PRNC ~ 190 PUERTO RICO NUCLEAR WATERS 'A MANUAL FOR HYDROGRAPHIC CRUISES Prepared for the Puerto Rico Water Resources Authority By the Staff of Puerto Rico Nuclear Center of the University of Puerto Rico May 1975, OPERATED BY UNIVERSITY OF PUERTO RICO UNDER CONTRACT 'NO- AT (40-1)1833 FOR US ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION ---Page Break--- ---Page Break--- PRNC ~ 190 (A MANUAL FOR HYDROGRAPHIC CRUISES By E. D. Wood. May, 1975 ---Page Break--- ---Page Break--- TABLE OF CONTENTS ---Page Break--- Table of Contents (continued) ---Page Break--- A MANUAL FOR HYDROGRAPHIC CRUISES by E.D. Wood INTRODUCTION This handbook is intended to serve as a guide to persons planning and executing hydrographic cruises and those who interpret and evaluate the resulting data. It is expected that persons reading this manual will have some basic knowledge of the subject and will use the references cited. The general process is outlined in Table 1 and explained in the text. The Appendix contains examples of data sheets, detailed explanations for the station log sheet and computer programs used in data processing. ---Page Break--- Table 1. HYDROGRAPHIC RESEARCH Information required Stations-Depths Sampling frequency Coordination with other investigators Personnel Equipment Vessel Procedures Temperature Salinity Dissolved Oxygen Nutrients Special water chemistry Associated Data ---Page Break--- Table 1 (continued) SAMPLE ANALYSES STANDARDS Rev. Therm. BY Plots Salinities D.O. Nutrients pH, T.E., BOD, COD, R.N. DATA ASSEMBLY Data Reduction Computer Print Out Plots Standard depths Conversion Plots Reports Supporting Agency Out-of-house Publications ---Page Break--- HYDROGRAPHIC PROCEDURES Hydrographic Cruise Numbers Each cruise of a boat or ship receives a unique serial number containing two letters of the ship's name, a dash, and a three-digit Arabic number. For example, for the RY RLF Palumbo, "PA", then dash "-", then the three-digit number, "123." The final serial number reads PA-123. Usually, the number is used for all ship sampling from the time the vessel leaves port until it returns. The same cruise number may be used even though the vessel has put into port if the work is at one site or region. Multiple cruise numbers may be assigned if the chief scientist and/or the mission change before the vessel returns to its home port. Station Number Each station occupied by the ship receives a unique station number. Station numbers run consecutively continuing from one cruise to the next. The

Combination of the three digits of the cruise number and the last three digits of the station number make up the reference number for the station. Bridge Log At the time of sampling, the bridge officer is responsible for filling out a bridge log in duplicate. This log contains the following information: cruise and station numbers, dates and times, weather conditions, position, and type of sampling. The original copy goes to the chief scientist and the carbon copy is placed in the ship's file. (Example in Appendix.)

Crew The ship's captain has the overall responsibility for the ship's operation, the safety of the ship, and all persons on board. A scientist, usually the ranking staff member on the cruise, is designated as "Chief Scientist" and is responsible for the successful completion of the scientific effort. He is assisted by a "Cruise Leader." One or more "Group Leaders" may also be designated on a multiple discipline or round-the-clock sampling type of cruise.

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The chief scientist is responsible for the scientific effort and coordinates with the ship's captain to carry out the scientific effort. A cruise plan is made out under the direction of the chief scientist and furnished to the ship's captain and members of the scientific crew. The basic welfare of the scientific crew regarding job assignments, proper rest and nourishment, cleanliness of staterooms, etc., are the responsibilities of the chief scientist, as well as supervising the proper procedures and techniques for obtaining the desired scientific goal.

The scientific crew is obliged to refrain from ship's crew activities except when requested to act by a responsible member of the ship's crew, or if action is needed to prevent damage or harm to the ship, personnel, or equipment. Any unsolicited actions are reported to the watch officer as soon as practical. Upon request from the captain, the chief scientist should furnish a list of scientific personnel who can participate in the ship's watch. The chief scientist may delegate.

any or all of the above mentioned activities, but he is not relieved of responsibilities for them. A cruise plan is a flexible schedule of work to be done and a brief description of how the work is to be accomplished. How well it is followed depends upon the forethought of the originator, the preparedness of the entire crew, and the occurrence of non-controllable interferences. The cruise plan includes the following headings: I. Research Vessel Personnel II. Supporting Agency III. Cruise Name and Number IV. Dates: Equipment V. Total Days & Miles VI. Objectives and maps showing the cruise. A copy of the cruise plan is distributed to the scientific crew, the ship (several copies), project leader, division head, office in charge of the ship, and other interested parties. The cruise plan should be followed closely to accomplish the objectives, but changes can be at the discretion of the chief Scientist and/or the ship's captain. ---Page Break--- Hydrographic Station Log The data for each hydrographic station are recorded in duplicate on a station log sheet by the persons working on both. This sheet is composed of three sections. It is designed to have the data key punched for computer analysis. The first section is called the "Master Card" and contains the following: name of ship, cruise and station identification, position, date, time, depth, weather, and sea conditions. The second section is the "Parameter Card" which provides information on the casts: number, time, depths, oxygen calculation factor, and meter wheel correction factor. The third section is the “Data Card” and has the actual data for each depth. The cast number, depth of the sample, water sampling bottle number, thermometer numbers and readings, and individual sample bottle numbers are recorded in this section. U.S. Navy Hydrographic OF. Pub. 607 § G14). (A step-by-step explanation for filling out the station log is given in the Appendix.) Most oceanographic ships are equipped with a mechanical winch with a stainless steel wire rope of

about Smm (3/16") diameter of varying lengths with a lead weight on the end. This wire is fed through a motoring block about 3m (10 ft.) off the deck and down over the side of the ship. Sampling equipment is then clamped to the wire and lowered to the desired depth. The sampling equipment is usually handled by the scientific crew, while the operation of the hydro-winch falls to members of the ship's crew. The meter wheel is calibrated periodically by measuring a segment of wire passing through the meter wheel. The depth of the sample is determined mathematically using the wire angle and the meter wheel correction factor. The sample depth is also calculated from reversing thermometer data. Water samples are collected by lowering a bottle open at the end, to the desired depth, then closing the end plugs or valves with a "messenger" and returning the bottle to the deck of the ship. Several types of sampling bottles have been devised. A well-known oceanographic sampler is the Nansen bottle, which is clamped on the hydro-wire by one end, then the entire bottle is inverted and clipped into place. This bottle has connected, rotating valves, one at each end, and a rack which holds two to four thermometers. A number of other types of water samplers have been developed and some are available commercially. One such bottle, the Niskin bottle, is made of PVC which minimizes metal contamination. The model commonly used at the Puerto Rico Nuclear Center (PRNC) holds five liters and is sufficient for most sampling (twelve and thirty liter bottles are used also). The five liter bottles are equipped with thermometer racks holding three thermometers each. These bottles differ from the Nansen bottles in that they are clamped to the hydro-wire with two bolts, the ends are closed at depth by tripping two end plugs which are pulled together by a spring or elastic passing through the middle of the bottle, and the thermometers are reversed by a rotating rack on the side of the bottle. When sampling in series on a

cast, each bottle above the bottom one has a messenger attached to it. The messenger is a brass weight which clamps freely around the wire and is attached to the bottle by a short lanyard. The bottles are placed on the hydro-wire at predetermined intervals, recorded on the station sheet, and on a card used by the winch operator as shown below: Table 2. Example of information recorded on the Station Log and Winch Card. Estimated Meter Bottle cast Depth Wheel Slippage Number 303 1 100 1 1 25 7 2 1 50 50 3 1 100 Since all bottles are on the same cast (column 1), all are numbered the same under "Cast." If a second or third cast is necessary, either for samples at different depths, a malfunction in the cast, or additional samples at the same depth, the casts are so numbered, e.g., Cast 2, 3. The desired depth of the sample is entered (column 2) in descending order with depth being measured in meters positively down from the surface. The bottles are hung on the hydro-wire in reverse order with the meter wheel reading, shown in column 3, corresponding to the bottle numbers shown in column 5. The meter wheel reading is determined by subtracting the estimated depth of each bottle from the deepest depth sampled on the cast. The additional three meters (column 3, supra) on the ship are needed to get the last bottle to the water from the level of the "Hero's Platform." The "Hero's Platform" is a cage which extends from the side or stern of the ship in which a person stands while attaching the sampling equipment to the hydro-wire. The platform is usually equipped with a snap on a short rope, which secures the hydro-wire while attaching the equipment, and a tray to hold messengers and tools. Times are recorded on the station log sheet for the start of the cast, the time the bottles are down, and when the messenger is dropped. A minimum of three minutes is allowed for the bottles to equilibrate before being tripped. This allows time for the thermometers to come to equilibrium and for the bottles to be flushed. The times for the start of the haul, completion of the cast, and the initials of all scientific personnel active in the work at the station are also recorded. When the bottles are removed from the hydro-wire, the winch operator notes the meter wheel reading and notifies the scientific crew of any difference between the "down" and "up" readings. He also writes the difference down on the winch card as "slippage" (column 4).

Set-up for Cast

The scientific crew sets out bottles for the individual samples in the bottle rack before or during the lowering of the cast. Samples usually include salinity, dissolved oxygen, phosphate, and nitrate. The bottle numbers and the thermometer numbers corresponding to the sampling bottle number are recorded on the station log sheet. Great care is used to ensure that no mix-up occurs with respect to bottle and thermometer numbers. The person setting out the bottles checks to see that the cases are arranged with the smallest numbers in the upper left-hand corner and bottle numbers increasing from left to right and top to bottom (top = away from; bottom = toward the reader). The order of the bottle numbers is checked: 1) as the bottles are placed in the rack, 2) as the numbers are recorded on the station log sheet when the bottles are filled, and 3) again when they are returned to their respective cases. Thermometer numbers are recorded directly from the bottle (not from another sheet!) and checked with each reading. The initial set-up includes the strategic location of oxygen reagents, tools, messengers, magnifiers for reading thermometers, flashlight, and wire angle gauge.

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HYDRO TEAM

Hydro Area

The hydro area is a working area. No horseplay, unnecessary shouting, nor radios should be permitted. The winch man is not to be distracted nor his line of sight to the "A" frame blocked. Persons not active in the sampling should be encouraged to avoid interfering with the hydro work. The hydro team on deck at any one time usually consists of two to five persons.

Person in charge: the chief scientist, cruise leader, of a team. A number of duties may be assigned to specific members of the team and shared or rotated: hanging bottles, filling out station log sheets, setting up for sample bottles, drawing and treating oxygen samples, drawing other samples, reading thermometers, carrying bottles.

*NOTE: One person is responsible for hanging and retrieving sample bottles. The care of the bottles, thermometers, messengers, and directions to the bridge is their responsibility only!

Bottle Hanger: The “bottle hanger” has the winch man lower the lead weight over the side, attaches the wire to the ship with the snap, and "zeros" the meter wheel. The “bottle carrier” carries the sample bottle, hands the “bottle hanger" one bottle for the deepest measurement first, and then watches to see that no details are overlooked. Especially, the condition of the reversing thermometers prior to descent is checked. He then fetches the next bottle and the procedure is repeated. The "bottle hanger" attaches the bottles to the wire and tightens the clamps securely.

The following items are then prepared and checked:
- end plugs cocked
- air vent closed
- discharge cock closed
- thermometers reversed
- mercury bulb checked to see that all mercury has dropped
- messenger attached

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Next, the wire is released from the snap hook. The winch man is signaled to lower the bottles to the next edited depth. The "bottle hanger” may at any time request the Delage officer to maneuver the ship during the lowering or raising of the cast to reduce the wire angle, reduce roll, and protect the equipment from hitting on the sides to prevent damage to the ship by having the wire drawn against it.

It is the responsibility to watch the wire and sampling equipment at all times the wire is in the water, including the three-minute "soak" period, and to be especially vigilant while the ship's propeller is turning. The bridge should be reminded to keep an eye on the depth indicator when sampling gear is down.

and kept advised of the various stages in sampling. Drawing Samples If three or more people are on the hydro team, sample drawing should commence as soon as the "bottle carrier" has placed the first bottle in the rack. All bottles are rinsed at least three times. Special care should be given to rinsing dry bottles, especially if they contain salt crystals. These bottles should be soaked or washed with acid prior to use. The dissolved oxygen samples are drawn first, followed by the diband nutrients. (The order may be changed, but dissolved oxygen is usually first.) Dissolved Oxygen, Dissolved oxygen samples are drawn through a tube which extends to the bottom of the bottle. Two regular rinses of each are made. The stopper is rinsed each time. A rinse is made by inverting the bottle with the tube extending to the bottom, rinsing the walls, and allowing any air in the tube to escape. The stopper is held in the container during this operation. After about 100 ml have been added, the bottle is righted and allowed to fill to over the top. The tube is withdrawn from the water only at the end of the filling and while still flowing, immediately placing the tip of the dispenser a few millimeters below the surface. One milliliter of NaOH solution is added in the same fashion. The stopper is then dropped into place and the bottle is inverted several times to thoroughly mix the sample. If a precipitate is present at this point, the sample should be dumped and re-drawn. After 15 to 30 minutes, the oxygen bottles are reversed slowly several times to re-suspend the precipitate, then titrated with 1 ml of M12SO4 approximately 45 minutes after being drawn. The samples should be titrated within 24 hours. ---Page Break--- The method is similar to that found in Strickland and Parsons, 1968. The oxygen titer is calculated from the standardization process and entered on the station log sheet. The results are reported as milliliters per liter (ml/L), milligrams per liter.

(mg/l) and percent saturation (% sat.) Salinity Salinity samples are collected in 250 ml polycarbonate bottles with good-fitting screw caps. Care is taken not to use dry bottles unless they have been rinsed previously with fresh water. The bottles are triple rinsed and filled to the rim. A check is made, when putting the cases away, to see that all caps are secure. Salinity samples can be analyzed on shipboard or returned to the laboratory. Salinity is determined by an induction salinometer using standard (Copenhagen) water and a substandard collected from the open sea. The techniques used in the analyses are those recommended by the salinometer manufacturer. Results are reported in parts per thousand (‰). (Beckman, 1965 and Plessey, 1962). Nutrients Nutrients commonly measured in seawater are phosphate (PO_4), nitrate (NO_3) and silicate (SiO_2) because they are usually the limiting factors for phytoplankton in the surface waters. The analysis of silicate is sometimes deleted because SiO_2 is only limiting to those plankton, such as radiolarians, which use it in their skeletons. High concentrations of these complexes in surface waters are of interest because of their effect on biological communities. A moderate supply of nutrients is usually beneficial whereas an overabundance degrades the system. High nutrient concentration can be caused by upwelling of deep water from agricultural, industrial, and municipal run-off. The latter is more likely around Puerto Rico. Nutrient concentrations generally increase with depth. The nutrients measured are qualified with the word "reactive" because it is recognized that there is more of a particular nutrient present in the water than measured. However, it is assumed that the nutrient concentration measured represents the amount available to the plants at that particular time. Appreciable productivity is possible with low nutrients if the turnover rate of "bound" to "free" nutrient is rapid. Samples for the various nutrient analyses can be stored in a common bottle.

or in separate bottles. These bottles are usually plastic and not fully filled as they are generally frozen until the samples can be analyzed. Samples left exposed to light or heat will be altered by plankton growth and/or degradation of organic matter. Ammonia and nitrite (degradation products of nitrate) are usually not detected in open ocean samples. Therefore, their presence would indicate improper sample handling. The samples are analyzed by standard colorimetric methods as described in Strickland and Parsons, 1968. The data are reported as microgram atoms per liter (µg-at./l). Temperature Reversing Thermometers Oceanographic temperatures are measured in a number of ways. The most common and most accurate is with the use of the reversing thermometer. These thermometers are constructed in such a fashion that after equilibration at a desired depth, the mercury column is interrupted when the thermometer is turned end-for-end, thereby “fixing” the temperature so that it can be read on deck. These thermometers can be read to 0.01°C. Ideally, at least three reversing thermometers are used on each sampling bottle. Two have their mercury reservoir bulbs protected against pressure by an outer jacket of mercury. The third is unprotected. The pressure, and therefore the depth, can be determined by the difference in readings from the protected and unprotected thermometers. In addition to the main thermometer of each reversing thermometer, there is a small, or auxiliary, thermometer used to measure the temperature of the thermometer on deck so that the glass expansion effect can be determined. These thermometers must be handled with great care. They are never allowed to be horizontal. When preparing a bottle for sampling, the "bottle hanger" and the “bottle carrier" both check to see that the mercury has dropped uniformly. If the thermometer gives problems it may have to be tapped or removed from the rack and reversed several times with gentle tapping. The thermometers are usually allowed to

equilibrate with the deck temperature (out of direct sunlight) for 5 to 80 minutes before being read. A magnifying lens is used to read the thermometer to make sure they are lined up on the horizontal. One person reads the thermometers and a second person records the data on the station log sheet. The practice is for the reader to call out the sampling bottle number, followed by the left thermometer number, then the readings. For example, "Main (or Big T), twenty-one point four-six, Auxiliary (or little t), twenty-eight point seven.” The person recording data reads back the data as he records them. The process is then repeated for the middle and right thermometers, and on to the remaining bottles. The persons then change roles and go through the whole procedure again. This provides two complete and independent readings for each thermometer. The initials of those reading thermometers and the times that the readings were taken are also recorded on the station log sheet. The temperature data are computer processed upon return to the laboratory. They are inspected for errors and combined with other hydrographic parameters for the standard calculations and initial data print-out and plotting. Temperature is expressed in degrees Celsius (°C). (Equations are in the Appendix.) The bathythermograph (BT) is also commonly used to record temperature. The BT is a torpedo-shaped mechanical device, sensitive to both temperature and depth. A pen scribes an X-Y plot of the two parameters on a gold-coated slide. The slide has the following information scratched on the upper left corner: 1. cruise and station numbers 2. station name 3. date 4. time 5. depth 6. BT number The BT can be lowered with a hydrocast or by itself. It was actually designed to be used while the ship is underway. BT slides are commonly read by placing them into a calibrated viewer and recording depth and temperature where breaks in the profile occur. The points are then connected. The method we use at PRNC is to project

the slide onto a two-sided screen with a 35 mm slide projector. The temperature profile is then traced on a lined sheet of paper. The slide image is adjusted to fit the scale on the paper using reversing thermometer data for the surface and deep temperature corresponding to the BT. The paper scale has been checked previously by lowering the BT to known depths with reversing thermometers. Other Sampling Many other types of sampling may occur in conjunction with a hydrographic cruise. The basic data may be determined using other methods. Also, STD records, salinity, temperature and depth in profile, and oxygen can be determined using a polarographic probe either in situ or on samples brought to the deck. Special chemistry may include: pH, alkalinity, sulfide, trace metals, radionuclides, etc. In addition, sediment samples may be taken by core, grab or dredge. Plankton or fish nets may be towed, or the vessel may support small craft or be engaged in current measurements while hydrographic work is being carried on. Data Processing The chief scientist is responsible for assembling all data sheets and samples at the end of a cruise and for having them delivered to the proper people for the analyses. The thermometer readings are handled by a computer program which corrects for calibration errors and deck temperature. The program "REVTHR" (Appendix) also computes averaged protected thermometer values and the sampling depth where protected and unprotected readings are available. When all of the values are available, the data are put on punch cards, following the form of the oceanographic Station log, and processed by a program called "OCNSTN" (Appendix). This program provides punch cards to be run by another program "NocNst2", to plot the depth profiles of the parameters: temperature, salinity, sigma-t, oxygen and phosphate. The data from one station can be compared with the data from another station better if they are converted to standard depths. This is accomplished by a program, "AVOCN",

(Appendix) which also averages the data. The data are continually scanned for errors and inconsistencies. The print-outs are then ready for distribution to participating scientists and reports to funding agencies as shown in Table T w ---Page Break--- APPENDIX 15 ---Page Break--- STEPS FOR USE OF STATION LOG SHEET make carbon copy - Sample sheet, Table 15 14. Use penett 164, write neatly ~ numbers take excerpts: B12 3456789 fv. cruise and Station No. = From Bridge Log, e.g. "PA-GOL-O10 ~ Table 26 vy. Station - Name or Number designated by Chief Scientist, e.g. MIB=A0" + Palumbo vi. Vessel Name, 0.8.) RVR vEt. Local Date = Use Roman numeral month, e.g. 5-¥-71 master card ten Instructions country USA fe Number "32" ship Palumbo not yet Listed tats 3 attitude From Bridge log sheet "a0 aIr3t long. sos longitude from Bridge Log Sheet "780 44.2) * se-8 Marsden Squares jell igen ai So | $ | izle aoe tate 3 i ea ls, fu. MARSDEN

SQUARES use 30" risk 12} oralarr,orejor9 20° ee oan ir o+ lou : oe \ col gies oslo end 0 a 03204] 3) 339} 10° | t s4cis42 laa feaopsa..338, 18,371] 20% w rad radhadhnct dod aC 70 eT a ad 2d 1 PSS 10-4 date ont om 19 gst 25.27 Time GMT in hours and tenths of hr. e.g.) "14.6" For Puerto Rico, add hours to the messenger time of the first cast and round off to nearest tenth of an hour ---Page Break--- me Station Name 37 Depth in meters 38-38 Max. Sample Depth Bank wang Water color Table 4 FOREL WATER COLOR SCALE use Transparency 6-47 Waves. Din. Table § "COMPASS DIRECTION CODE 'True Direction From Which Surface Wind is Blowing or From Which Wave System is Approaching, in 10° intervals,. (WHO- Code 23), Instructions & spaces available for chief Scientists Station designation. "JB-@14" Sonic (or chart) Depth "#161" Fathoms to meters, Table 12 Meters to fathoms, Table 13 Drop last tie digits on deepest sampling depth. For 1880 m write "35" Ese Grease or eroh be), HiSatten or Bae | Vf Gimeno 'Greendyiiow Yeon seezee: Secchi disc depth (meters) "22" Direction waves coming from, el 1s: be ol gew, fon ---Page

Break--- space 48 49 50-51 52-59 57-62 63-08 8s 68 67 Item wave height 'Table "STATE OF WIND wav Wave period Wind Dir. Wind Speed Table 7 Air temperature Weather cloud type Cloud cover Vicinity 6 SEA eS Height Description Meters g calm-glassy- ° Calm-ripples: o-1/10 Smooth-wavelets~ 3/10-1/2 - 1/201 1/8 21/62 1/2 21/24 46 69 tary over 14 Number of seconds crest to crest. Same as for waves - use Table 5. In meters per second VELOCITY CONVERSION-KNOTS TO METERS PER SECOND 1 3 = wt Ht Re H at ite | Barometric Pressure in millibars using only 'two digits to the left of the decimal and one to the right 1021.6 becomes "21.6" 997.8 becomes "97.4", Table 19 Wet and dry bulb in °C to one decimal place (Relative humidity and temperature conversion tables are in H.O. 607). By code, Table # By code, Table 9 By code, Table 10 By code, Table 11 ---Page Break--- Space Item Instructions 88-70 Relative humidity in % (Rain = 100) From Bridge Log Sheet or calculated from wet/dry temperatures, 76 cruise Number From Bridge Log Sheet - Table 16 79 Station Number From Bridge Log Sheet - Table 26 % Bank Chronological Record of Events In the upper right corner of the Oceanographic Station Log (Table 15) is space to record the number of pages required for the particular station and Each cast is numbered sequentially with the times for each part of a cast. and the wire angle at the time the messenger was dropped. The time the cast was down and the messenger times are critical, All spaces should be filled in here including the initials of the scientific crew (observers) Parameter and Space Item Instruction 1 Cast Number Taken from the timed events recorded in the upper right as Local Messenger 'Taken from the timed events recorded in the upper right 6-9 Last Applicable Deepest depth sampled on this cast Depth 10-12 Wire Angle In degrees 3245, Final Down Reading Deepest depth plus the distance from the Hero's platform to the water surface 16-19 oxygen titler Concentration factor to determine oxygen values (From titration standardization

- Table 17.) Repeat of 1-19 for cast 2. Repeat of 20-38 for Cast 3 (the ocean station program i.e., limited to 3 casts per station.) 19 ---Page Break--- Item hak 88-69 veteran theel Factor calibration of Heter Wheel 0-71 Time Zone tones from the Greenwich Meridian. a7 card No. of age No. of total pages for the station: ram Reference number cruise and station masters 0 blank data card one card is punched for each sample depth, however, two lines are used for each depth to allow space for two readings of each thermometer and extra samples. pace Item Instructions 1 cast cast Number Estimated Depth Arrange numbers in their respective Columns to avoid confusion. 6-8 Meter Wheel Meter wheel reading is the deepest sampling depth minus the estimated depth. rot stip No. Amount @ bottle slips on the wire during the cast, i.e., the down reading minus the up reading of the meter wheel. s213 Reversing Bottle 'The number of the particular sample No. bottle. 19 'Thermometer No. Serial number of the left deep sea reversing thermometer Big "T" 'The reading of the main thermometer to one hundredth of a degree C. 23-95 Little " 'The reading of the auxiliary thermometer ‘to one tenth of a degree C. 26-97 Repeat of 1-25 for the middle thermometer. 20 ---Page Break--- 50-52 53-57 58-60 61-64 65-67 cen m73 79 80 Item Bridge Titra Phos. Nitra Reference No. Control No. 2a Instructions Repeat of 26-37 for the right ‘thermometer (usually an unprotected ‘thermometer). Salinity bottle number. Salinity as determined by the induction salinometer to a thousandth of a part per thousand. Oxygen bottle number. (After the oxygen values have been recorded, the spaces 52-60 can be used to enter the thermometric depths). The amount of titrer required to titrate the oxygen samples to a hundredth of a milliliter. (Nutrient bottle numbers are recorded (on the right side on shipboard, later covered with the nutrient concentration values for key punching. Cruise and station numbers 3 for continued data, 5 for end of station and § for end of data. ---Page Break---

S3uvNDS = N3GSYVH ---Page Break--- PART II OCEANOGRAPHIC CODES AND TABLES Tove &_weaTitee state code 0-48. No petition at the sharia Hovemns ser: 0 Ct dean or Opecitne dec 02 use of atyon the wise ww Charact. ob Ne Andromalare se ‘hen 03 cagletfrieaiy torning or Ses ah ‘evi Ina pn Tass, fit, and, ly ep by cok, weld or foveal fre, in: iia seo eae ca pata tat 9, Dawaiorm or annann it ‘Rant iheatip atte ship rig he a TDi fog omy 100 tre lee err wine Tr Ba Her tae cominuoun Mag LaF ie het “Seat 5 f TDs vies wo hana 14 Preptaion within eh, bat cag aries ie fone Son iil 16 Prenton within wiht aaa ‘ivesing! wat, falting a8 ‘rein. ‘alt Shomer) of Sas, or of rain i) Rall of of hall ant adeatorm tho with ut prea 20 sigh’ aerate dancin as decreed dae BY Bighy ox oderatn nnn Sr nations preceding haw 32 Sign Skits danttore Ta incre er agneretade Ry wom ol Taser ---Page Break--- ‘Table @ (continued) 34 Seve duvietorm or ants No, nppraciase “im ‘aide ferns SE Ree det oF can Tose Tralee Ging Genera Tow Bt Heary dating wom: Sigh or magento arti Geverty 20 Heavy drifting snow. 0" Pog at tance the ie ei ie ent f thove’ that ol the TFs in pte G foe ay cera BRED eeacemione Fogg See rary “aanay durin SRE IE soldier, eine hee lee Tas tm a a REDS ast ticeinn hates pees GE prceting Bog Saget oe Pag sees tins, shy no 10-98. recpatin athe sip a the dime 6 aa 50 rag po tenn tes SGA a ine of 5D ot eigen Dag po Gonng, e Molle af me i erson Brn ene i Dil ena. norte ot rial abe, sgt rls mrt Go" Rainy at teeing otermit- Sgt af ne of ‘est ‘aeton (1 Ral, bot ean, continuous Moderate ot time 2 Rain, wot recsag, later we! tri 8 nal ot trvvng comin i Tov wien Wray fie 8 Ral bot fcxing eostinaoak Bale teese signe BF Ha ere Sere or “ mae dratle and mow, Ge Ritordestesed snow, mot ‘ate or bene We ermtenttatof snow fen Sight a tne a Be Resumes ttt moe ack eesti Ba Totten eo -nontaken Madre at oe BB Gatnwcetalehigow nica Ve‘sbaraton Te Teermiten fof onon fakes Weg affine of Eoin mt 17 bre nto agar rh Tae err st ST RA Showers aboderate or = s « « sneer

alo lt hall Sef acow mined, moderate » ‘ese » HE thor with = aeees a a ers oa lat Bitiowe of obwrreston. 2 ---Page Break--- Panda an Table Scroun Tire cove jy, tatoo ot or ro, | 8 groes, * Sates tr eteennton (€ re Paci Snags GNTFICANT loud layer, cLouD TYPES Compiled hy the U.S. Werther Butea to aid inthe in ation atl ending of loud observations. Family “A” High Clouds: Cirrus (C1), Clerocumulus (Ce). Mean tower level, 6,000 me 20,000 fet Covet cms > honeteneenaetel 7 (Nore Further ithutotinns and seseriptions a. coude are eamtain din U8 iNvater Hanon iewlar § Secon! Faltian. "Auneh of Choad Forme and Cater for Sts of the Sy" The ion ‘may ‘aeparotig Imarine obververs at U.'S."Weathe? Hunted Peat Ofices end Blarine vvvtees Cove 1 CIRRUS» [~ t HA: Filaments or strands of cirrus scattered ‘tnd not increasing (often “Mares” Tails ‘ tne aca - f comrres Cove 1 {12 Dense cites in patch ot tite heaven + wsually “nat incressings pssbly. bat not sla, he etna the woe pa ot ---Page Break--- ‘Table 9 (continued) la © CIRRUS Covet H9; Cirrus, often anvilshaped; either the Temains of the upper portions of eumulo- ‘imbue or part of & distant cumulonimbus, the ree of which ia not viable Sco notes on 1.3 for coding requirements svhen cumulonimbus is present) «creas Cove 1 Tt: Cirrus (often ook-shaped), gradual Spresdng ox heap nad ols thicker. wet ean "pe ti tare - 1 eudig ne he {Rete th lt mon exp othe sins ftom “which thoy wre advancing 4 where owing to the effect of perspeetive they {My ane the appre of eorstats ‘aida _——— Cones 1&2 CIRRUS &CIRROSTRATUS oe HS: Cirrus und cirzosteatus, often. in bands pweard the horn oe eiemostras stone te gemaly sprenditg War fhe sky aud wouallythickeninye ns. 8h Dat tie continuous layer not reaching 432 alti resent, the angular altitude ig edge of the eirosteutus Cooest &2 CIRRUS CIRROSTATUS =) peer wernamam wren ea Ho; Cirrus and cirrostrats often in. bands sen tte lec aky and melting as aunt the continnons layer exceeding refers to the leading cge of the eirostratus ftyer 26 ---Page

Break--- Table 9 (continued) Cone 2 CIRROSTRATUS + f er eens ng the entire sky. During the day, when the sun issulcienty hove ie Hiraon, the sheets never titel enough to prevent shadows of objects ‘on the ground a © cinnosr Ratu: Cove 2 Us: Cierostratus not incrensing and not cover ing the whole sky; cirrus and rrocumuts may bo present TT cirocumulus is present, the ciroatratus inch dominate totaly the requirements ofGore 2. Ifthe estocumulve predominates, the sky would be coded as Code © crRKocUMULUS, Cove 3 9: Cirrocumulus alone or eirrocumulus with Smee Gtenanan, Bath rr presents (Caroumutin maybe pres t Cade't to Code 2 Lo Family “BY Middle Clouds: Atvocumul 20,000 feet me (Ac), Altostratus (As). Mean upper Level, 6,000 meters, lower level, 2,000 meters, 6,500 feet, - © ALrosrRares Cone 5 M1; Thin altostratus (semitransparent every= sper) through whit the sun of moon cas bo himly seen. A sheet of thin cloud resembles {HEN cetsteats from sehich its often ee sived without any break; but halo phenotn- a, gam pil te ant sen a vis, "and the sin ‘cr ‘moon app w Hf Teel : fot tas hind 2 ---Page Break--- Table 9 (continued) ALTOSTRATUS OR NIMBOSTRATUS > copes 8&7, Ma:"Thiek altstentus or nit portions o te slice the Peron may be vente by st patel or Tach and moon ate enpletey widen 1 Dy et leant nye parte of the elon sheet EGAN mag Be nts in opnenraner. Thick eRStemtos en he Yorn tr thick sree atontatas. oF by tbe tasng together St coudlete a a sheet of toeamalos ‘Mamtrats as derseed ster by a change from thick nlontratis the fang, rates nf ihe cid sls in a sheet oF Spa ali arcs ren foam nibogratus gees preepitaton es in Whe form of continuoi Fai Ur Sto Simbestatus usually has dank gray color ta owe oy ne is 8 eo onsideprent tenis precipitation, Beara Wich aney or ne MoU rear the Ci quite uajforiy atu i Rot pe Cone 4 al -Mge"Thin (eniteansparent) iaments notch n Pe ‘or ger pateies serared very ance nr we dt Cove 4 ALTOCUMULL Md: Thin. Gemitransparcnt)_altocumulus in dio often almnids or Reehaped); cloud Erments

Continuously shifting and/or occurring at various times, some somewhat discontinuous sheets of altocumulus come and go. Ms: Thin (semitransparent) altocumulus in bands or in layers gradually spreading over the sky and usually thickening as a whole; they may appear as the new "M5" designates one or perhaps two additional layers of altocumulus, usually of a shade. The amount and texture of which ---Page Break --- Table 9 (continued); Altocumulus cones. Mb: Altocumulus formed by the spreading out of gamma rays, with the speeding gamma waves creating a somewhat dark and soft appearance, and generally have rifts. There is some doubt as to what should be termed a sumolant or stratocumulus; at least one defines the cumulus cloud type then as being called Core 445. Altostratus and altocumulus both present at the same reference level. Type (a) Two layers of altocumulus, the lower of which may remain lower in places and for a short time, appearing somewhat similar to the altocumulus sheet. Effectively, it gives it the appearance of a double-layered altocumulus. It is noted on the lineata that systematically intensifies when it is spatially. Type (b) The under surface of stratocumulus is covered by not typical white calcareous and scaly structures. Altocumulus comm. 4: Altocumulus in appearance or type. ---Page Break --- Table 9 (continued) + Altocumulus systems are characterized by patches in polyhedral appearance. The phase shows irregularity in form and distribution in space, both horizontally and serially.

Cloudy: Stratocumulus (Stat 1), Nimbostratus (i), Mean upper level age to the surface: 2,000 meters, 6,500 feet; mean lower level. Family “D” Clouds With Vertical Development: Cumulus (Li): Cumulus with vertical development starting at one. These may resemble the following: completely formed but broken up by the wind (Fractosonal). They may appear more.

dame EFM fern sa deren te, bth ae > ‘asia, camivs clout ote “The presence of even msl the cumulus clone in et any pat hh lod Sod PR San nets the spreading portion from aloof, which ease Fingal be coded ant fatocarlusof ne watts are detached vce sloude usual in stern cara (See 1 for dear ofarvoromelis of tnd weather) Covi CUMULUS 9 0 Seen 12 Coma of ansieale elope, generally towering, with or without other cumulus | ‘rhs teas etaneyes > oe gcentonally wind-tosed und brakeny with - ea tee { ime ith oe kp on ups or hoods (iets) whie are fram the spree tape of ea ‘See 18 for 1s of eummalis of considerable” development and stestorammalus ‘sith bases at different levels) 30 ---Page Break--- ‘Tabla 9 (continued) boos © CUMULONIMBUS Cor 9 us with Top I king learnt Iv nt etter or anvil ith et a clouds of great vortic : fopa eosin pare AC Ioan of iow ersstal, the prrwente of sel, revealed hy a jrtil oe prveral nuetinisee tran of poevienaly we ating of cua having laty bose to) ees pee sTRATOCUMULU'S Coon 8 ‘of eumus; curls also afte pr Sgt te | see 4: Stratocurmutos formed by the sprog ont ~~ © STRATOCUMULLS Coon 6 1: Steatucumulie not formed by the spreading out of cum "This includes a wide variety of aspects of trom tin elo ingle level with sniitransparent part ot ven, lear spaces, to the ar ‘louda, often nt ii ly belore ratuyand storie code i applies ‘dominas ---Page Break--- ‘Table 9 (continued) STRATUS Ol FRACTOSTRATUS Cove 0 114; Strats of Fractostentus, oF both, but not fraetostentan of bad eet "These rlouds are nstally in low single layer ana mn he lesion extent. Clas propery code 0 whe i cd oan 8 "The discussion "feuetosirats” is med when ‘layer of stextus it Uroken ty ints Irregular shreds ERACTOSTRATUSOR FRACTOCEMULL'S Coos oes 17, Fractostentus amor feactocumtus of ba Teenther (aeud’) tual nice tia. Und rimbostaton "Chiyshd weather i eant the conditions suallprovag ime wd Sle tino ed Migr precip attacunton sous of td weather ax cesta darks receive te ithe so generally bore very merous a rage ino eset

covering the entire sky (Gee Li for description of the formations of food weather) cumulus cloud 68 SS & STRATOCUMULUS 18: Cumulus clouds formed by the spreading out of cumulus with bases at different levels. The higher cumulus clouds may extend up through the upper stratocumulus layer ---Page Break--- © CUMULONIMBUS Cloud 9 Lo: Cumulonimbus having a clearly defined (anvil) top, often anvil-shaped, with outflow clouds, stratocumulus, or cirrus. By extension at various levels, cumulonimbus often "produces severe weather" when detached from the parent cloud. All the different stages are not seen the fall of a real heavy shower is enough to characterize the cloud as a cumulonimbus. The 10¢ cloud cover can take any shape depending on the environment ---Page Break--- Sky obscured, 3) ---Page Break--- Sasde gained suded gang Sedge nasee S358¢ aes S2888 2ggag gases 2582 20822 Tag53 giseg GESe: geese aces | odase safes 3585 Hees WAH S2aue ade Hage wean ERE Geaae Sage Gee Gee Hae $8822 aRE22 Ge 33825 AR GASES S885 S525 BSS ageee E888 ---Page Break--- Table 13 DEPTH CONVERSION—METERS TO FATHOMS Face anega gets euese 8aRa a8 ate ae Msigd aaged Asses 22285 Saeete oer BRaRS 8S @ | Sa268 RABE e882 2252 eo | “284 a3iua segce | =| ssueg aacea caeee ian 3 rs aa He ie B3Scm d283 383ce Sessa Pere aig85 Meter gsegs S882 8888 sents oe | | a au | | as ---Page Break--- ‘Table 1WA - BAROMETRIC PRESSURE CONVERSION—INCHES TO MILLIBARS Meeting 90 wt ,000 mtbr. For example 48:48, an 0961008) 4.5 a08 | 0.07 | a08! 0.00 zi ‘ ES | & at a] gl g! | Re 8) eS, o Bi dl H Bs zl al a) ns Bs ggg ho Bt £1 8 Bie Bi BS 8 n) By a a| a! xl =| | Ee pag ag BP i) ne, alg y Bd » 2» nl gp, BIRR! a] 2) | 2 BB ee a 8 8 a a gu bal =k Table 148 BAROMETRIC PRESSURE CONVERSION™-MILLIMETERS TO MILLIBARS Nexting 900 and 09 ltr.

renal; 48=048, and 03 = 1063) ti ejelate| i iat gia gig z gg gi ui 2 Bg gla Ba) BB mom! wl a) os Bug ys #8) 8] a] 2 t 6 ---Page Break--- table 17. Oceanographic Stat fon Log WY" RF PALUMBO sen Oe X74 is ---Page Break--- COMPUTER PROGRAMS Page ref. REVTHR. 14 OcNSTN. 4 OCNSTN2..eeeeeeeseees TE AVOCN cesses 18 40 ---Page Break--- an va7t360) yomaye75: sorte PAGE a gevruRe THERMOMETES CORKEGTION PROGRAM (24/4/73 = UK) - 48 SPFCIFICAT {Oy INFORMATION a8 Lovieac “Coeuay ste, ces sToe a8 BYStNsTON NTHREATSAD, TTYPEA(S¥)sveACSB),FKAC5ED /OA(SE) te DIMENSION ALMA NCD.96) ,ATAUXCT BT ae eysenston — RHOMACS2) a8 DIWENSTON —THLCD), TaaC2) sDATE LAD a8 DIMENSTON 1 THRHG2)y INDEXCS 424 THC S420 4 TALS 2) “8 TerRMOMETE! TABLE SET#UP ano OUTPUT be MR TECG 9000) ab berTrinpoeedy aw NTauLes # te nee te aXe her te 2 Feary Go 10 8 a coro + ty 3 ee TECe, 902) ae 4S REAMC>, Howey FRBEAL) THRO CW) gLTYBEAGND YORE) /FKAUND ,GAOND 16 65 Yo. 42) o at ReAUC>, Bpae FARES an co to's a 42 READE BOue/ERRESY NOUMMY, CALMAINGCL ND L8L¢ 704 (ATAUXCT NDS 14167) ta TeewramMaGn .wt-a) 60 10 F as TE CITHPEAOD [EOL 108 ITYPEAOND E242) GO 1 9 3 WaITECas9uaSs NTABMA HT TYBEAOMD te Gait « ss Trentatmaen eon) Go 190.4 WetTeCes9az6) | ATHRMACA),4OUMRY se Gate ¢ a fe meITECSy 9009) “6 7 Stale Ned ‘ HETTEC6, 9986) WTABLE w TRONTAGLE Leo) CALL OXIT te SRETE E47 9999), 6 SRETRCS) 9998) OXTARWAINDg ETYPEALIUD «VOKOND FFRAO) UAC ‘ + (aiaarect Bray (Sy8eey UNAMALTD BatTEC 6.9009) CU Tasgase) CmeamAC Le ten SED MOET Ce equ) Ly ast Dark CAD SECTION AN PRANCH Taitraclee GnunteRs tree tlds NEteoew trouecne Tramp 2 READ THERMOMETER UATA tan noun NoaedeL Gia se sean SSyTEU6,9808) —— scaRD Sat RLav(>, 8882, ENgetvv 8, ERMESebO) TO EATAUKCL ND ety ema TAGLED a NOOTE CAML NTAPHE ETYPEA CTL TD ee ---Page Break--- a sae iron aust asea ass “ioe vartseny Jomaye75, sera7 Pace 2 aR avaneD COMPUTE LOgLeAL VARIASLES FOR ARANCHIAG CoLuze (ACRUFL EO, ACRUZ) .AND, (NCRUBS.£0,NCHUED _ Usta es NSTAS ca, uSTs G2 = (NEOTEL EU.udOT? AND, C2CABLA EO, ZCABL) USvoR= gwove CEL TARHCS) LEO,

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DEPT = Meates SHMPLIWG Jess eee * a aaa cans Staves cae 214.0 a St Ra spear ry Dice oer Tags * Ett ae ake cute Tiay cantaG PRU © Eee SouNIeo. TABLE IM Ho. BE AVE eda = ateea2ts ott cA CUZ et 7 Mave Prato = Ty aeene) # : . ons Seo ae Le seen Lhe Fe MAT ROS ESL ULE yc 109 TWOP tw HIRI = ROO EIS BODES Oe Bees ana PaiaT sas au a a B MEAL Cad 030 (Ses CATSE FLATS 9Lv: dF gsFuD Umer? ARS, YRS PUDAVT mba Tna oT nt Te Stet BORG TAA ey ty Sd Beman ny LeMAtPete Baar see) Fees nately winiyul VP ¢cbOe" Tey tSenECIURy EE oe ~ Teter) estat, ies STMaat seh esta _ ---Page Break--- CHAPTER 3 TEMPERATURE AND DEPTH CALCULATIONS 3.1, GENERAL REMARKS—The determination of true sea water temperatures and the depths at which they are obtained by means of deep-sea reversing thermometers requires calibration of these values. The temperatures observed in the field are often referenced to the 'temperature' observed in the lab. For the person seeking more detailed information on the derivation of these formulas, reference is made to GIS, Process, Ocean wave calculations included in determining the temperatures and depths of marine samples. The seconded on the Aah, which is 'ordinary' side rate, the use of thermometer aids in making the process easier. These analyses are often made for this purpose. 5-2 Deep-Sea Reversing Thermometer Calibration Corrections. Before each deep reversing thermometer can be used, it must be tested and precisely calibrated to determine the scales of the calibrator. This makes hydrographic office calibration sheets necessary, which include a calibration sheet for each thermometer. Thermometers are used at 44 charted points at sea, as shown in the provided information for each thermometer. See the caution sheet or card with the thermometer manufacturer's seal, number corresponding to that of the reversing thermometer being used, and obtain the value of mercury in the bulb of the main thermometer, called the variance for the correction for the thermometer scale, called the index correction to find the index corresponding for the auxiliary thermometer. The recorded constant of each main thermometer is called the pressure.

coefficient of each protected thermometer, labeled Q, is also given on the ‘3 THERMOMETER CORRECTIONS. To determine the true temperatures of the water samples, the protected thermometer reading must be corrected to allow for a formula to determine the depth at which the samples were actually taken. Similar corrections must be applied to the unprotected thermometers, to find the corrected temperatures of the protected thermometers. Thus, slightly different formulas are used to correct the unprotected thermometer readings. The formula to correct the unprotected thermometers is the same as the corrected temperatures of the protected thermometers; the calculations for the latter must be completed first. This is mainly for this reason: when protected and unprotected thermometers are paired on a Manacn bottle, the protected thermometer is placed in the left-hand protected tube and the unprotected thermometer is placed in the right-hand tube of the thermometer frame. The data are then recorded and the calculations carried out for the subject in the order in which they are read. S-4 Correcting the PROTECTED Thermometer The protected thermometer is corrected to give the true temperature of the water by the following formula: T = T0 + (Tn - T0) The corrected value of the protected freezing thermometer. This is the true water temperature. ---Page Break--- Fone #1. Deepen reversing thermometer corrections and history AR ---Page Break--- The uncorrected temperature reading is taken from the main protected reversing thermometer. The index correction for errors in the main protected thermometer scale is given on the calibration test gear and must be altered for the temperature read. This is the correction for the thermal expansion of the thermometer system, where the volume of mercury below the 0°C mark is determined at 0°C by the “reversed” reversing thermometer, expressed in degrees Celsius. It is given on the calibration sheet. The temperature reading of the auxiliary thermometer corrected for index is given on the calibration sheet. The temperature at which the reversed reversing

thermometer is read. The reciprocal thermal conductivity of ‘pension of the thermometer. The constant dependent upon the type of thermometer is defined to be the value obtained when the denominator of the fraction is taken to be R100 and the reading is 89° C. (uncorrected main thermometer reading on the scale 202° C.) (uncorrected auxiliary thermometer is shown on the A-label). From the calibration sheet for this thermometer, we find 203° C. the auxiliary thermometer index correction (in this case 07° C.) a 209° (index correction for the main thermometer at 0.39° C.). The total is 041. 9.38° + (0.20%) + (—0.01%, 9.12" 3-5). Correcting the UNPROTECTED Thermometer The “unprotected thermometer corrected by the following formula. The Pt 041 ‘degree reading is detected reversing thermometers function of both temperature and pressure. The uncorrected temperature reading of the main unprotected reversing thermometer. The index correction for errors in the main unprotected thermometer shown on the calibration sheet or card and must be interpolated for the temperature reading (Paper low as the calibration sheet will permit (TEV) (7. eK ©) This is the correct. Read Zero the corrected value of the protected reversing thermometer reading, (the seen temperature a deh of (a= The temperature reading of the unprotected thermometer corrected for index errors. The corrections are given on the cases sheet. This the comparator at which the “unprotected reversing Thermometers and Kamin server code of exception of the thermometer. This constant which is dependent upon the type of glass with ---Page Break--- which the thermometer is made. The Kelvins given on the scale is an example of correcting an unprotected thermometer. Given 6.40° C. (Uncorrected main thermometer reading on the scale 207° C.) (uncorrected toxins thermometer as shown on the scale. From thermometer 1.52° 072 C. the auxiliary thermometer index correction (in this sense 0APC) “for K=6100. From the correction for the main thermometer at 16.4° C. From the

paited. pro(cad thermometer we find Te=9.12°C. Find "asH8:404 99) (9.12207), 104 Tes eo) Aor + (0.22%) (0.0 ware. 3:6 REVERSING THERMOMETER CALCULATIONS WITH THE SLIDE RULE, “To Simplify the calculations of 3 iter f ‘The Deal vite reverse side of the slide has 9 theer-pluce table of eonmnes for wie xngdes of 1 to 60°" On the fk of the slide rule 6 a depth ronversion, table for fathoms to meters he fhe aca, ‘Determine K and tt ite value on n Sep 8: Tmt, Determine this value end toatl oy th ae “Sep tote Thc user (C) ia read from the Date dively below We valse Pat on BeCesale “Phe ig of (is ples when 7° greater than ‘Thengn of mine when Tefen 8 the UNPROTECTED Th ‘stide Rule mometer with 1 = Currectior for the sproteete th thealide rule es follows: "Rep 12 Vet Tra Determine this value and locat? it on tie Ale ‘Stop 2. Determinio K and get itv the Beseale under the vnlue for Vere ‘Sep 3: Tynty. Devermine this valve and locat tit on the Cacae ‘Step 420. The nnswer (C) ia rend from the Dscele directly below tho value Ty=f, on the Cea. Fhe wien of (in plue when Ty is greater than f "The sign of (is minus when Ty is fee than a 3-9 THERMOMETRIC DEPTH DETER- MINATION.-Alver the reversing thermometer feedings have been corrected, the thermomettic fret Nae bordered with see he thermmeters reversed, can he Suara ston mile oly ‘then protected and unprotected reversing Teac are pared oo a Nansen bottle Usially protected and unprotected. therm tuts aren ped on every boil but ony Masected det ‘There ave two methods in general use for de- termining thermonnetric depth Althouzh simic fae, nge mivelves direct use of « formula, while IE Ser int revoir rain Pane 08 the formulas Ech unprotected reversing thtr- seeder hg evunique’ graph called edepth ‘Toomely (22) graph fom whieh the depth cor- fection 1s read direedy S10. ‘Determining Thermometric Depth by Fora. ‘The thermometrie depth ray be de~ termined diteely by the following formula: aolk wheres "Z=The thermometric depth in motes ed rewing of the wipro net. ---Page Break---

iaweLe oF prorecrED ALCL ON ‘CALCULATION WHERE: Pw 16.40" 3 K Delo ners ‘Fiowe 8-8. Two drawings of reversing thermometer. The rule with protected an ‘= The mean density of the water column above the level of reversal. “This may be obtained from graphs, tables, or the computed ‘densities of the ‘station. “Graphs of these values for several areas are shown in figure 3-3 ‘and in table 17 Q=The pressure coefficient of the unprotected thermometer, expressed in protected calculations. res Celsius degree in the reading Ber. kglem increase in premont Balch Gans metrical Thermometer calibration certificate An example of the calculation of thermometric depth shown a also 16.17% ---Page Break--- Lc2si) (001275) ego. Za838 meters, are in the “Thermometric cally” te 100(7.— sph, 6 wh invother won 1 With "Te-Pe from the Difference column of the sheet (055) and determine the AZ (200 Bate ts value in the Correction column, Be to indicate if the correction is to be added to the difference times 100 and enter this (Gilg) in the Thermometric Depth (2) eal Fe A Se ene 12 Constructing a Depth Anomaly (a Graph, 1 — tin wad rote thermometer will register an increase SFOOIC” parameter of disappearance water, th 108 times tr dere tn se anproieta mn ater th fe glns> ard other act fare imposse to avoid tn mantfeetr {he unprotected thermometer hal pre foe oreo then solving ‘above. for depth 7) ‘The difference between the computed of thee metric depth and the ideal or assumed depth depth anomaly (82). For example, the ‘Wales ed to construct the 82 gph shown in ‘figure 3-4 are given below: a) at 8 ‘The values of a7 are plotted at the values of Ue curve drawn through the points A should‘be noted that the sample these are patie erry tat te Mnamerie dpi han the assumed or heal depth and @ the corrections obtained from this graph must be rat from. 1007.) to ‘obtain the 31a ACCEPTED DEPTH DETERMINATIONS. “There are, two methods. in general se for dete, the seep depth the best possible determination of Aepuhot Pach Nansen bottle at the time of several. ‘These are the

depth-affiliated method Grier lengthy minus the thermometric depth, 2) find the depth ratio method (thermometric depth, Z, divided by wire length, 2). In the first, reasonably accurate picture of the true tree shape during 'cust' is reproduced graphically and in the second the ratio of the teetno- ---Page Break --- REFERENCES Beckman, 1965. Instruction manual for Model RS-7B Portable Induction Salinometer. Beckman Instruments, Inc. Cedar Grove, NJ. Cochran, J.B., 1955, Instruction Manual for Oceanographic Observations. 2nd ed., I.O. Pub. No. 607, U.S. Navy Hydrographic Office, Washington, D.C. Duxbury, A.C. and P.A. Dinkins, 1966, Manual for Oceanographic Field Observations: Dept. of Ocean. U. of Washington, Seattle. La Fond, F.C., 1951, Processing Oceanographic Data. H.O. Pub. 614. U.S. Navy Hydrographic Office, Washington, D.C. Plessey, 1962. Operation and Maintenance Instructions Model 6220 Laboratory Salinometer. Plessey Environmental Systems. San Diego, CA. (Formally Bissett-Serman) + Strickland, J.D.H. and T.R. Parsons, 1968, A practical handbook of sea water analysis. Bull. 167. Fisheries Research Board of Canada, Ottawa. ™ ---Page Break --- ---Page Break ---