High-Resolution Temporal Sampling of the Nearshore Vertical Structure of Bioluminescence

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LONG-TERM GOALS

My long-term goal is to advance our understanding of the ecology of bioluminescent organisms and the mechanisms governing the temporal and depth-dependent variability of bioluminescence in the coastal ocean. With improvements in technology, finer-scale resolution and concurrent physical, chemical and biological data, I will examine the predictability of bioluminescence events in the nearshore coastal ocean.

OBJECTIVES

I propose to integrate a real-time bioluminescence capability into the existing observation network in the coastal waters off New Jersey. Obtaining high-resolution vertical structure of bioluminescence in conjunction with a suite of ongoing physical, chemical and biological measurements will advance our understanding of the mechanisms governing the temporal and depth-dependent variability of bioluminescence in the coastal ocean. Specifically I propose three objectives:

To adapt, fabricate and deploy a moored bioluminescence system on a robotic node 5 km off the central coast of New Jersey.

To quantify the physical, chemical and biological processes that define the spatial and temporal variability in bioluminescence for the nearshore coastal ocean, focusing on features associated with recurrent coastal upwelling.

To take advantage of the vertical structure time series in conjunction with ancillary measurements to identify the significant bioluminescent organisms and define the physical forcing of phytoplankton communities during summer upwelling events.

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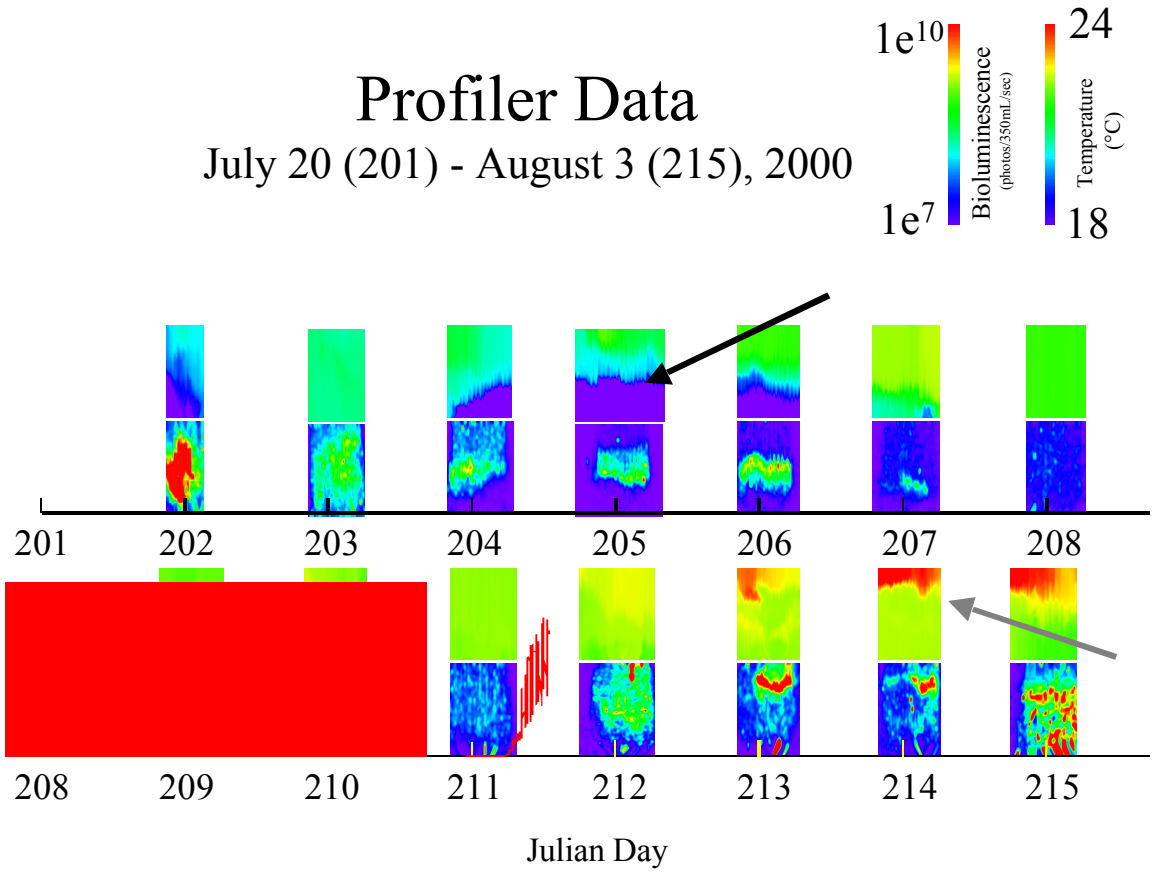


1. Profiler data from July 20 - August 3, 2000. Top contour panels for each day are temperature with bottom contour panels the bioluminescence potential. For each night sequence, contours represent 30 - 40 individual profiles. Overlaid on Julian Days 208 - 215 in red is the solar irradiance for each day. The bold black line indicates intrusion of cold water, with the grey line showing surface warming.

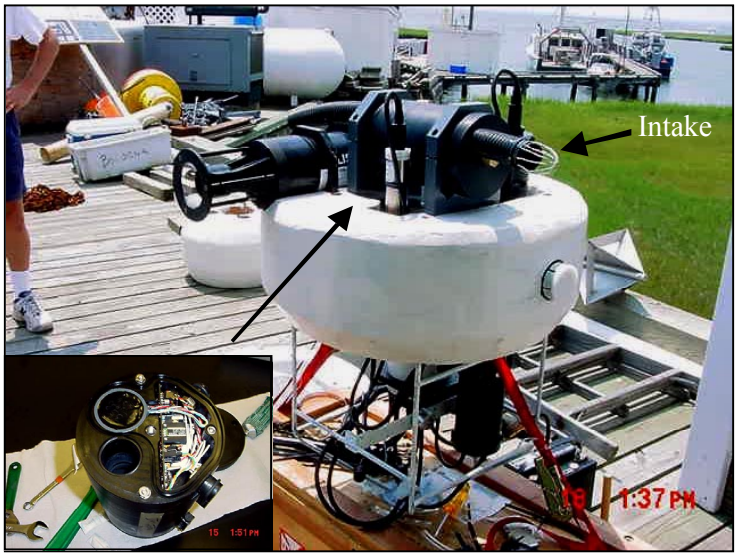
APPROACH

As a participating scientist with the Long-Term Ecosystem Observatory (LEO-15) at Rutgers University, my goal was to collaborate with physical/biological oceanographers in integrating a new profiling capability into the existing observational network. In addition to fabrication of the bioluminescence instrument, the general approach was to collect fine structure of bioluminescence approximately every 20 minutes and make concurrent measurements for plankton and physical/optical parameters (Figure 1). Concurrent measurements were made of temperature, salinity, and sigma-t (CTD), bioluminescence potential, chlorophyll fluorescence, spectral scattering, spectral absorption, spectral attenuation, particle size/abundance (LISST), irradiance and ADCP.

WORK COMPLETED

Bioluminescence bathyphotometer (BBP) was fabricated, calibrated and field tested. At the same time, the optical profiler was constructed and configured to integrate the BP.
BP was integrated into the optical profiler (Figure 2). Profiler was tested onshore to ensure proper power and communication.

Profiler with BP was deployed on July 18, 2000. The profiler was connected to the existing nodes for power and data exchange. The profiler then went through an initial operational test for the first two days.



2. Bioluminescence bathyphotometer (BBP) on profiler prior to deployment on July 18, 2000. Instrument intake is shown as well as a top view of the internal flow chamber (inset).

Data collection began on July 20, 2000. Direct real-time communication and operation of the profiler and the BP is now done remotely through a terminal at the Rutgers University Marine Field Station. Data collection is ongoing and analysis of the initial two weeks of data has taken priority (due to the dynamics) and is proceeding well.

RESULTS

Physical Dynamics: A temperature time-series measured by a vertical thermister chain located 0.5km from the optical profiler indicated that a rapid short-lived upwelling occurred on July 19, just prior to deployment. The water column was well mixed and beginning to warm when the first bioluminescence measurements were made (Figure 1). The water column remained mixed until the 22nd, when an intrusion of cooler water at depth from the shelf pushed up along the coast in response to winds from the southwest (the wind direction responsible for upwelling in the region). This cold water intrusion ended after three days and was replaced by warm mixed water. From the 25th until the 30th of July, the water column remained mixed and warmed ~1.5 °C. As the surface water continued to warm through August 3rd, the water column stratified and the temperature of the bottom water varied less than 0.5 °C. Over the course of the deployment, surface temperatures warmed from 18 to 24 °C.

Bioluminescence Potential: Bioluminescence potential over the course of the two-week deployment showed a full range of vertical distribution, from stratified layers to homogeneous distributions. On the first night of sampling, high bioluminescence signals of 1e^{11} photons/s were associated with cooler water at depth. As the water was advected out of the site, the signal decreased 2 orders of magnitude. This lower signal was also present the following cycle and the distribution of bioluminescent

organisms extended from the surface to 14m. As the cold water intrusion (see Figure 2) intensified the bioluminescent communities developed strong stratification and through JD 207 was strongly associated with the thermocline break. With the disappearance of the cold bottom water, was a 3-4 order-of-magnitude decrease in bioluminescence signal. With the warming of the surface layer and stratification in the final 4 days of the experiment, there was the development of another layer of high bioluminescence potential associated with the thermocline. There was a homogeneous distribution on the final day of the study that coincides with a decrease in stratification resulting from increased wind stress. Samples are presently being processed for identification in order to discern community structure changes associated with the dynamic changes in the bulk BBP signals.

IMPACT/APPLICATION

Although the data is only in its initial stages of analyses, it is clear that this using this bioluminescence platform will advance the ability to detecting fine-scale vertical changes in over time. In conjunction with the ancillary measurements it will also provide an opportunity to examine the mechanisms forcing the abundance and distribution of bioluminescent organisms. The installation and operation were successful and with continual operation, the vertical structure will be examined over a range of time scales from minutes to months.

TRANSITIONS

This project adds a new high-resolution nighttime bioluminescence capability to an existing network designed to predict the 3-dimensional structure of coastal currents, water density and in-water optical properties on the time scales of hours. Fine-scale vertical bioluminescent measurements coupled with ancillary physical/biological measurements will improve the ability to predict bioluminescent events in the nearshore littoral regions of the marine environment.

RELATED PROJECTS

1 – The installation and operation of the optical profiler is in collaboration with Chris von Alt (WHOI) and Oscar Schofield (Rutgers University). In addition to directly addressing the objectives above, data products from this profiler will be integrated into the ONR-Hyperspectral Coastal Ocean Dynamics (HyCODE) program of which I am presently a PI (ONR- N000149910197).

2 – The bioluminescence capability will support an ongoing collaboration with James Case (UCSB) and Chris von Alt (WHOI) to develop an autonomous underwater vehicle to measure bioluminescence in a spatial context. The BP sensors will be developed by the same lab, making vicarious in situ calibrations possible. I am presently initiating this ONR-funded project (ONR- N00014-00-1-0570).

3 – During the initial deployment of the profiler, collaborations with James Case (UCSB) and Steve Haddock (MBARI) continued at LEO-15 in order to further characterize the bioluminescent organisms in the coastal environment. Methods of collection included net sampling, Schindler trap sampling and manual collection by SCUBA.

PUBLICATIONS

This work was presented at the 11th International Symposium on Bioluminescence and Chemiluminescence from September 6-10, 2000 in Asilomar, California.

Moline, M.A., Case, J.F., Herren, C. and Schofield, O. 2000. Spatial and temporal variability of bioluminescence potential in coastal regions, Luminescence, 11, 218.

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