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The Oceanographic Cruise of the USCGC BURTON ISLAND to the Marginal Sea-Ice Zone of the Chukchi Sea --MIZPAC 77

Robert G. Paquette and Robert H. Bourke

February 1978

Interim Report for Period July 1977-February 1978

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NAVAL POSTGRADUATE SCHOOL Monterey, California

Rear Admiral Tyler F. Dedman Superintendent Jack R. Borsting Provost

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- Page 3 Figure 1. Station plot of MIZPAC 77 cruise. The position of the ice margin at the time of observation is also shown. 5 Distribution and intensity of finestructure during Figure 2. MIZPAC 77. Symbols are described in the text. Isotherms (°C) are the maximum temperature in the water column. 10 Station 80 salinity and temperature. The solid Figure 3. line was obtained while lowering, the dashed line while hoisting. The dotted line is the result of despiking the down trace but not smoothing. See Figure 4 for the smoothed curve. 14 Figure 4. Station 80. The down-going salinity profile is on the right as a solid curve. The dashed curve is the result of despiking and smoothing. The two
 - the result of despiking and smoothing. The two curves to the left give the contributions of the short time constant and long time constant corrections to the despiking. See Figure 3 for the unsmoothed corrected curve and to see the temperature transients which caused the salinity spikes.

THE OCEANOGRAPHIC CRUISE OF USCGC BURTON ISLAND TO THE MARGINAL SEA-ICE ZONE OF THE CHUKCHI SEA-MIZPAC 77

by

Robert G. Paquette and Robert H. Bourke Naval Postgraduate School, Monterey, CA

I. INTRODUCTION

This report presents the data and briefly describes the oceanographic results of the cruise of USCGC BURTON ISLAND into the region of the seaice margin of the Chukchi Sea during the period 24 July to 6 August 1977 as part of the program designated MIZPAC 77. The primary objective of the cruise was to find and characterize finestructure in the vertical temperature profiles and to discover its horizontal distribution and causes. This is the fifth cruise devoted to this general problem. Other cruises in 1971, 1972, and 1974 were reported by Paquette and Bourke (1973, 1976) and MIZPAC 75 by Zuberbuhler and Roeder (1976).

II. GENERAL DESCRIPTION

The scientific group boarded BURTON ISLAND at Nome, Alaska on the afternoon of 24 July, one day later than in initial planning. The scientists and their affiliations were:

Dr. Robert G. Paquette, Naval Postgraduate School, Chief Scientist
Dr. Robert H. Bourke, Naval Postgraduate School
LCDR Gordon P. Graham, Canadian Forces, Student at Naval Postgraduate School
Mr. Jonathan D. Trent, Naval Postgraduate School

Mr. Peter Becker, Applied Physics Laboratory, University of Washington, Seattle.

The scientific group disembarked at NARL, Barrow, Alaska on the afternoon of 6 August.

The measurements made were salinity and temperature profiles throughout the entire water column at 157 stations, using the Applied Physics Laboratory portable, hand lowered CTD. The lowering rate of the CTD was about 1 m sec resulting in a data rate of approximately three points per meter. The latter was checked systematically with Nansen bottles lowered on a second wire. Prior to leaving each station, the temperature and salinity were plotted utilizing a Hewlett-Packard 9100 series computer/plotter system. These rough plots were used to make immediate assessments of the presence of finestructure and to aid in the decision of where to make the next few stations. A current meter, which was intended to orient lines of closely spaced stations along the flow direction, was found to be of little utility because of the effects of the ship's iron on the magnetic compass. However, the failure to orient sampling lines along a presumed direction of propagation was at least partially overcome by running east-west lines as well as north-south lines in areas containing finestructure.

Because of the loss of one day of cruise time, no measurements were made in Bering Strait and the southern Chukchi Sea until the latitude of Pt. Hope was reached. Otherwise, we proceeded as in the general plan, exploring for finestructure along the ice margin from 70°N toward Barrow and studying it both in longitudinal and lateral sections when found. This resulted in much intensive study near Barrow followed, near the end of the cruise, by exploration near 71°N and, finally, a few more measurements near Barrow.

III. DATA

The CTD was standardized by means of a Nansen bottle lowered on a second wire to a depth just above the sea floor. Forty-nine such comparasons were in sufficiently unchanging water for temperature standardization and 40 for salinity. The mean CTD temperature and salinity errors were 0.08° C and $-0.021^{\circ}/_{\circ\circ}$, respectively. The standard errors of these means were 0.0051° C and $0.005^{\circ}/_{\circ\circ}$ and the standard deviations were 0.036° C and $0.025^{\circ}/_{\circ\circ}$. A correction was applied to the depth data to account for the difference in density between fresh and salt water, as the CTD pressure sensor was calibrated in fresh water.

The CTD records its data on a cassette which is eventually transferred to a seven-track tape by APL-UW for data editing and analysis at NPS. A computerized editing routine was written to remove erroneous data, interpolate data where necessary, make temperature, salinity and depth corrections, and remove spurious salinity spikes. The despiking and editing procedures are described in some detail in Appendix A.

Heading data for each station are listed in Appendix C. These contain station position and number, date/time of CTD lowering, water depth, type of navigation, wind, wave, and air temperature data, etc. Appendix B is an explanation of the codes used in Appendix C.

Plotting routines were used to display property profiles for each station: temperature, salinity, sound speed, and density (σ_t) . These are compactly plotted four stations per page and displayed in Appendix D. Stations taken in the deep water of the Barrow Canyon are shown two per page.

IV. RESULTS

The array of stations occupied is shown in Figure 1 together with an ice-margin position based principally upon observations made at the times stations were occupied. The ice-margin is thus not a single synoptic view, but a progressively distorted one which is more useful in describing ice-related phenomena. Synoptic views are also available.



An interesting feature of the ice in the region of Pt. Barrow is the large embayment to the WNW. Most of the satellite-derived observations show the embayment more or less closed near Pt. Franklin but the ship found an open passage. A projection of ice toward Pt. Franklin is a feature which persisted for several weeks.

Two groups of measurements were made from a hovering helicopter, one extending about 40 nmi into the ice and another group of stations in more or less open water which supplemented the ship-based stations. Helicopter operations proved highly useful, but could not always be used where they were most desirable because of persistent poor visibility.

The distribution of finestructure is shown in Figure 2 together with isotherms of the maximum temperature in the water column. The intensity of the finestructure, measured from the maximum peak-to-peak temperature fluctuation in the profile, is categorized as weak, moderate or strong. Weak structure, with amplitude 0.2° to 0.5°C, is indicated by a circle with a central dot; medium structure, with amplitude 0.5° to 1.0°C, is indicated by a circle with a cross; strong structure, with amplitude greater than 1°C, is indicated by a solid circle. Finestructure, so classified, is construed as being in or below the thermocline, not in the usually shallow upper layer. An open circle indicates fluctuations of microstructure size or the absence of any notable structure at all.

We decided to include the "nose" classification this year, after the opposite decision in 1975, because of a feeling that it may be an intermediate step in forming some types of deeper finestructure. The phenomenon we have called a "nose" in the past, in its simplest form, is a near-surface temperature maximum presumably formed by the cooling of an upper, warm mixed layer by ice or the overriding of such a layer with cold, dilute icemelt water from nearby ice. The noses this year differed from most past results in that they were sometimes as much as 30 meters thick instead of the customary 10-15 m. The nose may be complex, having various levels of finestructure within itself. This finestructure sometimes cuts into the usually sharp thermocline so as to make the depth of the thermocline doubtful and the nose can thus grade into a situation which we should classify as normal finestructure. Further, it seemed illogical to insist that the cooling be only at the surface since an initially cooled surface skin could be subsequently heated by solar radiation or overriden by warm dilute water. Therefore, a nose is recognized

- a. if there is a well-defined surface layer 5 or more meters thick with a cooling at the surface of at least 0.5°C as compared to the maximum temperature in the layer.
- b. if there is a well-defined surface layer in which there is moderate or strong finestructure.

The nose is indicated in Figure 2 by a tab on either side of the circle. If there is no structure in the nose, the tab is open; if there is medium or strong structure in the nose, the tab is filled solid.



It will be noted that much of the finestructure is concentrated between the 2° and 4°C isotherms of maximum temperature in the water column, a conclusion reached in studying earlier data. However, this is far from being an absolute rule: there are regions with no structure between the 2° and 4°C isotherms and one instance of strong structure near the 9° isotherm. This conclusion therefore, requires closer examination.

The following general results are presently apparent.

1. The ice margin crossings in the vicinity of 167°W were surprisingly like the corresponding measurements of MIZPAC 72. This appears to be a region with little finestructure.

2. Much finestructure was found in an embayment in the ice roughly 40 nmi square WNW of Barrow, even under ice. This is in agreement with the findings of MIZPAC 71 which operated in much the same area, but with a poorer understanding of the ice distribution. In the Barrow Canyon, where the water is deeper, finestructure was found as deep as 50 m. This is 15 to 20 m deeper than found on previous cruises. The finestructure and the embayment probably were due to the warm water of the coastal current which, in this case, had spread westward near Pt. Barrow. It is interesting that the ice was fairly close to shore farther south, near Pt. Franklin, and not melted away as one might expect if a continuous warm current moved northward near the surface.

3. The coastal current was warmer than in the past, up to 8° to 10°C. It was close to the coast between Pt. Franklin and Pt. Barrow, but farther away farther south. This reinforces our feeling that the tendency of the current to be away from shore in the more southerly latitudes is a geographical rather than a temporal phenomenon. Five crossings of the coastal current, between Icy Cape and Pt. Barrow, were made during this cruise. Analysis of these crossings should provide insight into the route of the warm Alaskan Coastal Current as it flows northeastward from the shallow waters off Icy Cape to the deeper waters of Barrow Canyon.

4. The salinity of bottom water behind the ice edge was relatively high, 33.4-33.6°/..., like in MIZPAC 71 and MIZPAC 72. What causes this large year-to-year variation in mean bottom water salinity, often greater than 0.5°/..., has not been established. It could be controlled by the amount of brine rejection occurring in winter in the shallows of the Chukchi Sea, a phenomenon which is a function of the severity of the winter. However, the cause might also be in river flows into the Bering Sea during the previous summer.

At the extreme bottom of many casts it was noted there was an apparent increase in salinity in the last half meter above bottom. We are undecided about whether this increase is an instrument artifact or a real phenomenon.

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APPENDIX A DESPIKING AND DATA EDITING

Introduction

Salinity spikes appear to be considerably more serious in 1977 than they were in 1975. This must be due to the instrument modifications made in the interim. Some objective despiking routine obviously was required. In October 1974 we had tested a despiking program for an old model Plessey STD based entirely on the concept of a first-order response equation for temperature and some phase shift between salinity and temperature, which Scarlet reported using, without the phase shift, in 1975. The method did not work well on our data. Constants which would correct the top half of a spike would overcorrect the bottom half. The reasons may lie in secondorder effects, perhaps complicated by the fact that we worked from the graphically recorded output rather than from digital data and thus included recorder response in the data. Or it may be that the technique which Scarlet found suitable for small spikes could not handle the very large spikes occurring in the Chukchi Sea data which were further exaggerated by the long thermometer time constant of the STD. Nevertheless, necessity prompted us to try again, with some success.

The data editing program to be described also is not completely new. We had one in MIZPAC 75. But the present program is considerably more versatile and automatic. It contains a "ratchet" or "latch" subroutine which prevents depth reversals similar to the one described by Scarlet. Our routine differs in that Scarlet threw out offending data whereas we replace offending points with interpolated points. This is necessary because we do not record time on the tape and must assume that the time step is uniform when despiking.

Despiking experiments have proceeded at the Applied Physics Laboratory, University of Washington (APL) and at the Naval Postgraduate School (NPS) with considerable general communication between the two laboratories. The method of handling the short time constant below is due mainly to G. Garrison of APL, the method of correcting temperature and the long time constant is due to R. G. Paquette of NPS. The details of implementation by APL and NPS are different and we have not intercompared results. The editing program described was evolved at NPS. APL uses a different technique.

Facts about the Instrument

The CTD is a portable digital instrument with a conventional threeelectrode conductivity cell and a thermistor as a temperature sensor. The cell constant of the cell is remarkably stable, judged by classical ideas about polarization phenomena in cells with unplatinized electrodes and relatively high electrode current densities. Perhaps this is due to the high operation frequency, <u>ca</u> 10 kHz, and the low electrode voltage, 13 mV. The three sensors of the instrument produce electrical frequencies which are counted in the instrument and the counts are recorded digitally on cassette tape. The sensor data set is sampled about 3 times per second in the order conductivity, temperature, depth. The fact that the conductivity and temperature measurements are separated by about 30 ms is a factor in the generation of salinity spikes and their subsequent removal.

Salinity Spikes-General

Spurious salinity spikes in a CTD record result from the lack of simultaneity between the conductivity and temperature measurement. The spikes are of consequence only when there are sharp temperature transients. A time lag may occur because of sampling lag, as above, or it may occur because of response lags in the sensors. The effect exists whether the salinity is computed digitally or by an analog circuit. When the temperature is retarded compared to the conductivity by either mechanism, the spike has the opposite sense from the first derivative of the temperature-time curve and conversely. If both measurements are effectively simultaneous but both are wrong because of sensor lag, the salinity, if slowly changing, may be correct.

Sources of spikes

In our investigation of the cause of salinity spikes, which sometimes exceeded 1°/... in magnitude, we found several sensor response errors.

- ^o A first-order lag in the temperature, with time constant 0.05 sec.
- [°] A first-order lag in the flushing of the conductivity cell with length constant about 18 cm.
- An error due to non-simultaneous sampling of conductivity and temperature and to a physical vertical displacement between the conductivity cell and the temperature sensor.
- [°] A long time constant in conductivity response apparently due to heat storage somewhere in the cell structure.

Recognition and Evaluation of the Long Time Constant

It may be of interest to know how the long time constant came to be recognized and evaluated. It was found only because data were recorded on the upward traverse of the CTD as well as when it was going down. It was then noted that the down-going salinity curve often did not agree with the up-going curve in the region below the thermocline where the temperature was unusually constant. No temperature-induced salinity error should have been generated in situ. Obviously the error must have been a long-lasting effect of a salinity or temperature transient which occurred at a shallower level and affected the down trace. The upward-going trace must have been essentially correct (except for the neglected effect of salinity change on conductivity) so long as the temperature was constant because the sensors usually were held near bottom for perhaps 10 seconds before beginning to hoist. The phenomenon under discussion may be seen in Figure 3, which shows the down and up salinity traces in Station 80 as well as the down and up temperature traces and the corrected salinity trace. One may easily find a time constant of about 5 sec in the approach of the salinity down trace to the up trace below the thermocline, taking the lowering rate to be 1 m/sec.



smoothed curve.

If such a time constant exists in other STD's and CTD's, there must be difficulties in removing spikes by the use of a single time constant. This is because the short and long time constants contribute differently to narrow spikes than to broad spikes; the short time constant influences the former more than it does the latter and conversely for the long time constant.

The Possibility of Second-Order Effects

All of the discussion of spike correction below will assume the simple first-order response equation for sensors. It should be kept in mind, however, that substantial second-order components may be present. Whenever there are two thermal masses in series with two thermal resistances involved in the transfer of heat from the water to the interior of the sensor, a second-order term enters the response equation. The temperature and salinity sensors must have had these characteristics to some extent, but it was not possible to find the multiplier of the second-order term. A second-order corrector basically takes out curvatures. It was found that the second-order constant could be adjusted to take out anomalies in the curves beautifully, but there was no way to tell whether the corrections corresponded to reality. Therefore, after a few experiments, the refinement was abandoned. It may be possible to revive it at some later date when more is known about the causes of variability of the sensor response constants.

Lack of Constancy of the "Constants"

A major problem in devising a spike correction technique is the fact that the response constants of the sensors are not constant. They change with rate of lowering, wire angle and relative horizontal motion between the sensor head and the surrounding water. If the constants had been nicely fixed, there would have been straightforward techniques for evaluating several constants. As it was, there was little hope of evaluating the second-order constant and little justification for trying to compute the effect of the flushing constant of the cell upon the conductivity directly, a matter which will be discussed below when the methods of spike correction are related in detail.

Theory and Algorithms for Correction of Spikes - Thermometer Correction

In the following paragraphs the nature, causes and method of correction of the several time constants are discussed.

We assumed that the thermometer followed a simple first-order law

$$T - T' = k_T \frac{dT'}{dt}$$

where T is the water temperature, T' the observed temperature, k_T the time constant of the thermistor and <u>t</u> the time. The bare thermistor had a nominal time constant of 0.03 sec. The protective shroud was expected to add to this. After a number of trials we picked 0.05 sec as the largest value which would not produce an overshoot at the bottom of the sharpest thermoclines. The temperature derivative was obtained from the first central difference

$$\left(\frac{dT'}{dt}\right)_{j} = \frac{T'_{j+1} - T'_{j-1}}{2h}$$

where h is the time step between samples, 0.33 sec.

The Time Lags and the Flushing Time Constant

The difference in sampling times of temperature and conductivity was 0.03 sec (temperature latest) plus an addendum of 0.01 sec because the thermometer was 1 cm deeper than the mouth of the cell. These were compensated by interpolating backward toward the previous temperature a fractional distance (0.01 + 0.03)/h or 0.012, using the equation

$$\Delta T_{j} = k_{c} T_{j-1} + (1-k_{c}) T_{j} - T_{j}'$$

where the constant k would be expected to be 0.12, from above, but was more effectively about 0.65. The extra 0.53 can be shown to approximate a correction for the flushing lag in the conductivity cell, which apparently has a time constant of 0.53 h or 0.18 sec. This corresponds to a length constant of 18 cm, or one cell length, which is reasonable.

There are some known theoretical weaknesses in treating the flushing time constant of the cell in this way. The method involves the assumption that there are no significantly large conductivity gradients that are not caused exclusively by temperature changes, which is the same as assuming that the true salinity always changes slowly. It also involves the assumption that the first backward temperature difference is proportional to $\partial c/\partial t$, where <u>c</u> is the conductivity. These are not always good assumptions. However, reasonable success with the techniques led us to postpone further refinements to a later date.

The Long Time Constant

The long time constant in the cell was modeled successfully as a thermal mass coupled to true water temperature by a thermal resistance corresponding to a time constant k_{L} . This mass passes fraction <u>F</u> of the difference between its temperature and true water temperature to the cell. It is a fairly realistic model. The thermal mass might be the cell body itself or the surrounding protective shroud.

The temperature, TC, of the thermal mass is accumulated at each step, starting with $TC_1 = T_1$ and assuming that the mean temperature difference between TC and T drives the temperature change in accordance with

$$TC_{j} = TC_{j-1} + \begin{bmatrix} T_{j}+T_{j-1} & -TC_{j}+TC_{j-1} \\ 2 & 2 \end{bmatrix} \frac{h}{K_{j}}$$

which ultimately gives

$$TC_{j} = \left[T_{j-1} + T_{j} + TC_{j-1} - \frac{(2k_{L} - h)}{h}\right] \frac{h}{2K_{I} + h} .$$

Then the temperature addendum contributed to the cell is $\Delta TC_j = (TC_j - T_j)F$, where F is about 0.15.

Difference Equation for Converting Temperature Error to Salinity Correction

At this point in the discussion, all the corrections have been computed in terms of their equivalent temperature corrections assuming C. may be taken as the observed conductivity. The effects of k_{c} and k_{t} on salinity were then computed separately by a difference equation derived from the salinity temperature - conductivity tables of H.O. Pub. SP-68 in the vicinity of 2°C and 30°/_∞. This equation is

$$S-S' = \frac{-11.0 \times 10^{-5} (T-T') - 2.28 \times 10^{-5} S'(T-T')}{76.8 \times 10^{-5} + 2.28 \times 10^{-5} T}$$

When the short time constant and the time lag were being corrected, T-T' was replaced by ΔT , above. When the long time constant was being corrected, T-T' was replaced by T + ΔTC ; - T'.

Example of Corrections

Figure 4 shows the original salinity curve from Station 80, the two components of the despiking correction and the resultant corrected curve. There were nearly always some small irregularities left after despiking. These were smoothed by means of a 9-point running mean. The corrected salinity curve before smoothing may be seen as the dotted curve in Figure 3.

Method of Finding Despiking Constants

The constants for despiking were determined in the following way. The despiking program was used intensively on about ten different stations, including some of the up traces, to become familiar with the effects of the several constants. In this way the general range of the constants and their variability was found. The constants k and F were determined as those which would make the down trace and the up trace match, or be nearly parallel below the thermocline. The constant k was chosen to remove spikes as well as possible. Sometimes it was necessary to adjust F also to remove spikes which meant that perfect matching of up and down traces was not possible. However, perfect matching is not a requirement unless the salinity curve is nearly vertical near bottom because a salinity gradient causes a small error in cell response which is not corrected by k, as was explained previously. The despiking program was then incorporated into the general editing program. During the general editing, further adjustments of the despiking constants were made before writing the corrected values on a new tape. A description of the general editing program follows.

Some Tests of Responses at Sea

Two stations were duplicated. In the first run of Station 46, the lowering was made by backing up 1/2 meter for each meter of lowering through half of the water column. The rest of the drop was made at normal speed, <u>ca</u> lm/sec. In the second run the lowering was normal. It was expected that the response of the sensors would be notably different. The spiking was less serious



Figure 4. Station 80. The down-going salinity profile is on the right as a solid curve. The dashed curve is the result of despiking and smoothing. The two curves to the left give the contributions of the short time constant and long time constant corrections to the despiking. See Figure 3 for the unsmoothed corrected curve and to see the temperature transients which caused the salinity spikes.

in the first case. However, it is curious that the despiking constants required for the first were the normal ones, k =0.65, F=0.15 whereas, for the second, k =0.38 and k =0.115 were required. The corrected results are very similar except near the surface where rapid real changes in properties are common. In Station 107, the first drop is normal and the second was made with the thermistor taped onto the multiplexer housing facing upward. The smaller spikes of temperature and salinity were smoothed in the second case, presumably by the turbulence generated by the multiplexer housing. This is a station in which the temperature transients are moderate and, although there were differences in the original curves, they are not dramatic enough to interpret in terms of the different cell-to-thermistor distance. Both lowerings were corrected with the standard constants and, when corrected, looked very similar.

Requirements for General Editing of Data

The CTD data require considerable editing besides the despiking, as will be noted below.

- Spurious high salinities frequently occur near the surface on the down trace, and the first one or more depths are occasionally very large. High apparent salinities are created by very low actual conductivities due either to melt water or to bubbles in the cell. The system records only four digits of a five-digit frequency count. Therefore, foldover occurs as a result of low values and the last four digits are at the top of the range and are read as high values.
- [°] Occasionally an absurd single value may occur in any of the measured parameters. Sometimes the error is too small to be distinguished automatically from real fluctuations.
- Near the top of a lowering there are duplicate values generated during the "soaking" period and also while the sensors are waiting near bottom while buttons are pressed on deck. The shallowest depth may be interspersed among other depths near surface; a similar result occurs near bottom because, after striking bottom, the sensor was immediately raised one or two meters. A method is required to remove the unwanted records and to start as shallow as possible and end as deep as possible.
- [°] Some lowerings were so full of noise as to require replacing them with the corresponding up trace. In such cases, special adaptations of the noise-removal and despiking routines were necessary and the data set was then inverted top-to-bottom.
- [°] When the ship rolls, loops are generated in the recorded traces because of sensor response problems. Records distorted by such reversals in depth had to be adjusted before despiking.
- [°] The several sensors have calibration errors, additive in the case of temperature and salinity, and a factor for converting from the

fresh-water to a salt-water calibration in the case of depth. A substantial depth discrepancy will be noted between down and up curves in Figure 3. The cause is only partly known and it was not corrected. The major contributions are a sampling lag of twice 255 ms and the probability that temperature features in the water were carried upward by the multiplexer housing of the CTD which preceded the sensors on the way up.

Description of the General Editing Program

The complete data editing program is a group of routines which may be invoked in sequence by commands entered on a control card read immediately before the data to be edited were read from tape. The following functions could be performed.

1) Eliminate an entire "station". Here the word station means those data isolated on the tape by interrecord gaps. Usually it was the up trace which was to be eliminated.

2) Eliminate sequential data records in up to two places on any station, the places designated by beginning and ending serial numbers of the records. This served to remove faulty values frequently found at the beginning of a lowering and the repetitious values usually found where the sensor head was stopped on or near bottom.

3) Interpolate between two good records as many records as were previously present in a faulty intervening group. This could be done in two places on any station.

4) Replace up to three records with images punched on cards.

5) Remove single-point spikes in depth, temperature or salinity. A single-point spike found in one of these was almost certainly an artifact and was replaced by the median between the J-l-th and J+l-th measurement.

6) Apply a depth ratchet so that, after the first 20 points, the depth cannot decrease. Records in which the depth has decreased as compared to D. are replaced by an equal number of records interpolated evenly between D. and the next depth which is equal or greater. At the beginning, the routine automatically discards records prior to the minimum depth found in the first 20 records. Where this routine was to be applied to an up trace, a variable, UP, was set true which caused all the depths to be temporarily replaced by their negatives so that the ratchet routine would work.

 Apply the despiking routine. The constants could be changed for each station.

8) Invert the sequence of records, putting the top at the bottom, this for a few cases in which the down trace was too faulty to be used.

9) Make additive corrections to salinity and temperature based upon the comparisons with Nansen bottles and correct depth for water density. 10) Recompute sound velocity and sigma-t from the corrected salinity and temperature.

The program then wrote the corrected data on a new tape, produced a printer plot of the corrected and uncorrected salinities and the contributions of the long-time constant and lag corrections separately.

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APPENDIX B

EXPLANATION OF HEADING CODES

The heading of the printed output uses the coding and format from NODC Publication M-2, August 1964, with a few exceptions. Heading entries which are not self-explanatory are as follows: MSQ is the Marsden Square, and DPTH is the water depth in meters. Wave source direction is in tens of degrees, but the direction 99 indicates no observation. The significant wave height is coded by Table 10 (Code \div 2 \sim height in meters) and the wave period is coded by Table 11 (Code ÷ 2 ~ period in sec); in each case X indicates no observation. Wind speed, V, is coded as Beaufort force, Table 17. The barometer is in millibars, less 1000 if more than 3 digits; wet and dry bulb temperature are in degrees C. The present weather is from Table 21 with cloud type and amount from Tables 25 and 26, respectively. The combination 4 X 9 indicates that clouds cannot be observed usually because of fog conditions. The visibility is from Table 27 which is roughly in powers of two with Code 4 = 1-2 km. The ice concentration, IC, is in oktas; amounts less than 1 okta are preceded by a minus sign and indicate concentrations in powers of ten, e.g., $10^{-4} = -4$.

The entry, COD, is a code to identify the accuracy of each station position based upon the navigation system used. Code 1 indicates a position determined by visual sightings or radar, Code 2 a position determined by navigation satellite, and Code 3 a position determined by DR.

APPENDIX C

HEADING DATA FOR MIZPAC 77 STATIONS

Heading data are listed on the following pages for MIZPAC 77. The coding conventions are those described in Appendix B. Note that Stations 67H through 71H and 97 are missing. Other stations in the helicopter series have much of the heading information missing.

MIZPAC 77 CTD STATIONS

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MIZPAC 77 CTC STATIONS

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LONG MSU MO EY YR H	165-25.0 269 07 28 77 04.2 0	164-3C.0 269 07 28 77 07.2 0	163-50.5 269 J7 28 77 05.3 J2	163-C0.0 269 07 28 77 12.0 024	163-CC.C 269 07 28 77 13.1 02	163-C0.0 269 07 28 77 14.7 020	163-00.0 269 07 28 77 15.7 02	163-00.0 269 07 28 77 16.6 028	163-00.0 269 07 28 77 17.5 029	162-C5.0 269 J7 28 77 21.1 030	162-C4.0 269 J7 28 77 22.4 J31	161-47.5 269 07 28 77 23.4 032	161-36.0 269 07 29 77 00.5 033	i61-25.0 269 07 29 77 02.5 034	161-35.0 269 07 29 77 04.8 035	161-43.0 269 07 29 77 C5.7 030	161-52.0 269 07 29 77 06.6 037	161-52.0 269 07 29 77 C8.1 03	162-12.0 269 07 29 77 05.5 03	161-23.C 269 07 29 77 11.6 04
P LAT LONG MSU MO CYYR H	72-01.0 165-25.0 269 07 28 77 04.2 0	71-4E.5 164-2C.0 269 07 28 77 07.2 0	71-32.1 163-50.5 269 07 28 77 05.3 32	71-14.6 163-60.0 269 07 28 77 12.0 02	71-05.2 163-CC.C 269 07 28 77 13.1 02	71-15.8 163-C0.0 269 07 28 77 14.7 020	71-25.6 163-00.0 269 07 28 77 15.7 02	71-28.5 163-00.0 269 07 28 77 16.6 028	71-30.5 163-00.0 269 07 28 77 17.5 029	71-22.0 162-C5.0 269 J7 28 77 21.1 030	71-15.0 162-04.0 269 07 28 77 22.4 031	71-16.0 161-47.5 269 07 28 77 23.4 032	71-11.5 161-36.0 269 07 29 77 00.5 033	71-22.6 i61-25.0 269 07 29 77 02.5 034	71-15.C 161-25.0 269 07 29 77 04.8 035	71-17.5 161-43.0 269 07 29 77 05.7 030	71-14.5 161-52.0 269 07 29 77 06.6 037	71-13.3 161-52.0 269 07 29 77 08.1 03	71-08.0 162-12.0 269 07 29 77 05.5 03	71-03-5 161-23.0 269 07 29 77 11.6 04
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MIZFAC 77 CTC STATIONS

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STA DPTH	041 44	042 45	043 46	044 43	045 23	046 42	647 47	048 47	049 50	050 47	051 48	052 51	053 52	054 56	055 52	056 54	057 47	058 45	059 48	060 47
HR STA DPTH	13.3 041 44	14.6 042 45	15.3 043 46	16.6 044 43	17.6 045 23	21.5 046 42	23.0 047 47	00.4 048 47	01.3 049 50	02.5 050 47	C3.2 051 4E	04.4 052 51	C7.5 053 52	C7.9 054 56	08.8 055 52	09.8 056 54	10.8 057 47	11.6 058 45	13.0 059 48	14.6 060 47
YR HR STA DPTH	77 13.3 041 44	77 14.6 042 45	77 15.3 043 46	77 16.6 044 43	77 17.6 045 23	77 21.5 046 42	77 23.0 047 47	77 00.4 048 47	77 01.3 049 50	77 02.5 050 47	77 C3.2 051 46	77 04.4 052 51	77 C7.5 053 52	77 67.9 054 56	77 08.8 055 52	77 09.8 056 54	77 10.8 357 47	77 11.6 058 45	77 13.0 059 48	77 14.6 060 47
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MO DY YR HR STA DPTH	07 29 77 13•3 041 44	07 29 77 14.6 042 45	07 29 77 15.3 043 46	07 29 77 16.6 044 43	07 29 77 17.6 045 23	07 29 77 21.5 046 42	07 29 77 23.0 047 47	07 30 77 00.4 048 47	07 30 77 01.3 049 50	07 30 77 02.5 050 47	07 30 77 C3.2 051 46	07 30 77 04.4 052 51	C7 30 77 C7.5 053 52	07 30 77 67.9 054 56	07 30 77 08.8 055 52	07 30 77 09.8 056 54	07 30 77 10.8 057 47	07 30 77 11.6 058 45	07 30 77 13.0 059 48	07 30 77 14.6 060 47
MSQ MODYYR HR STA DPTH	269 07 29 77 13.3 041 44	269 07 29 77 14.6 042 45	265 07 29 77 15.3 043 46	269 07 29 77 16.6 044 43	269 07 29 77 17.6 045 23	269 07 29 77 21.5 046 42	269 07 29 77 23.0 047 47	269 07 30 77 00.4 048 47	269 07 30 77 01.3 049 50	269 07 30 77 02.5 050 47	269 07 30 77 C3.2 051 46	269 07 30 77 04.4 052 51	269 C7 30 77 C7.5 053 52	269 07 30 77 07.9 054 56	269 07 30 77 08.B 055 52	268 07 30 77 09.8 056 54	268 07 30 77 10.8 057 47	268 07 30 77 11.6 058 45	268 07 30 77 13.0 059 48	268 07 30 77 14.6 060 47
LONG MSQ MO DY YR HR STA DPTH	161-C1.0 269 07 29 77 13.3 041 44	160-50.0 269 07 29 77 14.6 042 45	1¢0-41.5 265 07 29 77 15.3 043 4£	160-32.5 269 07 29 77 16.6 044 43	160-24.0 269 07 29 77 17.6 045 23	161-43.C 269 07 29 77 21.5 046 42	161-17.0 269 07 29 77 23.0 047 47	161-C6.0 269 07 30 77 00.4 048 47	160-5E.C 269 07 30 77 01.3 049 50	160-41.5 269 07 30 77 02.5 050 47	160-46.0 269 07 30 77 C3.2 051 48	160-31.5 269 07 30 77 04.4 052 51	160-15.0 269 C7 30 77 C7.5 053 52	160-1C.C 269 07 30 77 C7.9 054 56	160-00.1 269 07 30 77 08.8 055 52	159-23.0 268 07 30 77 09.8 056 54	159-26.5 268 07 30 77 10.8 057 47	159-31.0 268 07 30 77 11.6 058 45	159-12.C 268 07 30 77 13.0 059 48	159-15.3 268 07 30 77 14.6 060 47
> LAT LONG MSQ MO DY YR HR STA DPTH	7C-54.3 161-C1.0 269 07 29 77 13.3 041 44	76-51.5 160-50.0 269 07 29 77 14.6 042 45	7C-46.5 160-41.5 269 07 29 77 15.3 043 46	76-42.5 160-32.5 269 07 29 77 16.6 044 43	7C-35.0 160-24.0 269 07 29 77 17.6 045 23	76-43.5 161-43.6 269 07 29 77 21.5 046 42	7C-4E.0 161-17.0 269 07 29 77 23.0 047 47	76-51.2 161-66.0 269 07 30 77 00.4 048 47	7C-56.0 160-58.C 269 07 30 77 01.3 049 50	7C-55.5 160-41.5 269 07 30 77 02.5 050 47	7C-58.0 160-46.0 269 07 30 77 C3.2 051 4E	71-00.5 160-31.5 269 07 30 77 04.4 052 51	71-07.5 160-15.0 269 67 30 77 67.5 053 52	71-05.6 160-10.C 269 07 30 77 C7.9 054 56	71-13.6 160-00.1 269 07 30 77 08.8 055 52	71-05.E 159-23.0 26B 07 30 77 09.8 056 54	71-10.8 159-26.5 268 07 30 77 10.8 057 47	71-15.2 159-31.0 268 07 30 77 11.6 058 45	71-12.2 159-12.C 268 07 30 77 13.0 059 48	71-21.8 159-15.3 268 07 30 77 14.6 060 47
SHIP LAT LONG MSQ MO DY YR HR STA DPTH	BI 7C-54.3 161-C1.0 269 07 29 77 13.3 041 44	BI 7C-51.5 160-50.0 269 07 29 77 14.6 042 45	BI 7C-46.5 160-41.5 265 07 29 77 15.3 043 46	BI 7C-42.5 160-32.5 269 07 29 77 16.6 044 43	BI 7C-35.0 160-24.0 269 07 29 77 17.6 045 23	BI 7C-43.5 161-43.C 269 07 29 77 21.5 046 42	BI 7C-4E.0 161-17.0 269 07 29 77 23.0 047 47	BI 7C-51.2 161-C6.0 269 07 30 77 00.4 04B 47	BI 7C-56.0 160-58.C 269 07 30 77 01.3 049 50	BI 7C-55.5 160-41.5 269 07 30 77 02.5 050 47	BI 7C-58.0 160-46.0 269 07 30 77 C3.2 051 46	BI 71-0C.5 160-31.5 269 07 30 77 04.4 052 51	BI 71-07.5 160-15.0 269 C7 30 77 C7.5 053 52	BI 71-05.6 160-10.C 269 07 30 77 C7.9 054 56	BI 71-13.6 160-00.1 269 07 30 77 08.8 055 52	EI 71-05.E 159-23.0 268 07 30 77 09.8 056 54	BI 71-10.B 159-26.5 268 07 30 77 10.B 057 47	BI 71-15.2 159-31.0 268 07 30 77 11.6 058 45	BI 71-12.2 159-12.C 26B 07 30 77 13.0 059 4B	BI 71-21.B 159-15.3 26B 07 30 77 14.6 060 47

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HR STA DPTH	15.7 061 SC	17.1 062 45	18.6 J63 5C	21.3 064 54	065H	0 66 H	0 é 7 H	068H	069H	H 0 2 0	071H	23.0 072 54	00.6 073 54	02.4 074 56	03.5 075 57	04.8 076 55	C6.1 077 55	07.4 078 55	10.0 079 £1	11.0 380 62
YR HR STA DPTH	77 15.7 061 50	77 17.1 062 45	77 18.6 J63 5C	77 21.3 064 54	77 065H	77 066M	77 0ó7H	77 068H	77 069H	H010 77	77 071H	77 23.0 072 54	77 00.6 073 54	77 02.4 074 58	77 03.5 075 57	77 04.8 076 55	77 C6.1 077 55	77 07.4 078 55	77 10.0 079 £1	77 11.0 380 62
CY YR HR STA DPTH	30 77 15.7 061 5C	30 77 17.1 062 45	30 77 18.6 J63 5C	30 77 21.3 064 54	30 77 065H	30 77 066H	30 77 0ó7H	30 77 068H	30 77 069H	30 77 070H	30 77 071H	30 77 23.0 072 54	31 77 00.6 073 54	31 77 02.4 074 58	31 77 03.5 075 57	31 77 04.8 076 55	31 77 C6.1 077 55	31 77 07.4 078 55	31 77 10.0 079 £1	31 77 11.0 380 62
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MSQ MOCYYR HR STA DPTH	268 07 30 77 15.7 061 5C	268 07 20 77 17.1 062 45	268 J7 30 77 18.6 J63 5C	268 07 30 77 21.3 064 54	268 07 30 77 065H	268 07 30 77 066M	268 07 20 77 067H	268 07 30 77 068H	268 07 30 77 069H	268 07 30 77 070H	268 07 30 77 071H	268 07 30 77 23.0 072 54	268 UT 31 77 00.6 073 54	268 07 31 77 02.4 074 56	268 07 31 77 03.5 075 57	268 07 31 77 04.8 076 55	268 07 31 77 C6.1 077 55	268 07 31 77 07.4 078 55	268 07 31 77 10°0 079 £1	268 07 31 77 11.0 080 62
LONG MSQ MO CY YR HR STA DPTH	159-2C.1 268 07 30 77 15.7 061 5C	155-51.C 268 07 2C 77 17.1 062 45	159-25.0 268 J7 30 77 18.6 J63 5C	158-46.C 268 07 30 77 21.3 064 54	155-CC.C 268 07 30 77 065H	158-57.0 268 07 30 77 066M	158-45°C 268 07 30 77 067H	158-35.0 268 07 30 77 068H	158-34.0 268 07 30 77 069H	158-26.C 268 07 30 77 070H	158-10.0 268 07 30 77 071H	158-46.0 268 07 30 77 23.0 072 54	158-46.2 268 07 31 77 00.6 073 54	158-26.0 268 07 31 77 02.4 074 5E	158-26.C 268 07 31 77 03.5 075 57	158-16.0 268 07 31 77 04.8 076 55	158-16.0 268 07 31 77 C6.1 077 55	158-16.5 268 07 31 77 07.4 078 55	157-56.0 268 07 31 77 10.0 079 61	157-51.C 268 07 31 77 11.0 380 62
PLAT LONG MSQ MO CY YR HR STA DPTH	71-26.5 159-20.1 268 07 30 77 15.7 061 50	71-43.C 155-51.C 268 07 2C 77 17.1 062 45	71-43.0 159-25.0 268 J7 20 77 18.6 J63 50	71-43.0 158-46.C 268 07 30 77 21.3 064 54	71-30.0 155-CC.C 268 07 30 77 065H	71-33.3 i58-57.0 268 07 30 77 066H	71-36.C 158-45.C 268 07 30 77 067H	71-42.0 158-35.0 268 07 30 77 068H	71-47.2 158-34.0 268 07 30 77 069H	71-52.1 158-26.C 268 07 30 77 070H	71-41.0 i58-10.0 268 07 30 77 071H	71-34.0 158-46.0 268 07 30 77 23.0 072 54	71-33.6 158-46.2 268 07 31 77 00.6 073 54	71-30.0 158-26.0 268 07 31 77 02.4 074 56	71-35.0 158-26.C 268 07 31 77 03.5 075 57	71-40.0 158-16.0 268 07 31 77 04.8 076 55	71-45.0 158-16.0 268 07 31 77 C6.1 077 55	71-53.0 158-16.5 268 07 31 77 07.4 078 55	71-52.0 157-56.0 268 07 31 77 10.0 079 61	71-46.0 157-57.C 268 07 31 77 11.0 380 62
SHIP LAT LONG MSQ MO CYYR HR STA DPTH	81 71-26.5 159-2C.1 268 J7 30 77 15.7 061 5C	81 71-43.C 155-51.C 268 07 3C 77 17.1 062 45	81 71-42.0 159-25.C 268 J7 30 77 18.6 J63 5C	BI 71-43.0 158-46.C 268 07 30 77 21.3 064 54	BI 71-30.0 155-CC.C 268 07 30 77 065H	BI 71-33.3 i58-57.0 268 07 30 77 066M	EI 71-38.C 158-45.C 268 07 30 77 067H	BI 71-42.0 158-35.0 268 07 30 77 068H	BI 71-47.2 158-34.0 268 07 30 77 069H	BI 71-52.1 158-26.C 268 07 30 77 070H	81 71-41.0 158-10.0 268 07 30 77 071H	BI 71-38.0 158-46.0 268 07 30 77 23.0 072 54	EI 71-33.6 158-46.2 268 07 31 77 00.6 073 54	BI 71-30.0 158-26.0 268 07 31 77 02.4 074 56	81 71-35.0 158-26.C 268 07 31 77 03.5 075 57	BI 71-40.0 158-16.0 268 07 31 77 04.8 076 55	BI 71-45.0 158-16.0 268 07 31 77 C6.1 077 55	81 71-53.0 158-16.5 268 07 31 77 07.4 078 55	81 71-52.0 157-56.0 268 07 31 77 10.0 079 £1	81 71-46.0 157-57.C 268 07 31 77 11.0 080 62

MIZFAC 77 CTC STATIONS

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STA DPTH	081 65	062 64	083 112	084 55	085 117	086 55	J87 72	388 75	089H	H060	H16C	092H	093H	M940	H250	096 IC7	101 102	058 64	6 3 63	100 66
HR STA DPTH	12.3 081 65	13.3 062 64	14.3 083 112	15.4 084 55	17.C 085 117	13.1 086 55	19.0 J87 72	23.C 088 75	01.1 089H	M060 E.10	H16C 9*10	01.8 J92H	02.1 093H	02.3 094H	02.6 055H	C3. 8 096 1C7	05.7 097 107	C7.2 058 64	08.0 099 62	05.1 100 66
YR HR STA DPTH	77 12.3 081 65	77 13.3 062 64	77 14.3 083 112	77 15.4 084 55	77 17.C 085 117	77 13.1 086 55	77 19.0 J87 72	77 23.C 088 75	77 01.1 089H	77 01.3 090M	H16C 91.6 77	77 01.8 J92H	77 02.1 093H	77 02.3 094H	77 02.6 055H	77 C3.8 096 1C7	77 05.7 097 107	77 C7.2 058 64	77 08.0 099 62	77 05.1 100 66
CY YR HR STA DPTH	<u>31</u> 77 12•3 081 65	21 77 13.3 062 64	<u>31 77 14.3 083 112</u>	<u>31 77 15.4 084 55</u>	31 77 17.C 085 117	31 77 13.1 086 55	31 77 19.0 J87 72	21 77 23.C 088 75	01 77 01.1 089H	H090 £.10 77 10	CI 77 01.6 391H	01 77 01.8 J92H	CI 77 02.1 093H	01 77 02.3 094H	CI 77 02.6 055H	01 77 C3.8 J96 1C7	01 77 05.7 097 107	C1 77 C7.2 058 64	01 77 08.0 099 62	C1 77 05.1 100 66
MO CY YR HR STA DPTH	07 31 77 12+3 081 65	07 21 77 13.3 062 64	07 21 77 14.3 083 112	37 21 77 15.4 084 55	07 31 77 17.C 085 117	07 31 77 18.1 086 55	07 31 77 19.0 J87 72	07 21 77 23.C 088 75	08 J1 77 01.1 089H	08 01 77 01.3 090M	08 C1 77 01.6 J91H	08 01 77 01.8 J92H	08 C1 77 02.1 093H	08 01 77 02.3 094M	08 C1 77 02.6 055H	08 01 77 C3.8 J96 1C7	08 01 77 05.7 097 107	08 C1 77 C7.2 058 64	08 01 77 08.0 099 62	08 C1 77 05.1 100 66
MSG MOCYYR HR STA DPTH	268 07 31 77 12+3 081 65	268 07 21 77 13.3 062 64	268 37 31 77 14.3 083 112	268 37 31 77 15.4 084 55	268 07 31 77 17.C 085 117	268 07 31 77 13.1 086 55	268 07 31 77 19.0 J87 72	266 07 31 77 23.C 088 75	268 08 J1 77 01.1 089H	268 08 01 77 01.3 090H	268 08 C1 77 01.6 091H	268 08 01 77 01.8 J92H	268 08 C1 77 02.1 093M	268 08 01 77 02.3 094M	268 08 CI 77 02.6 055H	268 08 01 77 C3.8 J96 1C7	268 08 01 77 05.7 097 107	268 08 C1 77 C7.2 058 64	268 08 01 77 08.0 099 62	268 08 C1 77 05.1 100 66
G MSG MOCYYR HR STA DPTH	C.O 268 07 31 77 12.3 081 65	1.0 268 07 21 77 13.3 062 64	3.C 268 37 21 77 14.3 083 112	6.0 268 37 31 77 15.4 084 55	2.4 268 07 31 77 17.C 085 117	3.5 268 07 31 77 18.1 086 55	2.5 268 07 31 77 19.0 J87 72	5.0 268 07 21 77 23.C 088 75	4.0 268 08 31 77 01.1 089H	1.0 268 08 01 77 01.3 090M	7.C 268 08 C1 77 01.6 091H	7.5 268 08 01 77 01.8 J92H	C.1 268 08 C1 77 02.1 093M	3.0 268 08 01 77 02.3 094M	5.5 268 08 CI 77 02.6 055H	5.C 268 08 01 77 C3.E 396 1C7	5.0 268 08 01 77 05.7 097 107	4.C 268 08 C1 77 C7.2 058 64	4.8 268 08 01 77 08.0 099 62	4.5 268 08 C1 77 05.1 100 66
LŪNG MSG MOCYYR HR STA DPTH	158-0C•0 268 07 31 77 12•3 081 65	158-01.0 268 07 21 77 13.3 062 64	158-C3.C 268 07 21 77 14.3 083 112	158-C6.0 268 J7 31 77 15.4 084 55	157-32.4 268 07 31 77 17.C 085 117	157-33.5 268 07 31 77 18.1 086 55	157-32.5 268 07 31 77 19.0 J87 72	157-25.0 268 07 21 77 23.C 088 75	157-54.0 268 08 J1 77 01.1 089H	158-21.0 268 08 01 77 01.3 090M	158-47.C 268 08 C1 77 01.6 391H	158-47.5 268 08 01 77 01.8 092H	158-2C.1 268 08 C1 77 02.1 093H	157-53.0 268 08 01 77 02.3 094M	157-25.5 268 08 C1 77 02.6 055H	157-25°C 268 08 01 77 C3.8 096 1C7	157-25.0 268 08 01 77 05.7 097 107	157-24.C 268 08 C1 77 C7.2 058 64	157-24.8 268 08 01 77 08.0 099 62	157-24.5 268 08 C1 77 05.1 100 66
LONG MSG MO CYYR HR STA DPTH	0 158-00.0 268 07 31 77 12.3 081 65	0 158-01.0 268 07 21 77 13.3 062 64	C 158-C3.C 268 37 21 77 14.3 083 112	5 158-C6.0 268 37 31 77 15.4 084 55	1 157-32.4 268 07 31 77 17.C 085 117	2 157-33.5 268 07 31 77 13.1 086 55	5 157-32.5 268 07 31 77 19.0 J87 72	0 157-25.0 268 07 21 77 23.C 088 75	C 157-54.0 268 08 J1 77 01.1 089H	5 158-21.0 268 08 01 77 01.3 090M	5 158-47.C 268 08 C1 77 01.6 091H	4 158-47.5 268 08 01 77 01.8 092H	5 158-2C.1 268 08 C1 77 02.1 093M	E 157-53.0 268 08 01 77 02.3 094M	8 157-25.5 268 08 CI 77 02.6 055H	0 157-25°C 268 08 01 77 C3.8 096 1C7	0 157-25.0 268 08 01 77 05.7 097 107	E 157-24.C 268 08 C1 77 C7.2 058 64	C 157-24.8 268 08 01 77 08.0 099 62	0 157-24.5 268 08 C1 77 05.1 100 66
LAT LÜNG MSG MOCYYR HR STA DPTH	-35.0 158-0C.0 268 07 31 77 12.3 081 65	-33.0 158-01.0 268 07 21 77 13.3 062 64	-26.C 158-C3.C 268 07 21 77 14.3 083 112	-22.5 158-C6.0 268 J7 31 77 15.4 084 55	-23.1 157-32.4 268 07 31 77 17.C 085 117	-27.2 157-33.5 268 07 31 77 18.1 086 55	-31.5 157-32.5 268 07 31 77 19.0 J87 72	-35.0 157-25.0 268 07 21 77 23.C 088 75	-25.C 157-54.O 268 08 J1 77 01.1 089H	-15.5 158-21.0 268 08 01 77 01.3 090M	-14.5 158-47.C 268 08 C1 77 01.6 091H	-24.4 158-47.5 268 08 01 77 01.8 092H	-25.5 158-2C.1 268 08 C1 77 02.1 093H	-34.6 157-53.0 268 08 01 77 02.3 094H	-35.8 157-25.5 268 08 CI 77 02.6 055H	-25.0 157-25.C 268 08 01 77 C3.8 096 1C7	-25.0 157-25.0 268 08 01 77 05.7 097 107	-36.E 157-24.C 268 08 C1 77 C7.2 058 64	-42.C 157-24.8 268 08 01 77 08.0 099 62	-47.0 157-24.5 268 08 C1 77 05.1 100 66
LP LAT LÜNG MSG MOCYYR HR STA DPTH	1 71-35.0 158-0C.0 268 07 31 77 12.3 081 65	[71-33.0 158-01.0 268 07 21 77 13.3 062 64	1 71-26.C 158-C3.C 268 07 21 77 14.3 083 112	1 71-22.5 158-C6.0 268 37 31 77 15.4 084 55	1 71-23.1 157-32.4 268 07 31 77 17.C 085 117	[71-27.2 157-33.5 268 07 31 77 18.1 086 55	[71-31.5 157-32.5 268 07 31 77 19.0 J87 72	1 71-35.0 157-25.0 268 07 21 77 23.C 088 75	1 71-25.C 157-54.O 268 08 J1 77 01.1 089H	1 71-15.5 158-21.0 268 08 01 77 01.3 090M	[71-14.5 158-47.C 268 08 C1 77 01.6 391H	I 71-24.4 158-47.5 268 08 01 77 01.8 092H	I 71-25.5 158-2C.1 268 08 C1 77 02.1 093M	[71-34.6 157-53.0 268 08 01 77 02.3 094M	[71-35.8 157-25.5 268 08 C1 77 02.6 055H	[71-25.0 157-25.C 268 08 01 77 C3.8 096 1C7	[71-25.0 157-25.0 268 08 01 77 05.7 097 107	I 71-36.E 157-24.C 268 08 CI 77 C7.2 058 64	1 71-42.C 157-24.8 268 08 01 77 08.0 099 62	[71-47.0 157-24.5 268 08 C1 77 05.1 100 66
SHIP LAT LUNG MSG MOCYYR HR STA DPTH	81 71-35.0 158-0C.0 268 07 31 77 12.3 081 65	EI 71-33.0 158-01.0 268 07 21 77 13.3 062 64	BI 11-26.C 156-C3.C 268 07 21 77 14.3 083 112	BI 71-22.5 158-C6.0 268 37 21 77 15.4 084 55	BI 71-23.1 157-32.4 268 07 31 77 17.C 085 117	81 71-27.2 157-33.5 268 07 31 77 13.1 086 55	81 71-31.5 157-32.5 268 07 31 77 19.0 J87 72	BI 71-35.0 157-25.0 268 07 21 77 23.C 088 75	BI 71-25.0 157-54.0 268 08 01 77 01.1 089H	81 71-15.5 158-21.0 268 08 01 77 01.3 090M	BI 71-14.5 158-47.0 268 08 C1 77 01.6 391H	BI 71-24.4 158-47.5 268 08 01 77 01.8 092H	81 71-25.5 158-2C.1 268 08 C1 77 02.1 093H	81 71-34.€ 157-53.0 268 08 01 77 02.3 094M	81 71-35.8 157-25.5 268 08 C1 77 02.6 055M	BI 71-25.0 157-25.C 268 08 01 77 Cj.8 096 1C7	81 71-25.0 157-25.0 268 08 01 77 05.7 097 107	81 71-34.€ 157-24.C 268 08 C1 77 C7.2 058 64	81 71-42.C 157-24.8 268 08 01 77 08.0 099 62	81 71-47.0 157-24.5 268 08 C1 77 05.1 100 66

MIZFAC 77 CTD STATIONS

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DPTH	72	62	5 ¢	54	54	4 7	114	106	56	72	63	63	έC	63	70	u 1 U 1	רי ני	54	ω u	62
STA	101	102	103	104	105	100	107	108	1 39	110	111	112	113	114	115	110	117	118	119	120
НК	10.0	12.4	13.7	16.1	17.6	15.1	č.12	23.7	06.8	07.8	C8.8	10.2	11.0	12.0	13.3	16.2	21.1	22。2	23.1	00.1
MO CY YR	08 C1 77	08 C1 77	08 C1 77	08 01 77	08 01 77	08 C1 77	08 01 77	08 01 77	08 02 77	08 02 77	08 02 77	08 C2 77	08 02 77	08 C2 77	08 02 77	08 02 77	08 C2 77	J8 02 77	08 C2 77	08 03 77
MSQ	26 8	268	26 B	268	268	268	268	268	268	268	268	26 B	268	268	26 8	268	26 E	268	268	268
LGNG	157-24.0	157-50.0	158-16.0	158-45.0	159-01.0	158-53.0	158-21.0	157-3C.C	158-03.0	158-0C.O	158-0C.O	158-CE.E	158-02.0	158-00.5	157-57.C	158-46.0	159-0C.O	158-44.0	158-29.5	158-11.5
HIP LAT	81 71-53.0	BI 71-45.0	81 71-45.0	81 71-45.0	81 71-25.C	BI 71-21.0	BI 71-24.5	81 71-26.8	81 71-23.5	81 71-26.5	81 71-35.0	81 71-41.5	81 71-44.0	BI 71-45.4	81 71-55.5	BI 71-5C.0	81 71-35.0	81 71-35.0	81 71-35.0	81 71-35.0
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BAR	151	155	157	162	175	178	182	162	1 64	186	195	177	175	173	172	17C	165	155	151	157
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DPTH	6 2	63	13	5 C	51	5 E	u i (*1	15	63	31	46	34	42	4.2	4.5	46	4 E	45	45	45
STA DPTH	121 62	122 63	123 72	124 5C	125 51	126 58	127 35	128 19	129 63	130 31	151 46	132 34	133 42	134 43	135 45	136 46	137 46	138 45	139 45	140 45
HR STA DPTH	01.0 121 62	C1.8 122 63	02.7 123 73	05.6 124 SC	C9.5 125 51	11.2 126 58	12.9 127 35	14.3 128 15	15.4 129 63	18.2 130 21	21.2 151 46	00.9 132 34	04.4 133 42	05.7 L34 42	C7.2 135 45	08.5 136 46	10.6 137 46	12.4 138 45	14.3 139 45	15.6 140 45
YR HR STA DPTH	50 121 C.10 77	77 01.8 122 63	77 02.7 123 73	77 05.6 124 SC	77 09.5 125 51	77 11.2 126 58	77 12.9 127 35	77 14.3 128 15	77 15.4 129 63	77 18.2 130 31	77 21.2 131 46	77 00.9 132 34	77 04.4 133 42	77 05.7 134 43	77 67.2 135 45	77 08.5 136 46	77 10.6 137 46	77 12.4 138 45	77 14.3 139 45	77 15.6 140 45
CY YR HR STA DPTH	C3 77 01.0 121 62	C3 77 C1.8 122 63	C3 77 C2.7 123 72	03 77 05.6 124 5C	C3 77 C9.5 125 51	C3 77 11.2 126 58	C3 77 12.9 127 35	C3 77 14.3 128 15	03 77 15.4 129 63	03 77 18.2 130 21	C3 77 21.2 131 46	04 77 00.9 132 34	C4 77 04.4 133 42	04 77 05.7 134 43	04 77 07.2 135 45	C4 77 08.5 136 46	04 77 10.6 137 46	C4 77 12.4 138 45	C4 77 14.3 139 45	04 77 15.6 140 45
MO DY YR HR STA DPTH	08 C3 77 01.0 121 62	08 C3 77 C1.8 122 63	08 C3 77 C2.7 123 72	08 03 77 05.6 124 5C	08 C3 77 C9.5 125 51	08 C3 77 11.2 126 58	08 C3 77 12.9 127 35	08 C3 77 14.3 128 15	U8 03 77 15.4 129 63	08 03 77 18.2 130 21	08 C3 77 21.2 131 46	08 34 77 00.9 132 34	08 C4 77 04.4 133 42	08 04 77 05.7 134 43	08 04 77 C7.2 135 45	08 24 77 08.5 136 46	08 04 77 10.6 137 46	08 C4 77 12.4 138 45	08 C4 77 14.3 139 45	08 04 77 15.6 140 45
MSQ MO DY YR HR STA DPTH	266 08 C3 77 01.0 121 62	268 08 C3 77 C1.E 122 63	26E 08 C3 77 C2.7 123 72	268 08 03 77 05.6 124 5C	266 08 C3 77 C9.5 125 51	268 08 C3 77 11.2 126 58	268 08 C3 77 12.9 127 35	26E 08 C3 77 14.3 128 15	268 08 03 77 15.4 129 63	268 08 03 77 18.2 130 21	269 08 C3 77 21.2 131 46	269 08 J4 77 00.9 132 34	265 08 C4 77 04.4 133 42	269 08 04 77 05•7 134 42	269 08 04 77 C7.2 135 45	265 08 C4 77 08.5 136 46	269 08 04 77 10.6 137 46	269 08 C4 77 12.4 138 45	265 08 C4 77 14.3 139 45	269 08 04 77 15.6 140 45
LONG MSQ MO DY YR HR STA DPTH	157-54.9 268 08 C3 77 01.0 121 62	157-36.2 268 08 C3 77 C1.8 122 63	157-15.6 26E 08 C3 77 C2.7 123 73	158-07.1 268 08 03 77 05.6 124 5C	159-C6.5 268 08 C3 77 C9.5 125 51	156-54.C 268 08 C3 77 11.2 126 58	158-57.0 268 08 C3 77 12.9 127 35	158-53.5 266 08 C3 77 14.3 128 15	158-55.0 268 08 03 77 15.4 129 63	159-4C.C 268 08 03 77 18.2 130 21	160-45.0 269 08 C3 77 21.2 131 46	161-41.0 269 08 04 77 00.9 132 34	161-54.5 265 08 C4 77 04.4 133 42	162-12.8 269 08 04 77 05.7 134 42	io2-28.9 269 08 04 77 C7.2 135 45	162-25.8 265 08 C4 77 08.5 136 46	163-C5.0 269 08 04 77 10.6 137 46	162-22.5 269 08 C4 77 12.4 138 45	161-45°C 265 08 C4 77 14°3 139 45	161-25.5 269 08 04 77 15.6 140 45
2 LAT LUNG MSQ MO DY YR HR STA DPTH	71-37.4 157-54.9 268 08 C3 77 01.0 121 62	71-35.1 157-36.2 268 08 C3 77 C1.8 122 63	71-35.0 157-15.6 268 08 C3 77 C2.7 123 73	71-22.3 158-07.1 268 08 03 77 05.6 124 50	71-11.5 159-C6.5 266 08 C3 77 C9.5 125 51	71-1C.8 156-54.C 268 08 C3 77 11.2 126 58	71-01.0 158-57.0 268 08 C3 77 12.9 127 35	7C-57.C 158-53.E 26E 08 C3 77 14.3 128 15	71-06.0 158-55.0 268 08 03 77 15.4 129 63	7C-52.0 159-4C.C 268 08 03 77 18.2 130 21	7C-42.5 160-45.0 269 08 C3 77 21.2 131 46	70-35.5 161-41.0 269 08 34 77 00.9 132 34	7C-44.2 161-54.5 265 08 C4 77 04.4 133 42	7C-52.2 162-12.8 269 08 04 77 05.7 134 43	71-00.9 162-28.9 269 08 04 77 07.2 135 45	71-1C.0 162-25.8 265 08 C4 77 08.5 136 46	71-15.5 163-05.0 269 08 04 77 10.6 137 46	71-11.6 162-23.5 269 08 C4 77 12.4 138 45	71-08.2 161-45.C 265 08 C4 77 14.3 139 45	71-15.0 161-25.5 269 08 04 77 15.6 140 45
SHIP LAT LUNG MSQ MO CY YR HR STA DPTH	81 71-37.4 157-54.9 268 08 C3 77 01.0 121 63	EI 71-35.1 157-36.2 268 08 C3 77 C1.E 122 63	81 71-35.0 157-15.6 26E 08 C3 77 C2.7 123 72	BI 71-22.3 158-07.1 268 08 03 77 05.6 124 5C	81 71-11.5 159-C6.5 266 08 C3 77 C9.5 125 51	BI 71-1C.8 156-54.C 268 08 C3 77 11.2 126 58	81 71-01.0 158-57.0 268 08 C3 77 12.9 127 35	81 7C-57.C 158-53.E 26E 08 C3 77 14.3 128 15	81 71-06.0 158-55.0 268 08 03 77 15.4 129 63	81 7C-52.0 159-4C.C 268 08 03 77 18.2 130 21	BI 7C-42.5 160-45.0 269 08 C3 77 21.2 131 46	81 7C-35.5 161-41.0 269 08 04 77 00.9 132 34	81 7C-44.2 161-54.5 265 08 C4 77 04.4 133 42	81 7C-52.2 162-12.8 269 08 04 77 05.7 134 43	81 71-0C.9 i62-28.9 269 08 04 77 C7.2 135 45	81 71-1C.0 162-25.8 265 08 C4 77 08.5 136 46	81 71-15.5 163-C5.0 269 08 04 77 10.6 137 4E	81 71-11.6 162-23.5 269 08 C4 77 12.4 138 45	81 71-08.2 161-45.C 265 08 C4 77 14.3 139 45	81 71-15.0 161-25.5 269 08 04 77 15.6 140 45

MIZFAC 77 CTD STATIONS

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STA DPTH	141 45	142 5C	143 47	144 51	145 69	146 54	147 32	148 104	149 142	150 106	151 135	152 153	153 130	154 5C	155 108	156 51	157 66
HR STA DPTH	16.5 141 45	17.4 142 5C	19.4 143 47	20.6 144 51	22.3 145 65	23.2 146 54	G5.8 147 32	06.5 148 1C4	C7.5 149 142	05.2 150 106	11.6 151 135	12.8 152 153	14.1 153 12C	16.0 154 5C	16.3 155 108	17.5 156 51	18°5 157 66
YR HR STA DPTH	77 16.5 141 45	77 17.4 142 5C	77 19.4 143 47	77 20.6 144 51	77 22.3 145 65	77 23.2 146 54	77 65.8 147 32	77 06.5 148 104	77 67.9 149 142	77 05.2 150 106	77 11.6 151 135	77 12.8 152 153	77 14.1 153 120	77 16.0 154 SC	77 16.3 155 108	77 17.5 156 51	77 18°5 157 66
CYYR HR STA DPTH	04 77 16.5 141 45	C4 77 17.4 142 5C	04 77 19.4 143 47	C4 77 20.6 144 51	C4 77 22.3 145 69	C4 77 23.2 146 54	05 77 65.8 147 32	05 77 06.5 148 1C4	C5 77 C7.5 149 142	C5 77 09.2 150 106	05 77 11.6 151 135	C5 77 12.8 152 153	05 77 14.1 153 12C	C5 77 16.0 154 5C	C5 77 16.3 155 108	C5 77 17.5 156 51	C5 77 18°5 157 66
MO DY YR HR STA DPTH	08 C4 77 16.5 141 45	08 C4 77 17.4 142 5C	08 04 77 19.4 143 47	08 C4 77 20.6 144 51	08 C4 77 22°3 145 69	08 C4 77 23.2 146 54	J8 05 77 C5.8 147 32	08 05 77 06.5 148 1C4	08 C5 77 C7.5 149 142	08 C5 77 05.2 150 106	08 05 77 11.6 151 135	08 C5 77 12.8 152 153	08 05 77 14.1 153 13C	08 C5 77 16.0 154 5C	08 C5 77 16.3 155 108	08 C5 77 17.5 156 51	08 C5 77 18°¢ 157 &6
MSQ MO CYYR HR STA DPTH	269 08 C4 77 16.5 141 45	265 08 C4 77 17.4 142 5C	265 08 04 77 19.4 143 47	269 08 C4 77 20.6 144 51	269 08 C4 77 22.3 145 69	268 08 C4 77 23.2 146 54	268 38 05 77 05.8 147 33	268 08 05 77 06.5 148 1C4	268 08 C5 77 C7.5 149 142	268 08 C5 77 05.2 150 106	268 08 05 77 11.4 151 135	268 08 C5 77 12.E 152 153	268 08 05 77 14.1 153 12C	26E 08 C5 77 16.0 154 5C	268 08 C5 77 16.3 155 108	268 08 C5 77 17.5 156 51	26E 08 C5 77 18° 5 157 66
LONG MSQ MO DY YR HR STA DPTH	161-14.0 269 08 C4 77 16.5 141 45	161-CE.5 265 08 C4 77 17.4 142 5C	160-35.5 269 08 04 77 19.4 143 47	160-16.0 269 08 C4 77 20.6 144 51	160-C8.0 269 08 C4 77 22.3 145 69	159-58.0 268 08 C4 77 23.2 146 54	156-52.C 268 38 05 77 C5.8 147 32	157-C4.2 268 08 05 77 06.5 148 1C4	157-12.0 268 08 C5 77 C7.5 149 142	157-22.0 268 08 C5 77 05.2 150 106	156-30.0 268 08 05 77 11.4 151 135	156-3C.C 268 08 C5 77 12.8 152 153	156-28.5 268 08 05 77 14.1 153 13C	156-26.5 268 08 C5 77 16.0 154 5C	156-23.C 268 08 C5 77 16.3 155 108	156-46.9 268 08 C5 77 17.5 156 51	157-1C.0 26£ 08 C5 77 18.¢ 157 66
PLAT LONG MSQ MOCYYR HR STA DPTH	71-16.0 161-14.0 269 08 C4 77 16.5 141 45	71-15.3 161-CE.5 265 08 C4 77 17.4 142 5C	71-1C.5 160-35.5 269 08 04 77 19.4 143 47	71-02.5 160-16.0 269 08 C4 77 20.6 144 51	iC-56.5 160-C8.0 269 08 C4 77 22.3 145 69	70-54.0 159-58.0 268 08 C4 77 23.2 146 54	71-16.0 156-52.C 268 38 05 77 C5.8 147 32	71-22.5 157-C4.2 268 08 05 77 06.5 148 1C4	71-24.8 157-12.0 268 08 C5 77 C7.5 149 142	71-25.5 157-22.0 268 08 C5 77 05.2 150 106	71-28.0 156-30.0 268 08 05 77 11.6 151 135	71-34.0 156-30.0 268 08 C5 77 12.8 152 153	71-35.C 156-28.5 268 08 05 77 14.1 153 13C	71-44.0 156-26.5 268 08 C5 77 16.0 154 5C	71-4C.0 156-23.C 268 08 C5 77 16.3 155 108	71-4C.0 156-46.9 268 08 C5 77 17.5 156 51	71-40.0 157-1C.0 26£ 08 C5 77 18.° 157 66
SHIP LAT LONG MSQ MOCYYR HR STA DPTH	81 71-16.0 161-14.0 269 08 C4 77 16.5 141 45	BI 71-15.3 161-CE.5 265 08 C4 77 17.4 142 5C	81 71-1C.5 160-35.5 269 08 04 77 19.4 143 47	81 71-02.5 160-16.0 269 08 C4 77 20.6 144 51	81 iC-56.5 160-C8.0 269 08 C4 77 22.3 145 69	BI 70-54.0 159-58.0 268 08 C4 77 23.2 146 54	81 71-16.0 156-52.C 268 38 05 77 C5.8 147 32	81 71-22.5 157-C4.2 268 08 05 77 06.5 148 1C4	81 71-24.8 157-12.0 268 08 C5 77 C7.5 149 142	BI 71-25.5 157-22.0 268 08 C5 77 05.2 150 106	81 71-28.0 156-30.0 268 08 05 77 11.6 151 135	81 71-34.0 156-3C.C 268 08 C5 77 12.E 152 153	BI 71-35.C 156-28.5 268 08 05 77 14.1 153 13C	81 71-44.0 156-26.5 268 08 C5 77 16.0 154 5C	81 71-4C.0 156-23.C 268 08 C5 77 16.3 155 108	81 71-4C.0 156-46.9 268 08 C5 77 17.5 156 51	BI 71-40.0 157-1C.0 26€ 08 C5 77 18.9 157 66

TOTAL= 157

APPENDIX D

PROPERTY PROFILES FOR MIZPAC 77 STATIONS

This section contains plots of temperature, salinity, sound velocity and sigma-t for all of the stations of MIZPAC 77 which were recovered from the cassette tapes successfully. Station 97 is missing and of the sequence 65H through 71H, allotted for a helicopter expedition, only the first two were successful. Other "H" suffixes also indicate helicopter stations. It will be noted that Stations 46 and 107 are duplicated. Explanations of the differences between duplicates are given in Appendix A.

The basic four-per-page plot has a maximum depth of 70 m. All the stations were plotted in this way. In addition, deeper stations were plotted on a 140-meter depth scale, two per page. These are interleaved with the smaller plots. To assist in distinguishing curves the salinity curve has been doubled with a line 0.01 inches to the left and the temperature has been treated similarly with 0.015 inch spacing. The curves are also labeled, T for temperature, S for salinity, SV for sound velocity and ST for sigma-t.




MIZPAC 77 STD STATIONS





















MIZPAC 77 STD STATIONS








































































SELS MIZPAG 77 STD STATIONS





SELA MIZPAS 77 STD STATIONS





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