MBARI-ISUS Operation Manual

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Operation Manual For: MBARI-ISUS
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A. OVERVIEW

Figure A-1: The MBARI-ISUS with Rechargeable Battery Pack

Purpose

The MBARI-ISUS (commonly referred to as ISUS) is a spectrophotometer that uses ultraviolet absorption spectroscopy techniques to measure in situ dissolved chemical species. This sensor is a chemical-free, solid-state instrument that offers easy, accurate, real-time, and continuous nitrate concentration measurements. The MBARI-ISUS provides researchers with data essential to the study of physical, chemical, and biological processes in the ocean.

See *Figure A-1: The MBARI-ISUS with Rechargeable Battery Pack*

Background

The MBARI-ISUS was developed by Dr. Kenneth Johnson and Luke Coletti, of the Monterey Bay Aquarium Research Institute (MBARI). For a detailed description of the MBARI prototype system see their paper (Johnson, K., L. Coletti (2002), In situ ultraviolet spectrometry for high resolution and long-term monitoring of nitrate, bromide and bisulfide in the ocean, *Deep-Sea Research I*, **49**, 1291-1305). Satlantic and MBARI collaborated to make the instrument commercially available to researchers around the globe. Satlantic has made significant advances in both system hardware and computational software to provide customers with the state-of-the-art in in situ spectroscopic analysis.

Using advanced UV absorption techniques, the MBARI-ISUS calculates NO_3^- from the seawater absorption spectrum, without the need for chemical manipulation.

The MBARI-ISUS has the stability, sensitivity, and endurance to operate for extended periods of time with low maintenance. It has been successfully deployed in a variety of marine environments and operational modes, including:

- **Profiling systems** – High-resolution nitrate profiles allow insight into nutrient structures.
- **Fixed platform/moorings** – the flexible sampling schedule and internal data storage capacity allow easy integration into a monitoring program.
- **Towed vehicles** – the data is collected by the vehicle's data acquisition system or logged internally

Features

The features of ISUS include:

- Real-time Nitrate measurements
- Analog output port for easy integration with CTD and other sensors
- Low power, compact size
- Fast sample frequency
- High data precision and accuracy
- Deep operation
- Spectral analysis software (under development)

Specifications[1]

Performance

Precision:	± 0.05 µM
Accuracy:	± 2 µM
Detection range:	0.5 to 200 µM

Optics

Path length:	1 cm
Wavelength range:	200 – 400 nm
Lamp type:	Deuterium
Lamp lifetime:	1000 hours to 50% intensity at 240 nm

Electrical Characteristics

Input Voltage:	9 – 24 VDC (Non-isolated power input port) 19 – 75 VDC (Isolated power input port) 11 – 36 VDC (Optional isolated input range)
Current requirement:	1 Amp @ 12 VDC (nominal)
Power consumption:	12 Watts (nominal)
Data storage:	128 MB
Sample rate:	0.5 Hz (typical)
Telemetry options:	Analog output 0 – 4.096 VDC RS-232/RS-422 serial output User selectable baud rates (default 38400 bps)

Physical Characteristics

<u>Anodized Aluminum pressure case</u>

Depth rating:	1000 meters
Length:	19.10 inches (485.1 mm) – housing only 22.85 inches (580.4 mm) – including anode and standard probe guard 23.95 inches (608.3 mm) – including anode and biofouling guard
Diameter:	4.5 inches (114.3 mm)
Weight:	With standard probe guard: 12.8 lbs in air (5.8 kg), 1.5 lbs in water (0.68 kg) With biofouling guard 13 lbs in air (5.9 Kg), 1.7 lbs in water (0.77 Kg)
Operating temperature range:	0° to 35° C

[1] Specifications may change without notice.

MBARI-ISUS System

Principle of Operation

The MBARI-ISUS uses the UV (200-400nm) absorption characteristics of various chemical species to provide in situ measurements of their concentrations in solution. The system consists of four key components: a stable UV light source, a UV spectrometer, a fiber optic sampling probe and a processing computer. All components are housed within a single pressure case. A plastic guard covers and protects the sampling probe in profiling applications. An optional antifouling probe guard covers the sampling probe and provides interference from fouling organisms in moored applications. The precision calibration of the MBARI-ISUS uses standard sample solutions over a range of temperature conditions. The system is solid state and requires no user adjustments or chemicals to operate. Once powered up, the system begins to compute nitrate concentrations of solutions in the sample probe automatically.

Many dissolved inorganic compounds, including nitrate, nitrite, bisulfide, and bromide, absorb light at UV wavelengths.

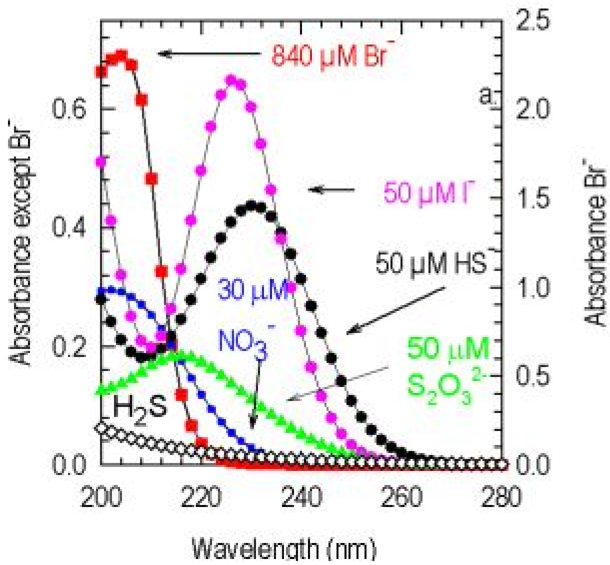

Figure A-2: Primary UV Absorbing Species in Seawater

Nitrate is one of the main nutrients required for growth of phytoplankton. Understanding the distribution of nitrate in the oceans is essential to understanding biological processes.

The MBARI-ISUS is designed to be a self-contained nitrate monitoring system that does not use 'wet chemistry' (i.e. does not require reagents) to determine nitrate concentration. Eliminating the use of wet chemistry results in a less complex, more reliable, and easier to use system.

The standard method for measuring nitrate in the past was to collect samples at sea, freeze them and bring them back to a lab, using a system called an autoanalyser. The autoanalyser relies on mixing chemicals with the sample to create a reaction that results in a coloured solution that can be quantitatively measured. Systems that use this technique in situ are complex because they require mixing limited shelf life reagents and loading these into the instruments.

The MBARI-ISUS is based on the well-known absorption characteristics of inorganic compounds in the UV portion of the spectrum from 200-400nm. By illuminating a sample of seawater with UV light onto a UV spectrometer, the absorption spectra can be measured. The calibration process of the system creates a library of absorption spectra for the main absorbing species in this region of the spectrum. Using an optimization process, the concentrations of the calibrated species spectra are adjusted until the computed spectrum matches the measured one.

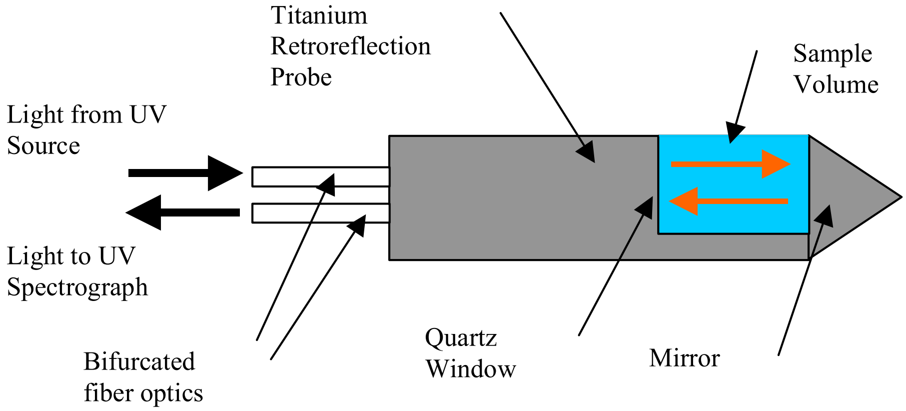

Figure A-3: Seawater Sample Illumination

Calibration

Calibration data is programmed into the system at Satlantic for nitrate computations. Calibrations are performed by measuring the absorption spectra of 48 samples from 0-40 µM nitrate, 0-35 psu salinity and 0-25 C temperature. These measurements fully characterize the system for the full range of field applications. Contact Satlantic for calibrations outside of this measurement range.

Operational Summary

The MBARI-ISUS is equipped with multiple interfaces for easy adaptation to individual applications. ISUS provides user data in four formats: analog outputs for easy interfacing to CTD systems (see Satlantic Tech Note – Interfacing the ISUS to a SeaBird CTD profiler), two telemetry formats (compressed concentration only formats and full spectral output), and full spectral output stored on an internal 128MB flash card. Details on the data formats can be found in Section D OPERATION. The MBARI-ISUS may be powered from a battery pack (rechargeable or high capacity replaceable cells) or from other external power sources.

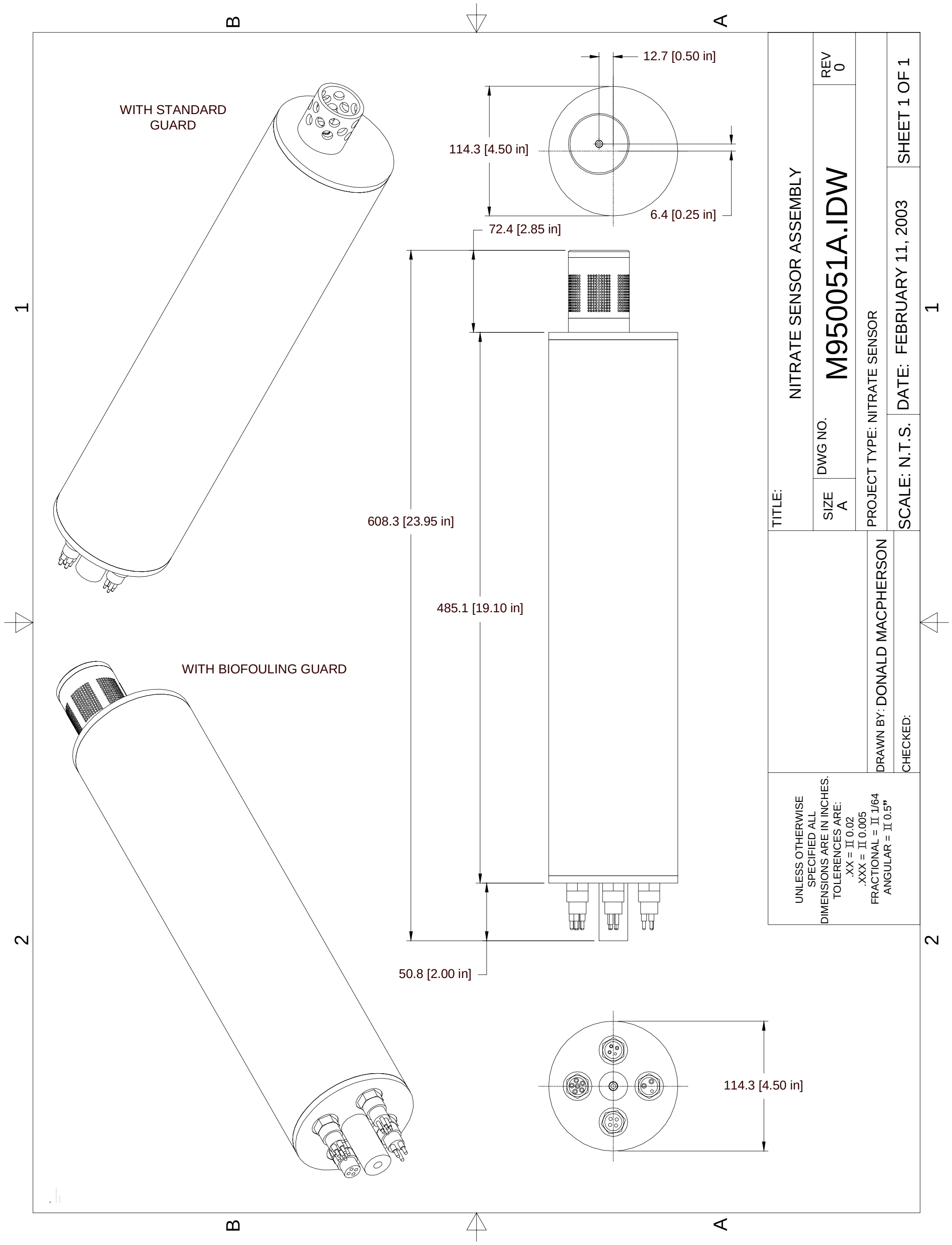

Figure A-4: The MBARI-ISUS Anodized Aluminum Body

Major Components

The major components of the MBARI-ISUS are the instrument body, the connector end cap, the probe end cap, and the external power source. A computer with a free RS-232 serial port (or a free USB port with a USB to RS-232 converter) is required to configure the ISUS and to offload data.

Please note that in this manual, the term RS-232 implies EIA-232.

ISUS Instrument Body

The MBARI-ISUS housing is a standard Satlantic pressure case design, consisting of a corrosion-resistant anodized aluminum tube with two anodized aluminum end caps. A 2" long zinc sacrificial anode provides further protection against galvanic corrosion.

See Figure A-4: The MBARI-ISUS Anodized Aluminum Body

Connector End Cap

The bottom end cap contains a zinc sacrificial anode and 4 bulkhead connectors; each bulkhead is a different “port” on the instrument. There are a variety of configuration options available for the CTD port. Normally, all of the connectors are Subconn or Impulse MCBH series, but optional SEACON Brantner XSJJ series are available for cold weather use. The pin-out and function of each configuration is described in the following sections. Please consult Satlantic if you require a custom interface.

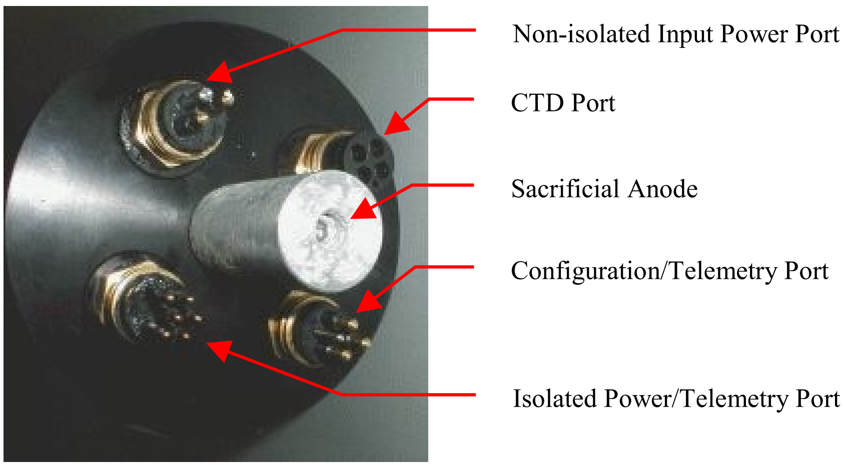

Figure A-5: Connector End Cap

Standard MCBH series Connectors

MCBH2M (2 pin male)- Non-isolated Input Power Port

This connector is used to provide power to the ISUS, typically from a battery pack or a bench top power supply for laboratory use.

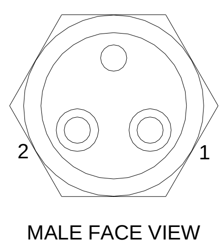

Figure A-6: MCBH2M Bulkhead

Pin	Name	Description
1	VBATT+	Input Power, 9-24 VDC
2	VBATT-/GND	Power common

MCBH3M (3 pin male)- Configuration/Telemetry Port
This port is used to provide bi-directional non-isolated RS-232 communications with the ISUS.

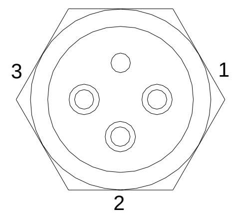

Figure A-7: MCBH3M Bulkhead

Pin	Name	Description
1	TXD	RS-232 Data from ISUS to computer
2	VBATT-/GND	Power common
3	RXD	RS-232 Data from computer to ISUS

MCBH6M (6 pin male)- Isolated Power and Telemetry Port
Some applications may require the use of isolated power and telemetry, or require that the instrument operate an extended distance from the power supply or logging computer. This port provides such functionality.

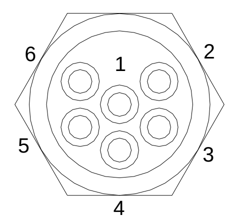

Figure A-8: MCBH6M Bulkhead

Pin	Name	Description
1	VIN+	Isolated Input power, 19 – 75 VDC
2	GNDISO	Isolated ground
3	TA	RS-485+
4	TB	RS-485-
5	TXD_ISO	Isolated RS-232 Data from ISUS to computer
6	RXD_ISO	Isolated RS-232 Data from computer to ISUS

CTD Port Bulkhead Configurations

The following Bulkhead Configurations (BC) are currently available for the CTD port on the MBARI-ISUS:

- BC-1: Isolated Analog Output
- BC-2: Isolated Analog Output with Power Input
- BC-3: Custom Foreign Device Interface

BC-1: MCBH4F (4 pin female)- Isolated Analog Output

This port is used to output an analog representation of the calculated nitrate concentration and salinity values. CTDs or other data loggers can record these voltages. The voltages are isolated and generated from precision 16-bit DACs (Digital-To-Analog Converters).

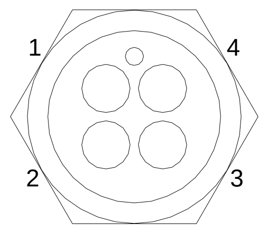

Figure A-9: MCBH4F Bulkhead

Pin	Name	Description
1	NITRATE+	Analog voltage representing the calculated nitrate concentration (0-4.096 V)
2	NITRATE-	Analog common
3	SALINITY+	Analog voltage representing the calculated salinity (0-4.096 V)
4	SALINITY-	Analog common

BC-2: MCBH6F (6 pin female)- Isolated Analog Output with Power Input

Similar to BC-1, however input power (9-24 VDC) can also be applied at this port. This is useful for external analog data loggers (such as some CTDs) with sufficient auxiliary power for the MBARI-ISUS.

Pin	Name	Description
1	VAUX-/GND	Power common
2	NITRATE+	Analog voltage representing the calculated nitrate concentration (0-4.096 V)
3	NITRATE-	Analog common
4	SALINITY+	Analog voltage representing the calculated salinity (0-4.096 V)
5	SALINITY-	Analog common
6	VAUX+	Input Power, 9-24 VDC

BC-3: MCBH4F (4 pin female)- Custom Foreign Device Interface
This port is used to allow the MBARI-ISUS to switch power to and obtain RS-232 telemetry from foreign instruments, such as a CTD. Custom firmware will be required in order to interface the foreign device – please consult Satlantic if you have a RS-232 instrument that you would like to have integrated with the MBARI-ISUS. This configuration is very useful as it allows the MBARI-ISUS to integrate other data into its telemetry stream. Consider using this configuration when you have a small RS-232 output CTD or pressure sensor.

To date, an Ocean Sensors OS200 CTD with a custom ROM has been integrated with the MBARI-ISUS.

Pin	Name	Description
1	DEV_GND	Power common (internally connected to VBATT-/GND)
2	DEV_TX	RS-232 data from device to ISUS
3	DEV_RX	RS-232 data from ISUS to device
4	DEV_PWR	+6 VDC to device (other voltages may be available on request)

Optional SEACON Brantner XSJJ Series Connectors

These connectors allow the ISUS to be used in areas where the air temperature can exceed the rated operating temperature of the Subconn connectors. However, extreme care should be used with these connectors. While their plastic and glass-reinforced epoxy bodies give them a lower operating temperature of -57°C, they are quite brittle. Be careful not to drop the mating connectors on to a hard surface (such as a ship's deck), as they will break.

Also notice that there are two 7-pin connectors used. Normally, the analog port will be marked with coloured tape. Notice, however, that the wiring helps prevent damage if the connectors are confused, as the power pin on one connector is a no-connect on the other.

XSJJ-2-BCR (2 pin)- Non-isolated Input Power Port
This connector is used to provide power to the ISUS, typically from a battery pack or a bench top power supply for laboratory use.

Pin	Name	Description
1	VBATT+	Input Power, 9-24 VDC
2	VBATT-/GND	Power common

XSJJ-3-BCR (3 pin)- Configuration/Telemetry Port
This port is used to provide bi-directional non-isolated RS-232 communications with the ISUS.

Pin	Name	Description
1	TXD	RS-232 Data from ISUS to computer
2	VBATT-/GND	Power common
3	RXD	RS-232 Data from computer to ISUS

XSJJ-2-BCR (7 pin)- Isolated Power and Telemetry Port
Some applications may require the use of isolated power and telemetry, or require that the instrument operate and extended distance from the power supply or logging computer. This port provides such functionality.

Pin	Name	Description
1	VIN+	Isolated Input power, 19 – 75 VDC
2	GNDISO	Isolated ground
3	TA	RS-485+
4	TB	RS-485-
5	TXD_ISO	Isolated RS-232 Data from ISUS to computer
6	RXD_ISO	Isolated RS-232 Data from computer to ISUS
7	N/C	Not internally connected

XSJJ-2-BCR (7 pin)- Isolated Analog Output
This port is used to output an analog representation of the calculated nitrate concentration and salinity values. CTDs or other data loggers can record these voltages. The voltages are isolated and generated from precision 16-bit DACs (Digital-To-Analog Converters).

Pin	Name	Description
1	N/C	Not internally connected
2	VAUX-/GND	Power common
3	NITRATE+	Analog voltage representing the calculated nitrate concentration (0-4.096 V)
4	NITRATE-	Analog common
5	SALINITY+	Analog voltage representing the calculated salinity (0-4.096 V)
6	SALINITY-	Analog common
7	VAUX+	Input Power, 9-24 VDC

Sacrificial Anode

The sacrificial anode is constructed from zinc and is 2” long and is 1” in diameter. It is mounted to the connector endcap using a 2” long 10-32 316 Stainless Steel screw. Its purpose is to help protect the aluminum housing from galvanic corrosion.

Galvanic corrosion is a common problem in marine environments. It occurs when dissimilar metals are brought into electrical contact in the presence of an electrolyte, such as seawater. One of the metals will become the anode and corrode faster then it would if the other were not present, depending on the metals’ location in the galvanic series of metals. As zinc is less noble than aluminum, it acts as the anode in the galvanic couple formed with the aluminum and is corroded first (hence the term ‘sacrificial’), helping to protect the aluminum housing against corrosion.

See Figure A-5: Connector End Cap

Satlantic recommends replacing the zinc anode when approximately 40-50% of the anode has corroded away.

Probe End Cap

The top or probe end cap consists of a retroreflection probe held in place by the probe retaining nut. The retaining nut is threaded on the outside, allowing a probe guard or biofouling guard to be easily installed.

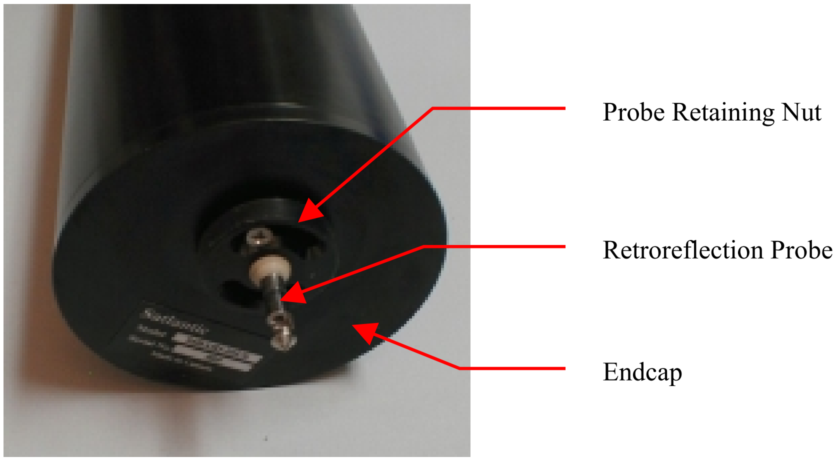

Figure A-10: Probe Endcap

Probe

The probe is a custom, high-quality retroreflection probe design, and is constructed from titanium and PEEK plastic in order to reduce the possibility of corrosion. A Delrin® probe guard is threaded over the probe to protect it from impact. An optional biofouling guard is also available. You may remove the guard to clean the probe – refer to the *Maintenance* section for details. NEVER REMOVE THE SCREWS HOLDING THE PROBE RETAINING NUT IN PLACE! You may damage the probe and risk flooding the instrument!

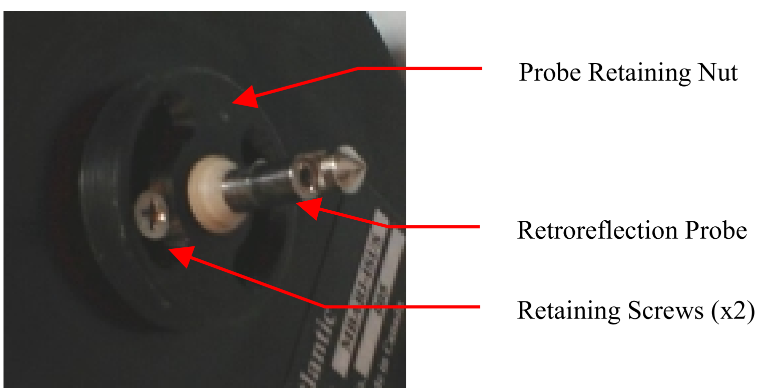

Figure A-11: Retroreflection Probe

The probe should be carefully cleaned before and after each deployment. Refer to the *Maintenance* section for details.

Probe Guards

There are currently two guards available to protect the retroreflection probe from damage: the *standard probe guard* and the *biofouling guard*.

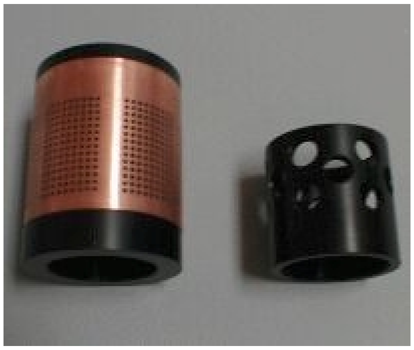

Figure A-12: Probe Guards

Standard Probe Guard

The standard probe guard is normally used in profiling applications. This guard is a simple Delrin® plastic tube with several large holes drilled in it to allow water to easily pass over the probe, while protecting the probe from impacts. The probe guard is threaded on one end to allow it to be attached to the probe retaining nut. The guard is 1.75" (44.5mm) long and 1.75" (44.5 mm) in diameter.

Figure A-13: Standard Probe Guard

Biofouling Guard

The *Biofouling Guard* (also referred to as the *anti-fouling cap*) is a novel approach to reducing the amount of marine biofouling on the probe optics. This guard essentially consists of an inner Delrin® support, Nitex™ filter cloth, a copper screen, and an end cap to hold the copper screen in place. The theory of operation behind the biofouling guard will be described below. Notes on assembling the biofouling guard (when replacing the filter cloth) can be found in the Assembling the Biofouling Guard section in section F MAINTENANCE. Basically, the copper prohibits growth on the guard and Nitex™ cloth, while the Nitex™ cloth filters the water and prevents organisms and sediments smaller than the cloth hole size (100 µm standard) from reaching the probe.

The biofouling guard is normally used in moored applications. It should not be used in profiling applications, as the biofouling guard may reduce temporal responsitivity.

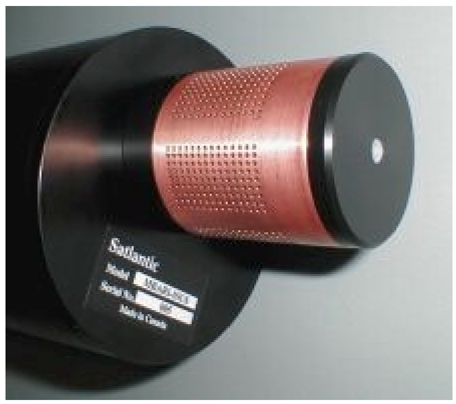

Figure A-14: Biofouling Guard

How the Biofouling Guard Works

Marine biofouling – the growth of marine organisms on submerged surfaces – is a common occurrence. It is found on marine structures such as wharves, boat hulls, and moorings. Unfortunately, ocean sensor optical detectors (such as the MBARI-ISUS probe) are also prone to biofouling, and various methods, particularly toxic coatings, have been used in an attempt to prevent it. However, less environmentally dangerous methods would be preferred.

Copper (and copper-based alloys, such as copper-nickel) has long been known to provide good resistance against biofouling. This characteristic has been used to advantage in a number of commercial products, and it has even been used as a cladding on ship hulls. The MBARI-ISUS takes advantage of this characteristic by mounting a copper screen around the probe. The copper prevents marine growth from occurring on the guard and the filter cloth beneath it, while also filtering out large particulate matter. Immediately beneath the copper is a layer of Nitex™ filter cloth with 100 µm hole size[2] which filters out small particles and marine organisms. The filter is passive, with sample water naturally flushing through the cloth.

[2] Other sizes are available from 5 µm and up and can easily be changed by the user

External Power Source

The MBARI-ISUS has an extremely flexible power supply system that allows it to be powered from a number of sources, depending on the application. Normally, a 12 V battery pack is used, and a rechargeable battery pack specifically designed for use with the ISUS is available from Satlantic.

Power can be supplied on either 2 or 3 of the 4 bulkhead connectors (refer to the connector section for details), depending on the bulkhead configuration. These sources are connected internally using diodes, preventing the possibility of shorting supplies. If power is available on more than one bulkhead, the one with the highest voltage will supply the ISUS.

The ISUS normally draws 1 A at 12 V while operating. However, when turning on the ultraviolet lamp, large current spikes may be required. This may be attributed to the large inductance of the lamp power supply. We recommend having a minimum of 2 Amps at 15 V available to supply these spikes. Normally, this is not a problem for battery packs, but some supplies may have difficulty supplying this. A battery pack is the best solution.

B. SAFETY & HAZARDS

Personal Safety

***** WARNING! ******

If you suspect that the ISUS has flooded, use EXTREME CAUTION around the instrument. The ISUS can operate at depths of up to 1000 meters. If the instrument leaked at depth it might remain highly pressurized when recovered and cause the end cap to be launched from the pressure case with extreme force if the plastic restraining screw and locking cord are removed. To date there has been no occurrence of this.

If you suspect a flood, make sure to check the instrument for signs of pressurization. If the instrument is pressurized you may notice the gap between the end caps and pressure case look to be extended. To relieve the instrument pressure, stand to the side of the instrument with the connector end cap pointing in a safe direction. Relieve the pressure by VERY slowly removing the plastic restraining screw, then VERY slowly removing the locking cord. Be extremely careful, as if the instrument is pressurized the end cap may be forced out of the housing with extreme force and at high velocity.

- The operators should always remain aware of the cable. Any cable or line released from a ship can be dangerous. Keep a safe distance from the cable coil on deck when the instruments are being used.

Instruments

- Do not leave instruments in direct sunlight when not in use. Direct sunlight can easily increase the internal temperature of the instrument beyond its maximum rating.
- Do not leave an in-water instrument unattended. Boat drift can entangle the cable and cause damage or instrument loss.

Cable

- To prevent damage to the conductors within the Kevlar™ strength member (if present), ensure that the cables are not pinched or bent to a radius less than 18 cm.

Connections

- Handle electrical terminations carefully, as they are not designed to withstand strain. Disconnect the cables from the components by pulling on the connector heads and not the cables. Do not twist the connector while pulling, as this will damage the connector pins.
- Do not use petroleum-based lubricants on Subconn® connectors. Connectors should be free of dirt and lightly lubricated before mating. Satlantic recommends using DC-111 silicone grease (made by Dow-Corning®) on the male pins prior to connection.

Troubleshooting

- While checking voltages with a multimeter, use extreme care to avoid shorting the probe leads. A shorted power supply or battery can output many amperes of current, potentially harming the user, starting fires, or damaging equipment.

Recovery

- Remember never to grab the electrical portion of the instrument cable during recovery. This can cause damage to the bulkhead connector and the underwater splice.
- Be sure to rinse seawater from the instrument with fresh water prior to storage. Corrosion resulting from failure to do so is not covered under warranty.

C. START UP

Preparation

Your MBARI-ISUS is a simple instrument to setup and operate. The instrument can be configured to operate in either continuous or scheduled modes, as outlined in the Operation section. Generally, requirements for operation are the same for both of these operating modes.

You will need the following items:

- DC power source (9 – 24 VDC for nonisolated power, 12-15V preferred)
- Computer with a free serial communications port for telemetry acquisition
- Data acquisition and processing software compliant with the Satlantic Data Format Standard (SatView and SatCon normally provided)
- The instruments calibration file (provided)

If you are not using your instrument in an embedded system, or you do not have your own data acquisition software, you may use the software provided by Satlantic. Two applications[3], *SatView* and *SatCon*, are available to you for any PC running Windows®[4] 95/98/NT/2000/XP. Both applications are compliant with the Satlantic Data Format Standard. SatView is a data acquisition and real-time display application. SatCon is a post processing application for telemetry logged with SatView.

Note that the ISUS normally logs data internally, so a data acquisition device is not required. This data is already processed, i.e. it is in a human-readable format, and can be readily loaded into spreadsheets. However, Satlantic's SatView software allows you to view the data in real time, while SatCon enables you to easily separate light and dark frames.

Also note that it is not necessary to use the software mentioned above to log the instrument telemetry. A properly configured terminal emulator can serve this purpose. In any case, there are a few standard communications settings needed for any computer application communicating with the instrument. All serial transmissions use 1 start bit, 8 data bits, 1 stop bit, and no parity. No flow control of any kind is used. Make sure that your software is configured with the baud rate specified for your instrument. These settings apply to both the RS-232 and RS-422 telemetry interfaces. For most applications, the default telemetry baud rate is 38400 bps.

[3] For more information on these applications, refer to the user's manuals distributed with the software.
[4] Windows is a registered trademark of Microsoft Corporation.

IMPORTANT! Both the RS-232 and RS-422 telemetry interfaces transmit the same information. The RS-232 interface provides bi-directional communication while the RS-422 is transmit-only. Normally, the RS-232 interface is used for configuring and testing your instrument. The RS-422 interface would normally be used for telemetry acquisition in the field using longer cables. Most computer serial interfaces are RS-232.

In preparation for assembly, the MBARI-ISUS components should be checked against the packing list to ensure that all required items are included. The dummy connectors should be removed and stored so that they can be replaced after the instrument is recovered. The instrument packing should be retained and reused to prevent instrument damage during transport.

Additionally, lubrication for the male pins prior to connection is required. We recommend DC-111 silicone grease (made by Dow-Corning). Do not use a petroleum base lubricant.

Connect the Cables

When making connections, proper alignment on the connector pins is critical to avoid damage. Connectors should be inspected to ensure they are free of dirt and then lightly lubricated before making connections. Visually ensure that the pins on the male connectors are properly aligned with (and partially seated into) the sockets on their female counterparts before pushing them together for final connection. Finally, ensure that the locking sleeve is securely fastened after connection.

Connect the instrument body, the computer and the battery to the deck unit, as follows.

1. Mount the ISUS to its deployment frame.
2. Mount the battery pack, if present, to the deployment frame.
3. Connect the configuration cable to the ISUS and a spare PC serial port.
4. Start a terminal emulator with the proper settings on the PC, and connect to the port.
5. Connect the power source to the ISUS.

Once the ISUS has been properly connected and power has been applied, an initialization sequence will begin automatically to ready the device for normal operation. The ISUS will output status messages as it goes through the initialization procedure – this will be displayed in the terminal emulator.

Using the MBARI-ISUS with SatView

If you are using the instrument in a profiling mode with real-time telemetry, it is possible to view the data in Satlantic's SatView software. However, you will need a long power/telemetry cable from Satlantic, as well as an RS-422 to RS-232 converter. Please contact Satlantic for further details.

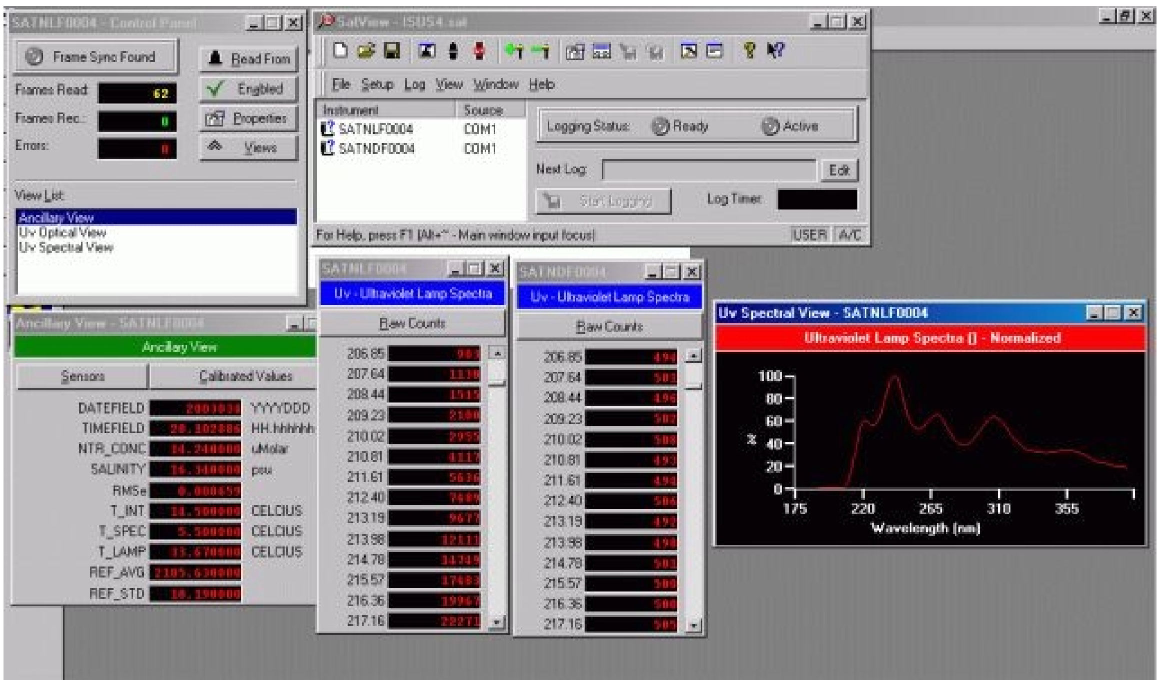

Figure C-1: SatView Real-Time Display

Using the MBARI-ISUS with a Seabird CTD

The MBARI-ISUS has been extensively tested with the SeaBird series of CTD profilers. It is very easy to integrate the analog output of the MBARI-ISUS with one of the CTDs ancillary inputs. For complete details, please refer to the application note entitled "Interfacing the ISUS to a SeaBird CTD Profiler", available from Satlantic.

Below is a screen shot from SeaBird's SeaSave software, highlighting the incredible vertical resolution available when the MBARI-ISUS is used in its profiling mode.

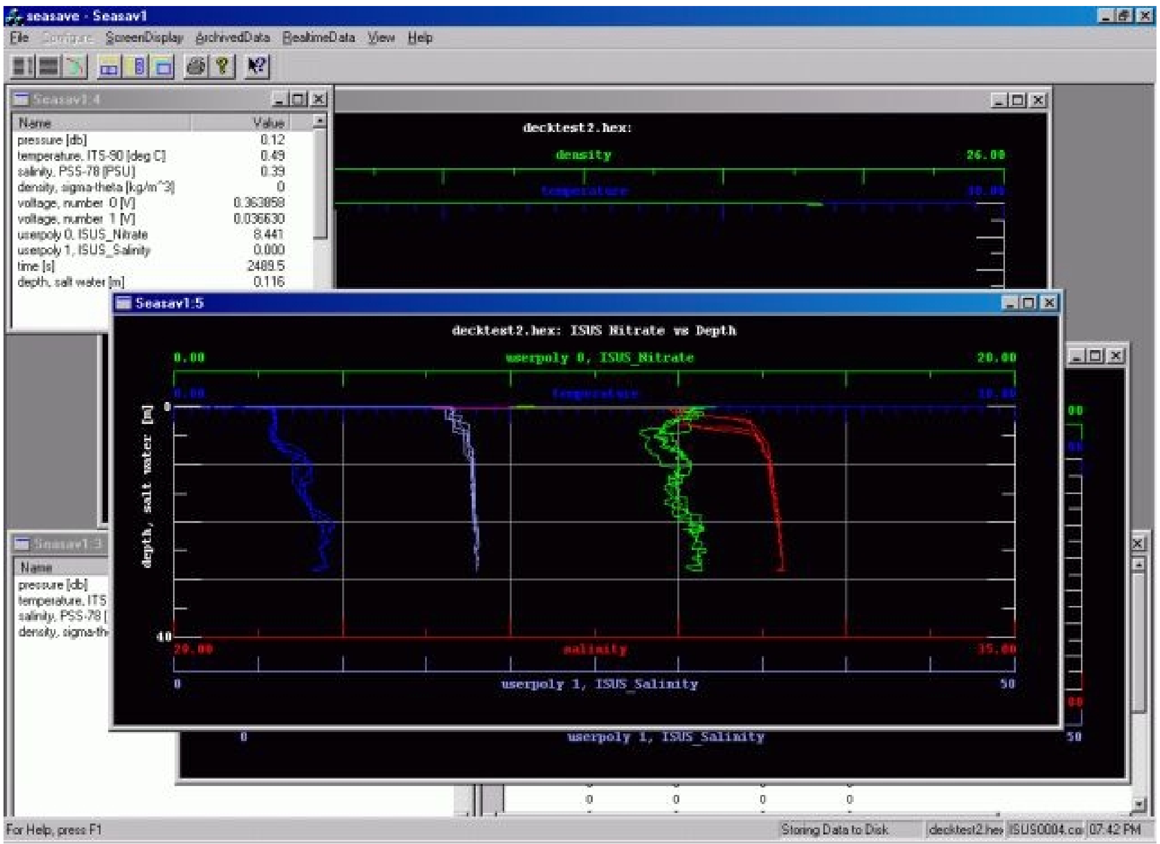

Figure C-2: SeaBird SeaSave screen capture

In the screen capture above, the bright green trace is the analog nitrate concentration signal to the CTD. Two up and down casts are shown. Here, the nitrate concentration was centered on approximately 12 µMolar. Notice the detail in the nitrate concentration profile. This test was performed in Halifax harbour, in Nova Scotia, Canada, on February 3, 2003.

The MBARI-ISUS and a battery pack were mounted to the CTD's lowering frame, as shown below. The frame was then simply lowered over the side of the boat, by hand.

Figure C-3: CTD, ISUS, and Battery Pack

The advantage of this approach is that it allows the user to obtain real-time data in a visible format, including depth, temperature, salinity, and nitrate concentration. It is very easy to identify structures such as thermoclines, haloclines, fresh-water surface layers, and so on, and their relationship with the nitrate concentration.

D. OPERATION

Operating Modes

For maximum flexibitlity, the ISUS has been designed with several user-selectable operating modes: CONTINUOUS, SCHEDULED, and TRIGGERED. Future ISUS units may include additional operating modes not described here.

The operating mode is retained in the ISUS's non-volatile EEPROM memory. At power-up, the operating mode is checked and the necessary initialization actions performed. If the user changes the operating mode, power will have to be removed and then reapplied (after approximately 1 minute). The operating mode can only be changed from the EEPROM menu (explained later).

Continuous

Continuous mode may also be referred to as "profiling". In this mode, the instrument will begin making measurements after a user-programmable delay from power-up, until instructed to stop with the 'S' (stop) command (or power is removed; refer to the section titled "A Note About ISUS Power Removal" for more details). Note that the start-up delay can be bypassed with the 'G' (go) command. The stop and go commands may be given over either the 3-pin configuration port or the 6-pin isolated power/telemetry port.

Each logging cycle starts a new log file on disk with the name **DIVEnnn.DAT**, where 'nnn' is incremented with each cycle (and is actually the value of the deployment counter saved in non-volatile memory). This is very useful in profiling applications, as each profile will be logged to a separate file. The name of the current log file is given at the beginning of each cycle. To stop a log, press the 'S' key; the ISUS may require several key presses to respond. The ISUS will re-enter the start-up delay loop, counting down the seconds until the next 'dive'. It is safe to remove power at this time, or to enter the configuration menu, press the 'M' key.

Scheduled

Scheduled mode is typically used in moored applications. The ISUS can be scheduled to periodically wake up, measure, and record data. Between samples, the instrument enters a very low-power sleep state to conserve power.

In scheduled mode, sampling can be configured to occur immediately after power up, after a fixed delay, or synchronized to a future time. The user simply configures the number of samples to record at each wake-up, and the number of minutes between sampling periods.

When in scheduled mode, press any key to wake up the ISUS. When it responds, you have 15 seconds in which to enter the menu with the 'M' command, otherwise the instrument will go back to sleep to wait for the next scheduled sample.

Triggered

The triggered mode has not yet to been implemented on the ISUS. There could be various forms of the triggered mode, with the most common being the ISUS responding to simple commands on the telemetry interfaces.

Telemetry Modes

The telemetry format for the ISUS, as with all Satlantic instrumentation, follows the *Satlantic Data Format Standard*[5]. This standard defines how Satlantic telemetry can be generated and interpreted. For every sample taken, the instrument will compose and transmit one frame of telemetry. The information contained in the frame will depend on the *telemetry mode* of the instrument. The instrument's *calibration file*[6] defines the specific format of the frame.

Two telemetry modes are available in the ISUS: *Full* and *Concentration*. Full telemetry mode provides all available information to the user, at the expense of increased frame and log file size. Concentration telemetry mode provides a greatly reduced frame, transmitting instead only the nitrate and bromide concentrations as calculated by the ISUS. The telemetry format for each mode is given in the tables below. Please note that either telemetry mode may be used regardless of the operation mode of the instrument.

Telemetry fields are output in ASCII format. All fields, with the exception of the INSTRUMENT field, are comma-delimited, regardless of the telemetry mode used (there isn't a comma between the INSTRUMENT and SN fields). Note that the maximum size of each field is given. Satlantic's data logging software (SatView) supports variable length frames, and as such the size of each field may change without affecting the calibration file. If integrating the ISUS with foreign data-logging devices, it will be necessary to rely on the comma delimiters to distinguish data fields.

In the following tables *AI* refers to ASCII Integer formatting, *AF* refers to ASCII Float formatting, and *AS* refers to ASCII String formatting. Please refer to the Satlantic Data Format Standard for more detail on these data types.

[5] For more information on this data format, refer to the *Instrument File Standard* document available from Satlantic

[6] For more information on calibration files, refer to the *Instrument File Standard* document available from Satlantic

FULL Telemetry Format

The format of an ISUS data frame when the instrument is in *FULL* Telemetry mode is given in the following table:

Field Name	Field Size (bytes)	Description
INSTRUMENT	6	An AS formatted field denoting the start of a frame of telemetry. The sequence normally starts with "SAT" for a Satlantic instrument. The next three characters would identify the type of instrument (or telemetry).
SN	4	An AI formatted string denoting the serial number of the instrument. This field combined with the INSTRUMENT field uniquely identifies the instrument. This combination is known as the frame header or synchronization string.
DATE	7	An AI formatted field denoting the date at the time of the sample, using the year and Julian day. The format is YYYYDDD.
TIME	9	An AF formatted field denoting the GMT/UTC time of the sample in decimal hours, to 6 decimal places.
NTR CONC	7	An AF formatted field representing the Nitrate concentration (µMol/L) to 2 decimal places, as calculated by ISUS.
SALINITY	7	An AF formatted field representing the Salinity (psu) to 2 decimal places, as calculated by ISUS.
RMS ERROR	10	An AF formatted field representing the Root Mean Square Error of the ISUS' concentration calculation, to 6 decimal places.
T_INT	7	An AF formatted field representing the temperature (to 2 decimal places) inside the ISUS housing, in degrees Celsius.
T_SPEC	7	An AF formatted field representing the case temperature (to 2 decimal places) of the spectrometer, in degrees Celsius.
T_LAMP	7	An AF formatted field representing the approximate temperature (to 2 decimal places) of the UV light source, in degrees Celsius.
REF AVG	7	An AF formatted field representing the average Reference Channel measurement (to 2 decimal places) taken during the sample time.
REF STD	6	An AF formatted field representing the variance of the Reference Channel measurements (to 2 decimal places) taken during the sample time.
SW DARK	8	An AF formatted field representing the Sea-Water Dark calculation (to 2 decimal places), in spectrometer counts.

Field Name	Field Size (bytes)	Description
SPEC AVG	8	An AF formatted field representing the average value of all spectrometer channels, to 2 decimal places.
C_CTD	7	**RESERVED FOR FUTURE USE.** An AF formatted field containing the conductivity measurement from an external CTD device.
T_CTD	7	**RESERVED FOR FUTURE USE.** An AF formatted field containing the Temperature measurement from an external CTD device, to 2 decimal places.
P_CTD	10	**RESERVED FOR FUTURE USE.** An AF formatted field containing the pressure measurement from an external CTD device.
RSRV1	10	**RESERVED FOR FUTURE USE.** Defaults to the ASCII string “RSRV1”.
RSRV2	10	**RESERVED FOR FUTURE USE.** Defaults to the ASCII string “RSRV2”.
RSRV3	10	**RESERVED FOR FUTURE USE.** Defaults to the ASCII string “RSRV3”.
CHANNEL(λ_1)	5	An AI formatted field containing the A/D counts of the start channel of the spectrometer, at wavelength λ_1.
CHANNEL(λ_2)	5	An AI formatted field containing the A/D counts of the spectrometer at wavelength λ_1.
…	…	…
CHANNEL(λ_n)	5	An AI formatted field containing the A/D counts of the spectrometer at wavelength λ_n.
…	…	…
CHANNEL(λ_{256})	5	An AI formatted field containing the A/D counts of the end channel of the spectrometer, at wavelength λ256.
TERMINATOR	2	This field indicates the end of the frame. The frame is terminated by a carriage return/line feed pair ($0D_{hex}$ and $0A_{hex}$).

The data in this frame is a maximum of 1436 bytes in size, excluding delimiters. If the comma delimiters are included, **the total maximum frame size is 1711 bytes**.

The ISUS is capable of closing an on-board shutter over the UV light source before sampling. The instrument can be configured to do this periodically to help track measurement drift, and can be used to provide a dark correction during post processing. To distinguish between *Light* and *Dark* frames in the telemetry output, the instrument uses different frame headers. This allows any telemetry acquisition system to distinguish between sensor readings taken with the shutter opened and closed.

Full frames generated with the shutter open (*light* frames) normally output ***SATNLF*** in the INSTRUMENT field. SATNLF is an acronym for “SATlantic Nitrate Light Frame”. Full frames generated with the shutter closed (*dark* frames) normally output ***SATNDF*** in the INSTRUMENT field. SATNDF is an acronym for "SATlantic Nitrate Dark Frame".

CONCENTRATION Telemetry Format

The format of an ISUS data frame when the instrument is in *CONCENTRATION* Telemetry mode is given in the following table:

Field Name	Field Size (bytes)	Description
INSTRUMENT	6	An AS formatted field denoting the start of a frame of telemetry. The sequence normally starts with "SAT" for a Satlantic instrument. The next three characters would identify the type of instrument (or telemetry).
SN	4	An AI formatted string denoting the serial number of the instrument. This field combined with the INSTRUMENT field uniquely identifies the instrument. This combination is known as the frame header or synchronization string.
DATE	7	An AI formatted field denoting the date at the time of the sample, using the year and Julian day. The format is YYYYDDD.
TIME	9	An AF formatted field denoting the GMT/UTC time of the sample in decimal hours, to 6 decimal places.
NTR CONC	7	An AF formatted field representing the Nitrate concentration (µMol/L) to 2 decimal places, as calculated by ISUS.
SALINITY	7	An AF formatted field representing the Salinity (psu) to 2 decimal places, as calculated by ISUS.
RMS ERROR	10	An AF formatted field representing the Root Mean Square Error of the ISUS' concentration calculation, to 6 decimal places.
TERMINATOR	2	This field indicates the end of the frame. The frame is terminated by a carriage return/line feed pair ($0D_{hex}$ and $0A_{hex}$).

The data in this frame is 52 bytes in size, excluding delimiters. If the comma delimiters are included, **the total maximum frame size is 58 bytes**.

The ISUS is capable of closing an on-board shutter over the UV light source before sampling. The instrument can be configured to do this periodically to help track measurement drift, and can be used to provide a dark correction during post processing. To distinguish between *Light* and *Dark* frames in the telemetry output, the instrument uses different frame headers. This allows any telemetry acquisition system to distinguish between sensor readings taken with the shutter opened and closed.

Concentration frames generated with the shutter open (*light* frames) normally output ***SATNLC*** in the INSTRUMENT field. SATNLC is an acronym for

"SATlantic Nitrate Light Concentration". Concentration frames generated with the shutter closed (*dark* frames) normally output ***SATNDC*** in the INSTRUMENT field. SATNDC is an acronym for "SATlantic Nitrate Dark Concentration".

Menus

To enter the ISUS' menu system, press the 'M' (menu) key while connected to the Configuration port. Note that if you are in Continuous mode, you will have to first stop telemetry with the stop command.

At any time in the menus, simply type H<Enter> to display the list of available commands for that menu. The corresponding key for each command is shown in square brackets, such as [T]. To exit the current menu, press <CTRL>C (hold the control key and press C).

Each menu has a distinct prompt so that you will always know which menu you are currently in. For instance, the prompt for the main (root) menu has the prompt ISUS>.

When a variable may be modified, the ISUS will prompt you with the following prompt:

```
Enter [1] to modify [0]?
```

The default response to this query is '0', i.e. no change to variable. Simply press the Enter key to enter the default (0) response. If you wish to modify the variable, press '1', then Enter.

Root Menu

The Root Menu is the main directory for the ISUS configuration menus. The Root Menu is identified by the `ISUS>` prompt.

The Root menu provides access to the *Setup*, *Data*, *File*, *Test*, *Info*, and *EEPROM* menus.

Setup Menu

The Setup Menu is accessed from the Root Menu. It provides access to various sub-menus required for configuring the ISUS. It is identified by the `ISUS_SETUP>` prompt.

The following sub-menus may be accessed from the Setup Menu:

- Deployment Setup
- Spectrometer Setup
- Fiberlite Lamp Setup
- Curve Fitting Setup
- Real Time Clock setup

These menus are explained in details in the following sections.

Deployment Setup Menu

The *Deployment Setup Menu* is accessed from the Setup Menu. The menu is identified by the `ISUS_SETUP_DEPLOY>` prompt.

This menu provides access to the following settings:

- Deployment Logging Mode
- Scheduled Logging Params
- Clear Deployment Counter
- Flash Filesize Limits

Deployment Logging Mode

Selecting this command simply displays the operating mode (called logging mode here). The operating mode can now only be changed in the EEPROM Menu.

Scheduled Logging Params

Selecting this command allows the user to change the time parameters used in the SCHEDULED operating mode. There are three options that may be changed here: the number of minutes between readings (normally 60 minutes); when the first logging event will occur (immediately, delayed, or synchronized to a future time); and whether or not to log real data. The third variable has no effect in current versions of the firmware, so please leave this setting unchanged.

Clear Deployment Counter

As the description implies, this command will clear the deployment counter. The deployment counter is used when generating the log file names in CONTINUOUS mode (DIVEnnn.DAT, where 'nnn' is the value of the deployment counter).

Flash Filesize Limits

This setting currently has no effect on the ISUS operation. It is reserved for future use. Please leave these settings unchanged.

Spectrometer Setup Menu

The *Spectrometer Setup Menu* is accessed from the Setup Menu. The menu is identified by the `ISUS_SETUP_SPEC>` prompt.

This menu provides access to the following settings:

- Integration Period
- Pre Scans
- Spectra Scans
- Darkcurrent Scans
- Collection Rate of DC Data
- Load Zeiss Coef File

Integration Period

Selecting this command allows the user to set the spectrometer integration time, in milliseconds. The normal setting is 700 to 850 ms. **THIS VALUE SHOULD NOT BE CHANGED, AS IT AFFECTS THE INSTRUMENT CALIBRATION!**

Pre Scans

Selecting this command allows the user to set the number of spectrometer pre-scans prior to collecting a data scan. This "cleans out" the spectrometer so that an accurate reading is taken. The normal setting is 2. **This setting should not be changed.**

Spectra Scans

Selecting this command allows the user to change the number of samples taken during each scheduled acquisition event when in SCHEDULED mode. The normal setting is 3. Modify this setting with caution, as the more samples per event, the higher the power consumption, which is very important in mooring applications.

DarkCurrent Scans

Selecting this command allows the user to select the number of dark samples taken during each acquisition event when in SCHEDULED mode. The normal setting is 1. Under most circumstances, the default setting is sufficient.

Note: this setting currently has no effect. It is reserved for future use.

Collection Rate of DC Data

Selecting this command allows the user to set the number of spectra scans per dark sample when in CONTINUOUS mode. The normal setting is 11, i.e. for every dark scan there are 10 normal spectra scans. As the dark sample values are used during nitrate concentration calculations, **it is advisable to leave this setting unchanged.**

Load Zeiss Coef File

Selecting this command allows the user to display the current fit coefficients for the spectrometer. This function is only useful to Satlantic personnel.

Fiberlite Lamp Setup

The *Fiberlite Setup Menu* is accessed from the Setup Menu. The menu is identified by the `ISUS_SETUP_LAMP>` prompt.

This menu provides access to the following settings:

- Total On Time (odometer)
- Power On Warmup Period
- Shutter during warmup
- UV "Cleaning" Cycle
- Reference Detector

Total On Time (Odometer)

Selecting this command displays the amount of time that the light source has been on. It also gives the option to clear this time. **WARNING! Do not clear this time!** It is necessary for tracking the life of the lamp.

Power On Warmup Period

Selecting this option allows the user to define the number of seconds the lamp is on before the first measurement is made. The normal setting is 5 seconds. **It is advisable to leave this setting unchanged.**

Shutter During Warmup

Selecting this option allows the user to define whether the shutter is open or closed during the lamp warmup period. The normal setting is OPEN. **It is advisable to leave this setting unchanged.**

UV Cleaning Cycle

Selecting this option allows the user to set the number of samples between UV "cleaning" cycles when in SCHEDULED mode, and how many seconds the cleaning cycle should last. The normal settings are 24 samples per cleaning cycle, with 30-second duration.

The idea behind the UV cleaning cycle is to help prevent biofouling of the probe. In scheduled (moored) applications, the UV lamp is only on for brief periods of time. The use of UV light is an excellent method for killing micro-organisms, and is often used in water treatment facilities. By doing an extended lamp "burn", microorganisms are discouraged from growing on the probe surfaces.

Note that increasing the duration of the cleaning cycle affects power consumption during moored applications. **It is advisable to leave this setting unchanged.**

Reference Detector

Selecting this option allows the user to change the reference channel setpoint for detecting when the light source turns on, and also allows the number of reference channel measurements that are made with each sample. **DO NOT CHANGE THIS SETTING**.

Curve Fitting Setup

The *Curve Fitting Setup Menu* is accessed from the Setup Menu. The menu is identified by the `ISUS_SETUP_CFIT>` prompt.

The Curve Fitting Setup Menu provides access to the following settings:

- Fitting Range
- Concentrations
- Baseline Model
- Load Ecoefs/Zero File
- Process a scan

Fitting Range

Selecting this option allows the user to set the wavelength range used to calculate the nitrate concentration. **WARNING! DO NOT CHANGE THESE SETTINGS!** The calculated nitrate value will be greatly affected.

The normal settings are over the 215 to 270 nm range.

Concentrations

Selecting this option allows the user to set the number of concentrations to be used in the fitting process (2 or 3).

WARNING! ONLY CHANGE THIS SETTING IF INSTRUCTED TO DO SO BY SATLANTIC. The nitrate calculation may be adversely affected.

Baseline Model

Selecting this option allows the user to set the baseline model used in the fitting calculations. The available options are linear, quadratic, exponential\linear, and exponential\quadratic.

WARNING! ONLY CHANGE THIS SETTING IF INSTRUCTED TO DO SO BY SATLANTIC. The nitrate calculation may be adversely affected.

Load Ecoefs/Zero File

Selecting this option allows the user to load and display the calibration file extinction coefficients. This option is useful for Satlantic personnel only. Depending on the ISUS firmware version, the calibration file will be either ECOEFZER.CAL or ISUS*xxxn*.CAL, where *xxx* is the instrument serial number and *n* is the letter revision of the file. The ISUS automatically uses the most recent calibration file.

Process A Scan

This option is currently not functional.

Realtime Clock Setup

The *RTC Setup Menu* is accessed from the Setup Menu. The menu is identified by the `ISUS_SETUP_RTC>` prompt.

This menu provides access to the following settings:

- Time Settings
- Power Cycle Settings
- Status Register Display
- Control Register Display

Time Settings

Selecting this option allows the user to enter the current time (in GMT\UTC) and the time zone offset.

The ISUS is configured at Satlantic to use GMT time. Please keep the instrument in GMT time, as changing it to local time may have an adverse effect on some of the other settings. Using GMT also eliminates errors due to daylight savings time. It is advisable to check this setting occasionally for accuracy.

Set the time zone offset as GMT – local time. For example, if GMT is 4 hours ahead of your local time, set the offset to +4. If GMT is 2 hours behind your local time, set it to –2.

Before any deployment, you should check the current time setting to make sure that the instrument has the correct GMT time.

Power Cycle Settings

Selecting this option allows the user to check the number of times power has been applied to the ISUS. The value may also be cleared. It may be useful to clear this option before a deployment, and check it at the end of the deployment.

Status Register Display

Selecting this option allows the user to check the status register of the clock. This function is only useful to Satlantic personnel.

Control Register Display

Selecting this option allows the user to check the control register of the clock. This function is only useful to Satlantic personnel.

Data Menu

The *Data Menu* is accessed from the Root Menu. The menu is identified by the `ISUS_DATA>` prompt.

This menu provides access to the following settings:

- Send Spectra
- Collect and Send Spectra

Send Spectra

Selecting this option allows the user to send a simple spectra frame on the telemetry ports without internal logging. This is a test function for use at Satlantic.

Collect and Send Spectra

Same as the Send Spectra function, but data is logged internally.

File Menu

The *File Menu* is accessed from the Root Menu. The menu is identified by the `ISUS_FILE>` prompt.

This menu provides access to the following settings:

- Flash Directory
- Download File

- Upload File
- Output File
- Rename File
- Erase File

Take care when using these functions, so as not to erase or rename a required file on the ISUS's internal flash disk!

Flash Directory

Selecting this option allows the user to display all the files currently present on the ISUS' flash disk. The amount of free space available is also displayed.

Download File

As the name suggests, selecting this option allows the user to download a file from the ISUS using either XMODEM or YMODEM protocols. Simply follow the on-screen instructions.

Upload File

As the name suggests, selecting this option allows the user to upload a file to the ISUS using the XMODEM protocol. Simply follow the on-screen instructions.

Output File

Selecting this option will output the user-selectable file to the screen; think of it as a 'replay' function. Take care; a large data file can take a long time to replay!

Rename File

As the name suggests, selecting this option allows the user to rename a file on the ISUS' flash disk.

Erase File

As the name suggests, selecting this option allows the user to erase a file on the ISUS' flash disk.

WARNING! Erased files are irretrievable! Never erase the calibration files (ISUSxxxn.CAL, ECOEFZER.CAL or ZCOEFDAT.CAL) files, as the ISUS will not function without them!

Test Menu

The *Test Menu* is accessed from the Root Menu. The menu is identified by the ISUS_TEST> prompt.

This menu provides access to the following settings:

- Spectrometer Power Toggle
- Fiberlite Power Toggle
- UV Lamp Toggle
- Visible Lamp Toggle
- Ref Channel Test
- Open Lamp Shutter
- Close Lamp Shutter
- DAC Output Test (submenu; used for CTD calibration)
- Alignment test
- Lamp Test
- Temperature tests
- Pump Test

As the names suggest, most of these functions are used for testing during instrument construction, and serve no useful purpose to the end-user. An exception is the DAC Output Test sub menu, which is required when calibrating the ISUS' analog output for use with a CTD. Please refer to the application note entitled "Interfacing the ISUS to a CTD Profiler" for more detail.

DAC Output Test

The DAC *Test Menu* is accessed from the Test Menu. The menu is identified by the ISUS_DAC> prompt.

This menu provides access to the following:

- Toggle DAC Power
- Low Output (both DACs)
- Center/midscale Output (both DACs)
- Max Output (both DACs)
- Nitrate DAC Output
- Salinity DAC Output
- Run Nitrate Test Profile
- Run Salinity Test Profile
- Configure Nitrate DAC maximum
- Configure Salinity DAC maximum

Only use the functions as described in the application note entitled "Interfacing the ISUS to a CTD Profiler" available from Satlantic. If you change the Nitrate or Salinity DAC maximums, you will have to recalibrate the CTD.

Info Menu

The *Info Menu* is accessed from the Root Menu. The menu is identified by the `ISUS_INFO>` prompt.

This menu provides access to the following:

- Build Info
- FLASH Info
- ISUS Header Info
- RTC(s) Info
- Touchmem Info
- Pixel To Lambda
- Enable Status Messages

These functions display various pieces of information about the ISUS. The "touchmem" refers to the Dallas Semiconductor 1-Wire devices used in the system (RTC and temperature sensors).

The pixel-to-lambda function converts a spectrometer pixel (1 to 256) to its actual wavelength, useful when trying to determine the ISUS fitting range.

The Enable Status Message function should have no effect. Please leave this setting unchanged.

Eeprom Menu

The *EEPROM Menu* is accessed from the Root Menu. The menu is identified by the `ISUS_EEPROM>` prompt.

This menu provides access to the following settings:

- Show EEPROM
- Baudrate
- Operating Mode
- Delay (Continuous Mode)
- Logging Enable
- Telemetry Mode
- Instrument SN

NOTE: WHEN EXITING THIS MENU, YOU WILL BE FORCED TO REBOOT THE ISUS INSTRUMENT. This guarantees that the changes you have made will take effect immediately.

Show EEPROM

As the name suggests, this function displays all settings currently saved to EEPROM memory.

Baudrate

Selecting this option allows the user to change the telemetry baud rate for the instrument. The default setting is 38400 bps, but 9600 or 19200 bps may also be used. Note that using a slower baudrate setting will negatively affect the instruments frame rate.

Operating Mode

Selecting this option allows the user to set the ISUS' operating mode to CONTINUOUS, SCHEDULED, or TRIGGERED. The default setting is continuous mode.

Delay (continuous mode)

Selecting this option allows the user to set the start delay, in seconds, when in CONTINUOUS mode. The default setting is 60 seconds.

Logging enable

Selecting this option allows the user to disable internal logging. It is not advised to do so!

Telemetry Mode

Selecting this option allows the user to set the data frames to either FULL or CONCENTRATION mode, as outlined in the *Telemetry Modes* section. The default setting is FULL.

Instrument SN

Selecting this option allows the user to change the instruments serial number. Only Satlantic personnel should use this function during instrument construction!

Use SEAWATER Darks

Selecting this option forces the MBARI-ISUS to use an estimate for the spectrometer dark reading for nitrate concentration calculations instead of closing the shutter on the UV light source. **DO NOT CHANGE THIS SETTING unless asked to do so by a Satlantic representative.** This option is only provided in case there are problems with the shutter functioning properly. The seawater dark method uses the lower 5 wavelengths to approximate the dark reading, assuming that these channels are strongly attenuated. Thus, this method only works in seawater as it depends on the strong UV attenuation characteristics of bromine.

A Note About ISUS Power Removal

Most data loggers that utilize flash disks for data storage require a shutdown procedure to ensure that the log files are not corrupted or the instrument rendered unusable when power is removed. The ISUS has a novel design that helps prevent this from occurring, so that it is actually safe to simply remove power without following a shutdown procedure. A non-battery based power backup circuit is used, which provides power to the controller long enough for the flash log files to be safely closed. This can easily be observed when power is removed from the system by the displayed message:

```
* Bad input power detected!  Implemented safe shutdown! *
```

This message is only displayed after any open files are safely closed.

If at all possible, it is advisable to be cautious and stop logging before removing power. Simply entering the Root Menu before removing power is a safe procedure.

E. RECOVERY

To recover the MBARI-ISUS, terminate data logging by issuing the stop command (the 'S' key) when it continuous mode. This can be done over either RS-232 port. Then simple remove the power connection, disconnect all cables, and replace all dummy connectors. When disconnecting a cable from the instrument, unscrew the locking sleeve, grasp firmly on the connector head and pull off the cable. DO NOT TWIST OR PULL ON THE CABLE DIRECTLY AS THIS MAY DAMAGE THE CONNECTORS OR THE CABLE. ALWAYS DISCONNECT THE POWER SUPPLY FIRST.

Always be sure to rinse the instrument with fresh water prior to storage in order to prevent corrosion. If seawater is allowed to remain in contact with the instrument in storage, particularly around bolts or other contacts of dissimilar metals, corrosion will occur. To not properly rinse the instrument before storage is considered misuse and warranty claims cannot be made under such circumstances.

F. MAINTENANCE

Preventative Maintenance

The MBARI-ISUS requires little maintenance. Protecting it from impacts, rinsing it with fresh water after each use, careful cleaning of the probe and properly storing the instrument with the dummy connectors in place when not in use will prolong the life of the instrument.

If the instrument is not working properly the following troubleshooting techniques can be followed. If these are not successful, contact Satlantic for more information.

Cleaning the Probe

In order to limit the possibility of damaging the probe, we suggest leaving the probe guard in place and simply use a Q-tip applicator through the guard holes to clean the probe. However, if you feel it is necessary to remove the probe guard, you may simply unscrew the guard by hand (with a counter-clockwise rotation). NEVER REMOVE THE PROBE RETAINING NUT – this is held in place with 2 to 4 countersunk screws. Doing so will likely damage the probe internally and flood the instrument!

To clean the probe, use the following procedure:

1. Acceptable cleaning agents include methanol or isopropyl alcohol using standard cleaning methods commonly used on soft coated optics. De-ionized water may be used, however it may leave spots that can affect transmission and absorption.
2. Do not soak the Q-tip or lens tissue with the cleaning agent. It will leave pools of liquid that will not dry properly. Just dampen the applicator with the agent.
3. The applicator should be moved over the probe in one direction and then discarded, or rotated to a different position so that contaminants are not rubbed across the surface.
4. Ensure that all probe surfaces are cleaned.
5. The probes should be rinsed with water or methanol before they are stored, or if they will not be used for a period of time.

The probes will have a small amount of carry over, so it may be necessary to rinse them off before moving to the next sample if no contamination is desired.

Assembling the Biofouling Guard

This section outlines the steps involved in assembling the biofouling guard. Normally, you will only have to disassemble and reassemble the guard when the Nitex™ filter cloth is replaced (before each mooring deployment).

The following figure shows the items necessary to assemble the biofouling guard:

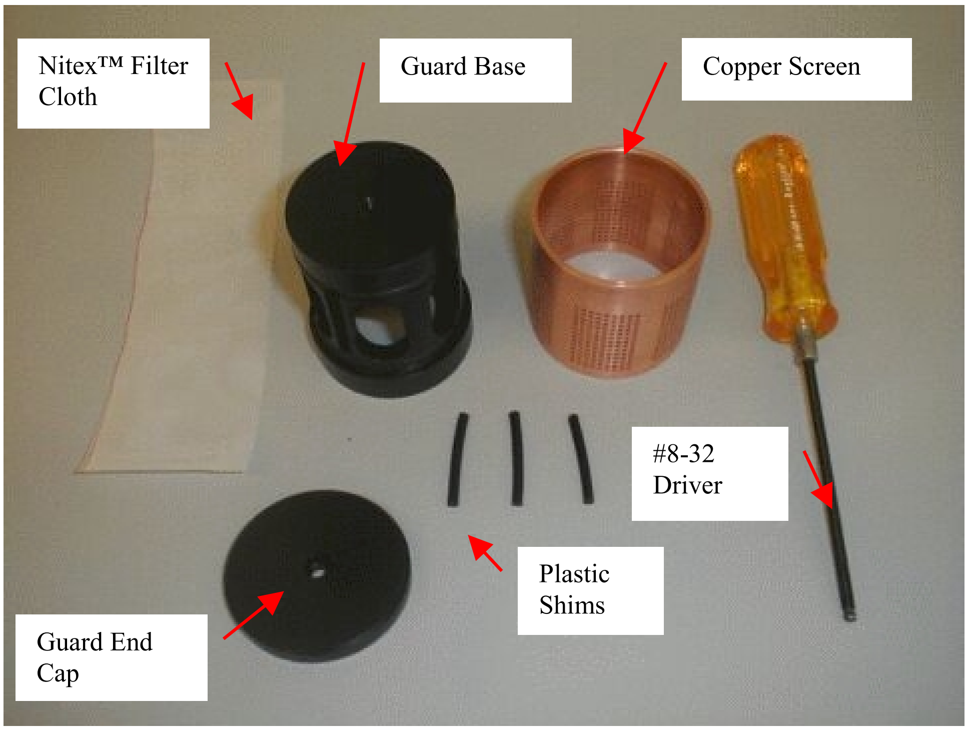

Figure F-1: Biofouling Guard Components

There are two 2-223 o-rings mounted on the guard base that help to hold the filter cloth against the copper screen. These o-rings only need to be replaced if they are damaged.

Assembling the guard is a delicate procedure and may take some time to complete. Be careful not to damage the probe when mounting it to the MBARI-ISUS.

The probe guard is assembled as shown in the following figure:

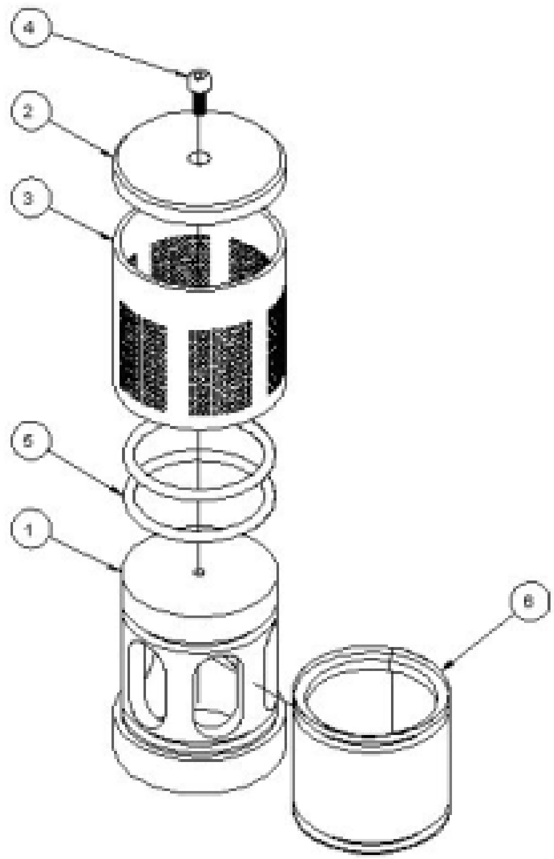

Figure F-2: Biofouling Guard Exploded Assembly

The following table details the components shown in Figure F-2: Biofouling Guard Exploded Assembly:

Reference Number	Component	Quantity
1	Probe Guard Base	1
2	Probe Guard End Cap	1
3	Copper Screen	1
4	Retaining Screw	1
5	2-223 O-ring	2
6	Nitex Filter cloth	1 (approx 2” W x 6.25” L)

Procedure

1. Ensure that the two 2-223 o-rings are installed. They are located at the top and the bottom of the biofouling guard base.
2. Wrap the Nitex™ filter cloth screen around the base. Ensure that the screen overlaps itself over any one of the three vertical shim grooves.

Figure F-3: Overlap the cloth over a groove

3. Wedge a plastic shim into the groove in the base where the filter cloth overlaps.

Figure F-4: Insert a plastic shim

4. While holding the plastic shim in place, begin to slide the copper screen over the filter cloth as shown. The shim should be beneath a solid portion of the copper screen (no holes). Try to align the scribe marks on the base and copper screen. **IMPORTANT: Ensure that the cloth does not wrinkle significantly as the copper is positioned**. This may take several attempts, as it is a relatively delicate procedure.

Figure F-5: Start positioning the copper screen

5. Insert the other two plastic shims into the remaining grooves.
6. Carefully slide the copper screen entirely over the Nitex™ and plastic shims. This will be a tight fit. Again, ensure that the cloth does not wrinkle as the copper slides into place. The shims serve to pull the cloth tight over the windows (holes) cut in to the guard base and ensures that the water cannot bypass the cloth.

Figure F-6: Slide the copper screen in place

7. Check to make sure that the cloth is properly positioned under the copper screen by looking inside from the bottom of the guard. The cloth should be stretched tight across the base holes. If the copper screen is correctly positioned the solid vertical sections of the copper screen (no machined holes) portions will be directly over the plastic shims and should not be visible through the cloth.
8. Attach the end cap using the 3/8” long 8-32 nylon screw.

Figure F-7: Attach the end cap

9. The completed biofouling guard is now ready to be installed on the MBARI-ISUS. Check to ensure that the scribe marks on the copper screen and base are aligned.

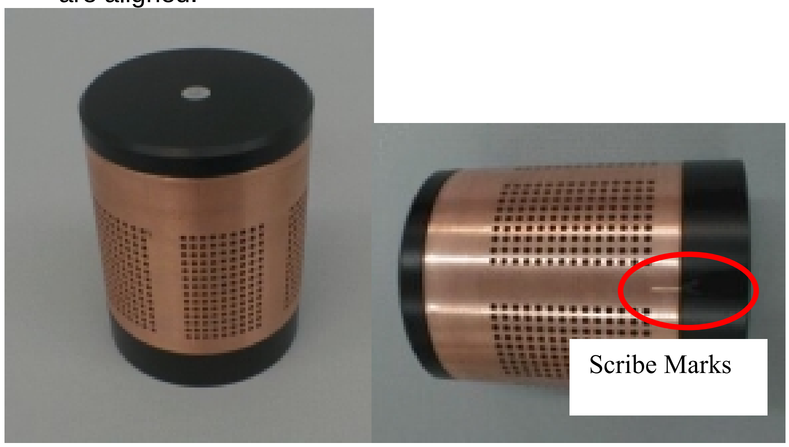

Figure F-8: Check for scribe marks

10. To mount the guard to the MBARI-ISUS, simply thread it on to the probe retaining nut and tighten by hand. Only hold on to the guard base, as shown. If you try to mount the guard while holding on to the copper, the copper will rotate on the base. Ensure that the scribe marks still line up, otherwise water flow through the filter cloth may be affected!

Figure F-9: Mounting the guard

Figure F-10: The ISUS with Biofouling Guard

Troubleshooting with a Terminal Emulator

If you are experiencing problems receiving data with your data acquisition software, there may be a problem with the instrument, its configuration, or its physical setup. You can check to see if the MBARI-ISUS is transmitting telemetry with a terminal emulator.

To do this, first complete the assembly procedure described in section C START UP. Connect the instrument to a computer running a terminal emulation program. For this test, you may use either the RS-232 interface directly, or the RS-422 interface through an appropriate level converter. You can therefore use the same physical configuration you would use in the field. However, if at a later point you need to gain access to the instruments menu system, you will need to use the configuration port (3 pin) RS-232 interface directly.

Once the instrument is powered up and is in normal operation with free-running telemetry, you should see a regular stream of ASCII data being output to the display. However, you should be able to periodically pick out the instruments frame header or synchronization string. This series of characters appears at the beginning of every frame of telemetry, as defined in your instruments calibration file. If you do not see the frame header, but you do see random characters, check that the baud rate of the terminal emulator is the same as for the instrument. If you so not see anything at all, make sure that no other application is using the serial port of the computer. If this checks out, there may be a hardware problem.

Troubleshooting for Hardware Problems

If a telemetry check using a terminal emulator failed to show any telemetry, you should check the physical connections of your instrument and supporting equipment.

To perform hardware checks, a multimeter with DC voltage measurement, resistance measurement, and continuity check capability is required.

WARNING! While checking voltages, extreme care should be used so as not to short the probe leads. A shorted power supply or battery can output many amperes of current, potentially harming the user, starting fires, or damaging equipment.

Check Connections

The cable connections of the system should be checked for continuity and correctness. Make sure that all Subconn® connectors are free of dirt and lightly lubricated before mating. Do not use petroleum-based lubricants. Satlantic recommends using a light coating of DC-111 silicone grease (made by Dow Corning®) on the male pins prior to connection. Also, ensure that the connections are complete and, if applicable, the locking sleeves are secure.

- Check that the power cable is properly connected to the power supply and the instrument.
- Check that all instrument interconnect cables are in place and properly connected.
- Check that the RS-232 cable is connected to the correct PC communications port.

Check the Supply Voltage ISUS

To check voltages, a multimeter with DC voltage measurement is required.

Procedure:

1. Set the multimeter to measure a DC voltage.
2. If using a battery as the power source, measure the voltage directly at the battery terminals with the multimeter. A new or fully charged 12 V battery usually measures in the 13 - 15 V range. If the voltage is low (under 11 V) then recharge or replace the battery. If using a DC power supply, set the output voltage in the range from 10 - 20 V, and check the voltage with the multimeter
3. Connect the power supply cable to the power source.
4. **Being extremely careful not to short the probe leads**, measure the voltage between the pins on the supply cable. It should read approximately the same as the measurement taken in step 2. If the voltages are not the same, recheck the power supply cable

connections. If the voltages are still not the same, the cable is likely broken and will need repair. A wire break can be confirmed with a *continuity check*.

5. If the voltage is within tolerance, connect the power supply cable to the ISUS.

6. Again, measure the voltage at the power supply terminals. The voltage should remain approximately the same as before, although there may be a small voltage drop when using a battery (battery voltage drops under load). If there is a significant voltage drop, disconnect the power immediately and check for shorts in the cable.

Check Cable Continuity

Often, system problems can be traced to cable breaks or shorts. Usually, these cable failures are a result of improper handling or storage. Cable continuity can be checked as outlined below. MAKE SURE ALL CABLES ARE COMPLETELY DISCONNECTED BEFORE PERFORMING THIS TEST.

Procedure:

1. Set the multimeter to measure continuity. The resistance measurement setting can also be used.
2. Check for continuity by measuring from pin 1 on one end of the cable to pin 1 on the other end. The meter should confirm that the connection is continuous by either giving an audible signal or measuring a low resistance. If there is not continuity, there is a break in the cable, which will require repair.
3. Repeat step 2 for all pins in the cable.
4. Check for shorts from pin 1 to all other pins by keeping one probe lead on pin 1 and touching the other probe lead to each of the other pins in the same connector in turn. Repeat this for all pins on the cable to make sure that all the pins are isolated from each other. The meter should read this as open or measure a very high resistance. If any of the pins are not isolated, there is a short in the cable, which will require repair.

G. WARRANTY

Warranty Period

The MBARI-ISUS is under one-year parts and labor warranty from date of purchase.

Restrictions

Warranty does not apply to products that are deemed by Satlantic to be damaged by misuse, abuse, accident, or modifications by the customer. The warranty is considered void if any optical or mechanical housing is opened. In addition, the warranty is void if the warranty seal is removed, broken or otherwise damaged.

Provisions

During the one year from date of purchase warranty period, Satlantic will replace or repair, as deemed necessary, components that are defective, except as noted above, without charge to the customer.

Returns

To return products to Satlantic, whether under warranty or not, contact the Satlantic Customer Support Department and request a Returned Material Authorization (RMA) number and provide shipping details. All claims under warranty must be made promptly after occurrence of circumstances giving rise thereto and must be received by Satlantic within the applicable warranty period. Such claims should state clearly the product serial number, date of purchase (and proof thereof) and a full description of the circumstances giving rise to the claim. All replacement parts and/or products covered under the warranty period become the property of Satlantic Inc.

Liability

If your MBARI-ISUS should be defective or fail to be in good working order the customer's sole remedy shall be repair or replacement as stated above. In no event will Satlantic Inc. be liable for any damages, including loss of profits, loss of savings or other incidental or consequential damages arising from the use or inability to use the MBARI-ISUS or components thereof.

H. CONTACT INFORMATION

If you have any problems, questions, suggestions, or comments about the instrument or manual, please contact us.

Location

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Business Hours

Satlantic is normally open for business between the hours of 9:00 AM and 5:00 PM Atlantic Standard Time. The Atlantic Standard Time zone is one hour ahead of the Eastern Standard Time zone. Normally, in the winter, AST is UTC-4, but it changes to UTC–3 during the daylight saving time period in the summer. Daylight saving time is in effect from 2:00 AM on the first Sunday in April until 2:00 AM on the last Sunday in October.

Satlantic is not open for business during Canada's statutory holidays, which are as follows:

New Year's Day	January 1st
Good Friday	The Friday before Easter Sunday (Easter Sunday is the first Sunday after the full moon on or following March 21st, or one week later if the full moon falls on Sunday)
Victoria Day	The first Monday before May 25th
Canada Day	July 1st
Halifax Natal Day	The first Monday in August
Labor Day	The first Monday in September
Thanksgiving Day	The second Monday in October
Remembrance Day	November 11th
Christmas Day	December 25th
Boxing Day	December 26th