XFWS-A 580 1-25 (1969)
U.S. Fish Wildl. Serv.
Spec. Sci. Rep. Fish.

588

# Processing of Digital Data Logger STD Tapes at the Scripps Institution of Oceanography and the Bureau of Commercial Fisheries, La Jolla, California



SPECIAL SCIENTIFIC REPORT-FISHERIES No. 588

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

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UNITED STATES DEPARTMENT OF THE INTERIOR
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Washington, D.C.
June 1969

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## ABSTRACT

The development of continuous sampling STD (salinity-temperature-depth) sensors as a prime data collection tool for oceanographic cruises has necessitated the development of techniques capable of handling the data with modern digital computing equipment. This paper describes one such technique that was developed for processing STD data collected as part of the EASTROPAC Survey Program. The description assumes that the data has been digitized and recorded on IBM compatible tape in the field. The computer programs needed for processing the basic data tapes are described, and a listing of the program with subroutines is given in the Appendix.

# Processing of Digital Data Logger STD Tapes at the Scripps Institution of Oceanography and the Bureau of Commercial Fisheries, La Jolla, California

By

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## INTRODUCTION

As part of the EASTROPAC Survey Program, computer programs were developed to process STD (salinity-temperature-depth) data from Bisset-Berman model 9006 systems,[2] and record them on incremental IBM compatible DDL's (digital data loggers), also manufactured by the same company. The accuracy and precision of these two instruments are described in the manufacturing brochures and are not discussed here. During the EASTROPAC Program, about 10,000 m. of field tapes were generated which required editing and data processing.

The purpose of this paper is to describe the methods developed for processing the field tapes to a point where the data produced from them may be compared with some independent calibration such as conventional Nansen casts or Niskin samplers, attached to the STD's.

In its present form, the DDL samples each of four channels of information about once every 0.2 second, and writes a seven-channel IBM compatible tape at a bit density of 200 bits per inch. At a drop rate of 60 m. depth per minute, salinity, temperature, depth, and the optional sound velocity channel are sampled five times in each 1-m. interval. Since the uncertainty of the depth sensor is about 1 m., at this maximum sampling rate, five values of temperature and salinity are available to produce one value per meter. The program described below is based on the premise that the original field tapes are recorded at this maximum rate. Slower sampling rates require slight modification of the low-pass filters used in the program. The fourth and optional channel of sound velocity is not used on any STD systems of the Scripps Institution of Oceanography, or the Bureau of Commercial Fisheries; therefore no description of schemes to process the optional channel is included.

## PRELIMINARY PROCESSING

When the field tapes are received at the data-processing center they are first passed through a computer routine which examines

[1]Work for this manuscript was done while the author was employed by the Bureau of Commercial Fisheries Fishery-Oceanography Center, La Jolla, Calif. 92037.

[2]Use of trade names does not imply endorsement by the Bureau of Commercial Fisheries.

them, file by file, and lists the binary length of the first record as well as the total number of records per file. Any parity errors in the records examined are also listed.

The ideal field tape contains no parity errors. The first record of the first file is an information record and, in the format used by us, is a three-digit number signifying the cast number for that particular cruise. The binary length of this record is always 1. The second file consists of the data recorded by the data logger and may contain any number of records depending, among other things, on the maximum depth attained and the drop rate. A 500-m. cast at a drop rate of 60 m. per minute has about 50 records per file.

In its present form the data logger is designed to produce a binary data record length of 52.[3] Thus, in the ideal field tape the files alternate between an information file containing only one record with a binary length of 1 and a data file with many records, all with a binary length of 52. The preliminary listing of the field tapes provides the programmer with a picture of how far his tapes deviate from the ideal. If the contents of the first record are printed during the preliminary listing, the cast numbers may be identified with individual data files.

The next step in the data processing is to produce, from the field tapes, a high-density tape which is free of parity errors and other anomalies which confuse the tape translation. In the transfer from low- to high-density tape, we have chosen to eliminate all records containing parity errors and records not of binary length 1 or 52. Our experience is that we lose no more than 3 percent of the original data in this way. The high-density tape, free of tape errors, is then considered to be the basic data; the original field tapes are erased, checked and readied for the next cruise.

## THE PROGRAM

The program and subroutine functions are outlined in figure 1, and a listing of the program, as run on the CDC 3600 at UCSD (University of California, San Diego), is provided in the Appendix. The main program RDEDTP (read and edit tape) reads in, from cards, a list of the files to be translated from the basic tape and a list of station numbers that are to be associated with data lists. The file containing the station number is read and translated if it is in the proper format. If it is missing or in an improper format, as determined from the preliminary tape listing, the proper station number is determined from a logbook for the data logger and is read in from a card.

The first subroutine, TRANS, translates, record by record, the digitized frequencies into salinity in parts per thousand, temperature in degrees Celsius, and depth in meters. Maximum and minimum bounds are specified for the depth so that any values outside these limits are rejected.

During the field operations, the sensor package is sometimes temporarily stopped at an intermediate depth to make adjustments to the pens or the winch. The data logger is usually left running on these stops, but the records are of no use in producing a vertical profile; subroutine BASKET is accordingly called to delete the records where the depth has not increased. The final control is a counter which provides for a jump out of TRANS before memory overflows can occur.

A sample output of the record produced by subroutine TRANS is given in figure 2. The fourth column of each set is an absolute counter for the file, which increases only when an acceptable set of salinity, temperature, and depth is translated. When the lower depth bounds are exceeded, the counter is not increased and that set of data is not saved for transmittal to the smoothing subroutine. The 0's printed at the beginning of the file in the first record indicate nonacceptable data, since the depth is less than the minimum of -0.2 m. set in the subroutine. In the first record of this file only 16 sets of salinity, temperature, and depth were acceptable.

Between TRANS and the next subroutine, the maximum and minimum values of salinity,

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[3]The magnetic tape record is 416 tape frames long, which is the equivalent of 52 computer records.

COMPUTER PROGRAM LINKAGE
FOR
PROCESSING DIGITAL STD TAPES

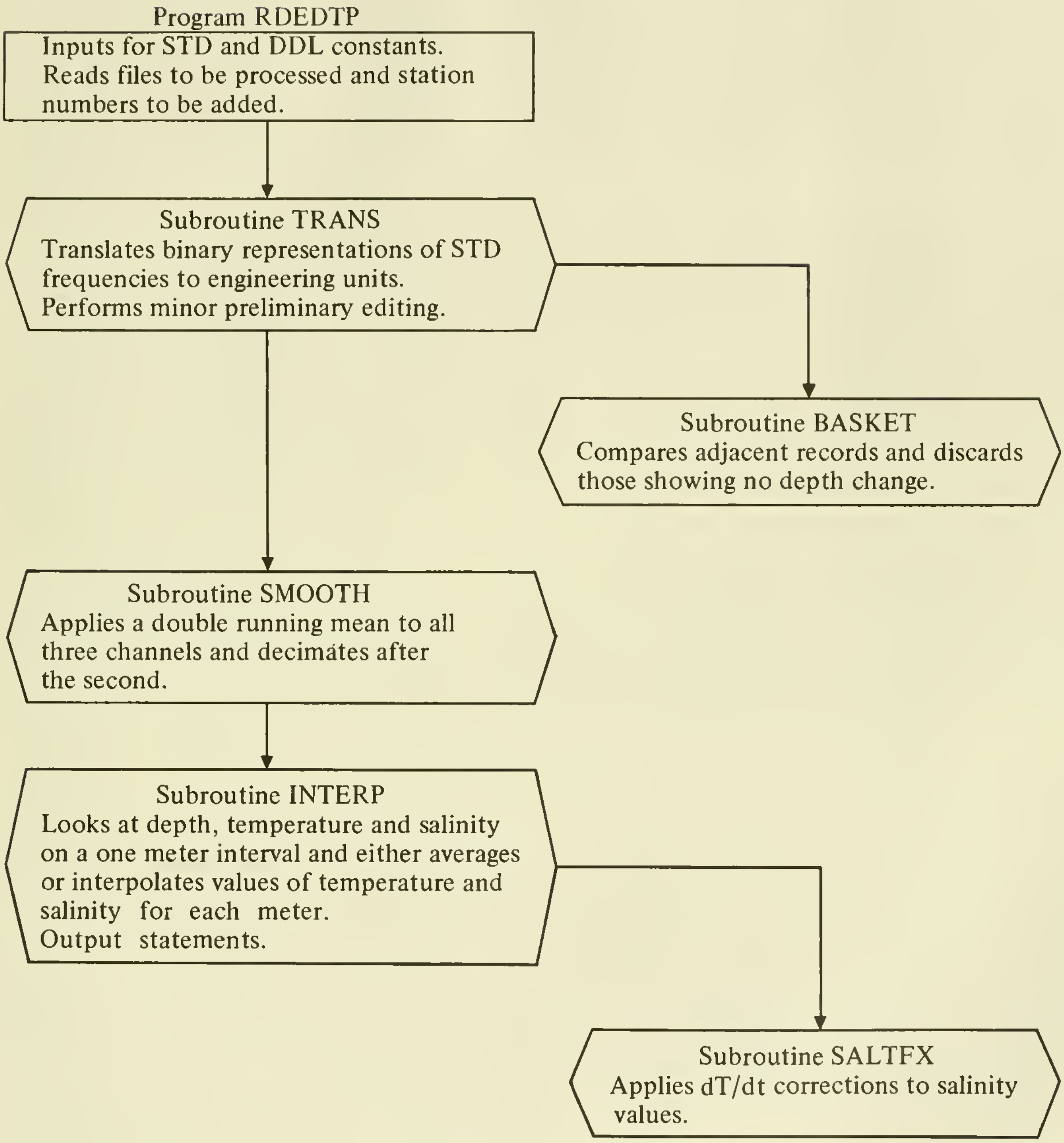


Figure 1.—Computer program linkage for processing digital STD tapes.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -.5 | 21.56 | 34.941 | -0 | -.6 | 21.55 | 34.940 | -0 | -.5 | 21.57 | 34.940 | -0 | -.3 | 21.57 | 34.939 | -0 |
| -.1 | 21.57 | 34.938 | 1 | -.5 | 21.56 | 34.949 | -0 | -.3 | 21.56 | 34.953 | -0 | -.5 | 21.56 | 34.947 | -0 |
| -.5 | 21.57 | 34.938 | -0 | -.5 | 21.58 | 34.934 | -0 | -.5 | 21.60 | 34.929 | -0 | -.6 | 21.59 | 34.933 | -0 |
| -.6 | 21.60 | 34.942 | -0 | -.5 | 21.60 | 34.944 | -0 | -.5 | 21.60 | 34.945 | -0 | -.5 | 21.60 | 34.950 | -0 |
| -.3 | 21.59 | 34.951 | -0 | -.1 | 21.60 | 34.942 | 2 | -.1 | 21.59 | 34.952 | 3 | .1 | 21.59 | 34.966 | 4 |
| .5 | 21.60 | 34.972 | 5 | .7 | 21.63 | 34.987 | 6 | .7 | 21.66 | 34.982 | 7 | .7 | 21.66 | 34.944 | 8 |
| 1.1 | 21.66 | 34.950 | 9 | 1.4 | 21.65 | 34.944 | 10 | 1.1 | 21.65 | 34.958 | 11 | 1.6 | 21.65 | 34.918 | 12 |
| 1.6 | 21.66 | 34.941 | 13 | 1.8 | 21.66 | 34.944 | 14 | 2.0 | 21.64 | 34.947 | 15 | 2.2 | 21.64 | 34.949 | 16 |
| 2.9 | 21.62 | 34.960 | 17 | 2.9 | 21.61 | 34.768 | 18 | 3.1 | 21.61 | 34.697 | 19 | 3.1 | 21.58 | 34.931 | 20 |
| 3.3 | 21.50 | 34.792 | 21 | 3.3 | 21.46 | 34.820 | 22 | 3.9 | 21.35 | 34.849 | 23 | 3.3 | 21.27 | 34.876 | 24 |
| 3.7 | 21.20 | 34.884 | 25 | 4.3 | 21.11 | 34.867 | 26 | 4.5 | 21.04 | 34.892 | 27 | 4.5 | 21.02 | 34.892 | 28 |
| 4.5 | 20.94 | 34.898 | 29 | 5.0 | 20.89 | 34.902 | 30 | 4.8 | 20.84 | 34.896 | 31 | 5.0 | 20.80 | 34.910 | 32 |
| 4.8 | 20.77 | 34.914 | 33 | 5.4 | 20.73 | 34.926 | 34 | 5.2 | 20.71 | 34.928 | 35 | 5.8 | 20.66 | 34.935 | 36 |
| 6.0 | 21.65 | 34.934 | 37 | 6.3 | 20.62 | 34.950 | 38 | 6.0 | 20.60 | 34.870 | 39 | 6.5 | 20.57 | 34.882 | 40 |
| 6.5 | 20.55 | 34.904 | 41 | 6.9 | 20.52 | 34.937 | 42 | 7.1 | 20.51 | 34.949 | 43 | 7.3 | 20.51 | 34.943 | 44 |
| 7.5 | 20.49 | 34.631 | 45 | 8.1 | 20.21 | 34.385 | 46 | 7.9 | 19.97 | 34.514 | 47 | 8.2 | 19.68 | 34.720 | 48 |
| 8.6 | 19.22 | 34.796 | 49 | 8.6 | 19.13 | 34.765 | 50 | 8.8 | 19.01 | 34.813 | 51 | 9.6 | 18.94 | 35.096 | 52 |
| 9.0 | 19.08 | 34.968 | 53 | 9.9 | 18.99 | 34.925 | 54 | 9.6 | 19.05 | 35.086 | 55 | 9.9 | 19.42 | 35.359 | 56 |
| 9.8 | 19.89 | 35.160 | 57 | 9.9 | 19.88 | 34.701 | 58 | 10.5 | 19.47 | 34.659 | 59 | 10.5 | 18.92 | 34.646 | 60 |
| 10.3 | 18.77 | 35.345 | 61 | 10.5 | 18.79 | 34.715 | 62 | 11.1 | 18.58 | 34.500 | 63 | 11.3 | 18.29 | 34.046 | 64 |
| 11.1 | 18.04 | 34.581 | 65 | 11.3 | 17.99 | 34.797 | 66 | 11.7 | 17.60 | 34.155 | 67 | 11.7 | 17.15 | 34.245 | 68 |
| 12.0 | 16.97 | 34.392 | 69 | 12.2 | 15.90 | 34.448 | 70 | 12.8 | 16.86 | 34.573 | 71 | 13.2 | 16.86 | 34.673 | 72 |
| 13.2 | 16.84 | 34.775 | 73 | 13.7 | 16.84 | 34.820 | 74 | 14.3 | 16.80 | 34.847 | 75 | 14.1 | 16.78 | 34.859 | 76 |
| 14.9 | 16.76 | 34.880 | 77 | 14.7 | 16.75 | 34.897 | 78 | 15.1 | 16.74 | 34.901 | 79 | 15.1 | 16.74 | 34.901 | 80 |
| 15.3 | 16.71 | 34.903 | 81 | 16.2 | 16.71 | 34.910 | 82 | 15.8 | 16.70 | 34.914 | 83 | 15.3 | 16.70 | 34.920 | 84 |
| 16.0 | 16.71 | 34.928 | 85 | 16.2 | 16.69 | 34.944 | 86 | 15.6 | 16.70 | 34.959 | 87 | 16.4 | 16.70 | 34.968 | 88 |
| 16.6 | 16.68 | 34.972 | 89 | 16.8 | 16.68 | 34.971 | 90 | 16.8 | 16.68 | 34.973 | 91 | 16.6 | 16.68 | 34.976 | 92 |
| 17.1 | 16.68 | 34.973 | 93 | 17.7 | 16.68 | 34.973 | 94 | 17.3 | 16.68 | 34.969 | 95 | 17.1 | 16.66 | 34.972 | 96 |
| 17.7 | 16.67 | 34.971 | 97 | 18.3 | 16.67 | 34.971 | 98 | 18.3 | 16.67 | 34.966 | 99 | 18.5 | 16.66 | 34.956 | 100 |
| 18.7 | 16.64 | 34.948 | 101 | 19.2 | 16.64 | 34.959 | 102 | 19.6 | 16.63 | 34.963 | 103 | 19.8 | 16.62 | 34.967 | 104 |
| 20.2 | 16.63 | 34.968 | 105 | 20.4 | 16.62 | 34.968 | 106 | 20.6 | 16.62 | 34.976 | 107 | 21.1 | 16.62 | 34.979 | 108 |
| 21.3 | 16.63 | 34.972 | 109 | 21.1 | 16.60 | 34.973 | 110 | 21.3 | 16.61 | 34.978 | 111 | 21.3 | 16.61 | 34.980 | 112 |
| 21.5 | 16.61 | 34.980 | 113 | 21.1 | 16.60 | 34.981 | 114 | 21.1 | 16.60 | 34.980 | 115 | 21.1 | 16.60 | 34.979 | 116 |
| 21.7 | 16.60 | 34.979 | 117 | 21.9 | 16.61 | 34.977 | 118 | 22.3 | 16.60 | 34.973 | 119 | 22.5 | 16.58 | 34.953 | 120 |
| 22.5 | 16.55 | 34.939 | 121 | 22.8 | 16.50 | 34.944 | 122 | 23.4 | 16.46 | 34.941 | 123 | 23.0 | 16.44 | 34.955 | 124 |
| 24.0 | 16.42 | 34.951 | 125 | 24.4 | 16.40 | 34.950 | 126 | 24.6 | 16.38 | 34.952 | 127 | 24.9 | 16.35 | 34.951 | 128 |
| 25.1 | 16.33 | 34.953 | 129 | 25.5 | 16.33 | 34.961 | 130 | 25.7 | 16.32 | 34.966 | 131 | 26.1 | 16.31 | 34.962 | 132 |
| 26.1 | 16.29 | 34.956 | 133 | 26.5 | 16.27 | 34.961 | 134 | 26.5 | 16.27 | 34.966 | 135 | 27.0 | 16.25 | 34.970 | 136 |
| 26.6 | 16.21 | 34.972 | 137 | 26.6 | 16.19 | 34.970 | 138 | 26.6 | 16.19 | 34.970 | 139 | 26.6 | 16.16 | 34.960 | 140 |
| 27.4 | 16.14 | 34.963 | 141 | 27.2 | 16.12 | 34.966 | 142 | 27.2 | 16.09 | 34.970 | 143 | 27.8 | 16.09 | 34.958 | 144 |
| 27.8 | 16.05 | 34.959 | 145 | 28.7 | 16.04 | 34.962 | 146 | 28.5 | 16.04 | 34.967 | 147 | 28.5 | 16.02 | 34.975 | 148 |
| 29.1 | 16.01 | 34.980 | 149 | 29.5 | 15.99 | 34.973 | 150 | 30.1 | 15.99 | 34.978 | 151 | 30.1 | 15.98 | 34.983 | 152 |
| 30.4 | 15.98 | 34.987 | 153 | 30.8 | 15.97 | 34.989 | 154 | 31.2 | 15.98 | 34.991 | 155 | 31.0 | 15.98 | 34.992 | 156 |
| 31.2 | 15.97 | 34.992 | 157 | 31.0 | 15.96 | 34.992 | 158 | 31.4 | 15.97 | 34.993 | 159 | 31.8 | 15.95 | 34.994 | 160 |
| 32.0 | 15.96 | 34.994 | 161 | 31.4 | 15.96 | 34.995 | 162 | 31.8 | 15.95 | 34.995 | 163 | 31.4 | 15.96 | 34.995 | 164 |
| 32.3 | 15.95 | 34.995 | 165 | 32.2 | 15.95 | 34.994 | 166 | 31.6 | 15.97 | 34.994 | 167 | 32.2 | 15.96 | 34.994 | 168 |
| 32.3 | 15.94 | 34.992 | 169 | 32.7 | 15.96 | 34.994 | 170 | 33.3 | 15.96 | 34.994 | 171 | 32.9 | 15.93 | 34.990 | 172 |
| 32.9 | 15.95 | 34.992 | 173 | 33.5 | 15.95 | 34.993 | 174 | 33.9 | 15.94 | 34.992 | 175 | 34.1 | 15.93 | 34.993 | 176 |

Figure 2.–Salinity, temperature, and depth values translated by subroutine TRANS. The fourth column is a counter which increases only when a value is acceptable for transmission to subroutine SMOOTH. The 0 counter values at the top of the first page denote inacceptable observations as the depth falls outside the minimum limit. The station was EASTROPAC 75.115, an STD cast to a nominal depth of 150 m.

temperature, and depth as well as the total number of values retained are printed. This printing gives a check that determines whether any unrealistic values were used in the subsequent filtering and averaging routines.

The third subroutine, SMOOTH, performs low-pass filtering to the three channels and decimates. The low-pass filters are a running mean; the numbers for the averages depend on the recording and drop rates. Since our procedures normally produce about five values every meter, a running mean of 5 is applied. Decimation occurs after the second running mean and depth values are rounded to the closest 1-m. interval.

The final subroutine, INTERP (interpret), is an averaging and interpolation package. Values of temperature and salinity that occur in the same 1-m. interval are averaged. Where there are no values in a meter interval, one is linearly interpolated from adjacent values. After this procedure, subroutine SALTFX (salt fix) is called and salinity values are corrected for swift changes in the temperature gradient according to the formula:

$$S = \left(\frac{\partial T}{\partial z}\right) R \tau K S'$$

where $S'$ is the apparent salinity

$\frac{\partial T}{\partial z}$ is the rate of change of temperature with depth

$K$ is a constant (~ -0.09 p.p.t. per 1°C.)

$\tau$ is a thermometer time constant (~0.35 sec.)

and $R$ is the drop rate.

A final output statement follows this last subroutine.

Figure 3 represents the final output from the data-processing program. Preceding the data are the station number and the total number of observations within the bounds set in TRANS and transmitted to subroutine SMOOTH. Below are the maximum and minimum values of salinity, temperature, and depth used by the smoothing subroutine. Finally, the number of data sets transmitted from SMOOTH to the final subroutine INTERP are given. The data interpolated to a 1-m. interval follow below.

A comparison of the DDL output with the analog output of the STD is presented in figures 4-6. A 600-m. station was chosen for the comparison as it presents most of the features normally encountered on an STD cast. Figure 4 is a reproduction of a cast made near the equator in the eastern Pacific. The surface temperature and salinity noted at the top of the trace were determined from a continuous recording surface TS recorder, periodically checked by bucket temperature and surface-water sample salinity. The numbers adjacent to the profiles represent the salinity scale (4) and the temperature scales (6, ....., 3) used during the cast. The salinity trace is displaced upward (toward a shallower depth), by 5 m. on the depth scale, from the temperature to allow the two pens to cross without interfering with one another. This particular paper does not have the scales printed directly, but they are identical to those at the bottom of figure 5. The spikes in the salinity trace are a feature common to almost all STD casts. They are considered to be a result of a failure of the electronic system in the salinity sensor to respond to sudden changes of the temperature gradient and do not reflect the true salinity at those locations.

Figure 5 is a computer generated plot of the 1-m. values as output from the data processing program. The scales are identical to those of figure 4. The temperature profile is identical to the analog plot reproducing fully temperature inversions and sudden changes in gradient. The salinity trace, when the vertical pen displacement is accounted for, is also reproduced with some spikes totally eliminated and others partially eliminated. The failure to eliminate all the salinity spikes reflects the fact that not all the spike-forming processes are known. The manufacturer has recently noted that there is an intermittency in a portion of the electronic system that responds to a sudden change in temperature gradient as well as a lag response function in the operation of the conductivity to salinity circuitry. The manufacturer claims to have remedied this circuitry problem in the newer model 9040 STD system. In addition, the numbers used in the salinity correction formula given above are only approximate and may be seriously in error for some instruments and for very different drop rates than assumed here.

It is for these reasons that additional filtering is applied to the salinity trace alone. Figure 6 presents a running mean of 10, applied to the salinities used to produce the profile in figure 5. The type of secondary salinity filtering will ultimately depend on the user's application of the data.

STATION 511

ORIGINAL NO OF OBS. 815

MAX.TEMP. 21.66 MIN.TEMP. 13.17 MAX.SAL. 35.359 MIN.SAL. 34.046 MAX.DEPTH 156.8 MIN.DEPTH -.1

NUMBER OF DATA PTS.AFTER SMOOTHING 262

VALUES INTERPOLATED AT 1 METER INTERVALS

| DEPTH (M) | TEMP (OC) | SALN (0/00) | DEPTH (M) | TEMP (OC) | SALN (0/00) | DEPTH (M) | TEMP (OC) | SALN (0/00) | DEPTH (M) | TEMP (OC) | SALN (0/00) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21.64 | 34.955 | 2 | 21.64 | 34.934 | 3 | 21.55 | 34.838 | 4 | 21.17 | 35.002 |
| 5 | 20.83 | 34.984 | 6 | 20.64 | 34.926 | 7 | 20.53 | 34.996 | 8 | 19.99 | 34.919 |
| 9 | 19.10 | 34.954 | 10 | 19.26 | 35.057 | 11 | 18.16 | 34.869 | 12 | 17.12 | 34.632 |
| 13 | 16.86 | 34.653 | 14 | 16.80 | 34.822 | 15 | 16.74 | 34.978 | 16 | 16.70 | 34.945 |
| 17 | 16.68 | 34.975 | 18 | 16.67 | 34.973 | 19 | 16.64 | 34.965 | 20 | 16.63 | 34.970 |
| 21 | 16.61 | 34.981 | 22 | 16.58 | 34.989 | 23 | 16.48 | 34.979 | 24 | 16.40 | 34.970 |
| 25 | 16.34 | 34.965 | 26 | 16.30 | 34.981 | 27 | 16.20 | 35.005 | 28 | 16.08 | 34.994 |
| 29 | 16.02 | 34.986 | 30 | 15.98 | 34.990 | 31 | 15.97 | 34.994 | 32 | 15.96 | 34.996 |
| 33 | 15.95 | 34.994 | 34 | 15.94 | 34.994 | 35 | 15.94 | 34.993 | 36 | 15.94 | 34.993 |
| 37 | 15.94 | 34.993 | 38 | 15.94 | 34.993 | 39 | 15.94 | 34.994 | 40 | 15.92 | 34.992 |
| 41 | 15.91 | 34.987 | 42 | 15.90 | 34.984 | 43 | 15.89 | 34.977 | 44 | 15.87 | 34.969 |
| 45 | 15.81 | 34.986 | 46 | 15.71 | 34.990 | 47 | 15.63 | 34.997 | 48 | 15.56 | 35.000 |
| 49 | 15.52 | 34.992 | 50 | 15.51 | 34.981 | 51 | 15.48 | 34.993 | 52 | 15.44 | 34.999 |
| 53 | 15.41 | 34.991 | 54 | 15.39 | 34.986 | 55 | 15.36 | 34.990 | 56 | 15.35 | 34.985 |
| 57 | 15.33 | 34.980 | 58 | 15.31 | 34.990 | 59 | 15.27 | 34.997 | 60 | 15.25 | 34.994 |
| 61 | 15.24 | 34.988 | 62 | 15.20 | 34.986 | 63 | 15.15 | 34.988 | 64 | 15.06 | 34.997 |
| 65 | 14.98 | 34.995 | 66 | 14.94 | 34.989 | 67 | 14.90 | 34.993 | 68 | 14.86 | 34.997 |
| 69 | 14.83 | 34.994 | 70 | 14.82 | 34.995 | 71 | 14.81 | 34.998 | 72 | 14.81 | 34.988 |
| 73 | 14.80 | 34.946 | 74 | 14.74 | 34.963 | 75 | 14.40 | 35.079 | 76 | 13.86 | 35.091 |
| 77 | 13.71 | 34.983 | 78 | 13.69 | 34.959 | 79 | 13.68 | 34.967 | 80 | 13.66 | 34.973 |
| 81 | 13.64 | 34.973 | 82 | 13.64 | 34.971 | 83 | 13.63 | 34.971 | 84 | 13.63 | 34.971 |
| 85 | 13.62 | 34.970 | 86 | 13.62 | 34.968 | 87 | 13.63 | 34.969 | 88 | 13.62 | 34.971 |
| 89 | 13.62 | 34.971 | 90 | 13.62 | 34.970 | 91 | 13.61 | 34.969 | 92 | 13.61 | 34.969 |
| 93 | 13.61 | 34.968 | 94 | 13.60 | 34.969 | 95 | 13.59 | 34.969 | 96 | 13.59 | 34.968 |
| 97 | 13.59 | 34.968 | 98 | 13.58 | 34.968 | 99 | 13.58 | 34.967 | 100 | 13.58 | 34.967 |
| 101 | 13.58 | 34.968 | 102 | 13.57 | 34.967 | 103 | 13.57 | 34.967 | 104 | 13.56 | 34.967 |
| 105 | 13.56 | 34.965 | 106 | 13.55 | 34.966 | 107 | 13.54 | 34.965 | 108 | 13.54 | 34.963 |
| 109 | 13.52 | 34.969 | 110 | 13.49 | 34.969 | 111 | 13.48 | 34.959 | 112 | 13.46 | 34.954 |
| 113 | 13.45 | 34.957 | 114 | 13.43 | 34.960 | 115 | 13.42 | 34.962 | 116 | 13.41 | 34.959 |
| 117 | 13.40 | 34.956 | 118 | 13.40 | 34.956 | 119 | 13.40 | 34.957 | 120 | 13.40 | 34.957 |
| 121 | 13.40 | 34.958 | 122 | 13.40 | 34.957 | 123 | 13.40 | 34.957 | 124 | 13.39 | 34.957 |
| 125 | 13.39 | 34.954 | 126 | 13.39 | 34.955 | 127 | 13.38 | 34.955 | 128 | 13.38 | 34.956 |
| 129 | 13.37 | 34.956 | 130 | 13.37 | 34.954 | 131 | 13.37 | 34.954 | 132 | 13.37 | 34.954 |
| 133 | 13.37 | 34.955 | 134 | 13.36 | 34.954 | 135 | 13.37 | 34.954 | 136 | 13.36 | 34.954 |
| 137 | 13.36 | 34.953 | 138 | 13.36 | 34.959 | 139 | 13.34 | 34.952 | 140 | 13.34 | 34.950 |
| 141 | 13.32 | 34.949 | 142 | 13.30 | 34.948 | 143 | 13.28 | 34.948 | 144 | 13.26 | 34.947 |
| 145 | 13.24 | 34.949 | 146 | 13.21 | 34.950 | 147 | 13.19 | 34.945 | 148 | 13.19 | 34.942 |
| 149 | 13.19 | 34.944 | 150 | 13.18 | 34.944 | 151 | 13.18 | 34.943 | 152 | 13.18 | 34.942 |
| 153 | 13.18 | 34.943 | 154 | 13.18 | 34.943 | 155 | 13.18 | 34.943 | 156 | 13.18 | 34.943 |
| 157 | 13.18 | 34.945 | | | | | | | | | |

Figure 3.–Final output of acceptable values at 1-m. intervals from subroutine INTERP. The station number is printed at the top. Below is the number of observations transmitted to subroutine SMOOTH. The maximum and minimum values transmitted of salinity, temperature, and depth are listed below the numbers of observations. The number of data points after smoothing indicates the number of observations transmitted to subroutine INTERP. (One observation consisted of one value of each of salinity, temperature, and depth.)

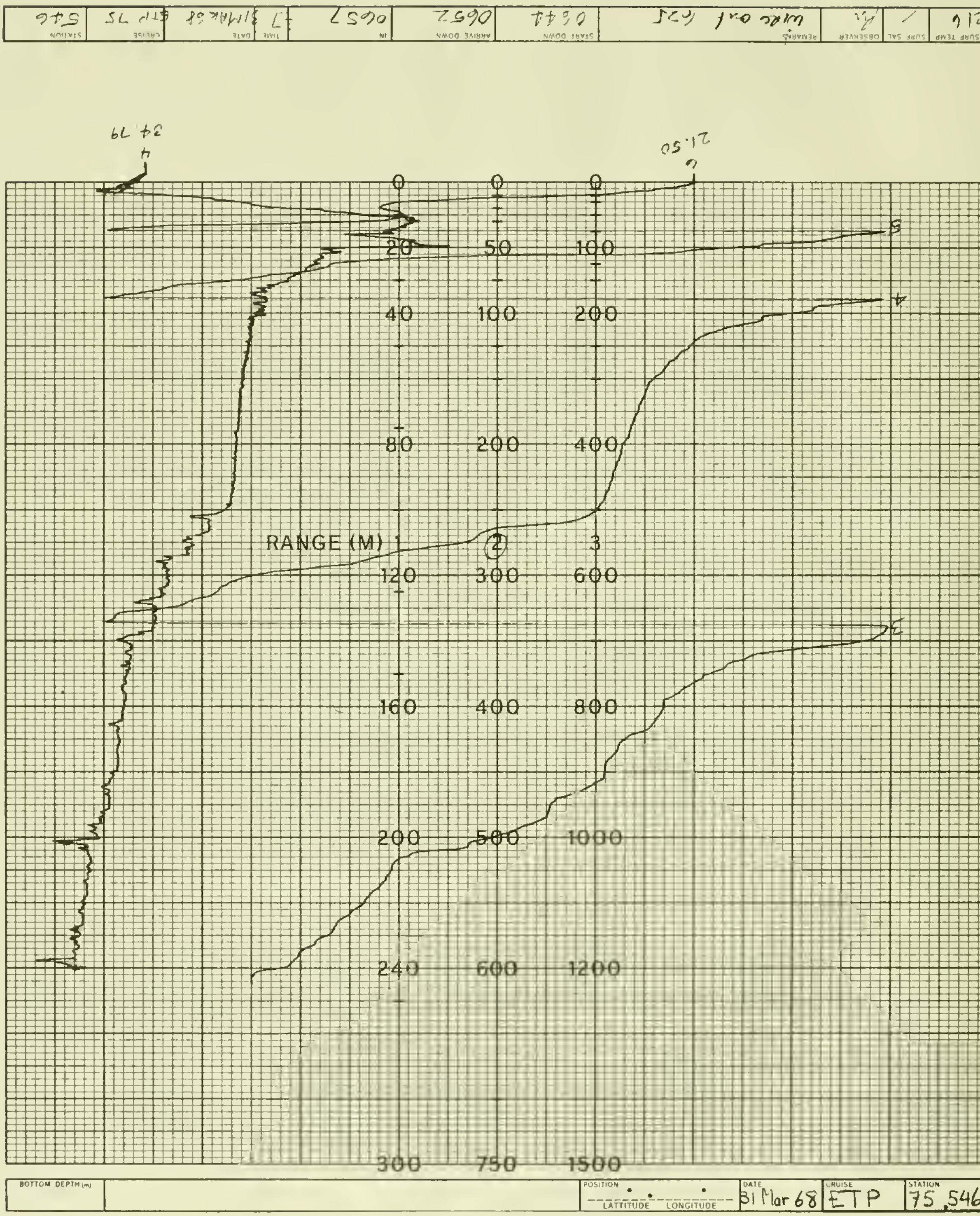


Figure 4.–Reproduction of original analog trace of station 546, made on EASTROPAC cruise 75 (15 February to 15 April 1968). Cast was to 600 m. Surface salinity and temperature at top of figure were determined from continuous recording surface TS recorder.

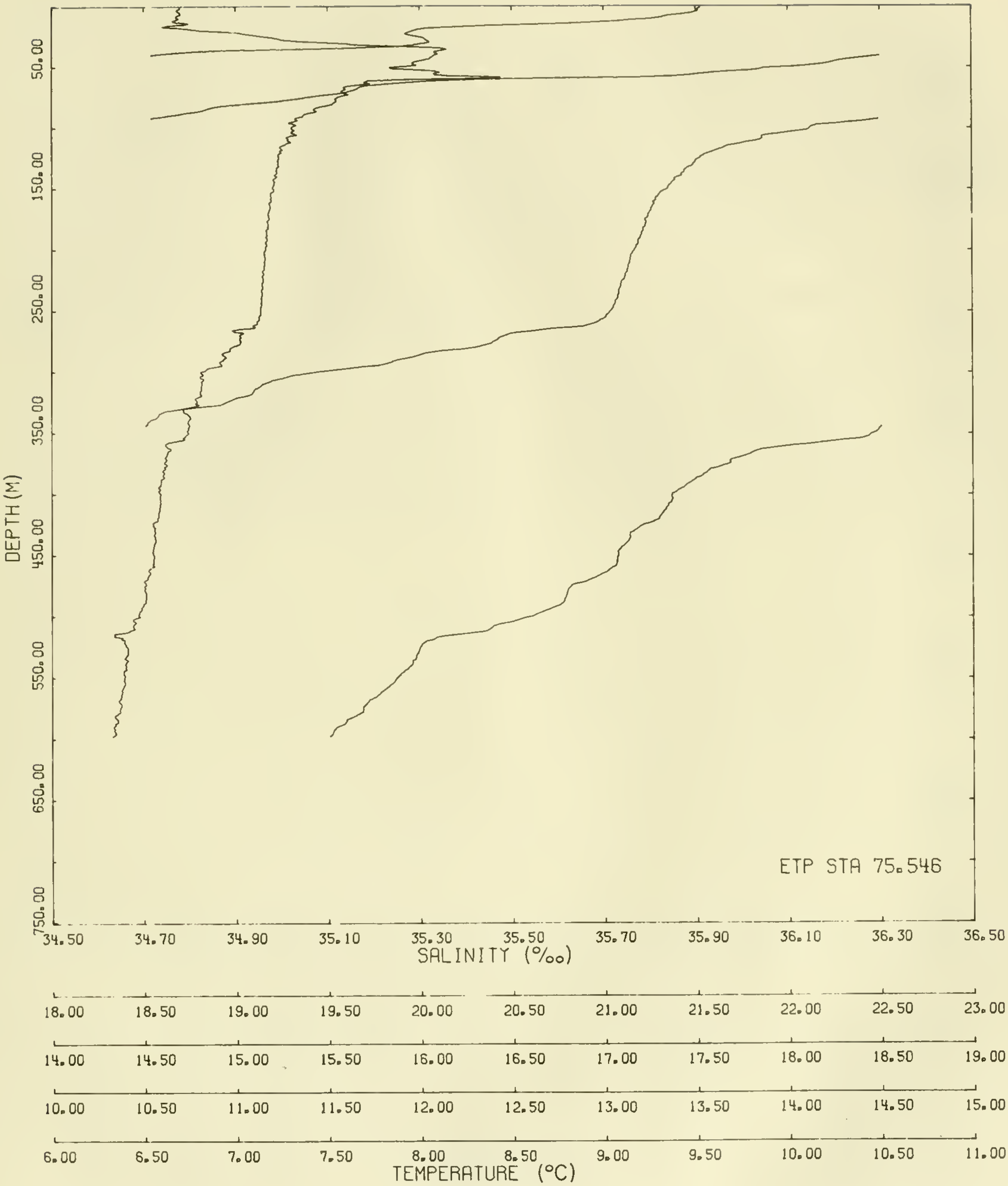


Figure 5.–A plot of the processed digital data logger values as output from the data processing program. Salinity, temperature, and depth scales are identical to those in figure 4.

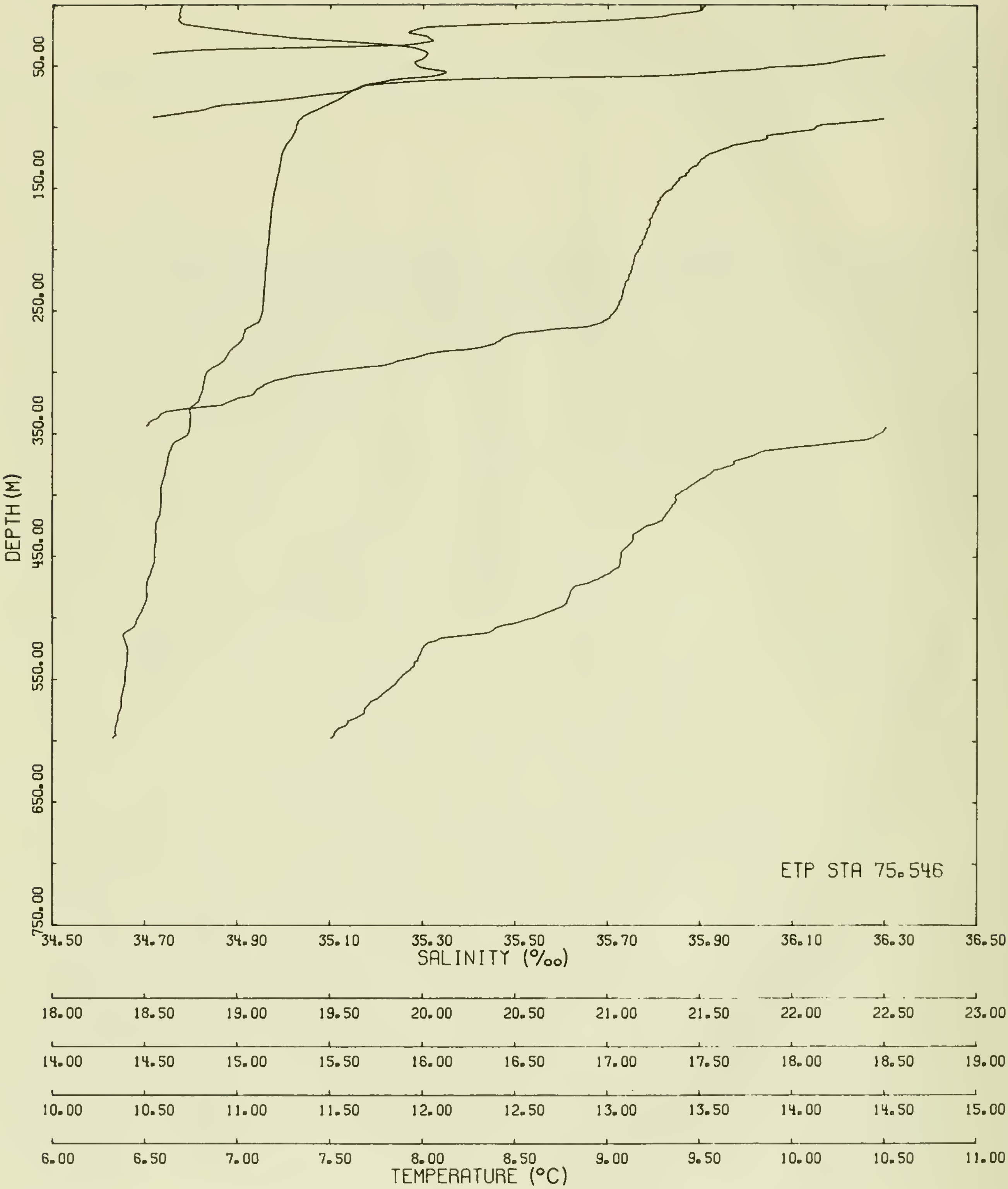


Figure 6.--Plot of processed values with additional filtering applied to the salinity values. The scales are identical to those in figure 5.

## CONCLUSIONS

The computer program discussed here presents one approach to the data processing of STD digital data logger tapes. There are undoubtedly many alternative techniques which may do just as well. The system described above, however, has the virtue of having been used for nearly 2 years, and it is felt that this program produces a set of data which most nearly represents the signals generated by the STD sensor package, in a form easily interpreted by most of those who need to work with the data.

The additional problems of relating these data with independent measurements and of eliminating random and systemic errors are peculiar to individual instruments, cruises, personnel, and techniques, and almost always must be determined by the experimentor. The method used on the EASTROPAC data was to take the output of the program described here, compare these data with the independent calibrations, and then correct on the computer for any drift or offset noted during the cruise. In addition, the salinity trace is filtered to produce a profile similar to that shown in figure 6.

## ACKNOWLEDGMENTS

The author wishes to express his appreciation to Alan R. Longhurst and Bruce A. Taft for their support during the development of this program and to Miriam K. Oleinik and Edward H. Coughran for their comments on the manuscript.

# APPENDIX

A listing of Program RDEDTP and subroutines as used on the University of California, San Diego CDC 3600 computer. Questions concerning individual library subroutines should be directed to the UCSD computer center, La Jolla, Calif. 92037.

```
      PROGRAM RDEDTP
C  THIS PROGRAM IS FOR PROCESSING DDL TAPES WITH BIN. LTH. 52, 4 CHANLS
      TYPE INTEGER A,B,C ,FLSTA
      DIMENSION A(80),KK(8)
      DIMENSION NFILE(500),ISTFL(100)
      COMMON     DD(3300),TT(3300),SS(3300),MO,ISTA
      COMMON     TM,TB,SM,SE,DM,DB,DEPK,SALK,TEMPK
C  THESE CONSTANTS ARE FOR THE SIO DDL AS OF 2/68
      DEPK=95. $ SALK=63. $ TEMPK=7.
C  THIS SET OF DATA CARDS ARE FOR SIO NO. 2 FISH
      DFMIN=9712. $ DFMAX=11288. $ DMIN=0. $ DMAX=1500.
      TFMIN=2127. $ TFMAX=4193. $ TMIN=-2. $ TMAX=35.
      SFMIN=4995. $ SFMAX=7901. $ SMIN=30. $ SMAX=40.
      TM=(TMAX-TMIN)/(TFMAX-TFMIN)
      TB=(TMIN*TFMAX-TFMIN*TMAX)/(TFMAX-TFMIN)
      DM=(DMAX-DMIN)/(DFMAX-DFMIN)
      DB=(DMIN*DFMAX-DFMIN*DMAX)/(DFMAX-DFMIN)
      SM=(SMAX-SMIN)/(SFMAX-SFMIN)
      SB=(SMIN*SFMAX-SFMIN*SMAX)/(SFMAX-SFMIN)
C  NUMFIL IS THE NUMBER OF FILES TO BE TRANSLATED
C  NFILE(I) ARE THE FILES TO BE PROCESSED
C  NOSTA2 IS THE NUMBER OF OF FILES WITH NO HEADING INFO
C  ISTFL(I) ARE THE FILES THAT NEED STATION NUMBERS
C  ILL IS THE FIRST FILE TO BE PROCESSED
C  IFLMAX IS THE LAST FILE TO BE PROCESSED
      READ 22,NUMFIL $ READ 21, (NFILE(I),I=1,NUMFIL)
      READ 22, NOSTA2 $ READ 21,(ISTFL(I),I=1,NOSTA2)
 21   FORMAT (16I5)
 22   FORMAT (I5)
      IFLMAX=116
      NS=1 $ ILL=1
 60   NF=NFILE(ILL) $ CALL TAPEPOS (11,NF,0) $ ILL=ILL+1
      BUFFER IN (11,1) (A(1),A(52))
 100  IF (UNIT,11) 100,400,60,200
 200  LL=LENGTHF(11) $ GO TO 401
 400  LL=LENGTHF(11) $ IF (LL.EQ.52) 399,401
 399  PRINT 58
 58   FORMAT (1H0,32H NO STATION NUMBER FOR THIS CAST )
      ISTA=ISTFL(NS) $ NS=NS+1 $ PRINT 421,ISTA $ BACKSPACE 11
      GO TO 501
 401  LK = 8*LL $ DO 406 IBI=1,LL $ KABC=A(IBI)
 406  DECODE (8,410,KABC) KK
 410  FORMAT (  8R1)
      ISTA=100*KK(1)+10*KK(2)+KK(3) $ PRINT 421,ISTA
 421  FORMAT (14H0 STATION     ,I5)
      NF=NFILE(ILL) $ CALL TAPEPOS (11,NF,0) $ ILL=ILL+1
 501  CALL TRANS
      IFILE=LUFILE (11) $ IF(IFILE.GE.IFLMAX) 900,890
 890  GO TO 60
 900  CONTINUE
      END
```

```
        SUBROUTINE TRANS                                                        1
        TYPE INTEGER A,B,C                                                      2
        DIMENSION A(80),B(500),KK(8),D(32),T(32),S(32),NO(32),DX(32)            3
        COMMON    DD(3300),TT(3300),SS(3300),MO,ISTA                            4
        COMMON    TM,TB,SM,SE,DM,DB,DEPK,SALK,TEMPK                             5
        KR=1 $ J2=0 $ JE=0                                                      6 - 8
 499    BUFFER IN (11,1) (A(1),A(80))                                           9
 500    IF (UNIT,11) 500,550,800,550                                            10
 800    IF (JE) 52,499                                                          11
 550    LL=LENGTHF(11)                                                          12
        LK=8*LL $ JE=1 $ IA=1                                                   13 - 15
        DO 600 IY=1,LL $ KABC=A(IY) $ DECODE (8,410,KABC) KK                    16 - 18
 410    FORMAT (8R1)                                                            19
        DO 601 IX=1,8$ B(IA) = KK(IX)                                           20   21
 601    IA =IA +1                                                               22
 600    I=0  $  DO 49, IV=1,LK,13                                               23   24
        DY = B(IV)*1024 + B(IV+1)*32 + B(IV+2)                                  25
        SY = B(IV+3)*1024 + E(IV+4)*32 + B(IV+5)                                26
        TY = B(IV+6)*1024 + E(IV+7)*32 + B(IV+8)                                27
        SV = B(IV+9)*1024 + E(IV+10)*32 + B(IV+11)                              28
        I=I+1                                                                   29
        D(I) =(DM*DEPK*5.E6)/(DY+32768.)+DB                                     30
        S(I) =(SM*SALK*5.E6)/(SY+32768.)+SB                                     31
        T(I) = (TM*TEMPK*5.E6)/TY+TB                                            32
        IF (D(I).GT.1110..OR.D(I).LT.-.2)491,612                                33
 612    J2=J2+1 $ NO(I)=J2                                                      34   35
        DD(J2)=D(I) $ TT(J2)=T(I) $ SS(J2)=S(I) $ DX(I)=D(I)                    36 - 39
        GO TO 490                                                               40
 491    NO(I)=0 $ DX(I)=DD(J2)                                                  41   42
 490    CONTINUE                                                                43
C       PRINT 431,(D(I),T(I),S(I),NO(I),I=1,32) $ PRINT 432
 431    FORMAT (4(X,F6.1,F7.2,F8.3,I5,3X))                                      44
 432    FORMAT (1H0)                                                            45
        IF (J2.GT.3265) 50,51                                                   46
 50     GO TO 52                                                                47
 51     CALL BASKET (DX,J2,KR)                                                  48
        GO TO 499                                                               49
 52     MO=J2-1                                                                 50
        DMAX=ARRAYMAX(DD,MO) $ DMIN=ARRAYMIN(DD,MO)                             51   52
        TMAX=ARRAYMAX (TT,MO) $ TMIN=ARRAYMIN (TT,MO)                           53   54
        SMAX=ARRAYMAX (SS,MO) $ SMIN=ARRAYMIN (SS,MO)                           55   56
        PRINT 56,MO $ PRINT 57,TMAX,TMIN,SMAX,SMIN,DMAX,DMIN                    57   58
 56     FORMAT (1H0,20H ORIGINAL NO OF OBS., I5)                                59
 57     FORMAT (1H0,11H MAX.TEMP.,F6.2,2X,10H MIN.TEMP.,F6.2,2X,10H MAX.SA      60
       1L. ,F7.3,2X,10H MIN.SAL. ,F7.3,2X,10H MAX.DEPTH,F6.1,2X,10H MIN.DE
       2PTH,F6.1)
        CALL SMOOTH                                                             61
        END                                                                     62
```

```
      SUBROUTINE BASKET (D,J2,KR)
      DIMENSION D(2),DR(300)
      DR(KR)=(D(1)+D(2)+D(3)+D(4)+D(5))/5.
      IF (KR.LE.5) 72,70
   70 IF (IBAD) 74,73
   73 DKP=DR(KR-1)
      IBAD=1
   74 IF(DR(KR).LT.DKP) 69,72
   69 IF (J2.LT.33) 75,71
   71 J2=J2-32
      GO TO 75
   72 IBAD=0
   75 CONTINUE
      KR=KR+1
      END
```

```
(6.2A)                                                   JOB 2603  02/25/69   PAGE 1

          SUBROUTINE SMOOTH                                              1
          DIMENSION X(3300),Z(3300),ID(3000)                             2
          COMMON D(3300),T(3300),S(3300),M,ISTA                          3
          K=1                                                            4
        4 IF (K-2) 20,21,22                                              5
       20 DO 5 I=1,M                                                     6
        5 Z(I)=T(I) $ GO TO 30                                           7   8
       21 DO 6 I=1,M                                                     9
        6 Z(I)=S(I) $ GO TO 30                                          10  11
       22 DO 7 I=1,M                                                    12
        7 Z(I)=D(I) $ GO TO 30                                          13  14
       30 X(1)=Z(1) $ X(2)=(Z(1)+Z(2))/2. $ M2=M-2                      15 - 17
          DO 10 I=3,M2                                                  18
       10 X(I)=          (Z(I-2)+Z(I-1)+Z(I)+Z(I+1)+Z(I+2))/5.          19
          X(M)=Z(M) $ X(M-1)=(Z(M-1)+Z(M))/2.                           20  21
          IF(K-2)40,41,42                                               22
       40 DO 12 I=1,M                                                   23
       12 T(I)=X(I) $ GO TO 60                                          24  25
       41 DO 13 I=1,M                                                   26
       13 S(I)=X(I) $ GO TO 60                                          27  28
       42 DO 14 I=1,M                                                   29
       14 D(I)=X(I) $ GO TO 61                                          30  31
       60 K=K+1$ GO TO 4                                                32  33
       61 CONTINUE                                                      34
C         PRINT 3,(D(I),T(I),S(I),I,I=1,M)
        3 FORMAT (4(X,F6.1,F7.2,F8.3,I5,3X))                            35
          DO 70 J=3,M,3                                                 36
          D(J)=(D(J-1)+D(J)+D(J+1))/3. $ T(J)=(T(J-1)+T(J)+T(J+1))/3.   37  38
       70 S(J)=(S(J-1)+S(J)+S(J+1))/3. $ J=1                            39  40
          DO 100 I=3,M,3 $ D(J)=D(I) $ T(J)=T(I) $ S(J)=S(I)    $ J=J+1 41 - 45
      100 JJ=J-1 $ JJP=JJ                                               46  47
          DO 300 I=1,JJP                                                48
      300 ID(I)=D(I)+.5 $ L=0 $ K=1                                     49 - 51
          DO 200 I=2,JJP $ IF(ID(I).GE.ID(K))220,200                    52  53
      220 L=L+1 $ ID(L)=ID(I) $ T(L)=T(I) $ S(L)=S(I)   $ K=I           54 - 58
      200 CONTINUE                                                      59
          PRINT 450,L                                                   60
      450 FORMAT (1H0,36H NUMBER OF DATA PTS.AFTER SMOOTHING ,I5)       61
          CALL INTERP (L,ID,T,S,ISTA)                                   62
          END                                                           63
```

```
          SUBROUTINE INTERP (MC,D,T,S,ISTA)
          DIMENSION D(2),T(2),S(2),DD(1112),TT(1112),SS(1112)
          TYPE INTFGER D,DD
          K=0 $ D(2)=D(1)
          DO 100 I=1,MO
          M=1 $ IF(D(I+M).EQ.D(I)) 10,14
   10     M=M+1
          IF(D(I+M).EQ.D(I)) 10,15
   15     SUMT=0 $ SUMS=0 $K=K+1 $ XM=FLOATF(M)
          DO 30 N=1,M $ SUMT=SLMT+T(I-1+N)
   30     SUMS=SUMS+S(I-1+N)
          DD(K)=D(I) $ TT(K)=SLMT/XM $ SS(K)=SUMS/XM $ I=I+M-2
          GO TO 100
   14     INK=D(I+1)-D(I) $ FINK=FLOATF(INK)
          DO 50 J=1,INK
          K=K+1 $ FJ=FLOATF(J) $ DD(K)=DD(K-1)+1
          TT(K)=T(I)+(T(I+1)-T(I))*(FJ/FINK)
   50     SS(K)=S(I)+(S(I+1)-S(I))*(FJ/FINK)
          IF (DD(K).EQ.D(I+2)) 51,100
   51     K=K-1
  100     CONTINUE
          CALL SALTFX (K,SS,TT)
          PRINT 20 $ PRINT 440 $ PRINT 441
   20     FORMAT (1H0, 48H  VALUES INTERPOLATED AT 1 METER INTERVALS       /)
  440     FORMAT(1H0,116HDEPTH    TEMP     SALN              DEPTH    TEMP     SALN
         1          DEPTH    TEMP     SALN              DEPTH    TEMP     SALN       )
  441     FORMAT(1H0,115H  (M)    (0C)    (0/00)                 (M)     (0C)    (0/00)
         1             (M)    (0C)    (0/00)              (M)     (0C)    (0/00)     /)
          PRINT 1,(DD(I),TT(I),SS(I),I=1,K)
    1     FORMAT (4(X, I6 ,F7.2,F8.3,8X))
          PRINT 11
   11     FORMAT (1H1)
C         WRITE (10) ISTA,K $ WRITE(10)(DD(I),TT(I),SS(I),I=1,K)$ ENDFILE 10
          END
```

```
(6.2A)                                                    JOB 2603   02/25/69     PAGE 1

              SUBROUTINE SALTFX (MC,S,T)
              DIMENSION S(2),T(2)
              M4=MO-4
              DO 130 I=4,M4
              S(I)=S(I)*(1.-0.0212*1.118*0.35*((T(I+1)+T(I-1))/T(I))*
             C(-T(I+3)+9.*(T(I+1)-T(I-1))+T(I-3))/24.)
       130    CONTINUE
              END
```

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