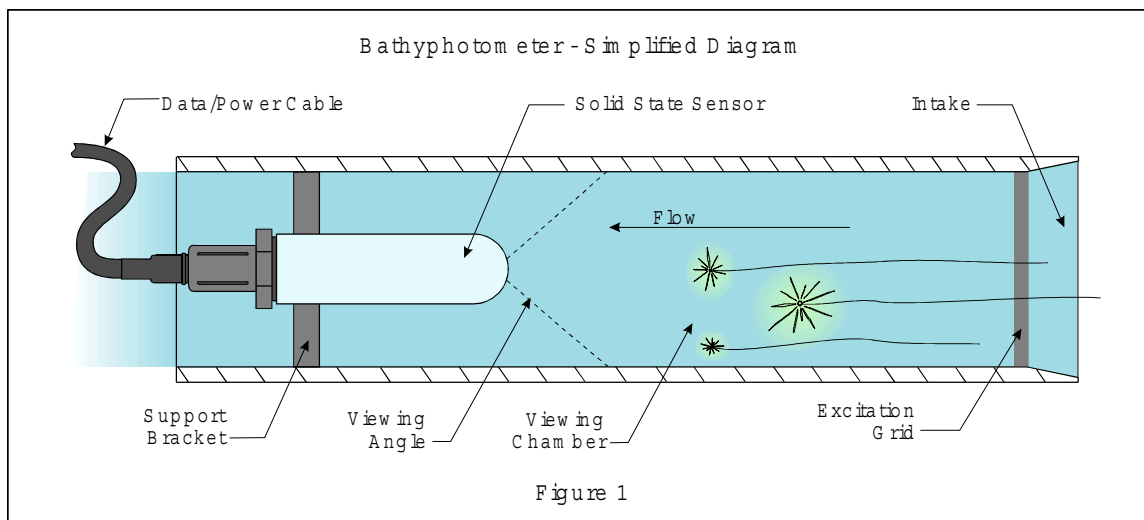
Bioluminescence in the ocean has been measured with low spatial resolution in both the horizontal and the vertical. A useful measurement however is determining bioluminescent activity for the purposes of identifying fronts. A small economical solid state sensor will allow investigators to add BL measurements to their experiments. All circuitry designed must be low power and small enough to be used as part of an expendable system.

APPROACH

The technical approach addresses the requirements to develop a low power solid state sensor with a compact housing and provide communications for moderate length cables (2 Km) and expendable wire systems. Previous designs have relied on Photomultiplier Tubes (PMT) as the optical sensing element. Their cost, size, and requirement for a high voltage supply for the most part prohibit them from being used in an expendable. A photodiode however while not as

Report Documentation Page			Form Approved OMB No. 0704-0188		
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 30 SEP 1999		2. REPORT TYPE		3. DATES COVERED 00-00-1999 to 00-00-1999	
4. TITLE AND SUBTITLE A Compact Bathyphotometer				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) Woods Hole Oceanographic Institution, Woods Hole, MA, 02543				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 Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 4	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

sensitive as a PMT can detect a wide range of bioluminescent activity. By using a microcontroller, the photodiode output can be sampled at a relatively high rate and converted to a digital data stream. The light levels can be integrated in the digital domain to yield a wide dynamic range. The expected spatial resolution for this instrument moving at 4 meters per second is below a meter.



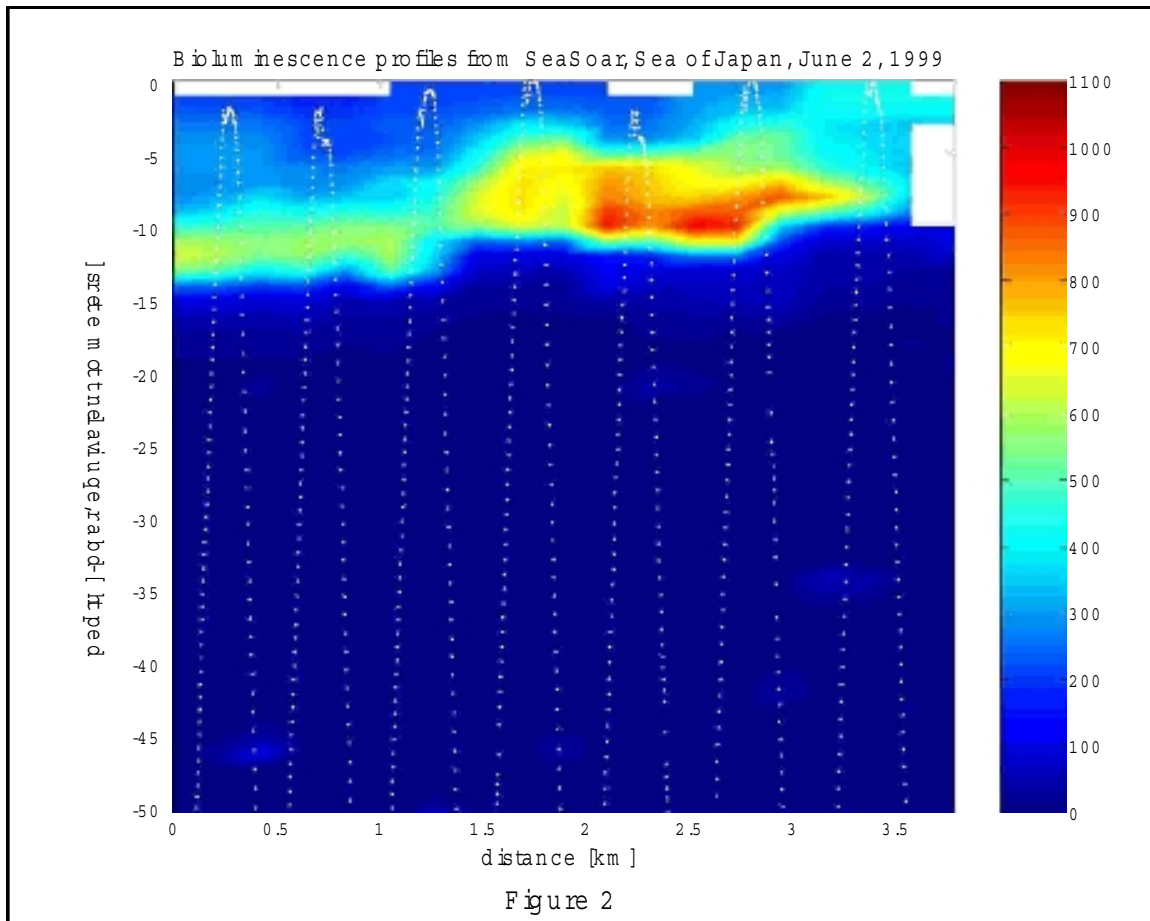
A simplified drawing of the Compact Bathyphotometer (CBP) is shown in Figure 1. This design employs a simple cylindrical chamber to view BL activity. The vehicle or free fall motion flushes the chamber and organisms striking the excitation grid emit light. A solid state sensor measures the light and sends the data to an acquisition system. Chamber diameters as small as 10 cm have been used and chamber lengths are typically 30 cm with the overall instrument measuring 50 cm long. We are developing a microcontroller based instrument that measures two channels of light, pressure, and temperature. The power supply and communications drivers all mount on the same surface mount technology board. A coin type battery powers the circuit.

WORK COMPLETED

In FY 99 the CBP has been deployed twice as a prototype. Printed circuit boards and an improved enclosure have been developed. Optical calibration procedures and tow tank tests have been identified. Improvements have been made to the hardware and software to extend low end sensitivity. In water hardware tests with the communication circuit over expendable wire have been successful. Test cruises have been identified with related hydrography including conductivity, temperature, chlorophyll, PAR, and turbidity measurements.

RESULTS

This instrument has been deployed on the undulating towed vehicle Seasoar as part of the East Sea Project. Continuous measurements were made for 12 days. An example of data is shown in Figure 2. The bioluminescence shown is in a relative scale, however a level of 800 is perceptible to a dark adapted human eye. The bioluminescence tracked the chlorophyll signal extremely well.



The dotted lines show the path of the SeaSoar. Ship speed is nominally 8 kts. This was the first use of the all digital instrument with an integrated pressure sensor. A recording real time graphical display program was also developed.

IMPACT/APPLICATIONS

The potential for making a Bathyphotometer an out of the box instrument for both hard mounted underway and over the side (expendable) measurements will improve the world wide data base.

TRANSITIONS

This instrument will be made readily available to NAVOCEANO and other naval investigators for cross calibration with more sophisticated systems (for example, HIDEX).

RELATED PROJECTS

The digital expendable aspect of this instrument is lending itself to other expendable probes. While the development of this project has focused only on BL measurements, it would not be

difficult to reconfigure this sensor for 2 channel light extinction measurements. The microcontroller core is easily programmed to support other sampling algorithms and data output structures.

REFERENCES

Widder, E.A., J.F. Case, S.A. Bernstein, S. MacIntyre, M.R. Lowenstine, M.R. Bowlby, and D.P. Cook. (1993) A new large volume bioluminescence bathyphotometer with defined turbulence excitation. *Deep Sea Res.* 40(3): 607-627.

Widder, E.A. (1997) Bioluminescence - Shedding some light on plankton distribution patterns. *Sea Technology* March 1997:33-39.

Kocak, D.M., N.D.V. Lobo, and E.A. Widder. (1999) Computer vision techniques for quantifying, tracking and identifying Bioluminescent plankton. *IEEE J. Oceanic Engineering* 24(1):81-95.

Widder, E.A and S. Johnsen (in press) 3D spatial point patterns of bioluminescent plankton: A map of the "minefield" *J. Plank. Res.*

Fucile, P.D., Bahr, F, Brink, K, Neilson, D, Gawarkiewicz, G, Lee, C, Feb. 1998. Finely Resolved Physical and Bioluminescence Measurements Near Shelfbreak Fronts. *Proceedings of AGU Ocean Sciences Meeting*, abstract.

Fucile, P. D., Sept 1996. A Low Cost Bioluminescence Bathyphotometer. *Proceedings of the Gulf of Maine Ecosystems Dynamics Symposium*, abstract.
vehicles.