INTRODUCTION

TAPS* is a self-contained oceanographic instrument that measures acoustical backscattering (volume scattering strength, Sv) at six frequencies along with depth, temperature, and date/time (Fig. 1). It was designed to meet the need for a portable, multi-frequency acoustic sampler for estimation of the size-abundance of zooplankton in relation to the depth-temperature structure of their habitat. It may be deployed in cast mode (alone or together with conventional samplers such as CTD's or net systems) to obtain vertical structure information or it may be fixed to a moored or bottom-mounted structure to obtain echosounder time series data for measurements of natural variability in space and time. TAPS may be used in lakes and rivers as well as in the ocean.

TAPS runs on internal NiCad batteries, thus it may be deployed on a variety of submerged platforms or even on a hand-fed line from a dock or small boat. The internal battery is sufficient for approximately 8-10 hours of submerged operations at normal temperatures (slightly less at low temperatures). Since the unit contains depth-sensing power control which switches off the majority of the electronics when the unit is not submerged, the actual operational lifetime may be greater.

The internal micro-computer provides 128 Mbytes of non-volatile internal storage for data. This will normally provide more storage than can be used by TAPS in several days.

Provision has been made to allow the user to connect one or two external sensors to TAPS and have these data incorporated into the normal data stream. Suitable external instruments include conductivity sensors, fluorometers, and irradiance sensors. Some user setup and/or modification of the interconnection may be necessary, requiring the unit be opened. Factory assistance is available for those who need help in configuring TAPS for special instruments.

TAPS weighs approximately 16 kg in air and is slightly negatively buoyant in water. It is sufficiently portable to permit hand deployment from small boats using light manila lines. When deployed from a hydro winch, additional weight is usually required to keep wire angles small.

There are two basic modes of operation for the TAPS. The first of these, referred to here as **CAST MODE**, has the TAPS measuring acoustic backscattering from a fixed volume (approximately 2-3 liters) at a fixed range (1.4 m) from the transducer end of the TAPS. These values, expressed as volume scattering strength (Sv), together with date, time, depth, temperature, and up to two ancillary values, are stored in internal memory for later recall (or, in **INSTRUMENT MODE**, output immediately as ASCII-HEX characters for storage by an external computer). The basic user-adjustable parameter is the number of pings per data set, which controls the time interval between data sets as well as the statistical accuracy of the acoustical measurements. The user can also set the depths at which TAPS starts and stops taking data. The design application for this mode is vertical profiling such as is done with CTD's.

It is also possible to store raw samples of echo amplitudes in the **RAW CAST MODE**. In this mode, the echo amplitude samples that would normally be squared and summed to form a sample of mean echo intensity are stored as the raw amplitude values. These data can be post-processed to produce data identical to CAST MODE data as well as various statistical measures.

The second operating mode, referred to here as **SOUNDER MODE**, resembles the operation of an echosounder. Samples of backscattering are taken every 192 μSec -- approximately one half of the transmit pulse length -- out to a user-specified maximum range up to 32 m. Range-gated echo samples are averaged over a user-specified number of pings before being either stored in internal memory or transmitted via the serial link to a remote computer. The sounder mode is designed to provide information on spatial structure out to ranges of up to 32 meters, depending upon frequency. The

* TAPS once stood for Tracor Acoustic Profiling System. The vagaries of business find us now a part of BAE SYSTEMS so the acronym has lost some of

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Figure 1. TAPS external views. The six acoustic transducers are the circles on the endcap visible in the top picture. Each channel uses a separate transducer. The connectors for I/O, power switching, and external sensors are visible in the lower picture, as is the thermistor. The depth sensor is on this endcap as well.

mode of deployment is flexible as the user may affix TAPS to a structure,such as a pier; setup TAPS in up/downward looking modes to inspect vertical structure; or use the TAPS in a vertical cast mode while obtaining information on horizontal variability at the same time.

GUIDED TOUR

TAPS is housed in a 15.2 cm diameter cylindrical aluminum pressure case (Fig. 1) rated for operation to 1000m depth. Six individual transducers are mounted in one end of the case, aligned with their acoustic axes parallel to the center axis of the case. Operation in CAST mode would thus normally require that TAPS be suspended with the case axis horizontal so that acoustic data arise from the same depth as measured by the depth sensor. SOUNDER applications would require the TAPS be 'aimed' in the appropriate direction to obtain the spatial coverage desired.

The other end of the housing contains several waterproof jacks, a thermistor, and a pressure sensor (Fig. 2). The depth sensor may be chosen from several maximum ratings (e.g., 50, 100, 300, 500, and 1000 psia for maximum depths of 24, 58, 194, 330, and 670 m) by the purchaser and can be changed in the field. It is important to note that **the maximum depth rating of TAPS is usually limited by the depth sensor** rather than the case--exposure of the depth sensor to more than twice the rated pressure can cause damage to the sensor; exposure to much more than twice the rated pressure can cause failure and possibly damage to TAPS.

The 2-pin female shorting connector is used to turn TAPS on and off. Installing the shorting plug on this connector applies battery power to the internal computer and starts the user-specified data collection mode. User communications with the TAPS are also available with this plug installed.

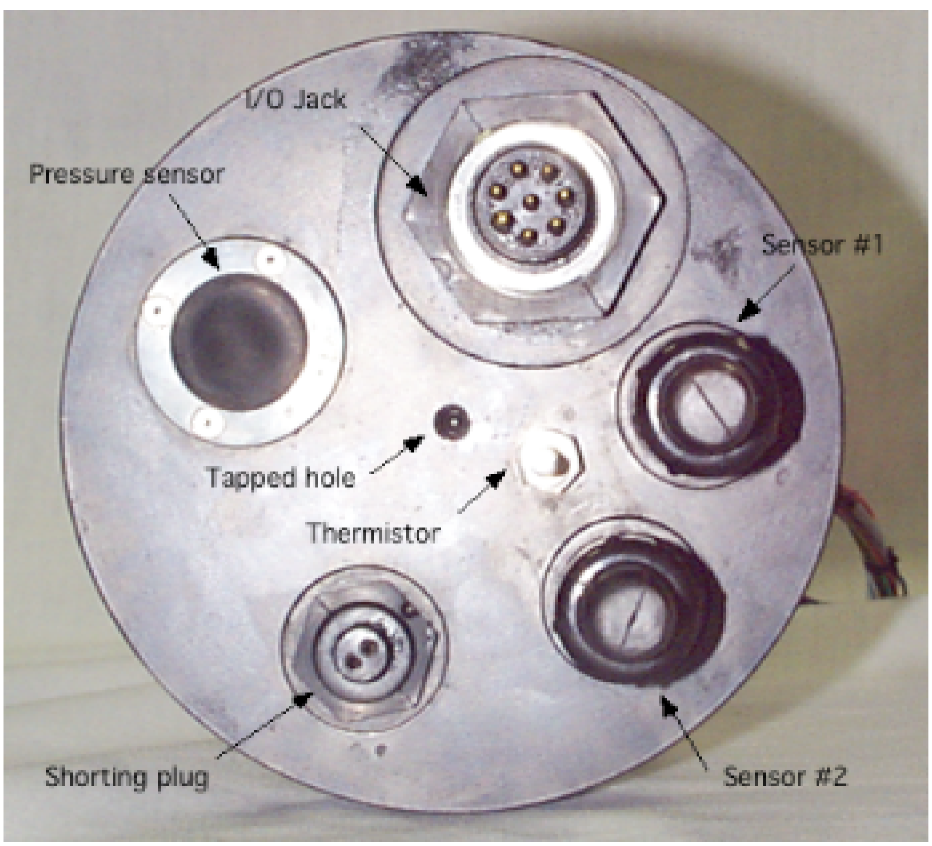

Figure 2. View of TAPS connector endcap, showing locations of sensors and jacks.

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Removing the shorting plug turns TAPS off. The shorting plug should be installed only when operating TAPS; **do not store or ship TAPS with this plug installed**.

The 8-pin I/O connector is used to charge the internal battery and to communicate with the TAPS internal micro-computer. Several cables are supplied which mate with this connector. The short cable with a DB-9 serial connector on the other end is intended for use with a laptop computer to dump data and/or to reprogram TAPS. This cable is ideal for quick data dumps while TAPS is on deck between casts or checking the TAPS setup just prior to deployment.

An 8m cable is provided to connect TAPS to the charger/IO unit. This cable would normally be used when charging TAPS or for dumping data. In addition, a longer cable may be attached to this connector for remote operations. TAPS may be powered through this cable and data stored on a remote computer. See the section on **SOUNDER MODE** for more information.

When not in use, the 8-pin TAPS connector must be protected with the dummy plug and retainer supplied.

Two additional connectors are provided for connection of external sensors to TAPS. These are typically 3 and 4 pin male jacks wired for direct connection to instruments such as the SeaBird™ SBE-4 conductivity sensor, the WetLabs WetStar™, or the SeaTech™ fluorometer. When not used, these connectors must be protected with the dummy plugs and retainers supplied.

The thermistor is located towards the center of the endcap, protected to some extent by the electrical connectors.

The pressure sensor is located beneath a nylon/neoprene membrane retained by a zinc retaining ring. The membrane covers an oil-filled chamber above the pressure sensor. This arrangement is necessary to eliminate the temperature-dependence of the strain-gauge pressure sensor as TAPS passes through strong thermoclines.

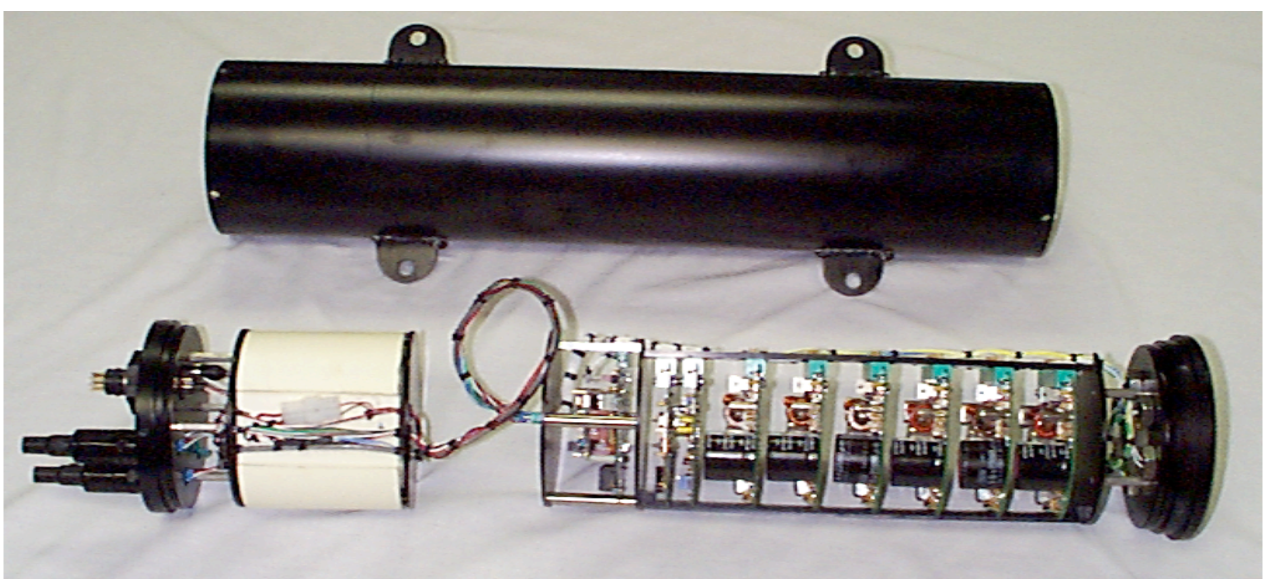

Figure 3. TAPS-6 (early versions) removed from pressure case. The connector endcap is on the left; attached to it is the battery (white cylinder). The transducer endcap is on the right; attached to it is the electronics card cage. Later versions of TAPS differ in the arrangement and mounting of the electronics cards.

Inside the case, TAPS consists of two assemblies (see Fig. 3). An electronics frame is attached to the transducer endcap. This frame contains the CPU card, a power control card, a receiver card, and three dual-transmitter cards.

The CPU card contains a small micro-computer that controls the functioning of TAPS; a 14-bit analog-to-digital converter (ADC) to digitize the acoustic channel outputs, depth, and battery voltage; a 14-bit-plus-sign ADC to digitize the thermistor output; serial interface (RS-232); and non-volatile memory for data storage.

The power control card contains switches to permit CPU control of power to the transceivers and to any external sensors. Signal conditioning for the depth sensor is performed on this card. This card also contains the charge regulator for the internal battery. Diodes are used to select between the internal battery and external power—the source with higher voltage is used to power TAPS, thus external battery packs as well as shore power may be used when desired.

External sensors may be connected to TAPS. Provision for conditioning the signals from these sensors is made on the power control card. Signals from sensors with frequency outputs are buffered and applied to frequency-counting circuitry on the CPU card. Signals from voltage-output sensors are buffered and applied to the main ADC. See the **EXTERNAL SENSORS** section for more information on setting up this card for particular sensors.

Attached to the connector endcap is the battery housing, containing a 21.6V NiCad battery. This assembly is connected to the electronics with a high-reliability military connector and a wiring harness. This harness is sufficiently long to permit removal of the connector endcap and battery housing, disconnection of the connector, and then removal of the transducer endcap and electronics cage.

CHARGER UNIT

The TAPS internal battery may be charged using the CHARGER/IO box provided (see Fig. 4). This unit connects to the TAPS with an 8m cable useful for testing and/or charging TAPS on a workbench.

This unit contains a current-limited power supply that is capable of both charging the TAPS internal battery and providing sufficient power to run TAPS through a long (up to 600m) cable for extended duration data collection. The charge voltage may be monitored on the two jacks on the front panel.

A serial port (DB-9) is provided on the front panel of the charger to permit reprogramming TAPS or dumping data while TAPS is connected to the Charger. A standard null-modem cable (DB-9 female to DB-9 female) is used to interconnect a PC with the TAPS. Again, the 2-pin shorting plug <u>must</u> be installed to turn on the CPU inside TAPS if communications are desired. This plug is not required for charging the battery, however.

Another short cable is provided with TAPS. This cable has an 8-pin under-water connector on one end and a DB-9 serial connector on the other. This cable can be used to connect a laptop computer to TAPS when it is inconvenient to use the cable supplied with the CHARGER/IO unit. Simply plug this cable into TAPS and into a laptop running any popular terminal program. The termimal program should be set for 19200 baud, 8 data bits, 1 stop bit, and no parity (19200-N-8-1). The shorting plug must be installed to supply power to the TAPS CPU.

Figure 4. TAPS charger/IO unit. A TAPS interconnect cable is attached. A DB-9 connector (lower left on front panel) is supplied for connection to the serial port of a host computer. Charging voltage may be measured on the front panel test jacks. AC power and charge state are indicated on the panel lights.

USING THIS MANUAL

This manual has been broken into sections that seem (to the designers, anyway) logical. This section contains the introductory material to introduce TAPS to a new user. Additional information on the acoustical bases for the measurements may be found in Appendix 2. Data analysis, including inversion of the acoustical data to estimate size-abundance of scatterers, is covered in Appendix 3.

CAST mode operations are covered in a separate section. This discussion covers the basic operation of TAPS in CAST mode, the role of the user-specified operating parameters, how to retrieve data after casts, and how to erase memory to make room for more data. Charging the battery is covered in this section. The related **RAW CAST** and **INSTRUMENT** modes are covered in this section also.

SOUNDER mode operation is also given a separate section, although much of the material in the CAST mode section will be assumed therein.

The **PROGRAMMING** section describes how the user can change between operating modes. Each operating mode is a separate program contained on the compact-flash memory card and must be loaded into non-volatile RAM to change the mode. Once loaded, this mode will operate each time TAPS is powered-up.

A variety of external sensors may be connected to TAPS. Information on installing external sensors and configuring the interface is presented in the **EXTERNAL SENSORS** section.

The **MAINTENANCE AND TESTING** section contains hints on troubleshooting TAPS and suggested actions are covered. Disassembly and reassembly of TAPS is described; e.g., for installation of the instrument interface card. Reference is made to schematics and wiring diagrams provided in Appendix 4 and parts lists provided in Appendix 5.

A separate section, **Appendix 1: CALIBRATIONS**, is provided for calibration data. It is suggested that TAPS be calibrated on a regular basis and that a calibration history be retained by the user (as is done at the factory). This section is a useful place to keep calibration data on the instrument interface also; as a user-configured part, any factory setup can become obsolete in short order.

Appendix 2: Basic Acoustics is included to provide a simple introduction to the physics of underwater sound as used in TAPS. References to source material are provided.

Matlab® m-files that may be useful in displaying and analyzing TAPS data are described in **Appendix 3: Data Analysis**. The basis for inversion of TAPS data to estimate size-abundance of zooplankton is presented along with tips on choosing certain parameters of the inversion.

Schematics and wiring diagrams, together with some theory of operation descriptions, are provided in **Appendix 4: Schematics**. This section is intended to complement the Troubleshooting suggestions in the **MAINTENANCE AND TESTING** section.

At any given time, certain sections of this manual may be missing or incomplete. Updates, consisting of one or more complete sections and, possibly, a revised index, will be sent at irregular intervals to registered TAPS owners. PDF versions of this manual are contained on the data CD supplied with TAPS.