A map of the Georgia coast and estuary system, showing the coastline and major waterways. The map is overlaid with a grid of latitude and longitude lines. The latitude lines are labeled 31 and 32, and the longitude lines are labeled 81. The map is oriented with North at the top.

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A CTD SYSTEM:
DESCRIPTION, OPERATION,
DATA ACQUISITION AND PROCESSING

by
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INTRODUCTION

The level of sophistication of today's marine research dictates the need for a rapid, reliable and accurate system for acquiring and processing temperature and salinity data.

In order to meet these needs, we at the Skidaway Institute of Oceanography have acquired a conductivity/temperature/depth (CTD) system. With principal support from the U. S. Department of Energy, we have developed the software and made numerous modifications to the hardware of the system, facilitating the principal task of investigating and explaining the chemical and physical processes in the South Atlantic Bight.

The purpose of this report is to describe our CTD system, document the developments and improvements we have made thus far, and relate our practical experience. It is hoped this report will be useful to oceanographers who now have, or will in the future have, a CTD system. The system is in a continual state of upgrading and modification, so this report represents the state of our system as of May 1978. Recent additions to the system are an HP Flexible Disk Unit (0.5 megabyte) and an HP-BCD Interface Bus. The XBT has also been interfaced to the HP 9825A.

DESCRIPTION OF THE SYSTEM

The CTD system, shown schematically in Figure 1, has four major components: 1) the underwater unit, consisting of the depth, conductivity, and temperature sensors, and a mixer that powers the sensors and multiplexes the signals; 2) the winch, conductor wire, and Rosette Multi-Bottle Array fitted with a variety of Niskin sampling bottles; 3) the deck unit that powers the rosette and the CTD sensors and filters and digitizes the multiplexed CTD signal; and 4) the data processing system. The data processing system is actually two separate systems, one which records the raw data digitally on magnetic tape and another that performs real-time data processing and stores and displays the data in a variety of ways (i.e., Hewlett-Packard (HP) tape cartridge, calculator plotter, printer and analog plotter). All components of the CTD system are listed in Table 1. In the following discussion, the hardware components, the shipboard operating procedure, and the software of the system will be described, some in more detail than others. Troubleshooting problems, causes, and repairs for those problems that we have encountered are listed in Appendix I.

The CTD Sensor System

The CTD unit consists of the three sensors powered by a 120 ma constant current supply in the mixer. The sensors output AC signals of frequencies that are proportional to the parameters being sensed (Table 2). The AC signals from these sensors are multiplexed by the mixer and transmitted through a single conductor to the deck unit. Thus, only one conductor is required by the CTD for input power and an output multiplexed signal. To

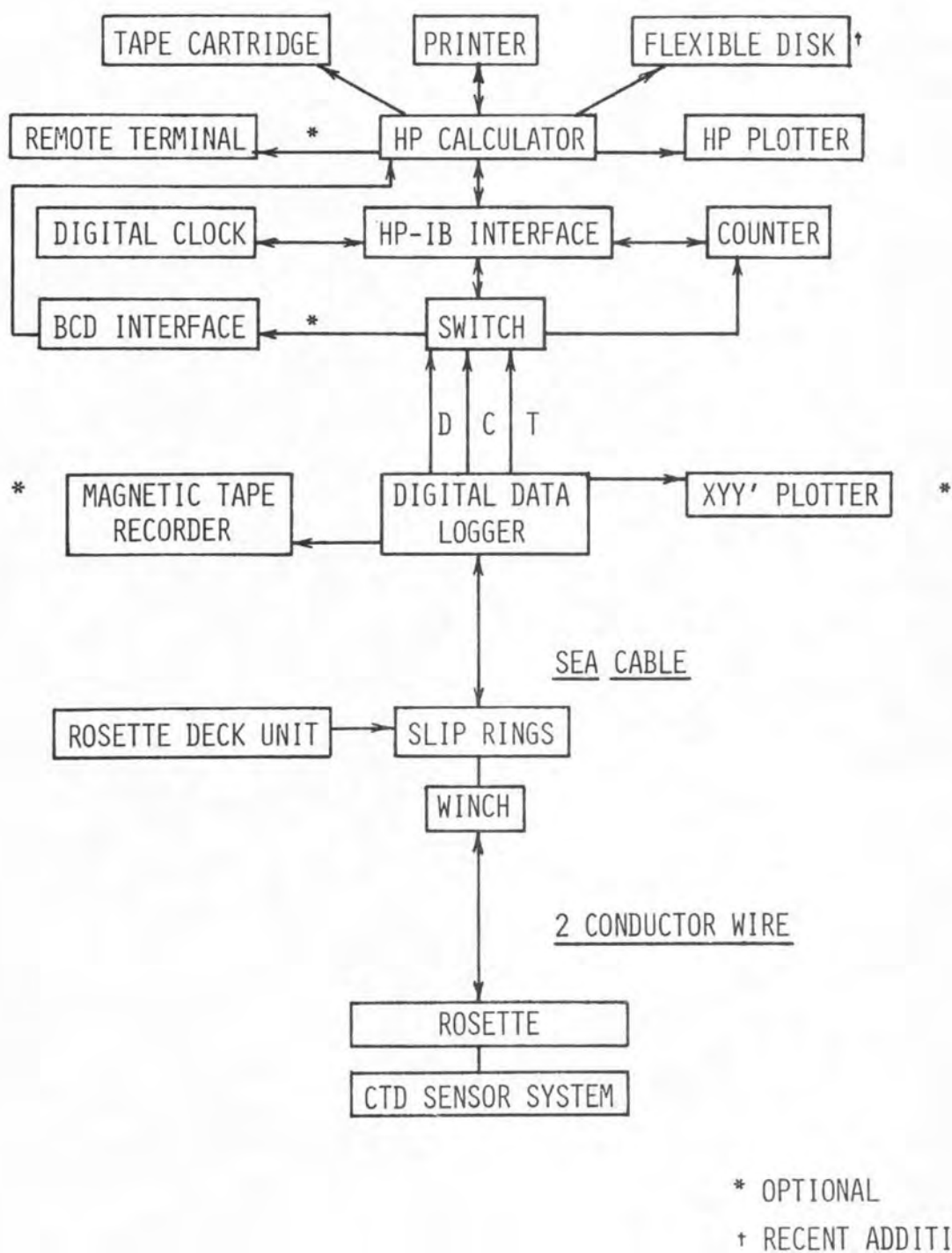


Figure 1. Schematic of CTD System.

Table 1. Component List of the CTD System.

Plessey Model 9400 System
Plessey Model 6500 Conductivity Sensor
Plessey Model 4500 Temperature Sensor
Plessey Model 4600 Pressure Sensor
Plessey Model 4400 Mixer
General Oceanics Rosette Multi-Bottle Array Model 1015 Mark V
Plessey Model 7400 Winch
Plessey Model 8400 Digital Data Logger
HP 7046A X-Y Recorder
Kennedy Model 1600 Incremental Magnetic Tape Recorder
HP 59307A VHF Switch
HP 98034A HP-IB Interface
HP 5328A Universal Counter
HP 59309A HP-IB Digital Clock
HP 9825A Calculator
HP 9862A Calculator Plotter
Texas Instruments Silent 700 ASR Electronic Data Terminal

guard against applying reverse voltage to the CTD sensors, a reverse biased diode is installed on the input power line to the mixer. Our system is dismantled and reassembled frequently and such protection is good insurance against damaging the sensors.

Table 2. Parameters Measured and Sensor Ranges.

Parameter	Frequency Range	Sensor Range
Temperature	2127-4193 hz	-2-35 ⁰ C
Conductivity	4995-7901 hz	0-60 mmhos/cm
Depth	9712-11288 hz	0-600 m

The pressure vessels housing the sensors protect the sensors to 600 meters; however, flooding of the vessels, even at shallow depths, has been a problem. According to Plessey, Inc., replacing the plastic endcaps with stainless steel endcaps has solved the flooding problem. When our system is not functioning properly and flooding is suspected, the sensors are disassembled and dried out. Pins in the connectors are also examined and dried out when wet. Care should be exercised when handling the O-ring seals for the connectors. Silicone grease is used to seal the connections. It should be used sparingly to avoid insulating the electrical connecting pins.

We have spare C, T, and D sensors, connectors, Scotchcast electrical splicing kits, and wire harnesses so that any malfunctioning part can be replaced on board, allowing sampling to proceed after repairs are made.

The Winch and Rosette Multi-Bottle Array

The winch should be equipped with at least two conductor oceanographic electromechanical cables and the appropriate slip rings. One conductor is for the CTD and the other for the rosette. The winch should be capable of lowering and raising at rates of 15 m/min or less. This low winch speed is necessary so that enough data points are collected to average over one meter increments, especially in strong thermoclines such as those encountered in the South Atlantic Bight.

Most oceanographic ships are equipped with conductor winches. However, the wire and/or slip rings are often in disrepair and should be checked out beforehand. We bring a portable winch for backup. Our portable winch (Plessey Model 7400) has 250 m of 4-conductor wire and runs on 110 Volts AC power at a constant speed of 15 m/min. It handles a maximum load of 200 pounds, which is of minimum acceptable capability. Changes have been made to improve the operation of the winch. The operating switch installed by Plessey, Inc. burned out after very little use, so a heavy duty switching

relay was installed. The new switch also increases safety since a spring returns it to the off position upon release; therefore, the operator cannot leave the switch unattended while the CTD is being raised or lowered. Solid state relays will be installed soon in order to minimize the electrical noise that spikes the data signals. An occasional overhaul and repainting of the winch housing is necessary due to corrosion from salt spray. It should also be disassembled, cleaned, and lubricated regularly.

The Rosette Multi-Bottle Array is manufactured by General Oceanics, Inc. as are the Niskin bottles mounted on it. The rosette is mounted on a frame which encloses the CTD sensor system (Figure 2). Reference to the "Fish" includes the sensors and rosette as one unit. The sensors are located beneath the rosette so that they are not in the wake of the rosette as the Fish is lowered through the water column. Conversely, during the upcast the sensors are in the wake of the rosette, degrading the data. During the upcast, the Niskin bottles are triggered serially on command from the deck unit at desired depths.

Plessey, Inc. had designed the system so that the sea cable from the winch's single slip ring entered the rosette deck unit, then continued on to the digital data logger (DDL). The wire harness connected to the winch wire went through the rosette, then to the sensors. With only one path as such, powering the rosette with the high voltage required to trip a bottle interrupted the connection to the sensors.

We have modified the system and now use multi-conductor wire, allowing separate rosette and sensor operation. A branching cable connects the slip ring wires to the rosette deck unit and the DDL. An underwater harness branches from the winch wire connector to the rosette and to the CTD sensors.

The rosette requires continual maintenance to perform reliably. After every cast the cam/trip mechanism should be washed with fresh water and sprayed with a penetrating lubricant such as CRC. Recommended spare parts are appropriate relays for the winch, rosette, and rosette deck unit and SCR for the rosette deck unit.

A Helle pinger is mounted on the frame of the Fish to aid in recovery if the Fish becomes severed from the conductor wire. A buoy, chain, and anchor are also kept ready to use to mark a lost instrument.

The Deck Unit and Data Processing System

The Plessey Model 8400 Digital Data Logger (DDL) provides power to the CTD sensors, receives and demultiplexes the CTD signal, and determines the frequencies for depth, conductivity, and temperature for output to recording devices.

Several modifications were made to the DDL that make control of the system more convenient. An on-off switch for power to the Fish, as well as voltage and current meters, were installed in the front panel of the DDL that readily indicate the power status of the Fish. Thus, an opened, closed, or shorted circuit in the system can easily be detected. One input

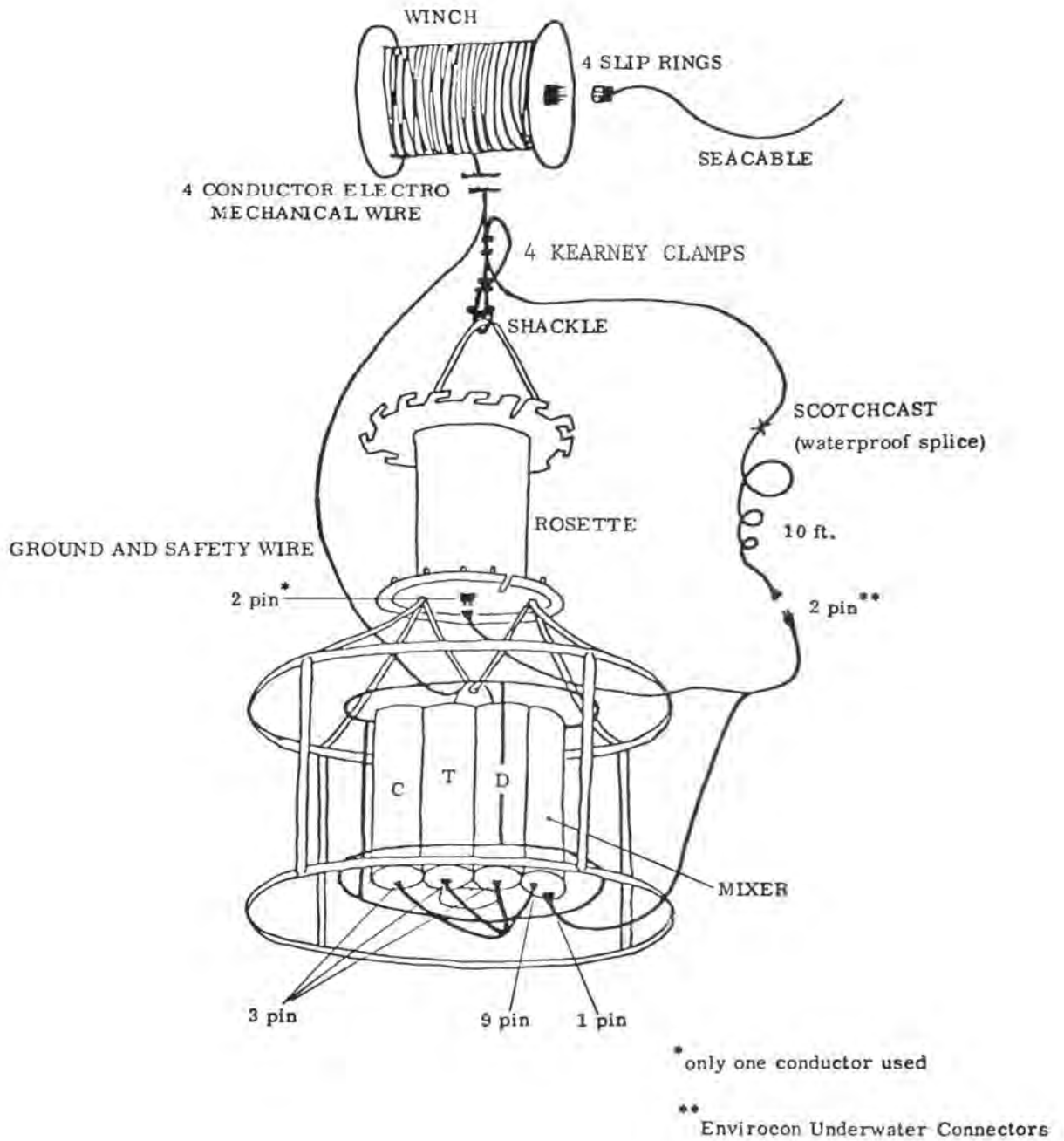


Figure 2. Underwater Assembly.

and two outputs may be connected to one of the three channels, and a switch and porter LEDs for selecting a channel also were installed in the front panel of the DDL. The two outputs allow an oscilloscope and frequency counter to monitor any one channel at a time. A signal generator can be attached to the input. When using a winch with a short wire, a capacitor is put on the DDL input line to attenuate the signal, simulating a longer wire, and thus preventing interference of one channel with another. Another modification was the replacement of the 741 operational amplifier in the DDL with a higher grade ultra-linear operational amplifier.

Spare parts for the DDL include spare counting and digitizing boards. D, C, or T counting and digitizing boards are essentially interchangeable. The plastic integrated circuits (ICs) that Plessey, Inc. used on our unit are less reliable than ceramic ICs and do not stand up to the humid, salt-air environment. Consequently, our boards have been sprayed with a sealer to reduce failure. The newer Plessey, Inc. units, however, are equipped with ceramic ICs.

The digital signal output from the DDL is recorded on a Kennedy Model 1600 Incremental Magnetic Tape Recorder. The digital-to-analog converter in the DDL outputs an analog voltage proportional to the input range which drives an HP-'YYY' Recorder (Model 7046A). The DDL folds the signals proportional to 0 to 10 Volts full scale (Table 3). We have found that ship-board generators are not stable, therefore, a line conditioner is required. The greatest problem caused by a power failure is that the magnetic tape must be started up again and the lack of continuity will cause tape reading errors when it is played back.

Table 3. Analog Characteristics.

	D	C	T
Full Scale	0-600	0-80 mmhos/cm	-5-35 ⁰ C
Ranges	4	8	8
Folded Range Scale	0.06666 v/m	1 v/mmhos/cm	2 v/ ⁰ C
Scale on Paper	0.25 cm/m	2.5 cm/mmhos/cm	5.0 cm/ ⁰ C
Finest Line Reading	0.4 m	0.2 mmhos/cm	0.02 ⁰ C

After this CTD system was in use for one year, an HP 9825A Calculator and peripherals were added which decreased the time and cost of data acquisition. The HP recording devices are the 9862A Plotter and the tape cartridge and printer in the 9825A Calculator.

CTD Assembly

Loading and assembling the components of the CTD system aboard various ships can become routine, as it has for us. The deck unit must be situated in a dry, preferably air-conditioned lab. Most of the HP components are rack-mounted, and the racks are bolted to lab tables. Everything that is not in a rack is secured with rope or tape.

A full complement of tools and spare electronic parts is necessary (see Appendix II for a complete list). If the ship does not have adequate communications between the lab, deck, and bridge, a portable intercom system is placed so that the deck unit operator can talk with the winch operator. The CTD sea cable must reach the deck, where it is affixed to the slip rings on the winch. Enough conductor wire is unspooled from the winch to reach the Fish after it is put through a block or metering wheel on an A-frame or boom that can be extended away from the ship. A splice must be made to join the Envirocon underwater connector that mates the two pin connectors on the wire harness of the Fish to the conductor wire used on most ships' winches. Using Scotchcast over the spliced wire is a convenient method of waterproofing underwater connections. Scotchcast is mechanically and electrically sound because of its rigidity, unlike underwater tape that can bend and break. Our small winch is equipped with the connector that joins the conductor wire and Fish.

Niskin bottles appropriate for the anticipated sampling are mounted on the rosette. Invariably, a rack to hold three reversing thermometers (two of the protected type and one unprotected) is put on the bottle that will be tripped at the deepest sampling depth. Expendable Bathythermograph (XBT) pins (one ground to a point and another to a flat blade) are convenient tools to cock the bottles on the rosette and to rotate the cam/trip mechanism. While not in use, the Fish should be secured in a shaded place to protect the rosette's rubber pressure-compensating diaphragm and reversing thermometers.

Early CTD tests indicated that the pendulum motion of the Fish while in the air between the deck and the water should be dampened by weight suspended from a rope harness beneath the Fish. In practice, the pendulum motion ceases as the weight enters the water. In calm-to-moderate seas, a 10-pound weight is used. In heavy seas more weight is added in accordance with the capacity of the winch. Our winch can support 30 pounds in addition to the weight of the Fish.

OPERATING PROCEDURE

To utilize ship time to the fullest, the CTD should be ready for a cast before arriving on station. The sensors are powered up for a short time on deck, and the frequencies for D and C are recorded to use as offsets from the manufacturer's zero D and C frequencies during the ensuing cast. In order to prevent accidents, power to the Fish is on only during a cast. The rest of the deck unit has power to it throughout the cruise to insure electronic stability.

The HP plotter is programmed for 5 to 30°C and 0 to 400 meters full scale and the 'YYY' recorder plots conductivity and temperature-versus-depth proportional to the analog voltage output by the DDL (Table 3). The 'YYY' recorder must be calibrated often with a precision 10 Volt source to check the 0 to 10 Volts full scale. Both plotters are made ready before arriving on station.

Operating the CTD recording devices requires a complex system of button-pushing. Explicit instructions are displayed on the front of the deck unit (Table 4). Any deviation from this procedure produces a non-standardized tape recording, making processing costly and time consuming. The standard tape recording for the Kennedy should have an identification (header) for each station cast followed by a file gap (blank mark of a specific length) and the cast data followed by a file gap. Missing or extra file gaps must be reported so that tape errors can be found and corrected.

A minimum of two people can operate the CTD. One person on deck runs the winch and guides the Fish into the water while the second person in the lab operates the data acquisition system and fills in the station sheets (Figure 3). Prior to lowering the Fish, the depth at a station should be determined by a depth sounding device, either on the bridge or in the lab. The data acquisition operator instructs the winch operator when to put the Fish in the water and when to lower and raise it. At the beginning of a cast, all of the data-recording devices should be simultaneously set into action. During the downcast, the HP Calculator is programmed to display depth so that the data acquisition operator can tell the winch operator when to stop lowering the Fish. Then the plotter pens are raised, and the programming is switched to a soak routine. After four minutes (to allow the reversing thermometers to equilibrate), the bottom sample bottles are tripped from the rosette deck unit. During the upcast, new plotter paper is used or the pens are raised to trace over the downcast plot. The vertical temperature plot is used to decide where to stop and trip bottles on the upcast (Table 5). While the Fish is stopped at the predetermined sampling depths, the rate of data acquisition is slowed down by using a mid-depth soak program.

After the surface sample bottles are tripped, power to the Fish is turned off, and the Fish is brought on deck and secured. The rest of the CTD operation may be carried out while the ship is steaming towards the next station. Dissolved oxygen, nutrient, salinity and other samples are drawn from the Niskin bottles into appropriate collecting bottles, treated, and stored as needed. The data acquisition operator records the bottle numbers for the samples taken on the station sheets. The reversing thermometers are read, and temperatures are recorded on the station sheets for calibration of the CTD temperature sensor. After the samples are taken, the rosette cam/trip mechanism should be rinsed with fresh water and sprayed with a marine lubricant. Then the cam must be reset and the Niskin bottles cocked in preparation for the next cast. The station sheets and plots are filed, and all data acquisition devices are made ready for the next station.

Examples of other forms we use are in Appendix VI.

Table 4. CTD Operating Procedure.

-
-
1. Determine the depth of the water column.
 2. Turn Rosette ON (Small button under "8400 DIGITAL").
 3. Set heading data. (10(00)) for upcasts; 00(00) for downcasts).
 - *4. Push "ENTER" five times; push "FILE GAP" once.
 5. Set up HP programming (trkl, ldf0, RUN). Try to time the readiness of the HP to receive data so that steps 6 and 7 can immediately be completed.
 6. When ready to begin cast push "START" on recording control (tape should begin moving in short increments). Turn on recorder "SERVO" and put pen on "RECORD".
 7. Lower CTD (stop 2-3 meters from the bottom).
 8. Change to scan 10 at bottom of cast. LIFT PEN.
 9. Follow the 4 minute soak instructions on the HP.
 10. Push "STOP" after soak. Change back to scan 0.
 11. Push "FILE GAP" once.
 12. Follow steps 3-6 for upcast.
 13. Raise CTD to desired depths and "FIRE" Niskin bottles. (Change to scan 1 while firing bottles).
 14. Turn Rosette off (small button under "8400 DIGITAL").
 15. For the next cast, repeat procedure with step 1.
 16. When tape is completed change header to 9999 and push "ENTER" five times, then push "FILE GAP" three times, rewind and remove tape.

*IF "FILE GAP" IS PUSHED TWICE IN A ROW OR NEGLECTED AT ANY TIME, PLEASE NOTE THIS ON THE RESPECTIVE STATION SHEET. DO NOT "ENTER" A HEADER AND "FILE GAP" MORE THAN ONCE. JUST NOTE THE ERRONEOUS HEADER NUMBER.

STATION SHEET

CRUISE _____

GRID STATION _____

CONSECUTIVE STATION _____

LOCAL TIME IN _____ DAY _____ MONTH _____ YEAR _____ DEPTH _____ WIRE ANGLE _____

MAGNETIC TAPE NO. _____ KEYWORD _____ HEADER (d) _____ SCAN RATE (d) _____
 (u) _____ (u) _____

SURFACE FREQ:	DEPTH _____	COND. _____	TEMP. _____
BOTTOM FREQ:	DEPTH _____	COND. _____	TEMP. _____
MID DEPTH FREQ:	DEPTH _____	COND. _____	TEMP. _____
MID DEPTH FREQ:	DEPTH _____	COND. _____	TEMP. _____
MID DEPTH FREQ:	DEPTH _____	COND. _____	TEMP. _____
SURFACE FREQ:	DEPTH _____	COND. _____	TEMP. _____

MIXER
 407 411
 COND
 615 660
 TEMP
 720 737
 DEPTH
 817 837

THERMOSAL TEMP. _____
SURF. BUCKET TEMP. _____
TIME OUT _____

CTD SENSORS				SAMPLE BOTTLES				REVERSING THERMOMETER						
Depth	Depth	Meter	Niskin	O ₂	S ^o /oo	Nut	Misc.	#	Main	Aux	V ₀	I	G _f	T _w
Freq.		Wheel	Bottle											

Reversing Thermometer
 Correction Calculation:

$$T_w = T_{obs} + C + I$$

V₀, I and G_f are obtained from
 specifications for thermometers

$$C = \frac{(T_{obs} + V_0) (T_{obs} - T_{aux})}{1/G_f - 100}$$

*Depth Freq. on deck _____
*Cond. Freq. in air _____
O.K. for T calib. (B) _____
O.K. for S calib. (B) _____ (M) _____ (S)

Figure 3. Station sheet.

Table 5. Suggested Sampling Depths.

Depth less than 50 m:

Mixed - Surface and bottom
 Two-Layer - Surface, above or below the
 thermocline and bottom

Depth greater than 50 m and less than 100 m:

0, 25, 50, 75, 100 (or bottom)

Depth greater than 100 m:

0, 50, 100, 150, 200, 300, 400 (or bottom)

Cyber Processing

After a cruise, the magnetic tape is sent to the University of Georgia Computer Center and stored in their tape library. The tape is then processed at Skidaway where there is access to interactive time-sharing of the University's Control Data Corporation Cyber 70 through a telephone link.

During the shipboard CTD operations, binary coded frequencies are recorded on 7-track magnetic tapes by the Kennedy recorder. The processing of tape data has been adapted from that described by Scarlet (1975). Table 6 shows the basic data flow, though program modifications are necessary for the special situations that arise for each new data set. The programs are listed in Appendix III. The final programming step, NUTMERG, merges additional station data, i.e., nutrients, weather, latitude, longitude, etc., to the CTD data for submission to the NODC. This final product is stored on magnetic tape in our computer system and all data, i.e., CTD, XBT, chemical, etc., are available from the NODC.

Another program, CEMLIST, calculates specific volume anomaly, oxygen saturation and apparent oxygen utilization (from the International Oceanographic Tables, 1966), and the distance between successive stations from the NODC formatted data. CEMLIST reformats the NODC data for presentation in a technical report.

Temperature Lag. The Plessey temperature sensor time constant is reported to be 0.35 seconds. The depth and conductivity sensors each have a reported 0.1 second time constant, so that temperature lags behind depth and conductivity. Therefore, the "real" T at the time that D and C are sampled must be calculated from the "indicated" T. From Scarlet, 1975:

Table 6. Cyber CTD Data Flow: Shipboard Acquisition to NODC Submission.

Data Source/Disposition	Program	Data File	
Digital Data Logger to Tape	CTDRUN (Copies tape data to a computer file)	KEYWORD	
	MAGREAD (Converts binary coded data to decimal)	BIRANG	
	CTDUNIT (Converts decimal units to engineering units)	LAG	
	LAGFILT (Temperature lag and course filter)	CAL	
	Primary Calibration from Bottle Casts	BROENK (Calculates salinity and sigma-t)	LATCH
		DLATCH (Removes decreasing and repeated depths)	CTDATA
		CTDAVE (One meter averaged data)	AVE
		NODCFO (Converts to NODC format)	NODC + HEAD
		NUTMERG (Merges NODC data with headers and chemical data)	
		Submission to NODC	
CEMLIST (Calculates specific volume anomaly, oxygen utilization, etc.)	TECHNICAL REPORT		

$$T_{R(n)} = T_{I(n)} + \frac{\tau (T_{I(n+1)} - T_{I(n-1)})}{2 \sigma}$$

where: T_R = real T

T_I = indicated T

τ = sensor time constant

σ = sampling rate

$n = 1, 2, 3, \dots$ (each CTD scan)

The sensor with the slowest time constant determines the fastest rate at which a CTD scan can be updated by the digital-to-analog converter in the DDL. The T time constant of 0.229235 seconds governs the fastest rate for this system. Setting the scan interval to 00 provides the fastest rate. The scan interval can be set as high as 99, with each of the 100 increments slowing the sampling rate down by multiples of 0.229235 seconds. The temperature lag of this system can be calculated from:

$$T_{R(n)} = T_{I(n)} + \frac{0.35 (T_{I(n+1)} - T_{I(n-1)})}{(2)(0.229235)(\text{Scan} + 1)}$$

Offsets and Course Filter. Depth and temperature offsets (Table 7), determined by the on-deck frequencies for depth and temperature, are applied in program CTDUNIT. The offsets correct for the deviation of the zero depth and temperature frequency readings from the frequencies preset by the manufacturer. Our temperature sensor has shown no signs of drift or offset with age when compared with protected reversing thermometer readings, so no offset has been applied. In addition, no offset is determined for conductivity though it, like depth, has been observed to drift slightly with age. This drift is compensated for in BROENK by a salinity offset from a comparison of bottle salinity with CTD salinity. This salinity offset may be depth dependent due to the effect of pressure on the conductivity sensor. A simple test for this is a linear regression analysis of bottle salinity less CTD salinity versus depth. When sampling at depths less than 50 meters or when no pressure effect is apparent, the mean offset from bottle salinities less CTD salinities for all stations is most appropriate.

LAGFILT course filters electronic, slip ring, and winch noise. The windows for the filter are ± 5 m, ± 0.8 mmhos/cm and $\pm 0.5^\circ\text{C}$.

Depth Latch and Averaging. The normal descent rate of 0.25 meters/second and scan rate of 0.229 seconds should provide 17 scans/meter. The number of scans/meter varies because the motion of the Fish reflects ship roll. Repeated depths are removed by the DLATCH program. The average number of scans (remaining) through a 1 meter interval is 10 ± 7 . Scans of data 0.5 meters above and below each 1 meter are averaged for depths less than 100 meters and data 2.5 meters above and below each 5 meters are averaged for depths greater than 100 meters.

Table 7. CTD Offsets.

Cruise	D(m)	T(°C) S/N 720	S(%) (Bottle-CTD) or equation	Sal. Eq. (from)	Data Source	Deepest Calib. depth
OBIS V (July-Aug. 1976):						
Hydro 1	None	None	+ .138 ± .030	Knowles	XYX	55m
			+ .333 ± .023	Knowles	XYX	55m
Bio 1	None	None	+ .099 ± .008	Knowles	XYX	55m
Hydro/Bio 2	None	None	+ .090 ± .017	Knowles	XYX	55m
Aborted Hydro 3	None	None	+ .101 ± .022	Knowles	Mag tape	55m
Bio 3	None	None	+ .073 ± .025	Knowles	Mag tape	55m
Hydro 4	None	None	+ .064 ± .021	Knowles	Mag tape	55m
Bio 4	None	None	+ .019 ± .008	Knowles	Mag tape	55m
Hydro 5	None	None	+ .068 ± .009	Knowles	Mag tape	55m
CI 12 (December, 1976)	None	None	$S = S_0 + 0.023 - 1.57 \times 10^{-4}D$	Broenkow	Mag tape	438m
AD 477 (April, 1977)	+1.714	None	$S = S_0 + .007 - 4.97 \times 10^{-4}D$	Bennett	Mag tape	192m
BF 38 (May, 1977)	+2.29	None	+ .06 ± .015	Broenkow	HP	74m
CI 03 (July, 1977)	+2.29	None	$S = S_0 + .101 - 3.05 \times 10^{-4}D$	Broenkow	Mag tape	204m
BF 57 (September, 1977)	+2.29	None	$S = S_0 + .118 - 5.19 \times 10^{-4}D$	Broenkow	Mag tape	196m
CI 07 (November, 1977)	+3.24	None	Not determined*	Broenkow	XYX	
BF 07 (February, 1978)		None	- .003 ± .004	Broenkow	HP	209m
PIERCE (March, 1978)	+4.57 (-1.14)**	None	+ .042 ± .013	Broenkow	HP	398m
CI 01 (April, 1978)		None	+ .125 ± .013	Broenkow	HP	253m
BF 21 (May, 1978)		None	+ .136 ± .011	Broenkow	HP(& XYX)	15m

*Change C sensor (S/N 615 replaced with S/N 660); **change D sensor (S/N 817 replaced with S/N 837)

Salinity. Salinity is calculated from CTD scans using shortened equations adapted from those of Bradshaw and Schleicher (1965) and Cox et al. (1967) by Broenkow (1977) (Table 8). To determine the effects of pressure and temperature on the conductivity sensor, uncorrected and then corrected salinity calculations are required according to the steps in Table 9.

CTD Calibration. The CTD system is calibrated against water samples from rosette bottles tripped in mixed layers to insure that the sensors and the bottles are both sampling the same water. When a mixed layer is not observed, a comparison cannot be made at that station. Consequently, an offset equation is derived from the available data and applied to the entire cruise (Table 7). A Plessey Model 6230N Lab Salinometer is used to determine the salinity of water samples from the rosette bottles.

The Onslow Bay 1976 project was an exception. Each leg of the project had its own offset. At times, more than one offset was necessary during a single leg because of repairs to the CTD system. Many problems were encountered during this initial break-in period. Modifications to the system, as described on pages 1-7 of this report, overcame many of the problems.

Upcasts. Our original Plessey CTD system was set up using a one-conductor wire that would carry the multiplexed C, T, and D and rosette bottle tripper signals. Sending the signal to trip a bottle interrupted the data reception from the CTD (actually sending spiked signals). For this reason, only downcast data was recorded on tape, and bottles were tripped on the upcasts.

The system has since been modified. Two wires and the shield (used for a ground wire) of a four-conductor wire are used, separating the CTD and rosette signals. Upcast data is recorded, unaffected by bottle tripping. However, the sensors lie in the wake of the rosette during upcasts and this causes turbulent disturbance of the water being sampled; therefore, the data reported to NODC and in technical reports are the downcasts only, except where downcast data is lost or incomplete.

CTD Error Analysis. The Plessey Model 9400 CTD system has the following rated accuracy, resolution, and time constants (Table 10). Since salinity is not measured directly, it has to be calculated from the parameters indicated in Table 10, resulting in the composite errors of the C, T, and D sensors and the salinity equation.

Table 8. Broenkow's Salinity Equations.

$$R_z = 1 + .01((1.551 - .0453T + 59 \times 10^{-5}T^2) + \frac{1}{4}(35-S)(.043 - .0017T + 23 \times 10^{-6}T^2))\{1.037 \times 10^{-3}Z - 32 \times 10^{-9}Z^2\}$$

$$A_T = (676547 + 20131.5T + 99.89T^2 - .1943T^3 - .00672T^4) 10^{-6}$$

$$R_T = \frac{C(S,T,Z)}{R_z A_T 42.896}$$

$$\Delta_{15} = R_T(R_T-1)(T-15)\{96.7 - 72R_T + 37.3R_T^2 - (.63 + .21R_T^2)(T-15)\}10^{-5}$$

$$R_{15} = R_T + \Delta_{15}$$

$$S^0/00 = .08996 + 28.2972R_{15} + 12.80832R_{15}^2 - 10.67869R_{15}^3 + 5.98624R_{15}^4 - 1.32311R_{15}^5$$

where: R = conductivity ratio

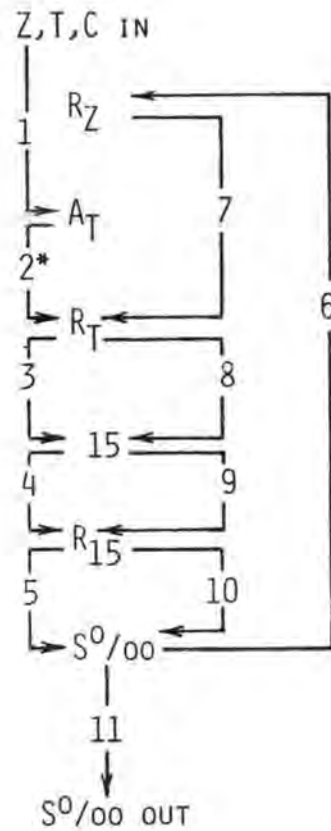
Z = depth (meters)

T = temperature ($^{\circ}$ C)

C = measured conductivity (mmhos/cm)

S = salinity ($^{\circ}$ /00)

Table 9. Flow Using Broenkow's Salinity Equations.



*without the R_Z term

R_Z = pressure effect on conductivity

A_T = temperature effect

R_T = $R(S, t, p)$ conductivity ratio

Δ_{15} = t_{15} correction (International Oceanographic Tables, 1966)

R_{15} = $R(S, 15^{\circ}\text{C}, 0)$

Table 10. Specifications for Plessey Model 9400 CTD System.

	Conductivity	Temperature	Depth
Accuracy	± 0.03 mmho/cm	$\pm 0.02^{\circ}\text{C}$	± 1.5 m
Resolution	0.0002 mmho/cm	0.0001 $^{\circ}\text{C}$	0.0012 m
Time Constant	0.1 sec	0.35 sec	0.1 sec

We have progressively used several different compact sets of salinity equations in the HP calculator, going from Knowles (1973) to Bennett (1976) to Broenkow (1977). The Knowles equation does not consider the influence of depth on the calculation of salinity and, therefore, is not recommended. Both Bennett and Broenkow include depth dependence. The Bennett equations apparently have received considerable acceptance and use (Lewis and Perkin, 1978). We have gravitated further, now using the equations of Broenkow (1977). These equations give a better fit to Jaeger's (1973) table of salinities calculated from experimental conductivities, temperatures, and depths than Bennett for the temperature, depth, and salinity ranges we experience in our work (Table 11). This in turn gives a better real time look at the salinity structure before introducing the salinity calibration data.

By varying "real" C, T, and D by the rated sensor accuracies in the salinity equation, the maximum error attributable to each sensor can be determined. Those stations with deep casts that have a low conductivity and temperature have been found to cause the maximum error, therefore, those "real" data are used to determine each parameters' effect on the salinity equation. The composite maximum error has been approximately ± 0.06 ‰ for the "real" data sets. However, the standard deviation of all mixed layer samples taken for salinity calibration purposes implies greater accuracy, namely ± 0.03 ‰ after offset. We believe this value is a more realistic measure of the quality of the data set, except in strong thermoclines ($\Delta T > 1^{\circ}\text{C}/\text{m}$).

Hewlett-Packard System

The previously described digital magnetic tape recording has many advantages. However, there are several serious disadvantages. The principal weaknesses are the lack of onboard confirmation of data acquisition, no real time presentation of data, and costly computer analysis. In an effort to avoid these disadvantages and provide a more redundant system, we have assembled a data acquisition system based on a Hewlett-Packard 9825A calculator.

Presently, our HP-CTD data acquisition system is in the final developmental stages. The remaining problems are principally with software. Our intentions are to use the HP tape cartridge or flexible disk as a primary

Table 11. Jaeger Pressure, Conductivity, Temperature, Salinity Table.

Depth	Pressure	Conductivity	Temperature	Experimental	Knowles	Bennett	Broenkow
m	dbar	mmhos/cm ²	°C	Salinity ppt	Salinity ppt	Salinity ppt	Salinity ppt
0.00	0.00	25.381	0.00	30.200	30.163	30.186	30.183
0.00	0.00	29.267	5.00	30.200	30.177	30.188	30.186
0.00	0.00	33.340	10.00	30.200	30.184	30.187	30.192
0.00	0.00	37.582	15.00	30.200	30.187	30.188	30.196
0.00	0.00	41.977	20.00	30.200	30.189	30.188	30.197
0.00	0.00	46.510	25.00	30.200	30.193	30.187	30.199
0.00	0.00	51.149	30.00	30.200	30.188	30.186	30.197
1714.00	1723.00	39.146	15.00	31.000	-	30.989	31.003
1714.00	1723.00	43.629	20.00	31.000	-	30.988	31.004
0.00	0.00	38.606	15.00	31.118	31.105	31.105	31.113
0.00	0.00	38.094	13.80	31.619	31.610	31.611	31.619
0.00	0.00	44.580	20.90	31.619	31.610	31.608	31.618
0.00	0.00	50.571	27.20	31.619	31.611	31.605	31.618
0.00	0.00	29.021	0.00	35.000	34.976	34.992	35.000
1714.00	1723.00	29.779	0.00	35.000	-	34.993	35.007
3427.99	3446.00	30.451	0.00	35.000	-	34.996	35.023
5141.99	5169.00	31.035	0.00	35.000	-	34.995	35.040
6855.98	6892.00	31.541	0.00	35.000	-	34.993	35.069
0.00	0.00	33.443	5.00	35.000	34.987	34.995	34.998
0.00	0.00	38.073	10.00	35.000	34.989	34.990	34.999
0.00	0.00	42.896	15.00	35.000	34.990	34.991	35.000
1714.00	1723.00	43.623	15.00	35.000	-	34.987	35.004
3427.99	3446.00	44.269	15.00	35.000	-	34.988	35.012
5141.99	5169.00	44.838	15.00	35.000	-	34.993	35.025
0.00	0.00	47.891	20.00	35.000	34.989	34.989	34.998
0.00	0.00	53.046	25.00	35.000	34.993	34.988	35.000
1714.00	1723.00	53.746	25.00	35.000	-	34.985	35.000
0.00	0.00	58.324	30.00	35.000	34.989	34.988	34.999
0.00	0.00	47.186	15.00	38.951	38.944	38.945	38.956
1714.00	1723.00	48.020	15.00	39.000	-	38.989	39.008
1714.00	1723.00	53.495	20.00	39.000	-	38.989	39.009
0.00	0.00	46.290	13.80	39.333	39.319	39.320	39.330
0.00	0.00	54.130	20.90	39.333	39.321	39.320	39.331
0.00	0.00	61.369	27.20	39.333	39.322	39.315	39.331
0.00	0.00	32.880	0.00	40.196	40.178	40.192	40.205
0.00	0.00	37.869	5.00	40.196	40.192	40.198	40.203
0.00	0.00	43.090	10.00	40.196	40.194	40.194	40.205
0.00	0.00	48.524	15.00	40.196	50.192	40.193	40.203
0.00	0.00	54.151	20.00	40.196	40.188	40.188	40.199
0.00	0.00	59.961	25.00	40.196	40.193	40.187	40.202
0.00	0.00	65.911	30.00	40.196	40.190	40.186	40.201

data storage device, with the Kennedy tape recorder and HP XYY' recorder available as backup units. The expanded scale of the HP XYY' recorder (0.20/cm, 0.4 (mmhos/cm)/cm, 4 m/cm) still makes it valuable for determining at which depths to trip Niskin bottles on the upcast, having plotted T and C versus D during the downcast.

A single HP tape cartridge, which is structured with two parallel tracks, contains programs for the CTD acquisition on one track and has space for data storage for as many as 30 stations on the other. The programs are listed in Appendix IV. The master program instructs the operator how to initiate a CTD cast. Special function keys are defined by this program that enable interactive control of data acquisition modes, i.e., downcast, upcast, soak routines. All subsequent programs prompt the operator on procedures and ask for the necessary variable entries, i.e., offsets, data storage, file numbers. An example of the internal printer output is shown in Appendix V.

The data acquired by the HP is treated using a software scheme similar to the Cyber programming but is real time (Table 12). While the CTD is on the deck of the ship the frequencies for D and C are entered following the station number. These variables are used in the frequency to engineering unit conversion as the frequencies for zero D and C.

Three scans of CTD are acquired and the temperature lag is calculated similar to the Cyber programming:

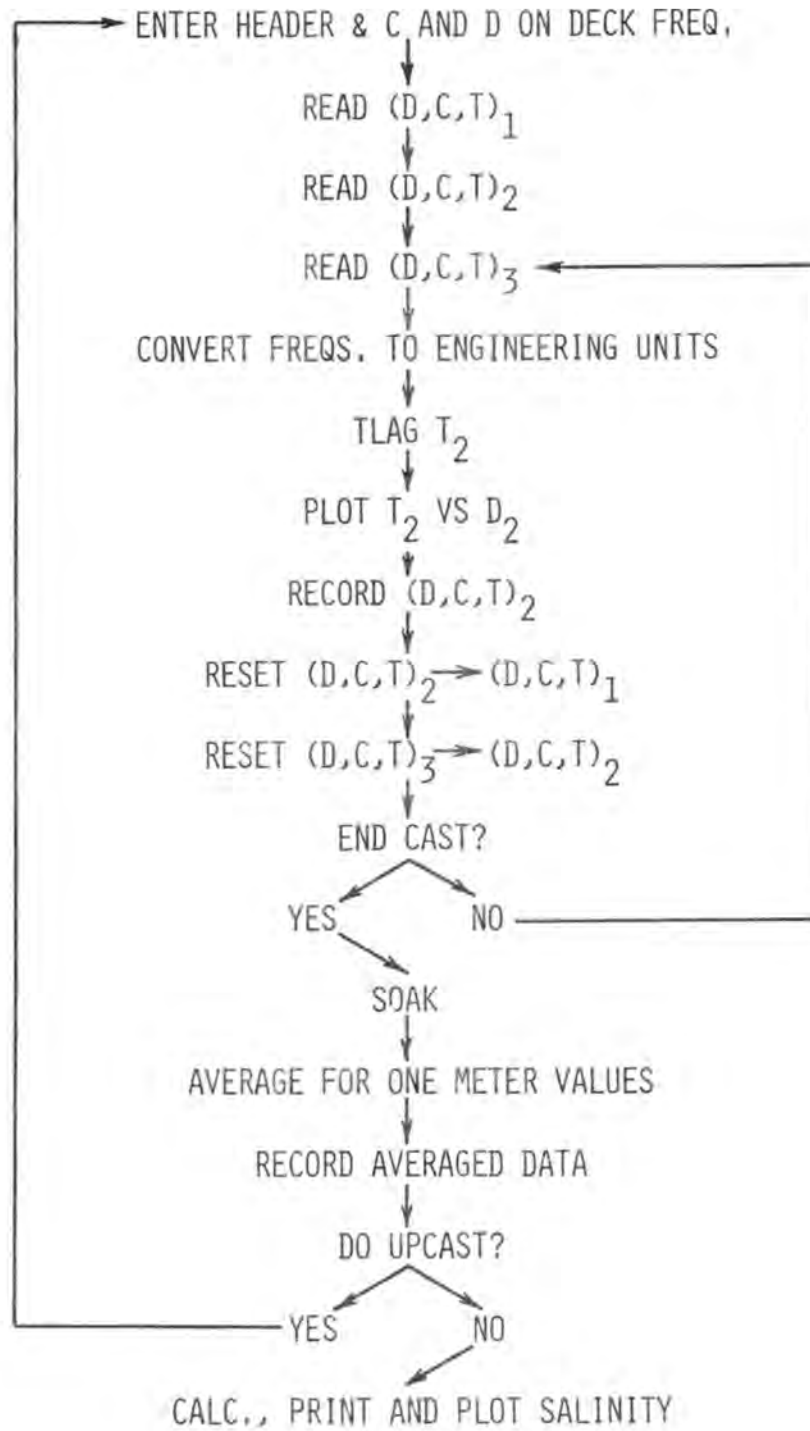
$$T_{R(n)} = T_{I(n)} + \frac{0.35(T_{I(n+1)} - T_{I(n-1)})}{2(0.405)}$$

The difference is the sampling rate; 0.405 seconds are required for the HP to acquire and process a CTD scan. The length and complexity of the HP data acquisition program governs the sampling rate. Further data processing is done after data is acquired and recorded on preliminary tape cartridge files at this fastest sampling rate. A T-versus-D plot is done in real time.

After the CTD Fish is lowered to within 3 meters of the bottom, data collection is stopped and a soak routine begins. Depth, temperature, and salinity are displayed and printed during the four minutes that the reversing thermometers remain at a constant depth for equilibration. T and S printed during the soak are used to calibrate the CTD against the reversing thermometers and salinity bottle samples taken at that depth.

The preliminary down cast data is then averaged for each meter and recorded permanently on the HP tape cartridge. Data collection during upcasts is taken in the same manner. If calibration is to be done at depths other than the deepest sample depth, a mid-depth soaking routine is used to print D, T, and S while a rosette bottle is being tripped. The mid-depth soak can be used at any time the CTD Fish is stopped, so that excessive data is not recorded. At the end of the upcast the preliminary data is averaged to meter increments and recorded on a permanent file.

Table 12. HP-CTD Data Acquisition Scheme.



Our HP calculator was purchased with 8k bytes of core memory. With the program taking up one-fourth of the core, only 100 CTD scans could be input before the array had to be recorded on a preliminary file. The core was then free to receive 100 more CTD scans. As much as two meters of data were missed while the calculator stopped to record each 100 scans. Sixteen k bytes of memory were recently added. Initial tests indicate that 80 m can be stored in an array before copying to the tape cartridge. Use of disk would eliminate this problem.

Further data processing is done aboard ship. Salinity (preferably from downcast data) is plotted versus depth. Until calibration data becomes available, plots are made using uncorrected salinity values. Temperature and salinity onshore-offshore transects are plotted in vertical cross section as well as horizontal plots and station locations. The HP software for this was developed at Skidaway Institute.

SUMMARY

The system described herein is a powerful tool for hydrographic data collection and reduction. Over 900 vertical CTD profiles and 45 hours of horizontal profiling (pumping water over the sensors in a bucket on deck) have been successfully completed in the two years since purchasing the initial system components. Through the first year, a 96% success rate was achieved while the system was being tried and upgraded. The success rate improved in the second year and continues to do so.

The portability of the system has allowed us to work from many of the ships available for research in the South Atlantic Bight. We take part in cooperative cruises and can operate on a minimum of manpower.

Real time data processing aboard ship has been achieved. The HP programmed plotter provides immediate visual presentation of the data. The sensors show drift with time; therefore, an extension calibration scheme is performed for every cruise. Once calibrated and formatted for NODC, cruise data is presented in technical report form.

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APPENDIX I.

Troubleshooting

This section summarizes some of our problems and cures in a troubleshooting chart. This is not an attempt to list every possible problem nor the probable remedy.

CTD TROUBLESHOOTING

PROBLEM	PROBABLE CAUSE	CORRECTION
*No C, T, and D signals in air	1) Have not made all connections (DDL-slip rings - CTD) 2) Bad ground 3) Short in armored cable 4) Bad mixer 5) Bad connection to C, T, and D sensors from mixer	1) Check connections 2) Check ground 3) Cut off bad part of cable and re-scotchcast 4) Replace or repair mixer 5) Check connection for too much dielectric grease
Loss of C, T, or D signal in air	1) Bad counter or digitizing board in DDL 2) Bad connection to sensor	1) Replace or repair board 2) Check connection for too much dielectric grease
Loss of C, T, or D signal or some combination of signals in air but recovery of signal with depth	1) Too much silicone dielectric grease in connection	1) Clean connector pins and sleeves
Loss of all signals as Fish enters water	1) Bad ground 2) Leak in C, T, D, or mixer pressure housings containing electronics 3) Leak in 9 pin or 3 pin plugs to sensors	1) Check ground 2) Disassemble and dry with alcohol and Q-tips 3) Dry and seal with silicone dielectric grease
Loss of C, T, and D signals at depth but recovery with return to ship	1) Wire crimped and wedged in pressure housing of mixer	1) Replace or repair wire

*See "Volt-Amp Meter Readings" for troubleshooting problems (page 30).

PROBLEM	PROBABLE CAUSE	CORRECTION
Occasional spiking (blinking) in C, T, and D signals	1) Fluctuation in AC system 2) Wet or bad connection to slip rings 3) Loose ground 4) Some stress on a connector (on ship or on Fish) 5) Wet 9 pin or 3 pin connectors on sensors	1) Use different wall sockets for power cords 2) Check slip ring wiring 3) Check ground 4) Check all connectors 5) Dry pins
Spiking of C, T, and D signals when winch is turned on or off	1) Relays to winch	1) Solid state relays would be an improvement
Occasional D spiking beginning at a particular depth from one cast to the next	1) Bad armored conductor cable	1) Inspect cable and cut off bad section
Spiking (blinking) of C signal in high salinity water but O.K. in air or in low salinity water. Also note on XYY' that while signal occasionally spikes, conductivity remains too constant (false reading)	1) Defective frequency plug on C board in DDL (Changes the limit of acceptable frequencies which it will allow to pass into DDL for processing)	1) Replace plug or capacitor on plug
Blinking C and analog (XYY') spikes	1) Capacitor to attenuate Fish power to DDL when using a short conductor wire is not in place	1) Connect capacitor
Severe noise on XYY' and/or HP 9825A and Plotter in air or at depth	1) Plotter picking up stray radio frequency from radio communications (Single Side Band) 2) Data lines too near AC power lines	1) Prohibit radio communications while doing CTD cast 2) Separate Data lines from AC power lines

PROBLEM	PROBABLE CAUSE	CORRECTION
Good signals to DDL but nothing to 'YYY' plotter	1) S3 switch on back of DDL in wrong position	1) Flick switch to proper position
Good signals to DDL but nothing to frequency counter	1) Bad conductor between the two	1) Repair or replace conductor
Not tripping bottles in air	1) Incorrect armored cable hookup 2) Bad ground 3) Loose or wet connection on Fish 4) Bad relays in deck box 5) Bad step motor 6) Bad cold solders in deck unit	1) Check hookup 2) Check ground 3) Check connections 4) Replace relays 5) Repair or replace step motor 6) Check solders
Bottles trip in air but not in water	1) Leakage in armored conductor cable	1) Cut off bad cable and re-sotchcast (entire cable may be bad)

Our Plessey 8400 Digital Data Logger, which also powers the CTD, was modified to indicate sea cable voltage and amperage on the front panel. The following table is very useful for troubleshooting.

Volt-Amp Meter Readings

Problem	Indication of Problem
CTD on Deck:	
Open Circuit	high voltage, low amperage*
Short Circuit:	low voltage, correct amperage
Short is in deck unit	2 Volts
Short is in Fish	5 Volts
During CTD cast:	
Short Circuit	voltage decrease
Corrosion	voltage increase

*For our 250 meter, 4-conductor wire the normal readings are 30 Volts and 135 milliamps.

APPENDIX II.

Cruise Supplies

CRUISE SUPPLIES

General

Drafting supplies

Ruler

Dividers

10 point dividers

Rubber station stamp and ink pad

Stop watch

HP-55 hand held calculator and power cord

Meter-fathoms-feet disc

2 boxes of pencils (#2)

2 magic markers (black)

Graph paper for XY' and 9862A plotters (25 x 38 cm)

15 legal size white envelopes

2 clip boards

10 large plastic bags

Spare tubing for Niskin Bottles

2 spare Niskin end caps (tops)

Spare lanyards and micro-press clamps for Niskin Bottles

Pair of stainless steel wing bolts for each Niskin Bottle (in tool box)

2 scotch cast (type 82-A1) (2 others in electronics box)

1 box scotch auto-electric sealing compound (live rubber tape)

5 G.O. messengers (for Niskins in case of CTD failure)

Inclinometer (wire angle)

Bicycle stretch straps

3 - radiator specialty straps (black rubber) for CTD

1 pair of gloves

50' 1/8" nylon line (for tying down)

50' 1/4" clothes line (for tying down)

2 cans of CRC spray

4 nutrient freezing boxes

2 ice chests (if entering another port)

Nutrient Bottles

Large dissolved oxygen (B.O.D. Bottles)

2 boxes of large salinity bottles (70 total)

1 box of small salinity bottles (50 total)

2 black pails with attached rope

Bucket thermometer and spare thermometer (0.1°C increments)

Weather radio

Anchor, 500 ft. of line and buoy

Desk lamp

Lab stool

Lawn chairs

2 unprotected thermometers

4 protected thermometers (7715 and 7718 are best)

10 and 30 lb. weights

CTD weight harness

Thermometer reader-magnifier

7 small Niskin Bottles (1.7 liter) - 3 with thermometer racks

2 large (5.0 liter) Niskin Bottles

NODC sheets

Ringbinder reinforcers

Cruise Supplies - General (cont'd)

"Cruise Log" ring-binder notebook with: cruise plan, cruise log, data cassette logs (10), cruise section logs (10), station sheets (120), XBT event log (15), CTD procedure, D, C, T frequency conversion tables, protected and unprotected thermometer calibration sheets (copies), oxygen analysis procedure (3), oxygen data sheets (15)

XBT Tester

XBT test canister

XBT chart paper (0-200 m roll)

XBT's

XBT recorder

XBT gun

Plessey Lab Salinometer

Standard seawater

CTD-Rosette with Helle Pinger

CTD Winch + 3 welding brackets

CTD parts box

ELECTRONIC GEAR

EQUIPMENT MANUALS

OXYGEN ANALYSIS SUPPLIES

TOOL BOX

CRUISE SUPPLIES

ELECTRONIC GEAR

Electronics box

HP 9825A (calculator), power cord and packing box
 HP 9862A (plotter), interface, power cord and packing box
 HP 59307A (VHF switch), *Interface HP-IB and power cord
 HP 59309A (Clock), *Interface and power cord *connected piggyback
 HP 5328A (Counter), *Interface and power cord
 HP 204C (Frequency oscillator) and power cord and leads
 Plessey DDL
 Kennedy Recorder and power cord
 HP 7046A (XYY') and power cord
 DDL - Recorder Interface
 DDL - (XYY' Plotter) Interface
 3 leads: DDL from switch
 1 lead: switch from counter
 G.O. Rosette Tripper Box
 4 conductor sea cable: (Winch to DDL and Rosette Tripper Box)
 Spare harness (9 pin with 3 three pin connectors for C, T, and D) - (in CTD Parts Box)
 Assorted spare wires and connectors for CTD (in CTD Parts Box)
 Mounting board (for calculator and plotter)
 2 multiterminal power strips (be sure they have fuses in them)
 Voltmeter and leads (check that it is operational)
 Solder iron and solder
 Spare mixer, conductivity, temperature, and depth sensors (in CTD Parts Box)
 Data Cassettes
 Program Cassettes
 Rolls of printing paper
 Pens for plotters (9862A and 7046A XYY')
 HP Tape head cleaner
 Kennedy tape head cleaner kit
 Check output on 10 volt calibration of XYY' plotter (is it 10 volts?)
 Labels for magnetic tapes
 3 or 4 magnetic tapes for Kennedy tape drive
 Intercom system (winch to DDL communications)
 2 rolls of electric tape

CRUISE SUPPLIES

EQUIPMENT MANUALS

HP 9825A Calculator: Operating and Programming
HP 9825A Calculator: System Test Booklet and Test Cartridge 09825-90035
HP 9825A Calculator: Quick Reference Guide
HP 9825A Calculator: General I/O Programming
HP 9825A Calculator: Extended I/O Programming
HP 9825A Calculator and Plotter: Plotter Programming
HP 9825A Calculator: Advanced Programming
HP 9825A Calculator: String Variable Programming
HP 9825A Calculator: Systems Programming
HP 98034A HP-IB Interface: Installation and Service Manual
HP 59307A VHF Switch: Operating and Service Manual
HP 59309A ASCII Digital Clock: Operating and Service Manual
HP 7046A X-Y Recorder: Operating and Service Manual
HP 5328A Universal Counter: User and Service Manual
HP 204C/204D Oscillator: Operation and Service Manual
HP Option 020 Digital Voltmeter: Installation and Service Manual
HP Software General Statistics Binder with 3-tapes
Kennedy Model 1600 Incremental Tape Recorder: Operation and Maintenance Manual
G.O. Model 1015 Rosette: Instruction Manual
G.O. Model 3070 Film Recording Thermograph: Instruction Manual
Plessey Model 7400 Winch: Instruction Manual
Plessey Model 9400 CTD System: Instruction Manual
Plessey Model 8400 DDL: Instruction Manual
Sippican Model R-603 XBT System: Instruction Manual
Plessey Model 6230N Laboratory Salinometer

CRUISE SUPPLIES

OXYGEN ANALYSIS SUPPLIES

3 copies of Oxygen Analysis procedure (in "Cruise Log" notebook)
15 Oxygen Data Sheets (in "Cruise Log" notebook)
1 roll duct tape
1 roll masking tape
paper towels
2 boxes kimwipes
1 clip board
1 pipette bulb
2 - 50 ml Lowy pipettes (and tubing)
2 - 10 ml (.05 ml increment) burettes (and tubing)
2 clean 5.0 ml pipettes
2 clean 1.0 ml pipettes
1 clean 50.0 ml pipette
2 - 10 ml graduate cylinders
6 automatic pipettes (plunger type) with 6 to 10 dispensing tubes (preset 3 of them for 0.5 ml and 1 for 2.5 ml) - these are backup to Oxford Dispensers
4 clean erlenmeyer flasks (125 ml)
1 - 250 ml beaker
1 - 600 ml beaker
2 - 300 ml B.O.D. bottles
3 squeeze bottles of distilled water
1 squeeze bottle of acetone
titration lamp
3 - 0.5 ml Oxford Reagent Dispensers (check to see that they work)
2 extra dispenser bottles
Jug of distilled water
2 ring stands
4 clamps
4 pieces of tubing to cushion and secure burette and pipet with clamps
Vacuum pump (be sure it works)
Trap for vacuum pump (and tubing)
Magnetic stirrer and 2 stir bars
1 pair scissors
Box of Para Film
Sulfuric acid
Starch indicator solution (2 liter)
.01 N Iodate standard (at least 500 ml)
Alkaline Iodide Soln. (1 liter)
Manganous sulfate soln. (1 liter)
6 liters thiosulfate solution (+ stopper and tubing attachments)
300 ml BOD Bottles

CRUISE SUPPLIES

TOOL BOX

1 roll masking tape
 1 roll duct tape
 1 roll electric tape
 1 tube silicone lubricant, 1 tube silicone glue
 1 can PVC cement
 1 magic marker (black)
 1 hammer
 3 screw drivers
 2 phillips screw drivers (large and small handled)
 6 jewelers screw drivers
 Channel lock pliers
 Needle nose pliers
 Regular pliers
 Cutting pliers
 Vise grips
 Cable cutters (that don't fit in Tool Box)
 Allen wrenches
 Tape measure
 Small ratchet set
 *1 knife or cutting tool
 Triangle file for Copenhagen water
 Niskin bottle cocker and screw driver
 Electric drill (Separate from box)
 Drill bits
 *1 pair scissors
 8" adjustable wrench
 2 - 1/2"-9/16" open end wrenches
 1 - 1/2" wrench o/c
 1 - 9/16" wrench o/c
 2 - 3/8"-7/16" open end wrenches
 1 - 3/8" wrench o/c
 1 - 7/16" wrench o/c
 1 - 1/4"-5/16" open end wrench
 1 - 5/16" wrench o/c
 1 - 3/4" chisel
 Wire strippers

ACCESSORIES TO TOOL BOX

2 - 1/8" thimbles
 2 - 3/16" thimbles
 2 - 7/16" thimbles
 Pair of stainless wing bolts for each Niskin bottle
 Nuts and bolts for securing DDL and XYY' plotter
 2 shackles
 Hard wire (for securing shackles)
 Wire clamps (U-bolts)
 2" C-clamps
 Assorted bolts, wood screws, and screw eyes

APPENDIX III.

Cyber Programs

The following programs are written in CDC Fortran IV extended time sharing (FTNTS). The language is identical to Fortran IV except for the addition line numbers and the relaxed column requirements. These programs are stored and run in compiled (binary) form.

PROGRAM CTDRUN

```
SIO.  
USER, SIO3, ****.  
SETUP, U3002=BF07.  
REQUEST, TAPE, VSN=U3002, HI, F=S, PO=R, LB=KU.  
DEFINE, BF07, BFCK.  
COPY, TAPE, BF07.  
REWIND, TAPE.  
COPY, TAPE, BFCK.  
REWIND, BF07, BFCK.  
VERIFY, BF07, BFCK, R.  
DAYFILE.  
REPLACE, OUTPUT=CK.  
EXIT.  
DAYFILE.  
REPLACE, OUTPUT=CK.
```

PROGRAM MAGREAD

```

00100 PROGRAM MAGREAD (BF07,BIRANG,OUTPUT,TAPES=BF07,TAPE6=OUTPUT,
00110+ TAPE7=BIRANG)
00120C THIS PROGRAM IS DESIGNED TO CONVERT CTD DATA ON MAGNETIC TAPES
00130C TO A BINARY RECORD (PROPORTIONAL TO FREQUENCY) FOR FURTHER
00140C CALCULATION TO SALINITY,TEMPERATURE, AND DEPTH VALUES.
00150 INTEGER K(54),M(45),HEAD
00170 INTEGER I0,I1,I2,I3,I4,I5,I6
00180 INTEGER SCAN0,SCAN1,SCAN2,SCAN3,SCAN4,SCAN5,SCAN6
00190 INTEGER Z0,Z1,Z2,Z3,Z4,Z5,Z6
00200 INTEGER C0,C1,C2,C3,C4,C5,C6
00210 INTEGER T0,T1,T2,T3,T4,T5,T6
00215 ISTA=0
00222C MASK WITH J
00225 J=0000 0000 0000 0000 0001 B
00230 28 BUFFER IN (5,1) (M(1),M(45))
00240 IF (UNIT(5)) 25,24,13
00250 25 N=M(1)
00260 HEAD=AND(SHIFT(N,3),J)*8000 +AND(SHIFT(N,4),J)*4000
00270+ +AND(SHIFT(N,5),J)*2000 +AND(SHIFT(N,6),J)*1000
00280+ +AND(SHIFT(N,9),J)*800 +AND(SHIFT(N,10),J)*400
00290+ +AND(SHIFT(N,11),J)*200 +AND(SHIFT(N,12),J)*100
00300+ +AND(SHIFT(N,15),J)*80 +AND(SHIFT(N,16),J)*40
00310+ +AND(SHIFT(N,17),J)*20 +AND(SHIFT(N,18),J)*10
00320+ +AND(SHIFT(N,21),J)*8 +AND(SHIFT(N,22),J)*4
00330+ +AND(SHIFT(N,23),J)*2 +AND(SHIFT(N,24),J)*1
00334C HOPEFULLY 9999 WAS ENTERED ON THE MAGNETIC TAPE AFTER THE LAST CAST.
00335 IF (HEAD.EQ.9999) GO TO 8
00340 WRITE (7,23)HEAD
00345 23 FORMAT ("9999",/,I4)
00346 GO TO 28
00348 24 WRITE (6,26)HEAD
00350 26 FORMAT (/"***",I4,"***=THE HEADER NUMBER")
00351C COUNT THE NUMBER OF STATIONS
00352 ISTA=ISTA+1
00355 ICOUNT=0
00360 9 BUFFER IN(5,1)(K(1),K(54))
00370 IF(UNIT(5))15,14,13
00380 15 CONTINUE
00390C COUNT THE NUMBER OF RECORDS OF DATA
00400 ICOUNT=ICOUNT+1
00410 5 DO 2 L=1,7
00420 I0=K(7*L-6)$I1=K(7*L-5)$I2=K(7*L-4)$I3=K(7*L-3)$I4=K(7*L-2)$I5=K(7*L-1)
00430 I6=K(7*L)
00460 SCAN0=AND(SHIFT(I0,3),J)*80+
00470+ AND(SHIFT(I0,4),J)*40+
00480+ AND(SHIFT(I0,5),J)*20+
00490+ AND(SHIFT(I0,6),J)*10+
00500+ AND(SHIFT(I0,9),J)*8+
00510+ AND(SHIFT(I0,10),J)*4+
00520+ AND(SHIFT(I0,11),J)*2+
00530+ AND(SHIFT(I0,12),J)*1
00540 Z0=AND(SHIFT(I0,15),J)*32768 +AND(SHIFT(I0,16),J)*16384
00550+ +AND(SHIFT(I0,17),J)*8192 +AND(SHIFT(I0,18),J)*4096

```

```

00560+ +AND(SHIFT(I0,21),J)*2048 +AND(SHIFT(I0,22),J)*1024
00570+ +AND(SHIFT(I0,23),J)*512 +AND(SHIFT(I0,24),J)*256
00580+ +AND(SHIFT(I0,27),J)*128 +AND(SHIFT(I0,28),J)*64
00590+ +AND(SHIFT(I0,29),J)*32 +AND(SHIFT(I0,30),J)*16
00600+ +AND(SHIFT(I0,33),J)*8 +AND(SHIFT(I0,34),J)*4
00610+ +AND(SHIFT(I0,35),J)*2 +AND(SHIFT(I0,36),J)*1
00620 C0=AND(SHIFT(I0,39),J)*32768 +AND(SHIFT(I0,40),J)*16384
00630+ +AND(SHIFT(I0,41),J)*8192 +AND(SHIFT(I0,42),J)*4096
00640+ +AND(SHIFT(I0,45),J)*2048 +AND(SHIFT(I0,46),J)*1024
00650+ +AND(SHIFT(I0,47),J)*512 +AND(SHIFT(I0,48),J)*256
00660+ +AND(SHIFT(I0,51),J)*128 +AND(SHIFT(I0,52),J)*64
00670+ +AND(SHIFT(I0,53),J)*32 +AND(SHIFT(I0,54),J)*16
00680+ +AND(SHIFT(I0,57),J)*8 +AND(SHIFT(I0,58),J)*4
00690+ +AND(SHIFT(I0,59),J)*2 +AND(SHIFT(I0,60),J)*1
00700 T0=AND(SHIFT(I1,3),J)*32768 +AND(SHIFT(I1,4),J)*16384
00710+ +AND(SHIFT(I1,5),J)*8192 +AND(SHIFT(I1,6),J)*4096
00720+ +AND(SHIFT(I1,9),J)*2048 +AND(SHIFT(I1,10),J)*1024
00730+ +AND(SHIFT(I1,11),J)*512 +AND(SHIFT(I1,12),J)*256
00740+ +AND(SHIFT(I1,15),J)*128 +AND(SHIFT(I1,16),J)*64
00750+ +AND(SHIFT(I1,17),J)*32 +AND(SHIFT(I1,18),J)*16
00760+ +AND(SHIFT(I1,21),J)*8 +AND(SHIFT(I1,22),J)*4
00770+ +AND(SHIFT(I1,23),J)*2 +AND(SHIFT(I1,24),J)*1
00780 SCAN1=AND(SHIFT(I1,27),J)*80 +AND(SHIFT(I1,28),J)*40
00790+ +AND(SHIFT(I1,29),J)*20 +AND(SHIFT(I1,30),J)*10
00800+ +AND(SHIFT(I1,33),J)*8 +AND(SHIFT(I1,34),J)*4
00810+ +AND(SHIFT(I1,35),J)*2 +AND(SHIFT(I1,36),J)*1
00820 Z1=AND(SHIFT(I1,39),J)*32768 +AND(SHIFT(I1,40),J)*16384
00830+ +AND(SHIFT(I1,41),J)*8192 +AND(SHIFT(I1,42),J)*4096
00840+ +AND(SHIFT(I1,45),J)*2048 +AND(SHIFT(I1,46),J)*1024
00850+ +AND(SHIFT(I1,47),J)*512 +AND(SHIFT(I1,48),J)*256
00860+ +AND(SHIFT(I1,51),J)*128 +AND(SHIFT(I1,52),J)*64
00870+ +AND(SHIFT(I1,53),J)*32 +AND(SHIFT(I1,54),J)*16
00880+ +AND(SHIFT(I1,57),J)*8 +AND(SHIFT(I1,58),J)*4
00890+ +AND(SHIFT(I1,59),J)*2 +AND(SHIFT(I1,60),J)*1
00900 C1=AND(SHIFT(I2,3),J)*32768 +AND(SHIFT(I2,4),J)*16384
00910+ +AND(SHIFT(I2,5),J)*8192 +AND(SHIFT(I2,6),J)*4096
00920+ +AND(SHIFT(I2,9),J)*2048 +AND(SHIFT(I2,10),J)*1024
00930+ +AND(SHIFT(I2,11),J)*512 +AND(SHIFT(I2,12),J)*256
00940+ +AND(SHIFT(I2,15),J)*128 +AND(SHIFT(I2,16),J)*64
00950+ +AND(SHIFT(I2,17),J)*32 +AND(SHIFT(I2,18),J)*16
00960+ +AND(SHIFT(I2,21),J)*8 +AND(SHIFT(I2,22),J)*4
00970+ +AND(SHIFT(I2,23),J)*2 +AND(SHIFT(I2,24),J)*1
00980 T1=AND(SHIFT(I2,27),J)*32768 +AND(SHIFT(I2,28),J)*16384
00990+ +AND(SHIFT(I2,29),J)*8192 +AND(SHIFT(I2,30),J)*4096
01000+ +AND(SHIFT(I2,33),J)*2048 +AND(SHIFT(I2,34),J)*1024
01010+ +AND(SHIFT(I2,35),J)*512 +AND(SHIFT(I2,36),J)*256
01020+ +AND(SHIFT(I2,39),J)*128 +AND(SHIFT(I2,40),J)*64
01030+ +AND(SHIFT(I2,41),J)*32 +AND(SHIFT(I2,42),J)*16
01040+ +AND(SHIFT(I2,45),J)*8 +AND(SHIFT(I2,46),J)*4
01050+ +AND(SHIFT(I2,47),J)*2 +AND(SHIFT(I2,48),J)*1
01060 IF (L.EQ.7)6,12
01070 12 CONTINUE
01080 SCAN2=AND(SHIFT(I2,51),J)*80 +AND(SHIFT(I2,52),J)*40
01090+ +AND(SHIFT(I2,53),J)*20 +AND(SHIFT(I2,54),J)*10
01100+ +AND(SHIFT(I2,57),J)*8 +AND(SHIFT(I2,58),J)*4
01110+ +AND(SHIFT(I2,59),J)*2 +AND(SHIFT(I2,60),J)*1

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01120 Z2=AND(SHIFT(I3,3),J)*32768 +AND(SHIFT(I3,4),J)*16384
01130+ +AND(SHIFT(I3,5),J)*8192 +AND(SHIFT(I3,6),J)*4096
01140+ +AND(SHIFT(I3,9),J)*2048 +AND(SHIFT(I3,10),J)*1024
01150+ +AND(SHIFT(I3,11),J)*512 +AND(SHIFT(I3,12),J)*256
01160+ +AND(SHIFT(I3,15),J)*128 +AND(SHIFT(I3,16),J)*64
01170+ +AND(SHIFT(I3,17),J)*32 +AND(SHIFT(I3,18),J)*16
01180+ +AND(SHIFT(I3,21),J)*8 +AND(SHIFT(I3,22),J)*4
01190+ +AND(SHIFT(I3,23),J)*2 +AND(SHIFT(I3,24),J)*1
01200 C2=AND(SHIFT(I3,27),J)*32768 +AND(SHIFT(I3,28),J)*16384
01210+ +AND(SHIFT(I3,29),J)*8192 +AND(SHIFT(I3,30),J)*4096
01220+ +AND(SHIFT(I3,33),J)*2048 +AND(SHIFT(I3,34),J)*1024
01230+ +AND(SHIFT(I3,35),J)*512 +AND(SHIFT(I3,36),J)*256
01240+ +AND(SHIFT(I3,39),J)*128 +AND(SHIFT(I3,40),J)*64
01250+ +AND(SHIFT(I3,41),J)*32 +AND(SHIFT(I3,42),J)*16
01260+ +AND(SHIFT(I3,45),J)*8 +AND(SHIFT(I3,46),J)*4
01270+ +AND(SHIFT(I3,47),J)*2 +AND(SHIFT(I3,48),J)*1
01280 T2=AND(SHIFT(I3,51),J)*32768 +AND(SHIFT(I3,52),J)*16384
01290+ +AND(SHIFT(I3,53),J)*8192 +AND(SHIFT(I3,54),J)*4096
01300+ +AND(SHIFT(I3,57),J)*2048 +AND(SHIFT(I3,58),J)*1024
01310+ +AND(SHIFT(I3,59),J)*512 +AND(SHIFT(I3,60),J)*256
01320+ +AND(SHIFT(I4,3),J)*128 +AND(SHIFT(I4,4),J)*64
01330+ +AND(SHIFT(I4,5),J)*32 +AND(SHIFT(I4,6),J)*16
01340+ +AND(SHIFT(I4,9),J)*8 +AND(SHIFT(I4,10),J)*4
01350+ +AND(SHIFT(I4,11),J)*2 +AND(SHIFT(I4,12),J)*1
01360 SCAN3=AND(SHIFT(I4,15),J)*80 +AND(SHIFT(I4,16),J)*40
01370+ +AND(SHIFT(I4,17),J)*20 +AND(SHIFT(I4,18),J)*10
01380+ +AND(SHIFT(I4,21),J)*8 +AND(SHIFT(I4,22),J)*4
01390+ +AND(SHIFT(I4,23),J)*2 +AND(SHIFT(I4,24),J)*1
01400 Z3=AND(SHIFT(I4,27),J)*32768 +AND(SHIFT(I4,28),J)*16384
01410+ +AND(SHIFT(I4,29),J)*8192 +AND(SHIFT(I4,30),J)*4096
01420+ +AND(SHIFT(I4,33),J)*2048 +AND(SHIFT(I4,34),J)*1024
01430+ +AND(SHIFT(I4,35),J)*512 +AND(SHIFT(I4,36),J)*256
01440+ +AND(SHIFT(I4,39),J)*128 +AND(SHIFT(I4,40),J)*64
01450+ +AND(SHIFT(I4,41),J)*32 +AND(SHIFT(I4,42),J)*16
01460+ +AND(SHIFT(I4,45),J)*8 +AND(SHIFT(I4,46),J)*4
01470+ +AND(SHIFT(I4,47),J)*2 +AND(SHIFT(I4,48),J)*1
01480 C3=AND(SHIFT(I4,51),J)*32768 +AND(SHIFT(I4,52),J)*16384
01490+ +AND(SHIFT(I4,53),J)*8192 +AND(SHIFT(I4,54),J)*4096
01500+ +AND(SHIFT(I4,57),J)*2048 +AND(SHIFT(I4,58),J)*1024
01510+ +AND(SHIFT(I4,59),J)*512 +AND(SHIFT(I4,60),J)*256
01520+ +AND(SHIFT(I5,3),J)*128 +AND(SHIFT(I5,4),J)*64
01530+ +AND(SHIFT(I5,5),J)*32 +AND(SHIFT(I5,6),J)*16
01540+ +AND(SHIFT(I5,9),J)*8 +AND(SHIFT(I5,10),J)*4
01550+ +AND(SHIFT(I5,11),J)*2 +AND(SHIFT(I5,12),J)*1
01560 T3=AND(SHIFT(I5,15),J)*32768 +AND(SHIFT(I5,16),J)*16384
01570+ +AND(SHIFT(I5,17),J)*8192 +AND(SHIFT(I5,18),J)*4096
01580+ +AND(SHIFT(I5,21),J)*2048 +AND(SHIFT(I5,22),J)*1024
01590+ +AND(SHIFT(I5,23),J)*512 +AND(SHIFT(I5,24),J)*256
01600+ +AND(SHIFT(I5,27),J)*128 +AND(SHIFT(I5,28),J)*64
01610+ +AND(SHIFT(I5,29),J)*32 +AND(SHIFT(I5,30),J)*16
01620+ +AND(SHIFT(I5,33),J)*8 +AND(SHIFT(I5,34),J)*4
01630+ +AND(SHIFT(I5,35),J)*2 +AND(SHIFT(I5,36),J)*1
01640 SCAN4=AND(SHIFT(I5,39),J)*80 +AND(SHIFT(I5,40),J)*40
01650+ +AND(SHIFT(I5,41),J)*20 +AND(SHIFT(I5,42),J)*10
01660+ +AND(SHIFT(I5,45),J)*8 +AND(SHIFT(I5,46),J)*4

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01670+ +AND(SHIFT(I5,47),J)*2 +AND(SHIFT(I5,48),J)*1
01680 Z4=AND(SHIFT(I5,51),J)*32768 +AND(SHIFT(I5,52),J)*16384
01690+ +AND(SHIFT(I5,53),J)*8192 +AND(SHIFT(I5,54),J)*4096
01700+ +AND(SHIFT(I5,57),J)*2048 +AND(SHIFT(I5,58),J)*1024
01710+ +AND(SHIFT(I5,59),J)*512 +AND(SHIFT(I5,60),J)*256
01720+ +AND(SHIFT(I6,3),J)*128 +AND(SHIFT(I6,4),J)*64
01730+ +AND(SHIFT(I6,5),J)*32 +AND(SHIFT(I6,6),J)*16
01740+ +AND(SHIFT(I6,9),J)*8 +AND(SHIFT(I6,10),J)*4
01750+ +AND(SHIFT(I6,11),J)*2 +AND(SHIFT(I6,12),J)*1
01760 C4=AND(SHIFT(I6,15),J)*32768 +AND(SHIFT(I6,16),J)*16384
01770+ +AND(SHIFT(I6,17),J)*8192 +AND(SHIFT(I6,18),J)*4096
01780+ +AND(SHIFT(I6,21),J)*2048 +AND(SHIFT(I6,22),J)*1024
01790+ +AND(SHIFT(I6,23),J)*512 +AND(SHIFT(I6,24),J)*256
01800+ +AND(SHIFT(I6,27),J)*128 +AND(SHIFT(I6,28),J)*64
01810+ +AND(SHIFT(I6,29),J)*32 +AND(SHIFT(I6,30),J)*16
01820+ +AND(SHIFT(I6,33),J)*8 +AND(SHIFT(I6,34),J)*4
01830+ +AND(SHIFT(I6,35),J)*2 +AND(SHIFT(I6,36),J)*1
01840 T4=AND(SHIFT(I6,39),J)*32768 +AND(SHIFT(I6,40),J)*16384
01850+ +AND(SHIFT(I6,41),J)*8192 +AND(SHIFT(I6,42),J)*4096
01860+ +AND(SHIFT(I6,45),J)*2048 +AND(SHIFT(I6,46),J)*1024
01870+ +AND(SHIFT(I6,47),J)*512 +AND(SHIFT(I6,48),J)*256
01880+ +AND(SHIFT(I6,51),J)*128 +AND(SHIFT(I6,52),J)*64
01890+ +AND(SHIFT(I6,53),J)*32 +AND(SHIFT(I6,54),J)*16
01900+ +AND(SHIFT(I6,57),J)*8 +AND(SHIFT(I6,58),J)*4
01910+ +AND(SHIFT(I6,59),J)*2 +AND(SHIFT(I6,60),J)*1
01920 WRITE (7,7)SCAN0,Z0,C0,T0,SCAN1,Z1,C1,T1,SCAN2,Z2,C2,T2,SCAN3,
01930+ Z3,C3,T3,SCAN4,Z4,C4,T4
01940 7 FORMAT (4(I4,1X,I5,1X,I5,1X,I5,/),I4,1X,I5,1X,I5,1X,I5)
01950 2 CONTINUE
01960 6 WRITE (7,3)SCAN0,Z0,C0,T0,SCAN1,Z1,C1,T1
01970 3 FORMAT (I4,1X,I5,1X,I5,1X,I5,/ ,I4,1X,I5,1X,I5,1X,I5)
01980 GO TO 9
01990 13 WRITE (6,16)
02000 16 FORMAT (/"THERE IS A PROBLEM. THE DATA IS NOT BEING READ RIGHT."/)
02010 14 WRITE (6,10)ICOUNT
02020 10 FORMAT ("*****",I3,"*****=THE NUMBER OF RECORDS")
02030 GO TO 28
02040 8 WRITE(7,77)
02045 77 FORMAT("9999")
02046 WRITE(6,78)ISTA
02047 78 FORMAT("###",I6,"###=THE NUMBER OF CASTS NOW ON TAPE7.")
02048 STOP
02050 END

```

PROGRAM CTDUNIT

```

00100 PROGRAM CTDUNIT(INPUT,BIRANG,OUTPUT,LAG,TAPE5=BIRANG,TAPE7=LAG,
00110+ TAPE4=INPUT,TAPE6=OUTPUT)
00120C THIS PROGRAM READS FREQUENCIES (BINARY RANGE,BR) FROM BIRANG,
00130C   CONVERTS THEM TO DEPTH, CONDUCTIVITY, AND TEMPERATURE, AND
00140C   WRITES THE NEW DATA SET ON A FILE DESIGNATED BY TAPE7.
00150 INTEGER HEAD,SCAN,W
00160 INTEGER ZBR,CBR,TBR
00170 REWIND 5
00180 I=0
00185 WRITE(6,8)
00187 READ(4,9)CDR
00190C   W IS THE PRE-HEADER WRITTEN ONTO BIRANG TO IDENTIFY NEW CASTS.
00200C   W=9999. THE HEADER NUMBER FOLLOWS.
00210 10 READ (5,11)W
00220 12 READ(5,13)HEAD
00230 IF(EOF(5))6,16
00235 16 CONTINUE
00240 WRITE(7,14)HEAD
00250C   I COUNTS THE NUMBER OF CASTS.
00260 I=I+1
00270 J=0
00280 2 IF(EOF(5))6,7
00290 7 READ (5,3)SCAN,ZBR,CBR,TBR
00300 IF (SCAN.EQ.9999) GO TO 12
00310C   J COUNTS THE NUMBER OF LINES PER CAST.
00320 J=J+1
00330 Z=0.036621094*ZBR
00335 Z=Z+CDR
00340 C=0.002441406*CBR
00350 T=0.001220679*TBR-4.999208208
00360 WRITE (7,5)J,SCAN,Z,C,T
00370 GO TO 2
00380 6 WRITE (6,4) I
00390 WRITE(7,1)
00400C   THE FORMAT SECTION FOLLOWS
00410 1 FORMAT("9999")
00420 3 FORMAT (I4,1X,I5,1X,I5,1X,I5)
00430 4 FORMAT ("*****",I6,"*****=THE NUMBER OF CASTS NOW ON TAPE7.")
00440 5 FORMAT (I4,1X,I2,1X,F6.2,1X,F6.3,1X,F5.2)
00445 8 FORMAT("ENTER THE DEPTH CORRECTION FACTOR FOR THE CTD",/,
00446+ "IN THE FORMAT +X.XXX OR -X.XXX")
00447 9 FORMAT(F6.3)
00450 11 FORMAT (I2)
00460 13 FORMAT (I4)
00470 14 FORMAT ("9999",/,I4)
00480 STOP
00490 END

```

```

00100 PROGRAM LAGFILT(LAG,OUTPUT,LATCH,TAPE5=LAG,TAPE6=OUTPUT,
00110+ TAPE7=LATCH)
00120C THIS PROGRAM READS D, C, AND T FROM LAG, COURSE FILTERS THE DATA,
00130C     CALCULATES THE TEMPERATURE SENSOR LAG, AND WRITES THE NEW DATA
00140C     SET ONTO A FILE DESIGNATED BY TAPE7.
00150 INTEGER W,HEAD
00160 REWIND 5
00170 I=0
00180 READ(5,10)W
00190 GO TO 1
00200 2 WRITE(6,19)HEAD,M
00210 1 READ(5,10)HEAD
00220 IF(EOF(5))4,5
00230 5 WRITE(7,15)HEAD
00240 M=0
00250C     I COUNTS THE NUMBER OF CASTS.
00260 I=I+1
00290 READ(5,12)J1,S1,D1,C1,T1
00300 READ(5,12)J2,S2,D2,C2,T2
00310 3 IF(EOF(5))4,23
00320 23 READ(5,12)J3,S3,D3,C3,T3
00325 IF(EOF(5))4,28
00330 28 L=0
00340 IF(J3.EQ.9999)GO TO 2
00350 IF(D3.GE.D2+5.OR.D3.LE.D2-5)GO TO 30
00360 IF(C3.GE.C2+0.8.OR.C3.LE.C2-0.8)GO TO 30
00370 IF(T3.GE.T2+0.5.OR.T3.LE.T2-0.5)GO TO 30
00380 T=.76341*(T3-T1)/(S2+1)+T2
00390 WRITE(7,12)J2,S2,D2,C2,T
00400 J1=J2*J2=J3*S1=S2*S2=S3*D1=D2*D2=D3*C1=C2*C2=C3*T1=T2*T2=T3
00410 GO TO 3
00420 30 READ(5,12)J4,S4,D4,C4,T4
00423 IF(J4.EQ.9999)GO TO 2
00425 IF(EOF(5))4,26
00430C     M COUNTS THE NUMBER OF LINES OF DATA REMOVED BY THE COURSE FILTER.
00440 26 M=M+1
00445 L=L+1 * IF(L.EQ.5)GO TO 33
00460 IF(D4.GE.D2+5.OR.D4.LE.D2-5)GO TO 30
00470 IF(C4.GE.C2+0.8.OR.C4.LE.C2-0.8)GO TO 30
00480 IF(T4.GE.T2+0.5.OR.T4.LE.T2-0.5)GO TO 30
00490 31 READ(5,12)J5,S5,D5,C5,T5
00495 IF(J5.EQ.9999)GO TO 2
00497 IF(EOF(5))4,27
00500 27 IF(D5.GE.D4+5.OR.D5.LE.D4-5)GO TO 32
00510 IF(C5.GE.C4+0.8.OR.C5.LE.C4-0.8)GO TO 32
00520 IF(T5.GE.T4+0.5.OR.T5.LE.T4-0.5)GO TO 32
00530 J1=J4*J2=J5*S1=S4*S2=S5*D1=D4*D2=D5*C1=C4*C2=C5*T1=T4*T2=T5
00540 GO TO 23
00542 32 L=0 * GO TO 30
00544 33 IF(D4.GE.D2+20.OR.D4.LE.D2-20)GO TO 32
00546 GO TO 31
00550 4 WRITE(7,16)
00560 WRITE(6,17)I
00570C     FORMATS ARE AS FOLLOWS:
00580 10 FORMAT(I4)
00590 12 FORMAT(I4,1X,I2,1X,F6.2,1X,F6.3,1X,F5.2)
00600 15 FORMAT("9999"/,I4)
00610 16 FORMAT("9999")
00620 17 FORMAT(/,"**",I6,"**=THE NUMBER OF CASTS NOW ON TAPE7.")
00630 19 FORMAT("CAST",I4," LOST",I4," DATA PTS. THRU COURSE FILTERING.")
00640 STOP
00650 END

```

```

00100 PROGRAM BROE (INPUT,AVE,OUTPUT,SGSA,TAPE4=INPUT,
00110+ TAPE5=AVE,TAPE6=OUTPUT,TAPE7=SGSA)
00120C THIS PROGRAM READS D, C, AND T FROM AVE, CALCULATES SALINITY
00130C AND SIGMAT, AND WRITES THOSE PARAMETERS ONTO A FILE
00140C DESIGNATED BY TAPE7. THE SALINITY CALCULATION IS FROM
00141C BROENKOW.
00150 INTEGER W,HEAD
00160 C1=.03895414
00170 C2=-2.2584586
00180 REWIND 5
00190 WRITE(6,37)
00210 READ(4,36)COR
00230 I=0
00240 READ (5,12)W
00250 13 READ (5,12)HEAD
00260 IF(EOF(5))5,4
00270C I COUNTS THE NUMBER OF CASTS.
00280 4 I=I+1
00290 WRITE (7,21)HEAD
00300 7 IF(EOF(5))5,9
00310 9 READ(5,10)J,SCAN,D2,CSTP,T,M
00320 IF (J.EQ.9999) GO TO 13
00330 K=0
00332 AT=(676547+20131.5*T+99.89*T**2-0.1943*T**3-0.00672*T**4)*1.0E-6
00340 RT=CSTP/(AT*42.896)
00420 100 D15=RT*(RT-1)*(T-15)*(96.7-72.0*RT+37.3*RT**2-
00430+(0.63+0.21*RT**2)*(T-15))*1.0E-5
00440 R15=RT+D15
00450 S=-0.08996+28.29720*R15+12.80832*R15**2-10.67869*R15**3+
00460+5.98624*R15**4-1.32311*R15**5
00462 IF(K.EQ.1)GO TO 101
00464 RZ=1.0+0.01*(1.551-0.0453*T+0.00059*T**2+0.25*(35-S)*(0.043-0.0017*T
00465+ +2.3E-5*T**2))*(1.037E-3*D2-3.2E-8*D2**2)
00466 RT=CSTP/(RZ*AT*42.896)
00467 K=1 $ GO TO 100
00470C A CORRECTION FACTOR FOR SALINITY(BOTTLE)-SALINITY(CTD) IS ADDED
00480C TO ALL SALINITY VALUES.
00490C (IT MUST BE CALCULATED FOR EVERY CRUISE)
00500 101 S=S+COR
00510 F1=((T-3.98)**2)*(T+283.)/(503.57)*(T+67.26))
00520 F2=(T**3)*(1.0843E-6)-(T*T)*(9.8185E-5)+T*4.7867E-3
00530 F3=(T**3)*(1.667E-8)-(T*T)*(8.164E-7)+T*1.803E-5
00540 FS=(S**3)*(6.76786136E-6)-(S*S)*(4.8249614E-4)+S*.814876577
00550 SIG=-F1+(FS+C1)*(1.-F2+(F3)*(FS+C2))
00560 WRITE (7,20)J,SCAN,D2,CSTP,T,M,S,SIG
00570 6 GO TO 7
00580 5 WRITE(6,38)I
00590 WRITE(7,39)
00600C THE FORMAT SECTION FOLLOWS
00610 3 FORMAT (3X,I4,2X,F6.2,6X,F6.3,8X,F5.2,6X,F6.3)
00620 10 FORMAT(I4,1X,I2,1X,F6.2,1X,F6.3,1X,F5.2,1X,I4)
00630 12 FORMAT (I4)
00640 15 FORMAT (/, "HEADER NUMBER=",I4,/)
00650 21 FORMAT ("9999",/,I4)
00660 20 FORMAT (I4,1X,I2,1X,F6.2,1X,F6.3,1X,F5.2,1X,I4,2X,F6.3,1X,F5.2)
00670 36 FORMAT(F6.3)
00680 37 FORMAT("A SALINITY CORRECTION FACTOR FOR SAL(BOTTLE)-SAL(CTD)",/,
00690+ "SHOULD BE ENTERED IN THE FORMAT +X.XXX OR -X.XXX")
00700 38 FORMAT("***",I6,"***=THE NUMBER OF CASTS NOW ON TAPE7.")
00710 39 FORMAT("9999")
00720 50 STOP
00730 END

```

PROGRAM DLATCH

```

00100 PROGRAM DLATC (LATCH,OUTPUT,CTDATA,TAPE5=LATCH,TAPE6=OUTPUT,
00110+ TAPE7=CTDATA)
00120C THIS PROGRAM READS D, C, AND T FROM LATCH, REMOVES LINES HAVING
00130C   ASCENDING DEPTHS, AND WRITES THE NEW DATA SET ONTO A FILE
00140C   DESIGNATED BY TAPE7.
00150 DIMENSION J(6000),S(6000),D(6000),C(6000),T(6000)
00160 INTEGER HEAD,W
00170 REWIND 5
00180 I=0
00190 READ(5,10)W
00200 2 READ(5,10)HEAD
00210 IF(EOF(5))3,4
00220 4 WRITE(7,15)HEAD
00230C   I COUNTS THE NUMBER OF CASTS.
00240 I=I+1
00250 READ(5,12)JDOUT,SCAN,DOUT,COUT,TOUT
00260 READ(5,12)J1,S1,D1,C1,T1
00270 DO 1,K=1,6000
00280 READ(5,12)J(K),S(K),D(K),C(K),T(K)
00290 IF(J(K).EQ.9999)GO TO 2
00300 IF(EOF(5))3,5
00320 5 IF(D(K).LE.D1)GO TO 1
00330 WRITE(7,12)J1,S1,D1,C1,T1
00340 J1=J(K)*S1=S(K)*D1=D(K)*C1=C(K)*T1=T(K)
00350 1 CONTINUE
00355 WRITE(6,18)HEAD * GO TO 222
00360 3 WRITE(7,16)
00370 WRITE(6,17)I
00380C   FORMATS ARE AS FOLLOWS:
00390 10 FORMAT(I4)
00400 12 FORMAT(I4,1X,I2,1X,F6.2,1X,F6.3,1X,F5.2)
00410 15 FORMAT("9999",/,I4)
00420 16 FORMAT("9999")
00430 17 FORMAT("*,I6,"*=THE NUMBER OF CASTS NOW ON TAPE7.")
00435 18 FORMAT("STATION",I6," HAS OVER 6000 LINES:THE PROG. STOPPED.")
00440 222 STOP
00450 END

```

PROGRAM CTDAVE

```

00100 PROGRAM CTDAV (CTDATA,AVE,OUTPUT,TAPE5=CTDATA,TAPE7=AVE,
00110+ TAPE6=OUTPUT)
00120C THIS PROGRAM READS D, C, AND T FROM CTDATA, CALCULATES THE AVERAGE
00130C VALUES FOR POINTS FROM .5 TO .5 METERS, AND WRITES THE NEW
00140C DATA SET ONTO A FILE DESIGNATED BY TAPE7.
00150 DIMENSION J(100),S(100),D(100),C(100),T(100)
00160 INTEGER HEAD,W,S,Q,R
00170 REWIND 5
00180 I=0
00190 READ(5,1)W
00200 17 READ(5,1)HEAD
00210 IF(EOF(5))18,15
00220 15 WRITE(7,2)HEAD
00230C I COUNTS THE NUMBER OF CASTS.
00240 I=I+1
00250 DX=1.5
00260 13 N=0 $ P=0 $ F=0 $ G=0
00270 DO 10 K=1,100
00280 READ(5,3)J(K),S(K),D(K),C(K),T(K)
00290 IF(EOF(5))11,12
00300 12 Q=J(K) $ R=S(K)
00310 IF(D(K).GE.DX)GO TO 11
00320 IF(Q.EQ.9999)GO TO 11
00330 M=Q
00340C N COUNTS THE NUMBER OF POINTS TO BE AVERAGED.
00350 N=N+1
00360 P=P+D(K) $ F=F+C(K) $ G=G+T(K)
00370 10 CONTINUE
00380 11 IF(N.EQ.0)GO TO 22
00390 A=P/N $ B=F/N $ E=G/N
00400 GO TO 23
00410 22 IF(Q.EQ.9999)GO TO 17
00420 A=D(K) $ B=C(K) $ E=T(K)
00430 M=Q
00440 N=1
00450 23 WRITE(7,3)M,R,A,B,E,N
00460 IF(Q.EQ.9999)GO TO 17

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00470C  DX STEPS TO THE NEXT DEPTH FOR AVERAGING.
00480  DX=DX+1
00490  IF(DX.EQ.102.5)GO TO 30
00500  GO TO 13
00510  30 DX=DX+5
00520  N=0 $ P=0 $ F=0 $ G=0
00530  DO 31 K=1,100
00540  READ(5,3)J(K),S(K),D(K),C(K),T(K)
00550  IF(EOF(5))32,33
00560  33 Q=J(K) $ R=S(K)
00570  IF (D(K).GE.DX)GO TO 32
00575  IF(Q.EQ.9999)GO TO 32
00580  M=Q
00590  N=N+1
00600  P=P+D(K) $ F=F+C(K) $ G=G+T(K)
00610  31 CONTINUE
00620  32 IF(N.EQ.0)GO TO 34
00630  A=P/N $ B=F/N $ E=G/N
00640  GO TO 35
00650  34 IF(Q.EQ.9999)GO TO 17
00660  A=D(K) $ B=C(K) $ E=T(K)
00670  M=Q
00680  N=1
00690  35 IF(Q.EQ.9999)GO TO 17
00700  WRITE(7,3)M,R,A,B,E,N
00710  GO TO 30
00720  18 WRITE(7,4)
00730  WRITE(6,5)I
00740C  FORMAT SECTION:
00750  1 FORMAT(I4)
00760  2 FORMAT("9999",/,I4)
00770  3 FORMAT(I4,1X,I2,1X,F6.2,1X,F6.3,1X,F5.2,1X,I4)
00780  4 FORMAT("9999")
00790  5 FORMAT("**",I6,"**=THE NUMBER OF CASTS NOW ON TAPE7.")
00800  STOP
00810  END
```

```
00100 PROGRAM NODCFO(SGSA,OUTPUT,NODC,TAPE5=SGSA,TAPE6=OUTPUT,
00110+ TAPE7=NODC)
00120C THIS PROGRAM READS D,T AND S FROM THE CRUISE DATA FILE AND
00130C REWRITES THEM IN NODC FORMAT ON A FILE DESIGNATED BY TAPE7.
00140 INTEGER W,HEAD,X
00150 REWIND 5
00160 I=0 $ N=0
00170 READ(5,1)W
00180 10 READ(5,1)HEAD
00190 IF(EOF(5))20,21
00200 21 WRITE(7,2)HEAD
00205 WRITE(6,1)HEAD
00210 N=N+1
00220 X=0
00230 11 READ(5,3)J,D,T,S
00240 IF(J.EQ.9999)GO TO 10
00250 IF(D.GE.INT(D)+0.5)GO TO 24
00251 IF(T*10.GE.INT(T*10)+0.5)GO TO 25
00252 IF(S*100.GE.INT(S*100)+0.5)GO TO 26
00254 K=D $ L=T*100 $ M=S*100
00255 GO TO 23
00256 26 K=D $ L=T*100 $ M=S*100+1
00257 GO TO 23
00258 25 IF(S*100.GE.INT(S*100)+0.5)GO TO 27
00259 K=D $ L=T*100+1 $ M=S*100
00260 GO TO 23
00261 27 K=D $ L=T*100+1 $ M=S*100+1
00262 GO TO 23
00263 24 IF(T*10.GE.INT(T*10)+0.5)GO TO 28
00270 IF(S*100.GE.INT(S*100)+0.5)GO TO 29
00271 K=D+1 $ L=T*100 $ M=S*100
00280 GO TO 23
00281 29 K=D+1 $ L=T*100 $ M=S*100+1
00282 GO TO 23
00283 28 IF(S*100.GE.INT(S*100)+0.5)GO TO 30
00284 K=D+1 $ L=T*100+1 $ M=S*100
00285 GO TO 23
00286 30 K=D+1 $ L=T*100+1 $ M=S*100+1
00290 23 IF(K.EQ.X)GO TO 11
00300 WRITE(7,4)K,L,M
00310 I=I+1
00320 X=K
00330 GO TO 11
00340 20 WRITE(6,5)N
00345 WRITE(7,6)
00350C THIS IS THE FORMAT SECTION:
00360 1 FORMAT(I4)
00370 2 FORMAT("9999",/,I4)
00380 3 FORMAT(I4,4X,F6.2,8X,F5.2,7X,F6.3)
00390 4 FORMAT(26X,I5,I5,I5)
00400 5 FORMAT("***",I4,"***=THE NUMBER OF CASTS NOW ON TAPE7.")
00405 6 FORMAT("9999")
00410 STOP
00420 END
```

PROGRAM NUTMERC

52

```
00100 PROGRAM MERGEIT(INPUT,NOD,HEA,OUTPUT,FINAL,TAPE4=INPUT,
00110+ TAPE5=NOD,TAPE6=OUTPUT,TAPE7=FINAL,TAPE8=HEA)
00115+ THIS PROGRAM MERGES HEADER AND NUTRIENT DATA TO CAST DATA IN NODC FORMAT.
00120 DIMENSION IH(10)
00130 INTEGER W,HEAD,X,CT,Z
00140 REWIND5 $ REWIND8
00150 I=0 $ N=0
00160 READ(5,1)W
00170 41 BACKSPACE 8
00180 10 READ(5,1)HEAD
00185 IF(EOF(5))20,21
00187 21 READ(8,6)(IH(I),I=1,9),IP,IHEAD,IR
00190 IF(EOF(8))20,29
00200 29 CONTINUE
00210 22 WRITE(7,6)(IH(I),I=1,9),IP,IHEAD,IR
00219 N=N+1
00221 12 READ(8,9)Z
00222 IF(EOF(8))13,14
00223 14 IF(Z.EQ.31)GO TO 13
00224 BACKSPACE 8
00230 READ(8,7)KK,ISAL,02,P04,N03,SIO3,CT
00232 GO TO 11
00234 13 KK=999
00240 11 READ(5,3)J,K,L,M
00250 IF(J.EQ.9999)GO TO 40
00255 IF(K.GT.100.)GO TO 60
00257 IF(KK.EQ.2)GO TO 43
00260 IF(KK.LE.K)GO TO 43
00263 GO TO 44
00265 60 IF(KK.LT.K+2.5)GO TO 43
00282 44 WRITE(7,4)K,L,M
00283 GO TO 11
00285 43 IF(ISAL.EQ.0)GO TO 48
00287 WRITE(7,5)K,L,ISAL,02,P04,N03,SIO3,CT
00288 GO TO 12
00290 48 WRITE(7,8)K,L,M,02,P04,N03,SIO3,CT
00300 GO TO 12
00310 40 IF(KK.EQ.999)GO TO 41
00315 IF(J.EQ.9999)WRITE(7,8)KK,L,M,02,P04,N03,SIO3,CT
00317 GO TO 47
00320 45 WRITE(7,7)KK,ISAL,02,P04,N03,SIO3,CT
00323 47 CONTINUE
00330 READ(8,9)Z
00335 IF(EOF(8))10,46
00340 46 IF(Z.EQ.31)GO TO 41
00345 BACKSPACE 8
00347 READ(8,7)KK,ISAL,02,P04,N03,SIO3,CT
00350 GO TO 45
00360 20 WRITE(6,5)N
00370C THIS IS THE FORMAT SECTION:
00380 1 FORMAT(I4)
00390 2 FORMAT("9999",/,I4)
00400 3 FORMAT(I4,22X,I5,A5,A5)
00410 4 FORMAT(26X,I5,A5,A5,38X,"3")
00420 5 FORMAT("***",I4,"***=THE NUMBER OF CASTS NOW ON TAPE7.")
00430 6 FORMAT(9A8,A4,I3,A1)
00440 7 FORMAT(26X,I5,5X,I5,9X,A3,A3,6X,A3,A3,11X,I1)
00450 8 FORMAT(26X,I5,A5,A5,9X,A3,A3,6X,A3,A3,11X,I1)
00452 9 FORMAT(I2)
00453 51 FORMAT(26X,I5,A5,I5,9X,A3,A3,6X,A3,A3,11X,I1)
00455 52 FORMAT(30X,I3)
00460 STOP
00470 END
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PROGRAM CEMLIST

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00100 PROGRAM CEMLIST(PIERC,TEC,OUTPUT,INPUT,TAPES=PIERC,TAPE6=TEC,
00102+ TAPE8=OUTPUT,TAPE7=INPUT)
00104C
00105C   MODIFIED FEB. 1978 FOR CI-12 (DEC 76) CRUISE AND ON.  W.S.C.
00106C
00110C THIS PROGRAM CREATES OUTPUT FROM NATIONAL OCEANOGRAPHIC DATA CENTER
00120C INPUT FROM DIRECT ACCESS FILES. INPUT MUST BE NODC FORMATTED
00130C 80 CHARACTER CARD IMAGES. OUTPUT IS A COMPLETE LIST OF THE DATA
00140C IN TECHNICAL REPORT FORMAT. L.P.ATKINSON
00150 REAL NO3,RLAT(2),RLONG(2)
00160 INTEGER PD41,PD42,NO31,NO32,SI1,SI2
00170 REWIND5
00180 DATA C1,C2,C3,C4,D1,D2,D3/-173.4292,249.6339,143.3483,-21.8492
00190+,-.033096,.014259,-.0017/
00200 DATA AS1,AS2,AS3,AS4/1D-09,4886.,1.83E-05,.001/
00210 DATA A31,A32,A33,A34,A35,A36/.97264298,1E-09,4886.,1.83E-05,
00220+.01059094,-228.86167/
00230 DATA A1,A3,A3,A4,A5,A6,A7,A8,A9/1E-04,105.5,9.5,-.158,-1.5E-04,227.,
00240+28.33,-.551,.004/
00250 DATA B1,B2,B3,B4,B5,B6,B7,B8,B9,B10,B11,B12/10.,147.3,2.72,.04,
00260+.0001,32.4,-.87,.02,4.5,0.1,1.8,.06/
00270 DATA O/-28.1324/
00280 DATA FS1,FS2,FS3/6.76786136E-06,-4.8249614E-04,8.14876577E-01/
00290 WRITE(8,10)
00300 10 FORMAT("ENTER CRUISE HEADER, 20 SPACES MAX")
00310 READ(7,11)HEAD1,HEAD2
00320 11 FORMAT(A10,A10)
00330 WRITE(8,12)
00340 12 FORMAT("IF YOU WANT SIGMA CALCULATED TYPE YES OR NO")
00350 READ(7,13)SIGCAL
00359 13 FORMAT(A3)
00360 READ(5,79)NCONS
00361 79 FORMAT(T76I4)
00362 BACKSPACE 5 * IF(NCONS.EQ.1)GO TO 60
00363 WRITE(8,72)
00364 72 FORMAT("ENTER THE LAT. AND LONG. (DEG. & MIN.) OF THE LAST STATION ",
00365+ " IN NODC FORMAT:","/", " _____XXXXXXXX (4X,I2,I3,I3,I3)")
00366 READ(7,73)NLAT,NLATD,NLONG,NLONGD
00367 73 FORMAT(4X,I2,3(I3))
00368 ALAT=NLATD/10. * ALONG=NLONGD/10.
00369 RLAT(2)=NLAT+ALAT/60. * RLONG(2)=NLONG+ALONG/60.
00370 60 IPG=IPG+1
00371 IF(ISEC.EQ.0)GO TO 83
00372 IF(IPG.LT.50)GO TO 61
00373 83 IF(IPG.LT.42)GO TO 61
00374 WRITE(6,62)NSTA,NLTR,NDY,MONTH,NYR,AHR,NCONS * IPG=0 * ISEC=ISEC+1
00375 62 FORMAT(/,/,,12X," STA ",I3,A1,1X,I2"/",A4,"/",I2,2X,F4.1," GMT",1X,
00376+ "CONSEC STA",I4." [CONTINUED]"/,,38X,"OBSERVATIONS"/,

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00377+ T14"Z",T19"T",T25"S",T31"D",T36"SVA",T42"O2",T48"O2'",T53"AOU",
00378+ T59"PO4",T65"NO3",T72"SI")
00379 61 READ(5,1)LD
00380 IF(EOF(5))70,71
00390 71 CONTINUE
00400 IF(LD.EQ.4)GO TO 70$IF(LD.EQ.1)GO TO 80$IF(LD.EQ.6)GO TO 60
00410 IF(LD.EQ.3)GO TO 50
00420 80 BACKSPACE 5
00425 IPG=0 $ ISEC=0
00430 READ(5,2)NLAT,NLATD,NLONG,NLONGD,NYR,NMN,NDY,NHR,NCRU,NSTA,NZ
00440+,NWAD,NWHT,NWID,NWFO,NBAR,NAT2,NAT1,NWC,NCT,NCA,NVIS,NLTR,NCONS
00450 ALAT=NLATD/10.$ALONG=NLONGD/10.$AHR=NHR/10.
00600C WIND SPEED IS AS SPEED
00610C BAROMETER CALCULATION
00620 BAR=NBAR/10.
00630 IF(BAR.GE.0)GO TO 700
00640 BAR=BAR+900.$GO TO 701
00650 700 BAR=BAR+1000.
00660 701 CONTINUE
00690C WEATHER CODE IS AS IS
00700C CLOUD TYPE AS IS
00710C VISIBILITY AS IS
00720C MONTH TO ROMAN NUMERAL
00730 GOTO(751,752,753,754,755,756,757,758,759,760,761,762),NMN
00740 751 MONTH=# I#$GO TO 770
00750 752 MONTH=# II#$GO TO 770
00760 753 MONTH=# III#$GO TO 770
00770 754 MONTH=# IV#$GO TO 770
00780 755 MONTH=# V#$GO TO 770
00790 756 MONTH=# VI#$GO TO 770
00800 757 MONTH=# VII#$GO TO 770
00810 758 MONTH=#VIII#$GO TO 770
00820 759 MONTH=# IX#$GO TO 770
00830 760 MONTH=# X#$GO TO 770
00840 761 MONTH=# XI#$GO TO 770
00850 762 MONTH=# XII#$GO TO 770
00860 770 CONTINUE
00870C CLOUD AMOUNT CODE 9
00880 IF(NCA.EQ.9)NCA=1H*
00890C
00900C
00910C *****HEADER PRINTOUTS*****
00920 RLAT(1)=NLAT+ALAT/60.$RLONG(1)=NLONG+ALONG/60.
00930 IF(NCONS.GT.1)GO TO 2000
00940 DIST=0.$GO TO 2001
00950 2000 DEL)AT=ABS(RLAT(1)-RLAT(2))
00960 DELLON=ABS(RLONG(1)-RLONG(2))
00970 P=DELLON*COS((RLAT(1)+RLAT(2))*0.0087265)
00980 DIST=111.2*(P*P+DELLAT*DELLAT)**.5
00990 2001 RLAT(2)=RLAT(1)$RLONG(2)=RLONG(1)
01000 WRITE(6,550)HEAD1,HEAD2,NSTA,NLTR,NDY,MONTH,NYR,AHR,NCONS

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01010 550 FORMAT(///10X,A10,A10,1X," STA ",I3,A1,1X,I2"/",
01020+A4,"/",I2,1X,F4.1," GMT",1X,"CONSEC STA",I4)
01025 IND=IND+1
01030 WRITE(6,551)NLAT,ALAT,NLONG,ALONG,NZ,DIST
01040 551 FORMAT(/10X,"LAT ",I2,1X,F4.1,"N",2X,"LONG ",I2,1X,F4.1,"W",
01050+2X,"DEPTH =",I3,"M",2X,"DIST LAST STA = ",F5.1,"KM")
01055 IF(NWFO.EQ.0)WRITE(6,549)NWHGT
01060 IF(NWFO.NE.0)WRITE(6,552)NWFO,NWHGT
01070 552 FORMAT(/,10X,"WEATHER DATA",/,12X,"WIND SPEED      = ",I2,1X,"KTS",16X
01071+"SEA STATE          = ",A2)
01074 549 FORMAT(/,10X,"WEATHER DATA",/,12X,"WIND SPEED      = CALM",
01075+ 18X,"SEA STATE          = ",A2)
01077 IF(NWID.EQ.2H00)WRITE(6,74)
01078 74 FORMAT(12X,"WIND DIRECTION =          ",14X,"WAVE DIRECTION = ")
01081 IF((NWID.EQ.2H99).AND.(NWAD.EQ.2H  ))WRITE(6,75)
01082 75 FORMAT(12X,"WIND DIRECTION = VARIABLE",14X,"WAVE DIRECTION =")
01083 IF((NWID.EQ.2H99).AND.(NWAD.NE.2H  ))WRITE(6,76)
01084 76 FORMAT(12X,"WIND DIRECTION = VARIABLE",14X,"WAVE DIRECTION = ",
01085+ A2,"0 DEGR")
01090 IF((NWID.EQ.2H  ).AND.(NWAD.EQ.2H  ))WRITE(6,1002)
01100 1002 FORMAT(12X,"WIND DIRECTION = ",22X,"WAVE DIRECTION = ")
01110 IF((NWID.NE.2H  ).AND.(NWAD.EQ.2H  ).AND.(NWID.NE.2H99))WRITE(6,1003)NWID
01120 1003 FORMAT(12X,"WIND DIRECTION = ",A2,"0",19X,"WAVE DIRECTION = ")
01130 IF((NWID.NE.2H  ).AND.(NWAD.NE.2H  ).AND.(NWID.NE.2H99))WRITE(6,1004)
01135+NWID,NWAD
01140 1004 FORMAT(12X,"WIND DIRECTION = ",A2,"0", " DEGR",13X,
01145+"WAVE DIRECTION = ",A2,"0", " DEGR")
01150 IF((NWID.EQ.2H  ).AND.(NWAD.NE.2H  ))WRITE(6,1005)NWAD
01160 1005 FORMAT(12X,"WIND DIRECTION = ",22X,"WAVE DIRECTION = ",
01165+A2,"0 DEGR")
01170 553 CONTINUE
01300 WRITE(6,554)NAT2,NAT1,NCT
01310 554 FORHAT(12X,"AIR TEMP          = ",A2,1H.,A1,"C",17X,"CLOUD TYPE      = ",
01320+A1)
01330 WRITE(6,555)NWC,NCA
01340 555 FORMAT(12X,"WEATHER CODE     = ",A2,20X,"CLOUD AMOUNT     = ",A2)
01347C IF THERE IS VISABILITY DATA, PUT ",NVIS" AFTER BAR IN LINE 1350
01350 WRITE(6,556)BAR
01360 556 FORMAT(12X,"BAROMETRIC PRESSURE = ",F6.1," MB",8X,
01370+"VISIBILITY CODE = ",A1,"/10")
01380C WRITE OBSERVED HEADER CARD
01390 WRITE(6,3)
01400 3 FORMAT(/,38X,"OBSERVATIONS",/,T14"Z",T19"T",T25"S",T31"D",T36"SVA",
01410+T42"O2",T48"O2",T53"AOU",T59"PO4",T65"NO3",T72"SI")
01420 GO TO 60
01430 50 BACKSPACE 5
01440 READ(5,4)NDEPTH,NDEP,NTEMP,NSAL,NSIGMA,NOXY,PO41,PO42,NO31,NO32,S11,S12
01450 TEMP=NTEMP/100.$SAL=NSAL/100.$SIGMA=NSIGMA/100.
01460+$TK=TEMP+273.18$OXY=NOXY/100.
01470C***CALCULATE SIGMA T***
01480 IF(SIGCAL.NE.3HYES)GO TO 3000

```

```

01490 T=TEMP#SIGF1=((T-3.98)**2)*(T+283.)/(503.57)*(T+67.26)
01500 SIGF2=(T**3)*(1.0843E-6)-(T*T)*(9.8185E-5)+T*4.7867E-3
01510 SIGF3=(T**3)*(1.667E-8)-(T*T)*(8.164E-7)+T*1.803E-5
01520 SIGS=(SAL**3)*(6.767861E-6)-(SAL*SAL)*(4.82496E-4)+SAL*.814877
01530 SIGMA=-SIGF1+(SIGS+.03895414)*(1.-SIGF2+(SIGF3)*(SIGS-2.258458))
01540 3000 CONTINUE
01550C CALCULAT SVA(SPECIFIC VOLUME ANOMALY)
01560 FS=FS1*SAL**3+FS2*SAL**2+FS3*SAL
01570 A=NDEPTH*A1*(A2+A3*TEMP+A4*TEMP**2+A5*NDEPTH*TEMP)-
01580+(A6+A7*TEMP+A8*TEMP**2+A9*TEMP**3)
01590 B=((FS+D)/B1)*(B2-B3*TEMP+B4*TEMP**2-NDEPTH*B5*(B6-B7*TEMP+B8*
01600+TEMP**2)))*(-1.)+(FS+D)/B1**2*(B9-B10*TEMP-(NDEPTH*B5)*
01610+(B11-B12*TEMP))
01620 A350P=A31*(1.-NDEPTH*A32*(A33/(1.+A34*NDEPTH)+A35*NDEPTH+A36))
01630 ASTP=(1.-NDEPTH*AS1*(AS2/(1.+AS3*NDEPTH)+(A+B)))/(1.+SIGMA*AS4)
01640 SVA=ASTP-A350P
01650 SVA=SVA*100000.
01660 NSVA=SVA
01670 OXYSAT=EXP(C1+C2*(100./TK)+C3*ALOG(TK/100.)+C4*TK/100.
01680+SAL*(D1+D2*TK/100.+D3*(TK/100.）**2))
01685 ADU=OXYSAT-OXY
01690 IF(SAL.GT.0.00)GO TO 200
01695 IF(TEMP.EQ.0.0)GO TO 311
01700 IF(OXY.EQ.0.00)GO TO 250
01710 WRITE(6,210)NDEPTH,NDEP,TEMP,OXY,PO41,PO42,NO31,NO32,SI1,SI2
01720 210 FORMAT(10X,I3,1H.,I1,1X,F5.2,19X,F4.2,3X,1H.,5X,1H.,4X,A1,1H.,A2,2X,
01721+ A2,1H.,A1,2X,A2,1H.,A1)
01730 GO TO 60
01731 311 IF(OXY.EQ.0.0)GO TO 313
01732 WRITE(6,312)NDEPTH,NDEP,OXY,PO41,PO42,NO31,NO32,SI1,SI2
01733 312 FORMAT(10X,I3,1H.,I1,25X,F4.2,3X,1H. 5X,1H.,4X,A1,1H.,A2,2X,A2,1H.,A1,
01735+ 2X,A2,1H.,A1)
01736 GO TO 60
01737 313 WRITE(6,314)NDEPTH,NDEP,PO41,PO42,NO31,NO32,SI1,SI2
01738 314 FORMAT(10X,I3,1H.,I1,26X,1H.,5X,1H.,5X,1H.,4X,A1,1H.,A2,2X,A2,1H.,A1,
01739+ 2X,A2,1H.,A1)
01740 GO TO 60
01741 250 WRITE(6,251)NDEPTH,NDEP,TEMP,PO41,PO42,NO31,NO32,SI1,SI2
01750 251 FORMAT(10X,I3,1H.,I1,1X,F5.2,3X,1H.,5X,1H.,5X,1H.,4X,1H.,5X,
01751+ 1H.,4X,A1,1H.,A2,2(2X,A2,1H.,A1))
01760 GO TO 60
01770 200 IF(OXY.EQ.0.00)GO TO 300
01780 WRITE(6,5)NDEPTH,NDEP,TEMP,SAL,SIGMA,NSVA,OXY,OXYSAT,ADU,PO41,PO42,NO31,
01785+ NO32,SI1,SI2
01790 GOTO 60
01800 300 WRITE(6,6)NDEPTH,NDEP,TEMP,SAL,SIGMA,NSVA,PO41,PO42,NO31,NO32,SI1,SI2
01810 6 FORMAT(10X,I3,1H.,I1,3(1X,F5.2),2X,I3,3X,1H.,5X,1H.,5X,1H.,4X,A1,1H.,
01811+ A2,2X,A2,1H.,A1,2X,A2,1H.,A1)
01820 GO TO 60
01830 1 FORMAT(79X,I1)
01840 2 FORMAT(4X,I2,3I3,3X,3I2,I3,A3,I3,I4,8X,A2,A1,1X,A2,I2,I3,A2,A1,3X,A

```

```
01850+2,A1,A1,A1,A1,7X,I4)
01860 4 FORMAT(28X,I3,I1,I4,1X,I4,1X,I4,4X,I3,A1,A2,6X,A2,A1,A2,A1)
01870 5 FDMAT(10X,I3,1H.,I1,3(1X,F5.2),2X,I3,2X,F4.2,2(1X,F5.2),2X,A1,1H.,
01880+ A2,2X,A2,1H.,A1,2X,A2,1H.,A1)
01890 70 WRITE(B,77)IND
01895 77 FORMAT("###",I4,"###=THE NUMBER OF CASTS NOW ON TAPE7.")
01898 STOP
01900 END
```

APPENDIX IV.

HP Programs

The following programs are written for the HP 9825A desktop computer with the following options:

98214A 9862A Plotter - General I/O -
Extended I/O ROM

98210A String-Advanced Programming ROM

98324A Systems Programming ROM

and

24K core

The 9825A internal printer is 16 characters wide. Using a RS-232C interface to a T.I. Silent 700 ASR terminal provides an 80 character printout. Some characters are not the same, such as:

<u>HP</u>	<u>T.I.</u>
→]
Lower case	Little caps.
↑	^

The programs are stored by file on the internal cassette and are as follows:

<u>File</u>	<u>Name</u>
0	Master File
1	Special Function Keys
2	Taking a Cast
3	List D, C, T
4	Bottom Soak
5	Downcast Average
6	Mid-depth Soak
7	Upcast Average
8	Salinity Plot

The programs are stored on track 1, files 0-8. The preliminary data are stored on track 1 from file 10 on. The final data (filtered and meter averaged) is stored on track 0, file 0 on.

SPECIAL FUNCTIONS				SAL. PRINT	
S	END	END	START	NO	YES
	CAST	SOAK	mid-D		
S			SOAK		
	0-380	380-760			
	Cast D Scales				

Overlay used for Special Function Keys

MASTER PROGRAM

```

0: PRT " MASTER PROGRAM";PRT "  ♦♦♦♦♦♦♦♦";GTO +2
1: SFG 1
2: PRT "TYPE PROGRAM # AND PRESS          CONTINUE TO RUN"
3: IF FLG1=1;CFG ;GTO 17
4: PRT "ONE OF THESE:";SPC 1
5: PRT "0 THIS ONE          STOPS THE          MASTER PROGRAM"
6: PRT "1 THIS ONE          ALREADY LOADED  THE SPECIAL    FUNCTION KEYS"
7: PRT "2  TAKING A CAST"
8: PRT "3    LIST D,C,T"
9: PRT "4    BOTTOM SOAK"
10: PRT "5 DOWNCAST AVER."
11: PRT "6 MID-DEPTH SOAK"
12: PRT "7  UPGAST AVER."
13: PRT "8  SALINITY PLOT"
14: PRT "9  TEMP. PLOT"
15: PRT "10 1ST DATA FILE"
16: PRT "  ♦♦♦♦♦♦♦♦";SPC 2
17: ENT "PROGRAM #";P
18: IF P=0;GTO 20
19: TRK 1;LDK 1;LDP P
20: END

```

TAKING A CAST

```

0: DIM A(3,799)
1: TRK 1;LDR 1
2: IF FLG2=1;GTO 24
3: SPC 2;PRT "MONTH DAY TIME"
4: RED 720,W;FXD 0;INT(W/1E8)M;(W/1E8-INT(W/1E8))*1E2)D
5: (W/1E6-INT(W/1E6))*1E4)H
6: FMT 2,1X,F2.0,4X,F2.0,1X,F4.0
7: WRT 16.2,M,D,H
8: IF Z#0;GTO 16
9: ENT "DEPTH FREQ. OF CTD IN AIR"Z
10: ENT "COND. FREQ. OF CTD IN AIR",E
11: ENT "STATION NUMBER?",P
12: PRT "STATION NUMBER=",P;PRT "D FREQ IN AIR",Z,"*"
13: PRT "C FREQ IN AIR",E,"*"
14: PRT "WHEN THE CTD CAST ENDS PRESS SPECIAL FUNCTIONKEY F0.
15: PRT "FOR MID-DEPTH SOAKING,PRESS SPECIAL FUNCTIONKEY F2."
16: PRT "*";SPC 1;DSP "WAIT FOR AXES PLOT."
17: SCL 0,380,5,30
18: AXE 0,5,20,5
19: DSP "PRESS CONTINUE WHEN IT'S ALL RDY";STP
20: O)N;10)K
21: 1)M
22: GSE "READ"
23: FOR I=1 TO 799;O)A(1,I)A(2,I)A(3,I);NEXT I
24: GSE "READ"
25: GSE "CON"
26: D)P;C)Q;T)R
27: GSE "READ"
28: GSE "CON"
29: D)S;C)U;T)V)Q
30: GSE "READ"
31: GSE "CON"
32: IF FLG1=1;GTO "REC"
33: IF FLG3=1;CFG 2;PEN;TRK 1;LDR 6,0,0
34: D)W;C)X;T)Y
35: V+.35(Y-R)/.810)V
36: FXD 1;DSP "D=",S,"T=",V,M,K
37: FXD 3;PLT S,V
38: S)A(1,M);U)A(2,M);V)A(3,M)
39: S)P;W)S;U)Q;X)U;D)R;Y)V)Q
40: IF M<799;M+1)M;GTO 30
41: DSP "STOP WINCH (STOPPED AT",S,"M)"
42: PEN;TRK 1;RCF K,A[*];K+1)K;GTO 21
43: "CON":
44: (1/D-2)*.38071)D
45: (1/C-E)*.02065)C
46: (1/T-2127)*.01791-2)T
47: RET
48: "READ":
49: WRT 719,"B1";WRT 718,"PF762T";WAIT 30;RED 718,D

```

```
50: WRT 719,"B2";WRT 718,"PF762T";WAIT 30;RED 718,C
51: WRT 719,"B3";WRT 718,"PF763T";WAIT 30;RED 718,T
52: RET
53: "REC":
54: PEN;TRK 1;RCF K,A[+]
55: IF FLG2=1 OR D<5;GTO 57
56: DSP "NOW DO THE CALIBRATION SOAK.";GTO 60
57: FXD 0;PRT "THE FIRST AND LAST FILES OF THISCAST ARE      10 AND";K
58: PRT "      *****";SPC 2
59: IF FLG2=1 OR D<5;CFG ;PRT "UPCAST AVER. IS #7";TRK 1;LDF 0,0,1
60: TRK 1;LDF 4,0,0
61: END
```

LIST D,C,T

```
0: DIM A[3,799]
1: DSP "MAKE SURE DATA TAPE IS IN PLACE!";WAIT 1000
2: ENT "STATION NUMBER?";P
3: FXD 0;PRT "STATION NUMBER=";P
4: ENT "WHICH TAPE TRACK?";Q
5: PRT " D C T"
6: ENT "STARTING DATA FILE=";S
7: ENT "LAST DATA FILE=";N
8: FOR L=S TO N
9: TRK Q;LDF L,A[♦]
10: FOR J=1 TO 799
11: IF A[2,J]=0;GTO 18
12: IF A[1,J]>99;GTO 15
13: FMT 1,F4.1,F6.2,F6.2
14: WRT 16.1,A[1,J],A[2,J],A[3,J];GTO 17
15: FMT 3,F4.0,F6.2,F6.2
16: WRT 16.3,A[1,J],A[2,J],A[3,J]
17: NEXT J
18: PRT " "
19: NEXT L
20: DSP "D,C,T LISTED; WHAT NEXT?"
21: SFG 2;TRK 1;LDF 0,0,1
22: END
```

BOTTOM SOAK

```

0: PRT "◆◆◆◆SOAKING◆◆◆◆"
1: PRT "MONTH DAY TIME"
2: RED 720,W;INT(W/1E8)X;(W/1E8-INT(W/1E8)*1E2)Y
3: (W/1E6-INT(W/1E6))*1E4)Q
4: FMT 2,1X,F2.0,4X,F2.0,1X,F4.0
5: WRT 16.2,X,Y,Q
6: PRT "  D    T    S"
7: O)P
8: GSE "READ"
9: GSE "READ"
10: GSE "CON"
11: D)F;C)G;T)H
12: I+1)I
13: GSE "READ"
14: IF FLG2=1;GTO 59
15: GSE "CON"
16: O)J
17: IF R3-Q=4;GSE "WARN"
18: IF P>3;O)P;SPC ;GTO 9
19: IF D>F+5 OR D<F-5;P+1)P;GTO 12
20: IF C>G+.05 OR C<G-.05;P+1)P;GTO 12
21: IF T>H+.05 OR T<H-.05;P+1)P;GTO 12
22: GSE "SAL"
23: FXD 1;DSP "D=",D,"T=",T,"S=",S,I,K
24: IF I>=5;O)I;GTO 26
25: GTO 12
26: FMT 3,F3.0,F6.2,F7.3
27: WRT 16.3,D,T,S
28: GTO 11
29: "WARN":
30: PRT "◆";PRT "THE CTD HAS SOAKED FOR 4 MINUTES◆◆TRIP BOTTLE◆◆";PRT "◆"
31: PRT "PRESS SPECIAL FUNCTION KEY F1 AFTER THE TRIP. ◆"
32: RET
33: "SAL":
34: GTO +3
35: 1)J;.01(1.551-.0453T+5.9E-4T^2+.25(35-S)(.043-.0017T+2.3E-5T^2))3B
36: 1+B*(1.037E-3D-3.2E-8D^2)R4
37: (676547+20131.5T+99.89T^2-.1943T^3-.00672T^4)1E-63U
38: IF J=1;GTO +2
39: C/42.896U)R1;GTO +2
40: C/(R4+U+42.896)3R1
41: R1(R1-1)(T-15)(96.7-72R1+37.3R1^2-(.63+.21R1^2)(T-15))1E-5)R2
42: R1+R2)R3
43: -.092+28.3R3+12.808R3^2-10.679R3^3+5.986R3^4-1.323R3^5)S
44: IF J=0;GTO 35
45: RET
46: "CON":
47: (1/D-2)*.38071)D
48: (1/C-E)*.02065)C
49: (1/T-2127)*.01791-2)T

```

```
50: INT (R0/1E8)R1; (R0/1E8-INT (R0/1E8))*1E2R2
51: (R0/1E6-INT (R0/1E6))*1E4R3
52: RET
53: "READ":
54: WRT 719,"B1";WRT 718,"PF762T";WAIT 35;RED 718,D
55: WRT 719,"B2";WRT 718,"PF762T";WAIT 35;RED 718,C
56: WRT 719,"B3";WRT 718,"PF763T";WAIT 35;RED 718,T
57: RED 720,R0
58: RET
59: PRT " *****";SPC 1;FXD 0
60: PRT "THE FIRST AND LAST FILES OF THISCAST ARE      10 AND ";K;SPC 1
61: TRK 1;LDF 5,0,0
62: END
```

DOWNCAST AVERAGING

```

0: DIM A[3,799]
1: DIM B[3,80]
2: SPC 1;PRT "♦DOWNCAST AVER.♦"
3: ENT "LAST FILE OF PRELIM. DATA SET?";K
4: PRT "YOU TYPED";K
5: ENT "NEXT FILE FOR DATA STORAGE?";U;U>V
6: PRT "YOU TYPED";U
7: 1.5>E
8: 1>J
9: PRT "  D    C    T"
10: FOR L=10 TO K
11: TRK 1;LDF L,A[♦]
12: 0>P
13: FOR M=3 TO 799
14: P+1>Q
15: IF P=3;0>P
16: IF A[1,M]>A[1,M-Q]+5 OR A[1,M]<A[1,M-Q]-5;P+1>P;GTO 24
17: IF A[2,M]>A[2,M-Q]+.8 OR A[2,M]<A[2,M-Q]-.8;P+1>P;GTO 24
18: IF A[3,M]>A[3,M-Q]+.5 OR A[3,M]<A[3,M-Q]-.5;P+1>P;GTO 24
19: IF A[1,M]<E-1;GTO 24
20: IF A[1,M]>=E;GSB "STOR"
21: IF L=K AND A[1,M]=0 AND A[3,M]=0;GSB "STOR"
22: F+A[1,M]>F;G+A[2,M]>G;H+A[3,M]>H
23: I+1>I;0>P
24: NEXT M
25: SPC 1;NEXT L
26: REN;TRK 0;RCF U,B[♦]
27: FXD 0;PRT "THE FIRST AND LAST FILES OF SAVED DATA ARE";V;" AND";U
28: DSP "NOW DO THE UPCAST";WAIT 1000
29: SPC 2;PRT "FOR SOAKING WHILE A BOTTLE TRIPSPRESS S.F.K. F2."
30: TRK 1;LDF 2,0,0
31: "STOR":
32: IF F=0;GTO 45
33: F/I>F;G/I>G;H/I>H
34: IF F<99.5;GTO +4
35: FMT 5,F3.0,F7.2,F6.2
36: WRT 16.5,F,G,H
37: GTO +3
38: FMT 1,F4.1,F6.2,F6.2
39: WRT 16.1,F,G,H
40: F>B[1,J];G>B[2,J];H>B[3,J]
41: IF J=80;GSB "REC"
42: J+1>J
43: INT(F+.5)+1.5>E
44: GTO 46
45: E+1>E
46: 0>F>G>H>I
47: RET
48: "REC":
49: TRK 0;RCF U,B[♦]
50: FOR N=1 TO 80;0>B[1,N]>B[2,N]>B[3,N];NEXT N
51: 0>J;U+1>U
52: RET
53: END

```

MID-DEPTH SOAK

```

0: SFC 1;PRT "*****SOAKING*****"
1: PRT "WHEN THE UPCAST IS TO BE RESUMEDPRESS SPECIAL FUNCTION KEY F1."
2: PRT " D T S"
3: 0)P
4: GSB "READ"
5: GSB "READ"
6: GSB "CON"
7: D)F;C)G;T)H
8: I+1)I
9: GSB "READ"
10: IF FL62=1;GTO 47
11: GSB "CON"
12: 0)J
13: IF P>3;0)P;SFC ;GTO 5
14: IF D>F+5 OR D<F-5;P+1)P;GTO 8
15: IF C>G+.05 OR C<G-.05;P+1)P;GTO 8
16: IF T>H+.05 OR T<H-.05;P+1)P;GTO 8
17: GSB "SAL"
18: FXD 1;DSP "D=",D,"T=",T,"S=",S,I,K
19: IF I>=5;0)I;GTO +2
20: GTO 8
21: FMT 3,F3.0,F6.2,F7.3
22: WRT 16.3,D,T,S
23: GTO 7
24: "SAL":
25: GTO +3
26: 1)J;.01(1.551-.0453T+5.9E-4T^2+.25(35-S)(.043-.0017T+2.3E-5T^2))B
27: 1+B*(1.037E-3D-3.2E-8D^2)R4
28: (676547+20131.5T+99.89T^2-.1943T^3-.00672T^4)1E-6)U
29: IF J=1;GTO +2
30: C/42.896U)R1;GTO +2
31: C/(R4+U+42.896)R1
32: R1(R1-1)(T-15)(96.7-72R1+37.3R1^2-(.63+.21R1^2)(T-15))1E-5)R2
33: R1+R2)R3
34: -.092+28.3R3+12.808R3^2-10.679R3^3+5.986R3^4-1.323R3^5)S
35: IF J=0;GTO 26
36: RET
37: "CON":
38: (1/D-2)+.38071)D
39: (1/C-E)+.02065)C
40: (1/T-2127)+.01791-2)T
41: RET
42: "READ":
43: WRT 719,"B1";WRT 718,"PF762T";WAIT 30;RED 718,D
44: WRT 719,"B2";WRT 718,"PF762T";WAIT 30;RED 718,C
45: WRT 719,"B3";WRT 718,"PF763T";WAIT 30;RED 718,T
46: RET
47: PRT " *****" ;SFC 1
48: CFG 1,3;TRK 1;LDF 2,0,1
49: END

```

UPCAST AVERAGING

```

0: DIM A(3,799)
1: DIM B(3,80)
2: SPC 1;PRT "◆◆UPCAST AVER.◆◆"
3: ENT "LAST FILE OF PRELIM. DATA SET?";K
4: PRT "YOU TYPED";K
5: ENT "NEXT FILE FOR DATA STORAGE?";U;U)V
6: PRT "YOU TYPED";U
7: 500)E
8: 1)J
9: PRT "" D C T"
10: FOR L=10 TO K
11: TRK 1;LDF L,A[◆]
12: 0)P
13: FOR M=3 TO 799
14: P+1)Q
15: IF P=3;0)P
16: IF A[1,M]>A[1,M-Q]+5 OR A[1,M]<A[1,M-Q]-5;P+1)P;GTO 24
17: IF A[2,M]>A[2,M-Q]+.8 OR A[2,M]<A[2,M-Q]-.8;P+1)P;GTO 24
18: IF A[3,M]>A[3,M-Q]+.5 OR A[3,M]<A[3,M-Q]-.5;P+1)P;GTO 24
19: IF A[1,M]>E+1;GTO 24
20: IF A[1,M]<=E;GSE "STOR"
21: IF L=K AND A[1,M]=0 AND A[3,M]=0;GSE "STOR"
22: F+A[1,M]>F;G+A[2,M]>G;H+A[3,M]>H
23: I+1)I;0)P
24: NEXT M
25: SPC 1;NEXT L
26: REN;TRK 0;RCF U,B[◆]
27: DSP "NEXT..PLOT SALINITY; UP OR DOWN."
28: FXD 0;PRT "THE FIRST AND LAST FILES OF SAVED DATA ARE";V;"AND";U
29: PRT " ◆◆◆◆◆◆◆◆◆◆";SPC 2
30: PRT "SAL. PLOT IS #8"
31: TRK 1;LDF 0,0,1
32: "STOR":
33: IF F=0;GTO 45
34: F/I)F;G/I)G;H/I)H
35: IF F<99.5;GTO +4
36: FMT 5,F3.0,F7.2,F6.2
37: WRT 16.5,F,G,H
38: GTO +3
39: FMT 1,F4.1,F6.2,F6.2
40: WRT 16.1,F,G,H
41: F)B[1,J];G)B[2,J];H)B[3,J]
42: IF J=80;GSE "REC"
43: J+1)J
44: INT(F+.5)-1.5)E
45: 0)F)G)H)I
46: RET
47: "REC":
48: REN;TRK 0;RCF U,B[◆]
49: FOR N=1 TO 80;0)B[1,N]>B[2,N]>B[3,N];NEXT N
50: 0)J;U+1)U
51: RET
52: END

```

SALINITY PLOT

```

0: DIM K(3,80);SCL 0,380,32,37
1: DEF "DO YOU WANT THE PRINTOUT?";STP
2: SFG 4
3: ENT "FIRST FILE?";A
4: ENT "LAST FILE?";Z
5: FOR L=A TO Z
6: TRK 0;LDF L,K[*]
7: IF FLG4=1;GTO +2
8: FXD 0;SPC 1;PRT "◆◆◆FILE◆◆◆ ",L;PRT " D T S";FXD 2
9: FOR I=1 TO 80
10: 0)J
11: K(1,I)D;K(2,I)C;K(3,I)T
12: IF D=0 AND C=0;GTO 35
13: GTO +3
14: 1)J;.01(1.551-.0453T+5.9E-4T^2+.25(35-S)(.043-.0017T+2.3E-5T^2))B
15: 1+B*(1.037E-3D-3.2E-8D^2)R4
16: (676547+20131.5T+99.89T^2-.1943T^3-.00672T^4)1E-6)Z
17: IF J=1;GTO +2
18: C/42.8962)R1;GTO +2
19: C/(R4+Z+42.896)R1
20: R1(R1-1)(T-15)(96.7-72R1+37.3R1^2-(.63+.21R1^2)(T-15))1E-5)R2
21: R1+R2)R3
22: -.092+28.3R3+12.808R3^2-10.679R3^3+5.986R3^4-1.323R3^5)S
23: IF J=0;GTO 14
24: IF D>99;GTO 30
25: FMT 1,F4.1,F6.2,F6.2
26: IF FLG4=1;GTO +2
27: WRT 16.1,D,T,S
28: PLT D,S
29: GTO 34
30: FMT 2,F4.0,F6.2,F6.2
31: IF FLG4=1;GTO +2
32: WRT 16.2,D,T,S
33: PLT D,S
34: NEXT I
35: NEXT L
36: PRT " ◆◆◆◆◆◆◆◆◆◆";SPC ;PRT "PREP. FOR NEXT STATION";SPC
37: PEN;CFG 4;TRK 1;LDF 0,0,1
38: END

```

APPENDIX V.

Sample HP-CTD Cast Printout

The following is a sample listing of an HP-CTD cast. The various sections of the printout are as follows:

1. The Master Program (TRK1, FILE 0) provides access to the other programs. It also loads the special function keys.

2. Program 2 reads the clock and prints the month, day, and hour. It then asks for the station number followed by depth and conductivity zero frequencies.

*During the cast, both depth and temperature are displayed on the LED display. Special function key f0 ends the cast and puts the 9825A into a soak routine. The 9825A times the soak and after 4 minutes prints the time and continues. During the soak, 5 consecutive temperature values are averaged and printed unless one of the values varies by more than 0.05°C from others, in which case a space is printed. This visually displays the quality of the soak for calibration purposes.

*After the soak, program 4 prints the first and last preliminary data files, in this case files 10 and 13.

3. Program 4 loads and runs program 5 which prints the downcast one meter averaged data and asks where to store that data (files 8 and 9 in this case).

4. The upcast is similar to the downcast with final data stored on files 10 and 11.

5. Program 8 simultaneously prints and plots salinity values for the up and down cast if requested.

```

MASTER PROGRAM          144 13.50 35.629
*****
Type program #         146 13.26 35.627
and press
CONTINUE to run
one of these:
0 this one
  stops the
  Master Program
1 this one
  already loaded
  the special
  function keys
2 Taking a Cast
3 List D,C,T
4 Bottom Soak
5 Downcast Aver.
6 Mid-Depth Soak
7 Upcast Aver.
8 Salinity Plot
9 1st data file
*****

Month Day Time
  4 23 1046
Station number=
  118
D freq in air=
  9712
*
C freq in air=
  5005
*
When the CTD
cast ends press
Special Function
Key f0.
*
For Mid-Depth
soaking, press
Special Function
Key f2.
*
****SOAKING****
Month Day Time
  4 23 1107
  D T S
145 13.40 35.600
145 13.42 35.601
145 13.46 35.610
144 13.50 35.602

142 13.64 35.627
142 13.64 35.619

144 13.50 35.629
*****
The first and la
st files of this
cast are 10
and 13

*DOWNCAST AVER.*
you typed 13
you typed 8
  D C T
2.7 55.38 25.81
3.8 55.37 25.82
5.0 55.36 25.82
.
.
147 41.87 13.19

148 41.77 13.10
149 41.65 13.06

The first and
last files of
saved data are 8
and 9

For soaking whil
e a bottle trips
press S.F.K. f2.

Month Day Time
  4 23 1111
Station number=
  118
D freq in air=
  9712
*
C freq in air=
  5005
*
When the CTD
cast ends press
Special Function
Key f0.
*
For Mid-Depth
soaking,press
Special Function
Key f2.
*

****SOAKING****
When the upcast
is to be resumed
press Special
Function Key f1.
*
  3 25.00 36.092
  4 25.80 36.097
  4 25.80 36.086

  4 25.80 36.132
  4 25.80 36.093

  4 25.80 36.085
  3 25.80 36.084
*****

The first and la
st files of this
cast are 10
and 12
*****

Upcast Aver. is
#7
Type program #
and press
CONTINUE to run

**UPCAST AVER.**
you typed 12
you typed 10
  D C T
157 40.85 12.34
156 40.86 12.36
155 40.98 12.48
.
.
3.3 44.38 25.80
1.8 55.39 25.80
1.1 55.32 25.80

The first and
last files of
saved data are
10
and 11
*****

Sal. Plot is
#8
Type program #
and press
CONTINUE to run
*****

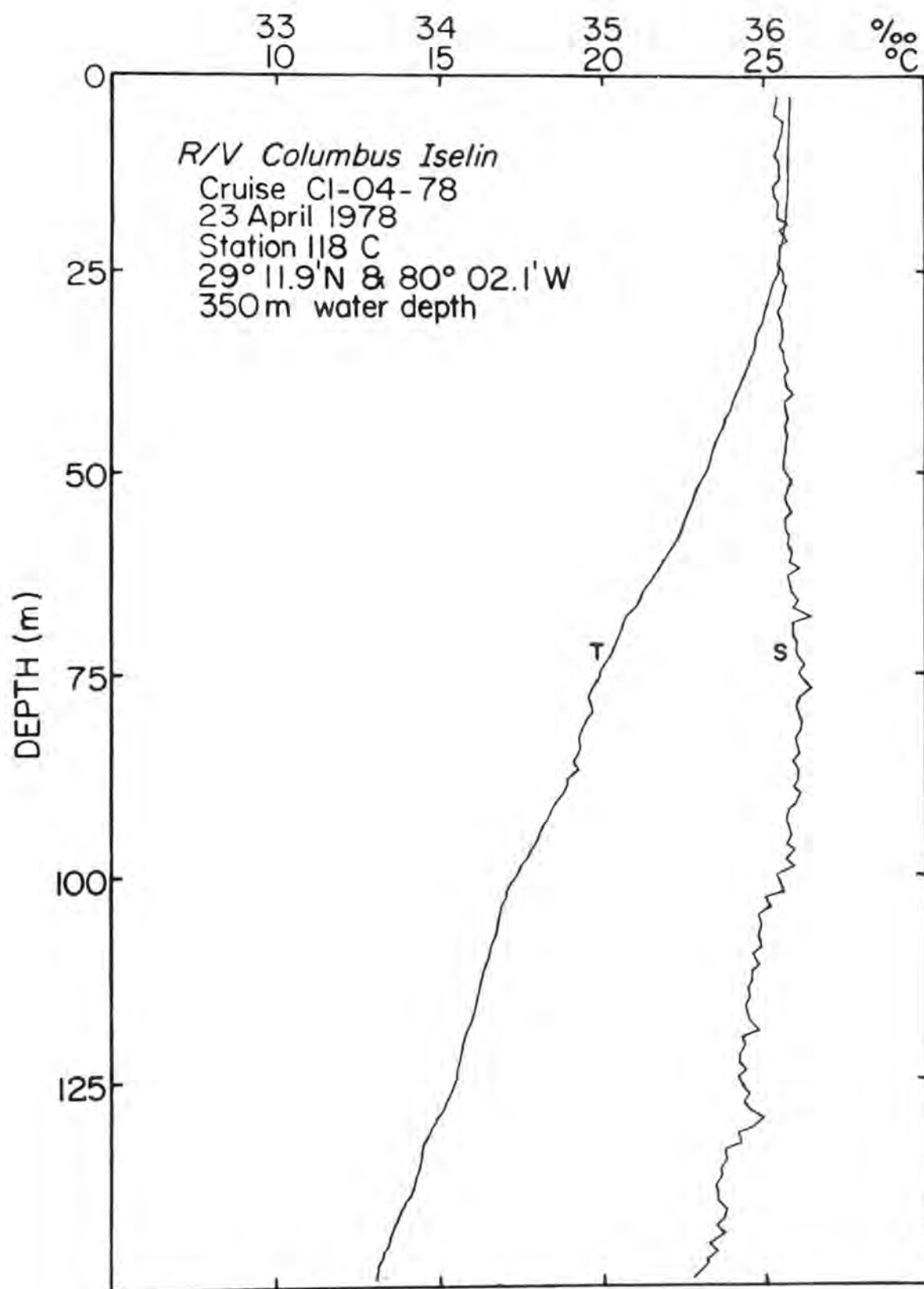
***File*** 8
  D T S
2.7 25.81 36.09
3.8 25.82 36.07
5.0 25.82 36.07
.
.
80.9 19.53 36.24
81.9 19.41 36.23

***File*** 9
  D T S
82.9 19.30 36.21
.
.
147 13.19 35.64
148 13.10 35.63
149 13.06 35.56
*****

prep. for
NEXT STATION

Type program #
and press
CONTINUE to run

```



APPENDIX VI.

Data Logging Forms

CTD-SALINITY ERROR ANALYSIS

SENSOR (Accuracy)	Maximum ‰ Error	
	Shallow	Deep
Conductivity ($\pm .03$ mmho/cm)		
Temperature ($\pm .02^{\circ}\text{C}$)		
Depth (± 1.5 m)		
‰ Equation: _____		
Total		

DIGITIZING (RESOLUTION)	Maximum ‰ Error	
	Shallow	Deep
Conductivity ($\pm .01$ mmho/cm)		
Temperature ($\pm .005^{\circ}\text{C}$)		
Depth ($\pm .10$ m)		
Total		

<u>(Values used for error analysis)</u>	
SHALLOW	DEEP
Cond. _____	Cond. _____
Temp. _____	Temp. _____
Depth _____	Depth _____

