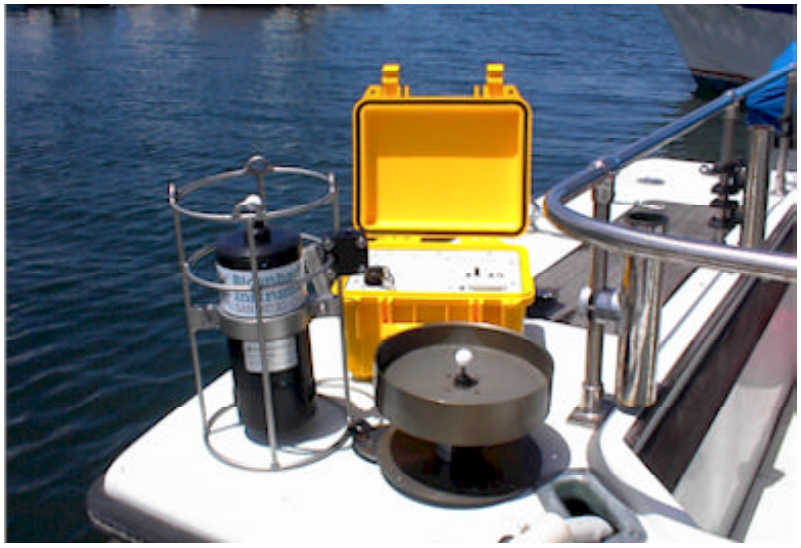
Biospherical Instruments Inc.

Optical Instruments for Environmental Monitoring

PNF-300 Profiling Natural Fluorometer System

The PNF-300 Profiling Natural Fluorometer is an integrated optical system designed to measure Photosynthetically Available Radiation (PAR) and Natural Fluorescence—the fluorescence from phytoplankton stimulated by available sunlight. Research conducted throughout the oceans of the world has shown that this measurement is related to photosynthetic rates and chlorophyll concentrations. Unlike strobe fluorometers, a natural fluorometer measures fluorescence emitted under the ambient light conditions that are driving photosynthesis *in situ*.

Battery-powered and easily deployed from vessels as small as inflatables, the PNF-300 system measures natural fluorescence, scalar irradiance of PAR (400-700 nm), temperature, and pressure/depth. Data from these sensors, as well as calculated chlorophyll concentration and instantaneous photosynthetic rates, are displayed in real time using Windows®-based PROFILER software provided with the system. To meet the requirements of a wide range of applications, this software supports both depth profiling, data analysis and time-series logging.



Measurements of natural fluorescence and PAR provide scientists with an important tool for investigating a variety of issues, including global phytoplankton productivity, water quality, and ocean optics.

The instrument was developed as part of a NASA-sponsored Small Business Innovative Research (SBIR) program entitled “New Approaches to Measurement of Chlorophyll, Related Pigments, and Productivity in the Sea.”

Key Features

- *Instantaneously measures natural fluorescence and PAR—indicators of phytoplankton productivity*
- *Provides data profiling and time-series logging of natural fluorescence, scalar PAR, water temperature,*
- *Matching surface sensor (QSR-2200) included*
- *Windows®-based PROFILER software operates the instrument and calculates such values as photosynthetic rates, volume fluorescence, and chlorophyll concentration*
- *Compact, rugged, battery-powered and hand deployed*

Underwater Scalar PAR Sensor

The ***Natural Fluorescence*** of chlorophyll *a* is defined as the total flux of light emitted by chlorophyll in a suspension of phytoplankton of unit volume under ambient light. Keifer *et al.* (1989) and Chamberlin *et al.* (1990) have shown that measurements of natural fluorescence and scalar irradiance provide accurate estimates of chlorophyll concentration as well as photosynthetic rate. The flux of natural fluorescence, F_f, can be used to estimate the instantaneous gross photosynthetic rate, F_c (Chamberlin *et al.* 1990):

$$F_c = \frac{(\phi_c / \phi_f)_{max} * F_f * k_{cf}}{k_{cf} + E_o \ (PAR)}$$

where $(\phi_c / \phi_f)_{max}$, an empirical constant, is the maximum value of the ratio of the quantum yields of photosynthesis and fluorescence, and k_{cf}, an empirical constant, is the value of irradiance when the ratio is equal to half of its maximum value.

With the PNF-300, profiles of irradiance, natural fluorescence, temperature, photosynthetic rate, and chlorophyll concentration may be recorded simultaneously.

Underwater Sensors

The upper sensor assembly of the PNF-300 includes an underwater PAR sensor. The quantum scalar PAR sensor consists of a 1.9 cm diameter solid Teflon® diffuser optically connected to the main housing by a black, resin-coated stainless steel-encased quartz light pipe. The field-of-view of the collector is scalar over nearly 4π steradians.

The lower sensor assembly includes a natural fluorescence ($L_u$chl) sensor as well as temperature and depth sensors and a cable interface. The natural fluorescence sensor is arranged to view upwelling nadir irradiance and is filtered to include the emission spectra of chlorophyll, while rejecting wavelengths less than 650 nm.

The temperature sensor is a platinum resistance transducer that operates from -5 to 35°C and has an accuracy of ±0.1°C. The depth sensor operates to 200 m full scale, with an accuracy of ±1% full scale. The instrument also allows the addition of two analog sensors.

Lowering Frame

A stainless-steel lowering frame supports and protects the unit as it is deployed via a 100-meter, Kevlar® reinforced cable. Longer cable lengths are available at additional cost.

Surface Reference

The associated surface PAR sensor (QSR-2200) uses the same Teflon® diffuser as the underwater PAR sensor and is scalar over 2π steradians (angle subtended by a hemisphere). It allows comparison of underwater and surface measurements to check instrument performance for interference from boat shadow or clouds. A 25-m weather-resistant cable is shipped with the surface instrument, although custom length cables are available at additional cost.

PNF-300 System Configuration

Underwater Fluorometer
- Natural Fluorescence Sensor ($L_u$chl)
- Scalar PAR Sensor
- Temperature Sensor (5 to 35°C)
- Depth Sensor (200 m depth range)
- Optional Support for Two Additional Sensors
- Lowering Frame (stainless steel)
- Lowering Cable (100 m standard; 200 m optional)

Surface Scalar PAR Sensor (QSR-2200) with 25-m surface cable

Windows®-based PROFILER operating and data-analysis software

Deckbox with RS-232 interface and 12 V, 6 AH rechargeable battery

Data Acquisition System

The PNF-300 system is equipped with a compact, battery-powered deckbox that provides computer interface and power distribution. Provided with the deckbox are an RS-232 serial interface cable, a 12 v, 6 AH rechargeable battery, and an AC Adapter/Charger that provides universal 85-264 VAC, 47-63 Hz recharging and AC to DC conversion.

Signals from all sensors are digitized and stored as 2-byte binary floating-point data. Data are retrieved as 12-bit resolution plus 3-bit exponent plus sign. The RS-232 format is 9600 baud, 8 bit, 1 stop, no parity, no handshaking.

PNF-300 system and PROFILER software require a Pentium®-1 / 350Mhz or better, PC with 32MB of RAM and RS-232 serial interface (for connection to the deckbox)

Natural Fluorescence Sensor Assembly

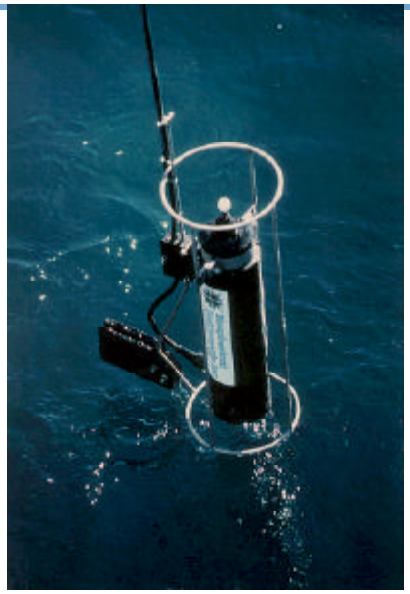
PNF-300 and PROFILER software can operate on most PC workstations. Additionally, a suitable battery-powered laptop provides great portability and immunity from shipboard power interruptions.

Software

PROFILER software is compatible with Windows® 98,NT,ME,2000, XP. The software is provided with the PNF-300 system and supports data acquisition and analysis functions for two modes of deployment—profiling and time-series logging. Data files are stored in an ACCESS® database format, allowing easy transfer to external applications.

Profiling mode is used when knowledge of the depth distribution of irradiance, chlorophyll concentration, and photosynthesis are required.

Data logging mode is used when time series of irradiance, temperature, chlorophyll concentration, and photosynthesis are required for applications such as *in situ* incubations or along a cruise track. Supporting software allows graphical display of the time series. Built-in functions provide capabilities for calculated chlorophyll concentration; instantaneous photosynthetic rate; integrated or averaged irradiance.



PNF-300 Deployment

References

Chamberlin, W.S., C.R. Booth, D.A. Kiefer, J.H. Morrow, and R.C. Murphy (1990). Evidence for a simple relationship between natural fluorescence, photosynthesis, and chlorophyll in the sea. *Deep-Sea Research*, 37(6): 951-973.

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Kiefer, D.A., W.S. Chamberline, and C.R. Booth (1989). Natural fluorescence of chlorophyll a: Relationship to photosynthesis and chlorophyll concentration in the western South Pacific gyre. *Limnology and Oceanography*, 34(5): 868-881.

White, B.N., D.A. Kiefer, J.H. Morrow, and G.F. Stolarik (1991). Remote biological monitoring in an open fished-water reservoir. *Journal American Water Works Association*, 83(9): 107-112.

**Specifications subject to change without notice*

Specifications

Physical

Diameter: 10 cm
Length: 32 cm
Depth Range: 200 m
Materials: Lightweight, rugged plastic housing
Weight: 2.0 kg (in air without frame), 3.6 kg (in air with frame)
Temperature Rating: -5 to 35°C
Lowering Frame: 316 stainless steel; 33 cm by 19 cm; weighs 1.6 kg (in air)

Underwater PAR Sensor

Collector: 1.9 cm diameter spherical Teflon® diffuser
Quantum Response: Flat from 400 to 700 nm
Field-of-view: Scalar over nearly 4π steradians
Typical Maximum Irradiance: 4,000 microE m^{-2} sec^{-1}
Smallest Resolvable Irradiance: 10^{-6} relative to full scale

Natural Fluorescence Sensor

Field-of-view: 26° full angle
Typical Full-scale: 50 nE m^{-2} str^{-1} sec^{-1}
Smallest Resolvable Radiance: 10^{-6} relative to full scale
Spectral Response: Equal (better than ± 10%) quantum response from 400 nm to 700 nm with response sharply attenuated above 700 nm and below 400 nm

Temperature Sensor

Type: Platinum resistance transducer
Range: -5 to 35°C
Accuracy: ±0.1°C
Resolution: 0.03°C

Depth Sensor

Range: 200 m full scale **Accuracy:** ±1% full scale **Calibration:** In meters, assuming a water density of 1.000 g cm^{-3}

Additional Sensors

QCP-2200 quantum cosine PAR sensor, transmissometer, fluorometer and instrument inclinometer available at additional cost.

Underwater Cable

100-m long, Kevlar®-reinforced, shielded underwater cable. No winch or additional lowering cable is required for profile operation. Typical weight in air 0.1 kg m^{-1}. (Custom cable lengths to 200 m are available at additional cost.)

Surface PAR Sensor (QSR-2200)

PAR Sensor: Quantum response flat from 400 to 700 nm
Field-of-view: Scalar over 2π steradians (angle subtended by a hemisphere)
Usable Irradiance Range: 5 to 10,000 µE m^{-2} sec^{-1}
Temperature Range: -5°C to 35°C
Housing: 20 cm in diameter and 15 cm high; weighs 1.1 kg
Surface Cable: 25 meters long, weather-resistant shielded cable. Other lengths available at additional cost.

Calibration

Both instruments are calibrated using a National Institute of Standards and Technology (NIST)-traceable 1000 watt-type FEL Standard of Spectral Irradiance. Annual calibration is recommended.

Digital Sensor Interface

Signals from all sensors are digitized and stored as 2 byte binary floating point data. Data are retrieved as 12-bit resolution plus 3-bit exponent plus sign. Autoranging data acquisition supplies 20-bit dynamic range. RS-232 format is 9600 baud, 8 bit, 1 stop, no parity, no handshaking.

Cable Interface

External analog sensor interface has two analog inputs available for connection of external sensors. The input voltage range allowed is ±10 volts full scale. Power available for these external sensors is +12 volts (maximum). Also provides RS-232 interface.

Deckbox

Battery-powered deckbox provides interface for both underwater and surface units. Includes 25-pin RS-232 connector. System is powered by a 12 V, 6 AH rechargeable battery. Normal operating time between charges is 29 hours. Recharge time is 24 hours.

Dimensions: 18 cm high by 28 cm wide by 25 cm deep
Weight: 5.0 kg

Universal AC Adapter/ Charger: 120-240 VAC, 60/50 Hz

Product is covered under U.S. Patent Numbers 4,804,849 and 4,178,101

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