A Compact Bathyphotometer

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LONG-TERM GOALS

To develop a compact and low cost Bioluminescence (BL) measuring Bathyphotometer. This real time system can be hull mounted, towed, or used as an over the side instrument. The low cost design allows it to be used as an expendable for underway measurements. The economy and simplicity of operation 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. This small economical solid state sensor allows investigators to add BL measurements to their experiments. All circuitry is designed to be low power and is small enough to be used as part of an expendable system. An easy to use computer interface allows use with almost any PC. Since the design uses a solid state solution, tolerance to high vibration and shock means that this instrument can be easily adapted for harsh environments.

APPROACH

The technical approach addressed 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 bathyphotometer designs have relied on Photo Multiplier Tubes (PMT) as the optical sensing element. Their cost, size, and requirement for a high voltage supply prohibit them from being used in an expendable. A photodiode while not as sensitive as a PMT, can detect a wide range of bioluminescent activity. When incorporated with a micro controller and optimized front end amplifier, the photodiode output can be sampled and converted to a digital data stream. The light levels can be integrated in the digital domain to yield a wide dynamic range. A high compliance data transmitter has

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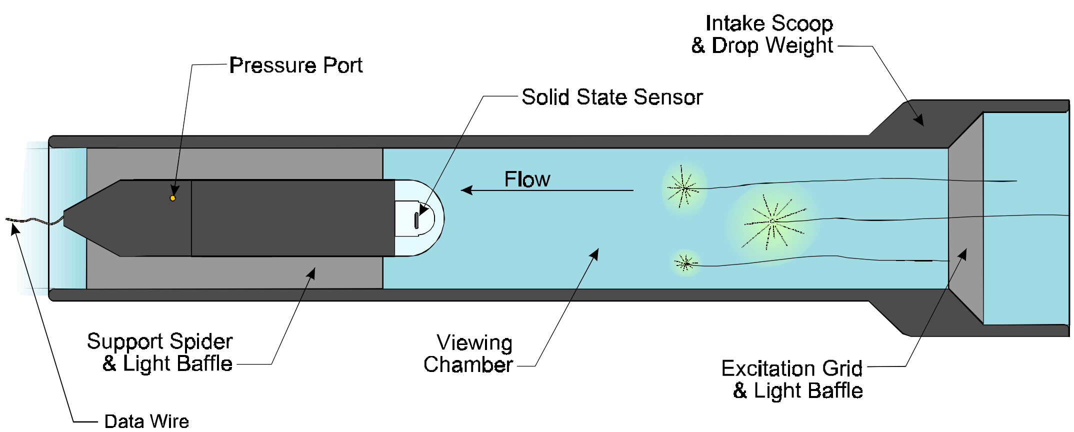
been designed to drive limited bandwidth XBT wire. The spatial resolution for this instrument moving at 2.5 meters per second is better than 0.5 meter. A light baffle system attenuates external incoming light (moonlight or ships lights) by 95% without moving parts.

An illustration of the expendable version of the Compact Bathyphotometer (CBP) is shown in Figure 1. This design employs a simple cylindrical chamber to view BL activity. A weight at the intake scoop causes the device to free fall flushing the chamber causing organisms to strike the excitation grid and emit light. A solid state sensor measures the light and sends the data to a shipboard acquisition system.



Expendable Bathyphotometer (XBP)

Figure 1

Figure 1

The chamber diameter is 10 cm and chamber lengths are typically 30 cm with the overall instrument measuring 50 cm long. The present design 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

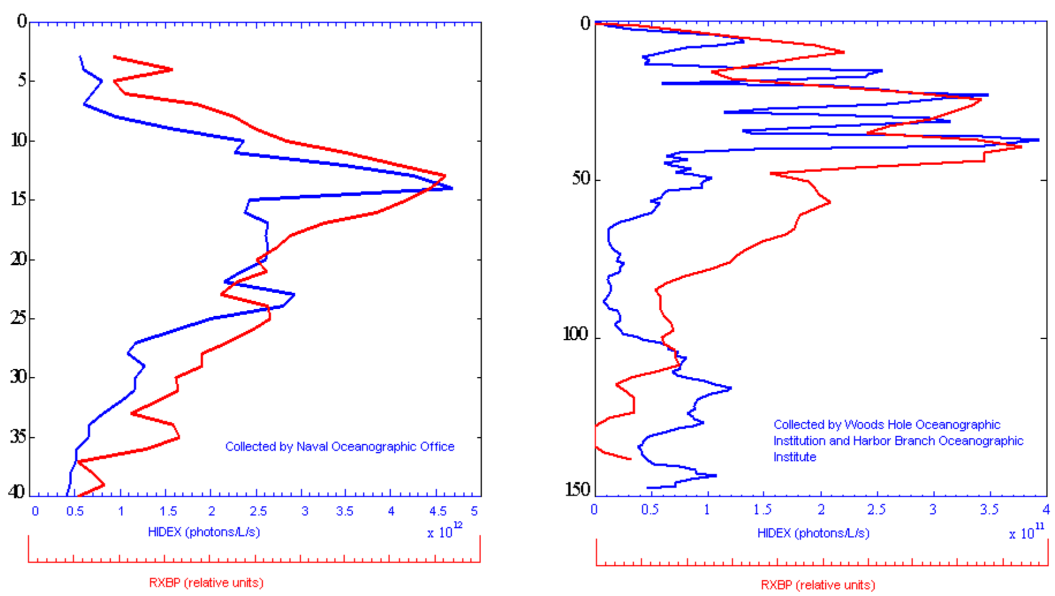
In FY 00 the CBP has been deployed both on a towed vehicle and as an over the side expendable with a recovery tether. Improvements have been made to the hardware and software to extend sensitivity. Over the side hardware tests with the communication circuit using expendable wire have been successful. A radiometric calibration was performed at NIST that showed very good linearity at low light levels. The real time graphical display program was improved to include calibration coefficients and to include probe serial numbers as part of the data file name. A pumped version was developed for laboratory calibrations using organisms. The system was also configured to operate on the Johnson Sea Link submarine to monitor bioluminescence generated by the thrusters. A compact display provided real time light and depth values.

RESULTS

This instrument has been deployed in an expendable mode as part of the Thin Layers Experiment and as part of NAVOCEANO bathyphotometer field surveys. Over 200 casts have been made. An example of an RXBP cast against HIDEX (The Navy standard bathyphotometer) in two different case waters is shown in Figure 2. This figure shows the RXBP matching well with the HIDEX profile. The bioluminescence shown is normalized to the HIDEX data.

During the Thin Layers Experiment in the Gulf of Maine, a time series was taken and is shown in Figure 3. The time between the HIDEX cast and the first RXBP cast is 104 minutes. After that the RXBP casts are spaced at intervals of approximately 15 minutes. Notice the thin layers shown in the HIDEX cast grouped near 50 meters as it moves down the water column. The units are relative to show the time relationship of the feature. The last RXBP cast was taken just before sunrise.

The fact that the RXBP could detect the same bioluminescent thin layers measured by HIDEX is an excellent indication of its sensitivity and general utility. The high flow rate and high sensitivity of the HIDEX system was specifically designed to assure accurate measurement of zooplankton bioluminescence, in addition to the dinoflagellate bioluminescence characteristically sampled by low-flow bathyphotometers. Bioluminescent thin layers in the Gulf of Maine are formed by aggregations of the copepod *Metridia lucens* (Widder et al., 1999). Such layers are a very good test of an expendable



RXBP profiles compared to High Intake Defined EXcitation (HIDEX) bathyphotometer system. (left) collected by Naval Oceanographic Office, data represent 1 m depth bins. (right) collected by Woods Hole Oceanographic Institution and Harbor Branch Oceanographic Institution, Thin Layer Experiment, Gulf of Maine, data represent 1 m depth bins with a 4 meter running average.

Figure 2

probe as they represent regions of high bioluminescence potential that could go undetected by a probe with low sensitivity and inadequate sampling statistics (i.e. overly long integration time relative to drop rate or too small of a sampling volume). Although the RXBP did not consistently detect these layers when using the small diameter detection chamber (5 cm), they were easily detected with a larger detection chamber (Diameter = 7.5 cm; Length = 30 cm). This capability is of both scientific and strategic importance as there is increasing evidence that zooplankton are significant contributors to the bioluminescence potential in many coastal regions. The present version incorporates a 10 cm diameter housing.

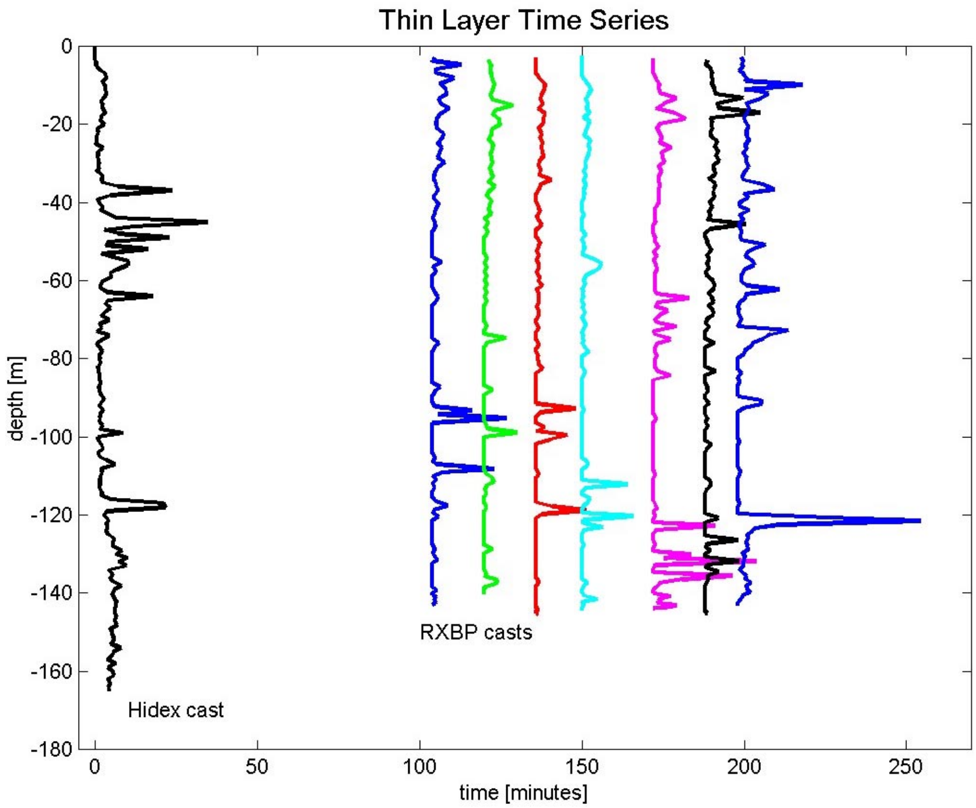


Figure 3

IMPACT/APPLICATIONS

There is a potential for making the CBP an economical bathyphotometer which can be used as an out of the box instrument for both vessel mounted underway and over the side (expendable) measurements. This will improve the world wide data base by enabling more investigators to routinely measure bioluminescence. The expendable is similar to an XBT in terms of operation.

TRANSITIONS

This instrument will be made available to NAVOCEANO and other Naval investigators for cross calibration with more sophisticated systems (for example, HIDEX). Emphasis on use by first time operators is being addressed. Configuring the system for non expendable applications has also been considered.

RELATED PROJECTS

The digital expendable aspect of this instrument lends 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 to measure other optical properties such as light extinction measurements (K) or backscatter. The micro controller core is easily programmed to support other sampling algorithms and data output structures. During daytime engineering casts the XBP was configured with a small aperture instead of an excitation grid to measure light extinction. The casts clearly showed the two attenuation coefficient slopes above and below the thermocline. An optical filter was also adapted to the housing and a program was written to calculate a K profile as a function of depth.

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