MOCNESS

BIOLOGICAL
ENVIRONMENTAL
SAMPLING
SYSTEMS

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February 1999

Figure 2: updated 2003/11/21

OPERATING AND MAINTENANCE INSTRUCTIONS

CONTENTS

1. OVERVIEW OF SYSTEM

1.1 General Description

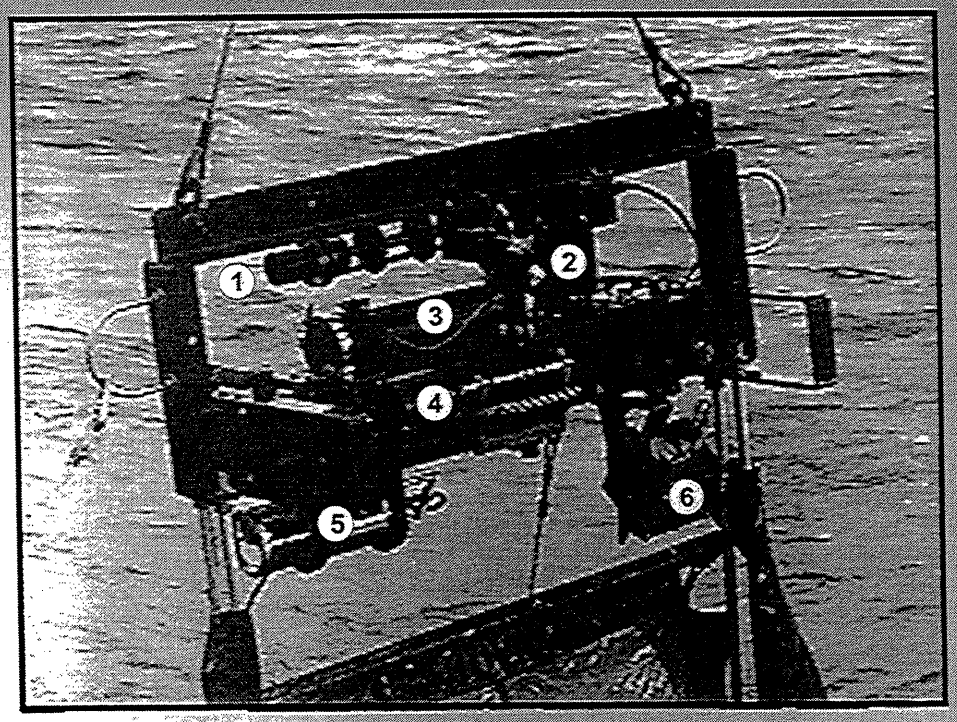
The Multiple Opening/Closing Net and Environmental Sensing System or **MOCNESS** is now a family of net systems based on the Tucker Trawl principle. There are currently 8 different sizes of **MOCNESS** in existence which are designed for capture of different size ranges of zooplankton and micro-nekton (Table 1; Wiebe et al, 1985). Each system is designated according to the size of the net mouth opening and in two cases, the number of nets it carries. The original **MOCNESS** (Wiebe et al, 1976) was a redesigned and improved version of a system described by Frost and McCrone (1974).

System	# of Nets	Width of Frame	Height of Frame	Net width	Mouth Area @ 45° towing angle	Length of Net	Approx. Weight in Air	Rec. Wire Diameter
MOCNESS-1/4	9	0.838 m	1.430 m	0.50 m	0.5 m^2	6.00 m	70 kg	6.4 mm
MOCNESS-1/4-Double	18/20	1.430 m	1.430 m	0.50 m	0.5 m^2	6.00 m	155 kg	7.4 mm
MOCNESS-1	9	1.240 m	2.870 m	1.00 m	1.0 m^2	6.00 m	150 kg	7.4 mm
MOCNESS-1-Double	18/20	2.560 m	2.870 m	1.00 m	1.0 m^2	6.00 m	320 kg	12.1 mm
MOCNESS-2	9	1.650 m	3.150 m	1.41 m	2.0 m^2	6.00 m	210 kg	11.8 mm
MOCNESS-4	6	2.140 m	4.080 m	2.00 m	4.0 m^2	8.44 m	460 kg	11.8 mm
MOCNESS-10	6	3.410 m	4.690 m	3.17 m	10.0 m^2	18.25 m	640 kg	11.8 mm
MOCNESS-20	6	5.500 m	7.300 m	4.47 m	20.0 m^2	14.50 m	940 kg	17.3 mm

Table 1. MOCNESS system dimensions and weights.

The **MOCNESS**-1/4 and the Double **MOCNESS**-1/4D carry nine and eighteen 1/4-m^2 nets respectively usually of 64 micrometer mesh and they have been used to sample the larger micro-zooplankton. The **MOCNESS**-1 (Figure 1) and the Double **MOCNESS**-1D carry nine and twenty 1-m^2 nets respectively usually of 335 micrometer mesh and are intended for use with the macrozooplankton. There are four midwater trawls: the **MOCNESS**-2 (with 2-m^2 nets), the **MOCNESS**-4 (with 4-m^2 nets), the **MOCNESS**-10 (with 10-m^2 nets) and the **MOCNESS**-20 (with 20 m^2 nets). These trawls typically carry five or six nets of 3.0 mm circular mesh; however, the **MOCNESS**-2 and -10 have been used with nine nets. All nets are dyed black to reduce contrast with the background.

All **MOCNESS** systems use the same underwater and shipboard electronics for flexibility and reduction of cost. The nets are opened and closed sequentially by commands through a single conductor armored cable from the surface. The electronics has 16-bits of resolution and the basic data stream consists of temperature, depth, conductivity, frame angle, flow counts, net number, and net response. An acquisition/controller computer retrieves data from the underwater unit at a rate of up to 2 times per second. Temperature (to approximately 0.01 C) and conductivity are measured with SEABIRD sensors. A modified T.S.K.-



Electronics and Sensors

1 Transmissometer

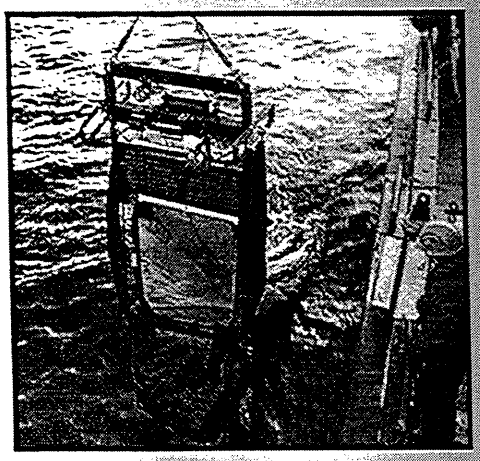
2 Flow Meter

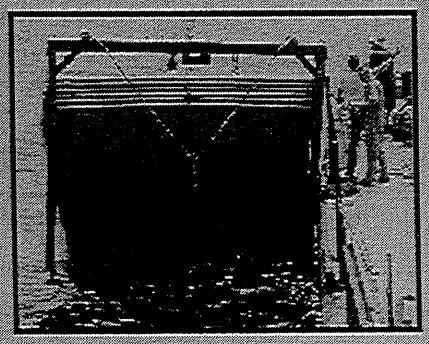
3 Underwater Unit

4 Motor and Toggle Release

5 Fluorometer

6 Conductivity and Temperature sensors





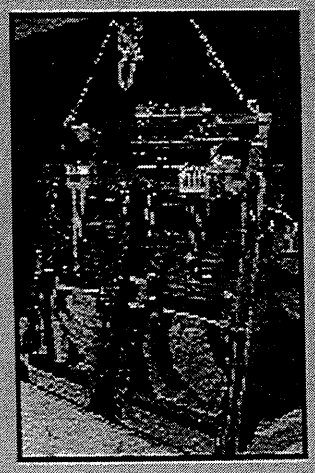


Figure 1. Field pictures of MOCNESS. Top and bottom left - 1-m^2 system. Bottom Center - 20-m^2 system. Bottom Right - Double ¼-m^2 system.

flowmeter (Tsurumi-Sikie-Kosakusho Co., Ltd.) is normally used to measure flow past the net. Both the temperature and salinity sensors and the flowmeter are attached to brackets which are mounted on the top portion of the frame so that they face directly into the flow when the frame is at a towing angle of 45°. An electronic pendulum angle transducer (Humphrey) measures the angle of the towed net through the water. A GPS unit providing latitude and longitude can be integrated into data stream. The electronics and mechanical frame can be modified to accommodate optional sensors: transmissometer, fluorometer, submarine photometer, bottom finding transducer (altimeter). Furthermore, acoustical and video (VPR) systems have been adapted for use on **MOCNESS** -1.

A microcomputer (together with disk drive, and printer) are the deck unit and permit shipboard real-time data acquisition and processing as well as net control. Salinity (to approximately 0.01 °/oo), net oblique velocity and vertical velocity, and volume filtered by each net is calculated after each string of data has been received by the computer. Raw and processed data are stored on disc (in separate files) and processed data can be printed out. Plots of net depth versus time, temperature and salinity versus depth, temperature versus salinity, and latitude versus longitude are made during a tow and displayed on the computer screen.

A motor/toggle release assembly is mounted on the top portion of the frame and stainless steel cables with swaged fittings are used to attach the net bars to the toggle release. A stepping motor in a pressure compensated case filled with oil turns the escapement crankshaft of the toggle release which sequentially releases the nets to an open then closed position on command from the surface.

Cod-end buckets for the **MOCNESS**-1/4 are constructed in two parts from 7.1 cm inside diameter PVC pipe. The upper portion of the bucket is a collar 9.8 cm in length which is attached to the cod-end of the net with a stainless steel hose clamp. The lower portion, a detachable bucket 19 cm in length, has a window covered with netting usually the same size as that used in the construction of the nets. Stainless steel Nielson fasteners are used to attach the bucket to the collar. Buckets for the other **MOCNESS** systems employ the same design, but use a larger diameter PVC pipe (15.2 cm inside diameter; upper portion length = 9.8 cm; lower portion length for the **MOCNESS**-1's = 33 cm; lower portion length for the larger trawls = 43.8 cm). A modified polyethylene funnel is placed between the upper and lower portion of the buckets at the time the buckets are assembled for a tow. This funnel helps prevent animals from being washed back into a net once it is closed thereby minimizing damage to them. The bottom of a 15.2 cm diameter funnel is cut to provide a 2.5 to 3.5 cm diameter opening into the bucket bottom and the rim is trimmed to fit into the ledge where the top and bottom portions of the bucket come together. The larger buckets have flotation in the bottom to make them nearly neutrally buoyant. The flotation insures that a bucket remains in the same plane as the net during a tow. There is usually enough drag on the nets and buckets to prevent them from tangling.

All **MOCNESS** systems incorporate the same basic design; the nets, the underwater electronics package, the environmental and net monitoring sensors, and electo/mechanical net release mechanism are mounted on a rigid frame and many of the components are interchangeable.

2. OPERATION OF THE SYSTEM AT SEA.

2.1 Assembly of **MOCNESS** on deck

2.1.1 Top frame brackets. Attach the front and rear guard brackets to the top I-beam. A pair of U-shaped brackets is mounted on the outside edge of the I-beam facing toward the rear.

They protect the pressure case and sensors. The other pair of U-shaped brackets is mounted facing forward on either side of the toggle release and motor drive assembly.

2.1.2 Lead weight. Secure the lead weight to the leading face of the lower I-beam using 3/8" stainless steel bolts.

2.1.3 Rods and net bars. Thread a 3/4" nut to the bottom of the threaded end sections of the four rods (3/4" diameter S/S for the **MOCNESS** -1/4; 7/8" for **MOCNESS** -1,-2, or -4). Insert the rods into the holes located at the edge of the upper I-beam. Slide the net bars onto the rear pair of rods in the correct order (bars are numbered 0 to 9 with no. 9 at the top) so that the tabs with the cable and swaged fittings face forward. Between net bars on each S/S rod, place 3 rings with trigger snaps. The trigger snaps attach to the grommets on the sides of the nets. A total of 54 ring-trigger snaps are required for a **MOCNESS**-1. Next, insert the four rods into the lower I-beam. Stopper nuts and flat washers should already be in place. Thread the set of nuts with flats and lock washers in place on the threaded portion of the rods until they are tight and the rods are evenly tensioned. The dacron flaps mount on the forward S/S rods (see section 2.1.9 below). The net response mechanism is mounted on the right hand (starboard) rod in the position cut into the dacron flap after the flap is put into place. On the **MOCNESS** -1, the net response mechanism in intended to be positioned approximately 12" above the top of the net bars when the bars are stacked on the bottom I-beam.

2.1.4 Motor and toggle. Mount the toggle-release and motor drive system on the center of the front side of the I-beam.

2.1.5 Bridle. Attach the bridle to the holes in the T-bar part of the frame using the shackles supplied with the bridle.

2.1.6 Underwater electronics. Place the underwater electronics unit on the top cradle position on the back side of the top I-beam so that the underwater bulkhead connectors face to the port side (left - as you face the direction the net travels through the water). Place the tie-down straps over the case and through the mounting holes on the I-beam. Use the 3/8 nuts to tighten the straps down loosely, but securely, because once the system is completely assembled, the pressure case must be rotated to adjust the angle transducer as described in section 2.2.3 below.

2.1.7 Battery Case. Install the underwater battery case on the bottom cradle position (back side of the top I-beam) parallel to the underwater electronics with the EO bulkhead connectors facing to the port side. Place the tie-down straps over the case through the mounting holes on the cradle and tighten them down securely.

2.1.8 Nets. **MOCNESS** nets are constructed with the leading edge of the top of the net equipped with two reinforcement loops. In side profile, the top of the net extends beyond the bottom a distance equal to the nominal mouth size of the net. Starting with net 0, slide a net retaining rod through the dacron loop on the bottom margin of the net mouth. Place the rod onto the net bar tabs and secure with a shackle through the tab hole. Put a net rod through the dacron and reinforcing loops at the top margin of the net mouth and place the rod on the tab of the next net bar. Next put the bottom of net 1 with the inserted net rod onto the same net bar as the top of net 0 and secure with a shackle. Repeat this procedure until all nets are

installed. The top of one net and the bottom of the next net should now be attached to the same net bar. Exceptions are the bottom of net 0 and the top of net 8. As the nets are being attached to the net bars, connect the trigger snaps to the grommet holes on the side of the nets.

2.1.9 Deflector flaps. The deflector flaps are designed to prevent contaminating organisms from entering folds of the nets when the nets are closed. The deflector flaps can be installed either before or after the nets are attached to the net bars. Open the velcro strip on the deflector flap and place the flap around each of the forward vertical SS rods. Note that one deflector flap has been cut to accommodate the net response mechanism and net bar trap. This flap should be placed on the starboard (right) side of the frame. The other has been cut to accomodate only the net bar trap (port side). Use shock cord to attach bottom and top of the deflector flaps to the frame. Also note that the electrical cable connecting the net response to the underwater unit should be lead inside the flap loop around the SS rod.

2.1.10 Net bar traps. Install the net bar traps at the bottom of each of the forward vertical SS rods. The deflector flaps are cut to enable the net bar traps be in direct contact with the rod. During installation and when loading the nets into the toggle release mechanism, the fingers in the traps should be pointed away from the rod on which the net bars slide. A length of 2" diameter PVC pipe which has been cut longitudinally in half can be used to hold the fingers tightly against the trap base during the process of rotating the trap so that the fingers face the adjoining vertical rod.

2.1.11 Net bar stops. Install the two net bar stops above the net bars, one on each vertical rod, after the net bars are loaded into the toggle release mechanisms. These stops are used to prevent the net bars from riding up and opening the net mouth before the bars are released by the toggle to prevent contamination.

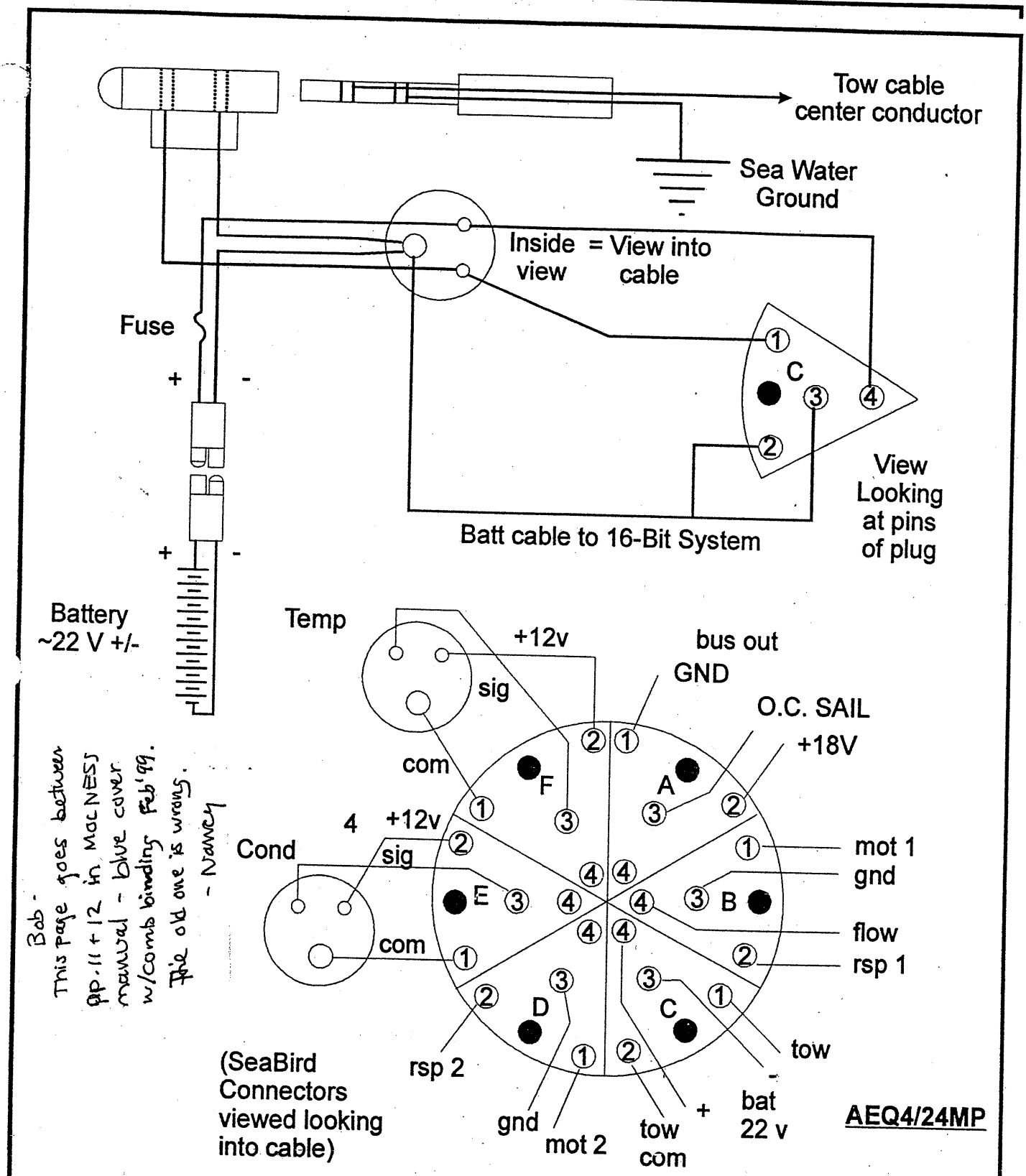
2.1.12 Cod-end buckets. Attach a cod-end bucket to each net with the appropriate hose clamp, being sure to tighten securely (#52 clamp for **MOCNESS**-1/4; #104 clamp for all other systems).

2.1.13 Flowmeter. Install the flowmeter with 2 1/4-20 SS cap screws onto the mounting bracket which is attached midway along the top-frame t-bar.

2.1.14 T/S sensors. Install the temperature and salinity sensors in the PVC sensor holder and attach the sensor holder onto the aluminum mounting bracket. Install the mounting bracket with sensors onto the top frame. Holes for mounting the bracket are located on the lower margin of the I-beam on the port side of the toggle release mechanism. Make sure the sensors are pointing forward into the flow when the net system is at a 45° angle.

2.1.15 Other sensors. Instructions for installing other sensors (transmissometer, fluorometer, altimeter, downwelling light) are included with each instrument.

2.1.16 Toggle adjustment. The toggle release and motor drive come from BESS properly adjusted. After maintenance, however, it may be necessary to adjust the cam so that each net bar is dropped with 30 degrees rotation of cam shaft (i.e., 3 steps of the rotary solenoid). This is done by loosening the Allen wrench screw of the U-joint coupling between the cam and



Bob - This page goes between pp. 11 + 12 in MocNESS manual - blue cover w/comb binding Feb '99. The old one is wrong. - Nancy

Figure 2. 16-bit MOCNESS Underwater Units Endcaps Wiring

motor shafts and adjusting the cam so that the center toggle has 1/32 to 1/16" clearance. Tighten down the screw, and with all toggles in a cocked position, rotate the coupled shafts carefully, checking to make sure each toggle is released on the third step and that there is adequate clearance.

2.2 Hookup of electrical cables

2.2.1 Tow cable. Test continuity of conducting cable before and after installing slip rings. The user must know the manufacturers cable specifications. As a rule, the cable resistance should be less than 500 ohms and its capacity less than 1.0 microfarad. Additional information about tow cables is given in sections 3.2.1 and 3.2.2 below.

2.2.2 Continuity test. Test continuity of conducting cable through conducting cable termination to deck unit signal input connector.

2.2.3 Cable Harness. All connections between the underwater unit, the sensors and other devices are made through a 6-sector 4-pin/sector pie bulkhead connector which is located on the end cap of the underwater unit (Figure 2). Sector A is the LAN connection (BUS) that would daisy-chain to either the optional sensor module or the altimeter. Sector B (M1R1F) is the main y-splice to the flowmeter, motor (left), and net response (left). Sector C (BATT) connects the battery case to the underwater unit and also provides the pathway for the tow (signal) cable for commands and data telemetry. In the case of a "Double" system, Sector D (M2R2) connects to motor (right), and net response (right); in the "Single" system, a dummy plug is present. Sector E (COND) connects to the conductivity sensor. Sector F (TEMP) connects to the temperature sensor. Take extreme care in inserting and withdrawing male connectors. **Always use a silicon lubricant in connector sockets.** Leakage of seawater into the sockets can occur if this is not done properly, resulting in shorting of the connector, destruction of the connector contacts by electrolytic corrosion, and malfunction of the instrument. Failure to plug male connectors into the right female sockets on the underwater electronics unit should not result in a serious permanent damage to the electronics, but the system will not work. Be careful!.

2.2.4 Impulse cables. The SeaBird temperature and conductivity sensors are connected to the underwater unit by Impulse cables with 3-pin female connectors at the sensor end. Silicon lubricant should be used around the base of the bulkhead connectors on the sensor before carefully aligning the female connector and pushing it onto the bulkhead connector.

2.3 System test and adjustment after assembly

2.3.1 Start-up. Once the entire unit is hooked up, load net bars and turn the system on using the power switch on the deck unit. Load the software on acquisition/control computer and carry out the setup procedure (See section III for details). Start the acquisition so that the net sensor parameter values are displayed on the screen.

2.3.2 Angle orientation. Adjustment of the underwater unit on frame to orient the pressure case so that the system reads a 45° angle when the frame is at a 45° angle, and 0° when the frame is vertically positioned can now be done. With the frame vertical, rotate the case until the

angle on the deck unit reads between 0 and 1 degrees. Check this adjustment by laying the frame horizontally, the deck unit should read between 89 and 90 degrees.

2.4 System test prior to every lowering.

2.4.1 Electrical readouts. Test all electrical readouts on deck unit by exercising each component.

2.4.1.1 Net command: Give the motor drive a net command. Check to see that motor has stepped and the display has indicated a command response.

2.4.1.2 Flow meter: Cause flowmeter to rotate until magnet passes reed switch several times. Make sure each switch closure was displayed by the display.

2.4.1.3 Net response: Simulate the passage of a net bar down the S/S rods. Again make sure the switch closure was displayed. Keep springs and lever well lubricated with WD-40 or equivalent, being careful not to contaminate the sensors.

2.4.1.4 Temperature, conductivity, and angle: These parameters read continuously, and they should be displayed on the screen at all times during operation. Temperature and conductivity are displayed as degrees and salinity units using the algorithm supplied with the sensor.

2.4.2 Battery charge. Check battery voltage of underwater unit on deck unit display to make sure batteries are charged (See instructions in Section II for changing batteries.)

2.4.3 Check-Out sheet. Appendix 1 contains a sample check-out sheet.

2.5 Trouble shooting in case system test shows problems.

2.5.1 Electrical connections. Check all plug connections, slip rings, cable continuity, etc. (See electronic section 2 part 4 for additional information.)

3. SHOOTING AND HAULING **MOCNESS**

3.1 Optimizing **MOCNESS** tow configuration

3.1.1 Towing angle. This system is designed to be towed at a 45° angle which is usually obtained with a ship's speed of approximately 2 kts. when difference in vertical current shears are minimal. Higher angles indicate higher net speed and vice versa.

3.1.2 Net speed. An algorithm for the calculation of net speed is given in Wiebe et al (1985).

3.1.3 Flying **MOCNESS**. Our current practice is to "fly" the system so that it is moving through the water at 2 +/- 0.5 kts. If net speed drops below 1.5 kts, ship's speed should be increased 1/2 to 1 kt. Although not precisely equivalent, the net can also be flown by maintaining the net angle between 55° and 35°. Both speed and angle should be monitored closely because most of the complications to tows have occurred during excessively low or high speeds.

3.2 Choice of conducting cable

3.2.1 Cable criteria. Any single conducting armored cable (where the conductor is used to transmit the signal and the armor is used as the ground return) will serve for the sending of data

between the underwater and deck units. The wire must be strong enough to withstand any realistically conceivable tension which might be experienced under tow. With the **MOCNESS**-1, we have seen wire tensions on 0 to 1000 m tows of approximately 3000 lbs. Our practice is to insist on a safety factor of at least 2 and preferably 3 in the breaking strength of the wire (e.g., 6000 to 9000 lbs.). For the larger **MOCNESS**-1D, -10, and -20 trawls, a much heavier conducting cable is required. We use .68" diameter cable (UNOLS standard) with a 40,000+ lb breaking strength for these systems. Some 3/8" diameter cables will supply this need. However, wire breaking strength is not the only factor which should be considered in choosing a wire diameter.

3.2.2 Cable dynamics. Relations between wire diameter and meters of wire out to get the net system to a given depth is also an important consideration. At any given tow speed, a given diameter cable will have an inherent angle which depends on its weight per unit length and its drag (a function of surface area). As a general rule, the larger the diameter cable, the larger the ratio of weight per unit length to drag and therefore the steeper the inherent angle at a given speed. Larger cable usually permits less wire to be paid out to get to a given depth and therefore cuts the time to shoot a net to depth. Larger cable also seems, in our experience, to tow straighter (with less catenary) thus reducing stalling of the net when hauling in.

3.3 Criteria for selecting a winch

3.3.1 Winch speed. Precision towing of **MOCNESS** requires reasonably fine control of winch speed, especially in the range of 1 to 30 meters per min. We generally pay out while shooting the net at 30 to 40 m per min; occasionally when angle and speed are optimized and the system is well below the surface, we may lower at 50 m per min. Hauling speeds are generally between 10 and 20 m/min, although on shallow units with finely spaced strata, a rate as low as 1 m/min may be required to evenly sample a stratum and at the same time filter adequate amounts of water.

3.4 Towing under windy conditions

3.4.1 Choice of course. In general, under windy conditions the ship should steam into the wind during a haul. When winds exceed 10 kts, there is sufficient wind set so that the towing course should be chosen to put the wind and swell on the side of the bow which corresponds to the side of the ship where the net is to be launched and recovered. This should keep the wire out from under the ship. It will also give the bridge some advantage in keeping the ship moving ahead at a slow speed if under calm conditions the ship has trouble reducing its speed to that optimal for towing.

3.4.2 Towing point. Under calm sea surface conditions, there is no preferred towing point; from the side or stern are equally good. But with high winds or heavy swell and a ship's course into the wind and sea, towing from the side has the advantage of minimizing the affect of ship pitch on the wire and net. Severe pitch can seriously effect the quality of the catch (jerking of the nets up and down can damage the organisms) as well as stress the nets and frame (causing net blowouts) or damage the cod end buckets. Towing from the ship's pitch pivot-point will minimize this effect.

3.4.3 To tow or not to tow? When is it too rough to tow? The decision not to tow will depend strongly on the stability of the ship in rough seas, the flexibility in adjusting the towing point between the side of the ship and the stern, and the ease of launch and recovery from the deck. Our system has been towed in winds up to 40 kts and seas of 8-15', but the collections under these conditions have not always been of the best quality. Perhaps the best advice is to be conservative until enough experience has been gained to judge the feasibility of towing under marginal conditions. This decision should be made with the safety of personnel during launch and recovery foremost in mind. While handling experience and ships capability play a large part in the decision, personnel safety should always be the dominant factor.

3.5 Towing in high surface current regimes.

3.5.1 Low wind conditions. Towing in high current regimes can prove tricky and requires constant monitoring and manipulation of ship's speed and course, and winch speed. In high current regimes, **MOCNESS** should be towed into the current regardless of wind direction. The reason for this lies in the fact that once the net is lowered below the region of high current, the net will experience a reduced speed through the water which can be compensated for by increasing ship's speed. If the course of the tow is across the current, adjustment of ship's speed will have little or no affect on the net speed and the ability to maintain net speed, and angle may be severely reduced or lost. A course with the current will result in excessive net speed and angle with the only compensator being to slow the ship down. Low ship speeds are usually difficult to obtain, but perhaps more important a low ship's speed (<2 kts) usually makes it difficult or impossible to hold the course true. In addition to a loss in ability to maintain net speed and angle within safe towing limits, towing with the ship traveling with a strong surface current will result in an inordinate amount of wire having to be paid our to reach a given depth.

3.5.2 Windy conditions. In cases where moderate or high winds are from a direction such that when the ship is steaming into the current, the wire would pass under the hull, a reasonable course of action is to anticipate this and fairlead the wire to a point off the stern so that no matter which way the wire tends, it cannot rub the hull or become tangled in the screw. (See notes above on preferred hauling point under high wind low surface current regimes.)

3.6 Flowmeter calibration

3.6.1 Calibration recommendations. The flowmeter(s) shipped with **MOCNESS** has not been accurately calibrated. The calibration has not been done because each flowmeter has a unique calibration factor which can change with time. We recommend that the flowmeter(s) be calibrated before and after each cruise. This can be done in a flow-tank or in the field by mounting the flowmeter(s) on a frame which can be towed over a measured distance. For field calibrations, paired runs over the measured distance should be made in opposite directions and averaged to eliminate errors introduced by naturally-occurring water movements. (See Section III 2.1.1.1 for more information.)

3.7 Maintenance of mechanical system.

3.7.1 Frame. Care has been taken to construct **MOCNESS** with 6061-T6-anodized aluminum and stainless steel which resists corrosion. However, over a period of time, all sites where the

stainless steel is in continuous contact with the anodized aluminum, corrosion may occur. It is strongly recommended that after each cruise or after approximately 30 days of at sea operations, the entire mechanical system should be disassembled, rinsed with fresh water, and every screw, nut, or bolt lubricated lanolin-based lubricants. It is especially important to take the motor drive and toggle release mechanism apart and clean/lubricate it every 30 days during operation and always before it goes into storage. Corrosion in this mechanism can seriously impair its operation.

3.7.2 Foam rubber. Net bar foam rubber should be replaced after every 10 to 15 lowerings or when it becomes frayed or torn. Open cell foam which does not collapse at depth should be used.

3.7.3 Motor. Visual checks should be made before each tow to ensure that the motor housing is not leaking fluid, and that the rubber diaphragm is not concave to the extent that fluid loss is indicated. Fluid can be added to the motor housing through the fill screws located on the end cap to which the motor and drive shaft are attached. Use type A or Dextron II automotive automatic transmission fluid in toggle motor drive case. Use of any other fluid may prevent the motor from stepping or cause the diaphragm to leak, voiding the warranty.

3.8 Logging tow information.

3.8.1 Data Sheet. A sample data logging sheet which provides a summary of activities during a tow is provided in Appendix 2. Also provided in Appendix 3 is a sample procedures sheet for getting the software ready for a tow.

SECTION II - ELECTRONIC SYSTEM.

1. OVERVIEW OF **MOCNESS** CONTROL SYSTEM

The **MOCNESS** III control system consists of two electronic units, a compact underwater Net Control Unit (NCU), and an acquisition/control computer equipped with a deck interface unit. The underwater unit which mounts on the top of the **MOCNESS** net frame, inter-connects to all frame mounted equipment. These include the stepper motor and toggle release assembly, the net response mechanism and the flow meter. A variety of sensors also plug into the underwater unit, typically, temperature and conductivity. Two other sensors are built into the underwater unit's case. These are pressure (depth) and net frame angle. The system may also include a variety of additional sensor modules plugged into the NCU, such as transmissometer, fluorometer, or oxygen sensor. The NCU unit also steps the net release motor and monitors the net open/close reed switch.

The deck unit connects to the underwater unit via slip rings and a single conductor armored cable using the armor as ground return. Software running on acquisition/control computer displays the variables sensed by the underwater package and, when the operator uses the mouse to press command buttons on the screen, net commands (which change nets) are sent to the underwater unit. Verification that nets are open/closed are displayed on the computer screen.

In the basic **MOCNESS** system, the underwater sensor package measures depth, temperature, conductivity, flow (turns of a propeller), net mouth angle and internal battery voltage. The acquisition/control computer displays these variables and simultaneously writes them to disk in both "processed" and "raw" formats. The basic system uses a stepper motor which drives a cam shaft mechanism to open and close up to nine nets sequentially. The command controls displayed on the computer screen are net command (3 steps), advance net count, reset flow, and end acquisition. Additional controls are available in the screen menus that provide for optional features. All functions in the underwater unit are controlled by the acquisition/control computer. Details about the operation and data acquisition software are given in Section III.

The deck unit and the underwater unit act as a bi-directional modem. The computer transmits commands to the Net Control Unit and the NCU sends data to the acquisition/control computer. Together they create a transparent connection from the acquisition/control computer's serial port to a "local-area-network" (LAN) on the net frame, and consist of a typical **MOCNESS** control system (Figure 3).

The Net Control Unit (NCU) is actually three logically separate subsystems. The first is power distribution and conditioning. The second is a modem to couple the tow cable to the LAN which serves all sensor systems on the net frame. The third is the first of the sensor module systems. On the basic **MOCNESS**, this is the only device on the net LAN. It is referred to by its net address, "#MN". It handles the sensors for depth, temperature, conductivity, net angle and net response. Additional sensor module systems can be added to the basic **MOCNESS** group by simply connecting them to the LAN. Each of these additional modules on the LAN has its own unique address. For example, the acoustic altimeter (used to accurately determine net altitude off the bottom) has the address "#MA". The optical sensor module has the address "#MO".

The **MOCNESS** system of modules are powered from a 20 VDC Nicad battery pack connected to the NCU. (Power is fed to all additional systems via a 4-wire LAN cable). The power requirements of the net release motor preclude powering the **MOCNESS** system down the cable without using very high voltages.

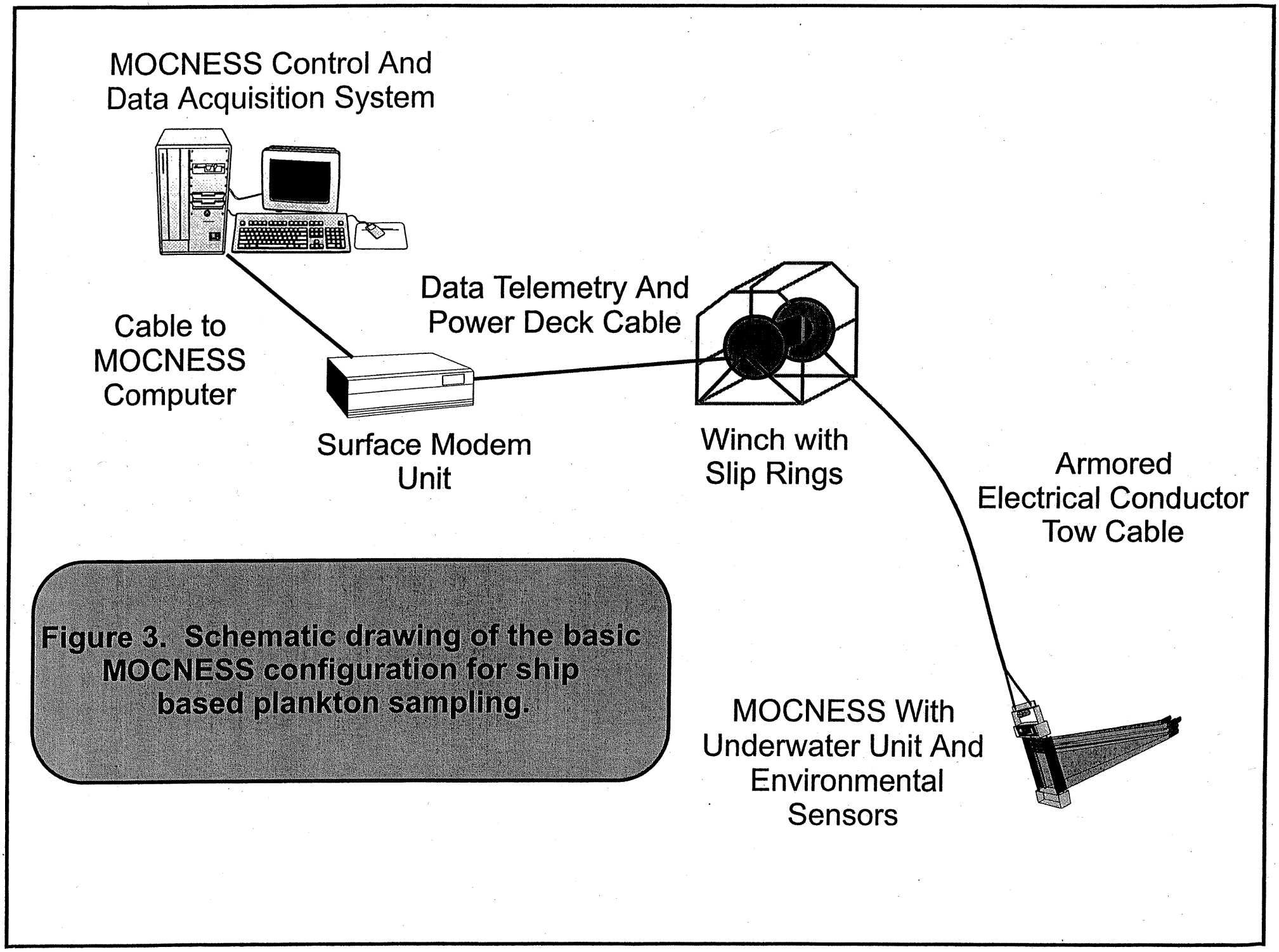


Figure 3. Schematic drawing of the basic MOCNESS configuration for ship based plankton sampling.

A rechargeable battery pack is a much safer option. To facilitate rapid turn-around, the battery is built into a separate pressure housing, which makes it easy to remove and replace (See the important information about battery charging and handling in Section II.6).

The **MOCNESS** System comes provided with a software package to perform data logging and display.

2. SPECIFICATIONS FOR **MOCNESS** CONTROL SYSTEM

The **MOCNESS** control system provides a half duplex interface from the deck computer (MS-DOS) to a group of sensors on the net frame. The system offers the following controls and sensors.

2.1 Net Control

For dual-net systems, the **MOCNESS** actuates two net-release motors and provides inputs for two net response sense switches.

2.2 Variables Measured

The basic **MOCNESS** system includes the following sensors

2.2.1 Pressure (Depth). The depth sensor is a thermally isolated titanium strain gauge. The standard range is 0-5000 decibars full scale with a least count of less than 0.5 decibars. (Other ranges may be supplied on request.) The sensor's internal temperature is measured and used to compensate for temperature drift..

2.2.2 Temperature. A Sea Bird Sensor is standard. Its frequency output is measured and sent to the surface for logging and conversion to temperature by the software in the **MOCNESS** computer. The system allows better than 1 milli-degree resolution at 10 Hz sampling rate.

2.2.3 Conductivity. A Sea Bird Sensor is standard. Its frequency output is measured and sent to the surface for logging and conversion to conductivity by the software in the computer. The system allows better than 1 micro mho/cm at 10 Hz sampling rate.

2.2.4 Net Angle. Net angle is measured over 0-90° with one degree resolution.

2.2.5 Flow. Flow past the net is measured by counting revolutions of a flow counter.

2.2.6 Net Count. Net response counts (0-99) are recorded when the response mechanism is activated by a falling net bar to indicate when a net has closed (i.e. net one closed and net 2 opened).

2.3 Data Rate

The data rate depends on the speed of the computer and the quality of the cable. The underwater unit defaults to 300 baud during initialization and automatically adjusts up to the highest rate the cable, in use, can accommodate. With a good cable, the system can operate at 2400 baud, sampling all variables at 2 times per second. Normally, this generates so much data

that slower sampling rates are desirable. One sample every 2 or 4 seconds is typical, although the hardware can operate much faster.

3. GETTING STARTED

If you are not familiar with the operation of the **MOCNESS** Control system, we suggest you read this section and practice with it on the bench before mounting it on the **MOCNESS** net frame. It is a lot easier to resolve problems when the unit is in the lab rather than on the deck of a ship. Often the **MOCNESS** is located on the fantail some distance away from the lab space with an uncertain electrical connection between the two! Familiarizing yourself with the system beforehand can make life a lot easier.

First, locate the rechargeable battery and check its voltage. A full charge reads approximately 20-22 volts. If it is lower than this value, charge it according to the section on battery maintenance. Remove the vent plug before removing the end cap from the battery case to equalize the internal and external pressure. Remember, NEVER CHARGE A BATTERY IN A PRESSURE CASE. Always use caution and charge in accordance with recommended manufacturers charging instructions.

3.1 Check-out of the Deck Unit.

Connect the computer's serial port (COM2) to the RS232 port on the rear of the deck unit. There are two DB25 connectors on the rear panel; carefully identify the one labeled for the control computer. After first making sure the line voltage is set correctly for your needs (this is an internal solder connection at the power supply. All 110 VAC units are shipped with a standard USA power cord whereas all 220 VAC units have an unterminated power cord), connect the deck unit's power cord to the power source,. Turning the deck unit on should result in a distinctive flashing pattern on the front panel monitor Light Emitting Diodes (LEDs) indicating a proper power-on-reset. Actuating the reset switch repeats the initialization to verify that it is working properly.

Next, run a terminal emulator program on the computer (such as Procomm or Red Ryder, or the one that comes with WINDOWS i.e. Terminal.exe) and set it up for 300 baud, 8 data bits, no parity, and one stop bit. No handshaking lines are used and all "protocols" like X-ON, X-OFF should be disabled. It should be set to full duplex.

Next type a few characters. The deck interface box should echo them back. If it doesn't, reset it and try again. If it still fails to echo, use a "blue box" to monitor your computer's RS232 lines to determine what's wrong. Computer serial interfaces often use the handshaking lines in strange ways. When the unit echoes characters, address the deck unit by typing the sequence "#MCH". (don't hit the return key!) The deck unit should respond with a brief "help file". If this is all working, you are ready to add the NCU.

3.2 Check-out of the Underwater Net Control Unit (NCU).

Identify the cable provided to connect the NCU directly to the deck unit. One end mates with the connector on the end-cap of the NCU and the other has a BNC which goes directly to the rear of the deck unit. The two green binding posts on the front panel of the deck unit must be shorted

together for this test. Connect the battery to the NCU at this time also. You don't need to attach the sensors or the net motor yet.

With the NCU powered and connected to the deck unit, re-address the deck unit and tell it to adjust itself for the current "cable" by typing the sequence "#MCA". The green LED on the deck unit's front panel should turn on (if there's a line connected) and, after a few seconds, you should see a reply on the computer screen of either "OK", "OPEN" or "SHORT" which indicates the status of the cable. (You might also get the reply "FAIL", if there is too much noise on the line to get a real reading.) Try disconnecting the BNC connector to the NCU and send "#MCA" again to verify that it can, in fact identify an open cable. (You can also stick a paper clip in the open BNC connector to create a short and try that as well.) When you re getting set up on a new ship, this quick cable diagnostic can be useful. If at any time the deck unit refuses to reply, just press the reset button and try again.

Reconnect the cable to the NCU and get the cable adjusted again with the "#MCA" command. When you have the "OK", send the sequence "#MNH". The NCU should respond with its unique help file. If it doesn't, recheck the connections, reset the deck unit, and try again. Make sure the battery is really connected to the NCU and is charged. Turn off the deck unit power when you are done. Within ten seconds, the NCU will sense that the deck unit is off and turn itself completely off. You do not need to disconnect the battery to shut off the power.

3.3 Check-out of the Motor, Flow, and Net Response.

Locate the net motor, the flow meter, and the net response switch, and their cables. Connect them to the NCU multiple sector connector. Follow the labels carefully and make sure the pins are properly lubricated (with DC4 Silicone grease). When all is connected, turn on the deck unit, reset it, and, using your terminal emulator, re-adjust for the cable with the command "#MCA" to get the NCU running. When you have the "OK", verify that the NCU is awake by sending "#MNH" to see its brief help file.

To step the motor, type "#MN+". The motor should step and a data frame appear on the terminal. Sending "#MN-" will elicit a data frame without stepping the motor. If you have a dual net system with two motors, the command to step the second motor is "#MN*". To check the response switches, call for a data frame from the NCU (with "#MN-") and note the net count values in the output string. Now flip one of the response switches and check the data frame again. The appropriate net count should increment.

Normally, three steps are required to cause the cam shaft to release a net bar. Each step of the motor is 10 degrees. The cam is precision machined so that it will release a net for every 30 deg. of rotation. If the alignment of the motor and camshaft is not optimum, the net may drop after two or four steps instead of the nominal three. In this case an adjustment must be made (see Section I part 2.1.16).

Spin the propeller of the flow meter. To check the flow meter switch closures, call for a data frame from the NCU (with "#MN-") and note the flow count values in the output string. These counts represent approximately (4.5) meters travel through the water and are used to calculate the flow through each net (however, see Section I, 3.6 on flow calculation above). When the acquisition software is running, the count is set to zero every time the unit

receives a net response or when the "flow reset" command button on the computer display is pressed with the mouse (in case the net response switch fails).

3.4 Check-out of the SeaBird Sensors.

Power down the NCU by turning off the deck unit. Connect the SeaBird sensors for Conductivity and Temperature. These probes are connected to the underwater unit with cables equipped with 3-pin Marsh Marine connector at one end and a triangular plug at the other. Plug temperature into the end-cap connector with a section labeled "TEMP" and conductivity into the section labeled "COND". Be very careful to keep the connectors clean and well greased since even the slightest electrical leak will reduce the accuracy of the measurements. To check the actual temperature and conductivity readings, a program containing the correct calibration data and the algorithms supplied by SEABIRD must be run. In addition, the program can compute salinity using the most current relationships linking temperature, pressure, and conductivity to salinity (see Lewis, 1980).

Without calibration baths, it is difficult to completely verify their proper operation, but a quick check is possible. Notice that unless the conductivity sensor is in seawater, it will not have a sensible frequency output at all. If you only want to check the NCU, you can use the SeaBird Temperature sensor alone and plug it alternately into either the T or C connector on the NCU case. This will provide a reasonable frequency to the internal counters, although it can only do one at a time.

Power up and initialize the system as above. (Send "#MCA", after the "OK", send "#MN-".) Identify the Sea Bird sensor period value in the output string and look at several subsequent values by repeating the "#MN-" command (If you don't need to "connect" to any device other than the NCU, you can just type the final "-" to get a data string. If it doesn't reply, type the full command, "#MN-") The value for temperature should stabilize after the first few replies. If you warm the sensor probe with your hand, you should see the value change rapidly. Note that this number is not the frequency from the SeaBird sensor, but a constant times the reciprocal of its frequency. See section 5 for details.

4. HOW THE **MOCNESS** LAN OPERATES.

The major limitation of any towed net system is the data handling capability of the cable available. We look forward to the day when fiber optic cables will be available on all ships, but the time isn't here yet and we have to use traditional cables for awhile longer. To complicate matters, there is no truly standard cable. Cables are variable in length, number of conductors, and condition.

The **MOCNESS** system is therefore designed to adapt to a wide range of cable parameters and make the best of whatever situation it faces. This results in a variable data rate depending on cable length and quality. Whenever fiber-optic cables become available, the current **MOCNESS** electronics will adapt easily and run at full speed.

A second limitation with the **MOCNESS** data system applies to data loggers in general. This is the problem of balancing the data rate with the capabilities of the control computer. If the data is coming at a steady rate, the control computer must process, display and log this in real time. If, for example, flushing a buffer to disk, takes longer then expected, data may be lost or, worse, the system

may hang. The **MOCNESS** avoids this problem completely by giving the computer absolute control of the data flow through the **MOCNESS** LAN. Essentially, whenever the computer is ready for new data, it sends out a data request to one of the modules on the LAN which immediately replies to the request with the appropriate data. When the computer is ready for another sample, it sends out another query and gets another answer. The program running on the computer thus controls the data rate. This may then be anything your system can handle up to the limit of the LAN's current maximum data rate.

Notice that all the data gathering devices on the LAN are designed to reply without any delay when queried. Internally, they are digitizing their sensors as fast as they can and holding the most recent result in a buffer. If queried, this most recent result is the value sent as the reply. In some cases, the **MOCNESS** will actually send an average of the variable since it was last asked. Details of how each variable is handled are presented in section 5 below.

In order for the LAN to work with a variety of cables, all components of the **MOCNESS** can work at all baud rates from 300 baud to 2400 baud. When the system is turned on, the deck computer addresses the deck interface box and commands it to trim its modem to match the current cable in use. If the interface box reports success, the computer then will attempt to query and get a reply from the NCU at the lowest rate, 300 baud. If this is successful, the computer must then send the command to all units to switch to 600 baud. The computer must also re-initialize its own interface for that rate. It then attempts to get a reply from the NCU at the new rate. It will continue this process of increasing the baud rate until it fails to connect to the NCU or it reaches 2400 baud. If it fails, it re-initialize the LAN to 300 baud (the default value), then sends the command to switch to the highest value that worked. After a last try to verify that the NCU is communicating reliably, the computer pronounces the LAN ready for use and announces the baud rate in use. All this is accomplished in only a few seconds and normally is done only once on powering up the system.

5. THE COMPONENTS OF THE **MOCNESS** ELECTRONICS SYSTEM.

This section presents detailed descriptions of the hardware components of the **MOCNESS** Control System. These are the Deck Interface Box, the Net Control Unit (NCU), the Optional Sensor module (OSU), and the GPS module (GPSU). Descriptions of some of these modules are given herein, others will be included with the modules.

5.1 The Deck Interface Box.

5.1.1 Hardware Connections. The deck interface box connects between your computer and the cable to the net system. It has an RS232 connector on the rear panel to connect to the serial interface of the computer or, for testing, to a "dumb" terminal. A BNC connector on the rear panel should connect to the conducting wire to the net. A second RS232 connector on the rear panel is available to monitor all communications on the LAN. This is an "out only" signal and is always at 9600 baud, 8 data bits with bit 8 zero, no parity and 1 stop bit. It DOES NOT change baud rate with the **MOCNESS** LAN, but is always at 9600 baud. (Monitoring the LAN directly is awkward since the software will change the baud rate as necessary to adapt to the trawl wire in use.)

There is a LAN connection on the front panel of the deck interface box for additional equipment. We offer an economical GPS unit which can be plugged in here. (We have found

it is much more convenient to have a GPS receiver on the same LAN as the other **MOCNESS** sensors than to attempt to interface the ship's GPS equipment into our data logging system, although this is possible.) For units without the optional GPS unit, a jumper is supplied and MUST be in place across the two binding posts. There are two toggle switch controls on the interface box, power and reset. If the **MOCNESS** system stops operating and the control computer cannot re-start data logging, you should press the reset button to allow the acquisition/control computer to regain control of the system. This is rare, but may happen with exceptionally bad slip rings which can get the computer confused by intermittent operation.

Indicator lights on the deck box show a distinctive pattern on reset, then show the baud rate in use. A green LED on the front panel monitors data flow on the LAN wire and should flicker during normal data logging operation.

5.1.2 Software Commands. The deck interface box accepts several commands from the acquisition/control computer. The user doesn't need to know much about these commands unless there is a need to test the system manually as described in "Getting Started", section 3 above. Generally, the program running in the computer will use these commands for you. Their function is given here for testing purposes. Not all commands are described here as some are built into the system, but are only useful for factory testing.

5.1.2.1 Connecting. When the deck unit is powered up or reset, it will switch to 300 baud. To connect to the deck interface, send the sequence "#MC" at the current baud rate. Then follow this address with any valid command. All commands will return a reply. Any unrecognized command will disconnect the device.

5.1.2.2 Nul Commands. Both the carriage return [cr] and the spacebar [sp] are nul commands that return only a prompt sequence, [cr],[lf],":",[etx]. Any command may be sent to the unit after the prompt without re-typing the full connect command.

5.1.2.3 Help File. The command "H" returns a brief help file giving the version of the firmware and a short description of the commands recognized. It returns the prompt.

5.1.2.4 Cable Adjust. The command "A" begins the cable adjust sequence. This will take a few seconds. The unit will eventually respond with a report on the condition of the cable. This will be "OK", "SHORT", "OPEN" or "FAIL". The unit will then send several [etx] characters at the current baud rate and reset its interface to 300 baud. The adjust sequence forces all other modules on the LAN to switch to 300 baud as well.

5.1.2.5 Query Cable Parameters. For advanced diagnostics, the deck unit can report, in a somewhat cryptic form, the settings it is currently using for the cable connected. It is used in factory system check-out. The command is "Q" and it will return the prompt. Advanced deck computer software can interpret this data and tell you about the health of the trawl wire.

5.1.2.6 Unblock Cable. If the cable is disconnected or becomes extremely noisy, the deck unit will recognize there is a problem and will block further signals from the cable to avoid

jamming the serial link between it and the computer. When the problem is repaired, the command "U" will remove the cable block.

5.1.2.7 Baud Switch. The sequence "#000bbbb" will set the interface baud rate to the value "bbbb" which must be either "0300", "0600","1200", or "2400"'. All modules on the LAN will switch immediately in response to this global command and none are allowed to reply until they hear their address at the new rate.

5.2 The Main Underwater Unit (NCU).

The NCU underwater housing holds three subsystems with separate functions: power control, modem interface and the main Net Control Unit node. This section describes these subsystems and describes how the sensors work in detail. There are no adjustments required in the NCU housing and it normally only needs to be opened to check and re-grease the o-ring seals.

5.2.1 Power control. The re-chargeable battery pack plugs into the NCU and provides power for all systems on the net frame. The NCU controls the distribution of the power. It is important to realize that when the deck unit is not powered up and connected to the NCU, NO POWER IS DRAWN FROM THE BATTERY. You may shut down the entire system simply by shutting off the power to the deck unit or by a normal exit of the acquisition program. The battery does not need to be removed except for recharging.

The main underwater unit supplies power to the optional module and altimeter when they are present. On the backside of the main underwater unit electronic board, a three-amp fuse protects the power switches against shorts and faults on the external LAN netowrk.

5.2.2 The Modem. The cable interface modem built into the NCU is a single, easily replaced module. Unfortunately, cables on a ship often get confused and it is possible that inadvertently, other systems that send high voltages down the wire (over 100 volts), can be connected to the tow cable at the same time that **MOCNESS** is connected.. These can cause damage to the **MOCNESS** equipment if they are used. Since it is impossible to completely protect the **MOCNESS** NCU from such unknown high voltages, we have separated the cable interface from the rest of the circuit and included several protection circuits. These are easy to replace if damaged.

5.2.3 The Net Control Node. #MN. This is the main "brain" of the **MOCNESS** net group. In the basic system, this is the only data gathering device and the only one needed to control net closing and opening. This section, and those for the other modules below, first presents the commands that the Control Node recognizes, then describes the details of the data format and how each sensor is scaled. As with the deck unit, the program running in your computer will use these commands for you. Again, their function is given here for testing purposes. You normally never have to use them directly unless you want to perform low level system testing.

5.2.3.1 Commands.

5.2.3.1.1 Connecting. To connect to the Net Control Node, send the sequence"#MN" at the current baud rate. Then follow this address with any valid command. All

commands will return a reply. Any unrecognized command will disconnect the device. Once you have connected to the unit, any valid command may be entered after a prompt sequence.

5.2.3.1.2 Nul Commands. Both the carriage return [cr] and the spacebar [sp] are nul commands that return only a prompt sequence, [cr],[lf],":",[etx]. After the initial connect command sequence is sent, any command may be sent to the unit after the prompt without re-sending the connect sequence.

5.2.3.1.3 Help File. The command "H" returns a brief help file giving the version of the firmware and a brief description of the commands recognized. It returns the prompt.

5.2.3.1.4 Data Request. The command "-" will return a data string followed by the prompt. The format of the data string is "#MN-N1 N2 AA FFFF PPPPP PTPT TTTTTT CCCCCC BBB[cr][lf]:[etx]" where the underlined portion is the reply. The fields are as follows and are discussed individually below.

- N1 net count, counts of left response switch, 00-99
- N2 net count, counts of right response switch, 00-99
- AA net angle in degrees, 00-90°
- FFFF flow counts, 0000-9999. Reset to 0000 with every net response
- PPPPP pressure value, converted to decibars by the deck computer
- PTPT a decimal number derived from the temperature sensor in the pressure sensor which is used to improve the pressure calibration.
- TTTTTT averaged Sea Bird temperature period, see below
- CCCCCC averaged Sea Bird conductivity period, see below
- BBB battery voltage, see below

5.2.3.1.5 Step Left Net Motor. The command "+" will step the left (or the main) net release motor once, then return a data string as above followed by the prompt.

5.2.3.1.6 Step Right Net Motor. The command "*" will step the right (or the auxiliary) net release motor once, then return a data string as above followed by the prompt.

5.2.3.1.7 Net Count Reset. The command "R" will reset the net response counters to 00.

5.2.3.1.8 Baud Rate. The sequence "#000bbbb" will set the interface baud rate to the value "bbbb" which must be either "0300", "0600", "1200", or "2400". All modules on the LAN will switch immediately in response to this global command and none are allowed to reply until they hear their address at the new rate.

5.2.3.2 Data format

5.2.3.2.1 Net Count, N1 and N2. These are two digit decimal numbers that are simply a count of the times the net response switches are toggled. They are reset by powering down the system and restarting as in performing a cable adjust or by sending the command "R".

5.2.3.2.2 Net Angle, AA. This is a two digit decimal number which varies from 00-90° and represents net angle in degrees.

5.2.3.2.3 Flow Counts, FFFF. This is a four digit decimal number which is simple count of the switch closing's on the flow counter. It is reset to 0000 with every net response.

5.2.3.2.4 Pressure, PPPPP. The pressure value is a five digit decimal number which is derived from the voltage on the titanium strain gauge pressure sensor. It is adjusted so that it will always have some small positive value to avoid having to deal with negative numbers. The calibration algorithm to convert this value to decibars is built into the acquisition computer software. There are no adjustments in the NCU.

5.2.3.2.5 Temperature of Pressure Sensor, PTPT. To achieve maximum accuracy of the pressure sensor, it is necessary to measure the temperature of the sensor itself and apply a correction. This four decimal digit number is derived from a temperature sensor built into the pressure strain gauge and is used by the acquisition computer software to correct the pressure value over varying temperatures.

5.2.3.2.6 Temperature Sensor Signal. The frequency from the SeaBird Temperature sensor is measured and processed in the NCU to generate the value TTTTTT, a 6 digit decimal number. This number is scaled as follows:

(frequency of the temp sensor)=K/(TTTTTT)

where K=1,258,291,200. Software in the deck computer uses this frequency value along with the individual sensor's calibration file to calculate temperature.

The number of significant digits in the value TTTTTT depends on the time between data requests. If you attempt to log data at ten samples per second, for example, the NCU doesn't have enough time to make a really good frequency measurement. (It is actually doing a multiple period measurement with a time resolution of 1/1.2288 seconds and at 10 Hz will have a resolution of 1 in 122880. This is actually much better then the accuracy of the sensor!) If you sample at one Hz however, you will get a result with higher resolution. You can sample as slowly as once every 10 minutes and the NCU will still calculate a valid number. Notice that for small deviations of the temperature signal where the temperature-period relation can be approximated by a linear function, the value you read will be an average of the data fluctuations since the last reading. Notice also that if you haven't read the data for over 10 minutes, the first data frame may be garbage due to overflow of the internal cycle counter. Subsequent data frames will be fine.

5.2.3.2.7 Conductivity Sensor Signal. Conductivity is handled exactly like the temperature frequency and the same scaling factor should be used. The connectors on the NCU end-cap for conductivity and temperature are, however, not truly interchangeable. The power and signal for the conductivity sensor are completely

floating and grounded only through the SeaBird sensor's body to eliminate any possible electrical noise contaminating the conductivity measurement. If you reverse the sensors, no harm will be done, but the conductivity may become noisy.

5.2.3.2.8 Battery Voltage. The voltage of the battery pack in a pressure case on the **MOCNESS** frame is a three digit decimal number. This number must be divided by 10 to get the actual battery voltage. The voltage is displayed on the data acquisition and control form during a tow.

5.3 The Optional Sensor Unit (OSU).

5.3.1 The Optional Sensor Node. #MO. This is a LAN module which provides access to one or more of four optional sensors, the Transmissometer, the Fluorometer, the Downwelling light sensor, and the Oxygen sensor, and a SeaBird underwater pump. The module draws power from the main MOCNESS battery whenever the system is turned on. The Option Module is based around a 16-bit A to D converter and a seven channel multiplexer. It is used to interface sensors with a voltage output to the MOCNESS data system. The system is scaled to accept inputs in the range of +5 volts to -5 volts. The inputs are differential to eliminate erros due to ground loops, but the common mode voltage range is limited to below a volt. (The system will work with larger common mode voltages, but the accuracy will degrade.

The Option Module also contains a regulated power supply to provide 12 volts to auxiliary sensors (typically a transmissometer and fluorometer). This supply may be turned on or off via commands over the LAN.

5.3.1.1 Commands.

5.3.1.1.1 Connecting. To connect to the Optional Sensor Node, send the sequence"#MO" at the current baud rate. Then follow this address with any valid command. All commands will return a reply. Any unrecognized command will disconnect the device. Once you have connected to the unit, any valid command may be entered after a prompt sequence.

5.3.1.1.2 Nul Commands. Both the carriage return [cr] and the spacebar [sp] are nul commands that return only a prompt sequence, [cr],[lf],":",[etx]. After the initial connect command sequence is sent, any command may be sent to the unit after the prompt without re-sending the connect sequence.

5.3.1.1.3 Help File. The command "H" returns a brief help file giving the version of the firmware and a brief description of the commands recognized. It returns the prompt.

5.3.1.1.4 Sensor Power On. The command "!P1" will turn the power on to the optional sensors connected to the option module (i.e. fluorometer, transmissometer, dissolved oxygen probe).

5.3.1.1.5 Sensor Power Off. The command "!P0" will turn the power off to the optional sensors connected to the option module (i.e. fluorometer, transmissometer, dissolved oxygen probe).

5.3.1.1.6 SeaBird Pump On. The command "!C1" will turn the power on to the optional SeaBird Pump connected to the option module .

5.3.1.1.7 SeaBird Pump Off. The command "!C0" will turn the power off to the optional SeaBird Pump connected to the option module .

5.3.1.1.8 Number of Channels. The command "!Nn", where n = 1 to 7, is used to select the number of sensor channels to be scanned. On power up, the default is set to 4 which is as described below.

5.3.1.1.9 Light Gain Settings. The commands "!G0" through "!G5" select the different modes and ranges for the downwelling light sensor.
!G0 V mode
!G1 5 mA/V
!G2 0.5 mA/V
!G3 0.05 mA/V
!G4 0.005 mA/V
!G5 0.00026mA/V

These are explained in more detail in a section below.

5.3.1.1.10 Data Request. The command "-" will return a data string followed by the prompt. The format of the data string is "#MO- C SF.FFFF ST.TTTT SO.XOXO SO.TOTO SL.LINL SL.LOGL SL.TLTL [cr][lf]:[etx]" where the underlined portion is the reply. The fields are as follows and are discussed individually below.

- C = 4 (default number of sensors).
- SF.FFFF Fluorometer value.
- ST.TTTT Transmissometer value.
- SO.XOXO Oxygen current value.
- SO.TOTO Oxygen temperature.
- SL.LINL Linear Downwelling light.
- SL.LOGL Log Downwelling light.
- SL.TLTL Light temperature.

5.3.1.2 Data format

5.3.1.2.1 Fluorometer value. This is a six place decimal number with a dynamic range of 16 bits (65536 points) of which 25206 points represent the 0-5 volt output of the Fluorometer. See Section III 4.7 for additional detail.

5.3.1.2.2 Transmissometer. This is a six place decimal number with a dynamic range of 16 bits (65536 parts) of which 25206 points represent the 0-5 volt output of the

Transmissometer. The first character is the sign of the number; it should always be positive. See Section III 4.8 for additional detail.

5.3.1.2.3 Oxygen Current. This is a six place decimal number with a dynamic range of 16 bits (65536 parts) of which 25206 points represent the 0-5 volt output of the Oxygen sensors. The first character is the sign of the number; it should always be positive. See Section III 4.9 for additional detail.

5.3.1.2.4 Oxygen Temperature. This is a six place decimal number with a dynamic range of 16 bits (65536 parts) of which 25206 points represent the 0-5 volt output of the Oxygen sensors. The first character is the sign of the number; it should always be positive. See Section III 4.9 for additional detail.

5.3.1.2.5 Downwelling Light (Linear Mode). This is a six place decimal number with a dynamic range of 16 bits (65536 parts) of which 25206 points represent the 0-5 volt output of the Photodiode in the current range setting. The first character is the sign of the number. As long as the sign is positive, the light value is valid; if at the highest sensitivity (!G5) the sign turns negative, the lower limit of resolution has been reached and the value is no longer valid. See Section III 4.10 for additional detail.

5.3.1.2.6 Downwelling Light (Logarithm Mode). This is a six place decimal number with a dynamic range of 16 bits (65536 parts) of which 25206 points represent the 0-5 volt output of the Photodiode in the current range setting. The first character is the sign of the number. As long as the sign is positive, the light value is valid; if at the lowest light levels the sign turns negative, the lower limit of resolution has been reached and the value is no longer valid. See Section III 4.10 for additional detail.

5.3.1.2.7 Light Temperature. This is a six place decimal number with a dynamic range of 16 bits (65536 parts) of which 25206 points represent the 0-5 volt output of a temperature thermister next to the Photodiode. The first character is the sign of the number; it should always be positive. See Section III 4.10 for additional detail.

5.4 The Global Positioning System Unit (GPSU).

5.4.1 The Global Positioning System Node (#GPS). This is a LAN module which provides access to a GPS receiver unit. Note that there is another method to obtain GPS data if there is a system of the ship which can supply the right character string to the acquisition computer on COM4. See description in Section III 2.2.1.3.

5.4.1.1 Commands.

5.4.1.1.1 Connecting. To connect to the Global Positioning System Node, send the sequence "#GPS" at the current baud rate. Then follow this address with any valid command. All commands will return a reply. Any unrecognized command will disconnect the device. Once you have connected to the unit, any valid command may be entered after a prompt sequence.

5.4.1.1.2 Nul Commands. Both the carriage return [cr] and the spacebar [sp] are nul commands that return only a prompt sequence, [cr],[lf],":",[etx]. After the initial connect command sequence is sent, any command may be sent to the unit after the prompt without re-sending the connect sequence.

5.4.1.1.3 Help File. The command "H" returns a brief help file giving the version of the firmware and a brief description of the commands recognized. It returns the prompt.

5.4.1.1.4 Data Request. There are a series of commands that will elicit replies with data from the GPS receiver. The command which is used in the Visual Basic data acquisition program is "#GPS?L". The following is a list of the commands and a representative response if the command query for data is not an instruction to the receiver to change its status.

#GPS?P,P view position
#GPS?P 4138.06,N,07036.73,W
#GPS?L,L,/ view position, alt, time & status
#GPS?L 010756,4138.06,N,07036.73,W,0,3,004,050,M,-034,M
#GPS?T,T view time
#GPS?T 011726,23,10,1994
#GPS!R Master Reset
#GPS!I Init Outputs
#GPS!S Force Sky Search
#GPS!C Clear all buffers
#GPS?F show Formats
:?Format of ?L reply
?L hhmmss,ddmm.mm,N,dddmm.mm,W,a,b,ccc,ddd,M,eeee,M
hhmmss = time UTC of fix
ddmm.mm,N = lattitude in deg & min North
dddmm.mm,W = longitude in deg & min West
a =1, GPS on, =0 GSP off (>10sec oold fix)
b =no. of satellites in use
ccc = HDOP
ddd,M height above sea level, meters
eeee,M geoidal height in meters
?B show bat, E=max, B6=min
?B=E

5.5 The Altimeter Unit (AU).

5.5.1 The Altimeter Node (#MAD). This is a LAN module which provides access to an Altimeter operating with a 12 kHz transducer. This module provides data on the altitude of the net systems depth above the bottom when the net system is closer to the bottom than the surface. The Altimeter has four parameters that are under the control of the Visual Basic program: Blanking time, Power Output, Pulse Width, and Ping Rate. There is a good manual on this unit that tells how it works.

6. BATTERY CARE.

The underwater unit is powered by an internal rechargeable battery pack since it needs very high current pulses for the stepper motor. The battery pack contains 16 type F-cells (each of 1.25 VDC @ 7AH) in the pack. In addition, the positive lead has an in-l;ine NAPA Automotive fuse (rated @ 10 amps) which is tucked into the space associated with a stand-off ring mounted on the battery case end cap. Shorting the battery will blow the fuse. All units are shipped with a separate battery pressure case. Check the battery to see if any of the cells have leaked. Check the battery voltage and charge the pack if necessary. Users should become familiar with the care and maintenance of NICAD batteries because with proper care and use, the life of a pack can be extended. Pay particular attention when charging or hooking up the pack to make sure positive and negative leads are not crossed.

6.1 Battery Handling.

NEVER ALLOW THE BATTERY TO BE CHARGED WHILE IN A PRESSURE HOUSING! BATTERIES UNDER CHARGE RELEASE HYDROGEN WHICH WILL MIX WITH THE OXYGEN IN THE CASE GENERATING AN EXPLOSIVE ATMOSPHERE. UNDER THIS CONDITION, A SPARK COULD IGNITE THE MIXTURE CAUSING AND EXPLOSION WHICH WILL DESTROY THE EQUIPMENT AND COULD CAUSE PERSONAL INJURY. ALWAYS FOLLOW THE BATTERY MANUFACTURERS RECOMMENDED CHARGING PROCEDURES.

6.2 Battery Charging.

The manufacturers recommended charge rate for this battery is 0.7 amps for 14 hours (procedures for charging should be followed exactly). A charging cable is included with the equipment. To charge the batteries, connect the plus (+) wire to the positive terminal of a current limited power supply and the negative (-) to the negative side; set the power supply to 700 milliamperes at about 24 volts. The time required to fully charge the batteries is 14 hours. A fully charged pack should read approximately 20 VDC. If the battery pack does not read 20 VDC or slightly higher right after charging, it may have one or more faulty cells.

7. SPARE PARTS.

The following is a minimal list of spare parts that should be available when operating the **MOCNESS** at sea.

- Fuse 3A microfuse 273003 for main underwater unit (by Littlefuse).
- Fuse 10A for battery pack, NAPA ATO 782-1108 (by Littlefuse).
- O-rings end caps (2-237 and 2-240).
- O-rings purge plug.
- Battery Pack.
- Cable harness and dummy plugs.
- Flow meter.
- reed switches for flow meter and net response.

SECTION III - THE ACQUISITION/CONTROL SOFTWARE.

1. PROGRAM OVERVIEW.

MOCNESS.EXE is a Visual Basic 3.0 program designed to run the 16-bit electronics system for **MOCNESS** under WINDOWS 3.11 or WINDOWS 95. It provides the framework to configure the **MOCNESS** electronics and sensors, establishes communications with the surface and underwater LAN system, enables control of the net system, carries out data acquisition and data storage, and provides a visual picture of the net and sensor parameter values during a tow.

The acquisition/control software is designed to run on a MSDOS/WINDOWS 3.11/WIN 95 based microcomputer with a 486 (or better) microprocessor, 16 megeabytes of ram, a 1 gigabyte (or larger) hard disk (drive c:), a local bus video board and screen with 800x600 pixel resolution, and two COM (RS232) ports (COM1 for a mouse, COM2 for hookup to the **MOCNESS** deck box). A third COM port (COM 4) is required if the Ship's GPS system is to be used to supply Latitudes and Longitudes to the program. This program must be located on Drive c: in subdirectory "c:\mocness". This subdirectory must have two sub subdirectories, "c:\mocness\moccnfg" that contains the configuration files, and "c:\mocness\mocdata" that is the location for screen capture bitmaps and can be used for **MOCNESS** data that are collected during a tow. In addition, several Visual Basic support files (*.vbx) must reside in the c:\windows\system subdirectory and the Windows 3.11 system.ini file under the {386Enh] section have a line added that enables buffering of the outgoing commands: COMxTXFIFO=1 This is supposed to reduce interrupt servicing and allow other tasks to run better.

To begin, set-up the **MOCNESS** electronics as described in sections I and II. Then turn on the acquisition/control computer. Once WINDOWS has booted-up, double click with the mouse on the **MOCNESS** Icon. This will activate the Visual Basic program and the **MOCNESS** Data Acquisition Form will appear (Figure 4). This form provides access to all of the relevant set-up and operations menus.

2. MENU DESCRIPTIONS.

2.1 Acquisition Setup: Click on the menu button, several options will appear (Figure 5):

2.1.1 Net Tow Info: If you select this option, another form (Figure 6) will appear which contains setup routines to:

* define the sensor systems on the **MOCNESS**.
* specify various constants to be used in the data acquisition.
* define tow information for printout on printer and disk data file headings.
* enable/disable writing data to a printer.
* define the sampling rate.

Provide the information and when through, use the mouse to click on the "OK" button. The information on the form, as edited, will be written out to a data file which resides in the "**MOCNESS**\config" subdirectory (mocmenu.dat - Appendix 4). The following is a more complete description of some of the options in this form. Additional detail about some of the items is given below in section 2.2 Hardware Setup.

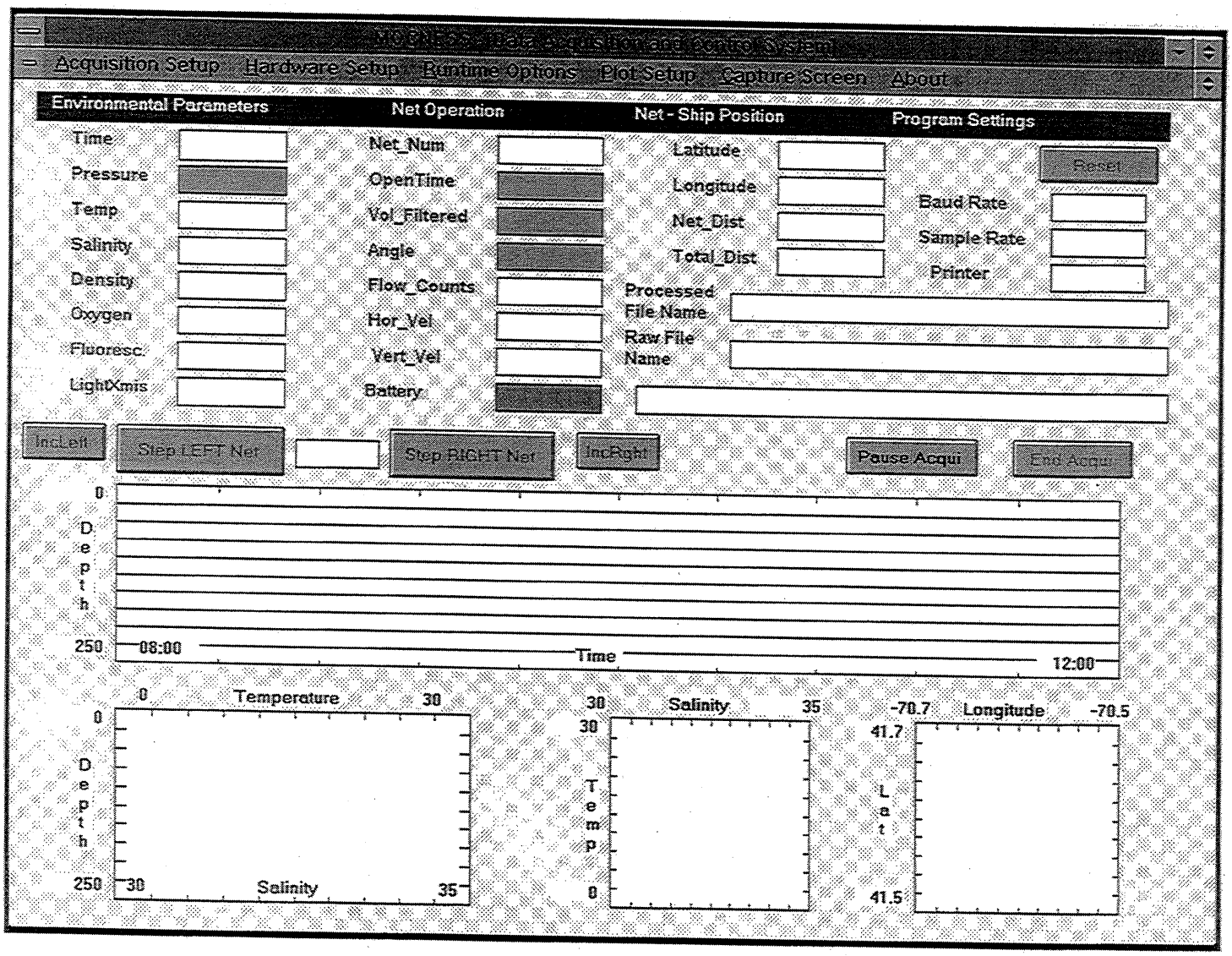


Figure 4. MOCNESS data acquisition and Control Form.

2.1.1.1 Flow Meter: The modified TSK flow meter requires a calibration value in meters per count. This value is determined by the user prior to a cruise. See also Section I 3.6.1.

2.1.1.2 Net Size: A variety of **MOCNESS** net sizes are currently in use ranging from systems with 1/4 meter^2 mouth area to one with a 20 m^2 mouth. These nominal mouth areas are those expected when systems are under tow and have a frame angle from the vertical of 45 degrees. It is the nominal mouth area which should be entered into this menu setting. Within the program, the mouth area is multiplied by 1.4 to reflect the mouth area of the net when the frame is vertical (0 degrees). It is the mouth area * 1.4 that is used in computation of the volume filtered. There is also a "□ Double" check box, which if checked, will result in two command buttons appearing on the data acquisition form, one for commanding the left net to sequence nets, and one for commanding the right net.

2.1.1.3 Printer: "Output to Printer" Check the box associated with this option and processed data will be sent to a printer at 8 second intervals. Printer selection is through the Windows Control Panel - Printers Selection module. To have pages printed during the tow, make sure the "□ use Print Manager" box in this Windows Control Panel dialogue box is <u>not</u> checked.

2.1.1.4 Select Baud Rate: Currently the default baud rate is 2400. After the sea cable has been setup, this option becomes enabled so that a baud rate can be selected that is other than the one selected automatically. If a new baud rate is selected, click the OK button and then select the Setup Sea Cable option to set the system to this new baud rate (See this section 2.2.4). Baud rates of 4800 and 9600 may be possible in the future.

2.1.1.5 Select Sample Rate: The default sample rate is 4 seconds. After the sea cable has been setup, this option becomes enabled so that another sample rate can be selected. The program determines what the maximum sample rate possible is depending upon the baud rate selected and the number of characters to be transmitted from the various SAIL modules. Sample rates higher than the maximum are disabled and are not selectable. Generally, the 4-second interval is optimal for most purposes.

2.1.2 Real Time Acquisition (Figure 5b): If you select this option, click the mouse on the "Processed Filename" and a dialogue box will appear that will allow selection of filename for writing processed data. We recommend using the file extension ".pro" to indicate the file contains processed data. When the "OK" button is clicked, the designated process file will be opened. A second file will also be opened into which raw data from the underwater unit will be stored. This "*.raw" file can be used in the playback mode to re-process the data. It serves as the backup in case there are problems with the processed data file. The data in the processed file are written in ascii to disk in a simple configuration which consists of:

rows1-4	Header information about sensors and the tow
row5	the column headings
succeeding rows	data for each column heading with each value separated by 2 spaces.

Figure 5. Acquisition Setup Selection Choices

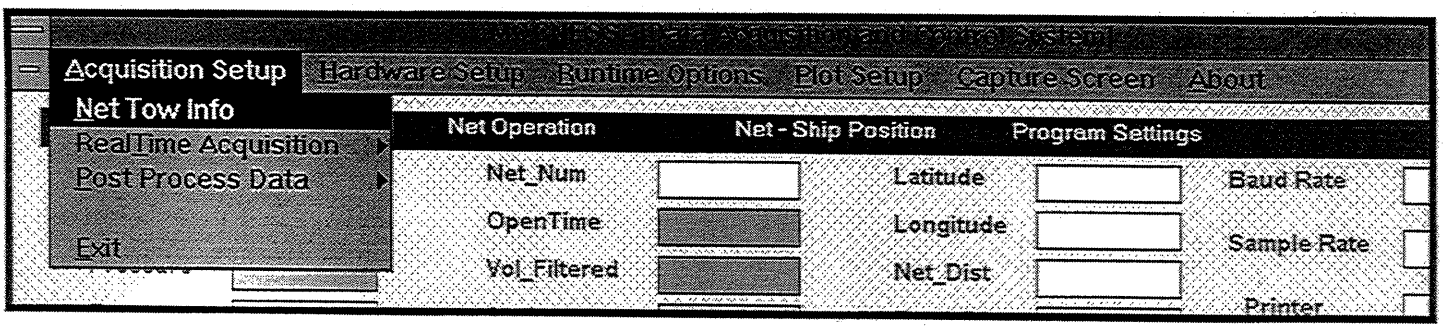


Figure 5a. Click on Net Tow Info to select the The Net Tow Information form.

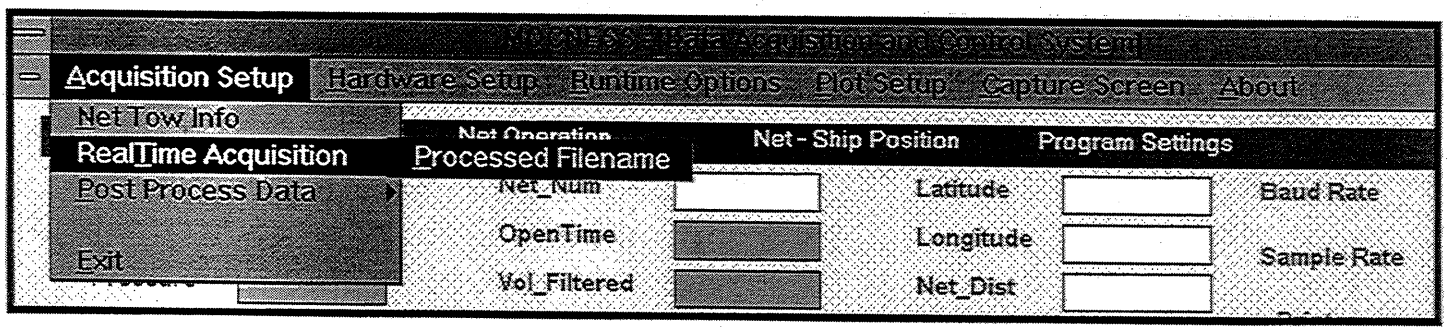


Figure 5b. Click on RealTime Acquisition and then Processed Filename to bring up the file dialog box.

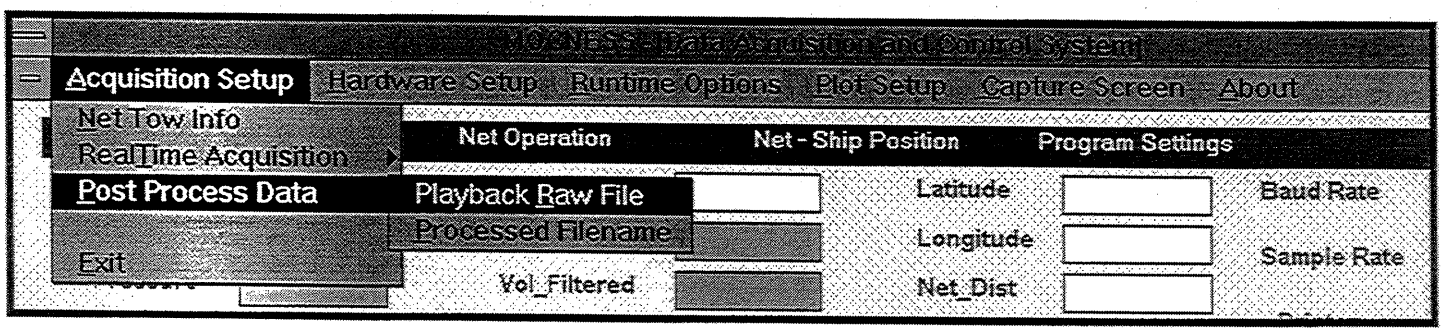


Figure 5c. Click on PostProcess Data and then Playback Raw File to bring up the file dialog box.

For each sequence of data coming from the underwater unit, a line of processed data is written to disk. Of particular importance is the fact that the disk files (processed and raw) are usually closed. The data are "appended" to the files after they are re-opened and after each line is written to the disk, the files are closed again. In the event of some operational failure and the program hangs up, the data already recorded will not be lost. (Note: if a file is used for one tow and then selected for another, the data from the first tow will remain and additional data , including a header, will be appended to the existing header and data. If this is not desired, use the program file manager to delete the file before re-using the filename.)

2.1.3 Post Process Data (Figure 5c): If you select this option, two menu items appear. Clicking on the "Playback Raw File" brings up a dialogue box enabling selection of a "raw" file to playback. To post process data, a "Processed Filename" is also required. After opening a raw file, return to this menu item and open a processed file. Opening this latter file is not mandatory if re-enactment of the tow for display purposes is all that is desired.

2.1.4 Exit: Once data acquisition has been ended, use "Exit" to leave the program.

2.2 Hardware Setup: Click on the menu button; Several options will appear (Figure 7).

2.2.1 Sail System Modules: In addition to the main Net Control Unit, three other optional modules are available (Figure 6):

2.2.1.1 Altimeter: The SeaScan Altimeter has been adapted for use on **MOCNESS**. If the altimeter unit is present, check the box next to "Altimeter Present". The altimeter has four settings (blanking time, pulse width, pulse power, ping rate) which are under operator control and should be modified to optimize its use under differing bottom conditions. The manual accompanying the altimeter describes the settings in detail. These settings can be modified while acquisition is taking place albeit with an interruption of data acquisition during the time the modifications(s) are taking place.

2.2.1.2 Optional Sensors: The Optional Sensor Unit (OSU) supports the SeaTech transmissometer and fluorometer, and the SeaBird oxygen sensor. If the OSU is present, check the box next to "Optional Sensors Present". This will enable the check boxes associated with the three sensors: transmissometer, fluorometer, and dissolved oxygen sensor. Checking a box activates the software which does the acquisition of data from the sensor and carries out the processing of the data. Sensor numbers need to be selected on Environmental Sensors form (Figure 7).

2.2.1.3 GPS: If the SAIL module GPS unit is present, check the box next to "SAIL GPS Present". A data string containing latitude and longitude will be sent from the GPS unit when called (#GPS?L). The program parses the string into latitude degrees and minutes and longitude degrees and minutes which are displayed along with other parameters on the CRT during the tow. The latitude and longitude values written to the processed data disk file as decimal degrees (i.e. minutes converted to fractions of a degree and added to the degrees). Northern hemisphere latitudes are positive and Southern hemisphere latitudes are negative. Thus, latitudes run from -90 to +90. Similarly western hemisphere longitudes are negative and eastern hemisphere

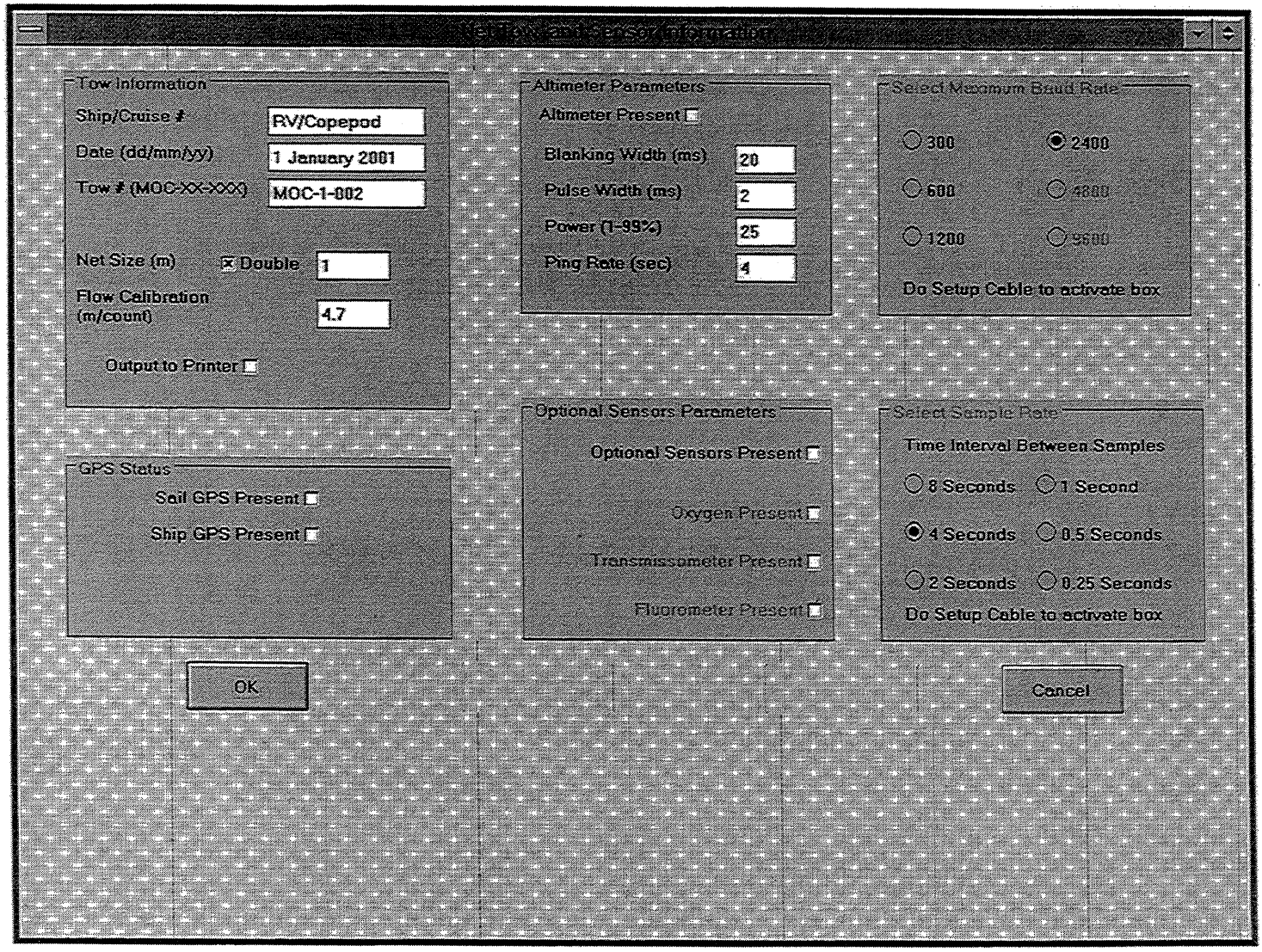


Figure 6. MOCNESS information form.

Figure 7. Hardware Setup Selection Choices

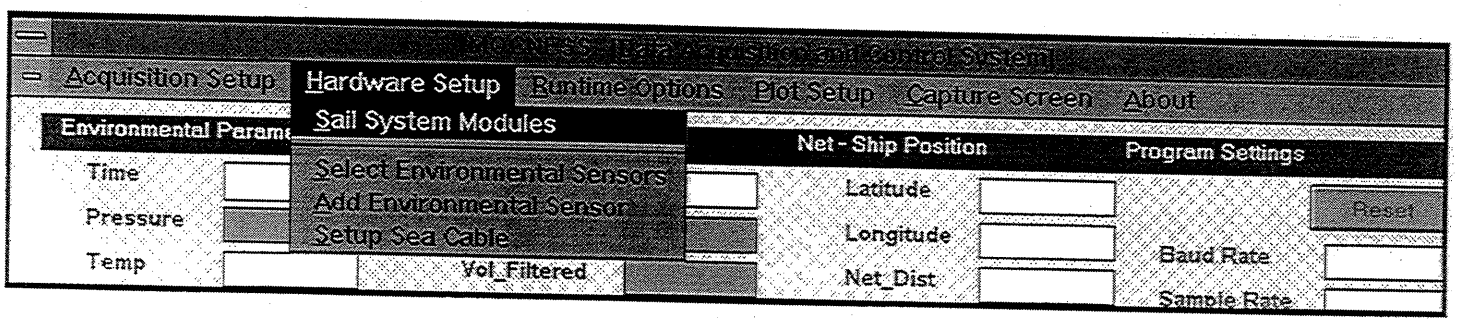
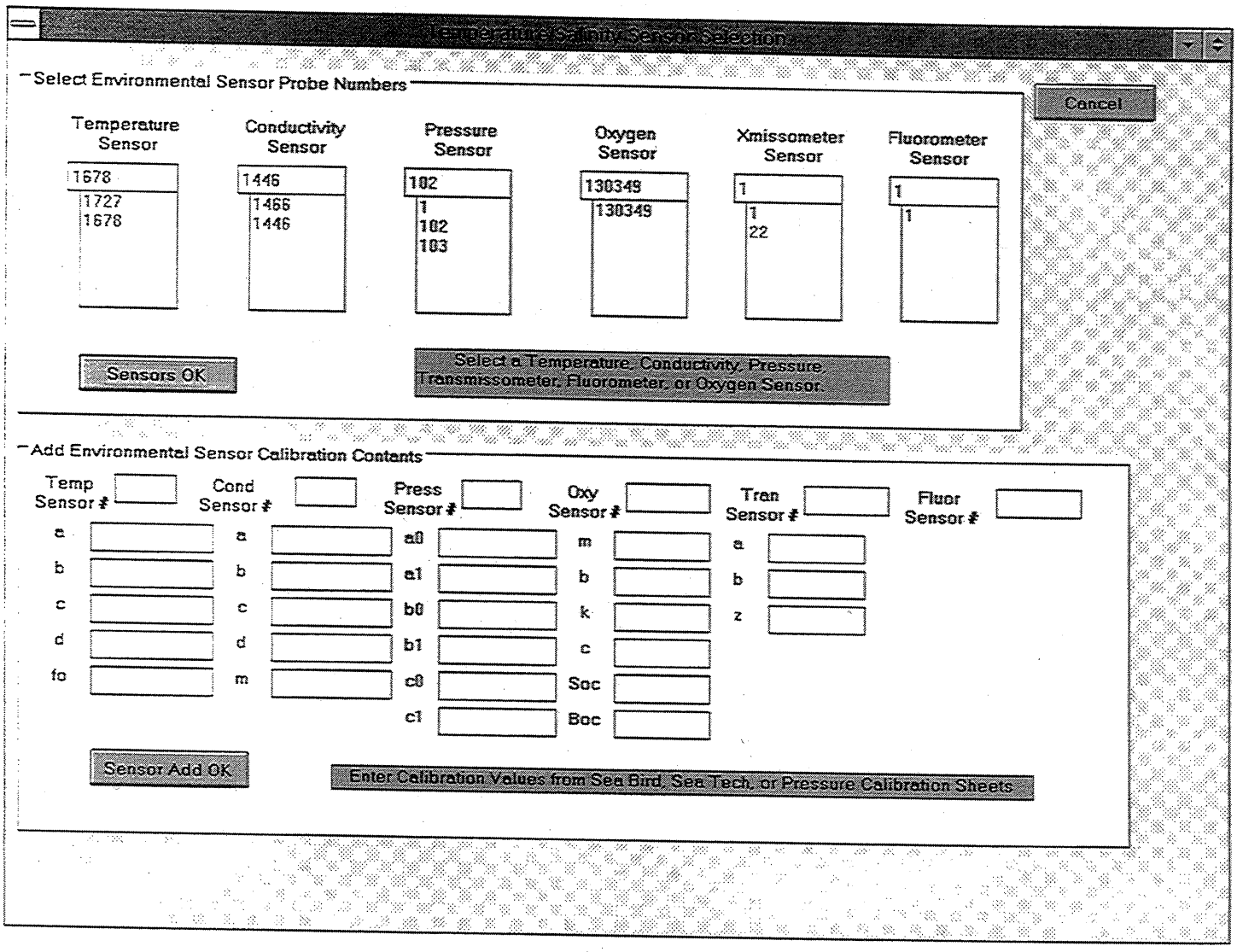


Figure 8. MOCNESS Sensor form.



longitudes are positive i.e. -180 to +180. The latitude and longitude data are used to compute the distance (meters) the **MOCNESS** travels from the starting point of the tow (i.e. when the acquisition program is started) and the distance traveled by each net. In addition, elapse time for each net is also computed. All three values are displayed on the acquisition display. The navigation data string in the above raw form is written to the raw data disk file alternately with the **MOCNESS** data string.

If the SHIP's GPS unit is present (connected to the deck computer through COM3), check the box next to "Ship GPS Present". The data coming from the ship's GPS unit must arrive at the com port at 1 second intervals and the character data string must be in the NEMA format:

$GPGLL,3202.931,N,12750.987,W[cr][lf]

or

$GPGGA,115703.359,4046.7463,N,06859.4679,W,3,06,1...[cr][lf].

The software can handle additional lines of data with other formats. A background interrupt timer monitors the com port and concatenates characters as they appear at the port into a data string which is parsed as described above.

Only one GPS unit can operate during a tow. If the SAIL GPS is on, the software will automatically turn the SHIP GPS off, and vice versa.

2.2.2 Select Environmental Sensors (Figure 7): The pressure, SeaBird, and Sea Tech sensors, each have a unique number and set of calibration constants (Figure 8). The sensor numbers which are listed in the menu are linked to data files containing the constants for computing conductivity and temperature given the frequency values output by the sensors or pressure given the temperature of the pressure sensor. These constants are read into the program instead of having the constants reside in the program. This eliminates the need to change the program every time a new set of probes is to be used with the program. Default values are displayed in the top portion of the list box. If these values are correct, click the mouse on the "Sensors OK" button. If not, click on the preferred probe and then select OK. The selected sensor numbers will become the new defaults. Each of the data files can be edited with text file editor or from within this program (See next item below) and saved as an ascii file. The files are required to reside in the subdirectory "**MOCNESS**\moccnfg".

cprobe.dat: contains a list of the conductivity sensor numbers for which there are dat files. A sample listing of three conductivity sensors in cprobe.dat is the following:

96
102
120

tprobe.dat: contains a list of the temperature sensor numbers for which there are dat files. A sample listing of three temperature sensors in tprobe.dat is the following:

514

535
542

pprobe.dat: contains a list of the pressure sensor numbers for which there are dat files. A sample listing of one pressure sensor in pprobe.dat is the following:

1

Other dat files which contain lists of the probe numbers available for selection are trprobe (a list of transmissometers), fprobe (a list of fluorometers), and oprobe (a list of dissolved oxygen sensors).

cond###.dat: contain the sensor constants required to convert frequency into conductivity, i.e. ac, bc, cc, dc, nc. The three sample files: cond96.dat, cond102.dat, and cond120.dat have the following data in them:

Constant	Sensor # 96	102	120
ac	2.46581083e-10	4.1166593e-9	2.37673736e-13
bc	0.498700514	0.474782259	0.534303778
cc	-0.0125731354	-0.0127070135	-0.00510274301
nc	8.7	7.5	11.4
dc	0.000333560864	0.000564649011	0.000073981716

temp###.dat: contain the sensor constants required to convert frequency into temperature i.e. at, bt, ct, dt, fo. The three sample files: temp514.dat, temp535.dat, and temp542.dat have the following data in them.

Constant	Sensor # 514	535	542
at	0.00362164002	0.00367561925	0.003659947
bt	0.000585124278	0.000591251218	0.000591229089
ct	0.0000142076115	0.0000167274072	0.0000185135023
dt	0.00000719842419	0.00000614280705	0.00000711512457
fo	6373.54	6031.4	6426.08

pres###.dat: contain the sensor constants required to convert frequency into pressure i.e. A0, A1, B0, B1, C0, C1. One sample file, pres1.dat, has the following data in it:

Constant	Sensor # 1
A0	-217.6176
A1	-1.162258E-03
B0	0.2046821
B1	3.23838E-07

C0	2.256545E-07
C1	-2.658385E-11

The program will not run properly without them and therefore requires that a temperature, salinity, and pressure probe be selected before acquisition can begin.

Temperature is computed from frequency according to the most recent formula provide by SeaBird:

$$\text{Temperature} = 1/(at+bt*(\ln(fo/f))+ct(\ln(fo/f))^2+dt(\ln(fo/f))^3-273.15$$

where f is frequency, and the other terms are defined above. Conductivity is also computed from frequency according to the most recent formula provided by SeaBird:

$$\text{Conductivity} = (ac*f^{mc}+bc*f^2+cc+dc*t)*(1-(9.57e^{-8}*p))$$

where f is frequency, t is temperature, p is pressure, and the other terms are defined above. The latter term is a correction for the compression of the glass tube in the conductivity sensor associated with increasing pressure. The pressure sensor reading is corrected for temperature effects using the temperature measurement made by a temperature sensor associated with the pressure sensor. Pressure is computed using the formula:

$$\text{Pressure} = A + B*N(P) + C*N^2(P)$$

where N(P) is the raw pressure that is output by the A/D converter associated with the pressure sensor, $A = A1*N(T_p) + A0$, $B = B1*N(T_p) + B0$, $C = C1*N(T_p) + C$, and $N(T_p)$ is the raw temperature output by the A/D converter measuring the temperature of the pressure sensor. The constants A0, A1, B0, B1, C0, and C1 are determined during the calibration of the pressure sensor.

2.2.3 Add Environmental Sensor (Figure 7): Selecting this menu item, provides access to a box structure in which constants for temperature, conductivity, pressure, transmissometry, fluorometry, or oxygen sensors may be entered (Figure 8). A separate file will be created for each individual set of sensor constants. In addition, the sensor number will be added to the appropriate sensor list.

2.2.4 Setup Sea Cable (Figure 7): This menu item must be selected before acquisition can begin. Clicking on the item will initiate the process of determining an acceptable baud rate for data telemetry between the deck unit and the underwater unit. The computer queries and modem responses are displayed just above the "Pause Acqui" and "End Acqui" command button on the data acquisition form. When the message displayed is "Communications set to #### baud. Ready to start acquisition", and the Environmental sensors have been selected, the system is ready for data acquisition.

2.3 Run Time Options

2.3.1 Acquire Data (Run) (Figure 9):

2.3.1.1 Start (Figure 9a): Select this option to being data acquisition after all setup has been completed. An error message will appear "Environmental Sensors not selected - Go to Hardware Setup Menu", if the T/C sensors have not been selected. Make your selections and return to this item to begin acquisition. Similarly, an error message will appear "Sea Cable not Setup - Go to Hardware Setup Menu", if this has not been done. Do this and return to this item to begin acquisition. Finally, a query "No Processed or Playback files have been opened. Ok to Continue?" will appear if no data filename has been specified for writing data to disk during real-time acquisition. If you wish to continue without writing data to a disk file, click on "yes". Otherwise, click on "no" and return to Acquisition Setup and RealTime Acquisition/Processed Filename to bring up the file dialog box.

2.3.2 Test Mode (Figure 9b):

2.3.2.1 Test Left Motor: Clicking on the Test Left Motor item will send a single net command and the motor should step one step. In the case where the net response failed to respond after the net command button was activated, this command can be used to give the left motor one more step to make sure the net bar was released. When there is only one motor on the net frame, it is the left motor.

2.3.2.2 Test Right Motor: Clicking on the Test Right Motor item will send a single net command and the motor should step one step. In the case where the net response failed to respond after the net command button was activated, this command can be used to give the right motor one more step to make sure the net bar was released.

2.3.2.3 Terminal: The windows terminal program can be run directly from the **MOCNESS** data and control program as long as data acquisition is not taking place. This enables testing of the communications systems and sail modules without having to leave the program. Clicking on the option will bring the terminal window up. Select 300 baud to start the communications session. See Section II for details about how to issue commands to the system.

2.4 Plot Setup (Figure 10):

2.4.1 Net Trajectory Plot
2.4.2 ParamVsDepth Plot
2.4.3 TS Plot
2.4.4 Position Plot

Clicking on any of the four menu items will cause a "set plotting parameters ..." form (Figure 11) to appear. Values to be used in setting the maximum and minimum values to be plotted should be entered. Note the need to enter latitude and longitude as degrees and fractions of a degree. Longitude should be a negative number in the western hemisphere (e.g. -70.5 is smaller than -70.0). Time should be entered as hours and minutes separated by a ":". Hour values can be entered alone i.e. 2000 hrs can = "20"of an hour on a 24 hour basis (e.g. 2030 should be entered as 20.5)

2.5 Capture Screen:

Figure 9. Runtime Options Selection Choices.

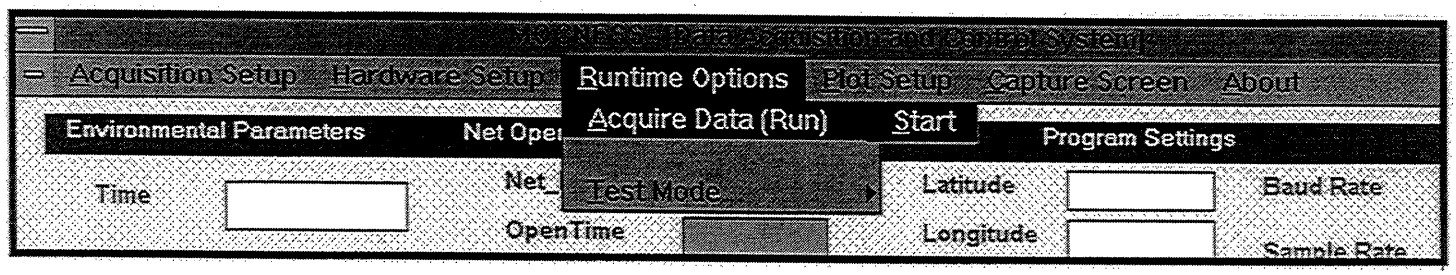


Figure 9a. Click on Acquire Data (Run) and Start to begin data acquisition.

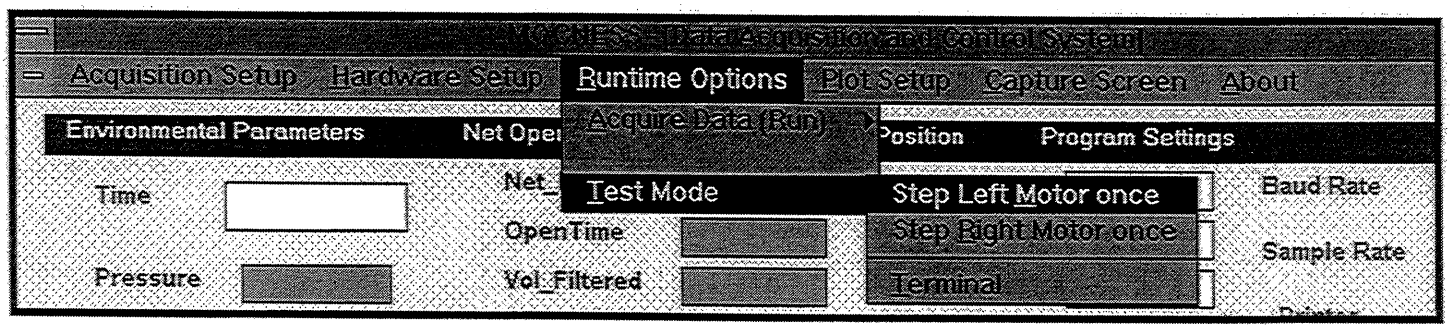


Figure 9b. Click on Test Mode and Step Left Motor once to step the motor.

Figure 10. Plot Setup Selection Choices.

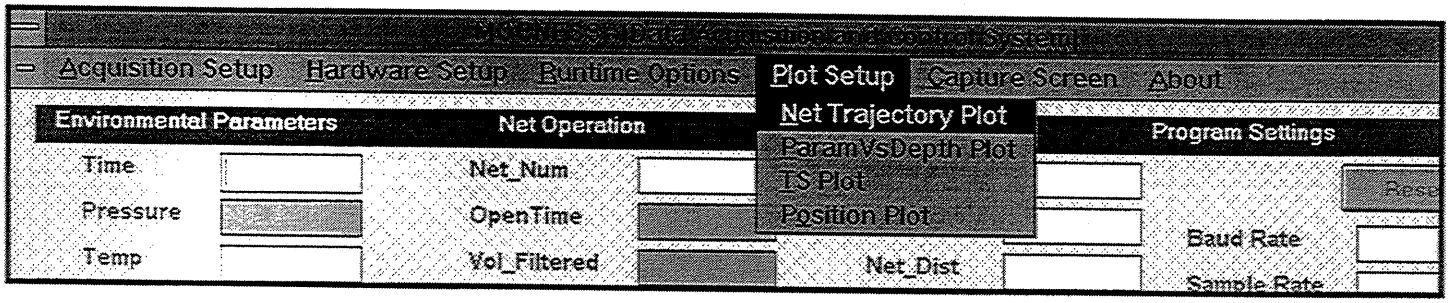
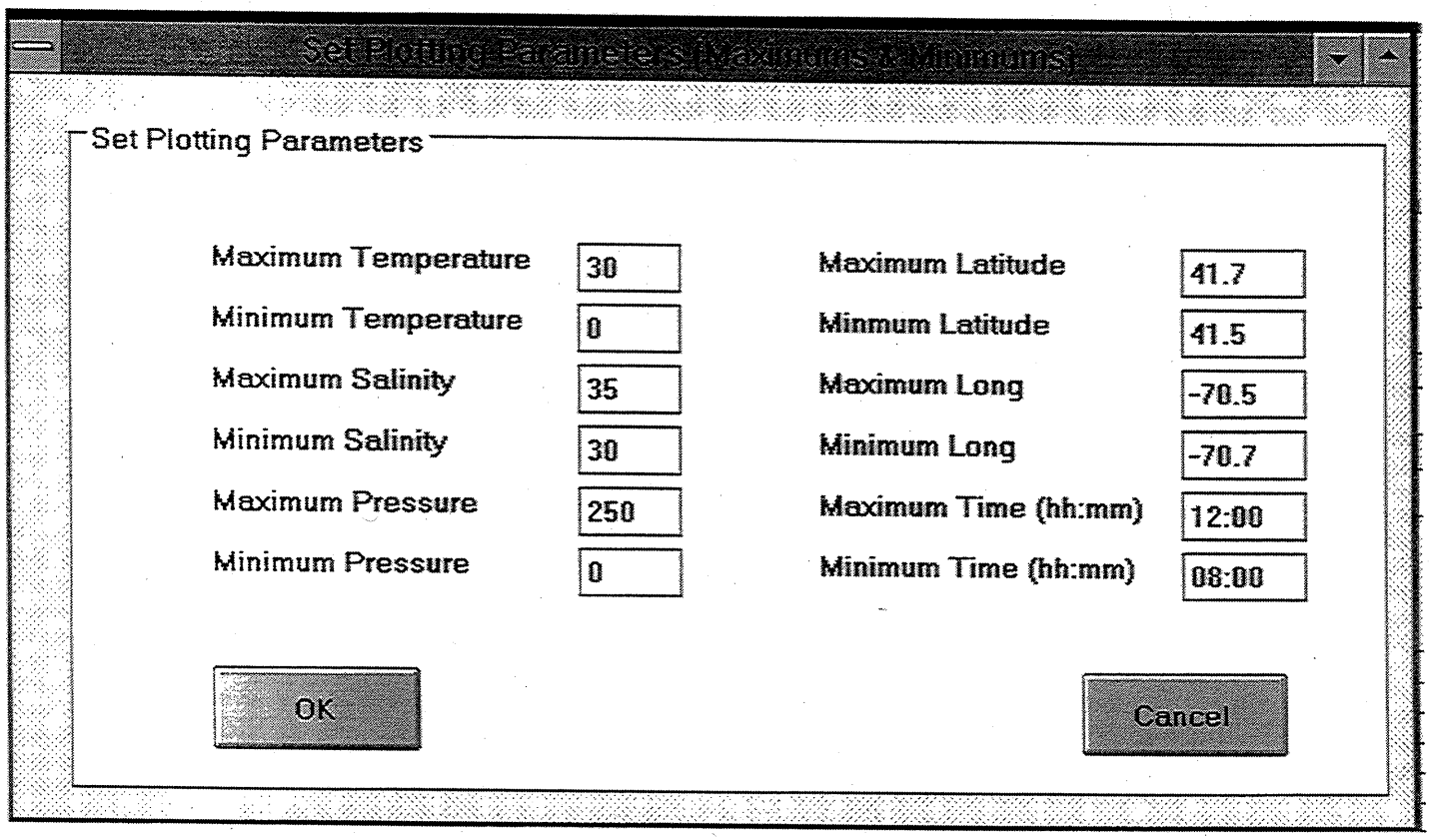


Figure 11. MOCNESS plot setup form.



Clicking on this menu item will cause the current screen to be captured and saved to "c:**MOCNESS**\mocdata" as a bit map file. The software assumes the format of the tow number in the NetTowInfo form is "m-XX-XXX", where the XX designates the net size and the XXX designates the tow number. The program will take the third and fourth characters and the right three characters of the tow number and will use them along with a sequential number counter (##) to build a filename which is used to designate the bit map i.e.

"m##XXXXX.bmp"

3. DATA ACQUISITION

During data acquisition, the data will be displayed on the **MOCNESS** Data Acquisition form. Once data acquisition has been initiated, clicking the mouse on command buttons will control the operation of the net. It is also possible to return to the setup menus and modify the setup. The command buttons do the following:

3.1 Net command:

Clicking the mouse on this button initiates the net command sequence. The motor step count will appear in the box above the net command button. Once a net response is received, the count box will be cleared. In the event that the net response fails to activate, if other evidence suggests the net command was successful, then click the Increment Net# button to complete the net change. If a net response is triggered as a result of the net-bar being released, as should happen after three commands are sent, the flow count and volume filtered will be zeroed, and the net number advanced.

If the double □ has been checked, tow command buttons will appear on the data acquisition form, one for commanding the left net to sequence nets, and one for commanding the right net. The Net_Num display box will display the sequential net number count for both sides of the double **MOCNESS** net system.

3.2 Reset:

The reset button does a complete reset of the net operation parameters (flow counts, net number, etc.). This is usually done after check-out of the system on the deck of the ship and just before the net is deployed on a tow. If the reset button is pressed, a caution message will appear asking you to "confirm reset". Select "yes" to complete the reset procedure and "no" to return to the previous state.

3.3 Increment Net#:

In the event that the net response fails to activate, if other evidence suggests the net command was successful, then click the Increment Net# button to complete the net change. This will zero the flow counts, volume filtered, open time, and net distance registers, and increment the net number register.

If the double □ has been checked, 2 increment net buttons (IncLeft and IncRight) will appear on the data acquisition form, one to simulate a net response on the left side and one to simulate a net response on the right side. Use these buttons as described above.

3.4 Pause Acqui:

Occasionally there is a need to stop the acquisition without re-setting all the parameters. Clicking the mouse on this button will bring up a pause form. Click on the "End Pause" button to resume acquisition.

3.5 End Acqui:

At the end of the tow, click the mouse on this button to end data acquisition and close all open files.

4. PROGRAM COMPUTATION AND REAL-TIME DATA PROCESSING.

4.1 Battery Voltage:

Battery voltage is measured on each data scan and is displayed on the **MOCNESS** data acquisition and control form (Figure 4). When the voltage is above 17.0 volts, the box will be shaded green. Below this value it will be shaded red indicating the need to replace and recharge the battery.

4.2 Conductivity => Salinity:

Salinity is computed using the 1978 Practical Salinity Scale Equations (IEEE Journal of Oceanic Engineering, Volume OE-5, #1, January 1980, page 14). The SeaBird sensors are calibrated using a value of conductivity at 35 ppt, 15°C, and 0 pressure of 42.914. This value is used in the computation of R (the ratio of measured conductivity to C(35,15,0) as part of the salinity routine. If salinity exceeds 50 or is less than 0 o/oo, as it will occasionally do when bad values are encountered or sea water leaks into the underwater connectors, it is set to 50.

4.3 Temperature => potential temperature (Θ) & Potential density (Sigma Θ):

The computational formulas for calculating potential temperature and potential density were taken from "Algorithms for computation of fundamental properties of seawater" (Fofonoff and Millard 1983, Unesco technical papers in marine science #44). These formulas are based on the practical salinity scale (PSS-78) and the international equation of state for seawater (EOS-80). This code has been checked using the check values provided by Fofonoff and Millard.

4.4 Net Speed:

The speed of the net through the water is based on a running total of flow counts over a 32-second time interval:

$$\text{Speed (knots)} = \text{flow counts} * cf/(32*3600/1852)$$

where cf is the flow meter calibration factor (meters/count), 32 = number of seconds for flow counter total, 3600 = seconds/hour, and 1852 = meters/nautical mile. Knots are used because this unit is most easily compared to ship speed.

4.5 Vertical Velocity:

The vertical velocity of the net is based on a running difference in pressure over a 32-second time interval:

$$\text{Vertical Velocity (m/min)} = c2*\Delta p$$

where c2 = 60sec/32sec and Δp is the pressure difference. The velocity is "-" when the net is descending and "+" when ascending. Units of meters/min are used because oceanographic winches metered in meters and winch speeds are specified in meters/min. If the vertical velocity exceeds 99 m/min, which is obviously due to a bad value, it is set to 99.

4.6 Volume Filtered:

Volume filtered by the net is computed at each sample interval and is based on the number of flow counts for that interval and the angle (Θ) of the net from the vertical, the flow meter calibration factor (cf), and the net mouth area at $\Theta=0°$ (ns).

$$\text{Volume } (m^3) = \text{flow count}*ns*cf*\cos(\Theta)$$

This volume is corrected by taking into account the changes in the angle the net faces the flow due to its vertical velocity. Equation 9b from Wiebe et al,(1985 - Marine Biology 87:313-323) is used to compute the angle addition, Phi, and 10b to compute the corrected volume based on Phi. (Note that these equations are given with angles in degrees; the program uses cp = $\pi/180$ to convert between radians and degrees since Visual Basic uses radians.) This corrected value is added to previous values so that a cumulated total is produced when the net is closed.

4.7 Fluorometer:

If a SeaTech or a Wet Labs fluorometer is present, fluorescence (in volts) is computed. An in-coming fluorometer value ranges from 0 to 5.0 volt scale (chlor). No attempt has been made to convert fluorometer volts to chlorophyll units. This requires careful calibration usually in the field using chlorophyll values taken from water samples collected close to the time and place where the fluorometer is used.

4.8 Attenuation Coefficient:

If a SeaTech transmissometer is present, light transmission (in volts) is computed using the formula provided by SeaTech for the 25 cm path length transmissometer. An in-coming transmissometer value ranges 0 to 5.0 volt scale (tr). The following equation is then applied:

$$\text{corrected output voltage} = K*((A/B)*(tr-Z))$$

where z = zero offset correction, A is the factory air calibration voltage, B is the present air calibration voltage, and K is the water calibration constant. The proportional transmission (ptr = corrected voltage/5.0) is used to compute the extinction coefficient, c:

$$c = -\ln(ptr)/0.25 \qquad \text{Units: /meter}$$

4.9 Dissolved Oxygen:

If a SeaBird dissolved oxygen sensor is present, dissolved oxygen is computed using the formulas provided by SeaBird that are supplied with the sensor. The two incoming oxygen sensor values, oxygen current (V_o) and oxygen temperature (V_T - internal to the probe), are voltages (0-5 volt scale). The following equations, taken from the SeaBird information sheets, are then applied:

$$oc = m * V_o + b$$

where oc is oxygen current in microamps, m = 1.0043e-5, and b = -1.6470e-8.

$$To = k * V_T + c$$

where To is the oxygen sensor internal temperature (°C), k = 6.4618, and c = -2.0904.

$$OX = [Soc * (oc + tau* doc/dt) + Boc]* OXSAT(T,s) *exp(tcor * [T + wt*(To - T)] + pcor * p)$$

where OX is the dissolved oxygen in ml/l, T is the water temperature (°C), To is the oxygen sensor internal temperature (°C), s is salinity (PSU), p is pressure (decibars), oc is oxygen current (microamps), doc/dt is the slope of oxygen current (microamps/sec), Boc is the oxygen bias, Soc is the oxygen current slope, wt is the weighting fraction of oxygen sensor internal temperature, tcor is the correction factor for membrane permeability, pcore is the pressure correction factor for membrane permeability, tau is the oxygen sensor response time, and OXSAT(T,s) is the oxygen saturation value.

$$OXSAT(T,s) = \exp(A1 + A2 * (100/T) + A3 * \ln(T/100) + A4 * (T/100) + s * (B1 + B2 * (T/100) + B3 * (t/100) * (T/100)))$$

where s is salinity (PSU), T is °C + 273.15 (absolute temperature), A1 = -173.4292, A2 = 249.6339, A3 = 143.3438, A4 = -21.8492, B1 = -0.033096, B2 = 0.014259, B3 = -0.00170. See the SeaBird information sheets for additional details.

4.10 Downwelling Light:

If a Downwelling light sensor is present, data for downwelling light appears in voltage channnels 5, 6, and 7 of the #MO node on the MOCNESS LAN. This system can operate in tow modes and several gain ranges. Which mode you select will depend upon what you need to look for. To understand the tradeoffs, it is important to understand how a photodiode works.

A photodiode operating into a short circuit will generate a current directly proportional to the intensity of the light falling on it. This is called the linear mode. The current can be measured and multiplied by the diode's calibration factor to give the light level. Most light intensities of interest are relatively low compared to direct sunlight and we have therefore provided a large area photodiode which generates on the order of 10 mA in direct sunlight. The light sensor should be useable in direct sunlight because the sun, on a clear day, provides one of the quickest ways to check calibration. With a 16-bit A to D converter, however, this gives inadequate sensitivity for many ocean applications. The MOCNESS light interface, therefore, provides five different gain ranges extending the range by over four decades. If the voltage in channel 5 is too close to zero for good resolution, set the gain to the next range. If the voltage approaches 3 volts (the op-amp's output

limit), select a less sensitive range. When operating in the linear mode the value of channel 6 should be almost zero. If channel 6 changes from zero, select a less sensitive range.

If a wider light range is needed, it is possible to operate a photodiode into an open circuit and measure the voltage that will depend on the light level. This dependency is highly non-linear, but is repeatable and may be calibrated. The MOCNESS electronics in this voltage mode is able to measure light intensity over more than eleven decades. The major shortcoming with using this photovoltaic mode is its temperature dependence which is difficult to characterize. In the photovoltaic mode, the diode voltage multiplied by -6 appears on channel 6. The voltage on channel 5 will be zero when in photovoltaic mode.

In order to be able to calibrate the sensor in photovoltaic mode, a thermister is imbedded in the endcap near the sensor and tracks its temperature accurately. The voltage across this thermistor appears on channel 7. The temperature must be calculated from the voltage using the following algorithm. This is shown as a MATLAB function, but may be converted to any suitable language.

```
function [T]=Ysi(Vt, Vcal, Ro)
% given Vcal, Vt, Ro, calculate temp for MOCNESS Thermistor
% (Ro = 121000, Vcal = 5.000, Vt is ch7 in MOCNESS)
% Use natural logarithms
% T is returned in degrees C

a = 2.511297526828006e-3;
b = 2.338396700652388e-4;
c = 4.092750265792616e-6;
Vs = 2*Vcal;
Rt = Ro/(Vx/Vt -1);
lnR = log(Rt/1000);
T = 1/(a+b*lnR + c*lnR*lnR);
T = T-273.15
end
```

To use the light sensor system, the 12-volt power must be on (Use the !P1 command) to provide power for the relays used in the gain and mode select. This is normally done by the surface control program running in the PC. If you need a continuous wide range and can tolerate the non-linearity, set the system to the photvoltaic mode with the !G0 command. Channel 6 in the data line will now give the voltage produced by the diode multiplied by -6.

If you need a linear output and can accept a range running from full sun on deck to only about 10e-7 below this level, select a linear range with the commands !G1 to !G5, where the first is for full sun and the last for the lowest light levels. Notice that each range is a factor of 10 more sensitive than the previous, except for the last (!G5) which only offers a factor of 2 more gain than the previous setting (!G4). The gain or mode can be changed at anytime. The light level indicated by the voltage in channel 5 combined with the scale factor for the gain setting used. This gives a light current produced by the photodiode that may be converted to absolute light levels after appropriate calibration.

5. THE MOCNESS SOFTWARE.

5.1 Software Policy.

The **MOCNESS** system is furnished to BESS customers with WINDOWS 3.11 or WINDOWS 95 and a Visual Basic program for system control and data acquisition. It is the customers responsibility to become proficient with the **MOCNESS** operating system. The system control and data acquisition program is copyrighted, and is not to be copied, or modified without the express permission of BESS. BESS has endeavored to make this program easy to use and error free. We welcome suggestions for additions and improvements to make the program more reliable, and user friendly. Minor up-dates to the program and "bug fixes" will be supplied to the customer at no charge. The cost for major modifications to meet the users special needs is negotiable.

SECTION IV - REFERENCES

Frost, B.W. and L.E. McCrone. 1974. Vertical distribution of zooplankton and myctophid fish at Canadian weather station P, with a description of a new multiple net trawl. Proc. Int. Conf. Engineering in the Ocean Environment. Halifax, Nova Scotia. IEEE J. oceanic Eng. 1: 159-165.

Lewis, E.L. 1980. The practical Salinity Scale 1978 and its antecedents. IEEE J. Ocean. Eng. OE-5(1): 3-8.

Wiebe, P.H., K.H. Burt, S.H. Boyd, and A.W. Morton. 1976. A multiple opening/closing net and environmental sensing system for sampling zooplankton. J. Mar. Res. 34: 313-326.

Wiebe, P.H., A.W. Morton, A.M. Bradley, J.E. Craddock, T.J. Cowles, V.A. Barber, R.H. Backus, and G.R. Flierl. 1985. New developments in the **MOCNESS**, an apparatus for sampling zooplankton and micronekton. Marine Biology 87: 313-323.

APPENDIX 1.

MOCNESS Check List

Pre-Tow

BUCKETS

Buckets on securely and taped? _____

Funnels in Buckets? _____

Hose clamps tight? _____

NETS

Nets in good shape (no rips or tears) _____

Rings and shackles (trigger snaps) all attached and tight? _____

SENSORS

Cables plugged in all the way? _____

Tubing removed from Cond. Probe? _____

Flow meter stop removed? _____

Echo sounder plugged in? _____

FRAME

Nuts and bolts tight esp vert rod nuts? _____

Net bar trap in place? _____

TOW BRIDLE

Bridle and Figi firmly attached, signal cable plugged in, and taped down clear of shackles etc. _____

Electrical Check-out

Under Water Unit Shorting Plug in? _____

Lite Unit Shorting Plug in? _____

Deck Unit on and displays all lit? _____

Green light (upper left on panel) on and flickering? _____

Check flowmeter by letting it spin for 3 or 4 counts. Did counts register on the deck unit? _____

Check net command by sending a command (person on deck should watch out for falling net bar). Did toggle release step? _____

Check net response by depressing trip bar. Did computer beep and net number counter increment, and flow counter reset to zero? _____

Post-Tow

Underwater Unit turned off? _____

Light Unit turned off? _____

Tube with freshwater back on Cond. Probe? _____

Frame tied down and secure? _____

Flow meter secured? _____

APPENDIX 2.

MOCNESS DATA SHEET

Cruise _____ Location _____ Tow # _____

Date _____ Wind Speed _____ Direction _____

Year/Day _____ Sea State _____

Local Time _____ to _____ Start Lat _____ Long _____

GMT Time _____ to _____ End Lat _____ Long _____

Net Size _____ Net Condition _____
Net Mesh _____

Processed Filename _____ Raw Filename _____

NET TOW INFORMATION

	Time Open	Angle	Flow Counts	Volume Filtered	MWO
Start					
Net 0 Down					
Net 1					
Net 2					
Net 3					
Net 4					
Net 5					
Net 6					
Net 7					
Net 8					
Closed					

SAMPLE INFORMATION

Net	Jar #
Net 0	
Net 1	
Net 2	
Net 3	
Net 4	
Net 5	
Net 6	
Net 7	
Net 8	

COMMENTS: _____

APPENDIX 3.

TO START MOCNESS ACQUISITION

1) Type **WIN** (to bring up Windows).

2) Double click on **"MOCNESS ACQUISITION"** Icon (To start Program)

3) Click on **"ACQUISITION SETUP"**

   - Select **"Net Tow Info"**
   - Change settings for tow (only those that need changing i.e. data, haul #, etc.)
   - Click **"OK"** if changes made ... otherwise **"CANCEL"**.

4) Click on **"ACQUISITION SETUP"** (again)

   - Select (click) **"REAL TIME ACQUISITION"** (for net tow)
   - You want data to be written to a file in **"c:\MOCNESS\MOCDATA"**. Do not write data to a floppy disk during acquisition.
   - Double click **"MOCDATA"**, then enter filename (e.g. m1-####.pro)
   - Click on **"OK"** to create both the *.pro and the *.raw file or **"CANCEL"** to exit without file creation.

5) Click on **"HARDWARE SETUP"**.

   - Select **"SELECT ENVIRONMENTAL SENSORS"**.
     - Select T/C sensor **"OK"** if sensor #'s in boxes ok.
     - Click on sensor # to select different sensor (if necessary), and then select **"OK"** when finished.
   - Select **"SETUP SEA CABLE"**.
     - This will activate the MOCNESS electronics to test the tow cable and determine the baud rate for data telemetry. It must be done before "ACQUIRE DATA (RUN) below.

6) Click on **"PLOT SETUP"**.

   - Select any option
   - Set max/min time
   - Set max/min latitude and longitude (in degrees and fractions of degrees)
   - Set depth max/min

7) Click on **"RUNTIME OPTIONS"**

   - Select **"ACQUIRE DATA (RUN)"** and start the station tow.

PRE-DEPLOYMENT CHECK OF THE SYSTEM

- Note bottom depth and your sampling bottom depth.

- Make up your tow profile and time table.

ON DECK

- Have a person on deck give you:
  - Flow counts (spin flowmeter to simulate flow).
  - Net command confirmation (send command from PC).
  - Net response (depress lever on net response)
- When all is ok, click on **"RESET"** command button to reset display.
- **MOCNESS** can go over the side, but have the winch operator hold it just below the sea surface to stabilize sensors, etc.

9) While running tow:

- Use **"NET COMMAND"** button (on 9-net system, both left and right on double system) to send 3-step commands to motor and drop net.
- Use **"INCREMENT NET #"** button if net response fails.
- Use **"RESET"** button to clear all net registers before a tow
- Use **"PAUSE"** button to temporarily stop acquisition during tow.

10) At end of acquisition:

- Click on **"END ACQUISITION"** command button and wait for "acquisition ended" message to appear in the message box on the screen.
- Click on **"ACQUISITION SETUP"**
  - Select **"EXIT"** to leave program.

APPENDIX 4.
Mocmenu.dat values

```
cf                  ' Flow calibration factor - m/count}
net_size            ' Net size - nominal meters on a side}
cprobe            ' Conductivity Probe #}
tprobe              ' Temperature Probe #}
pprobe              ' Pressure Probe #}
oprobe              ' Oxygen Probe #
trprobe             ' Transmissometer Probe #
fprobe              ' Fluorometer Probe #
alt_blank           ' Altimeter Blanking time (> width) - ms}
alt_width           ' Altimeter Pulse Width (1-20) - ms}
alt_power         ' Altimeter Power (1-99%) - %}
alt_rate            ' Altimeter Ping Rate - sec}
bot_warning         ' 1=on;0=off}
bot_warn_depth      ' Bottom Warning Depth - m}
altimeter_present ' Altimeter Present? (y-n)}
z1                  ' Tow number (e.g. MOC-Q-###)}
z2                  ' Date (day-month-year)}
z3                  ' Ship name & Cruise number}
gps_present         ' Able to get Lat and Long? (y-n)}
ShipGps             ' Able to get Ship Gps? (y-n)}
dat_out_file        ' Data filename}
iave                ' 0=at surface (avg1=not at surface}
dmm                 ' MOCNESS at the surface? (y-n)}
beepcode            ' 1=on;2=off}
dbb                 ' Beep alert for net command? (y-n)}
Option_present      ' Is Option System Present? (y-n)}
tran_present        ' Transmissometer Present? (y-n)
fluor_present     ' Fluorometer Present? (y-n)
oxy_present         ' Oxygen Present? (y-n)
aquimode            ' 1=realtime aqui;2=playback from disk}
drt                 ' Realtime aqui (not playback)(y-n)}
sample_rate         ' Sample rate (sec) for acqui- 4 =default}
Playback_file     ' Playback filename}
```

APPENDIX 5.

Visual Basic 3.0 Trappable Error Messages

Error Number	Message
3	Return without GoSub
5	Illegal function call
6	Overflow
7	Out of memory
9	Subscript out of range
10	Duplicate definition
11	Division by zero
13	Type mismatch
14	Out of string space
16	String formula too complex
17	Can't continue
19	No Resume
20	Resume without error
28	Out of stack space
35	Sub or Function not defined
48	Error in loading DLL
49	Bad DLL calling convention
51	Internal error
52	Bad file name or number
53	File not found
54	Bad file mode
55	File already open
57	Device I/O error
58	File already exists
59	Bad record length
61	Disk full
62	Input past end of file
63	Bad record number
64	Bad file name
67	Too many files open
68	Device unavailable
70	Permission denied
71	Disk not ready
74	Can't rename with different drive
75	Path/File access error
76	Path not found
91	Object variable not set
92	For loop not initialized
93	Invalid pattern string