SPECIFICATIONS FOR MULTIPLE WAVELENGTH FLUOROMETER/OPTICAL BACKSCATTER INSTRUMENTS ON MOBILE ASSETS AND PROFILERS

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Document Control Sheet

Version	Date	Description	Originator
0-01	5/18/2010	Derived Profiler specs from general Fluorometer spec.	Rob DelCoco
0-02	5/19/2010	Changed title to include all mobile assets and profilers	Rob DelCoco
0-03	5/21/2010	Revised according to SWG call 5/19 – changed BACK-001 to red wavelength from blue, green, red. Removed sampling rate SAMP-001 from mobile asset spec	Lorraine Brasseur
1-00	5/25/2010	Revised with SE comments, clarified SAMP-001 and SAMP-002; clarified meaning and language regarding excitation and emission wavelengths; added PACK-001	Lorraine Brasseur
1-01	6/09/2010	Partial changes from Tim, Oscar	Lorraine Brasseur
1-02	6/15/2010	Changes from Tim, Oscar, Ed Dever regarding backscatter and number of wavelengths required	Lorraine Brasseur
1-03	6/17/2010	Typos corrected, comments on optical backscatter, coastal and global sampling specifications made explicit – added SAMP-003 for cabled shallow profilers	Ed Dever, Lorraine Brasseur
1-04	6/17/2010	SE suggested wording accepted	Lorraine Brasseur
1-05	01/12/2011	Reformatted to new template	Arthur Salwin (Noblis)
1-06	01/19/2011	Moved linearity spec under accuracy heading for fluorescence. Added accuracy spec for backscatter. Combined lower detection limit with min value of range.	Arthur Salwin (Noblis)
1-07	01/26/2011	Changed document scope and purpose to include profilers and to clean up AUV and glider. Additional changes based on discussions with experts	Lorraine Brasseur
1-08	01/26/2011	Editorial fixes	Arthur Salwin (Noblis)

1-09	02/07/2011	Revised per comments received on ECR #1300-00117 & 1300-00118	Arthur Salwin (Noblis)
1-10	02/10/2011	Minor edits	Rob DelCoco
1-11	02/11/2011	New comment numbers incorporated	Arthur Salwin (Noblis)
2-00	02/15/2011	Approved by Systems Engineer. ECR #1300-000118	Ed Chapman
2-01	06/09/2011	Changed CHLO-007 and CDOM-004; replaced BACK-006 with BACK-007; minor editorial changes	Arthur Salwin (Noblis)
2-02	7/26/2011	Leave BACK-006 as “(Reserved)” to avoid jump in numbering. ECR #1300-00186	Rob DelCoco
2-03	10/03/2011	Administrative Changes and addition of requirements numbers for CDOM-003	Ed Chapman

Signature Page

This document has been reviewed and approved for release to Configuration Management.

OOI Senior Systems Engineer:  .

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1 General

1.1 Ocean Observatories Initiative (OOI) Overview

Although the ocean is central to the habitability of our planet, it is largely unexplored. Biological, chemical, physical, and geological processes interact in complex ways in the ocean, at the seafloor, and at the air-sea interface. Our ability to learn more about these processes is severely limited by technical infrastructure, and developing a more fundamental scientific understanding of these relationships requires new and transformational approaches to ocean observation and experimentation.

The Ocean Observatories Initiative (OOI) will lay the foundation for future ocean science observations. OOI will enable powerful new scientific approaches by transforming the community's focus from expedition-based data gathering to persistent, controllable observations from a suite of interconnected sensors. The OOI's networked sensor grid will collect ocean and seafloor data at high sampling rates over years to decades. Researchers will make simultaneous, interdisciplinary measurements to investigate a spectrum of phenomena including episodic, short-lived events (tectonic, volcanic, oceanographic, biological, and meteorological), and more subtle, longer-term changes and emergent phenomena in ocean systems (circulation patterns, climate change, ocean acidity, and ecosystem trends).

The OOI will enable multiple scales of marine observations that are integrated into one observing system via common design elements and an overarching, interactive cyberinfrastructure. Coastal-scale assets of the OOI will expand existing observations off both U.S. coasts, creating focused, configurable observing regions. Regional cabled observing platforms will 'wire' a single region in the Northeast Pacific Ocean with a high speed optical and high power grid. Global components address planetary-scale changes via moored open-ocean buoys linked to shore via satellite. Through a unifying cyberinfrastructure, researchers will control sampling strategies of experiments deployed on one part of the system in response to remote detection of events by other parts of the system.

A more detailed discussion of the Ocean Observatories Initiative can be found in the OOI Final Network Design.

1.2 Document Scope and Purpose

This document provides specifications for instruments on mobile assets and profilers that measure Optical Backscatter, Chlorophyll-a Fluorescence, and CDOM Fluorescence in seawater. These assets include gliders, Autonomous Underwater Vehicles (AUVs), wire-following profilers, and moored shallow/surface piercing profilers.

Gliders are buoyancy-driven, battery powered underwater vehicles that achieve propulsion by changing their volume by pumping to or from an oil-filled bladder. When they dive or rise, the glider's wings achieve lift allowing the glider to fly forward through the water. They can achieve speeds of about one tenth of those of the AUVs or ~25 to 35 cm s^{-1}. At the surface, gliders acquire position information using GPS and transmit data and receive commands via satellite.

AUVs are somewhat like instrumented torpedoes, though optimized for longer life at slower speeds while carrying a sensor payload. Optimum speeds for AUVs used in oceanographic applications are near 1.7 m s^{-1}, while maximum speeds of about 2.5 m s^{-1} may be reached. AUVs have a high payload capacity relative to gliders, and will carry a broad suite of sensors for interdisciplinary observations. They surface to obtain position fixes using GPS and while at the surface they also enter the OOI communications network using satellite telemetry.

Moored wire-following profilers contain a suite of sensors that are raised and lowered through the water column on a regular basis. These are generally used for deep measurements and profiles

that can extent to more than 1000 meters in depth. It is expected that these profilers will move vertically at speeds up to about 0.25 m/s.

Moored shallow/surface piercing profilers are expected to be used in the first 200 meters of the water column on OOI arrays. These profilers will carry a somewhat larger payload than wire-following profilers and can move vertically at speeds up to 0.5 m/s

1.3 Documents

1.3.1 Informational

The documents listed in this section are for informational purposes only and may not have been referenced in this specification.

- Consortium for Ocean Leadership, Inc. 2010, "Final Network Design", Washington, D.C. [Online] Available: http://www.oceanleadership.org/wp-content/uploads/2009/02/1101-00000_FND_OOI_ver_2-06_Pub.pdf

1.3.2 Applicable

These documents contain requirements and specifications applicable to the instrument specified. The referenced section, requirement, or specification shall be met by the instrument specified herein.

N/A

1.4 Definitions

1.4.1 Glossary and Acronyms

- **Accuracy** – Closeness of the agreement between the result of a measurement and the value of the measurand (or true value of the measurement). (Taylor and Kuyatt, 1994).
- **AUV** – Autonomous Underwater Vehicle
- **bb(λ)** – Optical Backscatter coefficient at wavelength λ
- **Cabled** – Any OOI platform that is connected to a communications/power cable connected to shore. The platforms on the backbone cable in the Northeast Pacific are examples.
- **CDOM** – Colored Dissolved Organic Matter
- **Coastal** – For OOI, a coastal or coastal ocean site is located on the continental shelf or upper slope at a depth of 1000 m or less.
- **EIA** – Electronics Industries Association
- **Instrument** – A device that contains one or more sensors and a method for converting the information from the sensor into a transmittable and storable form.
- **Objective Value** – The desired value of a technical parameter. This value, if provided, may be more challenging to achieve than the Threshold value. It is a goal, not a requirement, for the instrument.
- **OOI** – Ocean Observatories Initiative
- **Open Ocean** – Open ocean site is any site located at an ocean depth greater than 1000 meters or more than 500 km from shore.
- **Operate** – Correctly performing designed functionality.
- **ppb** – Parts per billion

- **Precision** – The closeness of agreement between independent measurements obtained under stipulated conditions of repeatability, generally expressed as a standard deviation (or standard uncertainty) of measurement results. Used as a measure of stability of an instrument/sensor and its capability of producing the same measurement over and over again for the same input signal (Taylor and Kuyatt, 1994).
- **Resolution** – The smallest amount of input signal change that the instrument/sensor can detect reliably.
- **PSS** – Practical Salinity Scale, the UNESCO Practical Salinity Scale of 1978 (PSS78). PSS defines salinity as a dimensionless conductivity ratio.
- **Sensor** – A device that will convert a physical phenomenon into an electrical signal that can in turn be digitized through the use of an analog to digital converter. A sensor is normally housed in an instrument. Data coming from sensors is normally raw and needs to be calibrated.
- **Survive** – Experience an event without major loss of hardware. System might experience loss of functionality requiring repair to return to normal mode functionality. An example of this is knockdown of a global mooring or loss of some part of the mooring resulting in the instrument descending to the bottom. Any internal memory in the instrument would remain accessible, but the sensors might need to be replaced to return to normal functionality.
- **Sustain** – Experience an event (environmental extreme or condition) without permanent loss of normal mode functionality. System may experience reduction of functionality during event.
- **Threshold Value** – The limiting acceptable value of a technical parameter. If this item does not meet the performance as specified by the threshold value, it may not be sufficient for inclusion in the OOI system.

1.4.2 Conventions

All values contained in this document are Threshold Values unless specifically stated otherwise.

The bidder shall ignore the references in angle brackets < > at the end of each specification. They are for internal OOI use only.

2 Specifications

2.1 Measurement

MEAS-001 All measurements (optical backscatter, chlorophyll-a fluorescence, and CDOM fluorescence) should be made by the same instrument. This is an objective.

2.1.1 Optical Backscatter

a) Measurement with unit(s)

Optical Backscatter coefficient (bb(λ) m^{-1})

b) Minimum Value

BACK-001 The instrument shall measure optical backscatter over a range with a minimum value of 0.001 bb(λ) m^{-1}. <L2-SR-RQ-3541, L4-CG-IP-RQ-393, L4-RSN-IP-RQ-360>

c) Maximum Value

BACK-002 The instrument shall measure optical backscatter over a range with a maximum value of 0.2 bb(λ) m^{-1}. <L2-SR-RQ-3541, L4-CG-IP-RQ-393, L4-RSN-IP-RQ-360>

d) Accuracy

While accuracy is important to this measurement, a threshold value for accuracy is not provided in this document.

e) Precision

While precision is important to this measurement, a threshold value for precision is not provided in this document.

f) Resolution

While resolution is important to this measurement, a threshold value for resolution is not provided in this document.

g) Drift

While drift is important to this measurement, a threshold value for drift is not provided in this document.

h) Response Times

Not specified

i) Sampling Frequency

BACK-003 The instrument shall be capable of measuring optical backscatter at a sampling frequency of 1 Hz. <L2-SR-RQ-3542, L4-CG-IP-RQ-223, L4-RSN-IP-RQ-361>

j) Dependencies

Not specified

k) Wavelength bands

BACK-004 The instrument shall excite and measure optical backscatter in at least one band in the visible spectrum. <L2-SR-RQ-3787, L4-CG-IP-RQ-551, L4-RSN-IP-RQ-609>

BACK-005 The instrument should excite and measure optical backscatter in two or more bands in the visible spectrum. This is an objective. <L2-SR-RQ-3788, L4-CG-IP-RQ-552, L4-RSN-IP-RQ-610>

BACK-006 (Reserved)

BACK-007 The instrument shall report measurements in all bands. <L2-SR-RQ-3892, L4-CG-IP-RQ-659, L4-RSN-IP-RQ-747>

2.1.2 Chlorophyll-a Fluorescence

a) Measurement with unit(s)

Chlorophyll-a concentration (µg/L)

b) Minimum Value

CHLO-001 The instrument shall measure chlorophyll-a concentration over a range with a minimum value of 0.03 µg/L for the coastal ocean. <L2-SR-RQ-3554, L4-CG-IP-RQ-217>

CHLO-002 The instrument shall measure chlorophyll-a concentration over a range with a minimum value of 0.01 µg/L for the open ocean. <L2-SR-RQ-3791, L4-CG-IP-RQ-555, L4-RSN-IP-RQ-366>

c) Maximum Value

CHLO-003 The instrument shall measure chlorophyll-a concentration over a range with a maximum value of 50 µg/L for the coastal ocean. <L2-SR-RQ-3554, L4-CG-IP-RQ-217>

CHLO-004 The instrument should measure chlorophyll-a concentration over a range with a maximum value of 125 µg/L for the coastal ocean. This is an objective. <L2-SR-RQ-3790, L4-CG-IP-RQ-554>

CHLO-005 The instrument shall measure chlorophyll-a concentration over a range with a maximum value of 10 µg/L for the open ocean. <L2-SR-RQ-3791, L4-CG-IP-RQ-555, L4-RSN-IP-RQ-366>

d) Accuracy

While accuracy is important to this measurement, a threshold value for accuracy is not provided in this document.

e) Precision

While precision is important to this measurement, a threshold value for precision is not provided in this document.

f) Resolution

While resolution is important to this measurement, a threshold value for resolution is not provided in this document.

g) Drift

While drift is important to this measurement, a threshold value for drift is not provided in this document.

h) Response Times

Not specified

i) Sampling Frequency

CHLO-006 The instrument shall be capable of measuring chlorophyll-a fluorescence at a sampling frequency of 1 Hz. <L2-SR-RQ-3555, L4-CG-IP-RQ-395, L4-RSN-IP-RQ-367>

j) Dependencies

Not specified

k) Wavelengths

CHLO-007 The instrument shall measure fluorescence between 675 and 700 nm induced by excitation between 425 and 490 nm. <L4-CG-IP-RQ-213, L4-RSN-IP-RQ-612>

2.1.3 CDOM Fluorescence

a) Measurement with unit(s)

CDOM concentration (ppb)

b) Minimum Value

CDOM-001 The instrument shall measure CDOM concentration over a range with a minimum value of 0.09 ppb relative to a quinine sulfate standard. <L2-SR-RQ-3557, L4-CG-IP-RQ-219, L4-RSN-IP-RQ-372>

c) Maximum Value

CDOM-002 The instrument shall measure CDOM concentration over a range with a maximum value of 500 ppb relative to a quinine sulfate standard. <L2-SR-RQ-3557, L4-CG-IP-RQ-219, L4-RSN-IP-RQ-372>

d) Accuracy

While accuracy is important to this measurement, a threshold value for accuracy is not provided in this document.

e) Precision

While precision is important to this measurement, a threshold value for precision is not provided in this document.

f) Resolution

While resolution is important to this measurement, a threshold value for resolution is not provided in this document.

g) Drift

While drift is important to this measurement, a threshold value for drift is not provided in this document.

h) Response Times

Not specified

i) Sampling Frequency

CDOM-003 The instrument shall be capable of measuring CDOM fluorescence at a sampling frequency of 1 Hz. <L2-SR-RQ-3558, L4-CG-IP-RQ-397, L4-RSN-IP-RQ-373>

j) Dependencies

Not specified

k) Wavelengths

CDOM-004 The instrument shall measure fluorescence between 425 and 480 nm induced by excitation between 345 and 380 nm. <L4-CG-IP-RQ-214, L4-RSN-IP-RQ-613>

2.2 Operational

See platform specifications.

2.3 Mechanical/Physical

See platform specifications.

2.4 Electrical

See platform specifications.

2.5 Data Storage and Processing

See platform specifications.

2.6 Software/Firmware

See platform specifications.

2.7 Platform Interfaces

See platform specifications.

2.8 Compliance

See platform specifications.

2.9 Safety

See platform specifications.

2.10 Shipping and Storage

See platform specifications.

2.11 Identification

See platform specifications.

2.12 Quality

See platform specifications.

3 Appendices

A-1. Specification Values by the Platform on Which the Instruments are Deployed

The following table provides specifications that vary by the platform on which the instrument is deployed.

Instrument Series	Cabled	Location	# Optical Backscatter Bands	Chlorophyll-a Measurement Required	Chlorophyll-a Range (µg/L)	CDOM Measurement Required	Platforms
Z	C	O	1	Y	0.01 - 10	Y	Shallow water profilers
Y	C	O	1	Y	0.01 - 10	N	Shallow water profilers
X	C	O	1	Y	0.01 - 10	Y	Deep profilers
W	U	C	1	Y	0.03 - 50 (see note 1)	Y	Wire-following profilers, Surface-piercing profilers, Gliders, AUVs
V	C	C	1	Y	0.03 - 50 (see note 1)	Y	Deep profilers, Surface-Piercing profilers
U	U	O	1 (see note 2)	Y	0.01 - 10	N (see note 3)	Wire-following profilers, Surface-piercing profilers, Gliders

Key:

Cabled:
- C denotes platforms attached to the electro-optic cable in the Pacific Northwest (cabled)
- U denotes platforms that have no cable connection to shore for power or data (uncabled)

Location:
- O is open ocean
- C is coastal

Note 1: The objective value for the upper limit of the range is 125 µg/L for Series W and V.

Note 2: Additional optical backscatter bands may be included if they do not impact biofouling mitigation, chlorophyll-a accuracy, size, weight, or power usage.

Note 3: CDOM may be included if it does not impact biofouling mitigation, chlorophyll-a accuracy, size, weight, or power usage.