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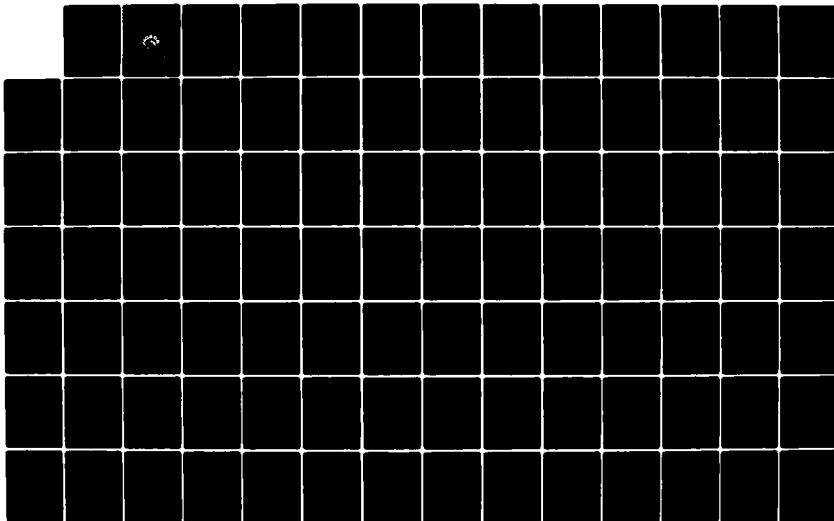
APP FY-80 TASK I AND II REPORT(U) NAVAL OCEAN RESEARCH
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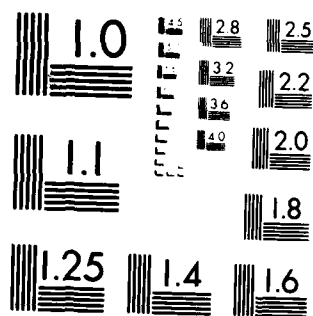
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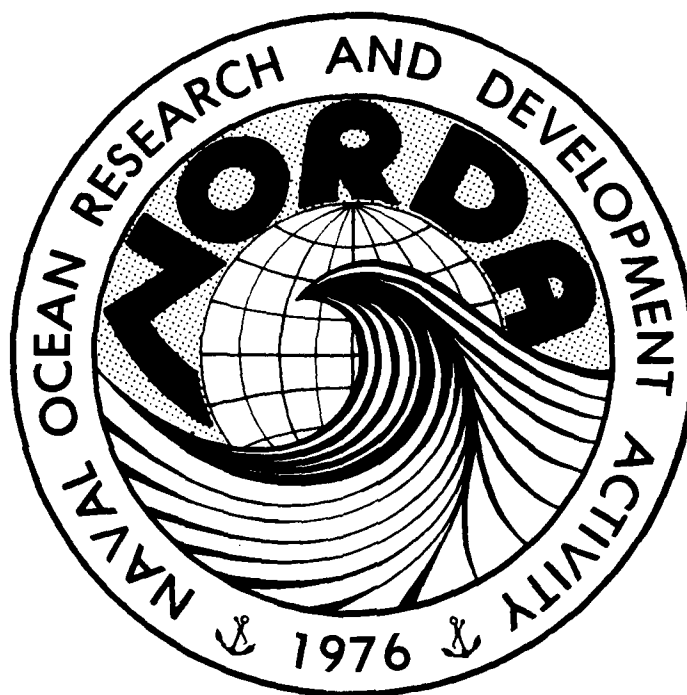
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NORDA Technical Note 69

Naval Ocean Research and
Development Activity
NSTL Station, Mississippi 39529

APP FY-80 Task I and II Report

ADA 124096



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September 1980

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APP FY-80 TASK I and II REPORT

PART (I)

"Comparisons of Vertical Sound Speed Profiles
from the SIMAS and ICAPS Environmental Data Bases
with High Quality CTD and STD data."

and

PART (II)

"Evaluation of the SIMAS and ICAPS Environmental
Data Bases, Data Handling Procedures and Merge Methodology"

by

E. HASHIMOTO

30 September 1980

RE: Classified References, Distribution
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ABSTRACT

This report consists of two major parts. Each part addresses different problems or issues. Part I is titled, "Comparison of "on-board" In-situ Vertical Sound Speed Profiles from the SIMAS and ICAPS Environmental Data Bases with High Quality CTD and STD Data", APP FY-80 Task #I. The purpose of Part I was to compare the SIMAS and ICAPS sound speed profiles with sound speed profiles from assumed oceanography (CTD or STD observations).

Part II is titled, "Evaluation of the SIMAS and ICAPS Environmental Data Bases, Data Handling Procedures, and Merge Methodology", APP FY-80 Task #II. The purpose of Part II was to compare and recommend the data bases, algorithms, merge techniques of either SIMAS or ICAPS. The major causes for the "significant" differences in the SIMAS vs. ICAPS sound speed comparisons were found to be in the merge methodologies and historical environmental profiles.

RECOMMENDATIONS

Based on the findings of Part I and II of this report, the following recommendations are forwarded:

- Philosophy

- Recommend that the ICAPS philosophy of reliance on the in-situ BT profile be adopted. In SIMAS, there appears to be far too much reliance on the integrity of its fixed, historical sound speed profiles. This heavy reliance on a fixed sound speed profile and a fixed criteria can lead to problems when operating in known physically dynamic ocean regions where the zones themselves meander and migrate horizontal, as well as, vertical distances.

- In-situ BT data handling

- Recommend that the ICAPS procedure (inputting of only observed pairs of depth-temperature pairs) be adopted as an "interim" procedure. The SIMAS procedures of inputting 7-9 inflection points (G. Brown) by use of a straight-edge to line up data points, and then picking off and using as input the numerical values where the straight lines intersect leads to inputting depth and temperature values which may have never been recorded.
- Recommend that APP favorably encourage any ongoing efforts to inputting not selected data points from a in-situ BT profile, but the inputting of the in-situ BT trace through a continuous recording procedure. This will eliminate the variable-inconsistent human factor of incorrect selections of inflection points along a BT trace.

- Historical Environmental Data Base

- Recommend that the ICAPS historical temperature and salinity data base be adopted on an interim basis.
- Recommend two alternatives to replace or modify the present ICAPS historical data bases:

- (a) *When available, replace the ICAPS temperature, salinity files with the temperature, salinity, density and sound velocity analyzed data sets from the Generalized Digital Environmental Model (GDEM) by Dr. T. Davis, (N00-022).*
- (b) *Using recent deep XBT data (as available) update the archival temperature file, particularly in the region of the deep sound channel.*
- Develop a more appropriate procedure to insure that the proper depth of the layer depths are properly specified (i.e., replacing the present procedure of manual interpretation and inputting of the *in-situ* temperature data with an automated procedure which utilizes and inputs the entire trace or profile taken).
- Recommend a more appropriate representation of the depth of the deep sound channel axis be developed.
- Additional Recommendations
 - *Recommend that the bathymetry files in ICAPS be replaced by the automated SYNAPS (Synthetic Bathymetric Profiling System).*

ACKNOWLEDGEMENTS

The author would like to express his appreciation towards certain individuals who have been associated with or assisted in segments of this study. Without the cooperation of these individuals, this study could not have been completed. Very special appreciation to Dr. A. L. Anderson (NORDA 320), Dr. J. A. Davis and Mr. R. Lauer (both with NORDA 321) for providing invaluable technical guidance, to LCDR A. Galus (NORDA 530) for providing funding support, to Mr. J. Schumacher (ODSI), Mr. G. Kerr and Mrs. C. Parker (both of NORDA 320) for providing support in the preparation of this report.

PART I

"Comparisons of Vertical Sound Speed Profiles
predicted from the SIMAS and ICAPS Environmental
Data Bases with High Quality CTD and STD data".

I. INTRODUCTION

The SIMAS (Sonar In-situ Mode Assessment System) and ICAPS (Integrated Command Anti-submarine warfare Prediction System) programs address different system applications but are similar in that each has been developed for use as an "on-board" prediction system. It is known that SIMAS and ICAPS do not employ identical environmental data bases. The extent to which these data bases differ is being addressed in a separate study. The purpose of this particular study was to:

- compare predicted SIMAS and ICAPS vertical sound speed profiles with observed, measured and recorded *in-situ* CTD (Continuous-Temperature-Depth) or STD (Salinity-Temperature-Depth) data.
- present, whenever possible, similarities or dissimilarities between the predicted SIMAS and the ICAPS sound speed profiles with the CTD and STD data.
- discuss the implications of these similarities and dissimilarities.
- compare the "goodness" of SIMAS and ICAPS to the "Assumed Oceanography".

Since this study was of limited scope it focused entirely on vertical sound speed profile comparisons. Reliable, processed CTD or STD data available to study was (17) records. Figure 1 presents the geographical locations of the test cases.

In an earlier study entitled, "Comparison of the ICAPS and SIMAS Historical Environmental Data Bases" by E. Hashimoto, NORDA 321, FY-79 APP Task II Report, dated 28 September 1979, the author compared vertical sound speed profiles from the SIMAS and ICAPS environmental data bases using XBT (expendable bathythermograph) data as input. It also presented "significant" differences found between the two environmental data bases. That report, which described the selection procedures of appropriate SIMAS and ICAPS historical sound speed profile, is being published as a NORDA Technical Memo #66 titled, "Comparisons of Historical and *in-situ* Vertical Sound Speed Profiles from the SIMAS and ICAPS Environmental Data Bases".

In the present study, SIMAS and ICAPS simulations of vertical sound speed profiles using the STD temperature data are compared to the measured sound speed profiles or profiles calculated by Wilson's equation.

Footnote: Comparison of bottom loss provinces and bottom loss versus grazing angle curves used by SIMAS and ICAPS were also conducted by the author. At 18 sites, ICAPS and SIMAS results were compared; bottom loss provinces were compared in the Mediterranean Sea. The results of this study are contained in NORDA Technical Note No. 71.

II. APPROACH USED IN STUDY

The approach used in this comparison study was to obtain and establish a set of test case profiles using measured ocean environmental data with which the predicted SIMAS and ICAPS sound speed profiles could both be compared. The test case profile data are from reliable CTD and STD observations. The CTD and STD observations are considered in this study as being the "assumed" or real oceanography. CTD and STD test cases were selected so as to avoid biasing the results towards any given system. The selections were made on the reliability (author's confidence in the observations) and availability (accessible in appropriate format to impact this study) of CTD and STD data.

Both CTD and STD probes have an accurate temperature sensor. The STD also measures salinity. The values of temperature from both sensors are recorded during the observation period. The literature generally states that the relative accuracy of the CTD is approximately $\pm 0.005^{\circ}\text{C}$ for temperature. The STD has a relative temperature accuracy of $\pm 0.02^{\circ}\text{C}$, a relative salinity accuracy of ± 0.02 parts per thousand.

Identical measured values of temperature from either the CTD or STD were used as input data for both SIMAS and ICAPS sound speed calculation programs and treated as if the values were those taken by *in-situ* XBTs. Vertical sound speed profiles were obtained from both systems. The SIMAS and ICAPS generated profiles were plotted together with the values of sound speed either measured (by the CTD), or calculated from Wilson's equation (for the STD). The intent for such plots was to illustrate the similarity between the SIMAS or ICAPS vertical sound speed profiles and the "assumed oceanography".

The designations used and the locations of the *in-situ* test cases are tabulated in Table I. The sources for the CTD and STD test cases are identified in Table II.

III. COMPARISONS

In this section the results of the various comparisons are presented along with supporting information. In the simulated comparisons of predicted SIMAS and ICAPS produced sound speed profiles with "assumed" oceanography, similarities and dissimilarities were found with the CTD and STD results (termed "assumed oceanography" in table XV).

In some cases, similarities and dissimilarities appear to be, more or less, consistent or reoccurring. In other cases, they appear unique in their occurrence. Presented, are the generalized similarities and major dissimilarities found when comparing the predicted SIMAS and ICAPS profiles with the assumed oceanography. The similarities and dissimilarities are indicated in the appropriate sections to follow.

- All temperature and salinity data from CTD and STD units were sent to NUSC and NAVOCEANO, for SIMAS and ICAPS processing, respectively.
 Naval Underwater Systems Center (NUSC)
 Naval Oceanographic Office (NOO)
- Results were returned to NORDA where they were plotted.
- The accuracy and correctness of all plots were triple checked to eliminate possible errors which may have resulted from (interpreting) reading the data sheets, key punching, unit conversion, or from plotting of incorrect data files.
- All profiles were generated by personnel at NUSC-New London, CT (for SIMAS) and NOO-Bay St. Louis, MS (for ICAPS).
- All "on-board" input data into SIMAS and ICAPS were identical *in-situ* temperature profiles recorded by the CTD and STD temperature sensors.
- Comparisons for similarity and/or dissimilarities in sound speeds ($\overline{SS}$) were conducted for values:
 - $\overline{SS}$, at the surface (Table III)
 - $\overline{SS}$, at the layer (SSL) (Table IV)
 - $\overline{SS}$, at 1000 feet (SS1000) (Table V)
 - $\overline{SS}$, at the sound channel axis (SSCA) (Table VI)

- Comparisons for similarity and or dissimilarities in depth (D) were conducted for values:
 D, at the layer (in feet) (DLD) (Table VII)
 D, at the depth of the sound channel axis (in feet) (DSCA) (Table VIII)

Figures 2-18 contain comparisons of vertical sound speed profiles which were generated from the SIMAS (dashed lines), and ICAPS (dotted lines) environmental data bases, and the in-situ CTD/STD (both as solid lines) observations.

Tables (IX), (X), (XI), (XII), (XIII), and (XV) present qualitative differences in sound speeds at the surface, at the layer, at 1000 feet, at the channel axis, in the depth of the layer and the channel axis, respectively. Table (XV) contains the numerical values of sound speeds computed from CTD and STD sensors. Table (XVI) contains the numerical values of sound speed computed from SIMAS. Table (XVII) contains the numerical values of sound speed computed from ICAPS.

V. SUMMARY OF THE COMPARISONS

As stated in the introduction, the purpose of this study was to compare predicted SIMAS and ICAPS sound speed profiles with (actual) CTD or STD data (considered as the "assumed oceanography"), to present the similarities or dissimilarities, and to discuss any implication of such similarities or dissimilarities for certain test cases.

Tabulations of the numerical qualitative term and quantitative terms for $\overline{SS}$ at the surface, at the layer, at 1000 feet, at the deep sound channel axis, at the depth of the layer, and at the deep sound channel axis were presented on tables (III thru VIII). There were certain similarities and dissimilarities which appear more frequently than others. Tables (IX thru XIV) are presented in an attempt to simplify these similarities and dissimilarities. The author, for SIMAS and ICAPS and the "assumed oceanography", has made comparisons of the values in sound speed (in ft/sec) at the surface, depth of the layer, at 1000 feet, and at the deep sound channel axis. Comparisons were made between (a) ICAPS and SIMAS predicted results with (b) measured sound speeds from CTD or sound speed calculations from Wilson's equation from STD measurements. A brief summary of these tables (IX) through (XIV) are as follows:

For Sound Speed Profile Comparison In Sound Speeds

- at the surface (17 test case comparisons):
 - "none to slight" differences:
 - ICAPS = 14 cases
 - SIMAS = 2 cases
 - "1 f/s <SS <7 f/s" differences:
 - ICAPS = 3 cases
 - SIMAS = 7 cases
 - "7 f/s <SS* <20 f/s" differences:
 - ICAPS = 0 cases
 - SIMAS = 6 cases
 - "20 f/s <SS** <40 f/s"
 - ICAPS = 0 cases
 - SIMAS = 2 cases
- at the layer, (SSL) (14 test case comparisons)
 - "none to slight" differences:
 - ICAPS = 14 cases
 - SIMAS = 2 cases
 - "1 f/s <SSL <7f/s" differences:
 - ICAPS = 3 cases
 - SIMAS = 7 cases

"7 f/s < SSL* < 20 f/s" differences:

ICAPS = 0 cases

SIMAS = 6 cases

"20 f/s < SSL** < 40 f/s" differences:

ICAPS = 0 cases

SIMAS = 2 cases

- in sound speeds at the channel axis out of 17 test cases:

"none to slight" differences:

ICAPS = 3 cases

SIMAS = 0 cases

"1 f/s < SSCA < 3 f/s" differences:

ICAPS = 4 cases

SIMAS = 2 cases

"3 f/s < SSCA* < 7 f/s" differences:

ICAPS = 2 cases

SIMAS = 5 cases

"7 f/s < SSCA** < 12 f/s" differences:

ICAPS = 5 cases

SIMAS = 4 cases

"12 f/s < SSCA*** < 20 f/s" differences:

ICAPS = 0 cases

SIMAS = 0 cases

"20 f/s < SSCA****" differences:

ICAPS = 0 cases

SIMAS = 3 cases

- in sound speeds at 1000 feet out of 17 test cases:

"none to slight" differences:

ICAPS = 10 cases

SIMAS = 0 cases

"1 f/s < SS1000 < 6 f/s" differences:

ICAPS = 5 cases

SIMAS = 7 cases

"6 f/s < SS1000* < 12 f/s" differences:

ICAPS = 2 cases

SIMAS = 3 cases

"12 f/s < SS1000** < 20 f/s" differences:

ICAPS = 0 cases

SIMAS = 4 cases

"20 f/s < SS1000*** < 75 f/s" differences:

ICAPS = 0 cases

SIMAS = 0 cases

"75 f/s < SS1000**** < 100 f/s" differences:

ICAPS = 0 cases

SIMAS = 2 cases

"100 f/s < SS1000*****" differences:

ICAPS = 0 cases

SIMAS = 1 case

In Depth:

- in the depth of the layer out of 17 cases:

"none to slight" differences:

ICAPS = 3 cases

SIMAS = 3 cases

"2 feet < DLD < 30 feet" differences:

ICAPS = 9 cases

SIMAS = 8 cases

"30 feet < DLD* < 90 feet" differences:

ICAPS = 3 cases

SIMAS = 4 cases

"90 feet < DLD** < 150 feet" differences:

ICAPS = 1 case

SIMAS = 0 cases

"150 feet < DLD*** < 250 feet" differences:

ICAPS = 1 case

SIMAS = 0 cases

"250 feet < DLD****" differences:

ICAPS = 0 cases

SIMAS = 2 cases

- in the depth of the primary sound channel axis, out of 14 test cases:

"less than 300 feet" differences:

ICAPS = 7 cases

SIMAS = 6 cases

"300 feet < DSCA* < 600 feet" differences:

ICAPS = 3 cases

SIMAS = 2 cases

"600 feet < DSCA** < 1200 feet" differences:

ICAPS = 4 cases

SIMAS = 2 cases

"1200 feet < DSCA*** < 2000 feet" differences:

ICAPS = 0 cases

SIMAS = 3 cases

"2000 feet < DSCA****" differences:

ICAPS = 0 cases

SIMAS = 1 case

- ICAPS utilized the CTD/STD input temperature data above 1000 feet more than SIMAS.
- The "rejection" of *in-situ* temperature information in SIMAS is clearly too restrictive. The consequent use of archival information results in large discrepancies with CTD/STD results.

VI. CONCLUSIONS

In the previous study (NORDA TM No. 66) which compared the SIMAS and ICAPS Historical and INSITU Environmental Data Bases vertical sound speed profiles and presented "significant" differences, there was no comparisons made with real INSITU measurements. In this study, this has been conducted to test for "goodness" and the results are presented.

Upon review of the comparison plots and the tables of similarities and dissimilarities, it is clear that ICAPS demonstrates a noteable superiority to SIMAS in its ability to predict measured sound speed from an "XBT" obtained from CTD or STD data. This does not imply, however, that ICAPS does not need improvement as will be discussed under recommendations.

The authors conclusions based on tables (III through VIII) and (IX through XIV) are as follows:

- "Assumed oceanography" was reproduced more closer by ICAPS.
- Sound speeds at the surface were reproduced more closer in the North Atlantic and North Pacific Oceans by ICAPS.

ICAPS reflects a significantly larger quantity (14 out of 17) of cases where the values of sound speeds at the surface agree (≤ 1 f/s) closely with the CTD/STD observations than SIMAS (2 out of 17).

Where ICAPS has zero cases, SIMAS showed 8 out of 17 cases where the values of sound speed at the surface differ between either 7 to 20 f/s, or 20 to 40 f/s.

- Sound speeds at the layer were reproduced more closer in the North Atlantic, North Pacific and Indian Oceans by ICAPS.

ICAPS reflects a significantly larger quantity (14 out of 17) of cases where the values of sound speeds at the layer agree (≤ 1 f/s) closely with the CTD/STD observations than SIMAS (2 out of 17).

Where ICAPS has zero cases, SIMAS showed 8 out of 17 cases where the values of sound speed at the layer differ between either 7 to 20 f/s, or 20 to 40 f/s.

- Sound speeds at 1000 feet were reproduced more closer in the North Atlantic Ocean by ICAPS.

ICAPS reflects a significantly larger quantity (10 out of 17) of cases where the values of sound speeds at 1000 feet

agree (<1 f/s) closer with the CTD/STD observations than SIMAS (0 out of 17). SIMAS showed 7 cases to be greater than 12 f/s at 1000 feet of which 3 of this 7 are greater than 75 f/s. ICAPS on the other hand shows all of its values at 1000 feet not exceeding 12 f/s.

- Neither ICAPS nor SIMAS were impressive in their handling of sound speeds at the sound channel axis.

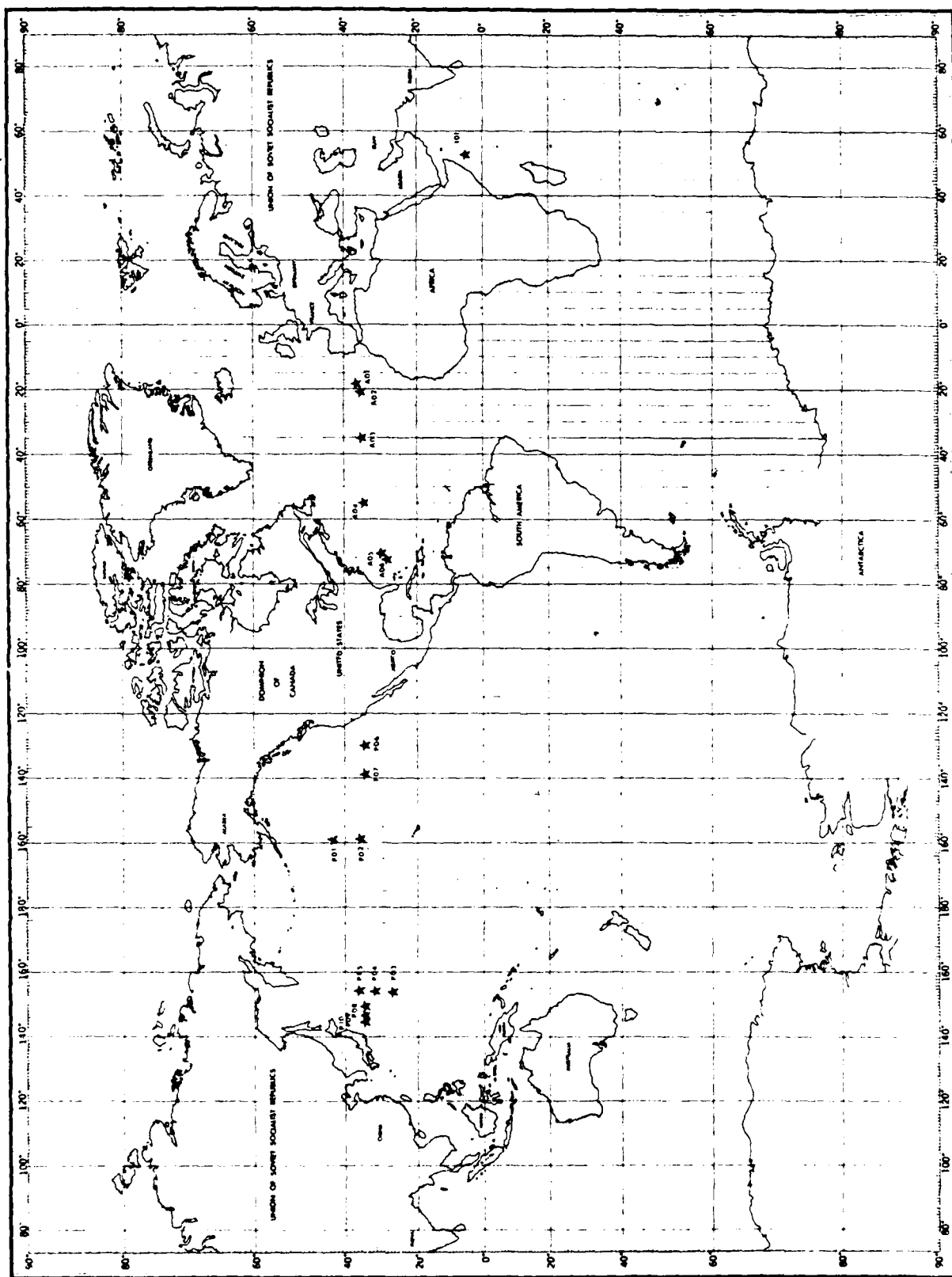
ICAPS showed that in 9 out of 17 cases, the values of sound speed at the axis were <7 f/s and SIMAS showed 7 out of 17 were <7 f/s. SIMAS showed 3 cases to be >20 f/s at the channel axis, and ICAPS had none.

- Neither ICAPS nor SIMAS were impressive in their handling of the depth of the layer.

ICAPS showed the depth of the layers to differ between 2 to 30 feet in 9 out of 17 cases and SIMAS shows the depth of the layers to differ between 2 to 30 feet in 8 out of 17 cases.

- Neither ICAPS nor SIMAS were impressive in their handling of the depth of the sound channel axis.

ICAPS showed the depth of the sound channel axis to differ between 0 - 300 feet in 7 out of 14 cases, and SIMAS showed it in 6 out of 14 cases. ICAPS showed the depth of the sound channel axis to differ by greater than 600 feet in 4 out of 14 cases and SIMAS showed it in 6 out of 14 cases.



GEOGRAPHICAL LOCATIONS OF THE SITES FOR COMPARISON

Fig. (1)

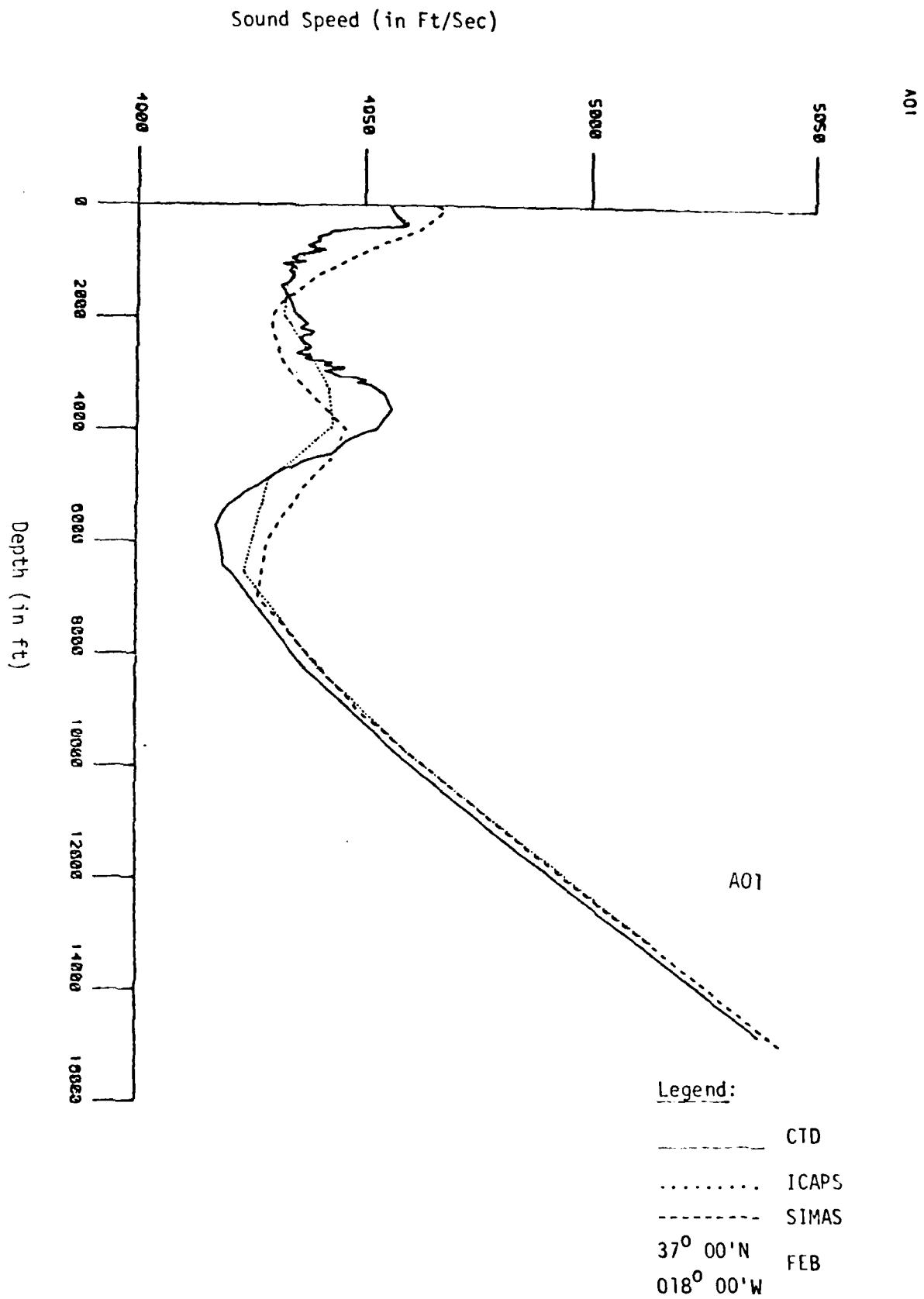


Fig. 2
13

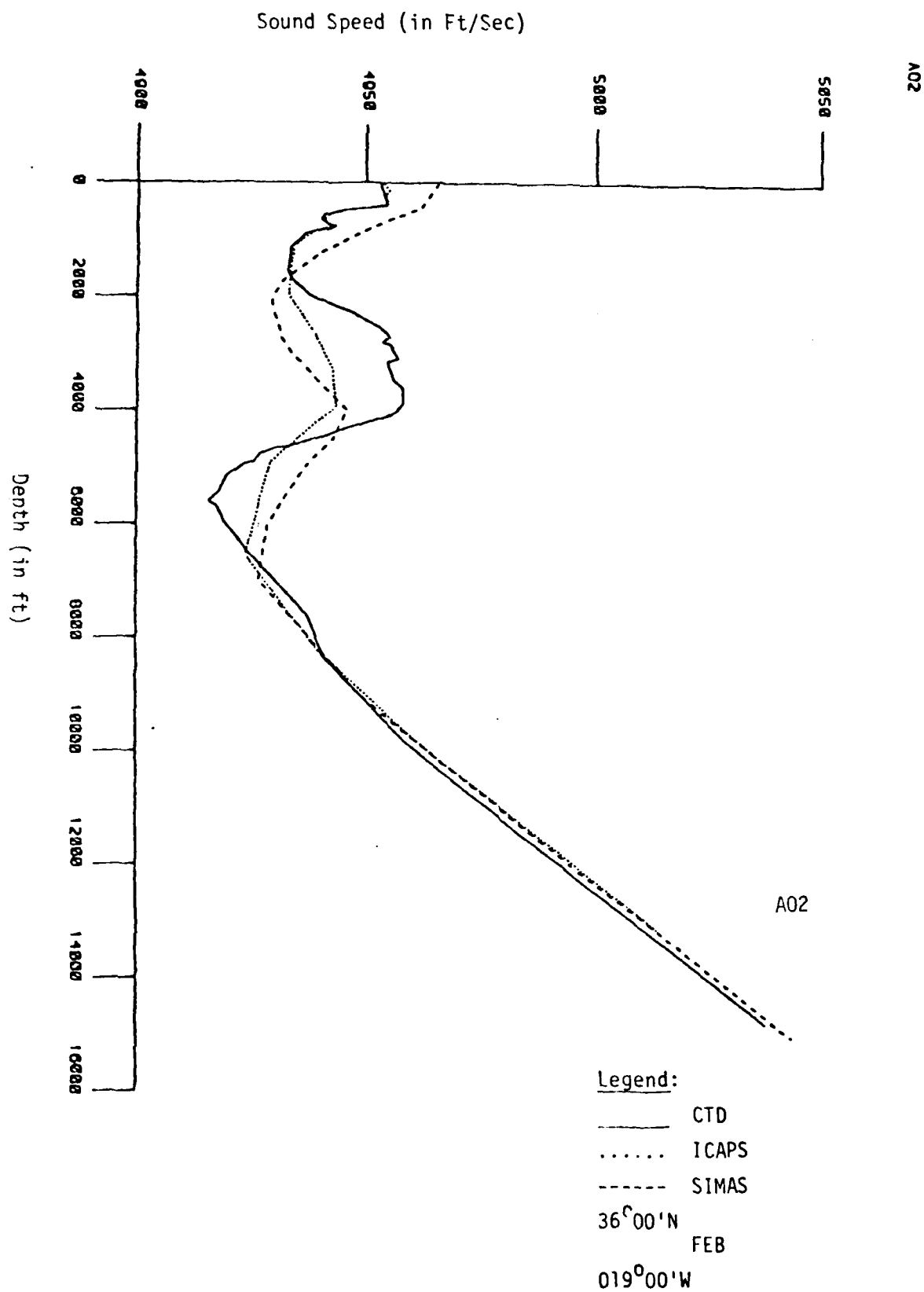


Fig. 3 14

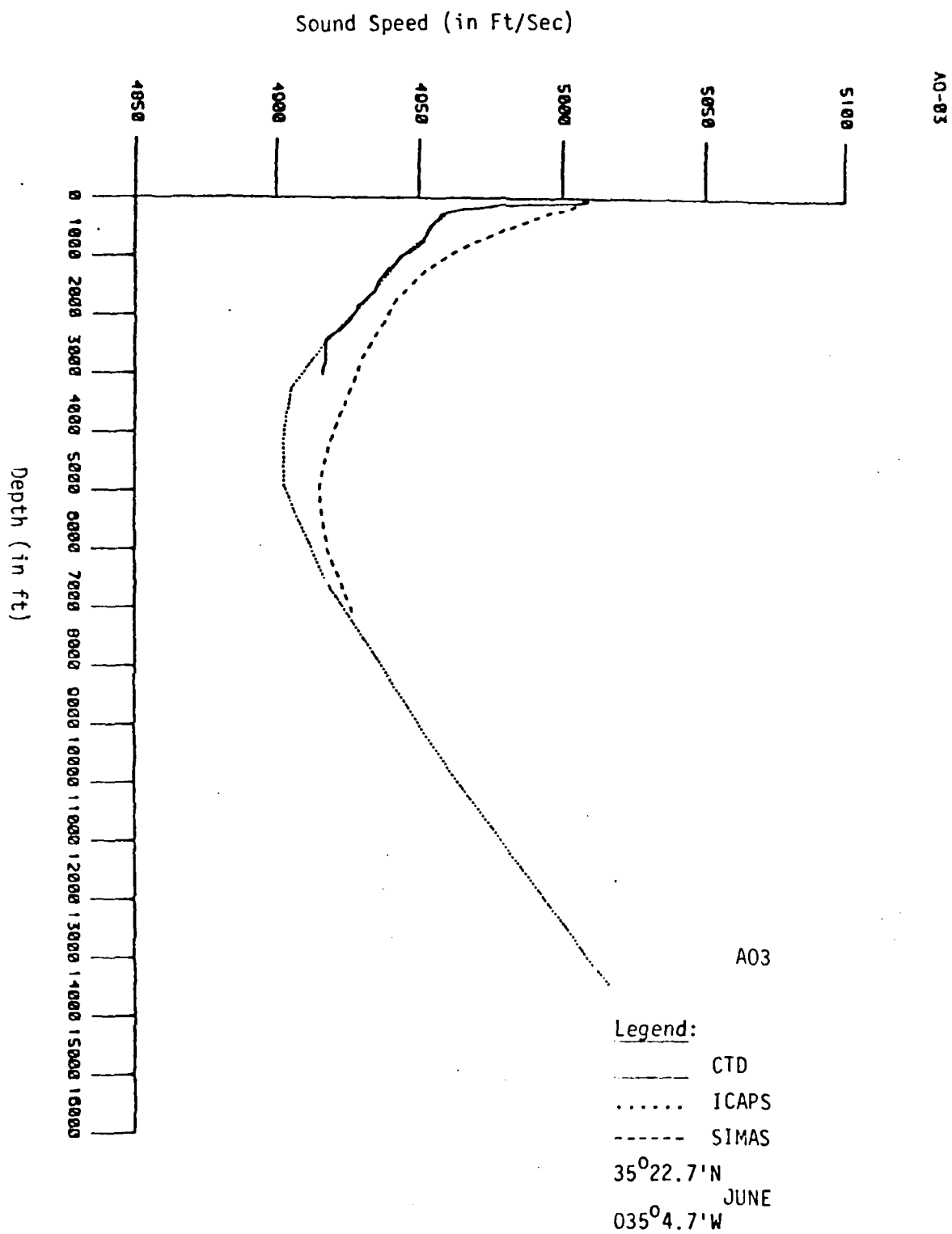


Fig. 4

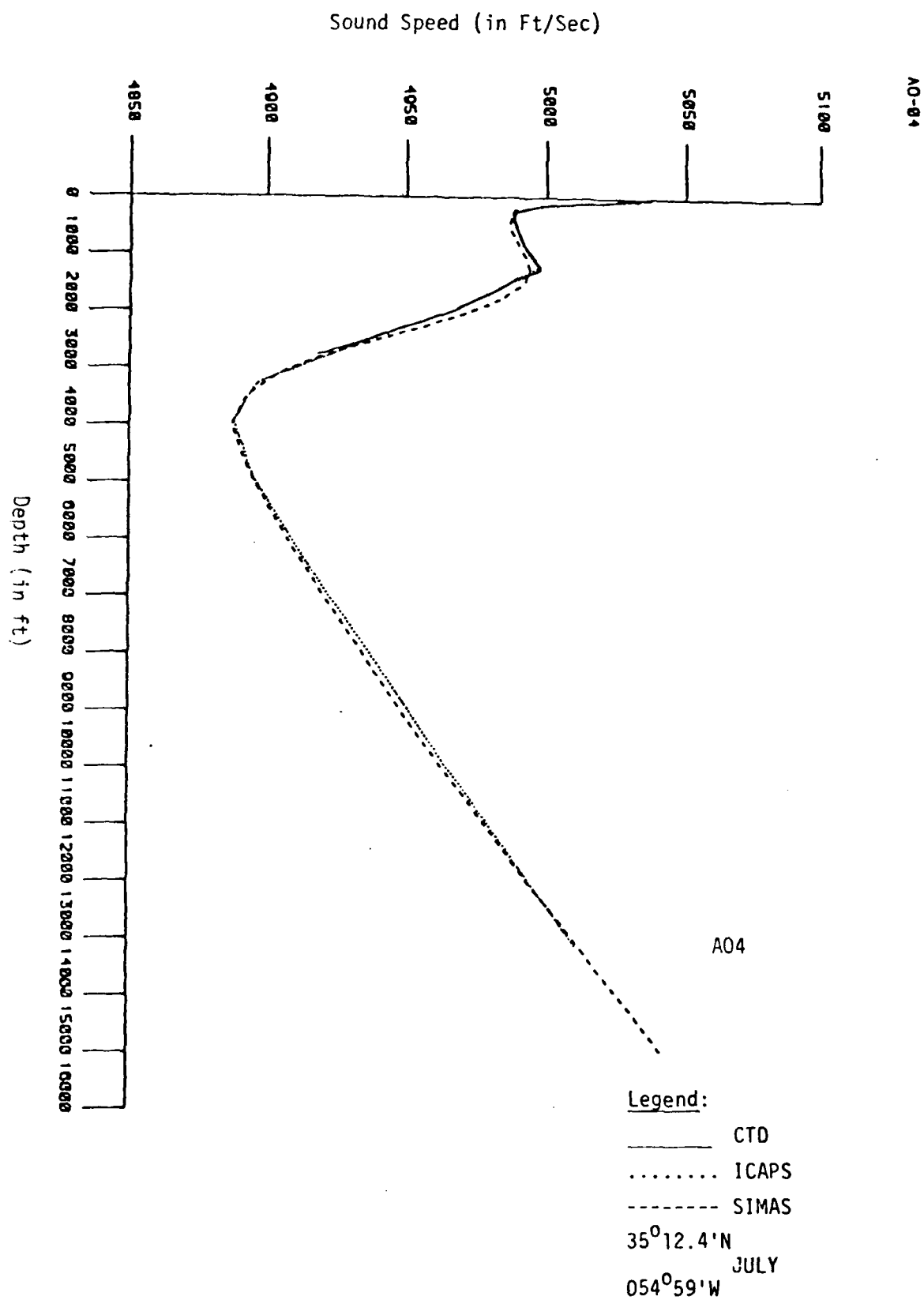
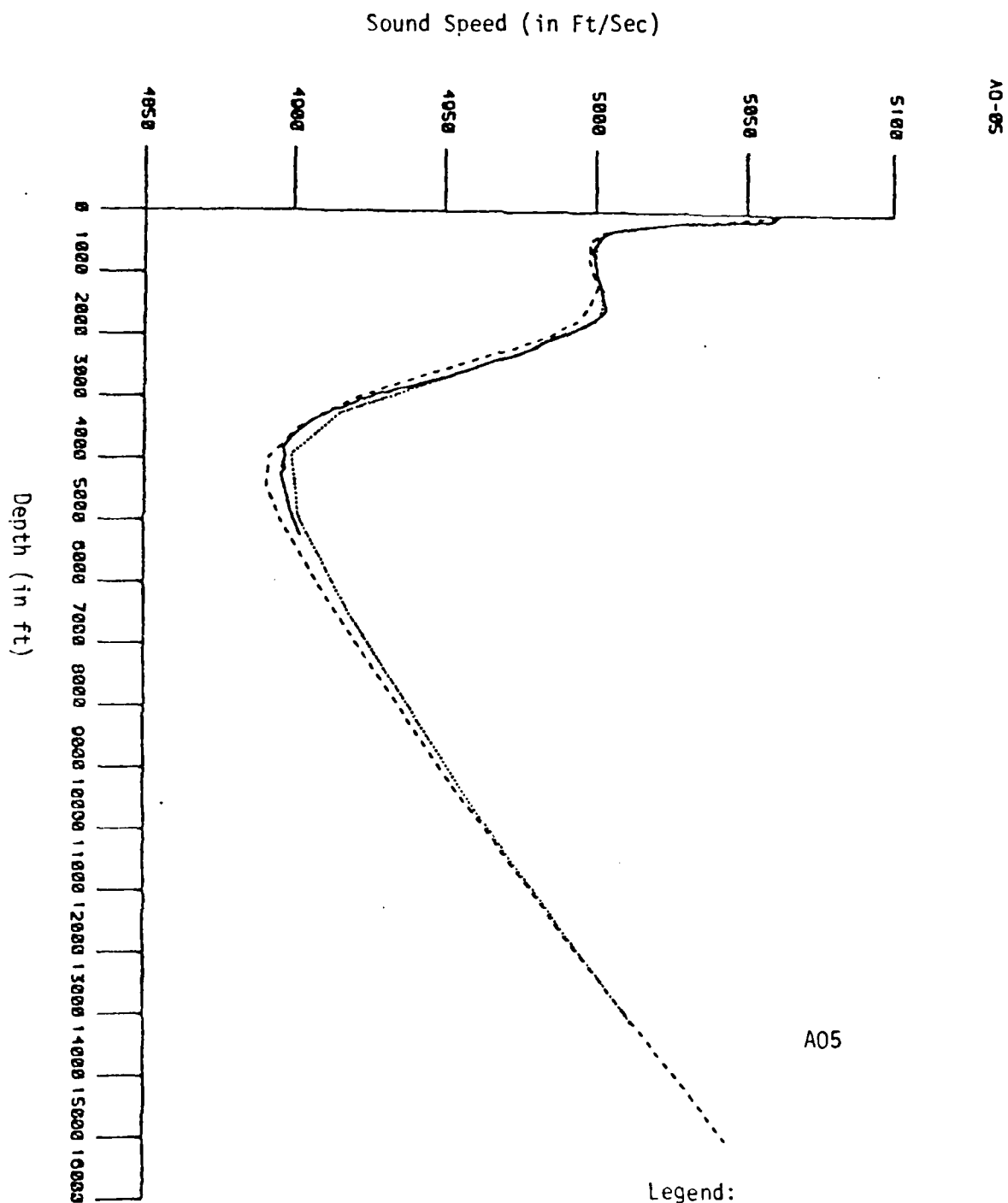


Fig. 5
16



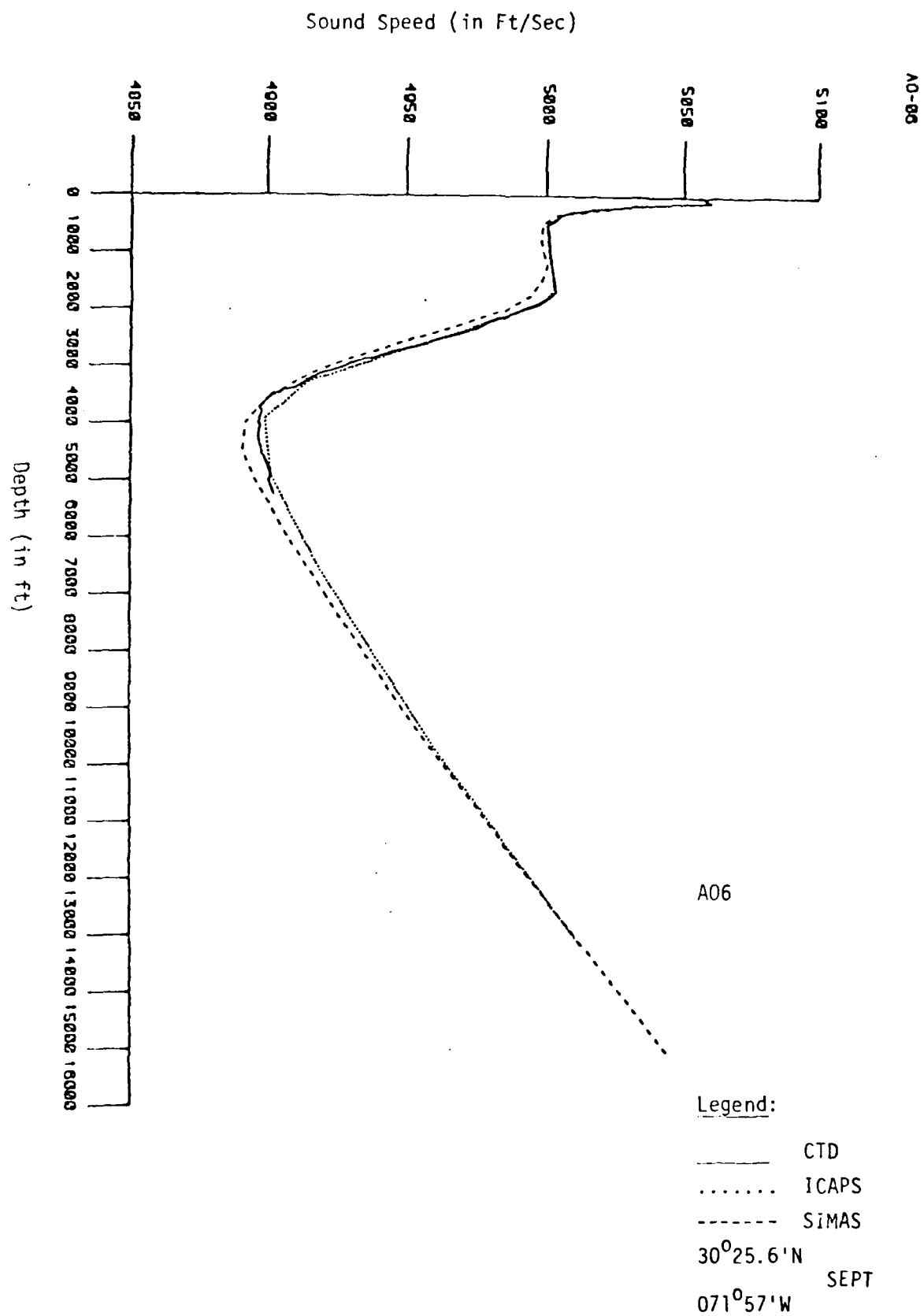


Fig. 7 18

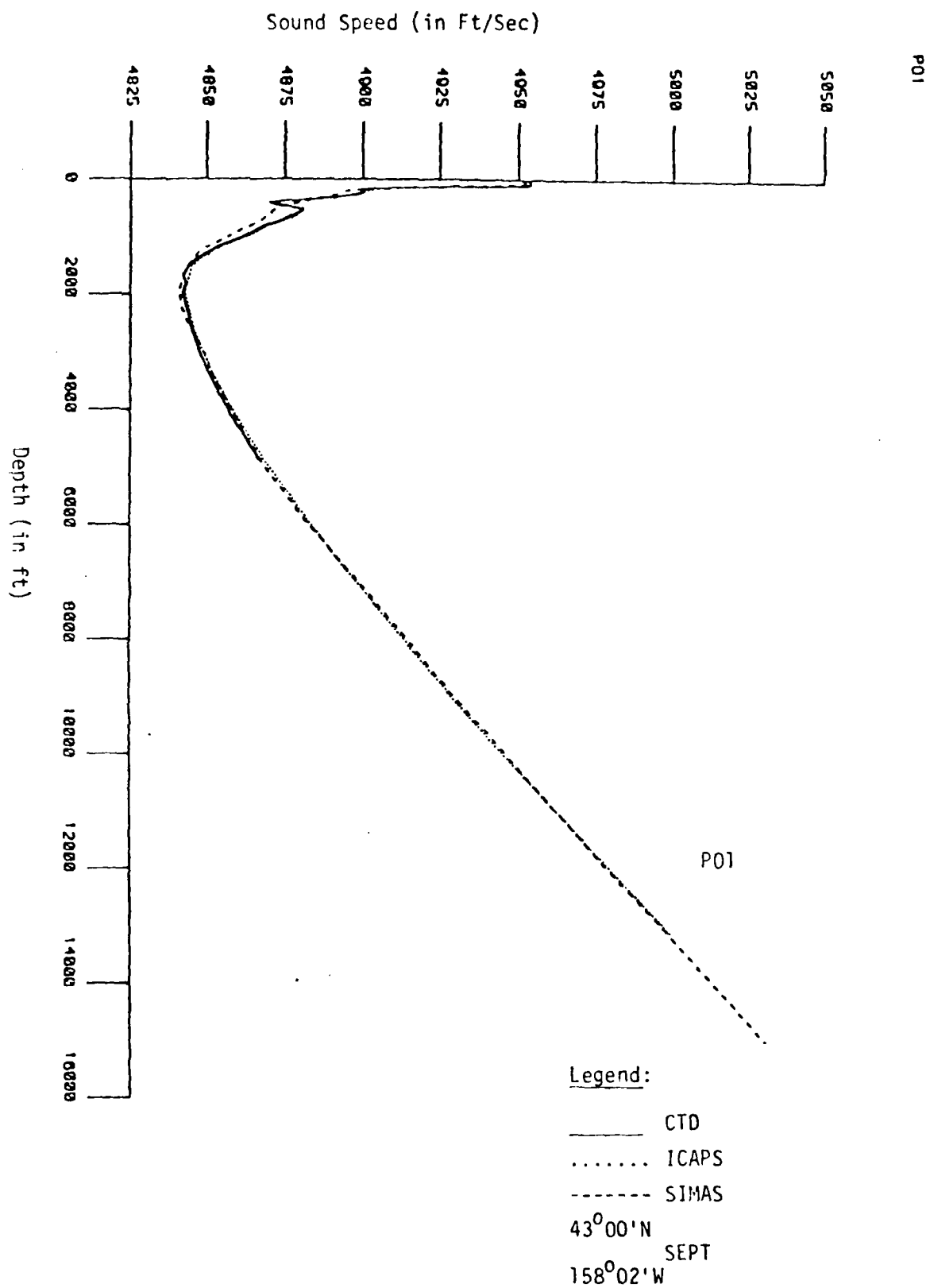


Fig. 8

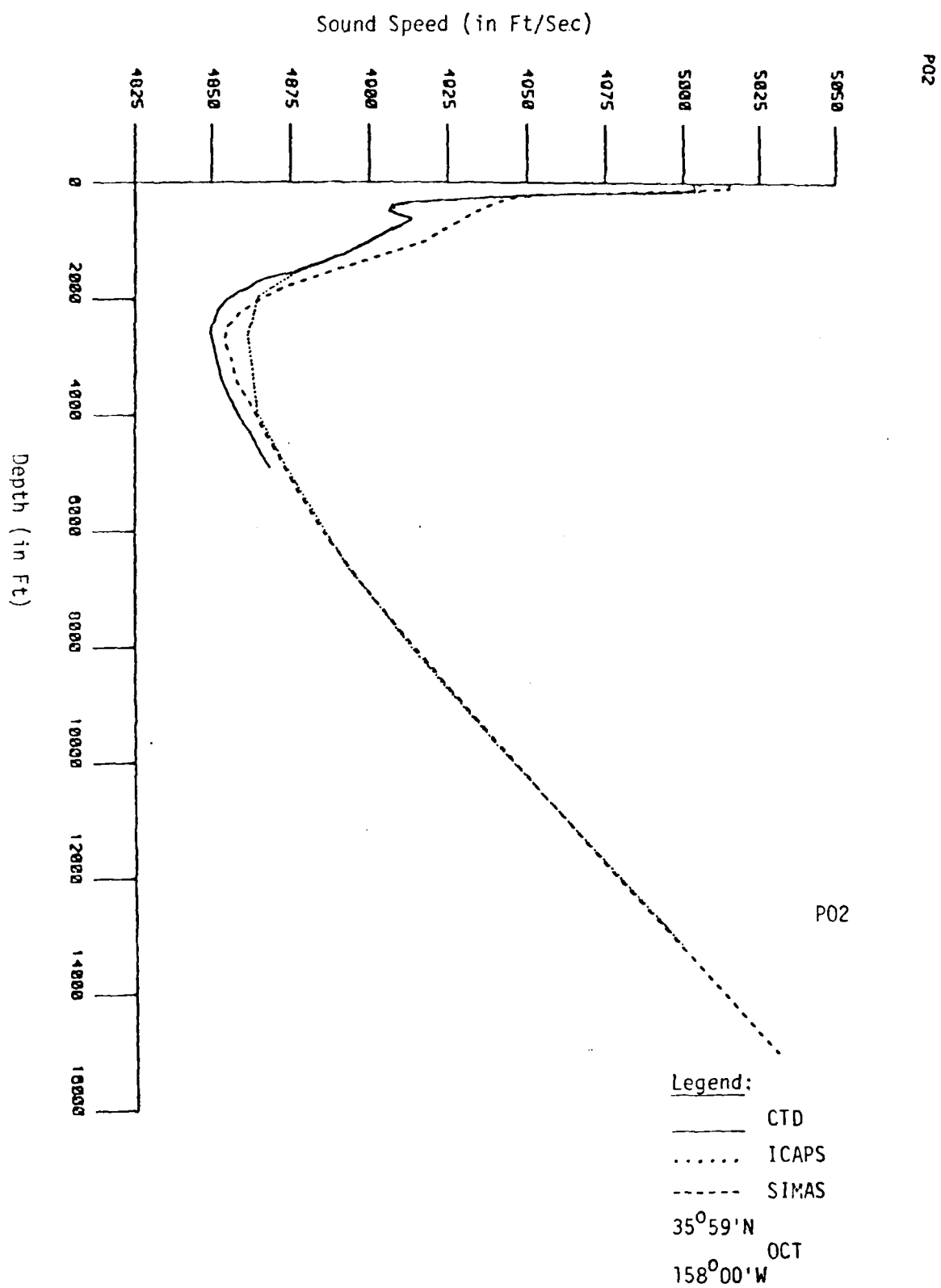


Fig. 9 20

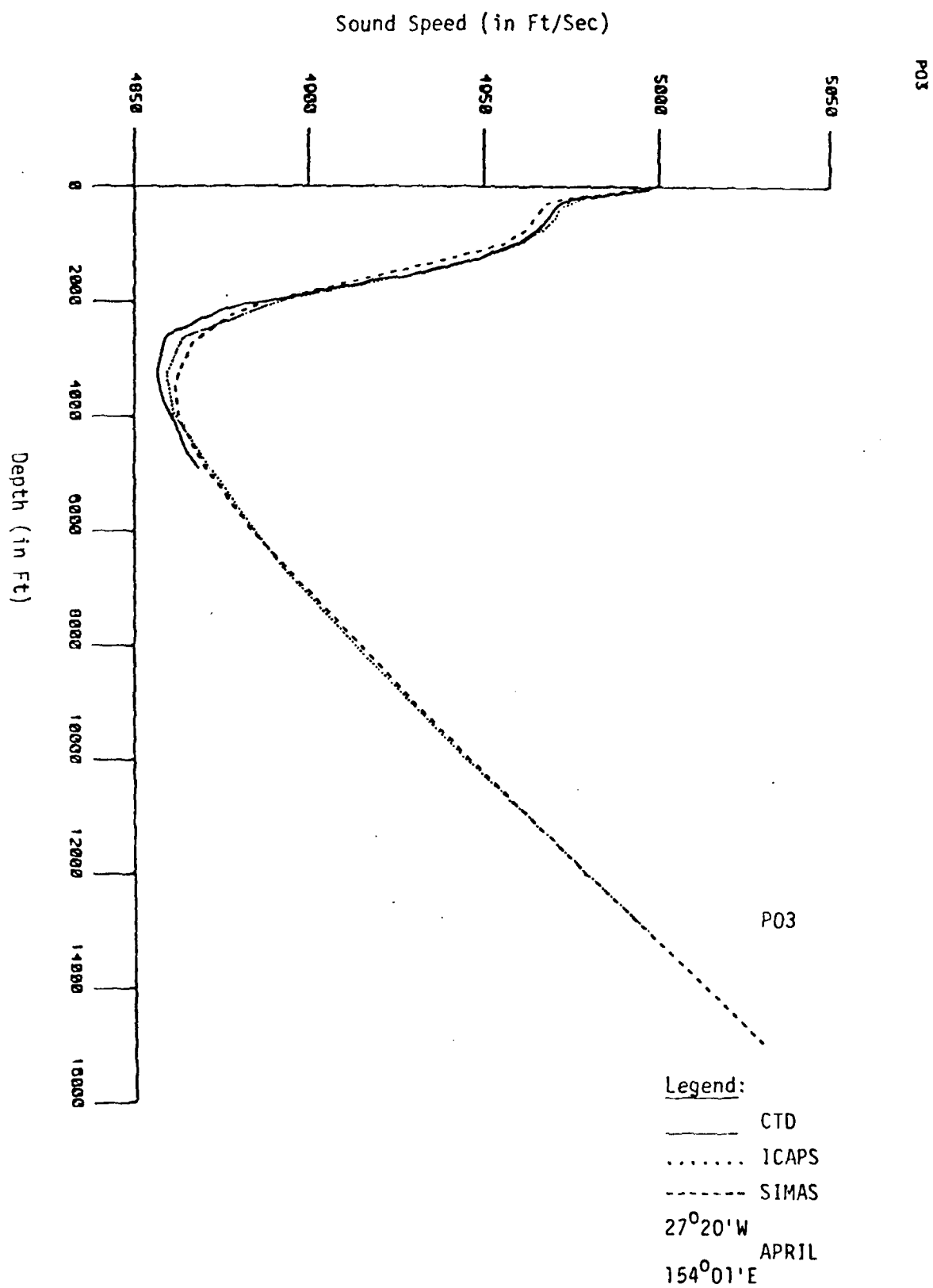


Fig. 10 21

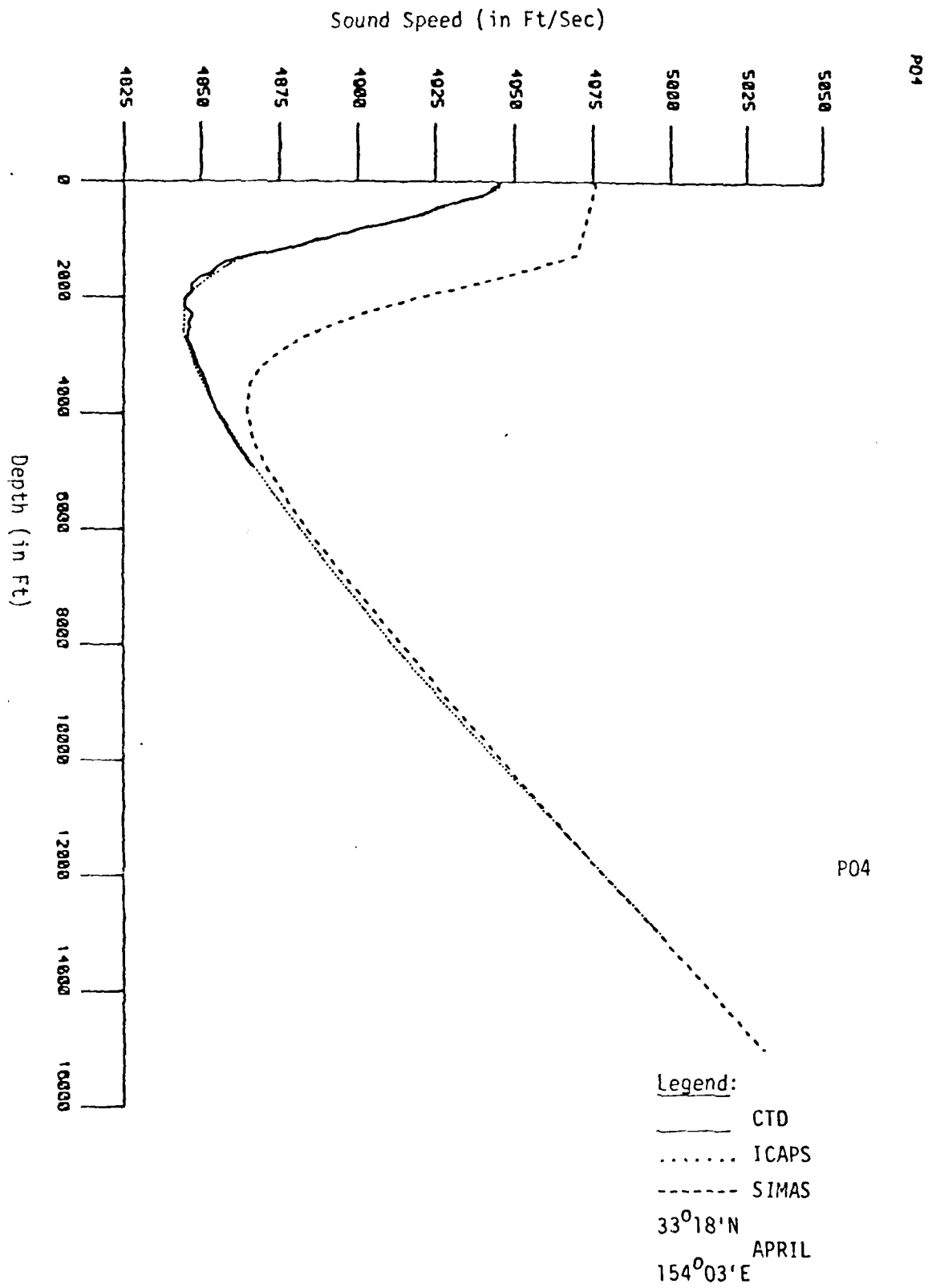


Fig. 11 22

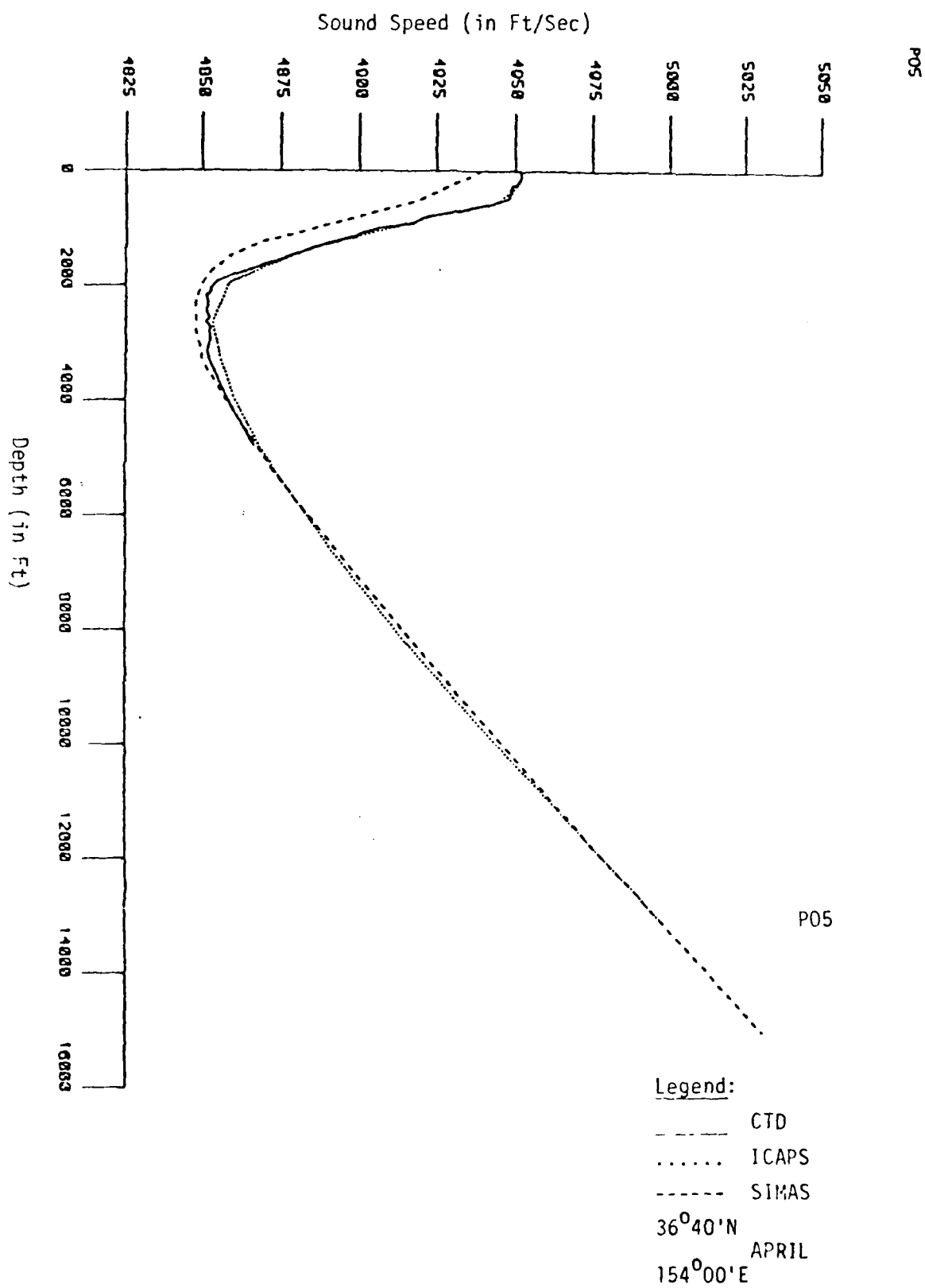


Fig. 12 23

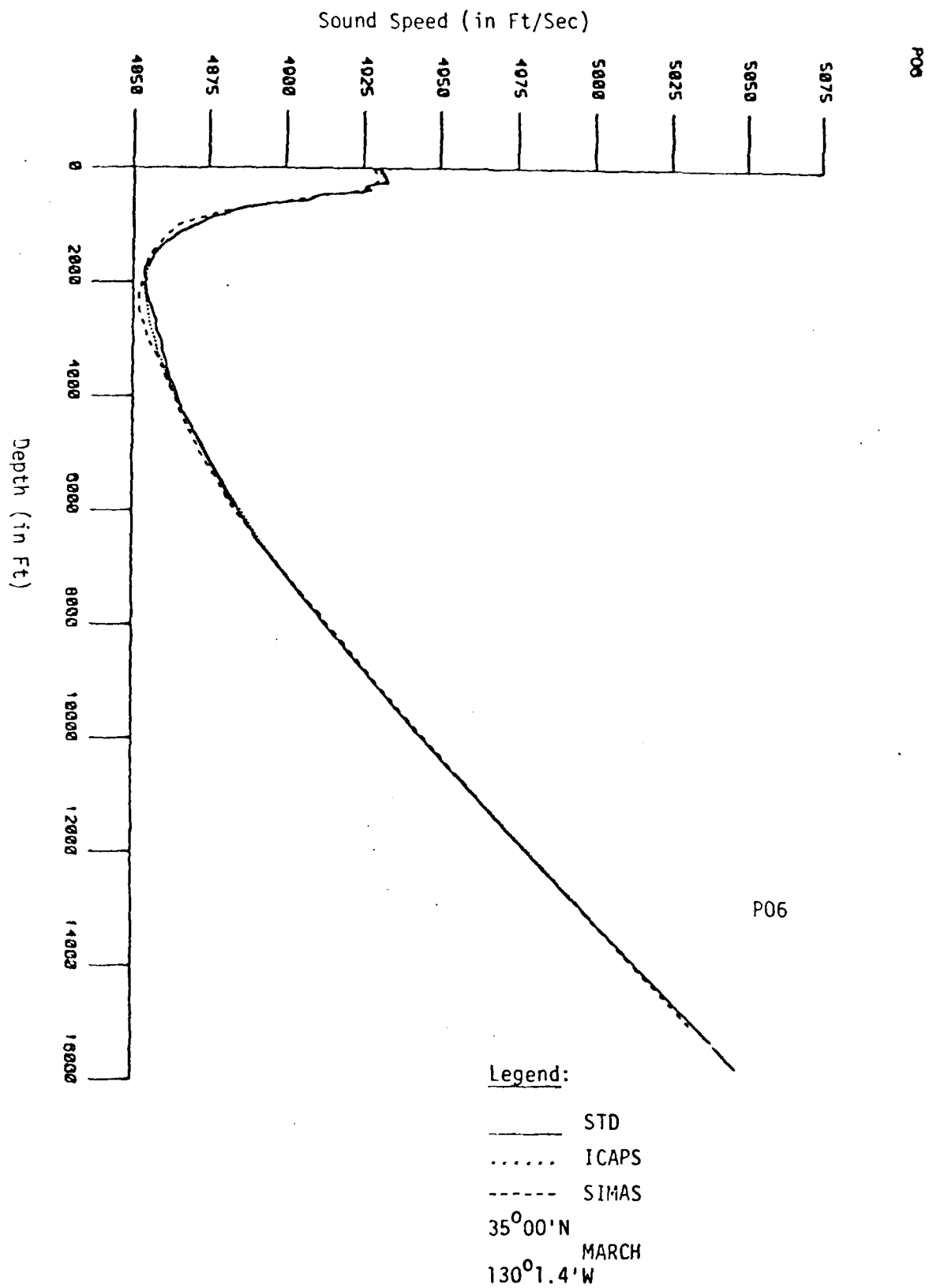


Fig. 13 24

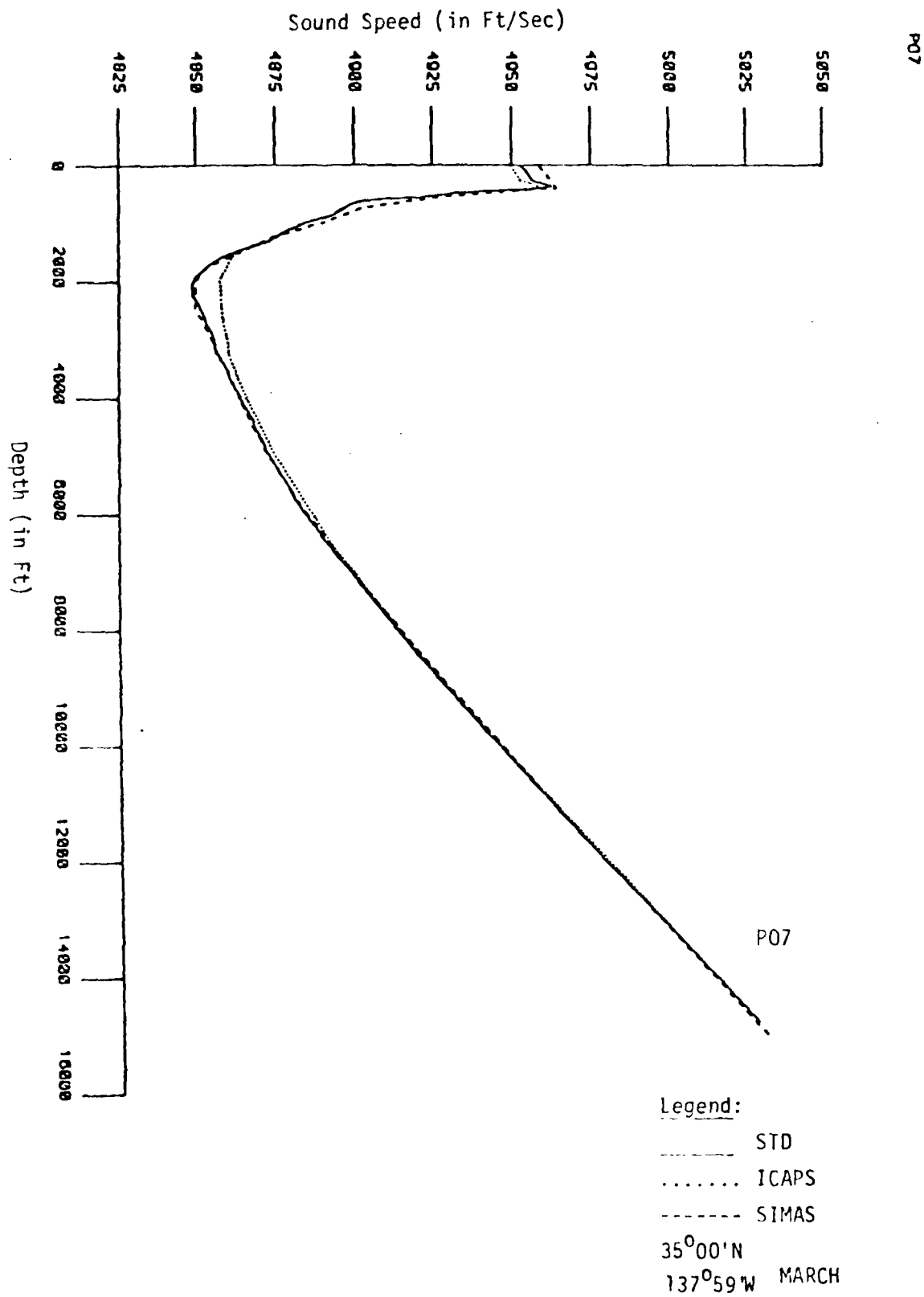


Fig. 14 25

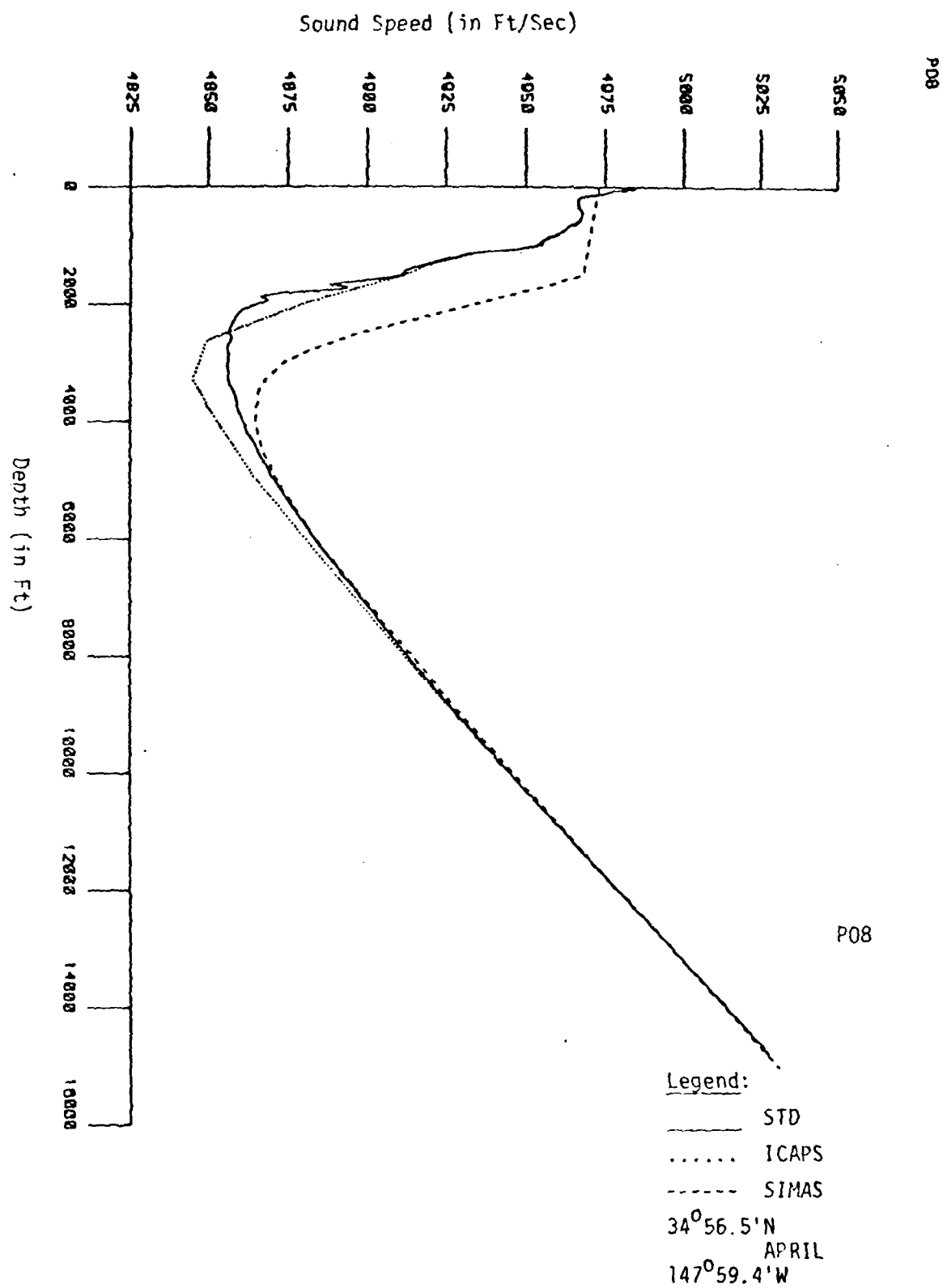
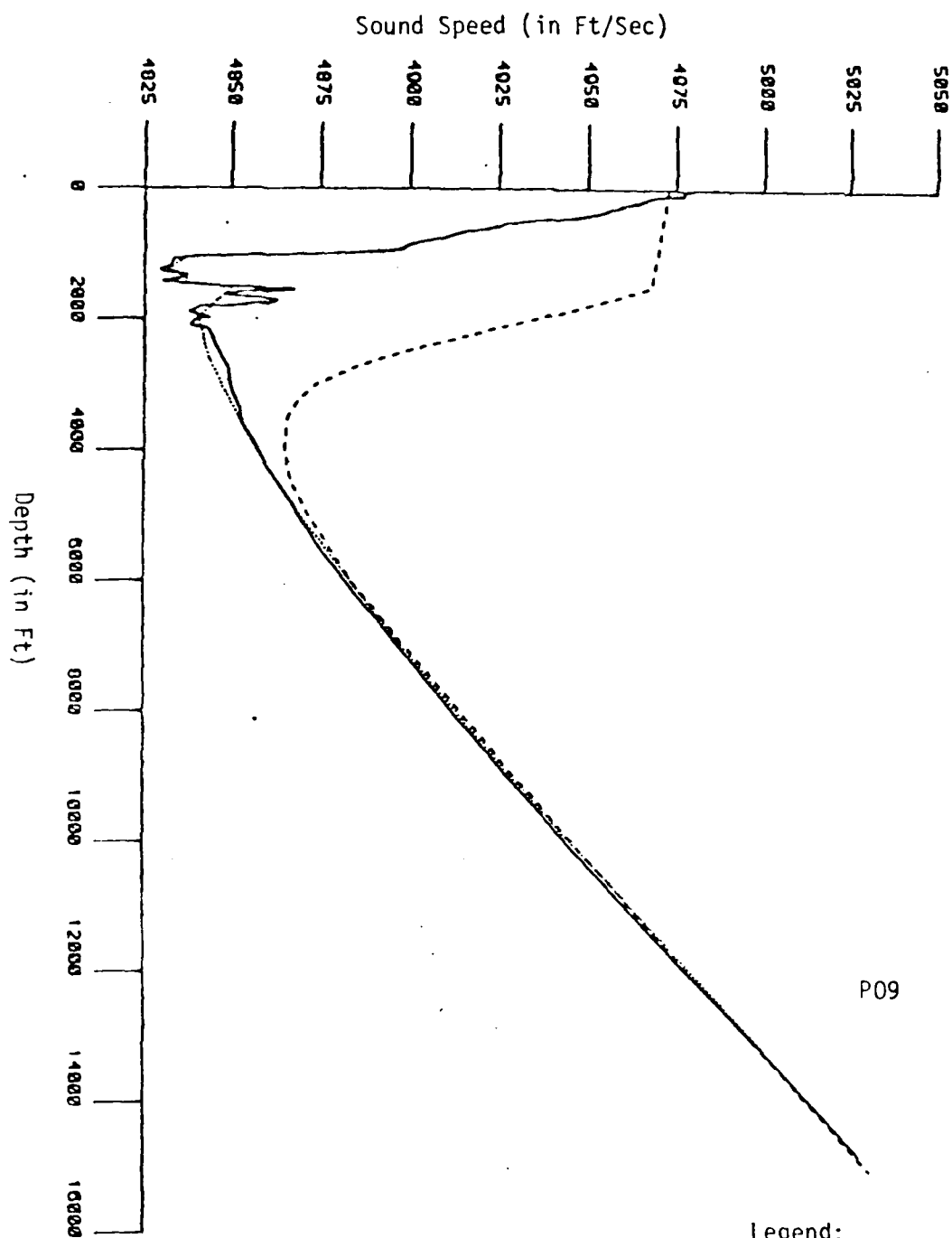


Fig. 15 26



Legend:

— STD
 ICAPS
 - - - SIMAS

$35^{\circ}12.2'N$

APRIL
 $147^{\circ}0.3'E$

Fig. 16 27

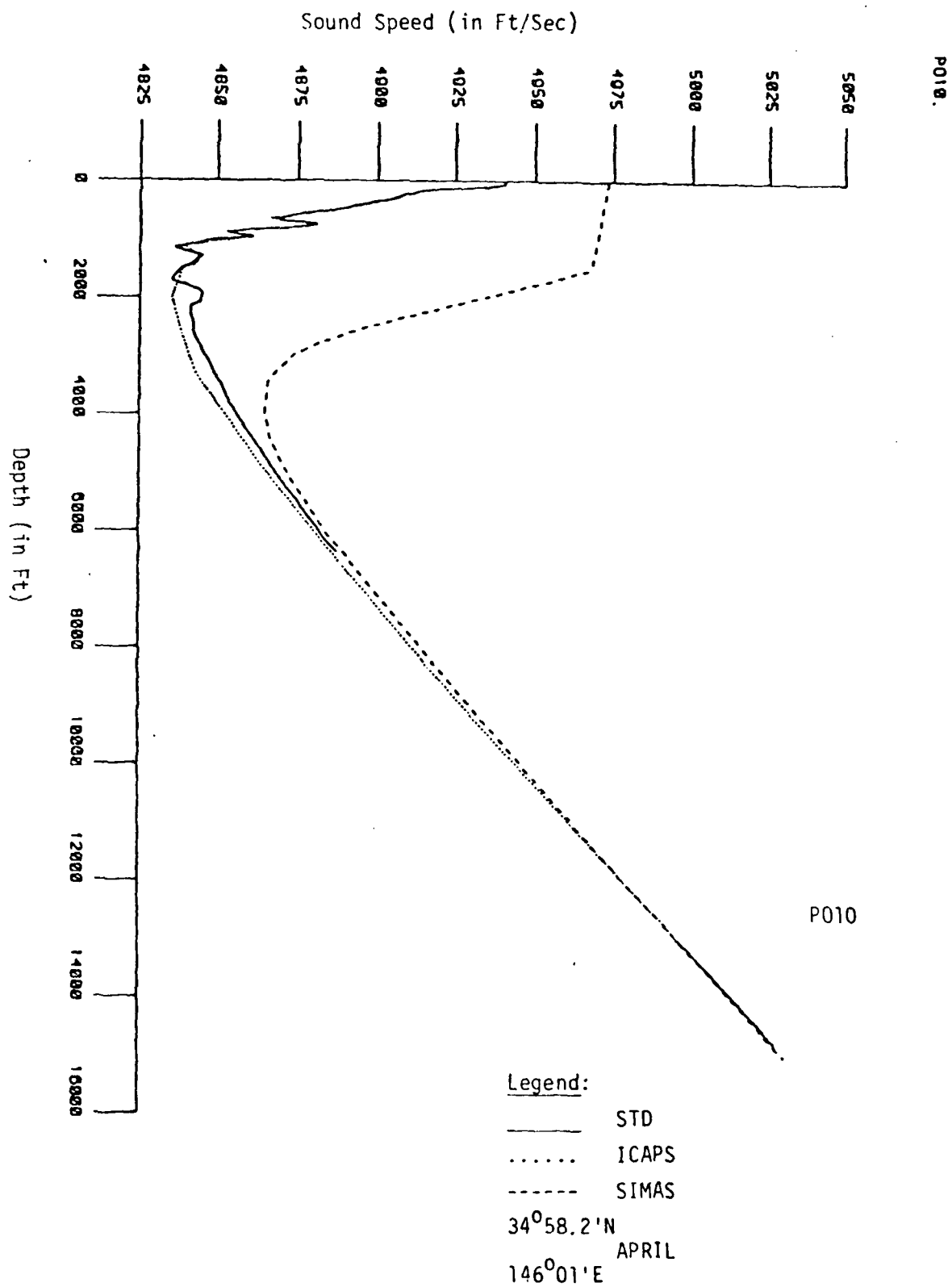
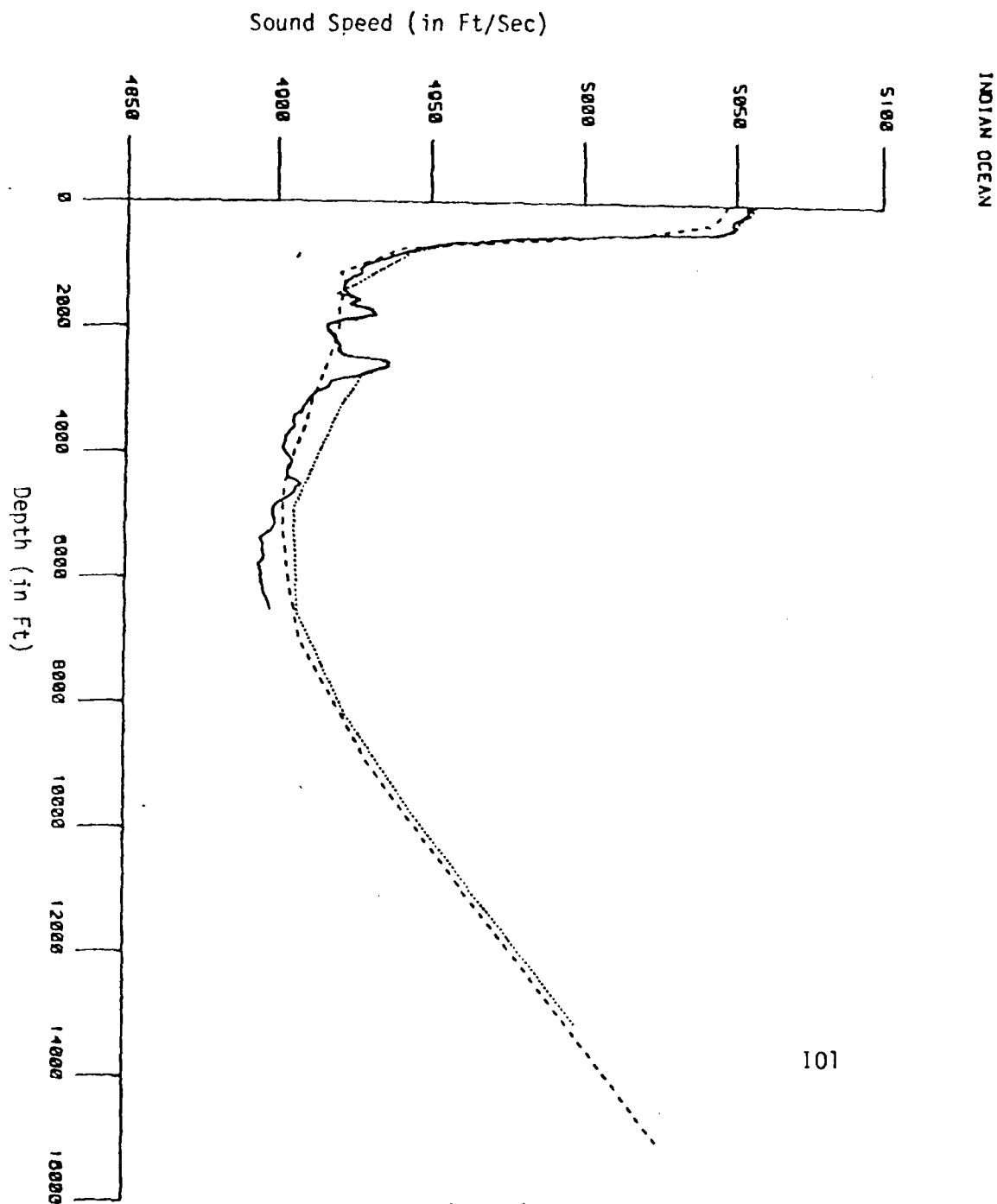


Fig. 17 28



101

Legend:

— CTD
 ICAPS
 ----- SIMAS
 4°49'N
 MARCH

053°02'E

Fig. 18

TABLE (I) DESIGNATORS & LOCATIONS OF SELECTED SITES
FOR SIMAS, ICAPS AND CTD/STD COMPARISONS

North Pacific Ocean

	<u>Latitude</u>	<u>Longitude</u>	<u>Month</u>
P01	43°00'N	158°02'W	(September)
P02	35°59'N	158°00'W	(October)
P03	27°20'N	154°01'E	(April)
P04	33°18'N	154°03'E	(April)
P05	36°40'N	154°00'E	(April)
P06	35°00'N	130°1.4'W	(March)
P07	35°00'N	137°59'W	(March)
P08	34°56.5'N	147°59.4'W	(March)
P09	35°12.2'N	147°0.3'E	(April)
P10	34°58.2'N	146°01'E	(April)

Indian Ocean

I01	4°49'N	053°02'E	(March)
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North Atlantic Ocean

A01	37°00'N	018°00'W	(February)
A02	36°00'N	019°00'W	(February)
A03	35°22.7'N	035°4.7'W	(June)
A04	35°12.4'N	054°59.0'W	(July)
A05	30°24.6'N	071°57.8'W	(September)
A06	30°25.6'N	071°57.0'W	(September)

TABLE (II)

Sources for the CTD and STD Test Cases

- I. Scripps Institute for Oceanography
 - a) CTD
J. Reid and K. Kenyon P01, P02, P03, P04, P05
 - b) STD
J. Reid and K. Kenyon P06, P07, P08, P09, P10

- II. Woods Hole Oceanographic Institute
 - a) CTD
M. McCartney A05, A06

- III. Naval Ocean Research and Development Activity
 - a) CTD
H. Perkins and D. Fenner A01, A02, I01

- IV. Naval Oceanographic Office
 - a) CTD
LCDR L. Danzler A03, A04

TABLE III. Numerical values of $\bar{SS}$ (in feet/sec) at the surface, and quantitative differences in $\bar{SS}$ (in feet/sec) at the surface.

Point Identifier	Point Location	Values of $\bar{SS}$ (in ft/sec) at the surface			Differences in $\bar{SS}$ (in ft/sec) at the surface	
		SIMAS	ICAPS	Assumed Oceanography	SIMAS-Assumed Oceanography	ICAPS-Assumed Oceanography
A01	37°00'N 078°00'W	4965.95	4955.65	4955.65	10.00	not applicable
A02	36°00'N 019°00'W	4965.95	4953.68	4953.02	12.93	.66
A03	35°22.7'N 035°4.7'W	5007.00	5008.14	5008.47	-1.47	-0.33
A04	35°12.4'N 054°59'W	5034.70	5036.03	5037.01	-2.31	-0.98
A05	30°14.6'N 071°57.8'W	5059.50	5059.65	5060.30	-0.80	-0.65
A06	30°25.6'N 071°57'W	5056.90	5057.35	5057.68	-0.78	-0.33
P01	43°00'N 158°02'W	4951.84	4954.34	4953.35	-1.51	0.99
P02	35°59'N 158°30'W	5014.93	5005.19	5002.89	12.04	2.30
P03	27°20'N 154°01'E	4994.43	4999.61	4998.63	-4.20	0.98
P04	33°18'N 152°03'E	4974.94	4945.15	4944.49	30.45	0.66
P05	36°40'N 154°00'E	4938.95	4953.35	4952.37	-13.42	0.98
P06	35°00'N 150°1.4'W	4927.73	4929.40	4930.39	-2.66	-0.99
P07	35°00'N 137°39'W	4958.44	4949.41	4952.66	5.78	-3.25
P08	35°56.5'N 147°16.4'W	4972.94	4983.54	4983.40	-10.46	0.14
P09	35°12.2'N 147°0.3'E	4972.94	4979.27	4979.60	-6.66	-0.33
P10	34°18.2'N 146°01'E	4972.94	4940.55	4940.10	32.84	0.45
P01	40°49'N 053°02'E	5047.40	5056.70	5055.05	-7.65	1.65

TABLE IV. Numerical values of $\bar{SS}$ (in feet/sec at the layer, and quantitative differences in $\bar{SS}$ (in feet/sec) at the layer.

Point No.	Point Location	Values of $\bar{SS}$ (in ft/sec) at the layer			Differences in $\bar{SS}$ (in ft/sec)	
		SIMAS	ICAPS	Assumed Density	ICAPS - SIMAS	ICAPS - Assumed
401	37°00'N 018°30'W	4967.75	4959.91	4959.26	-7.84	-6.5
402	36°00'N 019°00'W	4965.95	4954.99	4954.66	-11.9	-1.3
403	35°22.7'N 020°4.7'W	5008.10	5009.73	5009.73	+1.63	0
404	35°12.4'N 020°19'W	5035.30	5026.68	5027.01	-8.62	-0.3
405	34°23.4'N 021°07.8'W	5060.00	5046.35	5046.35	-13.65	-0
406	33°26.8'N 021°27'W	5090.10	5080.40	5080.36	-9.7	-0.4
407	32°00'N 022°02'W	4952.14	4954.34	4954.01	+2.2	-0.3
408	31°00'N 022°00'W	5015.42	5005.42	5005.88	-10.0	-0.5
409	27°20'N 024°01'E	4994.43	4999.61	4998.63	+5.18	-0.8
410	25°15'N 024°13'E	4935.92	4935.48	4935.38	-0.44	-0
411	26°20'N 024°01'E	4939.25	4953.35	4952.37	+14.1	+0.9
412	24°00'N 025°12'W	4930.02	4937.03	4932.85	+7.01	-3.2
413	22°00'N 026°2'W	4964.05	4959.93	4962.44	-4.12	-1.6
414	20°00'N 027°15'W	4972.93	4934.19	4933.26	-38.74	-0.9
415	18°17.2'N 027°00.3'E	4972.94	4926.97	4929.83	-46.97	-3.1
416	16°13.2'N 026°01'E	4973.04	4920.95	4920.59	-52.09	-3.4
417	14°00'N 026°0'E	4947.40	4916.20	4915.71	-31.2	-0.5

TABLE V. Numerical values of $\overline{SS}$ (in feet/sec) at 1000 feet, and quantitative differences in $\overline{SS}$ (in feet/sec) at 1000 feet.

Point Identification	Point Location	Values of $\overline{SS}$ (in ft/sec) at 1000 feet			Differences in $\overline{SS}$ (in ft./sec) at 1000 feet	
		SIMAS	ICAPS	Assumed Oceanography	SIMAS-Assumed Oceanography	ICAPS-Assumed Oceanography
A01	37°00'N 014°00'W	4944.94	4936.50	4936.62	9.32	-0.12
A02	36°00'N 013°00'W	4946.94	4936.49	4935.75	10.19	0.74
A03	35°02.7'N 013°04.7'W	4960.0	4944.12	4943.80	16.20	0.32
A04	35°12.4'N 014°03'W	4922.0	4903.96	4994.61	-2.61	-0.65
A05	35°04.6'N 011°07.8'W	4999.0	5000.40	5000.11	-1.11	0.29
A06	35°04.6'N 011°07'W	4999.0	5001.46	5001.10	-2.10	0.36
F01	35°00'N 156°02'W	4866.93	4862.5	4862.38	-5.45	0.22
F02	35°09'N 156°00'W	4917.95	4901.28	4899.10	18.85	2.18
F03	27°00'N 154°07'E	4945.94	4959.81	4959.24	-3.30	0.57
F04	23°15'N 154°03'E	4971.20	4849.64 4889.64	4846.54	94.66	3.10
F05	35°00'N 154°07'E	4886.95	4909.85	4906.91	-19.96	2.94
F06	35°00'N 153°11.4'W	4864.93	4870.33	4871.22	-6.29	-0.89
F07	35°00'N 153°09'W	4889.93	4884.20	4884.96	4.97	-0.76
F08	34°00.5'N 147°06.4'W	4909.62	4954.44	4953.18	16.44	1.26
F09	35°12.2'N 147°00.3'E	4960.61	4873.60	4880.59	89.02	-6.99
F10	34°58.2'N 146°01'E	4969.73	4856.26	4853.29	116.44	2.97
I01	4°49'N 013°02'E	4928.0	4937.12	4929.55	-1.55	7.57

TABLE VI. Numerical values of $\bar{SS}$ (in feet/sec) at the channel axis, quantitative differences in $\bar{SS}$ (in feet/sec) at the channel axis.

Point Number	Point Location	Value of $\bar{SS}$ (in ft/sec) at the channel axis			Difference in $\bar{SS}$ (in ft/sec) at the channel axis	
		SIMAS	ICAPS	Assumed Oreography	SIMAS vs. Assumed Oreography	ICAPS vs. Assumed Oreography
1	37°00'N 018°00'W	4926.94	4924.15	4917.92	8.02	6.23
2	36°00'N 019°00'W	4926.94	4924.15	4916.28	10.66	7.67
3	35°02.7'N 035°04.7'W	4911.00	4902.83	not applicable	not applicable	not applicable
4	35°02.4'N 034°03'W	4889.00	4880.39	not applicable	not applicable	not applicable
5	34°24.8'N 021°57.8'W	4891.00	4899.55	4894.94	6.06	6.11
6	34°25.6'N 021°57'W	4891.00	4899.22	4896.92	4.08	2.08
7	34°00'N 147°02'W	not applicable			not applicable	not applicable
8	35°09'N 136°00'W	4863.95	4861.40	4849.68	4.27	11.21
9	35°20'N 134°01'E	4861.95	4859.52	4856.89	5.06	2.13
10	35°08'N 134°03'E	4864.93	4844.43	4844.76	20.17	19.17
11	35°00'N 134°00'E	4847.94	4853.29	4851.32	13.34	1.47
12	35°00'N 134°01'W	4861.94	4853.61	4844.34	10.40	7.60
13	35°00'N 134°02'N	4849.94	4857.59	4849.82	1.12	9.06
14	34°06.5'N 147°09.1'W	4864.93	4846.00	4855.98	8.95	10.89
15	35°02.2'N 147°00.3'E	4864.93	4840.92	4838.43	26.50	26.50
16	35°08.2'N 146°01'E	4864.93	4835.24	4835.31	29.62	29.62
17	40°00'N 053°02'E	4802.00	4805.78	4804.30	7.70	11.48

TABLE VII. Numerical values of layer depth (in feet), quantitative differences in the depths of the layer (in feet).

Point Identifier	Point Location	Values of the layer depth (in ft)			Differences in layer depth (in ft)	
		SIMAS	ICAPS	Assumed Oceanography	SIMAS-Assumed Oceanography	ICAPS-Assumed Oceanography
A01	37°00'N 018°00'W	108.30	337.92	367.45	-259.15	-29.53
A02	36°00'N 019°00'W	0	154.20	387.13	-387.13	-232.93
A03	35°22.7'N 035°4.7'W	65.90	65.62	65.62	.28	0
A04	35°12.4'N 054°39'W	24.6	36.09	0	24.60	36.09
A05	30°24.6'N 071°57.8'W	36.10	65.62	32.81	3.29	32.81
A06	30°25.6'N 071°57'W	88.60	88.58	88.58	.02	0
P01	43°00'N 158°02'W	78.71	0	88.58	-9.87	-88.58
P02	35°53'N 158°00'W	78.71	127.95	98.42	-19.71	29.53
P03	27°20'N 154°01'E	0.0	0.0	0.0	0	0
P04	33°18'N 154°03'E	59.09	78.74	49.21	9.88	29.53
P05	35°40'N 154°00'E	19.68	0.0	98.42	-78.74	-98.42
P06	35°00'N 130°1.4'W	205.71	206.69	225.57	-19.86	-18.88
P07	35°10'N 137°19'W	401.90	367.45	368.11	33.79	-.66
P08	35°14.3'N 137°43.4'W	2.0	36.09	37.73	-35.73	-1.64
P09	35°12.2'N 147°0.3'E	0	36.09	13.12	-13.12	22.97
P10	34°58.2'N 146°01'E	70.90	68.90	39.37	31.53	29.53
P01	4°49'N 053°02'E	0	0	9.84	-9.84	-9.84

TABLE VIII. Numerical values of the channels axis depth (in feet), quantitative differences in the depths of the channel axis (in feet.)

Point Identifier	Point Location	Values of the channel axis depth (in ft)			Differences in the channel axis (in ft) depth	
		SIMAS	ICAPS	Assumed Oceanography	SIMAS-Assumed Oceanography	ICAPS-Assumed Oceanography
A01	37°00'N 016°00'W	6999.91	6561.60	5721.71	438.31	839.89
A02	36°00'N 015°00'W	6999.91	6561.60	5600.32	1399.58	961.28
A03	35°22.7'N 015°4.7'W	5000.00	4429.03	not applicable	not applicable	not applicable
A04	35°12.4'N 014°43'W	4000.00	3936.96	not applicable	not applicable	not applicable
A05	30°44.6'N 071°57.8'W	4500.00	3936.96	4268.32	231.68	-331.26
A06	30°25.6'N 071°57'W	4500.00	3936.96	4248.64	251.36	-311.68
A07	43°00'N 158°02'W	not	applicable		not applicable	not applicable
A08	35°09'N 154°00'W	2749.97	2624.64	2618.08	131.99	6.56
A09	35°20'N 154°01'E	3499.96	3280.80	3257.83	242.13	21.97
A10	35°18'N 154°03'E	3999.95	2624.64	2145.64	1854.31	479.00
A11	35°03'N 154°00'E	2499.97	2624.64	2627.92	-127.95	-3.28
A12	35°00'N 154°01.4'W	2374.97	1968.48	2059.36	315.61	-90.98
A13	35°00'N 154°09'N	2749.97	1968.48	2060.01	189.96	-91.53
A14	35°08.5'N 147°09.4'W	3999.95	3280.80	3058.03	941.92	941.92
A15	35°12.2'N 147°0.3'E	3999.95	1968.48	2089.87	1910.08	-121.39
A16	34°58.2'N 146°01'E	3999.95	1968.48	1712.91	2287.04	255.57
A17	40°49'N 014°02'E	5000.00	4921.20	5800.78	-800.78	-879.58

TABLE (IX)

Qualitative Differences in SS
at the surface

LEGEND: slight < 1 f/s
1 f/s < SS < 7 f/s
7 f/s < SS* < 20 f/s
20 f/s < SS** < 40 f/s

SITE (ID)	Differences in SS at the surface	
	SIMAS	ICAPS
A01	SS*	none
A02	SS*	slight
A03	SS	slight
A04	SS	slight
A05	slight	slight
A06	slight	slight
P01	SS	slight
P02	SS*	SS
P03	SS	slight
P04	SS**	slight
P05	SS*	slight
P06	SS	slight
P07	SS	SS
P08	SS*	slight
P09	SS	slight
P10	SS**	slight
I01	SS*	SS

TABLE (X)

Qualitative Differences in SS at
the layer

LEGEND: slight < 1 f/s
1 f/s < SSL < 7 f/s
7 f/s < SSL* < 20 f/s
20 f/s < SSL** < 40 f/s

SITE (ID)	Differences in SS at the layer	
	SIMAS	ICAPS
A01	SSL*	slight
A02	SSL*	slight
A03	SSL	none
A04	SSL	slight
A05	slight	slight
A06	slight	slight
P01	SSL	slight
P02	SSL*	SSL
P03	SSL	slight
P04	SSL**	none
P05	SSL*	slight
P06	SSL	slight
P07	SSL	SSL
P08	SSL*	slight
P09	SSL	SSL
P10	SSL**	slight
I01	SSL*	slight

TABLE (XI)

Qualitative Differences in SS
at 1000 feet

LEGEND: slight < 1 f/s
1 f/s < SS1000* < 6 f/s
6 f/s < SS1000** < 12 f/s
12 f/s < SS1000*** < 20 f/s
20 f/s < SS1000**** < 75 f/s
75 f/s < SS1000***** < 100 f/s
100 f/s < SS1000*****

SITE (ID)	Differences in SS at the 1000' feet	
	SIMAS	ICAPS
A01	SS1000*	slight
A02	SS1000*	slight
A03	SS1000**	slight
A04	SS1000	slight
A05	SS1000	slight
A06	SS1000	slight
P01	SS1000	slight
P02	SS1000**	SS1000
P03	SS1000	slight
P04	SS1000***	SS1000
P05	SS1000**	SS1000
P06	SS1000*	slight
P07	SS1000	slight
P08	SS1000**	SS1000
P09	SS1000****	SS1000*
P10	SS1000***	SS1000*
I01	SS1000	SS1000*

TABLE (XII)

Qualitative Differences in SS
at the channel axis

LEGEND: -- = no comparison made
slight. 1 f/s
1 f/s < SSCA < 3 f/s
3 f/s < SSCA < 7 f/s
7 f/s < SSCA* < 12 f/s
12 f/s < SSCA** < 20 f/s
20 f/s < SSCA***

SITE (ID)	Differences in SS at the channel axis	
	SIMAS	ICAPS
A01	SSCA**	SSCA**
A02	SSCA**	SSCA**
A03	--	--
A04	--	--
A05	SSCA*	SSCA*
A06	SSCA*	SSCA*
P01	--	--
P02	SSCA*	SSCA**
P03	SSCA*	SSCA
P04	SSCA****	slight
P05	SSCA*	SSCA
P06	SSCA	slight
P07	SSCA	SSCA**
P08	SSCA**	SSCA**
P09	SSCA****	SSCA
P10	SSCA****	slight
I01	SSCA**	SSCA**

TABLE (XIII)

Qualitative Differences in SS
at the layer depth

LEGEND: slight < 2 ft
2 ft < DLD < 30 ft
30 ft < DLD* < 90 ft
90 ft < DLD** < 150 ft
150 ft < DLD*** < 250 ft
250 ft < DLD****

SITE (ID)	Differences in layer depth (in feet)	
	SIMAS	ICAPS
A01	DLD****	DLD
A02	DLD****	DLD***
A03	slight	none
A04	DLD	DLD*
A05	DLD	DLD*
A06	slight	none
P01	DLD	DLD*
P02	DLD	DLD
P03	none	none
P04	DLD	DLD
P05	DLD*	DLD**
P06	DLD	DLD
P07	DLD*	DLD
P08	DLD*	DLD
P09	DLD	DLD
P10	DLD*	DLD
I01	DLD	DLD

TABLE (XIV)

Qualitative Differences in the depth
of the channel axis

LEGEND:

---- = no comparisons made
 0 ft < DSCA < 300 ft
 300 ft < DSCA* < 600 ft
 600 ft < DSCA** < 1200 ft
 1200 ft < DSCA*** < 2000 ft
 2000 ft < DSCA****

SITE (ID)	Differences in the depth of sound channel axis (in feet)	
	SIMAS	ICAPS
A01	DSCA*	DSCA**
A02	DSCA***	DSCA**
A03	--	--
A04	--	--
A05	DSCA	DSCA*
A06	DSCA	DSCA**
P01	--	--
P02	DSCA	DSCA
P03	DSCA	DSCA
P04	DSCA****	DSCA*
P05	DSCA	DSCA
P06	DSCA*	DSCA
P07	DSCA	DSCA
P08	DSCA**	DSCA**
P09	DSCA***	DSCA
P10	DSCA****	DSCA
I01	DSCA**	DSCA**

TABLE (XV). Numerical values of sound speeds (in feet/sec) for "assumed oceanography" profiles

ATLANTIC OCEAN

A01

0 00	1955 65	209 97	1957 29	367 45	1959 26	374 01	1958 60
380 57	1957 29	387 13	1955 98	393 70	1954 01	410 10	1952 70
413 38	1951 05	416 66	1949 41	423 22	1948 10	429 78	1946 79
436 35	1945 15	452 75	1943 51	479 00	1942 20	498 68	1942 85
544 61	1941 21	580 70	1939 57	646 32	1940 23	685 68	1938 59
738 18	1937 93	800 52	1941 54	810 36	1938 59	830 04	1939 90
853 01	1938 26	869 41	1935 30	902 22	1935 30	954 71	1934 00
1000 84	1936 62	1026 89	1934 98	1059 70	1932 03	1092 51	1934 32
1187 65	1933 34	1263 11	1934 65	1407 46	1933 34	1446 83	1931 70
1614 15	1933 01	1886 46	1934 65	2116 12	1937 61	2185 01	1935 96
2263 75	1938 91	2309 68	1938 26	2316 24	1936 62	2378 58	1935 96
2536 06	1938 26	2644 32	1935 30	2683 69	1938 26	2726 34	1937 61
2729 63	1936 95	2772 28	1938 59	2782 12	1940 55	2818 21	1942 85
2847 73	1941 21	2877 26	1942 20	2887 10	1945 48	2916 63	1945 48
2939 60	1943 84	2949 44	1941 21	2995 37	1943 18	3067 55	1944 82
3070 83	1945 15	3074 11	1946 79	3077 39	1948 43	3129 88	1950 40
3159 41	1948 43	3205 34	1951 38	3356 10	1954 66	3625 28	1955 98
3999 29	1952 70	4081 31	1949 41	4205 98	1946 13	4432 36	1942 85
4488 13	1939 90	4563 59	1936 62	4694 82	1933 34	4819 50	1930 06
5006 50	1926 78	5173 82	1923 50	5337 86	1920 54	5721 71	1917 92
6184 31	1919 23	6440 21	1919 56	6561 60	1921 20	8202 00	1936 62
9842 40	1958 93	11482 80	1984 19	13123 20	5010 77	14763 60	5038 00
16404 00	5066 87	16540 22	5071 13				

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A02

0 00	1953 02	387 13	1954 66	113 38	1953 68	118 66	1953 02
118 84	1952 37	429 78	1952 04	146 19	1950 40	156 03	1948 76
485 87	1947 45	175 72	1945 80	195 40	1941 18	528 21	1942 52
570 86	1940 88	652 88	1940 23	728 34	1941 87	764 43	1943 51
818 92	1941 87	836 60	1940 23	859 57	1938 50	902 22	1936 95
1036 73	1935 30	1151 56	1933 67	1561 66	1933 01	1761 79	1934 65
1863 49	1936 29	1978 32	1937 93	2050 50	1930 57	2076 75	1941 21
2142 36	1942 85	2194 86	1941 49	2250 63	1946 13	2316 24	1947 77
2388 42	1949 41	2600 60	1951 05	2532 78	1952 70	2647 61	1954 34
2726 34	1954 09	2811 65	1953 68	2847 73	1955 32	3087 23	1958 96
3146 29	1954 66	3477 65	1956 30	3602 32	1957 95	3871 34	1957 95
4051 79	1958 30	4120 68	1954 66	4140 37	1953 02	4228 95	1948 74
4304 41	1946 46	4389 71	1943 18	4478 29	1940 23	4550 47	1938 95
4635 77	1933 67	4671 86	1930 39	4763 72	1927 43	4917 92	1925 79
4924 48	1924 81	4993 38	1923 17	5068 84	1921 53	5180 38	1919 89
5452 69	1918 25	5600 32	1916 28	5688 91	1917 92	5967 77	1919 56
6151 50	1921 20	6299 14	1922 84	6492 70	1924 48	6561 60	1925 46
7611 46	1937 61	8202 00	1940 55	8320 11	1940 88	9842 40	1959 26
11482 80	1984 52	13123 20	5010 77	14763 60	5038 00	16404 00	5066 87
16879 71	5075 40						

A03

0 00	5008 17	42 65	5008 17	65 62	5009 13	88 58	5006 17
108 27	4986 82	131 23	4977 30	177 16	4970 74	200 13	4965 49
249 34	4960 24	272 31	4957 95	341 20	4957 29	508 52	4953 68
705 37	4951 71	744 74	4952 04	912 06	4948 10	997 36	4943 84
1174 53	4940 88	1213 90	4939 25	1430 43	4935 64	1601 03	4934 32
1728 98	4931 37	1856 93	4928 09	1899 58	4928 42	2109 55	4925 14
2283 44	4922 18	2326 09	4919 56	2447 48	4917 26	2828 05	4917 26
2956 00	4916 28	3038 02	4915 95				

A04

0 00	5037 01	36 09	5037 01	52 49	5031 43	72 18	5024 87
95 14	5012 08	121 39	5004 86	147 64	4998 95	177 16	4995 02
246 06	4989 77	300 42	4988 13	790 67	4991 41	1026 89	4995 02
1259 83	4987 64	1312 32	4995 34	1414 02	4990 43	1512 45	4986 49
1610 87	4982 88	1706 02	4978 61	1801 18	4974 68	1898 58	4969 75
1994 73	4966 47	2093 15	4960 90	2139 08	4957 62	2237 51	4952 37
2283 44	4948 43	2381 86	4943 18	2431 07	4939 90	2526 22	4934 65
2621 36	4929 07	2670 57	4824 48	2719 78	4921 53	2765 71	4917 92

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A05

0000	5060 30	13 12	5060 30	32 81	5060 63	82 02	5059 32
100 27	5057 35	121 39	5054 07	124 67	5052 10	127 95	5049 81
131 23	5046 20	134 51	5043 25	141 07	5040 29	147 64	5038 00
154 20	5035 04	157 48	5033 40	160 76	5031 11	173 88	5027 82
183 72	5025 53	196 85	5022 91	206 69	5019 95	229 66	5017 33
242 78	5014 05	205 74	5011 42	282 15	5009 13	305 11	5005 84
383 85	5002 50	567 58	4999 28	639 76	4998 63	744 74	4998 61
783 95	4999 28	938 31	5000 27	967 84	4999 94	1515 73	5002 89
1604 31	5002 80	1745 39	4999 61	1843 81	4998 33	1909 43	4993 05
1975 04	4989 77	2043 94	4986 82	2086 59	4983 54	2185 01	4980 25
2244 07	4978 97	2306 40	4973 69	2349 05	4970 41	2394 98	4967 13
2460 60	4963 85	2509 81	4960 57	2565 59	4957 29	2608 24	4954 01
2667 29	4950 73	2700 60	4947 45	2755 87	4944 16	2798 52	4941 21
2844 45	4937 61	2873 98	4934 65	2919 91	4931 70	2942 88	4928 42
3018 34	4925 14	3064 27	4921 86	3123 32	4919 56	3185 66	4915 95
3228 31	4912 67	3307 05	4909 72	3392 35	4906 44	3503 89	4903 16
3654 81	4899 88	3835 26	4896 59	3959 93	4897 58	4084 60	4896 59
4130 53	4897 25	4150 21	4896 27	4183 02	4897 58	4268 32	4895 94
4868 71	4899 22	5249 28	4902 50				

A06

0000	5057 68	13 12	5057 68	82 02	5059 32	88 58	5059 88
91 86	5050 32	95 14	5058 34	98 42	5055 71	101 70	5053 41
104 90	5050 46	111 55	5047 84	124 67	5044 56	131 23	5041 28
144 36	5038 00	160 76	5034 71	173 88	5031 70	180 44	5029 46
190 29	5026 51	200 13	5024 21	206 69	5021 27	219 81	5017 98
239 50	5015 03	262 46	5012 08	291 99	5008 80	344 48	5005 52
462 59	5002 56	521 65	4999 94	1200 77	5001 58	1686 33	5003 22
1811 00	4999 94	1906 14	4996 66	1961 92	4993 38	2020 97	4990 10
2080 03	4980 82	2135 80	4983 86	2198 14	4980 58	2263 75	4977 63
2335 93	4974 35	2381 86	4971 07	2427 79	4968 11	2467 16	4964 83
2513 00	4961 88	2552 46	4958 93	2611 52	4955 65	2654 17	4952 37
2886 98	4948 76	2723 06	4945 80	2769 00	4942 52	2824 77	4938 91
2854 30	4935 96	2900 23	4932 68	2959 28	4929 40	3015 06	4926 12
3074 11	4922 84	3123 32	4919 56	3208 62	4916 28	3277 52	4913 32
3375 94	4910 04	3408 75	4906 77	3480 93	4903 81	3566 23	4900 53
3723 71	4897 58	3795 89	4898 56	4002 58	4896 92	4028 82	4897 58
4248 64	4896 92	4530 79	4898 23	4894 95	4901 52	5006 50	4900 86
5246 00	4902 50						

PACIFIC OCEAN

P01

0 00	1953 35	88 58	1954 01	98 42	1953 02	108 27	1949 74
118 11	1941 87	127 95	1930 71	137 79	1919 23	147 64	1910 70
157 48	1905 45	167 32	1902 83	196 85	1899 55	236 22	1899 88
275 59	1897 25	285 43	1895 61	305 11	1892 00	324 80	1889 38
344 48	1886 09	354 33	1884 13	364 17	1881 17	374 01	1878 22
383 85	1875 27	403 54	1871 00	413 38	1870 02	462 59	1873 30
482 28	1875 60	501 96	1879 21	541 33	1880 85	620 07	1877 89
708 65	1874 61	757 86	1871 99	797 23	1869 04	875 97	1868 08
884 24	1863 13	1053 14	1859 85	1122 03	1856 24	1171 25	1853 61
1279 51	1850 34	1368 09	1847 38	1496 04	1844 10	1653 52	1842 46
1712 58	1842 46	1811 00	1843 12	1998 01	1842 13	2637 76	1845 41
3110 20	1848 37	3444 84	1851 64	3809 01	1854 93	4084 60	1857 88
4379 87	1861 16	4635 77	1864 11	4871 99	1867 07	4921 20	1867 72

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P02

0 00	5002 89	98 42	5003 88	147 64	5000 92	157 48	1996 60
167 32	4989 44	177 16	4979 60	187 01	1969 10	196 85	1959 91
206 69	4953 35	216 53	4948 76	226 38	1945 48	236 22	1942 85
246 06	4940 55	255 90	4937 93	265 74	1935 30	275 59	1932 68
285 43	4929 73	295 27	4926 78	305 11	1923 82	314 96	1920 87
324 80	4918 25	334 64	4915 62	344 48	1913 32	354 33	1911 36
364 17	4910 04	374 01	4909 39	393 70	1907 75	413 38	1907 09
511 80	4906 11	561 02	4909 39	610 23	1912 67	639 76	1913 32
738 18	4910 04	816 92	4906 77	905 50	1903 81	994 08	1900 53
1092 51	4897 25	1171 25	4894 30	1249 98	1891 34	1309 04	1888 06
1377 94	4884 78	1427 15	4881 83	1476 36	1878 88	1545 26	1875 93
1594 47	4872 97	1624 00	4870 35	1663 37	1867 07	1732 26	1864 11
1830 69	4861 16	1899 58	4858 21	2017 69	1854 93	2224 38	1851 64
2490 13	4850 00	2618 08	4849 68	3257 83	1852 30	3710 58	1855 58
4045 23	4858 86	4291 29	4862 14	4645 61	1865 43	4921 20	1868 71

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PACIFIC OCEAN

P03

0.00	1998.63	49.21	1995.34	98.42	1992.07	137.79	1985.50
157.48	1983.21	177.16	1980.25	196.85	1977.30	236.22	1974.35
324.80	1971.07	511.80	1968.77	757.86	1965.49	866.13	1962.54
984.24	1959.91	1053.14	1956.96	1112.19	1954.01	1181.09	1951.05
1259.83	1948.43	1299.20	1945.80	1338.57	1942.52	1387.78	1939.25
1427.15	1936.29	1476.36	1933.67	1515.73	1931.04	1555.10	1928.09
1584.63	1924.81	1604.31	1921.86	1633.84	1918.57	1692.89	1915.02
1722.42	1912.67	1751.95	1909.72	1781.47	1906.77	1820.84	1903.48
1860.21	1900.86	1899.58	1898.23	1929.11	1895.61	1958.64	1892.33
1998.01	1889.70	2017.69	1887.08	2037.38	1883.80	2066.90	1880.85
2116.12	1877.89	2175.17	1874.94	2263.75	1872.32	2312.96	1869.36
2431.07	1866.08	2490.13	1863.13	2568.87	1860.18	2657.45	1859.19
2716.50	1858.86	3228.31	1856.89	3287.36	1856.89	3769.64	1858.86
4143.65	1862.14	4625.93	1865.43	4921.20	1869.04		

P04

0.00	1944.49	49.21	1945.48	108.27	1943.18	157.48	1942.52
246.06	1939.90	275.59	1937.61	305.11	1934.32	364.17	1931.70
413.38	1928.09	462.59	1925.14	541.33	1922.18	600.39	1918.90
620.07	1916.61	619.60	1913.65	708.65	1910.70	738.18	1908.08
757.86	1906.11	777.55	1903.48	807.08	1900.86	875.97	1897.25
905.50	1894.63	954.71	1891.34	994.08	1888.06	1053.14	1885.11
1102.35	1882.16	1131.88	1879.53	1161.40	1876.91	1200.77	1873.63
1230.30	1870.35	1249.98	1867.07	1289.35	1864.11	1348.41	1860.83
1377.94	1858.21	1476.36	1854.93	1624.00	1852.30	1653.52	1849.68
1771.63	1847.05	1889.74	1847.05	2047.22	1844.76	2096.43	1845.09
2145.64	1844.76	2273.59	1847.38	2342.49	1847.05	2450.76	1846.07
2539.34	1846.40	2618.08	1845.74	2677.13	1845.74	3120.04	1849.02
3553.11	1852.30	3996.01	1855.58	4310.97	1858.86	4576.71	1862.14
4852.30	1865.43	4921.20	1866.41				

PACIFIC OCEAN

P05

0.00	1952.37	49.21	1951.71	68.90	1952.04	98.42	1952.37
226.38	1951.05	265.74	1949.09	314.96	1948.76	344.48	1948.43
374.01	1948.76	393.70	1949.09	413.38	1948.76	423.22	1948.43
482.28	1948.10	492.12	1947.77	501.96	1947.45	561.02	1944.16
590.54	1941.87	610.23	1939.57	639.76	1935.96	679.13	1933.01
718.50	1930.06	748.02	1926.78	767.71	1924.15	807.08	1920.54
895.66	1917.92	915.34	1915.62	944.87	1912.34	974.40	1909.06
1003.92	1906.11	1043.29	1903.81	1082.66	1900.86	1151.56	1897.91
1100.93	1895.28	1230.30	1892.00	1279.51	1889.38	1338.57	1886.09
1397.62	1882.81	1456.68	1879.86	1515.73	1876.58	1574.78	1873.30
1633.84	1870.35	1702.74	1867.07	1751.95	1864.11	1801.16	1861.16
1860.21	1858.21	1919.27	1855.25	2066.90	1852.63	2106.27	1852.96
2125.96	1852.63	2165.33	1851.32	2362.18	1851.97	2431.07	1851.32
2568.87	1852.30	2627.92	1851.32	2696.82	1852.30	2755.87	1852.03
2814.93	1852.30	2972.40	1852.63	3169.25	1851.64	3267.68	1852.30
3681.06	1855.58	4035.38	1858.86	4350.34	1862.14	4675.14	1865.43
4803.09	1867.07						

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P06

0.00	1930.39	90.22	1931.30	171.59	1932.22	255.57	1932.85
271.65	1931.77	288.05	1928.98	303.47	1927.37	317.91	1926.19
401.90	1926.88	434.05	1924.84	452.42	1916.48	469.15	1910.00
483.26	1909.72	534.11	1908.70	549.53	1908.01	566.59	1906.70
583.98	1903.98	599.73	1900.76	615.48	1897.71	631.55	1892.66
648.61	1890.52	665.67	1889.24	681.75	1887.54	697.83	1885.87
731.62	1884.91	761.47	1881.83	824.47	1880.03	843.49	1877.99
877.29	1875.50	942.57	1873.07	1007.53	1870.64	1059.70	1868.31
1124.33	1865.69	1221.11	1863.52	1303.13	1861.46	1403.20	1859.45
1502.61	1857.55	1615.47	1856.30	1713.89	1854.34	1829.70	1853.68
1944.86	1854.43	2059.36	1854.34	2173.20	1854.43	2336.59	1855.39
2501.94	1856.30	2661.38	1857.62	2829.36	1857.95	2992.75	1859.16
3173.85	1859.95	3330.90	1860.93	3502.25	1861.55	3714.85	1863.16
3928.76	1864.84	4076.39	1865.52	4222.39	1866.74	4388.07	1868.61
5338.52	1877.83	5521.26	1879.57	5717.12	1881.57	5912.00	1883.83
4583.93	1870.51	4783.41	1872.51	4992.07	1874.74	5159.06	1876.35
6108.85	1886.29	6323.09	1889.02	6438.57	1890.36	6553.73	1891.87
8200.88	1916.64	9849.62	1942.75	11489.36	1970.35	12771.82	1992.49
13132.71	1998.92	14772.45	5028.48	15755.05	5046.46		

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PACIFIC OCEAN

P07

0 00	171.26	4955.55	271.32	4956.73
303.15	368.11	4962.44	383.85	4961.26
401.90	433.72	4950.79	449.80	4941.11
467.19	501.31	4930.39	517.71	4927.23
533.46	565.94	4914.80	582.34	4909.91
598.75	629.91	4902.24	647.30	4900.40
682.41	795.59	4895.38	862.52	4893.34
910.42	993.10	4885.27	1041.98	4883.11
1091.52	1222.75	4876.02	1287.71	4873.73
1337.58	1436.01	4865.49	1500.31	4862.61
1548.87	1731.28	4854.40	1829.05	4852.20
1911.39	2220.77	4849.05	2404.50	4851.05
2618.41	2994.71	4856.01	3156.79	4850.11
3323.78	3680.40	4861.03	3863.14	4862.67
4043.26	4404.14	4868.12	4568.52	4869.30
4746.99	5159.39	4875.07	5387.73	4877.73
5568.50	5946.12	4883.73	6143.95	4886.39
6337.85	8210.86	4916.28	9851.26	4942.52
11490.67	13132.06	4998.92	14771.14	5028.32
16412.86				

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PACIFIC OCEAN

P08

0 00	1983 10	37 73	1983 86	55 12	1981 20	72 51	1977 63
88 91	1976 35	122 05	1974 18	139 11	1972 25	154 53	1969 23
169 95	1967 36	253 93	1966 18	351 37	1966 17	134 71	1967 69
581 69	1967 26	631 55	1965 88	677 81	1963 23	748 02	1961 98
794 94	1959 91	828 10	1958 70	860 55	1956 73	925 19	1954 76
1007 86	1953 02	1024 27	1951 19	1059 04	1948 14	1075 77	1944 89
1091 85	1940 16	1107 93	1937 05	1123 67	1933 60	1140 41	1931 99
1172 89	1929 80	1205 04	1927 86	1223 08	1926 09	1240 80	1924 12
1273 28	1921 36	1320 85	1919 30	1337 91	1917 59	1370 72	1914 67
1434 37	1912 41	1516 71	1910 64	1533 12	1909 03	1550 18	1906 27
1567 24	1903 88	1583 31	1901 12	1599 06	1899 45	1615 14	1896 92
1630 56	1894 33	1647 29	1890 56	1664 08	1888 16	1681 41	1889 90
1697 16	1892 59	1713 23	1893 80	1730 29	1893 80	1746 70	1892 33
1762 12	1889 41	1778 85	1883 67	1795 91	1877 99	1812 97	1874 41
1830 36	1871 40	1847 09	1869 04	1877 93	1866 38	1928 13	1868 87
1976 68	1867 69	2011 46	1865 33	2043 61	1863 39	2107 91	1860 73
2222 74	1858 80	2353 97	1857 52	2452 40	1856 54	2566 90	1857 12
2715 52	1856 18	2830 02	1856 14	2943 53	1856 27	3058 03	1855 98
3191 58	1856 50	3353 96	1856 57	3533 75	1858 44	3682 37	1858 86
3830 66	1859 12	3994 05	1860 93	4175 14	1862 31	4338 86	1863 95
4551 45	1866 05	4699 09	1867 59	4830 32	1868 97	4338 86	1870 74
5158 73	1872 97	5340 48	1875 14	5521 26	1877 46	4979 60	1879 66
5890 55	1882 29	6062 59	1884 49	6224 00	1886 79	5699 73	1889 21
6554 38	1891 54	8211 51	1916 11	9850 60	1942 49	6389 36	1889 21
13361 06	5002 73	14773 11	5027 96	16412 52	5057 61	11491 98	1970 18
19756 31	5119 59					18053 91	5087 80

PACIFIC OCEAN

P09

0 00	13 12	1979 60	37 07	1977 66	87 93	1977 17
101 38	122 05	1973 56	139 76	1968 02	172 90	1966 38
204 72	221 13	1964 70	236 55	1961 49	253 93	1959 88
287 07	318 57	1958 04	353 01	1955 22	368 43	1953 45
383 20	399 27	1952 20	417 32	1949 84	435 69	1947 51
451 44	466 86	1943 21	482 01	1936 13	499 87	1931 86
516 73	532 47	1929 20	582 34	1924 48	597 76	1923 10
614 82	630 24	1920 77	645 33	1915 75	677 81	1913 69
712 59	743 43	1911 62	760 82	1908 70	779 19	1906 34
795 92	828 73	1904 53	860 55	1899 71	924 86	1897 71
940 61	958 65	1895 51	976 69	1891 08	992 11	1879 34
1006 55	1021 64	1866 38	1039 69	1841 31	1058 06	1836 23
1075 77	1187 32	1833 60	1239 16	1829 60	1269 01	1830 29
1286 40	1302 81	1831 73	1319 87	1836 23	1336 60	1836 72
1385 15	1402 54	1834 75	1419 60	1830 29	1435 68	1831 11
1450 44	1466 85	1836 23	1484 56	1843 21	1500 64	1849 91
1516 06	1533 12	1860 01	1550 51	1867 46	1566 25	1862 18
1581 02	1598 41	1854 47	1616 12	1848 04	1648 27	1851 22
1664 68	1681 08	1856 18	1713 89	1863 03	1745 71	1860 67
1762 45	1778 85	1850 63	1795 25	1847 74	1811 33	1841 02
1877 27	1893 68	1838 55	1911 39	1840 49	1944 53	1840 03
1960 61	1974 71	1842 56	1990 79	1841 84	2007 52	1840 03
2089 87	2106 27	1838 43	2121 36	1840 52	2154 17	1843 57
2370 05	2598 72	1845 51	2764 07	1849 15	2928 77	1849 41
3126 60	3336 57	1850 46	3502 91	1852 50	3697 13	1854 24
3864 78	4040 63	1856 37	4206 97	1859 65	4386 76	1861 95
4586 56	4783 08	1864 14	4977 96	1868 87	5191 21	1871 50
5388 00	5583 92	1873 50	5798 81	1879 34	5994 35	1881 93
6192 51	6405 11	1884 75	6553 40	1890 23	8210 86	1915 13
9849 62	11096 32	1941 87	11488 05	1969 66	13130 09	1998 73
14773 44	16414 16	5027 89	18051 61	5087 77	19739 59	5119 26

PACIFIC OCEAN

P10

0.00	1940.10	39.37	4940.59	55.45	4940.49	70.54	4940.16
88.25	1936.32	104.66	4934.71	121.00	4930.88	136.81	4922.05
153.87	1917.16	171.26	4914.38	204.72	4911.72	220.14	4910.73
253.28	1908.11	303.47	4906.30	319.22	4904.60	334.97	4901.48
350.39	1899.41	367.12	4899.25	401.24	4896.17	417.97	4893.94
450.78	1892.30	466.53	4890.39	482.61	4888.23	516.07	4885.08
531.49	1882.48	546.91	4878.78	565.28	4876.55	597.43	4873.76
614.17	1872.05	629.59	4869.69	645.66	4867.43	662.72	4868.38
679.45	1869.86	694.87	4872.28	710.29	4874.35	729.32	4878.68
745.40	1860.58	778.86	4879.73	793.63	4878.16	811.67	4872.91
827.42	1868.41	844.48	4862.24	860.88	4857.19	877.29	4854.01
892.38	1852.79	908.78	4854.47	926.17	4857.52	942.25	4859.62
975.71	1861.06	992.11	4856.89	1008.52	4849.64	1024.92	4846.50
1073.48	1844.50	1090.87	4842.10	1107.93	4840.23	1124.33	4838.16
1139.09	1836.69	1154.84	4836.79	1172.23	4838.13	1207.01	4839.47
1239.49	1841.67	1255.89	4843.08	1270.65	4844.43	1286.73	4845.21
1384.17	1842.89	1449.79	4841.05	1500.31	4838.10	1630.56	4836.29
1712.91	1835.31	1745.06	4837.28	1780.49	4839.54	1828.39	4841.51
1861.53	1843.34	1878.26	4843.97	1910.08	4844.92	2091.84	4844.69
2157.78	1841.57	2287.70	4841.34	2433.70	4842.30	2565.59	4842.26
2732.58	1843.41	2911.05	4845.21	3092.15	4847.32	3271.94	4848.59
3468.46	1851.09	3667.61	4852.83	3880.20	4854.76	4076.07	4857.00
4271.93	1859.36	4470.75	4861.85	4684.00	4864.34	4862.47	4866.64
5043.25	1869.04	5240.42	4871.73	5421.52	4874.12	5602.62	4876.58
5798.81	1879.17	5978.60	4881.80	6177.09	4884.59	6357.21	4887.41
19726.46	5119.10	0.00	0.00	0.00	0.00	0.00	0.00
12984.09	4995.97	14771.47	5027.86	16411.21	5057.58	18051.61	5087.86
19726.46	5118.10						

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INDIAN OCEAN

101

0 00	5055 05	3 28	5055 05	6 56	5055 05	9 84	5055 71
13 12	5055 38	19 08	5055 05	22 97	5055 05	29 53	5054 73
32 81	5054 40	36 09	5054 07	39 70	5053 74	42 98	5053 41
46 26	5053 41	49 54	5053 41	52 82	5053 41	56 10	5055 38
59 38	5053 41	62 66	5053 41	65 94	5053 41	69 22	5053 41
72 51	5053 41	75 79	5053 74	79 07	5053 41	82 35	5053 41
85 63	5053 74	88 91	5053 41	92 19	5053 41	95 47	5053 74
98 75	5053 74	102 03	5054 07	105 31	5053 74	108 59	5053 74
111 88	5053 74	118 44	5053 74	121 72	5053 74	125 33	5053 74
128 61	5053 41	135 17	5053 41	138 45	5053 41	141 73	5053 41
145 01	5053 41	148 29	5053 09	151 57	5053 09	154 85	5052 76
158 13	5052 76	161 42	5052 43	164 70	5052 43	181 10	5052 10
197 50	5052 10	214 24	5051 45	230 64	5050 13	247 04	5048 82
263 45	5048 50	279 85	5048 82	296 26	5048 82	312 99	5048 82
329 39	5049 15	345 80	5049 48	362 20	5049 48	378 60	5049 48
395 01	5048 50	411 74	5047 51	428 14	5045 87	444 55	5045 21
460 95	5043 57	477 36	5039 64	493 76	5019 30	510 16	5011 75
526 57	5001 25	542 97	4991 08	559 38	4980 91	576 11	4978 61
592 51	4971 07	608 92	4968 44	625 32	4963 20	641 72	4959 59
658 13	4955 32	740 15	4946 79	822 17	4940 88	903 86	4936 29
985 30	4930 06	1067 90	4927 11	1149 92	4927 43	1231 61	4923 82
1313 63	4922 18	1395 65	4921 53	1477 34	4922 84	1559 36	4926 45
1641 06	4923 50	1723 08	4930 06	1804 77	4932 03	1886 46	4921 20
1968 48	4915 95	2050 17	4915 95	2138 42	4918 25	2213 56	4918 90
2296 56	4920 21	2377 27	4920 54	2458 96	4921 53	2540 65	4935 96
2624 64	4935 96	2704 04	4930 71	2785 73	4925 79	2870 70	4917 59
2952 72	4916 93	3030 80	4913 32	3112 49	4911 36	3194 19	4909 72
3275 55	4908 73	3357 24	4908 08	3438 93	4905 78	3520 63	4905 45
3608 88	4906 11	3683 68	4904 47	3765 05	4902 83	3846 74	4902 83
3930 96	4902 17	4009 79	4902 83	4091 49	4904 47	4172 85	4905 13
4254 21	4903 81	4335 91	4903 81	4417 27	4903 81	4501 91	4908 08
4593 12	4906 44	4661 69	4905 78	4743 05	4903 48	4824 42	4900 53
4906 11	4898 89	4987 47	4898 89	5068 84	4899 55	5150 20	4899 88
5240 28	4898 89	5312 93	4897 25	5394 29	4894 95	5475 66	4895 94
5560 30	4895 61	5638 05	4895 28	5719 42	4895 94	5800 78	4894 30
5882 14	4894 95	5963 51	4895 28	6044 55	4895 28	6125 91	4895 94
6207 27	4895 94	6288 31	4896 58	6369 67	4897 25	6453 99	4897 91
6532 07	4898 56						

TABLE (XVI). Numerical values of sound speeds (in feet/sec) for SIMAS profiles

ATLANTIC OCEAN

A01

0 00	1965 95	108 30	1967 75	119 99	1981 95	699 99	1953 91
999 99	1945 94	1240 98	1939 93	1499 98	1935 93	1749 98	1931 93
1999 98	1929 93	2249 97	1929 93	2499 97	1930 95	2749 97	1931 93
2999 96	1933 93	3249 96	1936 95	3499 96	1939 93	3999 95	1945 94
4999 95	1942 95	4999 94	1936 95	5999 93	1928 94	6999 91	1926 94
8999 89	1948 96	11999 85	1994 95	14999 82	5043 93	17401 20	5083 93

A02

0 00	1965 95	119 99	1961 95	699 99	1953 94	999 99	1915 94
1249 98	1939 93	1499 98	1935 93	1749 98	1931 93	1999 98	1929 93
2249 97	1929 93	2499 97	1930 95	2749 97	1931 93	2999 96	1933 93
3249 96	1936 95	3499 96	1939 93	3999 95	1945 94	4499 95	1942 95
4999 94	1936 95	5999 93	1928 94	6999 91	1926 94	8999 89	1918 96
11999 85	1994 95	14999 82	5043 93	17718 28	5089 24		

A03

0 00	5007 00	65 90	5008 10	200 00	5002 00	250 00	1996 00
500 00	4982 00	750 00	4970 00	1000 00	4960 00	1250 00	1952 00
1500 00	4947 00	1750 00	4942 00	2000 00	4939 00	2250 00	1936 00
2500 00	4933 00	2750 00	4930 00	3000 00	4928 00	3250 00	1926 00
3500 00	4924 00	4000 00	4920 00	4500 00	4917 00	5000 00	1915 00
6000 00	4918 00	7081 80	4926 70				

A04

0 00	5034 70	24 60	5035 90	95 50	5008 30	209 00	1988 50
498 10	4986 70	752 30	4988 90	987 30	4991 80	1000 00	1982 00
1250 00	4994 00	1500 00	4992 00	1750 00	4985 00	2000 00	1973 00
2250 00	4958 00	2500 00	4940 00	2750 00	4923 00	3000 00	1909 00
3250 00	4900 00	3500 00	4893 00	4000 00	4888 00	4500 00	1891 00
5000 00	4896 00	6000 00	4808 00	7000 00	4921 00	9000 00	1949 00
12000 00	4995 00	15000 00	5044 00	18534 60	5102 90		

ATLANTIC OCEAN

A05

0 00	5059 50	36 10	5000 10	196 90	5021 20	344 50	5001 90
492 10	4998 00	738 20	4997 40	1000 00	4999 00	1200 80	5000 30
1250 00	5000 00	1500 00	4998 00	1750 00	4994 00	2000 00	4985 00
2250 00	4970 00	2500 00	4953 00	2750 00	4937 00	3000 00	4922 00
3250 00	4911 00	3500 00	4902 00	4000 00	4892 00	4500 00	4891 00
5000 00	4896 00	6000 00	4908 00	7000 00	4921 00	9000 00	4949 00
12000 00	4995 00	15000 00	5044 00	18671 60	5105 20		

21

A06

0 00	5056 90	88 60	5059 10	164 00	5032 50	344 50	5003 30
492 10	4998 50	738 20	4997 90	1000 00	4999 00	1200 80	4999 90
1250 00	5000 00	1500 00	4998 00	1750 00	4994 00	2000 00	4985 00
2250 00	4970 00	2500 00	4953 00	2750 00	4937 00	3000 00	4922 00
3250 00	4911 00	3500 00	4902 00	4000 00	4892 00	4500 00	4891 00
5000 00	4898 00	6000 00	4908 00	7000 00	4921 00	9000 00	4949 00
12000 00	4995 00	15000 00	5044 00	18671 90	5105 20		

21

PACIFIC OCEAN

P01

0 00	4951 84	78 71	4952 14	187 01	4896 33	295 30	1888 75
492 09	4872 64	748 09	4866 84	1000 68	4856 93	1249 98	1847 94
1499 98	4843 94	1749 98	4841 93	1999 98	4840 95	2249 97	4841 93
2499 97	4843 94	2749 87	4846 95	2999 96	4848 96	3249 96	4850 93
3499 96	4852 93	3999 95	4857 95	4499 95	4862 93	4999 94	4868 94
5999 93	4882 95	6999 91	4898 96	8999 89	4929 93	11999 85	4978 94
14999 82	5030 94	17893 97	5083 04				

P02

0 00	5014 93	78 71	5015 32	89 99	5015 13	200 00	1957 95
300 00	4942 95	499 99	4933 93	999 99	4917 95	1249 98	1904 93
1499 98	4889 93	1749 98	4875 93	1999 98	4865 95	2249 97	1858 93
2499 97	4854 93	2749 97	4853 95	2999 96	4855 95	3249 96	1856 93
3499 96	4858 93	3999 95	4863 95	4499 95	4868 94	4999 94	1873 96
5999 93	4884 95	6999 91	4898 96	8999 89	4929 93	11999 85	1978 94
14999 82	5030 94	17999 77	5084 95	19831 15	5119 75		

P03

0 00	4994 43	98 39	4988 03	196 91	4973 82	295 30	1967 85
502 00	4905 23	748 09	4962 34	994 08	4956 04	999 98	1955 94
1249 98	4940 95	1499 98	4923 96	1749 98	4905 95	1999 98	1888 95
2249 97	4877 93	2499 97	4871 95	2749 97	4866 93	2999 96	1864 93
3249 96	4862 93	3499 96	4861 95	3999 95	4862 93	4499 95	1866 93
4999 94	4871 95	5999 93	4883 93	6999 91	4898 96	8999 89	1929 93
11999 85	4978 94	14999 82	5030 94	17999 77	5084 95	19846 05	5120 05

P04

0 00	4974 94	59 09	4975 92	1249 98	4969 95	1499 98	1955 94
1749 98	4938 95	1999 98	4919 95	2249 97	4903 94	2499 97	1890 95
2749 97	4880 95	2999 96	4873 96	3249 96	4868 94	3499 98	1865 95
3999 95	4864 93	4499 95	4866 93	4999 94	4871 95	5999 93	1883 93
6999 91	4898 96	8999 89	4929 93	11999 85	4978 94	14999 82	5030 94
18584 39	5095 44						

PACIFIC OCEAN

P05

0.00	1938.95	19.68	1939.25	199.99	1919.95	719.99	1902.93
899.99	1886.95	1219.98	1868.94	1499.98	1858.93	1719.98	1852.93
1999.98	1849.94	2219.97	1817.94	2499.97	1847.94	2719.97	1847.94
2999.96	1818.96	3219.96	1819.94	3499.96	1851.94	3999.95	1857.95
4499.95	1863.95	4999.94	1869.95	5999.93	1883.93	6999.91	1898.96
8999.89	1929.93	11999.85	1878.94	14999.82	5030.94	18510.16	5094.62

P06

0.00	1927.73	8.89	1927.93	205.71	1930.02	101.90	1924.55
534.08	1905.25	718.03	1880.13	992.80	1865.33	999.99	1864.93
1249.98	1859.95	1499.98	1855.95	1719.98	1853.95	1999.98	1852.93
2249.97	1851.94	2499.97	1851.94	2719.97	1853.95	2999.96	1854.93
3249.96	1857.95	3499.96	1859.95	3999.95	1863.95	4499.95	1867.95
4999.94	1872.94	5999.93	1883.93	6999.91	1898.96	8999.89	1929.93
11999.85	1878.94	14999.82	5030.94	16324.00	5054.73		

P07

0.00	1958.44	71.51	1959.65	204.69	1981.75	101.90	1964.05
533.49	1930.95	729.98	1902.93	993.20	1890.23	999.99	1889.93
1249.98	1873.96	1499.98	1863.95	1719.98	1853.95	1999.98	1849.94
2249.97	1849.94	2499.97	1849.94	2719.97	1852.93	2999.96	1854.93
3249.96	1856.93	3499.96	1859.95	3999.95	1863.95	4499.95	1867.95
4999.94	1872.94	5999.93	1884.95	6999.91	1898.96	8999.89	1929.93
11999.85	1878.94	14999.82	5030.94	17278.28	5071.95		

P08

0.00	1972.94	2.00	1972.94	1499.98	1967.95	1719.98	1951.94
1999.98	1933.93	2219.97	1915.95	2499.97	1897.94	2719.97	1883.93
2999.96	1873.96	3219.96	1868.94	3499.96	1865.95	3999.95	1864.93
4499.95	1868.93	4999.94	1871.95	5999.93	1883.93	6999.91	1898.96
8999.89	1929.93	11999.85	1978.94	14999.82	5030.94	17999.77	5084.95
19800.94	5120.34						

PACIFIC OCEAN

P09

0.00	1972.94	1499.98	1967.95	1749.98	1951.94	1999.98	1933.93
2249.97	1915.95	2499.97	1897.94	2749.97	1883.93	2999.98	1873.96
3249.96	1868.94	3499.96	1865.95	3999.95	1864.93	4499.95	1866.93
4999.94	1871.95	5999.93	1883.93	6999.91	1898.98	8999.89	1929.93
11999.85	1978.94	14999.82	5030.94	17999.77	5084.95	19223.25	5108.14

2

P10

0.00	1972.94	70.90	1973.04	1499.98	1967.95	1749.98	1951.94
1999.98	1933.93	2249.97	1915.95	2499.97	1897.94	2749.97	1883.93
2999.96	1873.96	3249.96	1868.94	3499.96	1865.95	3999.95	1864.93
4499.95	1866.93	4999.94	1871.95	5999.93	1883.93	6999.91	1898.98
8999.89	1929.93	11999.85	1978.94	14999.82	5030.94	17999.77	5084.95
19223.25	5108.14						

2

101

		LAT	04 19 N	LON 53	02 E	MARCH	
00	5047.40	82.40	5045.90	164.70	5045.10	329.40	5041.30
493.80	5019.00	740.20	4941.20	1000.00	4928.00	1150.00	4920.40
1250.00	4922.00	1500.00	4921.00	1750.00	4920.00	2000.00	4920.00
2250.00	4919.00	2500.00	4917.00	2750.00	4915.00	3000.00	4913.00
3250.00	4911.00	3500.00	4910.00	4000.00	4906.00	4500.00	4903.00
5000.00	4902.00	6000.00	4904.00	7000.00	4908.00	9000.00	4931.00
2000.00	4978.00	15000.00	5025.00	17550.00	5072.60		

TABLE (XVII). Numerical values of sound speeds (in feet/sec) for ICAPS profiles

ATLANTIC OCEAN

A01

0 00	137.79	1956.63	337.92	4959.91	383.85	1950.63
433.07	511.80	1942.52	567.58	4939.90	652.88	1910.23
708.65	725.06	1939.25	741.48	4938.26	800.52	1941.54
971.12	997.36	1936.95	1049.86	4934.00	1079.38	1932.36
1095.79	1377.94	1933.67	1525.57	4932.68	1988.48	1932.36
2624.64	3280.80	1942.20	3936.96	4943.18	4921.20	1929.07
6561.60	8202.00	4939.57	9842.40	4961.55	13123.20	5013.72
16404.00	17125.77	5084.91				

A02

0 00	154.20	1954.99	232.94	4954.01	311.68	1954.34
406.82	439.63	1952.04	469.15	4946.79	567.58	1941.21
688.97	754.58	1943.18	853.01	4939.25	1115.47	1934.32
1328.72	1525.57	1933.67	1968.48	4933.34	2624.64	1938.59
3280.80	3936.96	1943.51	4921.20	4929.40	6561.60	1924.15
8202.00	9842.40	1961.88	13123.20	5013.72	16404.00	5071.79
17913.17						

A03

0 00	22.97	5008.47	65.62	5009.13	88.58	5003.55
108.27	154.20	4974.68	200.13	4964.83	246.06	4960.24
436.35	675.84	4952.37	997.36	4944.18	1643.68	4933.34
2490.13	3280.80	4905.13	3936.96	4902.83	4921.20	4902.83
6561.60	8202.00	4939.57	9842.40	4961.88	13123.20	5011.75
13418.47						

A04

0 00	36.09	5036.68	52.49	5029.14	72.18	5022.91
95.14	121.30	5002.89	147.64	4996.98	206.69	4991.08
202.15	948.15	4993.05	1115.47	4986.00	1210.62	4997.64
1361.53	1706.02	4978.94	1994.73	4965.82	2526.22	4935.30
3280.80	3936.96	4888.39	4921.20	4895.61	6561.60	4916.61
8202.00	9842.40	4963.85	13123.20	5012.08	16404.00	5068.84
17716.32						

ATLANTIC OCEAN

A05

0.00	5059.65	65.62	5059.65	82.02	5059.32	104.99	5057.02
203.41	5020.28	249.34	5012.73	328.08	5004.53	426.50	5000.50
708.65	4999.61	935.03	5000.27	1089.23	5000.59	1230.30	5001.91
1312.32	5002.23	1482.92	5001.91	1706.02	5000.59	1902.80	4993.38
2099.71	4982.55	2230.94	4977.96	2378.58	4958.11	2493.41	4961.88
3280.80	4914.96	3036.96	4899.55	4921.20	4901.52	6561.00	4919.23
8202.00	4940.88	9842.40	4962.87	13123.20	5012.73	16404.00	5069.16
17519.47	5088.85						

#

A06

0.00	5057.35	59.05	5058.60	88.58	5060.30	164.04	5034.39
252.62	5012.73	344.48	5005.52	492.12	5000.59	1640.40	5002.56
1843.81	4998.30	2099.71	4985.50	2624.64	4953.68	3280.80	4914.64
3036.96	4899.22	4921.20	4901.52	6561.60	4919.23	8202.00	4940.55
9842.40	4962.87	13123.20	5012.73	16404.00	5069.16	17519.47	5088.85

#

PACIFIC OCEAN

P01

0 00	1954.34	108.27	4950.40	137.79	4919.23	157.48	4905.13
255.90	4899.22	285.43	4894.95	324.80	4888.72	374.01	4878.88
423.22	4871.33	521.65	4881.17	659.44	4877.89	787.39	4871.00
974.40	4863.79	1200.77	4853.29	1318.88	4849.68	1515.73	4845.09
1908.48	4842.79	2624.64	4846.07	3280.80	4851.32	3936.96	4857.55
4921.20	4889.04	6581.60	4891.34	8202.00	4916.28	9842.40	4942.52
13123.20	4998.95	16404.00	5058.34	17749.13	5082.94		

P02

0 00	5005.19	127.95	5005.52	157.48	4998.95	198.85	4961.88
265.74	4936.95	344.48	4914.64	442.91	4907.75	511.80	4907.75
629.91	4913.32	757.86	4909.72	984.24	4901.84	1151.56	4895.94
1318.88	4888.72	1515.73	4878.22	1968.48	4864.77	2824.64	4861.49
3280.80	4863.13	3936.96	4864.44	4921.20	4873.96	6561.60	4892.33
8202.00	4916.28	9842.40	4942.85	13123.20	4998.95	16404.00	5058.34
17978.79	5087.54						

P03

0 00	4999.61	39.37	4996.66	68.00	4995.34	78.74	4994.69
137.79	4986.82	196.85	4979.27	383.85	4971.72	561.02	4970.41
748.02	4967.13	1053.14	4958.27	1309.04	4945.80	1515.73	4932.03
1968.48	4893.97	2624.64	4864.44	3280.80	4859.52	3936.96	4861.49
4921.20	4872.32	6561.60	4891.34	8202.00	4915.95	9842.40	4942.52
13123.20	4998.63	16404.00	5057.68	19192.68	5108.53		

P04

0 00	4945.15	78.74	4945.48	167.32	4943.51	285.43	4937.93
413.38	4928.75	600.39	4920.21	718.50	4910.37	830.60	4900.53
1141.72	4880.19	1318.88	4863.79	1515.73	4856.24	1968.48	4845.09
2624.64	4844.43	3280.80	4849.02	3936.96	4855.25	4921.20	4867.07
6561.60	4889.70	8202.00	4914.64	9842.40	4941.87	13123.20	4998.63
16404.00	5057.02	17978.79	5085.57				

PACIFIC OCEAN

P05

0 00	1953.35	344.48	1919.74	590.54	1912.85	767.71	1925.48
954.71	1913.00	1181.09	1897.25	1318.88	1888.06	1515.73	1877.24
1968.48	1858.54	2624.64	1853.29	3280.80	1855.91	3936.96	1860.18
1921.20	1869.69	6561.60	1890.69	8202.00	1914.96	9842.40	1941.54
13123.20	1998.30	16104.00	5057.35	17978.79	5085.89		

P06

0 00	1920.10	206.69	1932.03	272.31	1931.04	334.64	1924.81
370.73	1926.15	403.54	1927.43	469.15	1912.01	534.77	1909.06
600.39	1901.19	666.00	1890.69	731.62	1884.78	793.95	1880.85
862.85	1875.93	928.47	1873.30	990.80	1870.88	1059.70	1868.05
1122.03	1865.10	1190.93	1863.79	1253.27	1862.14	1318.88	1860.83
1387.78	1859.19	1450.11	1857.88	1502.61	1857.22	1968.48	1853.61
2624.64	1855.25	3280.80	1858.86	3936.96	1863.79	4921.20	1873.30
6561.60	1892.66	8202.00	1916.61	9842.40	1942.85	13123.20	1999.28
16174.34	5052.13						

P07

0 00	1949.41	272.31	1953.02	318.24	1955.98	367.45	1958.93
103.54	1955.05	465.87	1933.01	534.77	1923.82	600.39	1905.78
666.00	1899.22	731.62	1896.92	797.23	1894.63	862.85	1893.31
925.19	1889.38	994.08	1884.45	1056.42	1881.83	1122.03	1879.21
1190.93	1876.58	1256.55	1875.27	1322.16	1872.64	1384.50	1868.38
1499.33	1862.47	1968.48	1857.88	2624.64	1858.54	3280.80	1860.83
3936.96	1865.43	4921.20	1874.29	6561.60	1892.98	8202.00	1916.93
9842.40	1942.85	13123.20	4999.28	16797.70	5063.26		

P08

0 00	1983.54	30.09	1984.19	55.77	1980.91	72.18	1977.30
137.79	1972.71	200.13	1966.15	469.15	1967.46	531.40	1967.46
793.95	1960.57	925.19	1955.32	990.80	1955.32	1059.70	1948.76
1125.31	1934.32	1322.16	1920.21	1502.61	1912.34	1968.48	1881.50
2624.64	1849.35	3280.80	1845.09	3936.96	1851.97	4921.20	1864.11
6561.60	1889.38	8202.00	1914.96	9842.40	1942.20	13123.20	1998.63
16104.00	5057.35	17978.79	5086.55				

PACIFIC OCEAN

P09

0.00	4979.27	13.12	4979.60	36.09	4976.97	88.90	4976.64
101.70	4973.36	141.07	4967.13	203.41	4964.18	400.26	4951.05
531.49	4927.11	597.11	4922.51	659.44	4914.31	725.06	4910.37
793.95	4904.47	859.57	4899.22	921.90	4896.59	990.80	4879.21
1059.70	4837.21	1253.27	4831.96	1318.88	4837.54	1450.11	4836.88
1499.33	4850.34	1968.48	4840.82	2624.64	4843.77	3280.80	4850.00
3936.96	4856.57	4921.20	4868.71	6561.60	4891.34	8202.00	4916.28
9842.40	4942.85	13123.20	4999.28	16404.00	5058.01	17978.79	5087.21

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P10

0.00	4940.55	68.90	4940.55	104.99	4934.98	137.79	4922.18
203.41	4912.01	400.26	4897.58	531.49	4883.14	597.11	4873.96
662.72	4867.07	695.53	4872.97	728.34	4878.88	761.15	4880.85
793.95	4878.88	859.57	4857.80	892.38	4852.96	925.19	4857.55
990.80	4857.55	1122.03	4839.18	1253.27	4842.79	1318.88	4844.10
1384.50	4843.77	1450.11	4842.13	1499.33	4838.85	1968.48	4835.24
2624.64	4838.52	3280.80	4842.79	3936.96	4851.64	4921.20	4864.44
6561.60	4888.72	8202.00	4914.64	9842.40	4941.87	13123.20	4998.30
16404.00	5058.01	17978.79	5087.21				

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0 00	5056 70	157 48	5054 10	246 06	5050 79	393 70	5019 81
459 31	5044 89	475 72	5041 83	492 12	5026 84	524 93	5004 20
577 42	4981 89	626 63	4966 80	659 44	4958 93	823 48	4943 51
1394 34	4922 84	1476 36	4919 23	1558 38	4927 11	1640 10	4924 48
1722 42	4931 04	1804 41	4932 36	1886 46	4925 14	1968 48	4916 28
2050 50	4916 61	2139 08	4919 23	2214 54	4919 23	2296 56	4920 54
2378 58	4919 56	2460 80	4922 18	2539 34	4936 29	2624 64	4936 62
2785 40	4927 43	3280 80	4920 87	3936 96	4914 64	4921 20	4905 78
6561 60	4907 09	8202 00	4923 17	9842 40	4946 46	13123 20	4998 63
16404 00	5054 40						

2

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PART (II)

"EVALUATION OF THE SIMAS AND ICAPS
ENVIRONMENTAL DATA BASE, DATA HANDLING PROCEDURES AND MERGE METHODOLOGY"

I. INTRODUCTION

The SIMAS (Sonar In-situ Mode Assessment System) and ICAPS (Integrated Command ASW Prediction System) environmental data bases are both being developed and available to APP. Each system has been designed and developed by different Navy activities and address different system applications. The common denominator between SIMAS and ICAPS is that both utilize an environmental data base of oceanographic parameters, both rely on an in-situ XBT (expendable bathythermograph) as input, and both have been developed as "on-board" prediction systems.

As requested by the APP Data Base Manager, NORDA 321 has been tasked to identify, as much as possible the reason(s) for the "significant" differences in the final computed sound speed profiles from previous SIMAS and ICAPS comparisons. In this portion of the report, the test comparisons and evaluations designed to identify the specific cause(s) or reason(s) for differences between the SIMAS ICAPS computed sound speed profiles are discussed.

II. BACKGROUND

In FY-79, a study ("comparison of the ICAPS and SIMAS Historical Environmental Data Base", by E. Hashimoto, dated 28 September 1979), was conducted to compare the SIMAS and ICAPS computed sound speed profiles at selected geographical locations, for a particular season or month. From this point, that report will herein be referred to as the **NORDA TM No. 66**. The purpose of that study was to present and compare any "significant" differences found between the SIMAS and ICAPS final computed sound speed profiles. The evaluation and cause for differences found specifically was not to be addressed in that study.

Since "significant" differences were found in the final computed vertical sound speed profiles, NAVSEA 06H4 and NORDA 534 (during an APP sponsored meeting on 21 Feb 1980) tasked NORDA 321 to conduct follow-on studies to evaluate the ability for SIMAS and ICAPS to reproduce real or assumed oceanography, and identify the cause(s) for previous differences. Part I of this report presented the ability of SIMAS and ICAPS to reproduce the assumed oceanography by using input temperature data from very accurate CTD (continuous-temperature-depth) or STD (salinity-temperature-depth) recorders.

The identification of possible cause(s) or reason(s) for previous differences found between the SIMAS and ICAPS computed vertical sound speed profiles will now be presented and discussed.

III. APPROACH USED IN THIS STUDY

In order for the author to properly determine or reasonably explain the "probable" cause(s) associated with the environmentally "significant" differences found in the APP FY-79 Task #2 Report, a very large effort was placed towards understanding several key areas:

- The review of all related documentation considered relevant to the profile generation process for each system (i.e., technical reports, software coding, etc.).
- Personal conversations with Cognizant individuals at the Naval Underwater Systems Command (NUSC - E. Podeszwa, Code 3351) and the Naval Oceanographic Office (NOO - P. Moresdorf, Code 9200).
- The identification of the sources for the oceanographic data used in the development of each historical base.
- The identification of the analysis procedure(s) used in the selection of historical sound speed profiles.
- The identification of the spatial and temporal resolutions used in each system.
- The identification and influences of the external and internal methodology employed by each system regarding the handling of in-situ XBT data
- The identification and influence of the selection criteria and retrieval procedures for the proper historical sound speed profile.
- The identification and influence of the merging techniques employed when combining the in-situ XBT with the historical deep profile.
- The identification and influence of the different sound speed equations.

The author had requested assistance from the Ocean Data Systems, Inc. Rockville, MD (Mr. J. Locklin and Mr. B. W. Scaife). This request was approved by the APP Data Base Manager. ODSI was requested to provide supportive in-depth investigations as required.

IV. THE STUDY

This section will describe the specific work conducted and material considered to properly address the issues presented in section III. In order to assist the reader in understanding the various investigations conducted, this section has been divided into several categories.

- differences in philosophies
- differences in Input BT data handling procedures
- differences in the historical environmental data base composition
- differences in the merge methodology of BT to historical
- differences in the application of salinity
- differences in the sound speed equations
- differences in the software program coding errors

A. Philosophies

There appears to be fundamental differences between ICAPS and SIMAS in their basic conceptual philosophies:

SIMAS = The entire SIMAS philosophy rests on the integrity of the historical sound speed profiles in the environmental data base.

ICAPS = The entire ICAPS philosophy rests on the integrity of the *in-situ* BT.

B. INPUT BT DATA HANDLING PROCEDURES

Both SIMAS and ICAPS utilize, as an initial in-situ input, a BT (bathythermograph) trace. Each system attempts to capture the salient features in the temperature profile by inputting selected pairs of depth and temperature along the trace. Although the philosophy to utilize an in-situ BT observation are similar, each system employs a different subjective procedure which determines what pairs of depths and temperatures will be used as input.

The following are brief descriptions on the BT data handling procedures employed by each system:

- SIMAS

Certain "significant" points of inflection along each BT profile are marked or noted by the SIMAS operator. These certain "significant" points of inflection are selected according to how well they (the observed data points) group themselves in a more or less a linear fashion (personal conversation with G. Brown, NUSC). The determination in the degree of linearity of the data points along a BT trace is accomplished by using a straight edge (i.e., ruler) to line up any data points which fall along the straight edge. While proceeding down the trace, if the linear distribution and direction of the observed data points should change, the straight edge is then reoriented in a new, different direction (personal conversation with G. Brown, NUSC). An example of this process is illustrated on figure 1. According to the personnel who have designed the SIMAS system, they prefer that the maximum number of inflection points be held to 7 points per input BT trace. As a result, all data points describing a given BT may not be inputted into SIMAS (e.g., if profile has 12 inflection points and a maximum of 7 are selected, your significant points could be omitted).

- ICAPS

Certain "significant" points of inflection along each BT profile are marked or noted by the ICAPS operator. The first depth-temperature pair inputted into ICAPS is the surface and the surface temperature. The remaining pairs of depth-temperature are selected by the operator according to inflection which exist in each BT trace where sudden changes in trend (positive to negative, negative to positive) or gradient (numerical value per unit depth) occur. The numerical values of depth-temperature must actually occur and be contained on the BT trace. All values inputted are observed values.

C. Historical Environmental Data Base Composition

Both environmental data bases have been developed using the ocean station data observations at the National Oceanographic Data Center (NODC).

Each system utilizes an environmental data base in two modes: with an in-situ XBT, or without an in-situ XBT (pure historical). Briefly presented below are the parameters on file and available in SIMAS and ICAPS:

	<u>SIMAS</u>	<u>ICAPS</u>	<u>COMMENTS</u>
<u>Temperature</u>	NO	YES	ICAPS Temperature profiles are surface to bottom.
a) monthly	NO	NO	
b) seasonally averaged	NO	YES	ICAPS Temperature profiles are seasonal surface to bottom.
c) annual	NO	NO	
<u>Salinity</u>	NO	YES	SIMAS uses a constant salinity 35 ppt surface to the bottom.
a) monthly	NO	NO	ICAPS salinity profiles are seasonal surface to bottom.
b) seasonally averaged	NO	YES	
<u>Density</u>	NO	NO	
a) monthly	NO	NO	
b) seasonally	NO	NO	
<u>Sound speed</u>	YES	NO	ICAPS computes all values of sound speed
a) monthly	YES	NO	
b) seasonally	NO	NO	SIMAS sound speed profiles are surface to bottom.

Bathymetry

In addition to sound speed, temperature and salinity, there is another parameter which is common to both SIMAS and ICAPS. This parameter is bathymetry (ocean bottom depth). Briefly described below are the characteristics and sources for the bathymetry used in each system:

o ICAPS (HEATON-NOO)

Automated, bathymetric depths recorded on the data files are those of the deepest identifiable bathymetric contour interval found in each 1/4-quadrangle (every 1/2° x 1/2° square or 30' x 30').

Source:

- North Atlantic and Mediterranean in Naval Oceanographic Office Special Publication #1304, 1975 (Confidential)
- North Pacific in Naval Oceanographic Office Special Publication #1301-2-3, 1973 (Confidential).
- North Indian Ocean in NMPCB Charts, Second Edition.

o SIMAS (Podeszwa - NUSC)

Manual point or area extraction off bathymetric contour charts.

Source:

- North Atlantic and Mediterranean in Naval Oceanographic Office Special Publication #1304, 1975 (Confidential)
- North Pacific in Naval Oceanographic Office Special Publication #1301-2-3, 1973 (Confidential).
- North Indian Ocean in NMPCB Charts, Second Edition.

D. MERGE METHODOLOGY

Each system computes sound speed as a final parameter. However, a basic difference exists in the manner in which SIMAS and ICAPS each merge to the In-situ BT observation. The basic difference is merging to a sound speed profile or merging to a temperature profile.

An outline description of the differences in the ICAPS and SIMAS methodology of generating sound speed profiles is illustrated below:

METHODOLOGICAL FEATURES OF SSP GENERATOR (ODSI)

ICAPS

Multiple water mass (up to 5) capability for each geographic area.

Historical data base contains for each water mass, temperature and salinity profiles (ZH_i , TH_i , SH_i), $i=1$, $NH \leq 45$.

Extend the Bathythermograph (BT) profile, (ZB_j , TB_j), $j=1$, NBT, with historical temperatures for corresponding water mass at depth below the last BT depth, and interpolate salinity values from historical profile.

Insert bathymetry and truncate SSP at bottom depth.

Utilize Wilson's equation to calculate SSP.

Calculate the layer depth.

SIMAS

A geographic area is represented by one water mass.

Historical data base contains for each water mass a sound speed profile (ZH_i , VH_i), $NH \leq 27$, and a representative near-surface salinity value, S .

Utilize Leroy's equation to calculate the SSP for BT profile with historical constant salinity. The BT profile may consist of up to 24 points.

Shift the BT SSP by the linearly interpolated velocity difference between historical SSP and BT SSP at 1000 ft. Next, extend below the BT SSP with unmodified historical SSP points.

Insert bathymetry and truncate SSP at bottom depth.

Adjust fathometer bathymetry and interpolate sound speed at adjusted bottom depth.

Calculate the layer depth.

Graphical presentations of the above outline description are given in the Logic Flow Diagrams of Appendix (A) and (B) for SIMAS and ICAPS, respectively.

- ICAPS = The numerical values of temperature from the In-situ BT observation are inputted into various sets of temperature criteria (as explained in Appendix (B)). After the in-situ BT profile has met certain established temperature criteria, it is *merged* with an analyzed seasonal *temperature* profile contained in the ICAPS environmental data base (see Appendix G). This merge temperature profile is then, inputted along with an analyzed seasonal salinity profile into Wilco's equation. A derived sound speed profile is then computed. At no time is the BT profile rejected or not used once it is inputted into the ICAPS system.
- SIMAS = The numerical values of temperature from the in-situ BT observation, along with a constant salinity profile (value of 35.00 parts per thousand), are both entered into Leroy's equation. A derived sound speed profile is then inputted into various sets of sound speed criteria (as explained in Appendix (A)). After the derived sound speed profile has met certain established sound speed criteria, it is *merged* with an analyzed monthly averaged *sound speed* profile contained in the SIMAS environmental data base. If the derived sound speed profiles does not meet the sound speed criteria, it is possible for that particular BT observation and the derived sound speed profile to be *rejected* and *not used* for failure to meet the criteria.

Upon rejection of an insitu XBT, a revised sound speed profile is computed. This revised sound speed profile is basically a modification of the SIMAS historical sound speed profile. According to investigations by Locklin and Scaife (ODSI), the historical SIMAS sound speed profile is revised as follows:

1. The value of the surface sound speed from the historical profile is used.

2. The value of the sound speed at the layer from the historical profile is used.
3. The value of the depth of the layer is revised: depth of the layer becomes the value of the second depth point off of the XBT trace. In other words, the new depth of the layer is the depth of the XBT layer.
4. Values of sound speed below the revised layer depth are those from the historical sound speed profile.

• *Differences caused by different merging techniques*

As stated above (and described in Appendix (B)) ICAPS does not reject the in-situ BT at any time. The values of temperature at the surface and and of temperature and depth at the boundary of the surface layer are inputted into ICAPS and maintained unaltered throughout ICAPS processing. SIMAS on the other hand will reject the entire BT if the sound speed criteria is not met. Upon rejection of a BT, the SIMAS system generates a revised sound speed profile for use. Below is a comparison of the differences in surface sound speeds and layer depths due to the different merging techniques when using identical BT as input. The major differences, as noted by an asterisk (*) are cases where SIMAS rejected the in-situ BT data and computed revised sound speed profiles. The sites (1C, 1F, 1F, etc. are test sites from Fig. 2 (taken from NORDA TM #66).

ICAPS AND SIMAS LAYER DEPTHS AND
SURFACE SOUND SPEEDS USING
IDENTICAL BT AND HISTORICAL PROFILES
(DIFFERENCES CAUSED BY MERGING)

Site	ICAPS		SIMAS	
	Layer Depth (ft)	Surface Sound Speed (ft/sec)	Layer Depth (ft)	Surface Sound Speed (ft/sec)
1C	469.2	4964	469.2	4943*
1F	357.6	4910	357.6	4881*
1F	65.6	4936	65.6	4944
2A	85.3	5046	85.3	5038*
2E	3281.0	4903	1220.5	4909
2E	72.2	4987	72.2	4982
2H	420.0	4912	52.5	4798*
3A	59.1	5059	59.1	5063

- o The historical sound speed profiles for both SIMAS and ICAPS were computed by the National Oceanographic Data Center (NODC) using Wilson's equation. Although ICAPS elects to continue using Wilson's equation during the conversion of the in-situ BT profiles to a sound speed profile, SIMAS switches to Leroy's equation for its conversion to a sound speed profile.

E. APPLICATION OF SALINITY

Each system employs different approaches in their application of salinity to the computation of sound speed. Obvious differences exist. For example, SIMAS uses a constant value of 35.00 parts per thousand (surface to the bottom) and ICAPS uses a seasonally averaged profile (surface to bottom). Although the applications of salinity differ, tests were conducted in an attempt to address the effects on the values of sound speed caused by the two different approaches. The effects on sound speed comparing constant salinity with variable and average salinity compared with 35.00 PPT salinity are presented in tables (I) and (II) respectively.

F. Sound Speed Equations

Common to both the SIMAS and ICAPS environmental data outputs is a vertical sound speed profile. The values of the SIMAS sound speeds profiles may differ from the ICAPS sound speed profiles because of the following:

Equation used to compute sound speeds

SIMAS

Lerou's Equation

ICAPS

Wilson's Equation

(Lerou) $\frac{dv}{ds} = 1.2 - 0.01(T-18)$ (equation applicable for salinities 30-40 PPT and temperatures 0-30°).

(Wilson) $\frac{dv}{ds} = 1.398 + 3.384 \times 10^{-3}(S-35) - 1.12 \times 10^{-2}T + 7.70 \times 10^{-5}P$
 $+ 7.77 \times 10^{-7}T^2 - 1.29 \times 10^{-7}P^2 + 3.16 \times 10^{-8}PT$
 $+ 1.58 \times 10^{-9}PT^2$

where v = sound speed (meters/sec)

s = salinity (PPT)

T = temperature (°C)

Table {IV} is taken from "An Examination of the Sensitivities of Acoustic Performance Prediction (APP) High Level Products to Variations in the Marine Environment", by P. Etter and D. R. Erwin, MAR Technical Report #243, April 1980, (SECRET). In the opinion of the author, based on previous work performed by Mr. Paul Etter (MAP Incorporated), the differences in the values of sound speed due to the differences between Lerou's and Wilson's equations are very small and not significant.

G. Software Coding Errors or Problem Areas

During their supportive investigation, ODSI had noticed some programming errors in the ICAPS and SIMAS computer codings. The specific errors uncovered for ICAPS and SIMAS have been documented by ODSI and are described in Appendix (C) and (D). Presented below from each system are a few selected program errors which are considered noteworthy:

Significant SIMAS Coding Errors:

- 1) Metric unit inputted data are converted at least twice into English units (i.e., 5 meters/second converted to 16.4 feet/second then reconverted ($16.4 \text{ m/s} \times 3.3$) to 52.6 feet/second).
- 2) Erroneous determination of the layer depth by execution of a DO Loop causing erroneous results, see appendix (C).

Significant ICAPS Coding Errors:

- 1) When the use of metric units are not specified, the historical bathymetry in meters is incorrectly multiplied by feet-to-meter conversion factor, see appendix (D).

Program "cautions" where potential errors can occur are contained on Appendix (E) and (F).

Coding errors described in Appendix C-F have been pointed out and presented to SIMAS (NUSC) and ICAPS (NOO) as this study was still taking place. The errors may have already been corrected by each system and if so, did not affect the results of this study.

H. Cause(s) of "significant" differences in the SIMAS and ICAPS sound speed profiles found in NORDA Technical Note #66.

In an attempt to determine the cause of the "significant" difference found in the sound speed profiles of NORDA TM No. 66 titled, "Comparison of the ICAPS and SIMAS Historical Environmental Data Bases", by F. Hashimoto, dated 28 September 1979, there were eight (8) sites randomly selected from that study for sampling. Each of the eight sites were evaluated. Evaluations by J. Locklin, B. Scaife (Ocean Data Systems, Inc.) were conducted to determine the degree of influence caused by the merge algorithm, the historical profile, the bathythermograph data or by the salinity. Table (III) below represents a matrix showing the relative significance of each factor at each site location.

Site	Merge Algorithm	Historical Profile	Bathythermograph Data	Salinity Variation	Location
1C*	Dominant		Slight		33.0°N, 172.5°W
1F*	Dominant		Slight		42.0°N, 143.5°W
1F	Dominant		Slight	Slight	same as above
2A*	Dominant	Moderate			13.0°N, 38.0°W
2E	Moderate	Dominant		Slight	47.5°N, 17.5°W
2E	Moderate	Dominant	Moderate		same as above
2H*	Dominant	Moderate			39.5°N, 68.5°W
3A*	Dominant				37.5°N, 17.5°E

TABLE III QUALITATIVE SIGNIFICANT CAUSE OF DIFFERENCES
IN SIMAS vs ICAPS COMPARISONS (ODSI)

* In these SIMAS generated results, the BT data is considered as probable errored data, so that the generated profile is the historical profile with a layer depth revision.

V. DISCUSSION

If one were to glance at both the ICAPS and SIMAS systems, one could conceivably conclude that both are extremely similar and do not differ significantly. This conclusion can be reached when the following are lightly considered:

- Both ICAPS and SIMAS have an environmental data base
- Both ICAPS and SIMAS utilize In-situ BT data as input
- Both compute a final sound speed profile
- Both are designed for "on-board" and "on-scene" prediction systems

Although both systems have and do all of the above, closer investigations, as presented in section IV and in the Appendixes, show that significant basic differences do exist and strongly indicate that the ICAPS and SIMAS systems are, indeed, not identical and do differ markedly in some areas.

The major areas where each system differ markedly are:

- in their philosophies, as described in section IV (A)
- in their handling of the In-situ BT data INPUT profile, as described in section IV (B)
- in the historical environmental data bases, as described in section IV (C)
- in their merge methodologies of BT to the historical profile, as described in section IV (D).

The areas where differences exist but do not appear to be significant are:

- in the application of salinity (between approximately 34.50 PPT to 36.00 PPT above 1000 feet).
- in the sound speed equations

The areas where immediate improvements can be made are:

- in bathymetry, through the use of a larger, more recent, higher resolution, automated data set of bathymetry. See Appendix (G) for description and details regarding resolution and coverage of SYNAPS by Mr. R. VanMyckhouse (NORDA).
- in the historical temperature, salinity and sound speed profiles through use of a larger (XBT, AXBT and BT) more recent (up to 1979), vertically stable, monthly temperature, seasonal salinity and

monthly sound speed data fields. Excerpts from the Pacific Sierra Research, Corp. (PSR) Report #922, "Evaluation of Standard Ocean Candidates", by J. Colborn, S. C. Daubin, Jr., E. Hashimoto, and F. J. Ryan, March 1980, describing the Generalized Digital Environmental Model by T. Davis (N00) are presented in Appendix (H).

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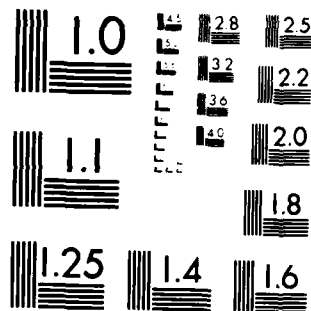
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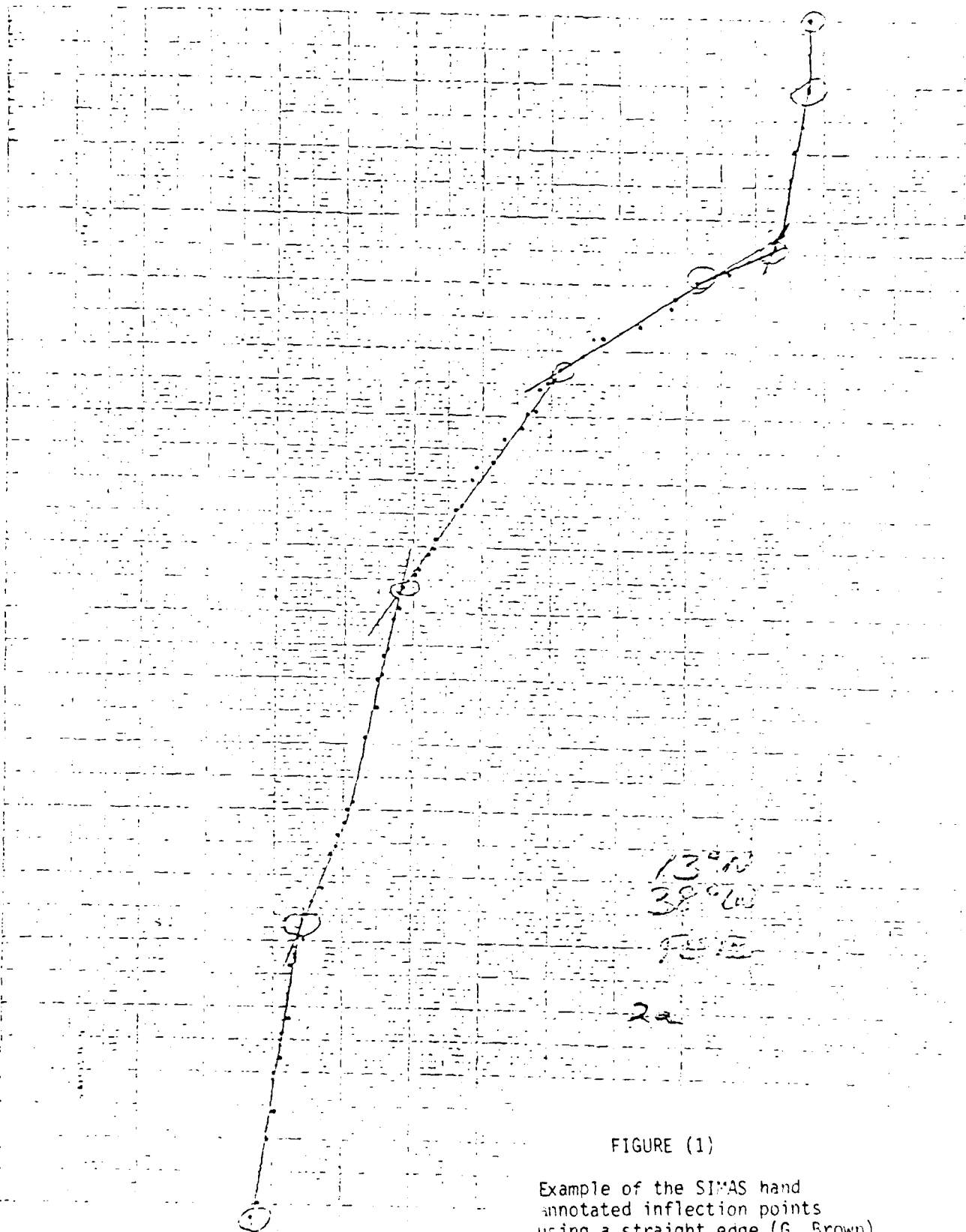


FIGURE (1)

Example of the SIMAS hand
annotated inflection points
using a straight edge (G. Brown)

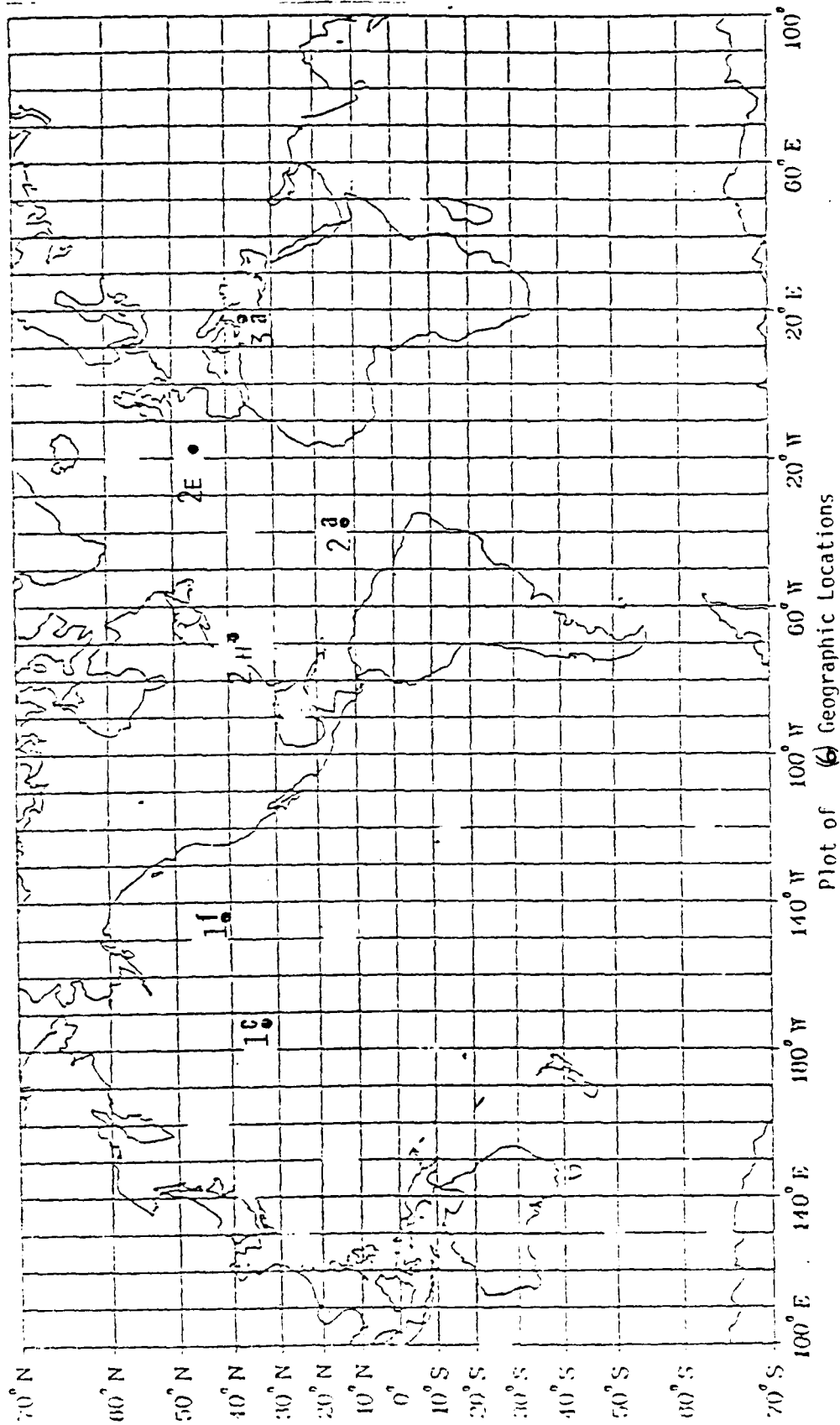


FIGURE 2

		SIMAS(S)		ICAPS(I)			
		Constant Salinity		Variable Salinity			
Site	Depth (ft)	Salinity (PPT)	Sound Speed (ft/sec)	Salinity (PPT)	Sound Speed (ft/sec)	ΔS (I-S)	ΔV (I-S)
1C	0.0	34.43	4964.8	34.41	4964.9	-0.02	0.1
	830.1		4948.5	34.33	4948.3	-0.10	-0.2
	1561.8		4911.4	34.07	4910.1	-0.36	-1.3
1F	0.0	33.66	4910.7	33.40	4910.0	-0.26	-0.7
	767.8		4885.9	33.98	4887.6	0.32	1.7
	1630.7		4852.9	33.97	4854.4	0.31	1.5
2A	0.0	36.34	5045.1	36.54	5046.1	0.20	1.0
	734.9		4948.6	36.19	4948.2	-0.15	-0.4
	1492.9		4912.8	35.33	4908.9	-1.01	-3.9
2H	0.0	33.72	4917.2	32.41	4912.2	-1.31	-5.0
	807.1		4920.3	34.76	4924.8	1.04	4.5
	1656.9		4873.4	34.91	4878.8	1.19	5.4

TABLE I: CONSTANT VERSUS VARIABLE SALINITY
EFFECTS ON SOUND SPEED PROFILES (ODSI)

Site	Salinity ($\bar{S}_{500}$) (PPT)	SIMAS Data Base Salinity(S) (PPT)	ΔS $\bar{S}_{500}-S$ (PPT)	Max ΔV est. (ft/sec)
1C	34.43	35.0	-.57	-2.62
1F	33.66	35.0	-1.34	-6.16
2A	36.34	35.0	1.34	6.16
2H	33.72	35.0	-1.28	-5.89

$\bar{S}_{500}$ = Value of ICAPS Salinity at
500 feet.

TABLE II: AVERAGE VERSUS 35 PPT
SALINITY EFFECTS ON SOUND SPEED (ODSI)

Table IV. The Maximum Difference in Sound Speed Among Three Frequently Used Sound Speed Equations (U) (THOMSON MARINE) - KITTAK

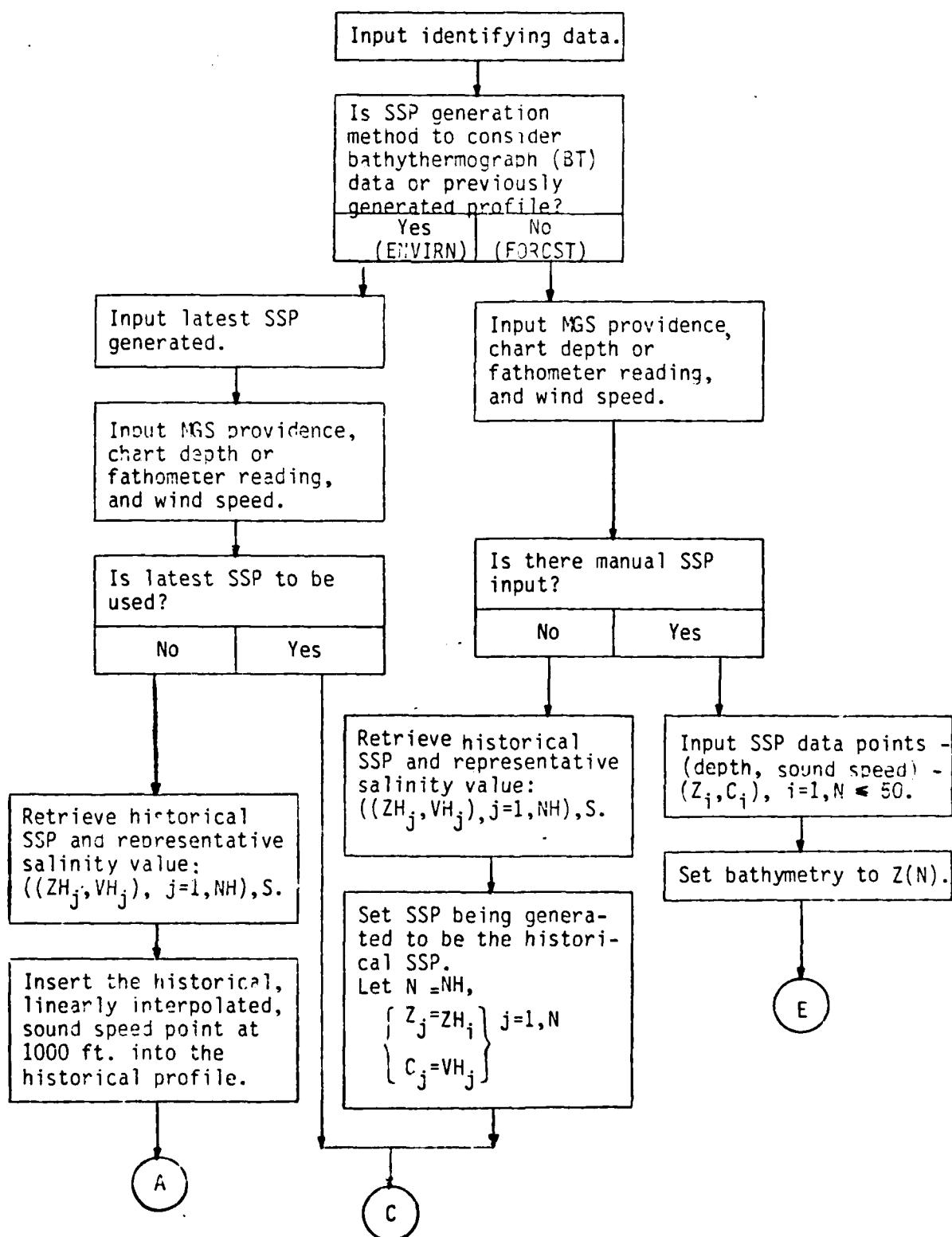
Point #	Depth (ft)	Sound Velocity (F/S)			Δ SVP (F/S)
		Leroy	Frye & Pugh	Wilson (Rev)	
1	0	5007.434	5006.395	5007.227	1.039
2	100	5009.078	5008.082	5008.871	.996
3	200	5010.719	5009.770	5010.520	.949
4	300	5011.883	5010.969	5011.680	.914
5	400	5013.043	5012.168	5012.844	.875
6	500	5012.738	5011.887	5012.543	.851
7	600	5012.422	5011.590	5012.230	.832
8	700	5012.094	5011.281	5011.906	.813
9	800	5011.754	5010.957	5011.566	.797
10	900	5011.398	5010.617	5011.215	.781
11	1000	5011.027	5010.266	5010.848	.761
12	1100	5009.746	5008.871	5009.566	.875
13	1200	5008.953	5007.996	5008.781	.957
14	1300	5008.664	5007.652	5008.492	1.012
15	1400	5007.848	5006.801	5007.676	1.047
16	1500	5007.539	5006.477	5007.367	1.062
17	1600	5005.246	5004.184	5005.078	1.062
18	1800	5002.414	5001.430	5002.258	.984
19	2000	4998.797	4997.867	4998.645	.930
20	2500	4987.629	4986.863	4987.508	.766
21	3000	4966.602	4966.023	4966.543	.079
22	3500	4933.992	4933.734	4933.996	.262
23	4000	4911.727	4911.713	4911.730	.015
24	4250	4907.180	4907.211	4907.184	.031
25	4500	4903.258	4903.320	4903.254	.066
26	4750	4901.484	4901.562	4901.480	.082
27	5000	4901.926	4902.020	4901.922	.098
28	5250	4902.355	4902.457	4902.348	.109
29	5500	4902.770	4902.875	4902.762	.113
30	5750	4905.465	4905.578	4905.461	.117
31	6000	4908.164	4908.281	4908.160	.121
32	6500	4915.109	4915.234	4915.109	.125
33	7000	4922.074	4922.215	4922.078	.141
34	8000	4936.840	4937.016	4936.855	.176
35	9000	4952.473	4952.695	4952.496	.222
36	10000	4966.656	4966.937	4966.695	.281
37	11000	4980.041	4981.289	4980.992	.348
38	12000	4996.094	4996.516	4996.160	.422
39	13000	5011.352	5011.848	5011.430	.496
40	14500	5034.816	5035.434	5034.902	.618

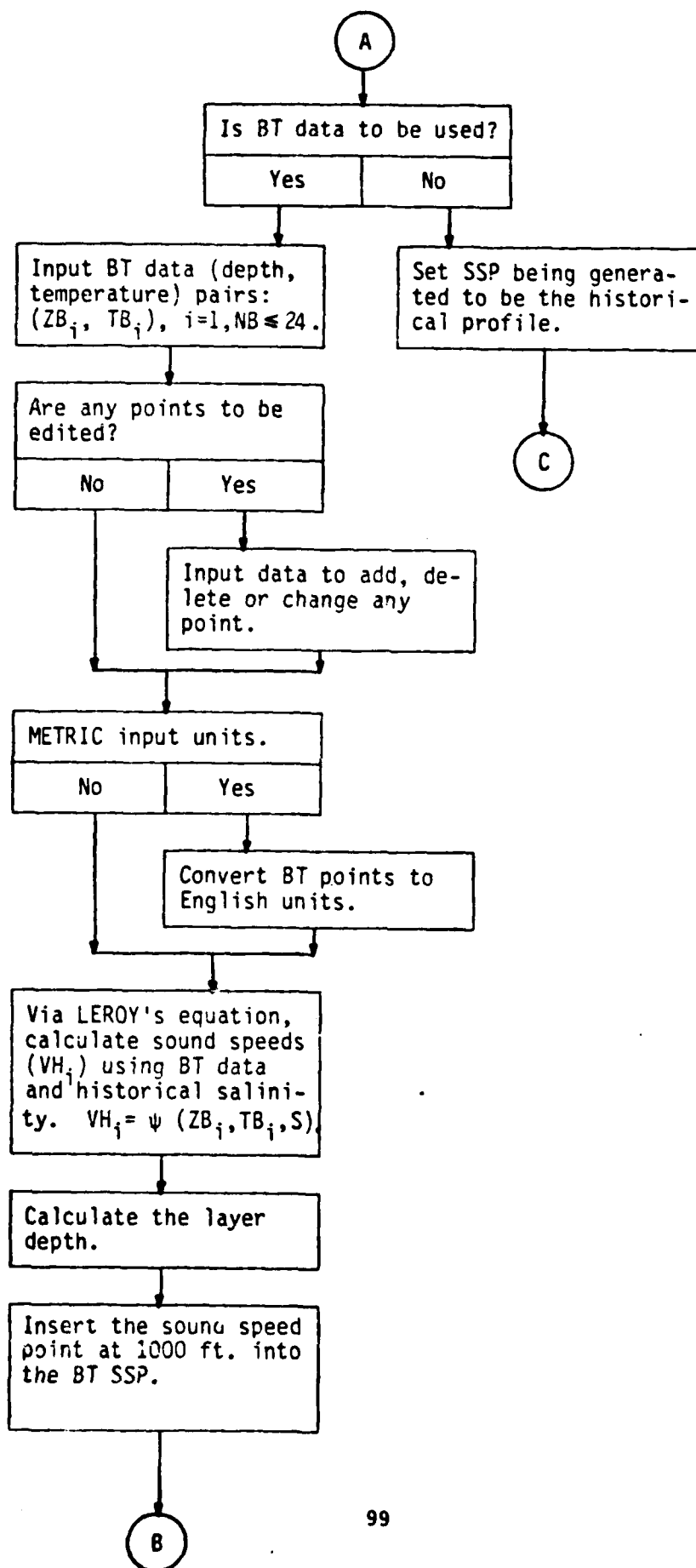
APPENDICIES

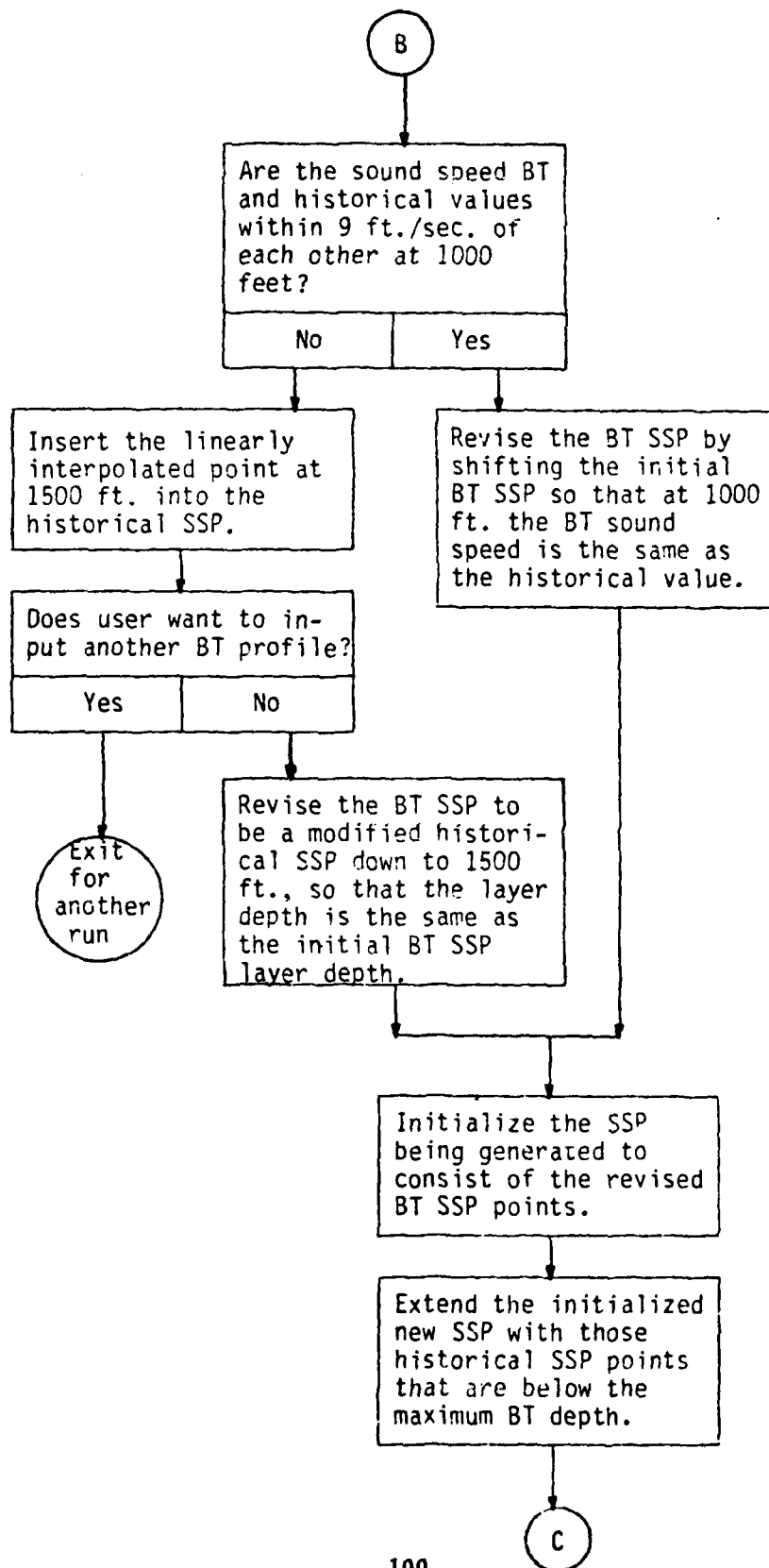
APPENDIX (A)
SIMAS LOGIC FLOW

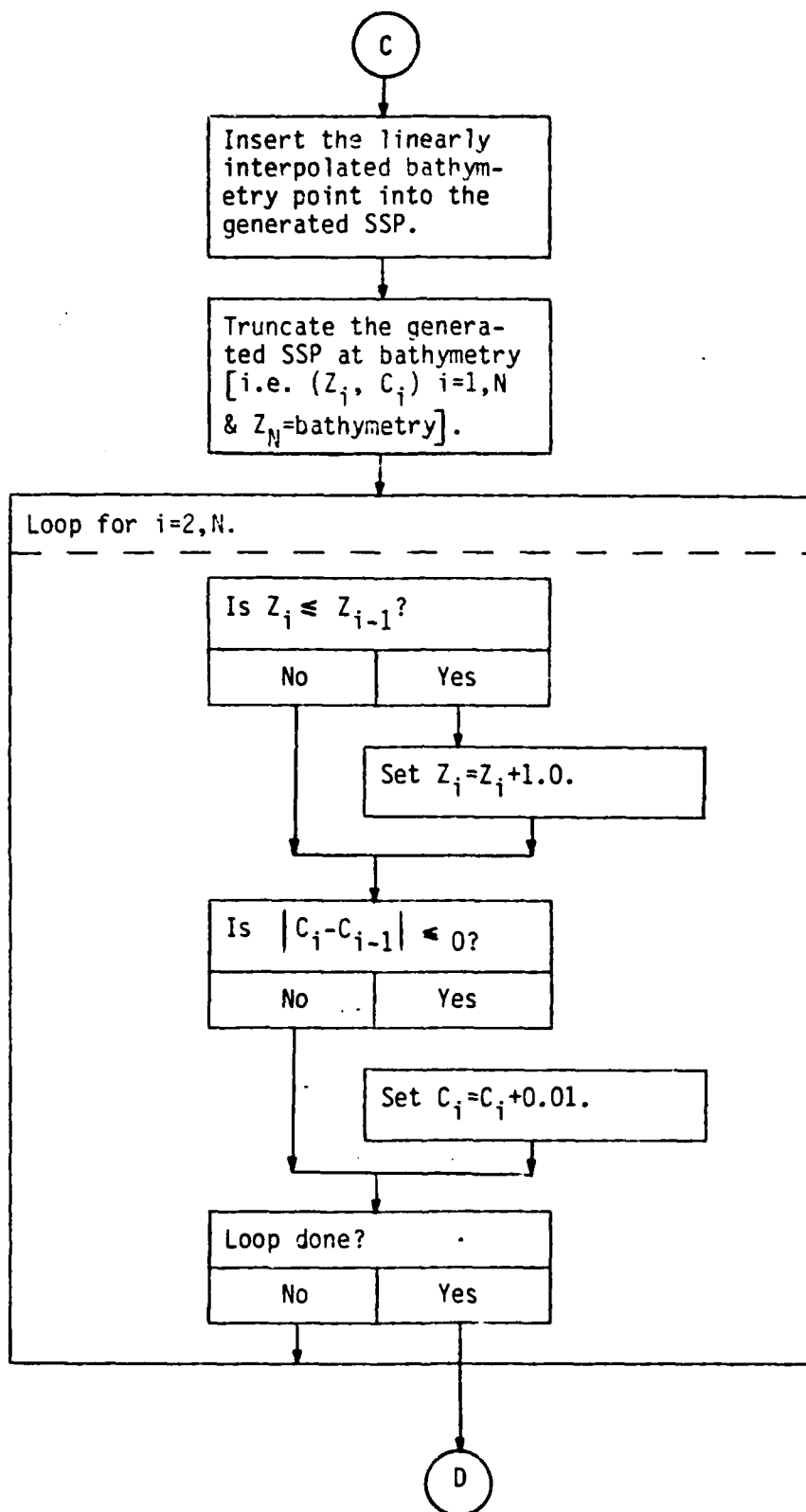
by
J. Locklin
and
B. Scaiffe

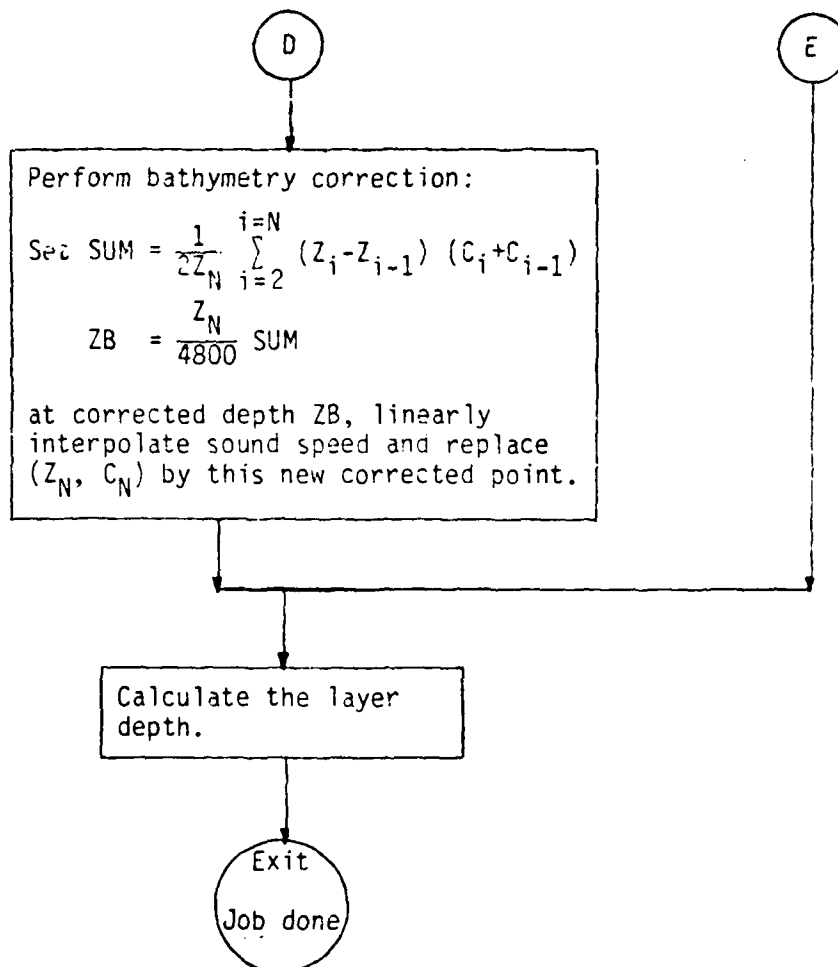
SIMAS Sound Speed Profile (SSP) Generation









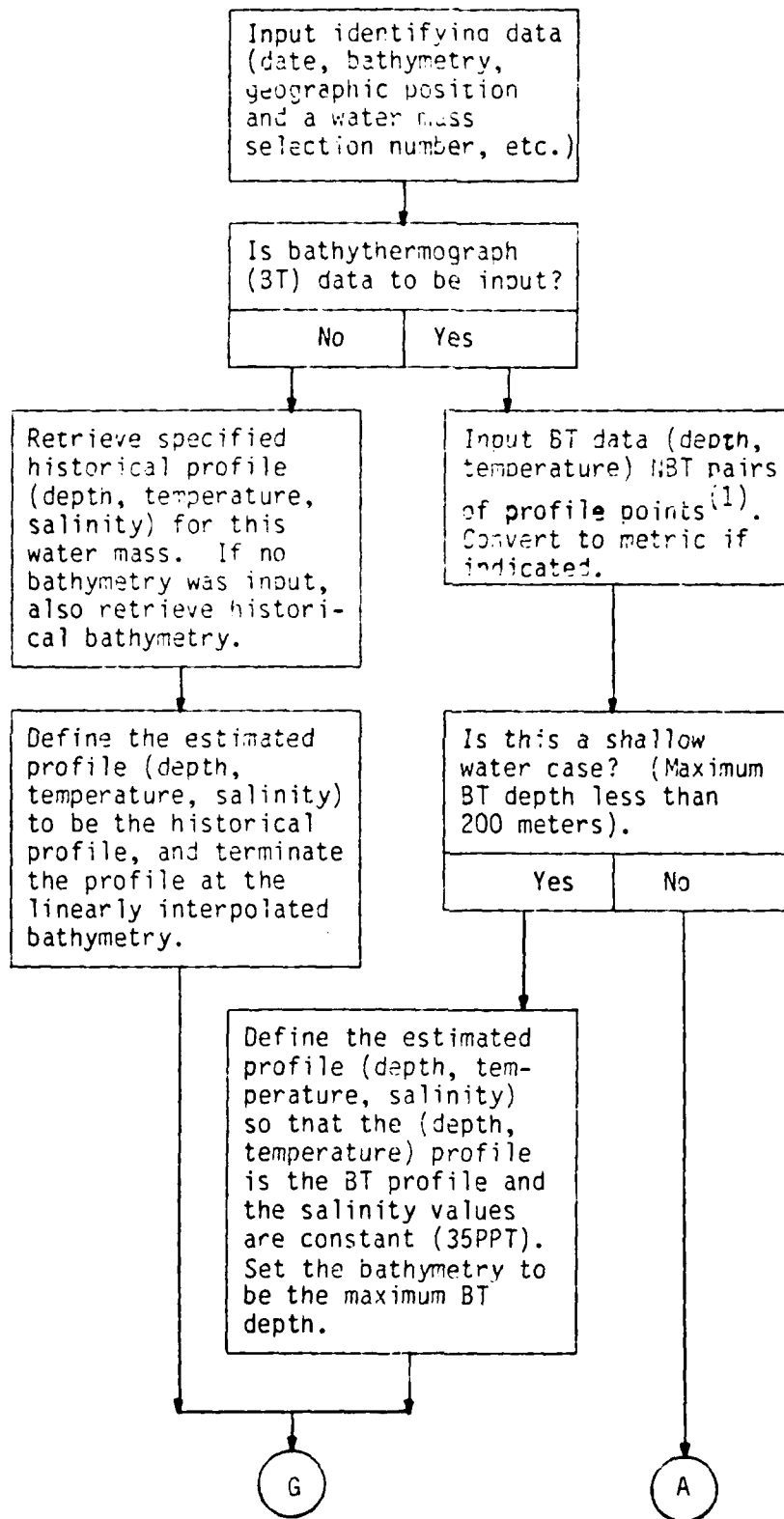


APPENDIX (B)
ICAPS LOGIC FLOW

by

J. Locklin
and
B. Scaiffe

ICAPS Sound Speed Profile (SSP) Generation (UNIVAC Version)



(1) NBT = { 16 Univac }
 { 30 Nova }

A

Select historical profile (depth, temperature, salinity) for this water mass
-- NH number of triple points and retrieve the merge weighting factor (MFACT).

Retrieve up to five
historical profiles
with 200m temperature
tolerances and
200-300m gradient
tolerances.

Linearly interpolate
the 200m and 300m BT
temperature values and
define the 200-300m
BT gradient.

Is there more than one
historical profile?

Yes

No

Has an historical pro-
file been specified?

No

Yes

Select first histori-
cal profile.

Select specified
historical profile.

Select an historical
profile using
tolerances.

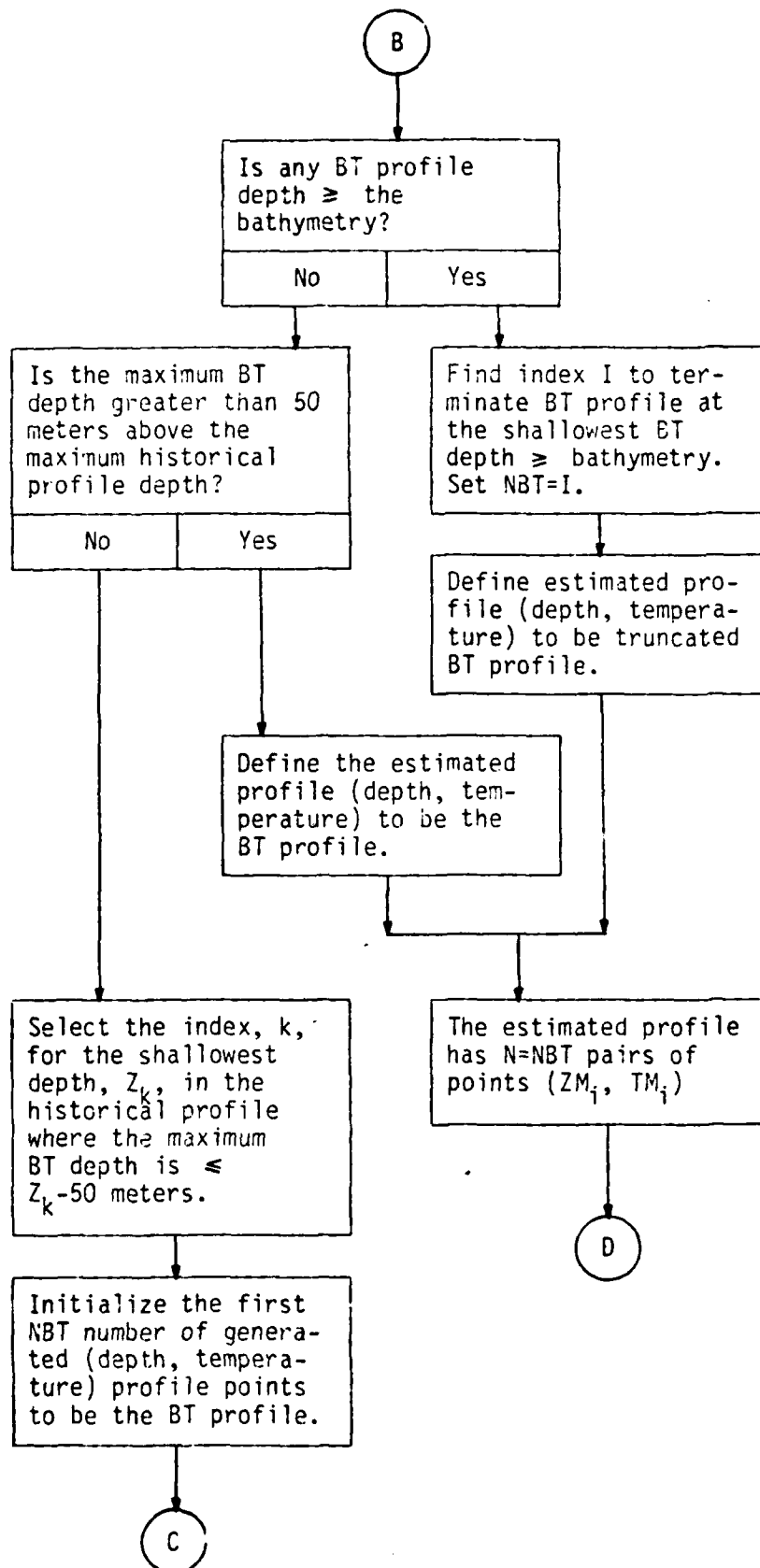
Is bathymetry needed?

Yes

No

Retrieve historical
bathymetry.

B



C

Complete the (depth, temperature) profile being generated by augmenting the initialized NBT number of points with the historical depths Z_i for $i=k, \dots, NH$ and modify the associated historical temperatures, T_i .

Let (ZM_j, TM_j) , $j=1, N$ be the initialized generated profile points ($N=NBT$).

Calculate $\Delta T = TM_N - T_{k-1} + \frac{(T_k - T_{k-1})(ZM_N - Z_{k-1})}{(Z_k - Z_{k-1})}$
 $X = MFACT/1000.$

Loop over historical profile for $i=k, \dots, NH$

Calculate $N = N+1$
 $ZM_N = Z_i$
 $\Delta T = (\Delta T)X(Z_i - Z_{i-1})/100.$
 $TM_N = T_i + \Delta T$

Is the depth, ZM_N ,
less than the
bathymetry?

Yes

No

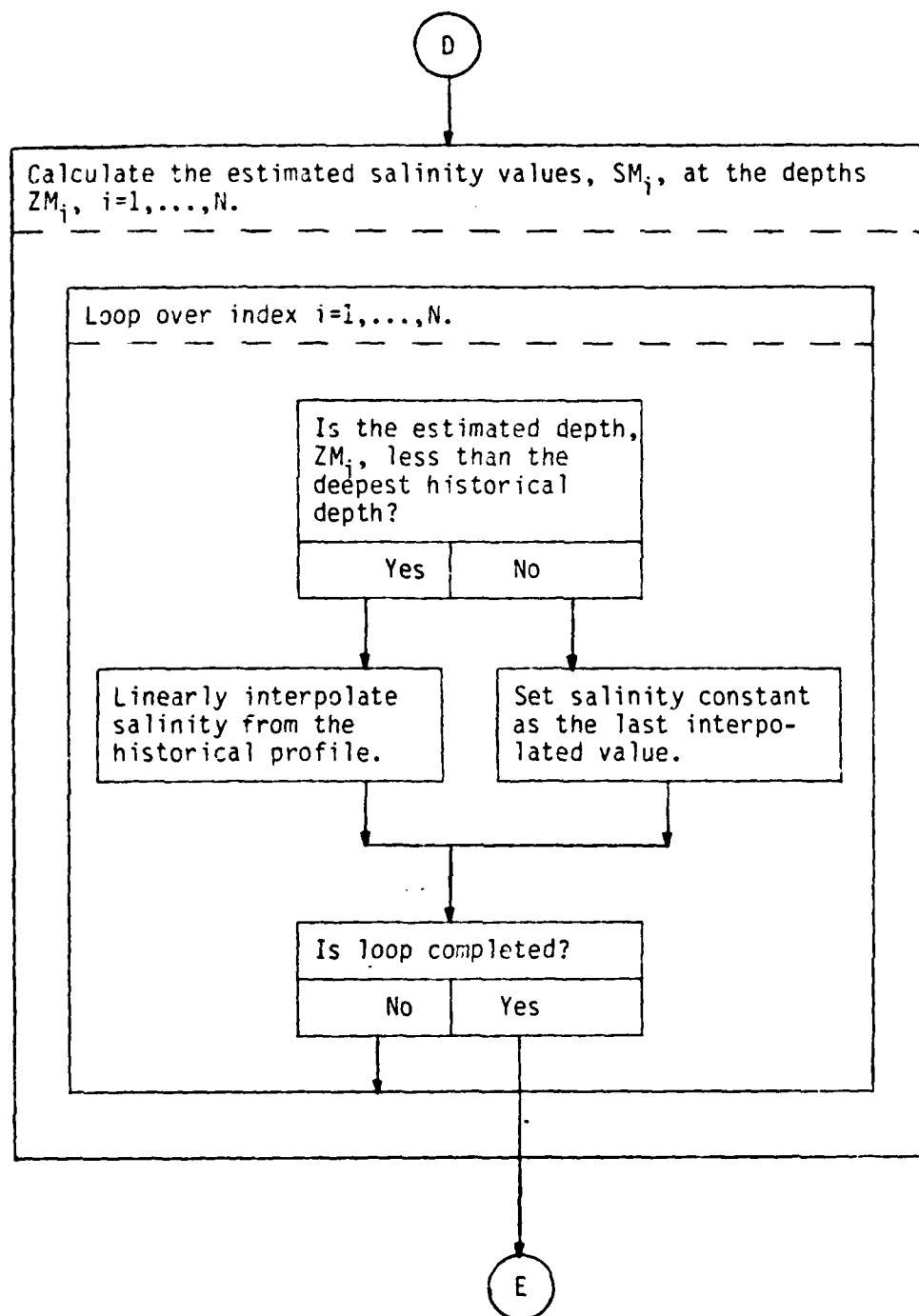
Is loop completed?

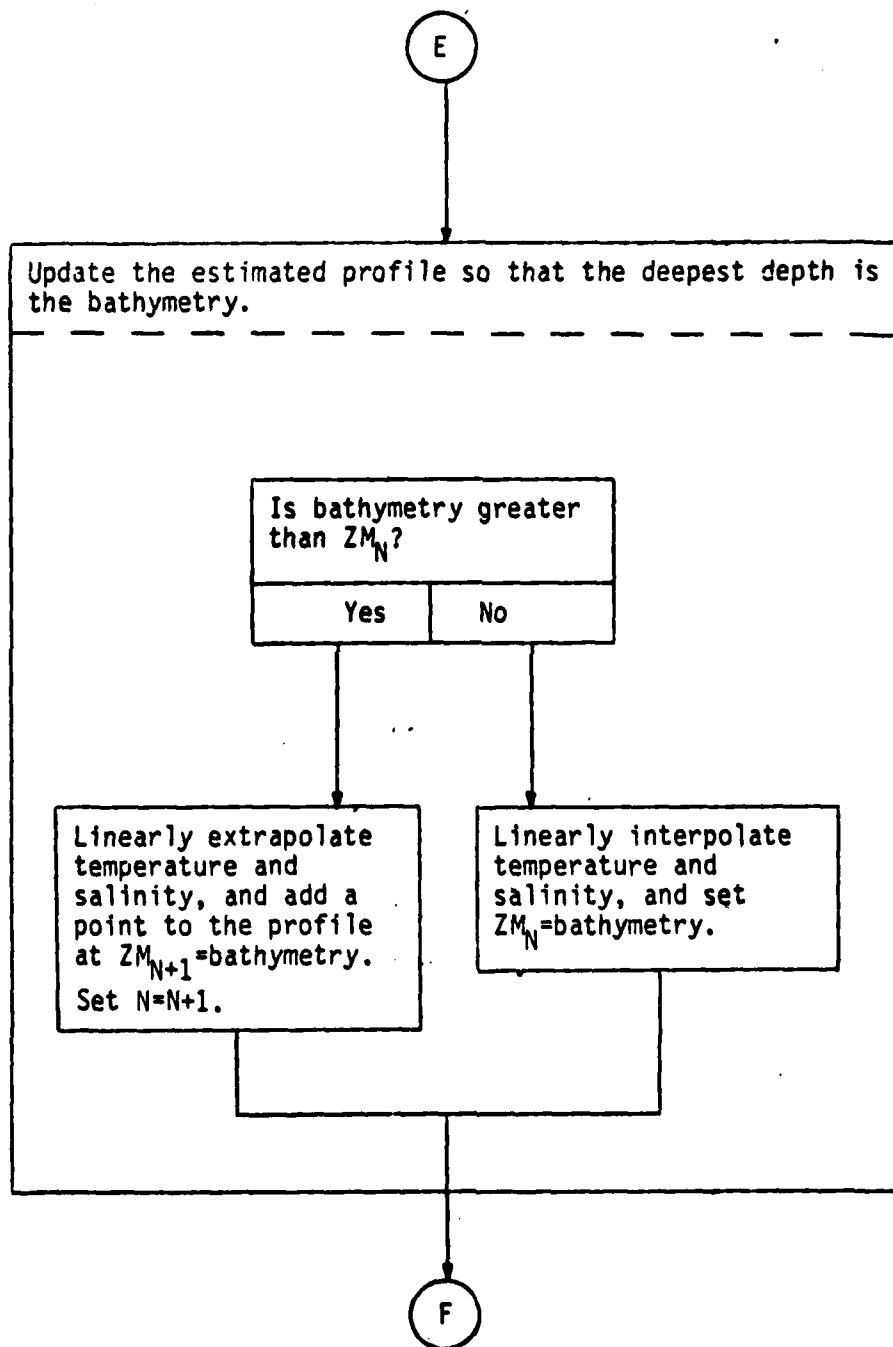
No

Yes

The estimated profile
now has N pairs of
points

D





F

Correct the estimated salinity values for stability.

Calculate the densities by the density function $\sigma_{T_i}(TM_i, SM_i)$, for $i=1, \dots, N$.

Loop over $j=1, N-1$.

Set $i=N-j$.

Is σ_{T_i} greater than $\sigma_{T_{i+1}}$?

Yes

No

Set $\Delta\sigma_T = \sigma_{T_{i+1}} - \sigma_{T_i}$
 $\Delta\sigma_T - 0.01$
 $\Delta S = \frac{\Delta\sigma_T - 0.01}{.7714 + (1.69)10^{-7} SM_i^3}$
 $SM_i = SM_i + \Delta S$

Recalculate σ_{T_i} .

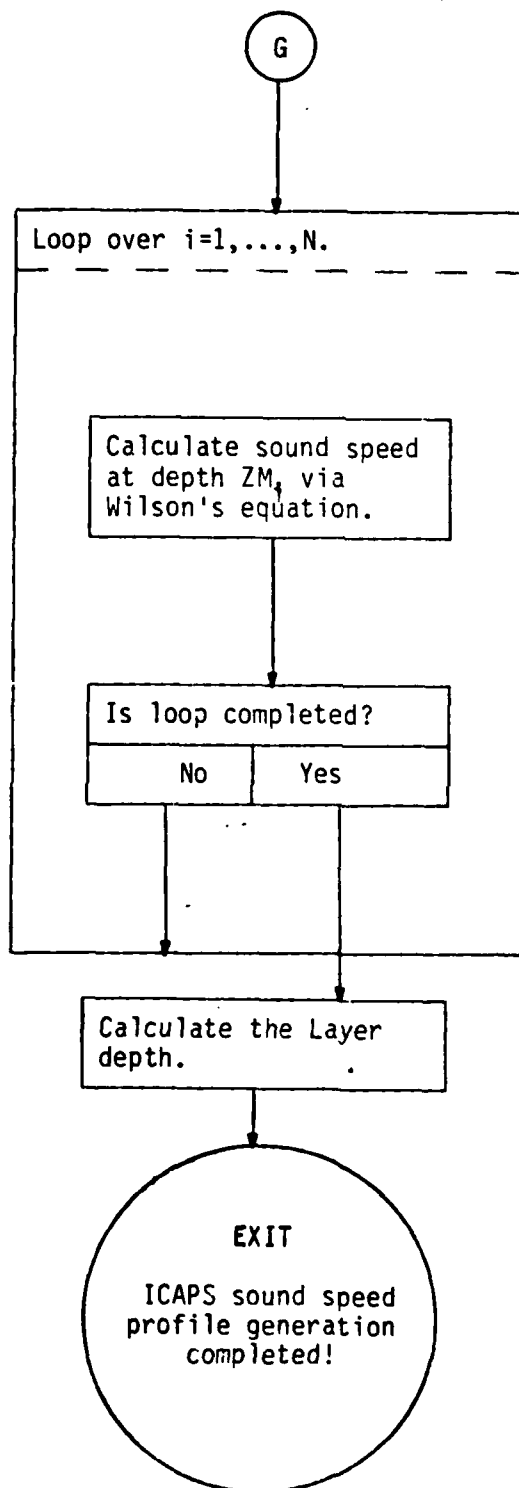
Is loop completed?

No

Yes

110

G



APPENDIX (C)

2. SIMAS

2.1 PROGRAM ERRORS

2.1.1 Conversion errors occur involving subroutines BT and EDITBT. Metric inputs are converted to English units at least twice. We understand that this is corrected at NUSC but not at NORDA.

2.1.2 Subroutine CKBT shows an error in the algorithm for modifying the historical data to reflect the BT profile layer depth. The DO loop at FORTRAN statement number 550 may be executed with $K=N15+1$, i.e.

DO 600 J=N15+1,N15

thus causing erroneous results.

APPENDIX (D)

1. ICAPS

1.1 PROGRAM ERRORS

1.1.1 Univac Version

1.1.1.1 The synthesized profile contains salinities that are initialized by interpolating values from the historical profile, and when a depth of the synthesized profile is equal to or exceeds the maximum depth of the historical profile (a most frequent occurrence) the salinity is set to be the historical salinity for the previous depth. This can be corrected by changing the inequality ".LT." to ".LE." in the IF statement following FORTRAN statement number 50 in subroutine MERGE. This code error will have negligible impact for the deeper profiles. For shallower profiles the impact will depend upon the effect on velocity by the error in salinity.

1.1.1.2 When the user wishes to use only the historical data (no BT data: NDP=0 and BOTZ 1.0) and metric is not specified (MOE $\neq$ "M"), the program incorrectly multiplies the historical bathymetry in meters by the feet-to-meters conversion factor, FTMT. This can be corrected by inserting after format statement number 9001 in the main program

IF (MOE .NE. 1 HM) BOTZ = FTMT*BOTZ

and deleting the statement immediately after FORTRAN statement number 10, and replacing FORTRAN statement number 100 with
100 CONTINUE.

1.1.1.3 An error message is not utilized when appropriate and an incorrect message is printed. Change the line just preceeding format statement number 1045 to read

WRITE (6, 1045) IBTYP2.

1.1.1.4 In the main program, there is an "MP" variable occurring just after format statement number 1013 that is not initialized. Apparently, this was to have been defined by "NP" in the preceeding call to subroutine COMPUX. This is corrected by changing "NP" to "MP," the last argument in the argument list for the "CALL COMPUX ..." statement, two lines after FORTRAN statement number 360.

1.1.1.5 Subroutine MERGE calls subroutine SGMTST to perform the water column stability algorithm from the bottom of the merged profile. Though this is in contrast with the NOVA version that starts from the bottom of the BT, it is more reasonable since the algorithm is applied just below the BT where merging occurs (refer to paragraph 1.1.2.2). Subroutine SGMTST has an incorrect DIMENSION statement allocating insufficient memory, particularly for the density array. The current dimension for 30 elements is not consistent with the calling routine. The arrays should be dimensioned for 50 elements each, since the calling routine, MERGE, identifies the arrays as for the merged profile. This is corrected by changing the dimension statement in subroutine SGMTST to read

DIMENSION T(50), S(50), SIGMA(50)

1.1.1.6 Under normal operating system usage, the density and stability calculations will be incorrect. Mixed expressions contain integers raised to negative integer powers which result in zero values.

1.1.1.6.1 Subroutine SIGMAT has an equation "B = ..." that contains the integer 10 raised to a negative integer power.

1.1.1.6.2 Subroutine SGMST has the equation "DS = ..." that contains two integer 10's raised to negative powers.

1.1.2 Nova 800 version

1.1.2.1 Same error as described in paragraph 1.1.1.1 above.

1.1.2.2 The program should perform the water column stability algorithm from the bottom of the merged profile as the Univac version does (refer to paragraph 1.1.1.5) — rather than from the bottom of the BT. Thus, the effects on density (refer to paragraph 1.3.4.2) due to temperature revisions by merging just below the deepest BT depth would be accounted for. This can be corrected by changing in subroutine MERGE, the FORTRAN statement just after statement number 100 to:

N=NOPTM-1

and two lines later, change to read

K=NOPTM-J.

APPENDIX (E)

2.2 PROGRAM CAUTIONS (SIMAS)

- 2.2.1 The generated SSP arrays are allocated for 50 points. Subroutine INSERT adds points to the generated profile, and subroutine ENVIRN extends the up to 25 revised BT profile points with historical points. The program does not properly check on this limit. Structurally, depth array element Z(51) is the location of velocity C(1), the surface velocity which could be changed to be the Z(51) value.
- 2.2.2 Subroutine BT can input up to 25 BT temperature profile points. Subroutine CKBT calls subroutine INSERT to augment the BT points with the interpolated temperature point at 1000 feet, whenever the input BT profile does not have a 1000 ft. point. Since the program allocates space for 25 BT points, an overflow can occur, so that the surface temperature, T(1), value is replaced by the overflow depth value, D(26).
- 2.2.3 Whenever the BT profile is augmented by a point at 1000 ft., extrapolation is performed when the profile is to be extended by a 1000 ft. point. The SIMAS program also does not consider the reasonability of the extrapolation, see paragraph 1.2.1.2 above.
- 2.2.4 In subroutines ENVIRN and FORCST, there is no test that the corrected bottom depth value is in the deepest (last) interval which ends with the input fathometer (or chart) value. Consequently, extrapolation may occur.
- 2.3 COMMENTS — The methodology is to shift the BT SSP so that at 1000 feet the shifted BT SSP has the same velocity value as does the historical profile. The shifted BT SSP is then extended by those historical profile points below the deepest BT SSP depth.
- 2.3.1 SIMAS assumes that the historical profile will always extend below the BT profile. This assumption can only be valid if, over each geographical area, the associated historical profile extends down to the deepest bathymetry in the area, and any deepest BT depth value would not be deeper due to measurement errors. Though the assumption will usually be valid, it is too strict for a general purpose production program. Since the program does not verify the input data to meet this assumption, errored profiles may result (refer to subroutine ENVIRN lines 0052 through 0063).
- 2.3.2 The criteria at 1000 feet does not assure a smooth transition below that depth from the bottom of the shifted BT profile and the attached historical points.
- 2.3.3 Assuming that the usage of the layer depth is important, a comment on the SIMAS layer depth algorithm is appropriate. Subroutine LAYER defines the layer depth to be the shallowest depth after which the velocity gradient first becomes negative. This algorithm requires that the BT data not be noisy, and it consists of points that only define the essential shape of the profile.

APPENDIX (F)

1.2 PROGRAM CAUTIONS

1.2.1 ICAPS, Univac and Nova versions

1.2.1.1 When a merged profile is created, the number of points defining the profile is not verified to avoid exceeding the allocated storage for a maximum of 50 points. In the event that a merged profile should have more than 50 points, the overflow would incorrectly redefine necessary program locations (e.g. the near-surface temperatures, TM(1), TM(2), ..., would be redefined by depth values ZM(51), ZM(52), ..., respectively, etc.)

1.2.1.2 When the bathymetry is below the ICAPS merged profile, the merged profile is augmented by one more point defined by the bathymetry, and temperature and salinity values extrapolated from the deepest (last) depth interval in the profile. The ICAPS program does not address the question "How reasonable are the extrapolated values?". Reasonability of these values is dependent upon how much deeper the extrapolation extends the profile with respect to the depth interval being extrapolated from, and the gradient on that same interval.

1.3 COMMENTS — ICAPS is a merge methodology that assumes the bathythermograph, BT, data is the best current information upon which to define a sound speed profile (SSP); and, the historical data extending below the BT profile is the most reasonable information available to merge with the BT data to form representative up-to-date SSP.

1.3.1 A shallow water case is defined when the deepest depth of the input BT data is above 200m. This excludes a merge with historical data -- e.g. an operator cannot input a shallow BT profile to merge with historical data for a deeper water mass. In shallow areas where BT data is sufficient, a shallow water case should be specified by another input parameter, rather than the deepest BT profile depth.

1.3.2 For a shallow water case, the salinity is set to 35 PPT. This is considered valid everywhere except in the Mediterranean Sea where 38 PPT is more appropriate. In keeping with the philosophy of making use of the "best" information available, historical data (salinity) should still be utilized whenever it's available.

1.3.3 Coding of constants is more efficient when using the form $+X.XXE+YY$, rather than $+X.XX*10.**(-YY)$ (see subroutines SGMTST and SIGMAT).

1.3.4 There are inconsistencies between the ICAPS program and the reference report, "The ICAPS Water Mass History File," by Alvan Fisher, Jr., May 1978.

1.3.4.1 The program implementation of the synthesized temperature algorithm (see Enclosure 5), is reasonable, though the approximation to the synthesizing algorithm is unnecessary.

- 1.3.4.2 The density (σ_t) stability algorithm described in Appendix A (reference (1)) does not correspond to the implementation. The document states, "... salinity inversion must coincide with a temperature inversion ...". The code assumes that if the density at depth Z_i is greater than the density at the depth below, Z_{i+1} , (starting from the bottom of the profile), then recompute the salinity at Z_i via the stability expression and use this "corrected" salinity value with the temperature to recalculate the density at depth Z_i . There is no application of the criteria to adjust salinities that are "... within temperature inversions that are more than the temperature maximum minus 0.25°C at the lower boundary of the inversion ...". One should note that the stability expression was derived for a constant temperature of 10°C and salinity ranges of 30 to 40 PPT. This algorithm to "correct" salinity is applied whenever the density does not monotonically increase with depth, and over the temperature ranges of the BT. The BT temperatures can range from approximately 4°C on up to 27°C . This wide range of temperatures suggests a temperature varying stability algorithm --e.g. at depth Z_i , adjust the historical salinity by the increment indicated by the change in temperature (merge temperature minus historical temperature) to stabilize the water column at depth Z_i ---.
- 1.3.5 Both program versions retrieve a historical profile as described in the report "Description of ICAPS Environmental Data Structure" by John Lever, NAVOCEANO TN 3700-82-79, March 1979. The report presents the file structure and the retrieval algorithm. The following comments may enable the report to be more useful; particularly for profile revisions.
- 1.3.5.1 Expand the text to specifically define the ordering of profiles (water masses) for a geographical location. Although the ordering is intrinsic to the retrieval design (refer to report figure 6), the following conditions being stated would clarify the profile data:
- When more than one water mass represent a geographical location, let $1 \leq N \leq 5$ be the number of profiles, then $\text{XMINT2}(i)$, $\text{XMAXT2}(i)$, $i=1, N$ must be defined (temperature tolerances at 200m), and
- 1) $\text{XMINT2}(i) < \text{XMAXT2}(i)$ for $i=1, N$
 - 2) $\text{XMINT2}(i) = \text{XMAXT2}(i-1)$ for $i=2, N$
- must be true for continuity. The exception to this is that two adjacent profiles can have the same tolerances, $\text{XMINT2}(j) = \text{XMINT2}(j+1)$ and $\text{XMAXT2}(j) = \text{XMAXT2}(j+1)$. For this exception, there must be a non-zero flag ($\text{NOGL}(j)$) in order to consider the $j+1$ profile. The tie breaker is the 200-300m gradient tolerances ($\text{XMINGL}(j)$, $\text{XMAXGL}(j)$) and ($\text{XMINGL}(j+1)$, $\text{XMAXGL}(j+1)$). When $\text{NOGL}(j)$ is non-zero, then $\text{XMINGL}(j)$ and $\text{XMAXGL}(j)$ must be defined. Profile j is selected for the BT temperature gradient less than $\text{XMAXGL}(j)$, otherwise profile $j+1$ is selected. If the gradient tolerances are given for $j+1$, then $\text{XMAXGL}(j) = \text{XMINGL}(j+1)$ must occur for continuity. In practice, the tolerances at $j+1$ are only necessary to make an output message meaningful when the BT gradient at 200-300m is greater than $\text{XMAXGL}(j+1)$.
- 1.3.5.2 On pages 3 and 9, state that the maximum number of points for a historical profile is 45.
- 1.3.5.3 On pages 10 and 11, the references labelled "400" should be labelled "80" in order to agree with the programs, as do the other labelled references.
- 1.3.5.4 On page 3, line 2 of the second paragraph, "NOPTS(N)" should be "NOPTI(N)" since NOPTS is set to the NOPTI(I) value for the selected profile.
- 1.3.5 On page 3, the text should state that $\text{NPRF} \leq 5$.

APPENDIX (G)
SYNTHETIC BATHYMETRIC PROFILING SYSTEM
(SYNBAPS)

BY
MR. ROGER VANWYCKHOUSE
(NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY)

Synthetic Bathymetric Profiling System

by

Roger J. VanWyckhouse
Ocean Acoustics Division
Naval Oceanographic Laboratory
Naval Ocean Research and Development Activity

The Synthetic Bathymetric Profiling System (SYNBAPS) is a combination of digital computer software (programs) and a random-access storage file of gridded bathymetric data, employed to rapidly generate random, great-circle, bathymetric profiles suitable for acoustic propagation modeling. SYNBAPS is completely automatic, requiring only the input, via a control card, of the latitude and longitude of the beginning point, the bearing, and the maximum range or the locations of the beginning and end points. The generated profile is available in two forms. The first is a computer drawn profile where range in whole nautical miles is plotted against depth, in either meters, fathoms, or feet; the second is a card image file of the same data. The profile outputs in the card image file are available on magnetic tape, punched cards or listing. Single depth point retrieval is another feature of the system.

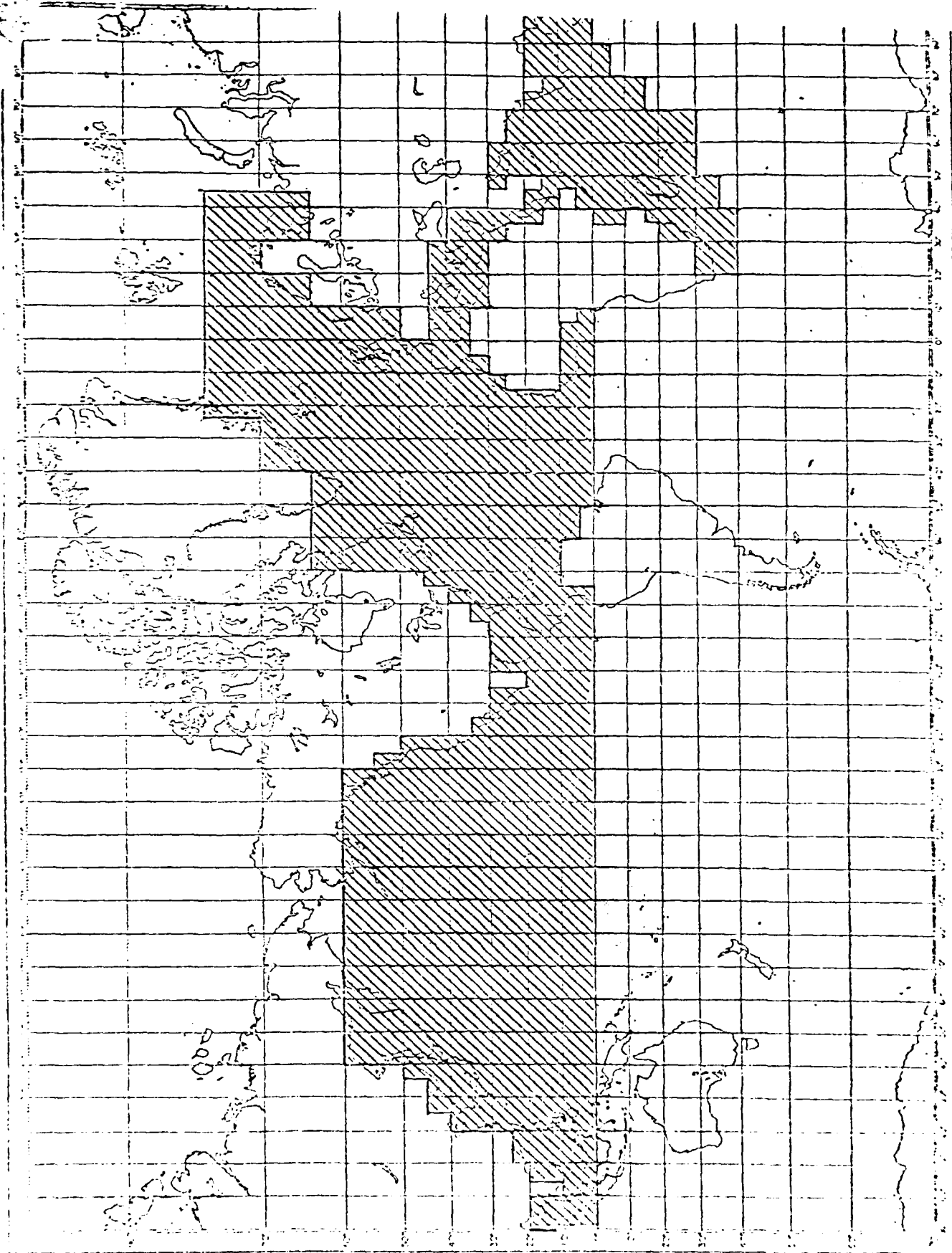
The need for a computerized bathymetric data bank and techniques for rapidly manipulating large quantities of data became evident as demand for bathymetric profiles increased and became more urgent. It became increasingly difficult to satisfy these demands through manual compilation of depth soundings, contouring, and profile constructions. A massive recompilation and reanalysis of bathymetric data, systematic revision of all bathymetric charts in the North Atlantic and North Pacific Oceans, including extension of chart coverage to the equator, was recently completed. The impracticality of using the existing official data bank of bathymetric soundings for machine generation of profiles became apparent. The need for a specialized bathymetric data bank to support acoustic - oceanographic modeling gave rise to development of a synthetic bathymetric profiling project using the new bathymetric contour charts as the data base. The project developed procedures for digitizing the contour charts, and computer programs and subroutines for data storage and retrieval and for profile generation.

The SYNBAPS data base was designed to meet the specific and immediate need for bathymetric profiles for acoustic modeling. However, properly used, the data base offers a myriad of applications beyond its preliminary design. The coverage of the data base is shown in figure 1.

Often in naval planning as well as in naval operations, speed is as important as accuracy when information is needed. SYNBAPS is not ideally suited to hydrographic charting because some high resolution detail is lost, but it provides very rapid responses. SYNBAPS has these additional features:

- Only gridded depth points are stored in the data bank (3,489,066 points),
- The locations of the depth points are logically structured on a Mercator projection by 5-longitudinal minutes/5-meridional part intersections,
- Random access to the data is by large blocks (691 five-degree squares),
- The data bank is updated by replacing the blocks of data,
- The size of the data bank is fixed once it has been created for an ocean area,
- Rapid contouring of five-degree squares of data for inspection or editing can be done directly for the Mercator projection, the most commonly used projection for bathymetric charts,
- Classified survey data, in chart form, can be incorporated in the data base with no compromise of security, the present data base is unclassified,
- Highly compacted forms of the accessing program and the data base can be used on shipboard or other platforms,
- Subsets of the data base can be used in other model data bases requiring bathymetry (a derivative of SYNBAPS with 1/6° resolution is being used in the Automated Signal Excess Prediction System (ASEPS) Data Base),
- The data base is available on one 9 track, 1600 bpi, EBCDIC code magnetic tape,
- The data base, a profile accessing program and an editing program are fully documented and provided with the system,
- In addition to the documentation provided with the data base the following references are available;

FIGURE 1. STUDENT'S CATCH DATA



APPENDIX (H)
GENERALIZED DIGITAL ENVIRONMENTAL MODEL
(GDEM)

BY
DR. T. DAVIS (NAVAL OCEANOGRAPHIC OFFICE)

PSR Report 922

EVALUATION OF STANDARD OCEAN CANDIDATES

J. G. Colborn
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March 1980

Final Technical Report
Contract N00014-79-C-0310

Sponsored by
Long-Range Acoustic Propagation Project
Naval Ocean Research and Development Activity
NSTL Station, Bay St. Louis, Mississippi 39529



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Overview

"This report describes and evaluates eight existing or proposed oceanographic models as candidates for Standard Ocean, a data retrieval system to be installed in the Long Range Acoustic Propagation Project (LRAPP) data bank. The primary purpose of Standard Ocean is to provide range-dependent sound-speed profiles for input to NORDA's numerical acoustic models. Standard Ocean will also be used to support the objective analysis of environmental data collected during exercises at sea. The candidate systems and their parent organization are as follows:

AUTO-OCEAN (NORDA)	GFDL (Geophysical Fluid Dynamics Laboratory, NOAA, Princeton University)
FIB/EOTS/EXTRA (FNWC)	
GDEM (NAVOCEANO)	HYDAT (FNWC)
ICAPS (NAVOCEANO)	SIMAS (NUSC/New London)
ODSI (Ocean Data Systems, Inc.)	

The Standard Ocean Evaluation Group assessed each candidate according to criteria indicated in the following description of desired Standard Ocean capabilities. Standard Ocean is to provide accurate, realistic, and seasonal (preferably monthly) surface-to-bottom profiles of sound speed, temperature, and salinity in each oceanic $1^{\circ} \times 1^{\circ}$ square. The sound-speed profiles should be in a format suitable for numerical acoustic models. The profiles should accurately reproduce all acoustically significant features. The degree of oceanic variability in each square should be indicated. Standard Ocean should operate rapidly and inexpensively; it should be easily usable by the nonspecialist. Finally, the candidate chosen should be competitive in acquisition cost and availability."

Generalized Digital Environmental Model (GDEM) by Dr. T. Davis, NOO

"GDEM is an objective-analysis program that produces fields of analyzed temperature, salinity, and sound speed on a 30'x30' grid over various depth ranges.* Preliminary analysis has been completed for the North Pacific and Mediterranean and is beginning for the North Atlantic. The Indian Ocean segment is to be completed sometime in the future. Observational data are insufficient to run GDEM in the southern hemisphere.

The GDEM component for the upper layer models seasonal temperature between the surface and the merge depth (400m),[†] annual salinity between the surface and either 400m in the Mediterranean or 800m in the Pacific, and seasonal sound speed from the surface to the merge depth in both oceans. The sound speed is derived from the analyzed temperature, salinity fields.

Below the surface models of temperature, salinity, and sound speed, there is a middepth, two-season (winter-summer) sound-speed model from 200m to 2450m. It is being augmented in the North Atlantic by a mid-depth temperature and salinity model.

The lowest component is an annual sound-speed model extending from 2000m to the bottom. There is no evidence that the developer intends to replace this model with a temperature or salinity model in the near future.

Of all Standard Ocean candidates using objective-analysis techniques, GDEM comes closest to reproducing the significant features in vertical sound-speed profiles. Comparison of model profiles with typical observed profiles

*This model has received our most detailed scrutiny to date.

[†]Merge depth, a variable peculiar to each ocean basin, is the depth at which two adjacent layers of the model are merged. In the early 1979 version of the model for the North Pacific, for example, that depth was fixed for the entire basin at 400m. We understand that the latest versions of the model adjust merge depth over the basin to fit the observed data.

for the North Pacific showed that GDEM maintains horizontal continuity yet preserves frontal structure in some cases. It appears to work well in areas with sparse data except the southern hemisphere. The 30'x30' grid spacing is the smallest of any model yet evaluated. Operation is rapid (3 min to edit an entire tape for one season in the North Pacific) and reported to be simple."

Model	Temperature	Salinity	Sound Speed	Coverage
GDEM	Seasonal, 30'x30', surface to 400m at standard depths monthly also available	Annual, 30'x30', surface to 800m at standard depths seasonal also available	Spatial resolution, 30'x30'. Temporal resolution (3 models): (1) seasonal, 0-400m, (2) 2 seasons, 200-2450m, (3) annual, 2000 m-bottom monthly also available	Mediterranean, N. Pacific, North Atlantic

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report consists of two major parts. Each part addresses different problems or issues. Part I is titled, "Comparison of "on-board" In-situ Vertical Sound Speed Profiles from the SIMAS and ICAPS Environmental Data Bases with High Quality CTD and STD Data" APP FY-80 Task #1. The purpose of Part I was to compare the SIMAS and ICAPS sound speed profiles with sound speed profiles from assumed oceanography (CTD or STD observations). Part II is titled, "Evaluation of the SIMAS and ICAPS Environmental Data Bases		

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Data Handling Procedures, and Merge Methodology." APP FY-80 Task #II. The purpose of PART II was to compare and recommend the data bases, algorithms, merge techniques of either SIMAS or ICAPS. The major causes for the "significant" differences in the SIMAS vs. ICAPS sound speed comparisons were found to be in the merge methodologies and historical environmental profiles.

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