

# **Feasibility Study for a Compact, Multi-Purpose Bioluminescence Detector**

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## **LONG-TERM GOALS**

My research objectives involve determining how low light phenomena, both bioluminescence and solar radiation below 200 meters, influence the distribution and behavior of marine organisms.

## **OBJECTIVES**

The objective is to test the feasibility of developing a low-cost, compact bioluminescence detector based on the design principles used to develop the High Intake Defined Excitation Bathypotometers (HIDEX-BP) (Widder et al., 1993). Specifically the design requirements are: 1) defined excitation in order to quantify the stimulus, 2) high flow rates in order to improve sampling statistics, and 3) a long residence time capable of measuring an entire flash.

## **APPROACH**

The basic design of the HIDEX-BP is such that bioluminescence is stimulated by hydrodynamically calibrated flow through a turbulence generating grid at the entrance to a large cylindrical detection chamber. An array of optical fibers, embedded in the walls of the detection chamber, collect light and direct it to a photomultiplier tube. Two of the high costs associated with this design are: 1) the high speed submersible pump and 2) the machining costs associated with embedding the fiber optics in the walls of the detection chamber. The approach has been to reduce these costs and simplify the design by using off-the-shelf components and to scale down the size to the minimum needed to maintain HIDEX-BP design principles.

## **WORK COMPLETED**

The mini-HIDEX has been constructed and is currently undergoing tests using laboratory cultures of bioluminescent dinoflagellates to calibrate the system biologically. The spatial distribution of stimulated bioluminescence in the detection chamber has been recorded using an intensified video camera viewing a full scale Plexiglas model of the mini-HIDEX. The throughput and field-of-view of the 3.5 in. light ring detector system has been measured and the field-of-view was found to be a good match for the spatial distribution of stimulated bioluminescence. Based on the throughput measurements a PMT light detector module was selected over the alternative silicon photodiode with built-in op amp that was being considered for this application. The light baffle/flow meter was constructed and a low cost, high-speed submersible pump, which met design specifications, was located and purchased. An integrating sphere system was designed and calibrated for the biological

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calibrations. As soon as the biological calibrations are complete the system will be set up for long-term data collection in a moored configuration off the HBOI sea wall.

## **RESULTS**

Results so far indicate that this low-cost compact system may be a viable alternative to the HIDEX-BP. The primary limitation seems to be the submersible pumps. The pump which we have located appears to be a good solution for shallow water environments but does not have an adequate depth rating for a profiling system. The critical importance of a high-speed pump that can capture fast swimming zooplankton, which may evade slower pumping systems, has been made apparent by our recent discovery of thin layers of bioluminescent copepods in the Gulf of Maine (Widder and Johnsen, 1998a; Widder and Johnsen, in press; Widder et al., submitted). These layers were discovered using the HIDEX-BP operated at a pump speed of 16 L/sec. The slower pumping rate of the mini-HIDEX (4 L/sec) should be adequate for most coastal bioluminescence, which is likely to be primarily dinoflagellates, ostracods and gelatinous zooplankton, however a faster pump speed would be desirable in a profiling system. With this in mind we have made the design modular so that it can be adapted to other pump and/or thruster designs. Additionally we have designed the light-ring detector system so that it can be adapted to our bioluminescence imaging system (see Related Projects below).

## **IMPACT**

There is very little data available on bioluminescence potential in coastal zones. Because of the extreme variability in these environments, extensive sampling is needed in order to develop some degree of predictive capability. The development of low-cost, compact bioluminescence detectors, which can be assembled from largely off-the-shelf components, could significantly increase the database on coastal zone bioluminescence. This would benefit both civilian and defense sectors by providing a valuable tool for biological oceanographers interested in plankton distribution patterns as well as providing standardized measurements for calculating the impact which bioluminescence may have on covert naval operations. Our results indicate that this design is feasible and a highly desirable alternative to the detector systems still in use, which are limited by low-flow, an undefined stimulus regime and short residence times.

## **TRANSITIONS**

Conclusions from this study will be made available through a publication in the open literature.

## **RELATED PROJECTS**

The design of the light ring detector system can be adapted to our on going efforts to develop an *in situ* video transect technique that uses the unique temporal and spatial characteristics of bioluminescent displays to identify sources. Using an intensified video camera to image bioluminescence in situ we have been developing a database of identified bioluminescent signatures (Widder et al., 1989; Widder et al., 1992; Widder et al., 1997). We have also been developing image recognition programs that can identify sources based on their signatures (Kocak et al., in press; Widder and Johnsen, 1998; Widder and Johnsen, in press; Widder, et al., in press). The light

ring detector module can be used in combination with the imaging system to provide the high-resolution intensity and kinetics data, which are the critical to accurate identifications. In another related project, accurate calibration of this unusual measurement geometry has been made possible with the development of the light wand calibration source developed in our laboratory with ONR support (see HIDEX-BP Calibrations report).

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