Examination of Thin Layers of Phytoplankton and Zooplankton with Emphasis on Bioluminescence

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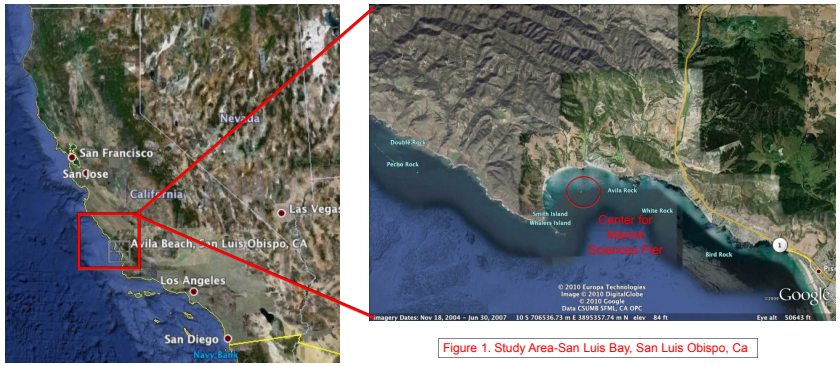


Figure 1. Study Area-San Luis Bay, San Luis Obispo, Ca

Background/Introduction:

•Thin layers of plankton are commonly found in coastal environments, with a vertical scale ranging from centimeters to a few meters, but extending horizontally over kilometers. The abundance of organisms in these layers is several orders of magnitude higher than background levels[1] and are persistent, lasting hours to days. These layers are highly productive and can contain 50-75% of the total biomass of the water column[2-4]. Thin layers are ubiquitous features in coastal environments with a profound influence on trophic interactions.

•Traditional sampling methods have proved inadequate for examining thin vertical layers [3, 5]. Recent advances in platforms (i.e. autonomous profilers) and sensors (i.e. fast response fluorometers and instruments measuring bioluminescence) have made it possible to characterize these thin layers.

•This study examined the planktonic species of these thin layers relative to the rest of the water column over a 2 week period in San Luis Obispo Bay. A traditional sampling method (Niskin bottle) was compared to a more recent method (autonomous profiler). We examined the change in the vertical positions of these layers as well as their impact on trophic interactions.

Methods

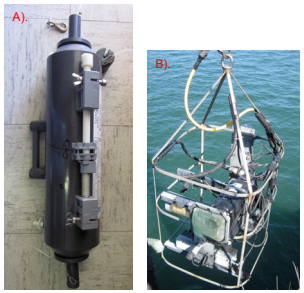
Profiler

•Beginning on 7/7/2010 at 0635 PDT the profiler began to sample the water column at half hour increments at the Center for Coastal Marine Sciences Pier (Figure 1). Each profile takes approximately seven minutes to complete. Sampling was conducted based on profiler data. All profile data within a two-week period was also analyzed for any seasonal changes (Figure 4).

•The profiler contains a CTD (which measures conductivity, temperature, and depth/pressure), Bathyphotometer (BP), and a turbidity sensor (Figure 2B). The BP utilizes an impeller that pumps water into the enclosed chamber to produce a turbulent flow that mechanically stimulates bioluminescence. A flow meter measures the rate in which water moves through the BP. This allowed calculation of the total volume filtered to extrapolate bioluminescence values applicable to a liter of water.

•Reviewed profile data (Figure 3) to determine if and where thin layers were present. Then used profiler with attached net to sample organisms at desired depths (within layer, above layer, and below layer) for quantification and identification.

Figure 2. A) Niskin Sampling Bottle and B) Profiler showing Bathyphotometer.



References

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Methods contd.: *Quantitative Phytoplankton and Zooplankton Analysis*

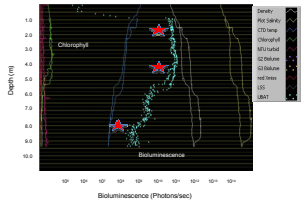
•Two methods of sample collection: net attached to BP (described previously) or a 5 liter Niskin bottle (Figure 2A). A niskin bottle was lowered into the water column until it reached the targeted depth. Weights were then lowered to trigger closure of the niskin bottle ensuring that only water at the targeted depth was sampled. The sample was concentrated using a 20 micron net.

•Regardless of which method was utilized, the sample was analyzed using a gridded sedgewick rafter slide (1mm). Counting of the slide was repeated four times for each water sample noting the organisms present and their abundance. These values were averaged to standardize effort and to reduce the likelihood of overestimating rare species.

Analysis

•Simpson's index of diversity was calculated for each sample. t-tests were also conducted on the different depths within the water column (i.e. different communities of organisms) to determine whether the communities were statistically different.

Figure 3. Profile generated on 7/19/2010.



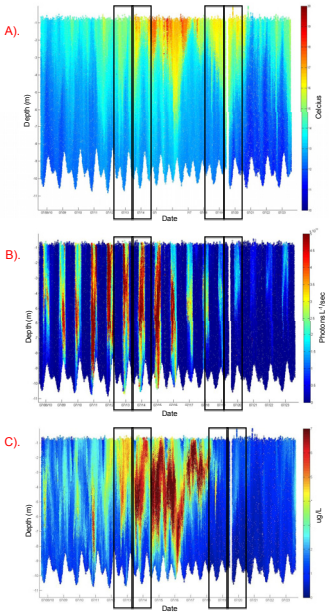


Figure 4. Time Series of Profiler Data throughout Study Period. Black boxes indicate sampling dates.
A) Temperature
B) Bioluminescence
C) Chlorophyll

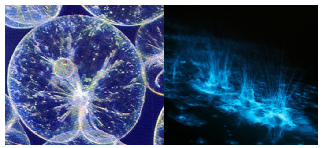


Figure 5. Left) *Noctiluca scintillans* (not to scale) and Right) Bioluminescent *Noctiluca scintillans* bloom.

Table 1. Abundance of *Noctiluca scintillans*, a Bioluminescent Species

	Date of Sampling	
Depth	7/19/10	7/20/10
Non-Peak Shallow	2X 10^3	5X 10^3
Peak*	8X 10^3	1X 10^4
Non-Peak Deep	3X 10^6	1X 10^6

Results and Conclusions

•Diversity Indexes were calculated for each method and compared using a t-test, which determined that the methods were not statistically different ($P < 0.31$). However, this could be attributed to the extremely small sample size (two sampling dates for each method). Another consideration is the width of the sample layers as they were fairly thick, with a width of a few meters. A niskin bottle would prove far more inferior to the profiler method had the sample layers been a few centimeters in width.

•Figure 4 shows three time series graphs across the two-week study period. In looking at the temperature graph (Figure 4A) a warm water body is evident on 7/16/2010, this same time period also shows very high levels of bioluminescence (Figure 4B). By the time the profiler sampling began on 7/19/2010, a colder body of water had moved in also showing less bioluminescence. Bioluminescent species were still present during the time period of data collection but in lower concentration. This clearly shows that the physical properties of the water body (i.e. temperature and salinity) primarily dictated the location of bioluminescence.

•Figure 3 shows an evening profile on 7/19/2010 noting depths that were sampled. These depths were then used to conduct t-tests comparing the abundance of a bioluminescent species, *Noctiluca scintillans* (Table 1, Figure 5). The results confirmed the hypothesis that the bioluminescent species should have a higher abundance in the peak of bioluminescence than in non-peaks ($P < 0.018$ for the shallow non-peak and $P < 0.048$ for the non-peak deep). I conducted similar t-tests for another bioluminescent species, *Protoperidinium depressum*, which were not statistically significant. However, its ecology explains this result as this species has a reduced flash intensity in comparison with *Noctiluca*. *Protoperidinium depressum* was much more abundant and evenly distributed throughout the water column, which explains its lack of adherence to the pattern demonstrated in *Noctiluca*.

•Future work could examine the vertical migration of phytoplankton and zooplankton throughout the night as opposed to only sampling at one time in an evening. This would provide behavior interpretation of where thin layers form to supplement the physical characteristics of layer formation as examined in this study. Future work could also examine the flash kinetics and flash duration to more accurately determine the source of bioluminescence.

Acknowledgements