LOPC™

LASER OPTICAL PLANKTON COUNTER

OPERATION AND MAINTENANCE MANUAL

BOT Brooke Ocean Technology Ltd

50 Thornhill Drive, Unit 11
Dartmouth, Nova Scotia
Canada B3B 1S1

Phone: (902) 468-2928
Fax: (902) 468-1388
e-mail: sales@brooke-ocean.com
www.brooke-ocean.com

The Laser Optical Plankton Counter was developed by Dr. Alex Herman of the Department of Fisheries and Oceans, Ocean Sciences Division, Bedford Institute of Oceanography

Fisheries and Oceans Canada | Pêches et Océans Canada

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Table of Contents

Caution! **The LOPC has a maximum depth rating of 660 m. Care must be taken not to exceed the maximum depth rating of the unit.**

Caution! **DO NOT leave the LOPC exposed to direct sunlight for extended periods of time, especially when powered. Heat build-up inside the unit can damage some of the sensitive electronics if allowed to reach excessive temperatures.**

Caution! **The LOPC is shipped calibrated and sealed, and does not contain any field serviceable parts. Opening the pressure case can introduce contaminants and affect the alignment of the laser and optics. Opening the pressure case without written BOT authorization will void the warranty.**

Caution! **The LOPC is designed to be used with different size sampling tunnels. Each tunnel MUST be factory aligned to its mating LOPC pressure case. The "prism mount", which houses the optical prism, is aligned relative to the tunnel on which it has been mounted. And that tunnel is ONLY usable with the LOPC pressure case it has been assigned to. As different size tunnels become available, each tunnel will be shipped with its own prism mount. DO NOT remove the prism from the tunnel. If this happens, a factory realignment of the prism relative to the instrument will be required.**

1 INTRODUCTION

The Laser Optical Plankton Counter (LOPC) was developed by Dr. Alex Herman, at the Bedford Institute of Oceanography (BIO) and is manufactured under license by Brooke Ocean Technology. The LOPC is shown in Figure 1.

Figure 1 - Laser Optical Plankton Counter

The prime application of the LOPC is the real-time characterization of plankton while being towed in an oceanographic or freshwater environment. In addition to counting plankton in the range of 100 microns to 3.5 cm, it is able to record their shape outlines, or profiles, for sizes greater than 1.5 mm.

The LOPC is powered externally, requiring 2 dedicated conductors in the sea cable. These wires provide power to the unit and communications between the instrument and the surface.

The LOPC can be used as a standalone unit or with other instrumentation. It has a serial interface for a CTD and a 0-5V analog interface for an auxiliary sensor such as a fluorometer. Data from these instruments is automatically integrated into the output data stream of the LOPC.

The LOPC is designed for operation in harsh marine environments. All electronics are housed in a single pressure case for enhanced reliability. The packaging is compact and adaptable - easily integrated into existing tow-bodies.

The LOPC has been designed to be ‘plug and play’ compatible with the Brooke Ocean Technology (BOT) Moving Vessel Profiler (MVP). The combination of an MVP/LOPC/CTD enables vertical depth profiles to be taken while the vessel is underway.

2 OPERATING PRINCIPLES

The LOPC electronics are housed in a single pressure case, which is physically mounted to the side of a 70 mm wide sampling tunnel. The relative positions of the optics and the mechanical housings are shown in Figure 2.

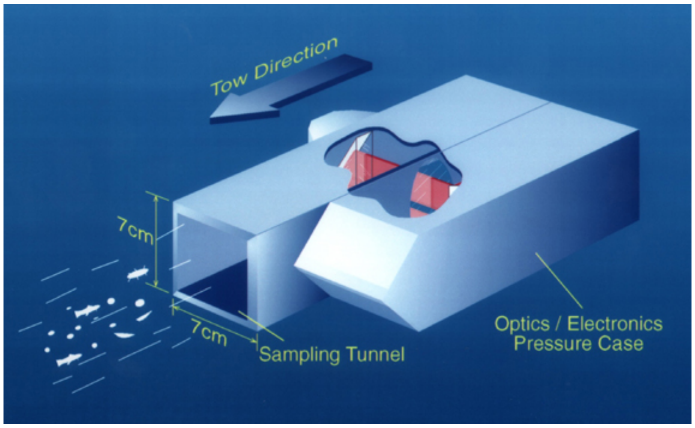


Figure 2

A beam of light, 35 mm wide by 1 mm thick, is transmitted across one half of the sampling tunnel and is reflected back through the remaining half. The light intensity of the returning beam is detected by a 35-element photo-diode array with 1 mm element spacing. The setup of the LOPC laser and optics is shown in Figure 3. (The space between the emitted and returning beams shown below is for illustration only.)

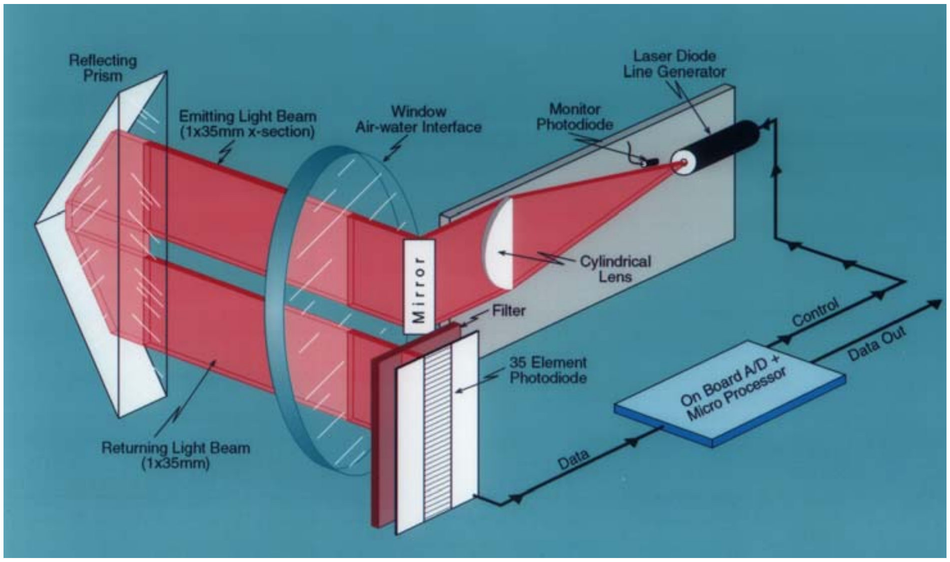


Figure 3

As illustrated in Figure 4, use of the full width of the 70 mm sampling tunnel is achieved using a 35 mm wide photo-diode array and a reflecting prism. When a particle (plankton) passes through either the emitted or reflected beam, it blocks a portion of the light that is detected on the photo-diode array.

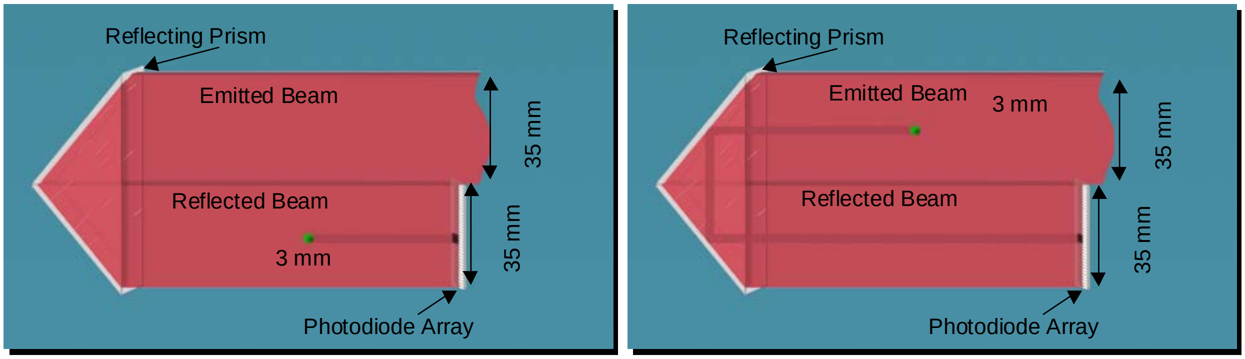


Figure 4

2.1 Size Measurement Principles: SEP & MEP

The measurement of plankton is characterized by two size ranges - single-element plankton (SEP) and multi-element plankton (MEP).

SEP is defined as the size range that is measured by a single photo-diode element and cannot be characterized by a shape profile. **MEP** is defined as a larger size range that is measured by multiple photo-diode elements thus providing the necessary data to reconstruct shape profiles.

An example of an SEP measurement is shown in Figure 5a. On the left hand side of the figure are 2 particles with spherical and ellipsoidal shapes. Each of the 2 particles passes over the photo-diode array within the confines of a single element (1 x 1 mm) only. The resulting size signal will be proportional to the particle area and will represent the ratio of particle area to the element area. In this example, there is no data available to reconstruct a shape profile.

The LOPC cannot distinguish between shapes of particle that are less than 1 x 1 mm (in profile when they pass through the beam). Although the two particles in the figure have different shapes, they produce the same size signal - the ratio of particle area to element area is the same for both. To simplify comparisons, the ellipsoidal shape is equated to a spherical shape that will produce the same ratio. In the figure, the spherical shaped particle has a diameter of approximately 500 microns. The ellipsoidal shaped particle has an Equivalent Spherical Diameter (ESD) of approximately 500 microns.

The same two particles on the right-hand side of Figure 5a are seen to be crossing the boundary between two elements. Generally, the data provided by 2 elements is still insufficient to adequately define the shape profile of a particle and so the measured areas are then summed to provide a single measurement of area and subsequently to estimate the particle ESD.

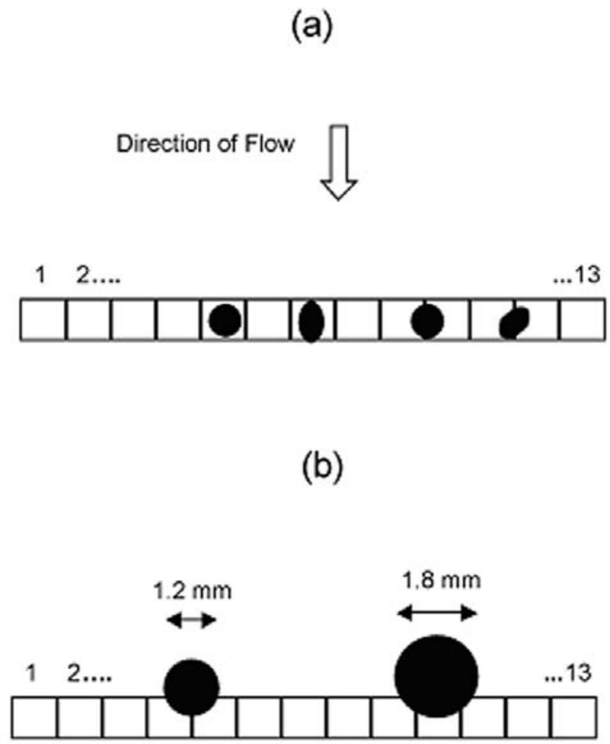


Figure 5

Figure 5b shows an example of particles with the size range of 1-2 mm. During their passage over the photo-diode array, there will be a finite probability of each particle passing over 2 or 3 elements. In the 2-element measurement, the particle areas will be summed while in the 3-element measurement, the data measured from each element is usually sufficient to reconstruct the particle shape profile and so the data is separately transmitted to the surface.

More definitive examples of the multi-element measurements of 3 elements or more are shown in
Figure **6**, which illustrates the measured signals from each element and the reconstruction of the approximated shape profile. In this example, there is enough data to reconstruct a shape profile.

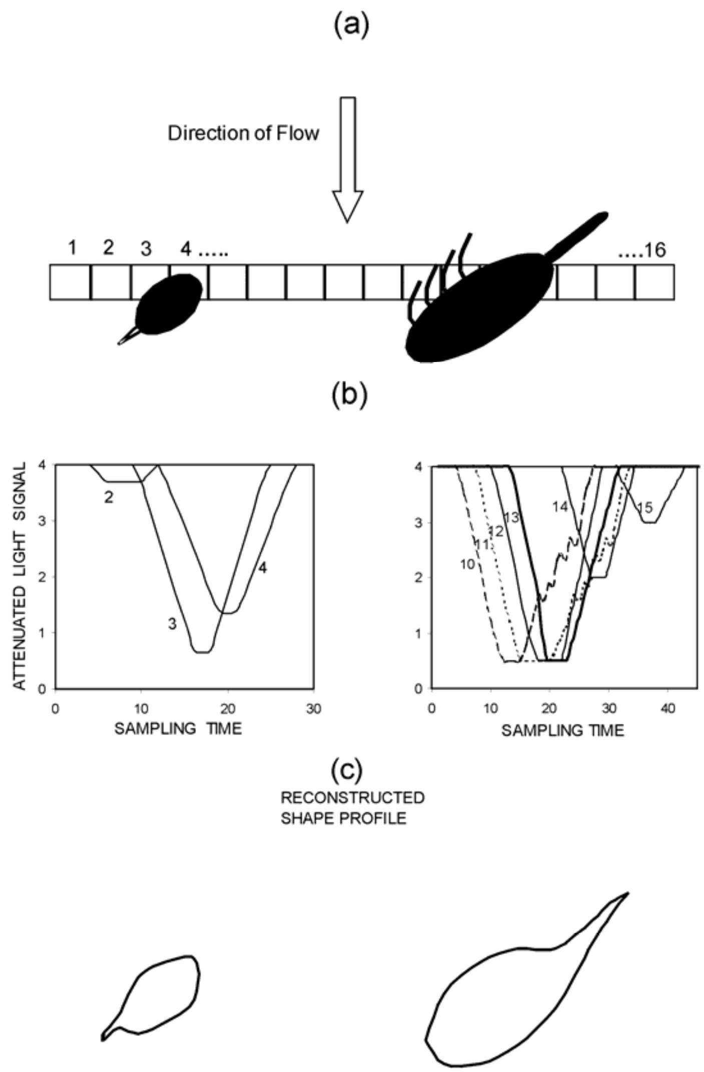


Figure 6

There exists an overlap between SEP and MEP size ranges and so the boundary is arbitrarily defined at approximately 1500 microns. The SEP size range therefore is defined as 100-1500 microns while the MEP size range is defined as 1500 microns to 3.5 cm. For a more detailed discussion of the LOPC operating and measurement principles, refer to A. Herman manuscript, http://www.alexherman.com

3 LOPC INTERNAL CALIBRATION

Each SEP-measured particle area is converted to an ESD and added as a count to a size histogram or 'bin' of 15 micron widths. Using 128 bins, the SEP size bin-histogram provides a size range of 0-1920 microns with a bin resolution of 15 microns. The SEP size distribution presented by the LOPC is therefore linear in ESD.

Every 0.5s (2 Hz), the LOPC outputs 128 bin counts that have been accumulated over the 0.5 second sample period. The LOPC Interface Software displays a running total of these counts. An example of a size distribution histogram that is displayed by the software is shown in Figure 7.

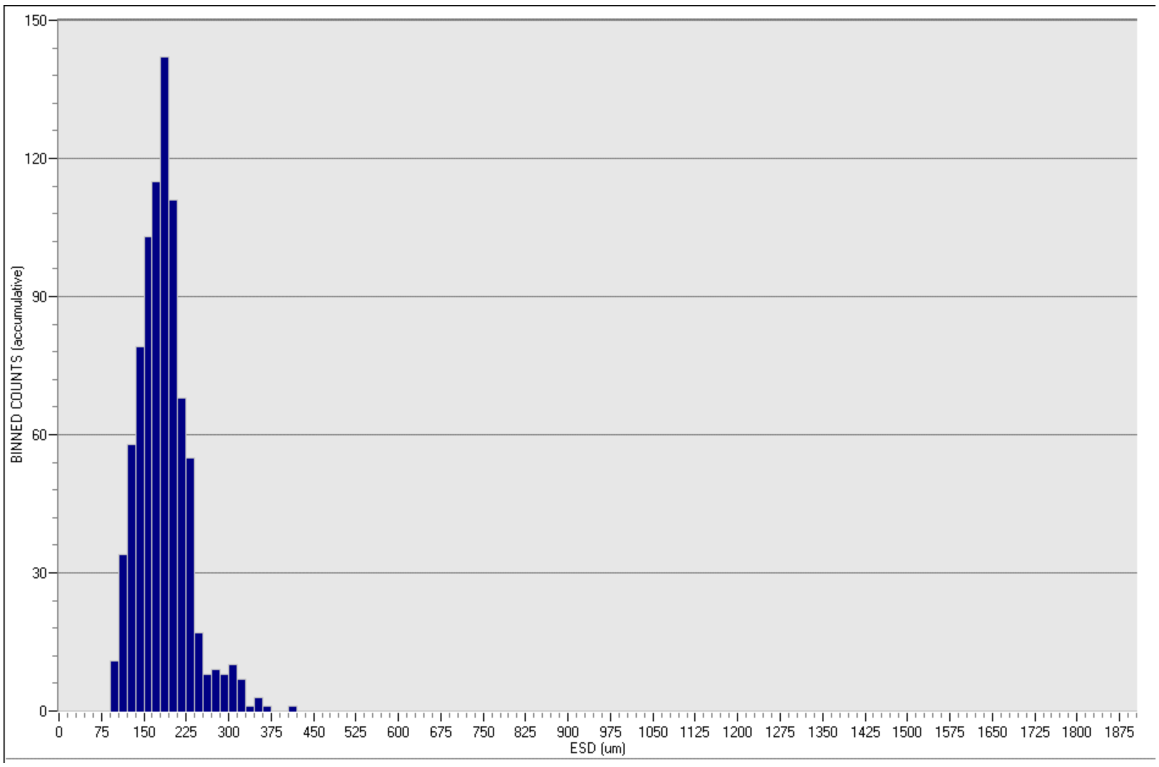


Figure 7 - LOPC Example Histogram

The internal LOPC calibration is established by the Bedford Institute of Oceanography (A. Herman) by using near-spherical beads. The calibration is designed to remain constant, enabling comparison of data among users.

3.1 Pre-cruise Calibration Check

A calibration check can be made prior to each cruise by simply dropping beads (3 sizes provided) through the LOPC tunnel. The following is a step by step procedure for performing the calibration check.

1. Position the LOPC with the tunnel in a vertical orientation, such as in Figure 8.

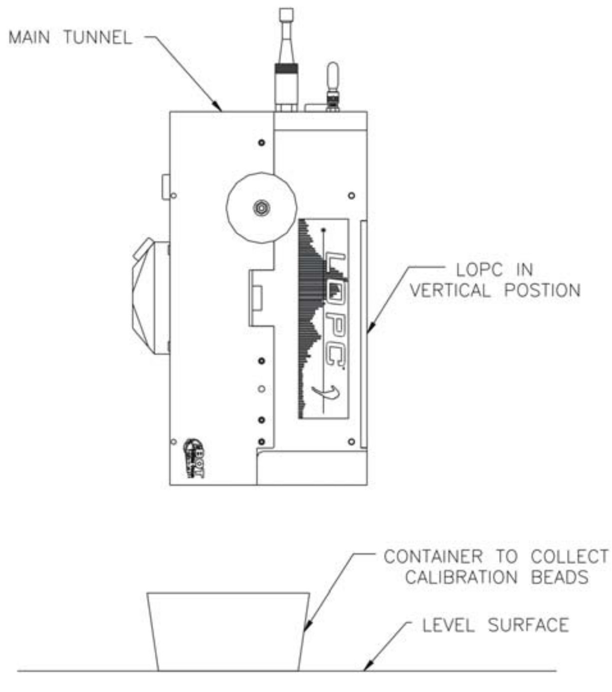


Figure 8

2. Power up the LOPC and start logging with the Interface software. (See section 6.1.2)
3. After logging has been started, use the calibration beads provided (bottles labeled GL-0191 and GL-0271) to reproduce the calibration check performed by BOT during Factory Acceptance Testing. A copy of the factory calibration is included in Appendix V.
4. Take a “pinch” of beads from the bottle, using forefinger and thumb, drop the beads through the tunnel. Roll the beads between tips of fingers to spread out the stream of falling beads. Attempt to drop the beads slowly to prevent clumping and thus increase accuracy of individual bead detection.
5. Start with the smaller beads (GL-0191). Dropping them through the tunnel will produce a peak on the lower end of the SEP histogram.
6. Next use the larger beads (GL-0271). Dropping these through will produce a peak near the upper end of the SEP histogram as well as some MEPs, which will appear in the MEP grid.
7. Using the Factory Calibration sheet found in the manual appendix, compare the peaks obtained by dropping beads with that of the original calibration check. Particle counts are determined by the number of beads that are dropped. In order to easily compare the calibration check, similar quantities of beads should be used to obtain a matching peak.

NOTE: Dropping beads through the LOPC produces a peak distribution with a finite width. The beads provided by BOT are sieved beads that have: i) a slightly elliptical shape, ii) a size range specified, and iii) a slight transparency (~10%). The peak distribution width will therefore reflect these variations. The peak position or mean size should not vary more than 10- 15% over time.

Figure 9 (for illustration purposes only) is an example of the main display showing the results after performing a calibration check. In the SEP histogram display, the resultant size distribution consists essentially of 2 broad peaks.

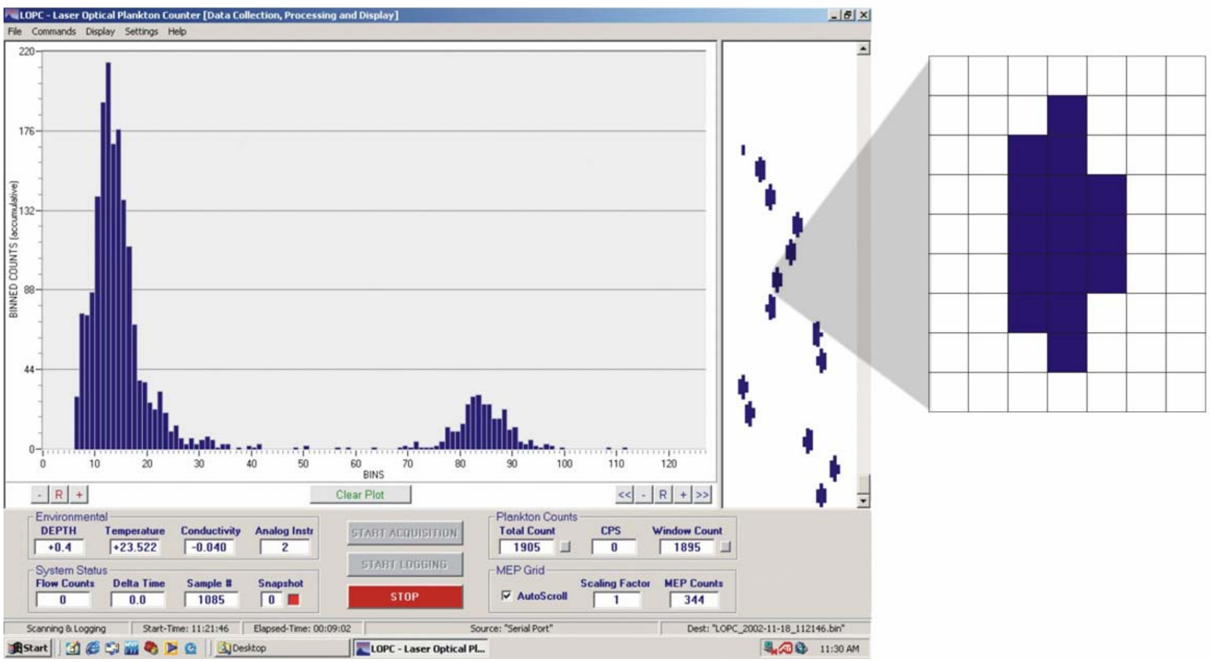


Figure 9 - Histogram Example

The smaller size beads produce an SEP peak in bins 6 to 27, or 90 to 405 microns. The larger size beads produce both an SEP peak (bins 70 to 100, or 1050 to 1500 microns) and a lesser fraction of MEP measurements.

A blow up of the MEP grid display is shown at the right of the figure. Both size distributions (at approx. 200 & 1200 microns) shown in Figure 9 are designed to provide a calibration stability check at the low and high ends of the scale and should reproduce (mean size position) over time within an error range of 10-15%. The larger nylon beads provided (6.3mm) are simply intended to provide a check of the MEP algorithms.

NOTE: The use of spherical beads for LOPC measurements or calibration checks, particularly those with smooth, reflective surfaces such as glass or polished metal, may produce inaccurate results.

The calibration check is a fundamental test of all system components including the electronics, telemetry/communication, laser/optics, microprocessors, and SEP/MEP algorithms. Once completed, the calibration check provides assurance to the user that the LOPC is fully operational.

3.2 Field Inter-comparisons

Inter-comparisons of LOPC measurements to samples collected by users are beyond the scope of this manual. Examples of methodology for performing such inter-comparisons can be found in scientific reports and literature (http://www.alexherman.com) and in communication with the user community.

4 LOPC SYSTEM COMPONENTS

The main components of the LOPC system are as follows (Figure 10):

- Deck unit
- Sea-cable (optional)
- LOPC
- LOPC Interface Software (running on user-supplied PC)

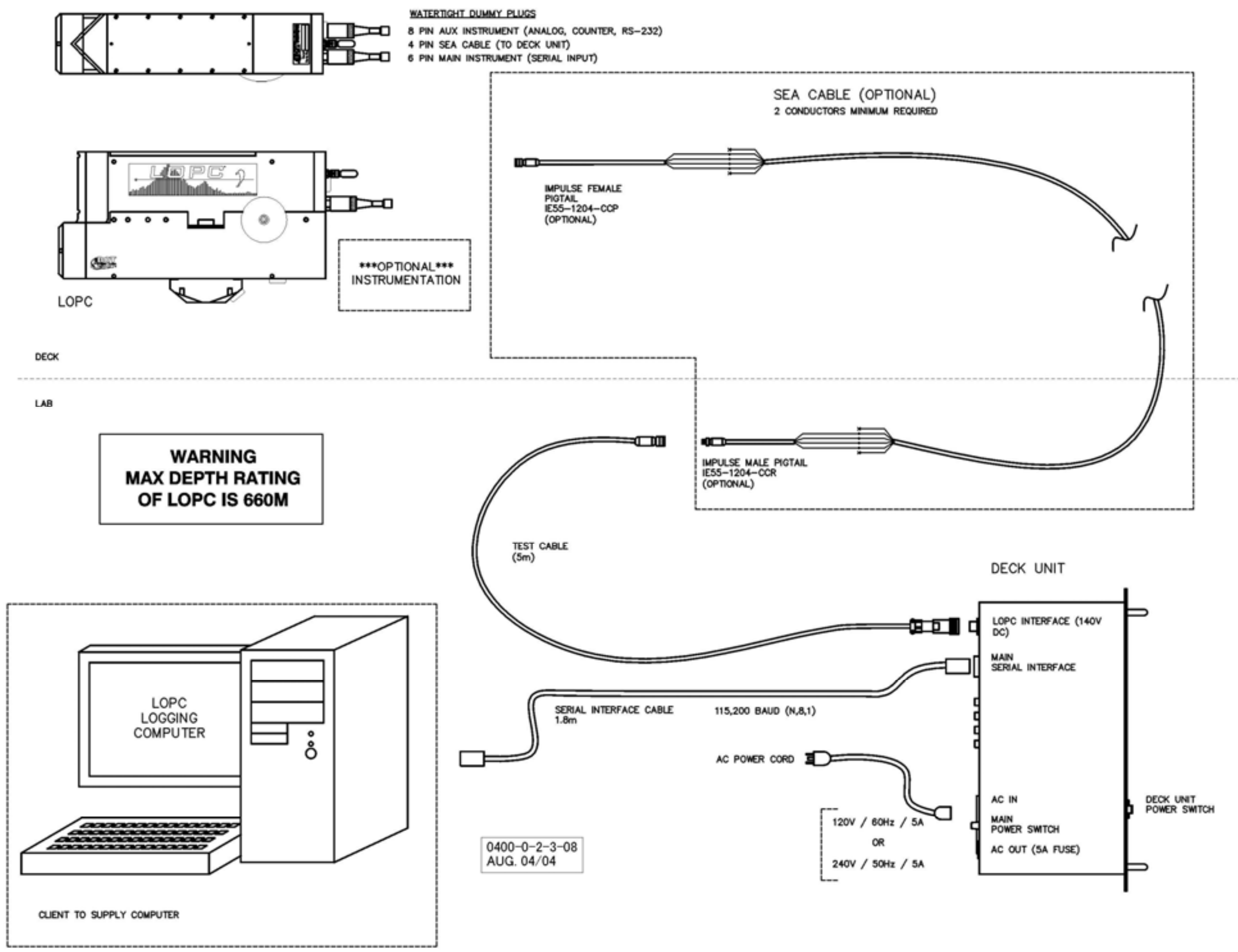


Figure 10

4.1 Deck Unit

The deck unit is responsible for all aspects of power and communication. The deck unit contains a DC supply that powers the LOPC and a power-line modem for communicating with it. A corresponding power-line modem is installed in the underwater probe which is configured to communicate directly with the deck unit. The modems are full duplex, operating in the 100 to 450 kHz frequency band.

4.1.1 Front Panel

The front panel of the LOPC Deck Unit is shown in Figure 11.

Figure 11 - Deck unit front panel

Power

Main power switch for the LOPC. When the switch is in the ‘1’ position, the deck unit and LOPC will be powered.

ON

This LED will illuminate whenever the *Power* switch is in the ‘1’ position and the deck unit is ready to power the LOPC.

Serial Interface

The serial interface panel contains LEDs that reflect the current status of LOPC communications.

LOCK	The deck unit is able to communicate with the power-line modem in the LOPC
ERROR	The deck unit is unable to communicate with the power-line modem in the LOPC
RX	The LOPC is receiving data.
TX	The LOPC is transmitting data.
AUX	Auxiliary sensor data is being received from the LOPC.

Instrument Test

This interface is a utility feature that allows a user to test any serial RS-485 instrument (such as a CTD) in the lab, before connecting it to the LOPC for deployment.

The instrument to be tested should be connected to the Turck connector (labeled "**Instrument**") at the bottom which will supply 12 volts to power the instrument. [See Appendix III for Turck connector part # and wiring pin-out] This instrument input is also linked to a communication controller inside the deck unit that will convert the RS-485 signals from the instrument to RS-232 signals and re-route them out the "**Serial Out**" DB-9 connector on the Instrument Test interface module. Now, the instrument can be controlled, tested and log data by connecting a PC to the RS-232 output (DB-9 connector) and using a terminal program such as HyperTerm™. The communications parameters are independent of the deck unit and are determined by the instrument being tested.

4.1.2 Rear Panel

The rear panel of the LOPC deck unit is shown in Figure 12.

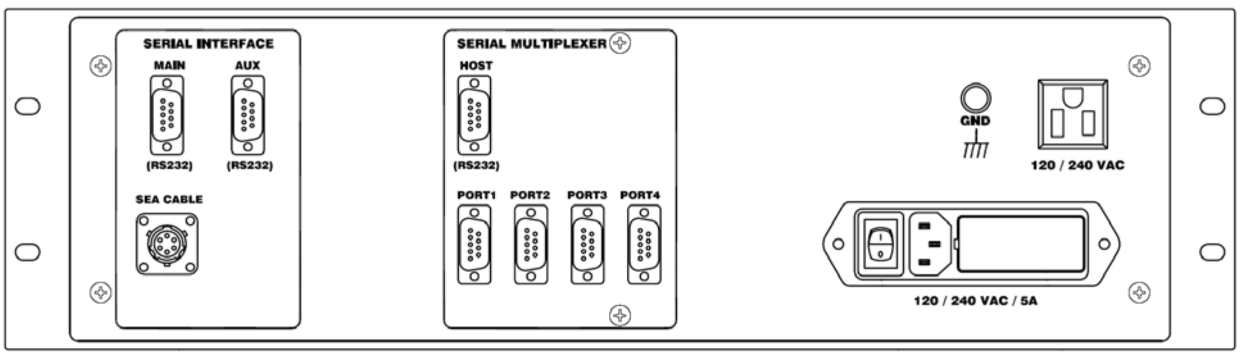


Figure 12 - Deck unit rear panel

Sea Cable

The power and communications hub of the LOPC. This connection provides power to the underwater LOPC probe and acts as the communication link between the surface and underwater power-line modems. [*See Appendix III – General Drawings, for part numbers, pin-outs and wiring diagrams for all deck unit connectors*].

Main

RS-232 communications link between the deck unit and the LOPC logging PC running the interface software. This connector is a standard female DB-9 connector. The communications parameters for this serial connection are: 115200 baud, 8-N-1.

AUX

The AUX interface is a feature of the deck unit that is mainly for use with tow bodies such as the Moving Vessel Profiler (MVP) or any other device or tow body that requires a source of pressure/depth data. As data is streamed from the LOPC probe, a communications controller in the deck unit monitors all CTD data in the data stream and re-routes this data through AUX as an output data stream.

To take advantage of this data, connect a serial cable to this output and feed it into any RS-232 serial device that you wish. The communication parameters for this output are 115200 baud, 8-N-1.

Serial Multiplexer

**** The Deck Unit MUX is an optional component and will only be available if requested by the user when the order is placed. ****

PORT1 through PORT4 are directly linked to an internal multiplexer which will merge all data streams into a single source and send it to the LOPC logging computer via the MAIN output port.

This can be very useful for inputting various RS-232 data stream that cannot be directly connected to the underwater probe. The multiplexing of data streams into one destination file provides automatic data integration for easy cross-referencing and analysis.

Some possible uses may be:

- Input a GPS/NMEA source into the data stream
- Input SBE 911+ CTD data from a logging PC running SEASAVE
- Input just about any RS-232 data source that is available at the surface

The HOST port is used to configure the multiplexer inputs.

Rear Power Block

A main AC power switch is located in the power block at the rear. The power block is factory configured for 120V or 240V (60/50Hz) operation depending on the region in which it will be used. The rear AC power switch must be in the on position for the deck unit to function properly.

AC Outlet

The auxiliary 3-prong AC outlet (also protected by 5A fuse) is made available to the user for extra equipment such as a computer (the voltage of this AC outlet will match the configured voltage of 120 or 220 V AC). ***Please note that turning off the power at the deck unit will not remove power from the AC outlet.*** This AC outlet will remain 'hot' as long as the deck unit is plugged in to a power source. This is so that powering off the deck unit will not cause you to inadvertently shut down any equipment that may be powered via the deck unit outlet.

WARNING: The AC outlet matches the supply voltage, which is configured at the factory for 120V or 240V.

4.2 Sea Cable

The LOPC uses between 15W and 20W of power, depending on any attached instrumentation. To reduce transmission line losses on long cable lengths, it is powered from a high-voltage/low-current power supply. The surface supply voltage is 140V DC, nominal.

The LOPC can be used on standard sea-cables. It has been successfully used on multi-conductor cables up to 3600m in length. When using multi-use sea-cables, care must be taken not to exceed the maximum depth rating of the unit.

WARNING: The standard LOPC has a maximum depth rating of 660m.

The LOPC requires two dedicated conductors in the sea-cable (armored cables and cables with a seawater ground cannot be used with the LOPC's power-line telemetry system).

The LOPC package includes a 5 m test-cable. The LOPC can be connected directly to the deck unit using the test cable, allowing pre-survey checks of the instrumentation to be carried out in a laboratory setting. See Figure 13.

Figure 13

Integration with an existing profiling platform or tow-body may require the construction of jumper cables that are compatible with the LOPC and deck unit. Figure 14 shows a generic wiring schematic. The test cable is used to interface the deck unit to the sea cable.

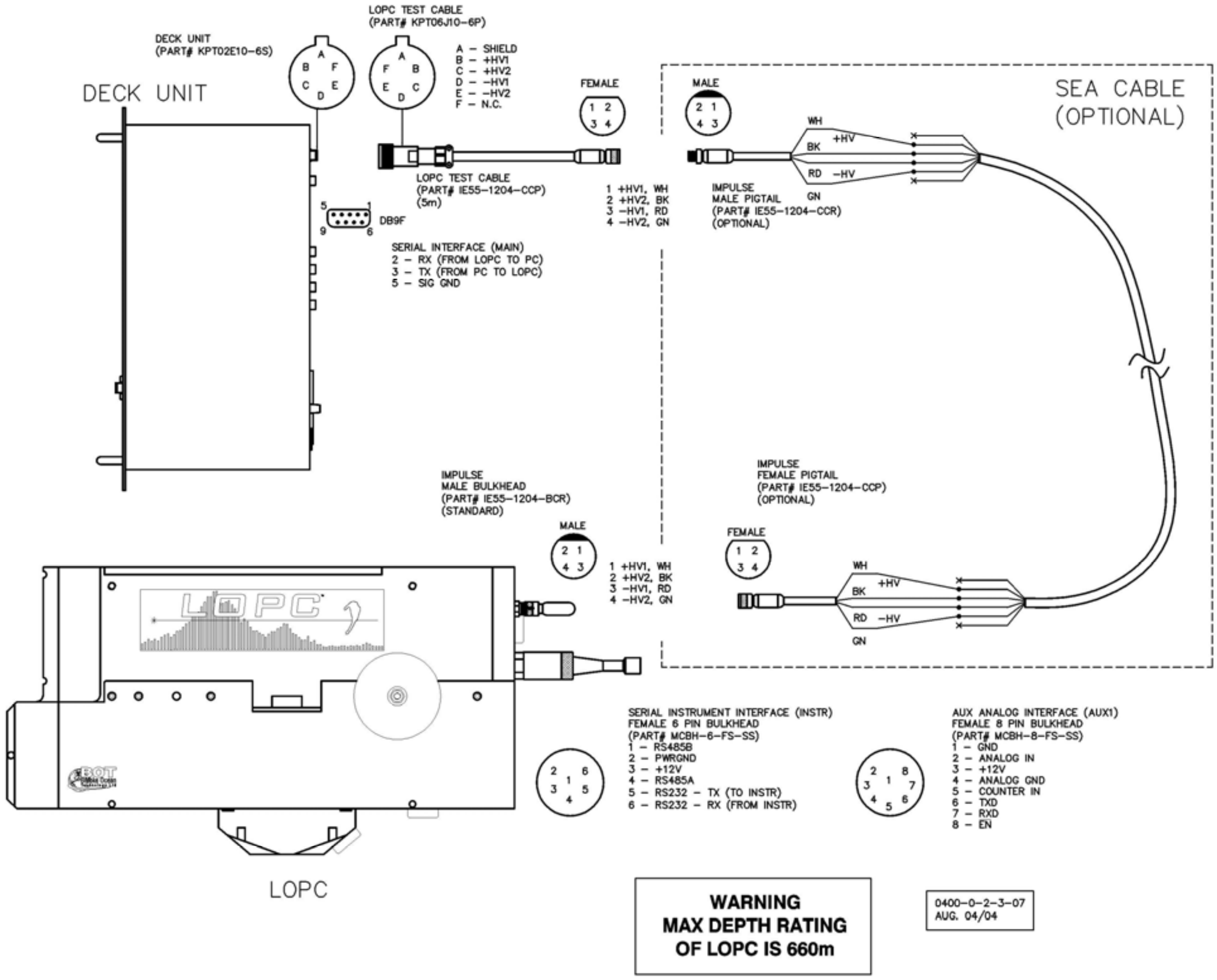


Figure 14

WARNING: Make sure that the deck unit is powered OFF when making connections to the LOPC or when servicing the sea-cable.

High voltages are present when the deck unit is ON.

The deck unit and test cable, use 4 conductors with 2 wires paired together in parallel - each pair functioning as a single conductor. The conductors are paired to decrease the inefficiencies of powering the instrument over a long sea cable. The LOPC is one of several 'plug and play' instrumentation payloads that can be installed in the MVP multi-sensor free-fall fish. This wiring configuration is standard for the MVP tow-cable.

Figure 15 is an illustration of how the LOPC is mounted in the MVP fish. Figure 16 is a photograph of the fish being deployed from an MVP300.

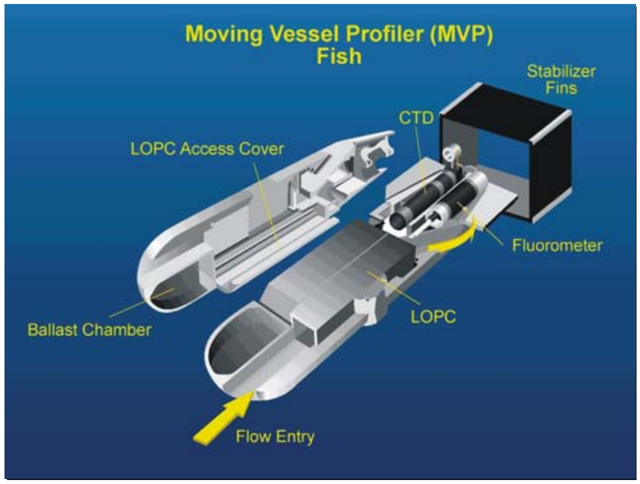


Figure 15

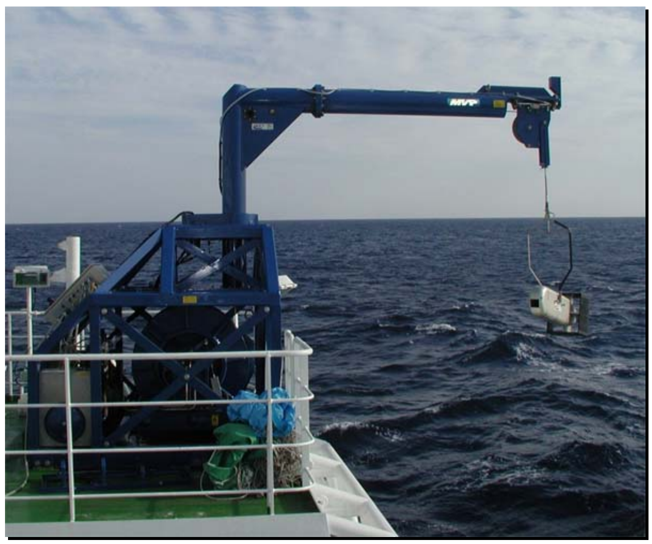


Figure 16

See section 7.2 for details on how to mount an LOPC with an MVP.

4.3 LOPC

The LOPC electronics are housed in a single pressure case. The LOPC does not contain any field serviceable parts, therefore, the pressure case should not be opened which may introduce contaminants and affect the operations of the unit.

WARNING: Opening the pressure case without written BOT authorization will void the product warranty.

The LOPC can be operated as a standalone instrument. With a CTD attached, it is a complete profiling package. The built-in serial interface can support a 12V instrument in RS485/422/232 format. The 0-5V analog interface can be used to log auxiliary data such as fluorometry. An example of an LOPC interfaced to an AML CTD and a fluorometer is shown in Figure 17. The LOPC can also accept an electronic counter input from an instrument such as a flow meter.

WARNING: Make sure that the deck unit is turned OFF when making connections to the LOPC or when servicing the sea-cable.

High voltages are present when the deck unit is ON.

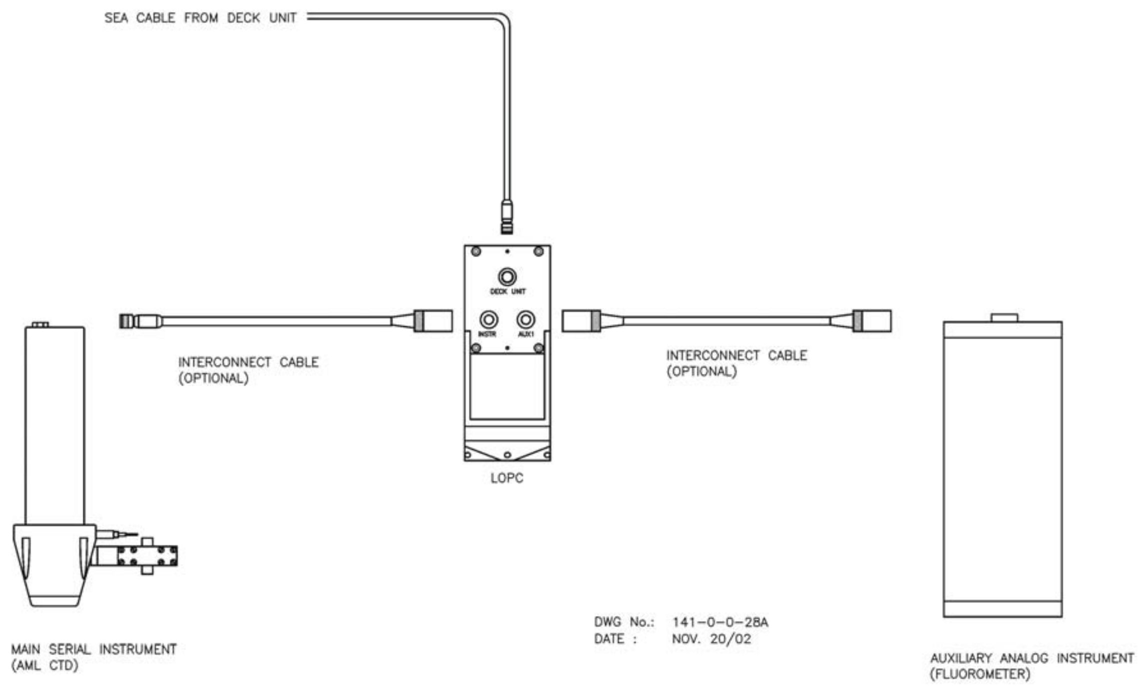


Figure 17

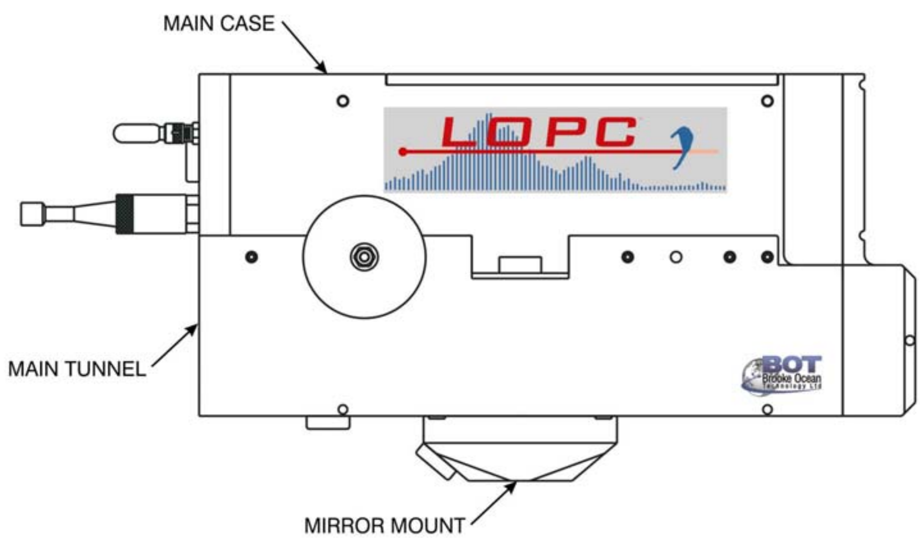
Each time the CTD outputs a data sample, the analog instrument is digitized by a 12-bit A/D. The raw count is appended to the end of the CTD data string. Data is transmitted to the surface in a binary format so as to maximize modem throughput. The CTD data strings are multiplexed with LOPC data prior to transmission. The standard serial interface is configured for the AML

Micro CTD, configured to automatically start on power up. Please consult with BOT if a CTD from a different manufacturer is to be used.

4.3.1 LOPC Sampling Tunnel

The LOPC is comprised of several main components (reference drawing in Appendix III). Of these components, the main sampling tunnel is designed to be interchanged with larger tunnels to increase sampling volume. The standard LOPC is shipped with a 70 mm wide sampling tunnel, and there is an optional 2.5x larger tunnel available. Although these tunnels are interchangeable with the LOPC pressure case, they must be factory calibrated and aligned to the LOPC prior to swapping.

NOTE: Removal of the Mirror Mount will cause misalignment of the LOPC optics.



4.4 Data Processing

The LOPC System includes a software package that is loaded on a PC supplied by the user. Minimum hardware requirements and detailed instruction on software operation are covered in a separate software manual (see Appendix II).

The software is used to configure the LOPC data processing parameters and will display the LOPC data in real-time while logging to disk for archiving and post-processing. A screen capture of LOPC data being collected is shown in Figure 18.

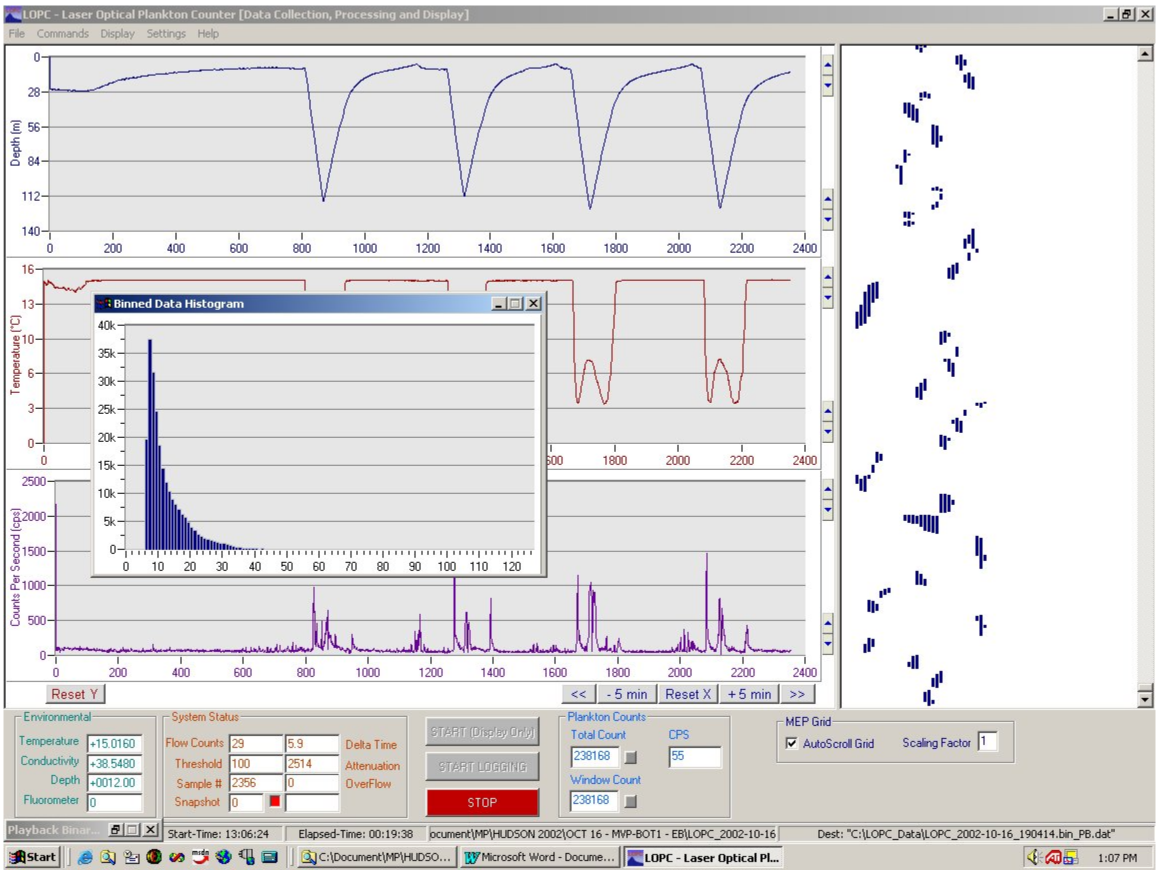


Figure 18

5 COMPLETE PACKAGE

The standard LOPC sensor package consists of the following (see Figure 19):

1. LOPC with dummy plugs
2. Deck unit with power cable
3. DB9F to DB9M Deck Unit - to - PC cable (1.8 m)
4. LOPC - to - Deck Unit test cable (5 m)
5. LOPC Operations and Software Manuals
6. LOPC Software and Manuals on CD
7. Calibration beads (3 sizes)
8. Shipping case

Figure 19

The following options can be ordered separately:

- Female impulse pigtail (IE55-1204-CCP)
- Male impulse pigtail (IE55-1204-CCR)
- LOPC DATALOGGER
- Sea Cable
- G.O. Flow meter
- Lab test stand
- Additional calibration beads
- CTD:

    AML Smart CTD

    SeaBird (Seacat Profiler) 19plus CTD

6 OPERATION

As a recommended practice, the user should take some time to operate the LOPC in the lab before deployment at sea. This will allow the user to perform operational checks, as well as becoming familiar with the instrument and software prior to sea trials.

6.1 Lab Operation

The following is a step by step guide that directs the user through the process of getting the LOPC up and running and performing operational checks in a lab or bench-top setting.

6.1.1 Power Up

1. Ensure the Deck Unit power is off.
2. Connect the Deck Unit power cord and plug the power cord into an AC source.
3. Use the Test Cable provided to connect the LOPC Deck Unit (connector labeled "**Sea Cable**") to the LOPC sea cable connection.
4. Connect any external serial instruments, such as a CTD, to the **INSTR** (Instrument) input connector on the LOPC. You can also connect an external analog or counter instruments to the **AUX** (Auxiliary) input connector. Refer to wiring diagrams (Appendix III) for proper pin-outs and connectors for these inputs.
5. To communicate with the LOPC from the logging PC, connect the serial cable (DB-9) provided from the Deck Unit (connector labeled "**Serial Interface - MAIN (RS-232)**") to the serial port of the logging PC.
6. Turn on the power to the system by flipping the power switch on the Deck Unit to the on position, '1'. The deck unit power can be verified by observing the power LED at the front of the deck unit.
7. To verify that power-up was successful, the user can observe the communication LED at the front of the deck unit. When the power is initially applied, but briefly after the '**MODEM – LOCK**' LED lights up, the user should see an instance of activity on the '**MAIN – TX**' LED as the LOPC broadcasts its boot-up sequence.
8. A simple check can be made to verify that the LOPC's laser is operational by inserting a strip of paper into the tunnel of the LOPC and piercing the laser beam. The beam should be viewable on the paper.

WARNING: Do not insert sharp objects into the LOPC tunnel!
The acrylic lens in the pressure case can be scratched, which may cause interference in the laser transmission path.

6.1.2 Communications Check

1. If not already installed, install the LOPC Interface Software from the Installation CD provided. Refer to the Software Operation Manual, Section 2.0, for installation instructions.
2. Configure the serial communication settings under the Settings menu on the interface (see Software Operation Manual, Section 4.1).

NOTE: All software settings should be properly configured before use to ensure correct operation. Refer to LOPC Software Manual.

3. With the LOPC powered up and all software settings properly configured, communications can be verified.
4. To check communications between the LOPC and the logging PC, click the "**Start Logging**" button on the interface to initiate scanning.
5. After starting logging, communications with the LOPC can also be verified by observing the sample number window (see Software Manual, Section 3.2.2). If the sample number begins incrementing after starting logging, communications with the LOPC is operational.
6. Communications between the LOPC and any connected external instruments can also be verified at this time by observing the digital controls for depth, temperature, etc. These controls should be displaying instrument values and NOT zeros if there is an external instrument (CTD) connected.

6.1.3 Calibration Check

Refer to Section 3.1

6.2 Ship-board Operation

WARNING: Make sure that the deck unit is turned OFF when making connections to the LOPC or when servicing the sea-cable.

High voltages are present when the deck unit is ON.

6.2.1 Sea Cable Connection

1. Connecting LOPC to Sea Cable (see Figure 14)

a. The underwater end of the sea cable will require a 4-pin female, IE55-1204 pigtail for mating with the LOPC. This pigtail connection with the sea cable will provide both power and communications to the LOPC and must be a proper underwater splice.

2. Connecting Deck Unit to Sea Cable (see Figure 14)

a. Connect the provided Test Cable to the Deck Unit's "**Sea Cable**" connector.

b. Using a 4-pin male, IE55-1204 pigtail, mate the pigtail connector with the mating end of the Test Cable.

c. The leads of the attached pigtail can be wired to a pluggable terminal block, such as those shown in Figure 20.

Figure 20 - Terminal Block Connectors

d. The mating end of the terminal block can be wired to leads of the surface end of the sea cable (inside the lab). When the terminal block is mated, the Deck Unit will be connected to the LOPC on deck providing power and communications.

6.2.2 Power and Communications Test

1. Power the Deck Unit with the AC power cord and connect the Deck Unit to the logging computer via the serial cable as previously described in the Lab Operation section (6.1).
2. Power up the Deck Unit, thus powering the LOPC, by pressing the power button.
3. When the LOPC Interface software is loaded, the status lights on the main window panel will indicate to the user if communication is established and if the LOPC is ready to start profiling.
4. Using the Interface Software, start logging data from the LOPC on deck by having someone drop sand, clay, salt, etc. (anything to generate data that you will not want to recover) through the LOPC tunnel.
5. If counts are being displayed on the screen, power and communications are acceptable.

NOTE: These steps can be performed to ensure proper operation before the instrument is deployed into the water.

WARNING: DO NOT leave the LOPC sitting in direct sunlight for extended periods of time while power is applied.

The LOPC utilizes high-speed signal processors that can overheat and be damaged in extreme circumstances.

6.3 User Configuration

The LOPC has optional configuration parameters that may need to be changed depending on the configuration in which a user may wish to use the system.

The LOPC outputs a menu on startup which indicates to the user a little of commands to which it will react. To load this menu, perform the following steps:

1. Connect the LOPC to the Deck Unit via 'Sea Cable' connector using the 5m test cable
2. Connect the Deck Unit to the PC via the 'Serial Interface – Main' connector using a serial cable.
3. On the PC, open a terminal emulation program such as HyperTerm (or any other) and configure the terminal to the port connected to the Deck Unit in step 2 and use the following communication parameters: 115200 baud, 8-N-1.
4. Now turn on the Deck Unit power.
5. After a few seconds the LOPC will finish initialization and the following menu system will be output to the terminal screen.

```
-------------------------------------------
  LASER OPTICAL PLANKTON COUNTER
-------------------------------------------
    LOPC VERSION:         2.37
    DSP FIRMWARE:         2.32
    DETECTION THRESHOLD:  100
    CALIBRATION COEFF:    1.00000
    MIN BACKGROUND:       512
    NEGATIVE THRESHOLD:   -100
    NEGATIVE TIMEOUT:     995
    FLOW CALC WINDOW:     10 - 20
    SCAN COUNT TIMEOUT:   3 - 1000
    ELEMENT SCAN WINDOW   0 - 34
    COMBINED ELEMENTS:    2
    LASER CTRL RANGE:     1650 - 2500
    LASER INCREMEMT:      1
    CONTROL INTERVAL:     50
    CONTROL OUTPUT:       2550
    LASER START UP:       2100
    LASER CONTROL:        ENABLED
    BKGRND COEFF A/B:     0.00499 / 0.99501
    SIGNAL COEFF A/B:     0.59999 / 0.40001
    DIRECT RS-232 MODE:   OFF
    SERIAL INPUT (CTD):   RS-232,9600,8-N-1
-------------------------------------------

    User Configuration        [C]
    Acquisition Scan Loop     [A]
    View Aux/Ctd Serial Data  [V]
    View Aux Analog Data      [F]
    Element Scan Loop         [S]
    Trigger Snapshot          [R]
    View Snapshot Data        [T]
    Store Snapshot Data       [P]
    View Binned Data          [B]
    View MEP Buffer           [M]
    Reset MEP Buffer          [W]
    View Filtered Inputs      [Z]
    View MEPs In Real Time    [G]
    Eeprom Dump               [D]
    Exit Program              [E]

    >> enter selection.....>>
```

This menu lists various items including the firmware versions, the LOPC's operational parameters, its current configuration and the menu items. The two items that are of particular interest to a user are the “DIRECT RS-232 MODE” (indicates if this options is ON or OFF) and the “SERIAL INPUT” configuration (RS-232 or RS-485 and the communication parameters).

To configure these options, the user must type a “**c**” at the main menu prompt which will load the “User Configuration” submenu (shown below).

```
-------------------------------------
  LOPC - USER CONFIGURATION
-------------------------------------
   DIRECT RS-232 MODE:  OFF
   SERIAL INPUT (CTD):
      Protocol    =     RS-232
      BaudRate    =     9600
      Comm-Params =     (8-N-1)
-------------------------------------

   Toggle Direct RS-232 Mode   [R]
   Configure Serial Input      [I]
   Format Flashcard            [F]
   Eeprom Dump                 [D]
   Quit to Main Menu           [Q]

    >> enter selection...>>
```

These configuration options are described in the following sections:

6.3.1 Automatic Direct RS-232 Mode

The LOPC may be used in a mode where the internal power-line modem and deck unit are bypassed, allowing direct communication with the LOPC via the AUX bulkhead connector.

This feature is useful to those users who may wish to integrate the LOPC with other sensor arrays that require RS232 communications. Note that the deck unit may still be used to power the LOPC but will not be responsible for communications in this mode.

To enable direct RS232 mode, simply connect the proper cable (refer to wiring diagrams in Appendix III) to the AUX bulkhead connector and apply power to the LOPC. To restore the standard communication mode, simply remove the special AUX cable and apply power to the LOPC.

6.3.2 Forced Direct RS-232 Mode

NOTE: This method of enabling direct RS-232 mode is not recommended. Should RS-232 communication be unavailable for any reason, there is no way to switch the unit back to normal communication mode.

Choose the ‘Toggle Direct RS-232 Mode’ option by typing an “**r**” at the menu prompt. This will load a message requesting action from the user.

```
DIRECT RS-232 MODE: <OFF>
Set state [ 0 = OFF, 1 = ON ]:  [0] ?
```

Type a “0” to turn Direct RS-232 Mode off or a “1” to turn the Direct RS-232 Mode on.

When Direct RS-232 Mode is enabled, all communications from the terminal window will stop. This is because enabling Direct RS-232 Mode will disable the power-line telemetry system and all communications must now be performed via the Direct RS-232 port on the 8-pin AUX bulkhead. See wiring diagrams in Appendix III for proper connection to the Direct RS-232 port. To return LOPC communication control to the Deck Unit's power-line modems, turn off the Direct RS-232 Mode via the User Configuration menu and disconnect any communication cables connected to the 8-pin bulkhead. Reconnect the PC to the Deck Unit's 'Serial Interface – Main' connector.

6.3.3 Configure Serial Input (CTD)

This configuration applies to the serial input to the LOPC via the **INSTR** bulkhead connector (6 pin). The LOPC is capable of accepting a serial data stream and integrating it with the LOPC data stream that is transmitted to the surface. This serial input is mainly used for a CTD input and the communication configuration can be modified by the user. The standard configuration for the LOPC is to accept a RS-485 serial input at 19200 baud with communication parameters 8-N-1. However, following the steps below, this configuration can be changed to accept other instruments such as the configuration for a Seabird SBE 19plus CTD as shown in the example.

1. Power off the LOPC and disconnect any Instruments

Ensure that the LOPC is initially powered off and disconnect any instruments that may be connected to the LOPC's **INSTR** bulkhead connector. The LOPC will have to be turned back on to perform the configuration, but leave any instruments disconnected until the configuration is complete. This is to avoid any bus contention on the internal data lines as the serial drivers are configured for proper input by the LOPC.

2. Access the Configure Serial Input menu

Power the LOPC and connect to the LOPC via a computer using a terminal program as described in the previous section. Load the User Configuration menu by typing "**c**" at the main menu. Then enter an "**i**" to access the 'Configure Serial Input' option. Accessing this option will force the LOPC to prompt the user to input several parameters:

```
+ Select Communication Protocol {0=RS-485 or 1=RS-232}  [1] ?
```

Select RS-485 or RS-232 for the serial communication protocol. For our example, SBE 19plus, RS-232 should be selected by typing a "1".

```
+ Enter Baudrate  [9600] ?
```

Enter the baud rate at which the serial instrument communicates. For the SBE 19plus enter "9600".

```
+ Select Comm Parameters {0=(8-N-1), 1=(7-E-1)}  [0] ?
```

Select the communication parameters for this device. For the SBE 19plus, select (8-N-1) by typing a "0" at this prompt.

When this configuration is complete, the LOPC will reset to re-initialize and activate the changes.

3. Connect the serial device

At this point you should test the configuration by connecting the serial instrument you wish to use to the **INSTR** input on the LOPC (See wiring diagrams in Appendix III for proper pin-out connections).

NOTE: The serial instrument you are using should be manually configured and set to auto-start before connected to the LOPC. For example, if using a Seabird 19plus CTD (a match for the configuration shown above), the CTD should be configured and put into sampling mode (STARTNOW) prior to connecting it to the LOPC.

4. Test the configuration

To test the serial input type '**v**' to 'View AUX/CTD Data' from the main menu and if configured/connected properly the serial data stream will begin displaying on the screen as seen below:

```
    >> enter selection.....>> [V]

Type any character to quit

0001.1 19.9900 15.0100 4071 0
0001.2 19.9800 15.0200 4071 0
0001.3 19.9700 15.0300 4068 0
0001.4 19.9600 15.0400 4070 0
0001.5 19.9500 15.0500 4071 0
0001.6 19.9400 15.0600 4069 0
0001.7 19.9300 15.0700 4070 0
0001.8 19.9200 15.0800 4070 0
0001.9 19.9100 15.0900 4070 0
0002.0 19.9000 15.1000 4068 0
0002.1 19.8900 15.1100 4070 0
0002.2 19.8800 15.1200 4070 0
0002.3 19.8700 15.1300 4069 0
0002.4 19.8600 15.1400 4069 0
0002.5 19.8500 15.1500 4070 0
0002.6 19.8400 15.1600 4069 0
0002.7 19.8300 15.1700 4070 0
0002.8 19.8200 15.1800 4071 0
0002.9 19.8100 15.1900 4070 0
0003.0 19.8000 15.2000 4068 0
0003.1 19.7900 15.2100 4070 0
0003.2 19.7800 15.2200 4071 0
0003.3 19.7700 15.2300 4069 0
0003.4 19.7600 15.2400 4070 0
0003.5 19.7500 15.2500 4070 0
0003.6 19.7400 15.2600 4069 0
0003.7 19.7300 15.2700 4070 0
0003.8 19.7200 15.2800 4070 0
0003.9 19.7100 15.2900 4071 0
0004.0 19.7000 15.3000 4069 0
0004.1 19.6900 15.3100 4069 0
```

To end the serial input test, type '**q**' to quit. The terminal program can now be closed and the serial input tested with the LOPC Interface Software before deployment.

NOTE: The LOPC will accept nearly any serial data via the INSTR input and integrate it within its own data stream to the surface. However, the surface software can only parse and process a select number of instrument inputs as listed in the software. Any instrument not in this list will not get parsed and displayed as observable data at the surface. If this is desired, please contact BOT for software modifications and upgrades.

6.3.4 Format Flashcard

Select this option to format the LOPC's internal flashcard. This option is generally not required unless requested by BOT staff.

6.3.5 Eeprom Dump

Selecting this option will output a list of all stored parameters that the LOPC uses in its processing and configuration. This list is illustrated below:

```
**********
# CFXVER=2.37
# DSPVER=2.32
# DIRECT_RS-232_MODE=0
# SERIAL_INPUT=RS-232,9600,8-N-1
# THRESHOLD=100
# CALIBRATION_COEFF=1.000
# MIN_BACKGROUND=512
# MINUS_THRESHOLD=-100
# MINUS_TIMEOUT=995
# FLOW_WINDOW=10-20
# SCAN_TIMEOUTS=3-1000
# SCAN_ELEMENTS=0-34
# BKGRND_COEFF_AB=0.005/0.995
# SIGNAL_COEFF_AB=0.600/0.400
# CF1_SN=51562
# BIOS=2.28
# PicoDOS=2.28
# LASER_SET_RANGE=1650-2500
# LASER_CTRL_INC=1
# LASER_INIT=2100
# LASER_CTRL_INTERVAL=50
# BKGRND_CTRL=2550
# CTRL_MODE=1
# COMBINED_ELMENTS=2
**********
```

This option cannot alter the EEPROM or its stored data in any way; it is for observation purposes only.

7 TOW BODY CONFIGURATIONS AND INSTALLATION

The LOPC has been designed with the knowledge that it will need to be mounted into numerous different styles of tow bodies. The LOPC is supplied with a bolt hole, mounting pattern on both sides of its pressure case, this allows for an adapter plate to be added which will allow mounting to the customer preferred tow body. To date, the LOPC has been mounted to the VLOPC Frame (Vertical Laser Optical Plankton Counter) (Figure 21) and on a Tow Net (Figure 22). The LOPC has also been integrated into the BOT Moving Vessel Profiler (MVP).

NOTE: The LOPC can be mounted onto numerous tow bodies. Please discuss your application with Brooke Ocean Technology to determine the most appropriate mounting configuration for alternative applications.

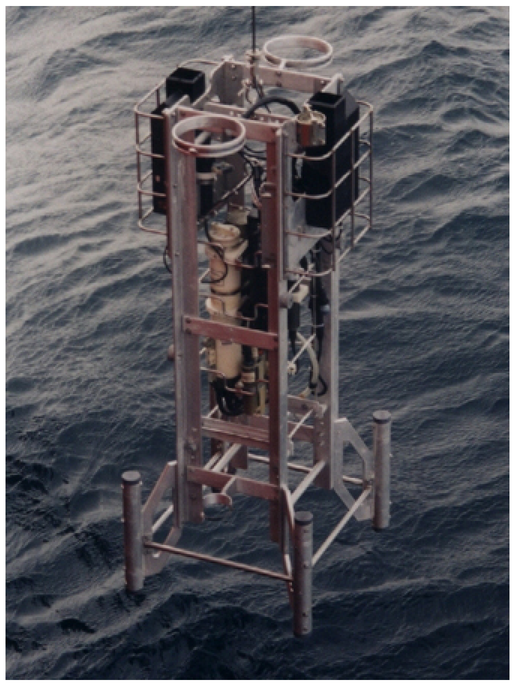


Figure 21 - VLOPC Frame

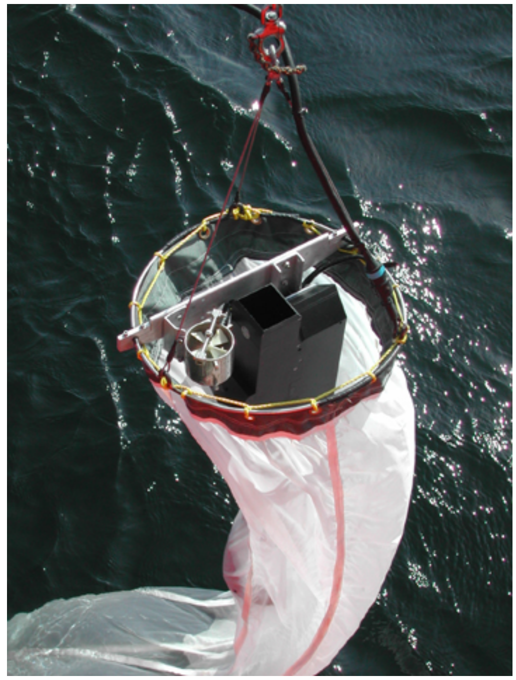


Figure 22 - Tow Net

NOTE: When mounting the LOPC to a tow body, every effort should be made to electrically isolate the LOPC from the tow body.

7.1 Moving Vessel Profiler (MVP)

The Moving Vessel Profiler (MVP) system is a self-contained profiling system capable of sampling water column profiles from a vessel moving at up to 12 knots, and deeper depths at slower speeds. The system provides vertical profiles of oceanographic data such as Sound Velocity, CTD, LOPC, etc. for various operations including the calibration of multi-beam sounder systems for hydrographic operations. The MVP is completely autonomous and can be controlled by computer without the requirement for personnel on deck. The system consists of a single or multi-sensor free-fall fish, an integrated winch and hydraulic power unit, towing boom and a remotely located user interface controller. An MVP300-1700 system is shown in Figure 23.

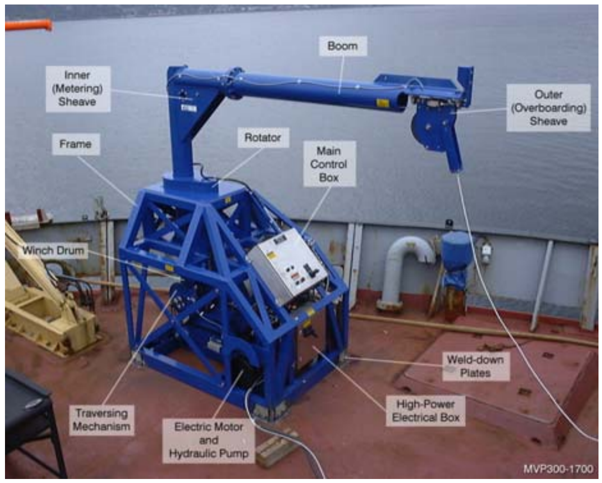


Figure 23 - MVP300-1700

7.2 Multi-sensor Free-fall Fish

The Multi-sensor Free-fall Fish (see Figure 24) is machined from aluminum with a stainless steel towing bridle. The sensor guard at the tail of the fish is manufactured from plastic and is bolted to the tail fins. The space provided in the internal cavity has been designed to be as flexible as possible and can be fitted with a variety of instruments.

Figure 24 - MSFFF

Installation of LOPC into MSFFF

1. Remove the Tunnel Extension from the LOPC (See Figure 25). The tunnel extension is held in place by 6 #4-40 bolts. See Appendix III for reference.

Figure 25 - LOPC with Tunnel Extension

2. Remove the dummy connector plugs from the LOPC. See Appendix III for reference.
3. Remove all of the anodes on the LOPC except the anode located on the end cap. See Section 8.3 for reference.
4. Refer to the MVP 300 Operations and Maintenance Manual for instructions on disconnecting the MSFFF from the MVP.
5. With the MSFFF disconnected from the MVP, the LOPC can be installed.
6. Refer to Drawing #0010-4-C-0-00, MVP300 Multi-Sensor Fish General Assembly, in the Appendix of the MVP 300 Operations and Maintenance Manual
7. Remove the eight (8) cap screws from the top access panel.
    - If the MSFFF has been purchased with additional sensor suites using a DTM, please refer to the MVP 300 Operations and Maintenance Manual for proper DTM removal.

NOTE: The DTM and any other sensors in the main MSFFF cavity must be removed prior to the LOPC being installed.

8. Carefully remove the top access panel. The top access panel is supplied with two clamps for securing a DTM. These clamps must be removed for the LOPC to fit. The clamps are held in place with two (2) cap screws each.

9. Slowly lower the LOPC into the MSFFF. The LOPC is lowered into the MSFFF with the bulkhead connectors pointing to the tail of the MSFFF. Take care to ensure that the MVP Tow Cable does not get pinched by the LOPC (See Figure 26).

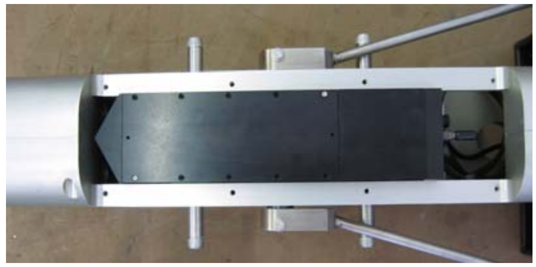


Figure 26

10. With the LOPC installed into the MSFFF, the MVP tow cable and sensors can be reconnected. To reconnect the tow cable and sensors remove the MSFFF side access panels (Figure 27). Be sure to secure the connections using the connector locking sleeves. Reinstall dummy connectors on the LOPC bulkheads not being used.

Figure 27 - MSFFF Access Panel

Once all connections have been made or dummy connectors installed, the access panels for the MSFFF can be reinstalled.

7.3 DTM Option

Some users have required the ability to integrate more sensors than are supported by the LOPC unit. In these cases, the system may be purchased with a BOT Data Telemetry Module (DTM) which provides the ability to multiplex data from additional sensors into the LOPC data stream.

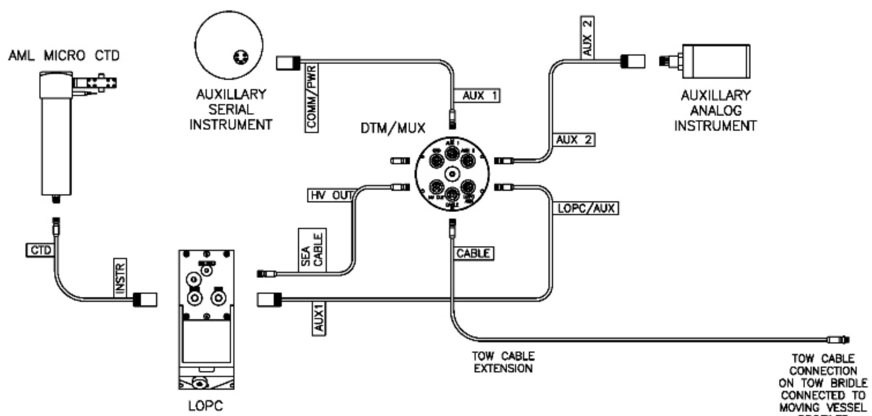


Figure 28 – LOPC connected to BOT DTM

There are no changes to general LOPC operation when used with a DTM. The LOPC software will collect additional data streams from the DTM and incorporate them into the standard output file.

7.4 Multi-Sensor Free Fall Fish II

To accommodate changing user needs, and increased demand for more sensors to be used in conjunction with the LOPC, BOT has developed a larger version of the MSFFF, shown in Figure 29. The fish in the photograph uses a BOT DTM to integrate data from four sensors, including an LOPC.

Figure 29 - MSFFF II

8 MAINTENANCE

The following section describes the maintenance that is required to ensure long term reliability of your Laser Optical Plankton Counter.

8.1 LOPC Maintenance

- Inspect the LOPC sensor for any signs of damage before and after all deployments. Visually inspect the pressure case to detect any deformation, corrosion, etc.
- Ensure that all three bulkhead connectors on the LOPC are capped off using the supplied dummy connectors when not in use. When the sensor is in use be sure to leave dummy connectors on any bulkheads not being used.

NOTE: If you unplug any of the connectors, be sure to apply a thin coat of silicone grease or spray to the bare conductors before re-connecting them.

**** 3M Silicone Spray is recommended for all water-tight connectors ****

WARNING: DO NOT open the pressure housing!
The LOPC is shipped calibrated and sealed. The LOPC does not contain field serviceable parts. Opening the pressure case can introduce contaminants and affect the alignment of laser and optics. Opening the pressure case without written BOT authorization will void the warranty.

- Inspect and clean connectors leading to the different components. Check for a build up of corrosion and fouling that may accumulate. Also check for cracks in the sleeves and re-tighten any loose locking collars.
- Wash down the system with fresh water after every use. (Be sure to cap any bare plugs and connectors prior to wash down.)
- Inspect the Main Tunnel. Look for debris, which may become lodged in the tunnel. Pay special attention to the slot in the tunnel, which leads to the optics prism. Ensure that this slot is free of any debris.
- Inspect the acrylic lens on the bottom of the main pressure case by using a mirror. Check that there are no scratches on the lens. Also check to see that there is not excessive salt build up on the acrylic lens. Any salt build up on the lens should be washed away with fresh water.
- Inspect electrical cables and connectors for any signs of damage.
- Clean all electrical connectors with a contact cleaner and silicone spray. When re-installing the connectors, use Dow Corning 111 waterproof silicone on the exposed contacts.

8.2 LOPC Cleaning

NOTE: Always flush the LOPC with fresh water after use.

The LOPC is a self-contained sensor. The laser and electronics are factory set and should not be removed or modified in any way, as this will cause misalignment and contamination. For this reason it is advised that the optics prism and acrylic lens should not be removed and cleaned separately from the sensor.

NOTE: In case of any failure, the LOPC should be returned to Brooke Ocean Technology for repair. A "Return Material Authorization" (RMA) number must be secured from BOT prior to return. The number must be displayed on the external packaging; otherwise BOT will not accept the shipment.

8.3 Corrosion Protection

The LOPC has several sacrificial anodes installed to help protect the aluminum housing from corrosion.

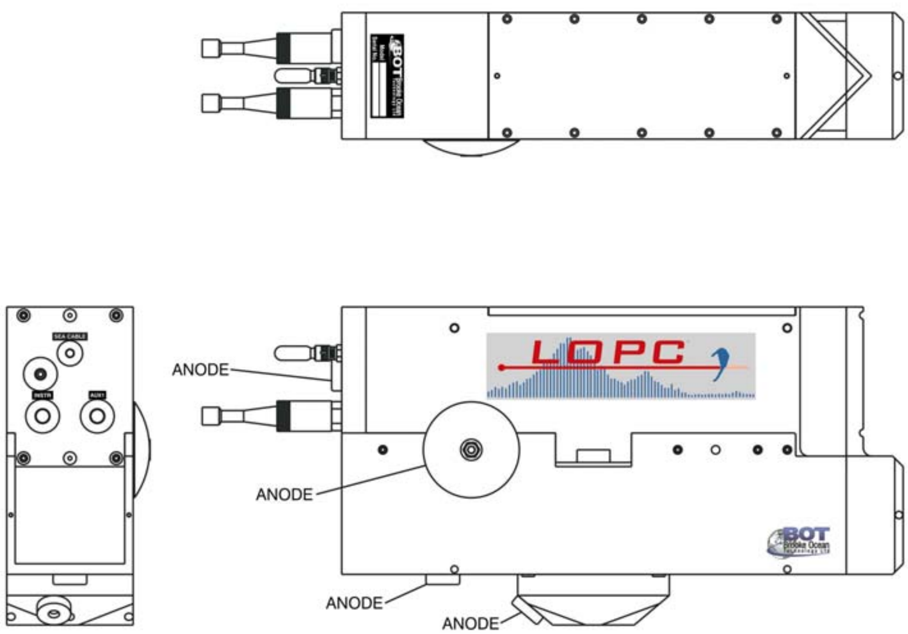


Figure 30

There are three small anodes mounted on the bottom and back of the LOPC, using #8-32UNC x 3/8" long socket head cap screws. The forth anode is larger and mounts to either side of the aluminum housing using a 1/4-20UNC x 3/4" long socket head cap screw. The larger anode uses one of the provided 1/4-20UNC mounting holes in the aluminum housing. This allows the anode to be moved to the opposite side of the aluminum housing when the LOPC is being mounted to a tow body.