Chelsea Technologies

Product & Application Study

MicroSTAF Deployable Single Turnover Active Fluorometer

Fully autonomous in-situ instrument designed to assess phytoplankton primary productivity

Why does Phytoplankton matter regarding climate change?

Seen from space, earth is unquestionably an ocean planet; a beautiful blue marble serenely floating in a cold empty void. Standing at any shore, the big blue appears endless and even somewhat empty, filled with nothing but water. But below the surface, the ocean is brimming with microscopic plants called Phytoplankton. If you were to take an empty glass and scoop up water from the shore, in that glass you would have between 75-100 million Phytoplankton.

Phytoplankton are the foundation of the aquatic food web, the primary producers, feeding everything from microscopic, animal-like zooplankton to the largest creature on earth, multi-ton whales. Small fish and invertebrates also graze on these plant-like organisms, and then those smaller animals are in turn eaten by bigger ones.

Phytoplankton can also be the harbingers of death – some species of Phytoplankton produce powerful biotoxins, making them responsible for harmful algal blooms often referred to as “red tides“. These toxic blooms can kill marine life and people who eat contaminated seafood. Phytoplankton also cause mass mortality in other ways. In the aftermath of a massive bloom, dead Phytoplankton sink to the ocean or lake floor. The bacteria that decompose the Phytoplankton deplete the oxygen in the water, suffocating animal life; the result is an ocean dead zone.

Climate change and the carbon cycle

Phytoplankton respond rapidly to environmental changes. During the past decade, researchers have discovered that global levels of Phytoplankton decrease as the ocean temperatures warm. Why? During the normal physical mixing process in the ocean, nutrients come up from the depths. Phytoplankton are fertilized; they grow; the nutrients become depleted, and the Phytoplankton die or are eaten by other organisms. And this mixing process continues, ad infinitum. Anything that slows down the movement of cold, deep water to the surface stops the flow of nutrients, which inhibits Phytoplankton growth. Over the past ten years we have seen large areas of the ocean warming up. As the surface waters warm, it essentially puts a cap on the mixing process that is crucial for all life on earth.

Science has focused on this trend, and studies confirm that there has been a decrease in global Phytoplankton productivity. For example, over the past decade ocean scientists have documented an increase in the area of subtropical ocean gyres - the least productive ocean areas. These low nutrient “marine deserts” appear to be expanding due to rising ocean surface temperatures. In UK waters, fish species are being affected by rising sea temperature and phytoplankton productivity is in decline. All these are discouraging signs, but there are options available to counter this trend: sea forestation, iron fertilisation and artificial upwelling, all mechanisms designed to encourage Phytoplankton productivity.

Through photosynthesis, Phytoplankton also consume carbon dioxide on a scale equivalent to forests and other land plants. Some of this carbon is carried to the deep ocean when Phytoplankton die, and some is transferred to different layers of the ocean as phytoplankton are eaten by other creatures, which themselves reproduce, generate waste, and die. Phytoplankton are responsible for most of the transfer of CO_2 from the atmosphere to the ocean. CO_2 is consumed during photosynthesis, and the carbon is incorporated in the Phytoplankton, just as carbon is stored in the wood and leaves of a tree. Most of the carbon is returned to near-surface waters when Phytoplankton are eaten or decompose, but some falls into the ocean depths. Worldwide, this “biological carbon pump” transfers about 10 gigatonnes of carbon from the atmosphere to the deep ocean each year. Even small changes in the growth of Phytoplankton may affect atmospheric CO_2 concentrations, which would feed back to global surface temperatures.

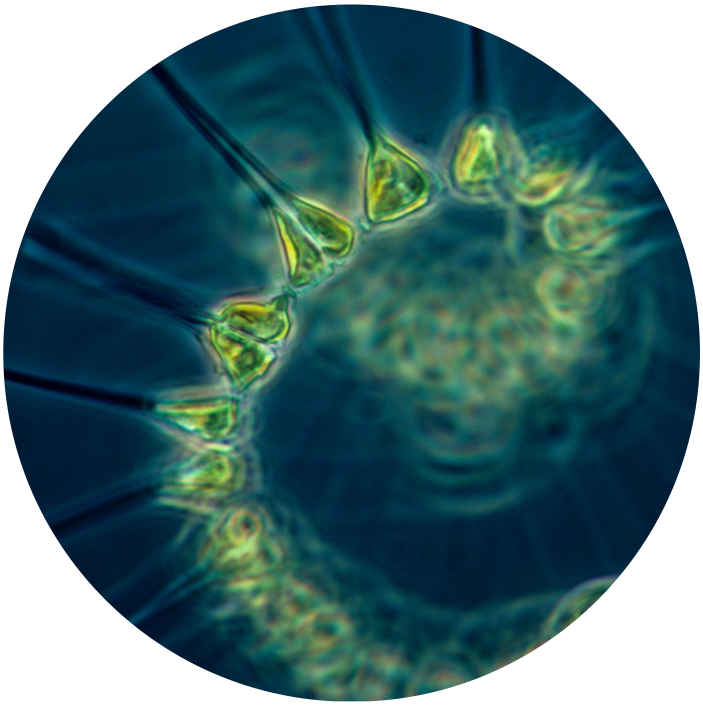
How is Phytoplankton productivity currently measured?

Currently, Phytoplankton samples are taken directly from the water at permanent observation stations or from ships and are measured in the lab using C14 assimilation experiments. Sampling devices include hoses and flasks to collect water samples, and sometimes, plankton are collected on filters dragged through the water behind a ship. Samples may be sealed and put on ice and transported for laboratory analysis, where researchers may be able to identify the Phytoplankton collected down to the genus or even species level through microscopic investigation or genetic analysis.

Although samples taken from the ocean are necessary for some studies, satellite technology currently accounts for most global-scale studies of Phytoplankton and their role in climate change. Individual Phytoplankton are tiny, but when they bloom by the billions, the high concentrations of chlorophyll and other light-harvesting pigments change the way the surface reflects light; the water may turn greenish, reddish, or brownish. Scientists use these changes in ocean colour to estimate Chlorophyll concentration and the biomass of Phytoplankton in the ocean.

Both of these traditional methods of measuring primary productivity make acquiring good data for ocean science challenging:

- Satellite remote sensing provides wide-scale monitoring, but produces large errors, requires validation and is unable to probe below the surface
- Traditional methods such as C14 fixation are slow, expensive laboratory-based processes requiring handling and training protocols for radioisotopes, with extremely long incubation times of 8-24hrs



What are the advantages of MicroSTAF?

Chelsea Technologies' Single Turnover Active Fluorometry (STAF) solutions provides a revolutionary new method to enable large-scale Phytoplankton assessment without the complications of conventional methodologies.

Until now, it has been difficult to find a single instrument capable of accurately measuring primary production at both high and extremely low concentrations of phytoplankton. Chelsea Technologies' new deployable active fluorometry system, MicroSTAF allows continuous monitoring of phytoplankton using the latest in STAF technology and combines an unparalleled sensitivity with a wide dynamic range.

MicroSTAF is capable of continuous measurement in extreme oligotrophic waters, open oceans, coastal waters and lakes with much greater precision than other methods. It provides a highly automated platform for running continuous Fluorescence Light Curves (FLCs) and incorporates new features to greatly improve the accuracy of STAF-based primary production assessment, including the correction of spectral errors, baseline fluorescence and the package effect.

Building on the LabSTAF system's proven reputation for the continuous interrogation of phytoplankton photosynthesis, MicroSTAF delivers the same scientific precision in a compact, low-power format ideal for integration with Marine Autonomous Systems (MAS), including surface AUVs, gliders, and floats.

MicroSTAF benefits from automation and exceptional sensitivity while requiring only 2 W of power, opening new possibilities for wide-scale and long-duration measurements. This step-change in deployability increases both the spatial and temporal coverage of STAF-based assessments of phytoplankton photosynthesis.

Benefitting from the same scientific advancements that have made LabSTAF a research standard, MicroSTAF features:

- Photochemical Excitation Profiles (PEPs) – enhancing STAF-based assessments through improved characterisation of phytoplankton photosynthetic parameters.
- Dual Waveband Measurements (DWMs) – providing full spectral correction and compensation for the package effect for more accurate fluorescence readings.

These features ensure that MicroSTAF delivers high-quality, comparable, data across a wide range of environments, from coastal zones to open oceans.

With an integrated pump for automated sample exchange and an optional Spectral PAR (SPAR) sensor, MicroSTAF brings full laboratory capability into the field.

The SPAR sensor measures spectral PAR at the point of sampling and optimises FLC protocols in real time, applying automated spectral correction for enhanced data quality.

Applications

- Analysis of the biochemistry & ecology of aquatic systems
- Verification of satellite data
- Facilitates measurement at scales from mesoscale eddies to oceanic fronts
- Climate change research & modelling
- Monitoring of algal bloom development & community structure
- Ecological monitoring to manage water catchments
- Identifying & mitigating sources affecting water quality in catchments

"We are thrilled to announce the launch of MicroSTAF — the culmination of more than 30 years of research and development in active fluorometry for monitoring primary productivity in the world's oceans.

MicroSTAF delivers the full functionality and exceptional performance of LabSTAF, our laboratory grade active fluorometer, in a compact, fully autonomous, and easily deployable sensor. Designed for seamless integration with a wide range of Marine Autonomous Systems, MicroSTAF represents a major step forward in ocean observation technology.

By enabling high resolution measurements of primary productivity across broader spatial and temporal scales than ever before, MicroSTAF will transform our ability to understand and monitor the health and dynamics of marine ecosystems."

Chelsea Technologies

sales@chelsea.co.uk
+44 (0)20 8491 9000
chelsea.co.uk

Address:
Chelsea Technologies Ltd
4 Tuscany Way, Yateley, Hampshire, GU46 6GF, UK