

NEW SUBMERSIBLE ACTIVE FLUOROMETER USED TO MONITOR PHOTOSYNTHETIC PARAMETERS AND ALGAL BIOMASS

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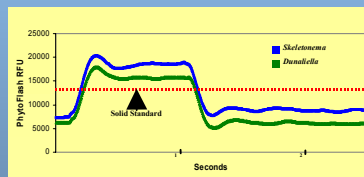
INTRODUCTION

Turner Designs, Inc has developed an *in situ* variable fluorescence system that can be used to determine the quantum efficiency of phytoplankton in both oligotrophic and mesotrophic environments. The PhytoFlash (patent pending) is distinct from other 'active' fluorometers on the market in that it is the first solid-state instrument capable of variable fluorescence measurements on natural concentrations of phytoplankton. The solid-state platform allows for a much wider range of uses due to the small size, power efficiency, more stable components, and lower price point.



PERFORMANCE TESTING

Response Curves



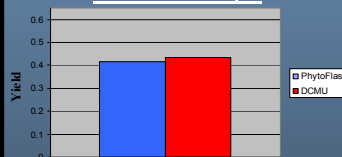
Response curves and physiological parameters of *Dunaliella salina* and *Skeletonema* were determined using the Blue LED PhytoFlash.

Physiological Parameters

| | <i>Dunaliella</i> | <i>Skeletonema</i> |
|-------|-------------------|--------------------|
| Fo | 5950 | 7450 |
| Fm | 17309 | 20273 |
| Fv | 11359 | 12823 |
| Yield | 0.656 | 0.642 |

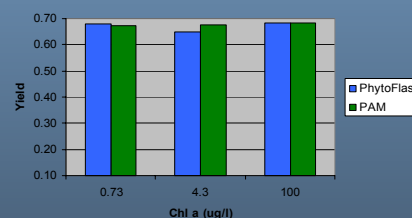
COMPARISON TESTING

PhytoFlash Yields versus DCMU Technique



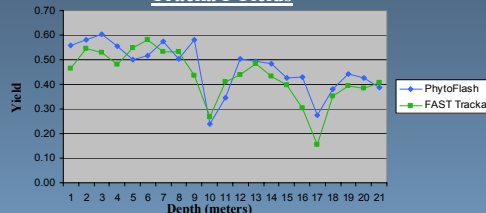
Yield comparisons of the diatom *Thalassiosira weissflogii* utilizing the fluorometric DCMU herbicide technique and the Turner Designs PhytoFlash Active Fluorometer (n=4).

PhytoFlash versus PAM Yields



Comparison of Turner Designs PhytoFlash submersible active fluorometer and the Walz PAM benchtop active fluorometer using green algae (*Dunaliella*) cultures at different concentrations

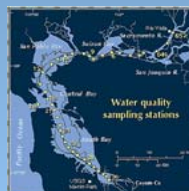
PhytoFlash versus Chelsea Fast Tracka I Yields



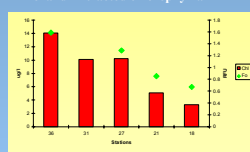
Comparison of Turner Designs PhytoFlash and Chelsea's Fast Tracka I during combined profiles in Monterey Bay.

IN SITU EXPERIMENTS

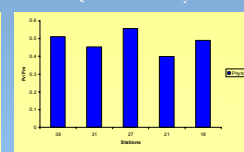
United States Geological Survey South Bay Cruise in San Francisco Bay, California.



Fo and Extracted chlorophyll a



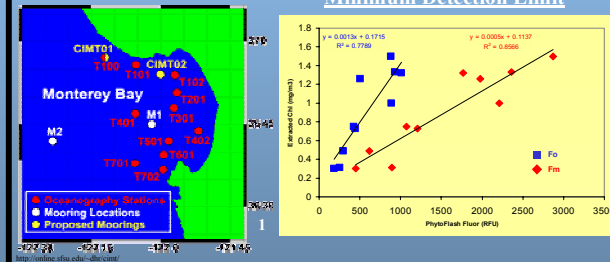
Quantum Efficiency



USGS Hydrographic Stations in San Francisco Bay, California, U.S.A.

Samples were collected at five sites during CTD profiles along a northern transect and tested on the PhytoFlash. The first graph presents a direct correlation between the Fo and extracted chlorophyll a. The second graph displays yields determined at each station. Phytoplankton samples comprised of mainly diatoms and dinoflagellates.

Minimum Detection Limit

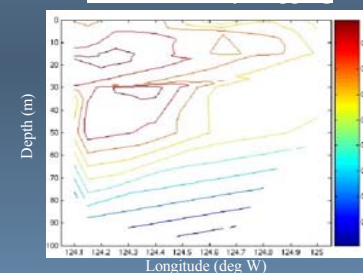


The PhytoFlash was integrated into the CIMT CTD January 2006 shipboard survey. Water samples were collected with Niskin bottles and processed for extracted chlorophyll *a*.

1. Data reflecting the correlation between Fo and Fm with extracted chlorophyll *a*. Calculated minimum detection limits (MDL) were 0.15 µg/l. MDL calculations were similar for Fo and Fm, suggesting yields are accurate at low chlorophyll *a* concentrations.

Coastal Ocean Projects Program/River Influences on Shelf Ecosystems
Columbia River, Oregon/Washington

FvFm Underway Mapping



The PhytoFlash was deployed as part of the NSF sponsored RISE program off the Oregon/Washington coast. Samples were collected from Niskin bottles, dark adapted for 30 minutes, and then run in laboratory mode. As expected there was a decrease in FvFm moving from onshore to offshore, and from surface to depth.

CONCLUSIONS

- The PhytoFlash is able to produce repeatable physiological parameters for freshwater and marine phytoplankton at low concentrations.
- The PhytoFlash is the first *in situ*, solid-state active fluorometer for use in natural waters.
- The PhytoFlash can be used for real-time data collection through the use of the internal data logger and battery pack or integrated into a CTD system.
- The PhytoFlash makes real-time, variable fluorescence measurements a reality for the research community.

ACKNOWLEDGEMENTS

We would like to thank Dr. Raphael M. Kudela and Atma Roberts from the University of California at Santa Cruz, Dr. Erik Smith and Tracy Buck from the University of South Carolina's Belle W. Baruch Institute for Marine and Coastal Sciences, Dr. Nick Welschmeyer from Moss Landing Marine Laboratories and his graduate students, Dr. Jacco Kromkamp from the Netherlands Institute of Ecology (NIOO-KNAW), and the USGS crew at Menlo Park, California.



The PhytoFlash can be integrated into a CTD or multi-parameter system, used in self-contained mode in conjunction with the internal data logger and attachable battery or in flow-through mode for laboratory work and in underway monitoring mode. The variable fluorescence measurement is being used in an ever-growing list of applications, such as;

- In situ* measurement of phytoplankton photosynthetic parameters
- Indicator of nutrient status of planktonic algae
- Detection of the onset of algae blooms
- Accurate measurement of algal biomass and monitoring algal community changes
- Measurement of non-photochemical quenching (laboratory mode)
- Ballast water monitoring

The PhytoFlash technique utilizes 3 low intensity LEDs to measure Fo and Fm and 6 high intensity LEDs to saturate cells in the sample chamber. The response curve from the saturating flash can be viewed in the laboratory mode. Unlike other 'active' fluorescence systems, the PhytoFlash does not provide induction curve data and is not designed as a physiological instrument for laboratory use. Rather, it is designed as a simplified and robust variable fluorescence system for submersible and/or laboratory use.

PHYTOFLASH SPECIFICATIONS

Optical Specifications

Excitation Filter <500 nm
Emission Filter 680AF80 nm
LED wavelength 460nm
Minimum Detection Limit 0.15 µg/l

Electronic Specifications

Sampling Rate 0.2 Hz
Saturating LED duration 200-10,000 ms, 200ms (default)
Data Format RS-232

Physical Dimensions

Length 12 inches 30.5 cm
Width 3 inches 7.6 cm
Weight (in air) 2.95 pounds 1.34 kg
Sample Volume 5.36 ml

PHOTOSYNTHETIC PARAMETERS

The PhytoFlash will provide the following parameters:

| | |
|-----------------|---|
| Fo | Minimum fluorescence |
| Fm | Maximum fluorescence |
| Fv | Variable fluorescence (Fm-Fo) |
| Fv/Fm (yield) | Maximum quantum yield of photochemistry in PSII |
| Blank | Calculated blank value used in calibration |
| Response Curves | Available during laboratory mode |