Naval Research Laboratory
Stennis Space Center, MS 39529-5004

NRL/FR/7323--93-9431

Users Guide to the Bathymetric Data Set Extraction Program

WESLEY J. YOUTSEY
ROBERT L. WOODYARD

Sverdrup Technology, Inc.
Stennis Space Center, MS 39529

Prepared for Ocean Dynamics and Prediction Branch

November 8, 1993

REPORT DOCUMENTATION PAGE

Form Approved
OBM No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	November 8, 1993	Final

4. TITLE AND SUBTITLE

Users Guide to the Bathymetric Data Set Extraction Program

5. FUNDING NUMBERS

Job Order No. 573509403
Program Element No. 0603207N
Project No. X0513
Task No.
Accession No. DN257017

6. AUTHOR(S)

Wesley J. Youtsey and Robert L. Woodyard

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Sverdrup Technology, Inc.
Stennis Space Center, MS 39529
Prepared for Ocean Dynamics and Prediction Branch, Code 7323

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Naval Research Laboratory
Oceanography Division
Stennis Space Center, MS 39529-5004

Space and Naval Warfare Systems Command
Washington, DC 20363-5200

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

NRL/FR/7323--93-9431

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This report is a users guide for a suite of programs that can be used to generate, plot, and modify bathymetric data files. This software has evolved over several years to meet the needs of the Naval Layered Ocean Model development. Each facet of the program is discussed, and examples are provided to show typical entries to the program.

14. SUBJECT TERMS

ocean models, military oceanography, data assimilation

15. NUMBER OF PAGES
17

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Same as report

CONTENTS

USERS GUIDE TO THE BATHYMETRIC DATA SET EXTRACTION PROGRAM

1.0 INTRODUCTION

As the result of the eddy-resolving global and basin-scale ocean model effort at the Naval Research Laboratory (NRL), the need to modify, plot and generate new bathymetric data files was recognized. The Bathymetric Data Set Extraction System (BATHYEXT) program was developed in an effort to meet that need. The suite of programs that comprise BATHYEXT allows the user to extract a new bathymetric file from the Earth Topography 5-minute (ETOPO5) bathymetric database (Sloss 1986), to plot a bathymetric data file, to smooth the data file, and to modify already-existing bathymetric files as needed. BATHYEXT was originally designed to use the Synoptic Bathymetric Profiling System, or SYNBAPS (VanWykhouse 1973) data set but now uses ETOPO5.

The development of BATHYEXT provides users with an easy-to-use interface that allows the manipulation of large bathymetric databases both efficiently and systematically.

2.0 PROGRAM OVERVIEW

BATHYEXT comprises several Fortran programs, which can be run on either a Sun workstation or a Silicon Graphics workstation using the UNIX operating system. The plotting software uses the Advanced Technology Center Graphical Kernal System (ATC-GKS) plotting libraries. BATHYEXT is executed interactively and is menu driven.

BATHYEXT is to be run interactively and in the foreground. To execute it, just type the name of the script when given a prompt.

```
% bathyext.scp
```

When BATHYEXT is executed, the main menu appears and provides the user with the six options available:

```
This command procedure can be used to:
    1. Extract a gridded bathymetric data set from the ETOPO5 database
       for any specified region and grid spacing. The first phase extracts
       the bathymetry data from the ETOPO5 database, and the second
       phase converts the data set to the proper format for input to the
       NRL ocean models, release versions 2.4 through 3.1.
    2. Plot and/or print an existing gridded bathymetric data set.
    3. Modify individual grid points in an existing data set.
    4. Apply a nine-point real smoother to an existing data set.
    5. Apply a non-linear smoother an existing data set.
    6. Exit this command procedure.
```

```
Select your option:
        1. Extract a new data set from ETOPO5.
        2. Plot/print an existing data set.
        3. Edit/modify an existing data set.
        4. Apply a nine-point smoother.
        5. Apply a non-linear smoother.
        6. Exit.
Enter 1,2,...,6
```

For most procedures in this program, a parameter file is needed to describe the ocean model topography file and region being operated upon. This parameter file, shown below, contains the latitude and longitude of the lower left-hand corner, the grid spacing in both the x and y directions, and the number of data elements in both the x and y directions. The current parameter file remains the default file until the user specifies otherwise. The menu to input a parameter file always appears after one of the options is chosen from the main menu.

The following menu is used to select a parameter file.

```
The default file name is: /320/youtsey/xbathy/param.tmp
$PARAM
XFD      = 109.12500,
YFD      = -20.00000,
IH       = 989,
JH       = 657,
DXD      = 0.1760000,
DYD      = 0.1250000,
FILNM    = 'top133c.d                                    '
&END

Select your option:
      1. Use default parameter file.
      2. Use an existing file as the parameter file.
      3. Enter a new parameter file.
Enter 1,2 or 3
```

where the parameter file is in Fortran namelist format and then

XFD = longitude of the lower left point of the data array,

YFD = latitude of the lower left point of the data array,

IH = number of data elements in the x direction,

JH = number of data elements in the y direction,

DXD = grid spacing (degrees) in the x direction,

DYD = grid spacing (degrees) in the y direction,

FILNM = the name of the file which is being operated upon.

The selection of option 1 allows the user to use the current parameter file, named param.tmp, to define the topography being used. The selection of option 2 allows the user to select a parameter file other than the default, and option 3 allows the user to generate a new parameter file. Option 3 also guides the user to enter the values needed to generate a new parameter file.

When option 3 is selected, the program guides the user through a series of prompts that allows a parameter file to be generated. Throughout this document, examples of typical entries will be shown in quotes.

```
PARAMETER INPUT SECTION

  ENTER SOUTHERN BOUNDARY LATITUDE                    YFD  ==> "-20.0"

  ENTER GRID SIZE IN J-DIRECTION (LAT)                JH   ==> "657"

  ENTER GRID SPACING (DEGREES LAT)/(GRID SPACE)       DYD  ==> "0.125"

  ENTER WESTERN BOUNDARY LONGITUDE                    XFD  ==> "109.125"

  ENTER GRID SIZE IN I-DIRECTION (LONG)               IH   ==> "989"

  ENTER GRID SPACING (DEGREES LONG)/(GRID SPACE)      DXD  ==> "0.17578125"

  ENTER BATHY DATA SET FILE NAME      ==> "param.p133d"

  ARE THE ABOVE ENTRIES CORRECT?
                        (Y)ES OR (N)O ==>
```

The bathymetry data file name is limited to 40 characters and should include the complete path name of the file, especially if it is different from the current directory.

2.1 Data Source

The ETOPO5 bathymetric database, developed by the National Geophysical Data Center, modified the Digital Bathymetric Data Base 5-minute (DBDB5) by improving the terrestrial topography. The ocean bathymetry in ETOPO5 is the same as that contained in DBDB5 and is given in uncorrected meters (based on a 1500 m/s sound speed) for each 5 min of world-wide latitude and longitude. DBDB5 is an update of the SYNBAPS II bathymetric database with modifications to the Northern Hemisphere, including the addition of the entire Arctic region up to the North Pole and the addition of the elevation of land points above sea level. The original DBDB5 data set was produced by the Naval Oceanographic Office under the sponsorship of the Office of Naval Research. The coastlines in DBDB5 are based on the World Data Base II (WDBII), digitized by the Central Intelligence Agency (1977).

3.0 EXTRACTING A BATHYMETRIC DATA FILE

The first option available from the main menu allows the user to extract bathymetric files from the ETOPO5 database. The database is stored in a file named BATHY.DAT (using the same format as the SYNBAPS data set) in the directory /home/argus/woodyard/xbathy/bathydata. Once the user has chosen a parameter file, the extraction of the data from the ETOPO5 database begins. As the extraction is performed the following messages are displayed to the screen. After every 25 records have been extracted, a message is sent to the screen listing the record number.

```
Checking to see if BATHY.DAT is available.

In luck! BATHY.DAT is already on the disk.

  DATA EXTRACTION PHASE

  OPENING BATHYMETRIC DATABASE
    WRITING OUTPUT RECORD FOR J =  25
    WRITING OUTPUT RECORD FOR J =  50
    WRITING OUTPUT RECORD FOR J =  75

END OF DATA EXTRACTION PHASE
```

Once the data have been extracted from the ETOPO5 database, this routine guides the user through a series of questions that will put the output file in the proper format for the Naval Layered Ocean Model. These include the model label (a three-digit number used to identify the resolution and domain of the model), HTOT (a depth equal to, or greater than the maximum topography depth; used by the model for scaling), and the depth of the land-sea boundary. The land-sea boundary depth value allows the selection of a depth at which the model coastline will occur. In practice, 200 m is used as the land-sea boundary in the NRL global- and regional-scale models. Values of 0.0 or less in the ETOPO5 database will be considered land points. Values greater than the value entered for the land-sea boundary are considered sea points, and those less than the land-sea boundary and greater than zero will be model land/plot sea points. In the file, model land/plot sea points are denoted by values of −1.0 and land points by values of −10.0.

```
DATA FORMATTING PHASE

     READING BINARY INPUT DATA

  ENTER LABEL (NUMBER) FROM OCEAN MODEL    LABEL1 ==> "133 "

  MAXIMUM BATHYMETRIC DEPTH IN DATA SET IS         ==> 6500.

  HTOT IS USED IN THE MODEL FOR SCALING. IT MUST BE
  GREATER THAN OR EQUAL TO THE MAXIMUM DEPTH.

  ENTER MAXIMUM MODEL BASIN DEPTH          HTOT    ==> "9999."

  ENTER DEPTH FOR LAND/SEA BOUNDARY        HBNDY   ==> "200."

  PERIODIC EAST/WEST BOUNDARIES?           (T/F)   ==> "f"

     WRITE FORMATTED OUTPUT FILE

END OF DATA FORMATTING PHASE
```

If periodic boundaries are not chosen, then the program will set every sea point on all four of the boundaries to model land/plot sea. If periodic boundaries are chosen, then only the northern and southern boundaries will be converted. After the bathymetry file has been generated, the program returns to the main menu.

3.1 Generating a New Data File

The extracted data set is generated from the ETOPO5 database using a nine-point interpolation scheme. The depth at a given sea point is calculated from the sum of the depths of nine surrounding points from the ETOPO5 data set weighted inversely by their distance from the point in the new data set. In the case where the point to be determined is extremely close (less than 0.0001 of a degree) to a gridpoint, the ETOPO5 value is used for the value of the given data point. This

interpolation technique tends to obscure islands that have deep water near their shore. These missing islands must be added by modifying the new data set to form realistic coastlines. With recognizable land features and islands, the plots are easier to read and provide more accurate model simulations.

BATHYEXT does automatic land masking of the topography file based on the high-resolution coastline contained in WDBII. The program checks the values of the nine ETOPO5 data points surrounding the point to be interpolated in the new data file to determine whether they are land or water. If five or more of these points are land, then the interpolated data point is also considered land.

4.0 PLOTTING A BATHYMETRIC DATA FILE

Once a bathymetry file has been generated, the user may want to display the file. The selection of option 2 from the main menu calls the routines for this to occur. When this option is selected, a parameter file name is selected and then the output file environment variable is chosen.

```
Environment variable (gksout) is required for plotting/printing.

Select your option:

      1. No plots or environment variable already set.
      2. Plots to be displayed in Sun Window.
      3. Plots to be displayed on Tektronix 4107.
      4. Output to be saved in a file (plots going to a printer).
      5. Plots to be displayed in X11 Window.


Enter 1,2,...,5
```

If option 4 is selected, the output is directed to a file and the program prompts the user to enter a file name. The selection of options 2, 3, and 5 direct the output onto the device corresponding to that option.

Once a destination for the output has been selected, the plotting menu appears, offering the following options:

```
DO YOU WANT:

    1. PLOT ONLY
    2. PRINTOUT OF DEPTH AND/OR INTEGER LAND/SEA MAP

            ENTER 1 OR 2 ==>
```

The first option from this menu allows the user to graphically display the file either to a file or to the computer screen. The second option allows the user to numerically display the file.

When option 1 is selected, the program will first ask the user to enter a title for the plot and the boundary between land and sea for the plot. A choice of –5.0 will display the boundary at the actual coastline, while an entry of 0.0 will display the boundary between the model coastline (model land/plot sea gridpoints) and the sea.

```
ENTER 40 CHARACTER TITLE FOR PRINTOUT/PLOT

MODEL LABEL IS 133 TITLE ==> "p133d topography"

ENTER LAND/SEA BOUNDARY DEPTH.
  ENTER -5.0 TO SEE ACTUAL COASTLINE                (HLAND) ==> "200."

THE FOLLOWING DEFAULT VALUES ARE SET.

   1) PLOTS WILL BE DIRECTED TO A POSTSCRIPT FILE
   2) COLOR TABLE FOR A POSTSCRIPT FILE
   3) MAXIMUM CONTOUR LEVEL =                     6500.000
   4) MINIMUM CONTOUR LEVEL =                     0.0000000E+00
   5) CONTOUR INTERVAL =                          500.0000
   6) A PLOT WITH FILL LAND AND DRAW COAST LINE
   7) RATIO (ON PLOT) OF 1 DEG. LAT. TO 1 DEG. LONG. =          1.000000


DO YOU WANT TO CHANGE ANY OF THESE ENTRIES?
                          (Y)ES OR (N)O ==>
```

The default plotting parameters will generate a color plot with thirteen colors. An example of such a plot is in Fig. 1. Examples of other plots which can be made are shown in Figs. 2 and 3. If the user does not wish to use the default plotting parameters, the program will ask if there is a file containing the parameters. If there is, the filename is entered. If not, the values are entered interactively through a series of questions by the program.

```
To modify the default color table or other items,
including the color fill parameters the user must
have a namelist input called CTABL already stored
in a file. Contents of this namelist can be found
in the comments of the Fortran program prplt.f If
you use the namelist input, it is assumed you will
supply all necessary parameters for plotting in
the namelist and you will not be prompted for
them.


DO YOU WANT TO INPUT THE NAMELIST FILE?
    (Y)ES OR (N)O ==>
```

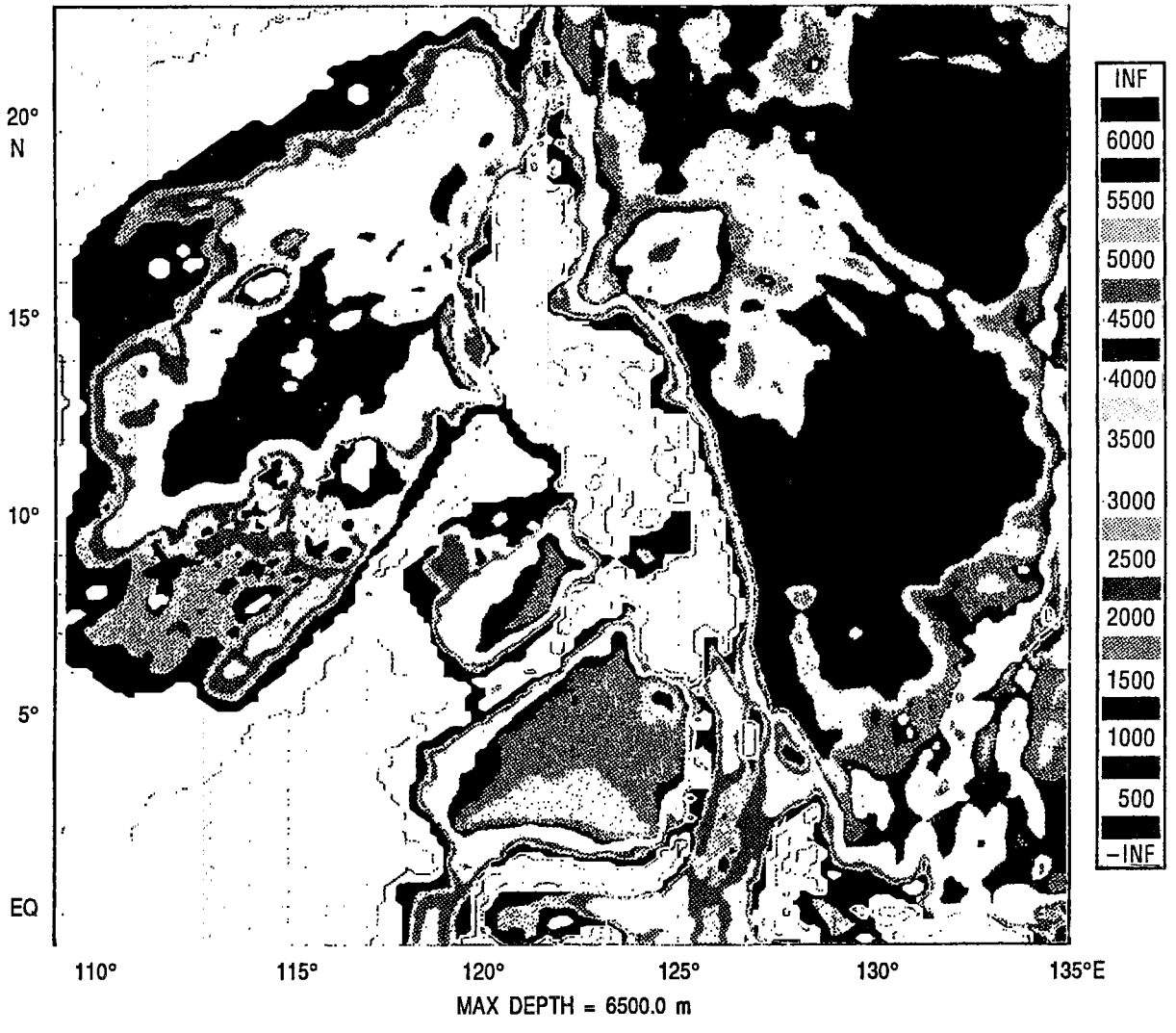

Fig. 1 — Plot of the Pacific Ocean using the default plotting parameters in BATHYEXT.

If the user elects to enter the namelist file interactively, the following questions are asked.

```
SUGGESTED DEVICE TYPES
5401 Sun WORKSTATION
3101 Tektronix 4107
1901 Postscript print file
6651 Tektronix 4693 print file
5300 X11 WORKSTATION
ENTER DEVICE TYPE                                   (IDEVIC)  ==> "1901"
ENTER NEGATIVE VALUE FOR DBT TO SUPPRESS CONTOURING
ENTER MAXIMUM CONTOUR LEVEL                         (BTI)     ==> "6500."
ENTER MINIMUM CONTOUR LEVEL                         (BTL)     ==> "0."
ENTER CONTOUR INTERVAL                              (DBT)     ==> "500."
RATIO (ON PLOT) OF 1 DEG. LAT. TO 1 DEG. LONG.                ==> "1."
```

```
DO YOU WANT:

    1. A PLOT WITH COASTLINE AND LAT-LONG
    2. A PLOT WITH COASTLINE AND NO LAT-LONG
    3. A PLOT WITH FILL LAND AND LAT-LONG
    4. A PLOT WITH FILL LAND AND NO LAT-LONG
    5. A PLOT WITH FILL LAND AND DRAW COAST LINE
EACH OF THE FOLLOWING OPTIONS
EXTEND THE LAT-LONG LINE OVER WATER
    6. A PLOT WITH COASTLINE AND LAT-LONG
    7. A PLOT WITH FILL LAND AND LAT-LONG
    8. A PLOT WITH FILL LAND AND DRAW COAST LINE

        ENTER 1,2,... OR 8 ==> "5"
```

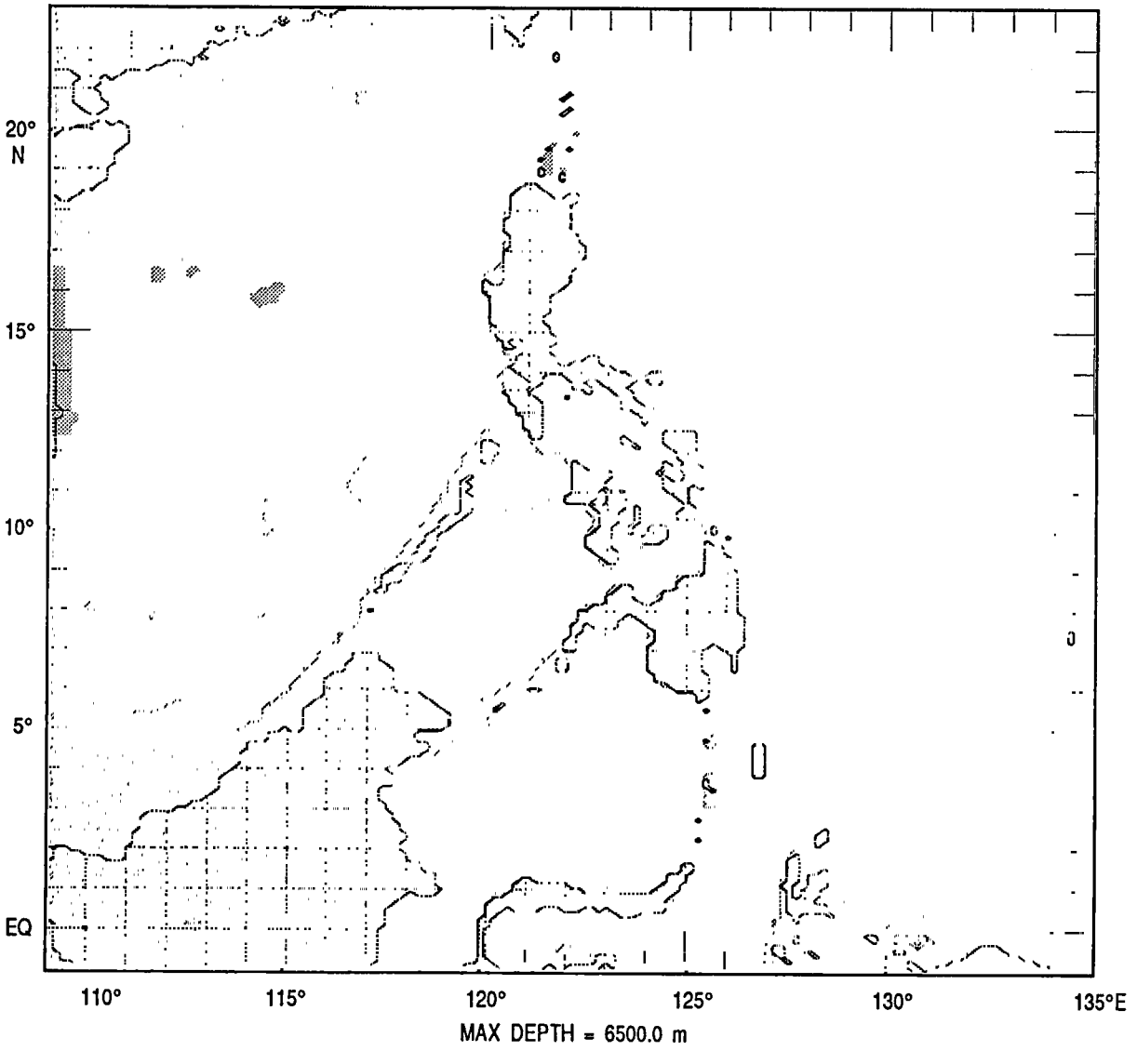

Fig. 2 — Black and white plot of the same region as in Fig. 1 with the contour intervals (DBT) set to zero.

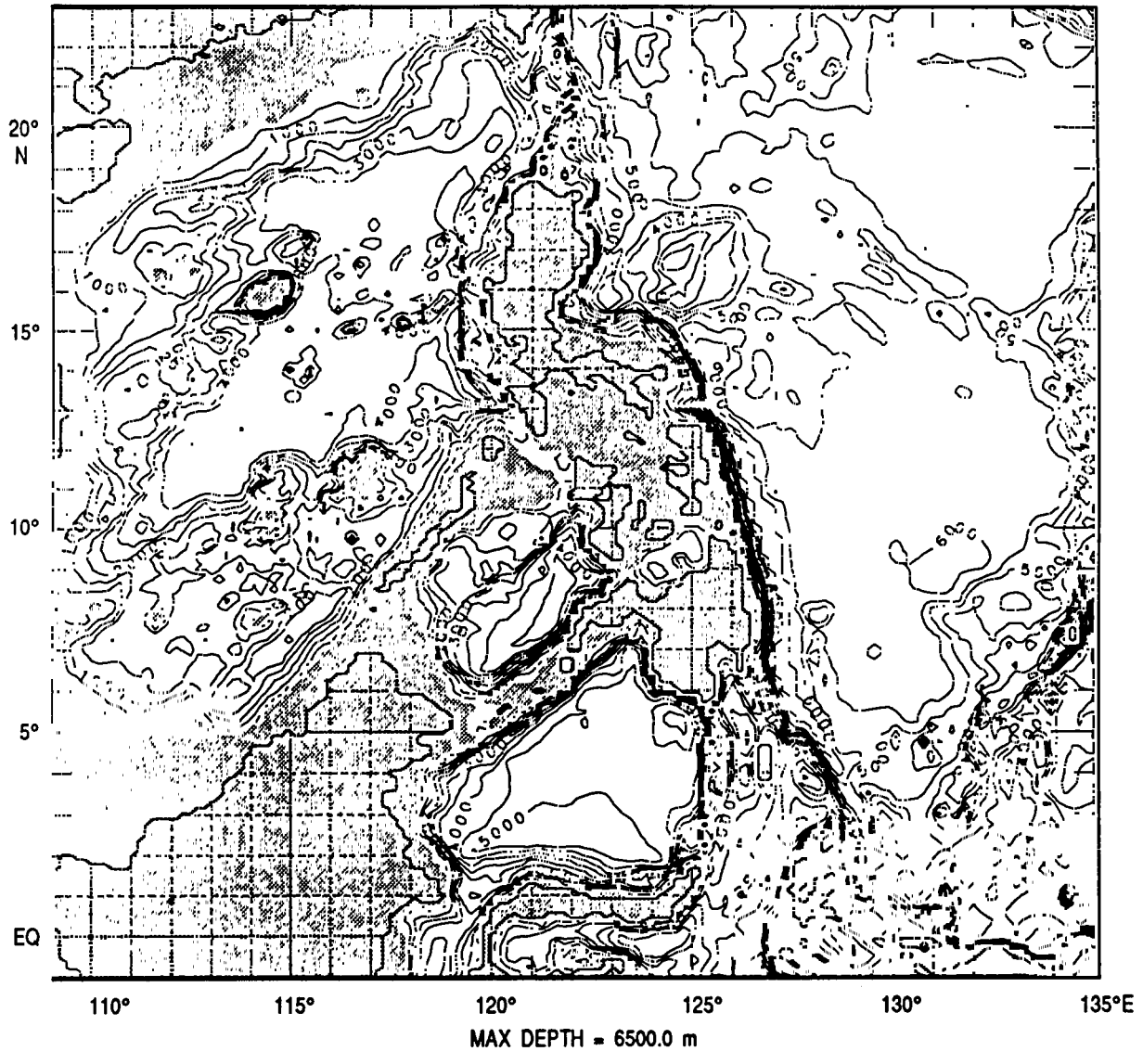

Fig. 3 — Black and white plot of the same region as in Fig. 1 with the contour interval set to 500.

After the plotting parameters have been provided to the computer, the next prompt will define the region for which the plot will be made.

```
DO YOU WANT:

    1. THE ENTIRE REGION
    2. SUB-REGION SPECIFIED BY USER INPUT INDICES
    3. SUB-REGION SPECIFIED BY USER INPUT LAT/LONG
    4. SUB-REGION SPECIFIED BY BLOCKS

        ENTER 1,2,3, OR 4 ==>
```

Option 1 will plot the entire domain defined by the bathymetry file, option 2 will plot a region defined by the user-input gridpoints, option 3 will plot a region defined by the user input latitude

and longitude, and option 4 will divide the entire domain into sections. These sections are defined by the user, who inputs the number of sections in the x and y directions to be plotted. An entry of IROW = 4 and JCOL = 5 will produce 20 plots –4 across in the x direction and 5 up in the y direction. After the plots have been made, if either option 2 or 3 from the region plotting menu was selected, the program will ask if more plots should be made.

After the plotting session has been completed the following messages will appear:

```
DO YOU WISH TO MAKE ANOTHER PLOT?

                    (Y)ES OR (N)O ==>

NORMAL RETURN FROM PRPLT.

PRINT FILE p133d.psp SAVED IN YOUR CURRENT DEFAULT DIRECTORY
```

If the user elects to make more plots, they will be added to the current output file.

After option 2 has been selected, a menu appears which allows the user to select (a) a printout of the bathymetry file depths written to a file or (b) a printout depicting the coastline as given by the bathymetry file.

```
DO YOU WANT A PRINTOUT OF:

   1. BATHYMETRIC DEPTH
   2. INTEGER LAND/SEA MAP
   3. BOTH

      ENTER 1,2, OR 3 ==>
```

After the user elects to print out the bathymetric depths, the following prompt is displayed.

```
DO YOU WISH TO PRINT OUT THE ENTIRE REGION?
                    (Y)ES OR (N)O ==>
```

If the user responds with a Y, the entire file of bathymetric depths is printed out. If the user responds with a N, a prompt appears that asks the user to enter the gridpoints that correspond to the first and last values of the plotting region in the x and y direction.

```
ENTER ISTART, ISTOP, JSTART, JSTOP ==>
```

The following is a portion of listing of a bathymetric depth file.

		58	59	60	61	62	63	64	65
		119.14	119.32	119.50	119.67	119.85	120.02	120.20	120.38
210	6.13	682.5	1283.4	1587.5	1470.4	1929.6	1849.2	1229.7	321.3
209	6.00	648.0	1234.3	1342.7	1597.1	1923.4	1146.9	369.3	-1.0
208	5.88	337.7	599.5	683.0	672.9	615.4	227.2	-1.0	-1.0
207	5.75	-1.0	218.0	288.3	253.6	-1.0	-1.0	-1.0	-1.0
206	5.63	-1.0	-1.0	-1.0	253.6	251.7	288.4	-1.0	-10.0
205	5.50	-1.0	-1.0	-1.0	262.3	295.8	457.5	-10.0	-1.0
204	5.38	-1.0	-1.0	241.6	299.2	358.7	430.5	-1.0	-1.0
203	5.25	-1.0	-1.0	397.2	434.5	507.9	-1.0	-1.0	258.1
202	5.13	-1.0	-1.0	387.3	497.3	302.1	-1.0	396.2	1091.0

The following is a portion of an integer land/sea map. These maps provide a depiction of the land and sea points for the entire domain, along with the latitude and longitude of the points and indices for the points in the x and y direction.

*126.7031E *128.4609E *130.2188E *131.9766E *133.7344E

J = 450 36.1250N ########## #####77... ....777#7 .....
J = 449 36.0000N ########## ######7... ....77#77 7.....
J = 448 35.8750N ########## ######7... ....777777 7.....77
J = 447 35.7500N ########## ######7... ....777777 777...7777
J = 446 35.6250N ########## ######70.. ......7777 7777777777 777######7
J = 445 35.5000N ########## #####70000 .....77777 77777##### ##########
J = 444 35.3750N ########## #####00000 00000#7777 7777###### ##########
J = 443 35.2500N ########## ####700000 0000077777 777####### ##########
J = 442 35.1250N ########## ###7700000 0000777777 77######## ##########
J = 441 35.0000N ########## 7777000000 0007777777 7######### ##########

where # is a land point,

7 is model land/plot sea point,

0 represents a sea point shallower than the land/sea boundary,

. represents a sea point deeper than the land/sea boundary.

5.0 MODIFYING A BATHYMETRIC DATA FILE

The selection of option 3 from the main menu allows the user to modify an existing topography file. After the appropriate parameter has been selected, the topography file modification begins. The first prompt displayed by the program allows the user to enter a substitution code and a corresponding data value. The substitution codes allow the user to modify the individual points in the bathymetry file by entering the substitution code corresponding to a particular value rather than typing multiple key strokes.

The next prompt allows the user to select the rate at which the display will be refreshed during the modification. For most applications, a value of 1 is suggested. Next, the subregion map will appear. This display allows the user to move through the topography, to view bathymetry depths, to and edit the individual points.

The subregion map displays a 20×10 array of symbols which correspond to the type of data which exists at that gridpoint. An 8 is displayed for sea points, a 7 for model land/plot sea, and a 1 for land points. This display will also list the depth of the gridpoint being operated upon, with a value of –10.0 being displayed for land points and –1.0 for model land/plot sea points.

```
SUBREGION MAP

ACTION CODES ARE: P - CHANGE POSITION, V - CHANGE VALUE, O - TOPMOD, X - EXIT
L - RIGHT, H - LEFT, K - UP, J - DOWN, W - REFRESH, Q - QUIT
R - MOVE TO POINT NEAREST INPUT LAT,LONG, D - DISPLAY BATHYMETRIC DEPTHS

                                        CODE      VALUE
105       88888888 8888888888 88          1      -10.00000
104       88888888 8888888888 81          7       -1.00000
103       88888888 8888888888 81
102       88888888 8888888888 88
101       88888888 8888888888 88
100      >88888888 8888178888 88
99        88111111 8888888888 88
98        88111111 8888888888 88
97        88118888 8888888888 88
96        88888888 8888888888 88
                    ^
                   102

POINT (126.9010E, 7.6250S) HD(102,100) = 1.4562600E+03

ENTER ACTION CODE OR SUBSTITUTION CODE ==>
```

The user can choose the following options:

```
1) K  - INCREMENT J
2) J  - DECREMENT J
3) H  - DECREMENT I
4) L  - INCREMENT I
5) P  - POSITION TO A NEW POINT HD(I,J)
6) R  - MOVE TO A NEW LAT/LONG POSITION
7) V  - INPUT A NEW VALUE FOR HD(I,J)
8) O  - USE THE TOPMOD PROGRAM
9) D  - DISPLAY BATHYMETRY DEPTHS
10) W - REFRESH DISPLAY
11) Q - QUIT, DO NOT SAVE CHANGES
12) X - EXIT
```

Movement in this discussion refers to the changing of location by the program from one gridpoint to another. The first six action codes are related to movement through the file, with the first four action codes allowing the user to move through the data, at a user-specified rate of 1 to 9 gridpoints in the selected direction. The option P allows the user to move to a specified gridpoint, and option R allows the user to move to a point specified by an input latitude and longitude. Option V allows the user to change the value of a gridpoint from the current value to a new one. Substitution codes can also be used to modify the values at gridpoints. For example, all that would be needed to change the current gridpoint to a model land point would be to enter option 1 when prompted to enter a new command.

Option D allows the display of the bathymetry in a 9×9 gridpoint array centered around the current location as shown below:

```
SUBREGION MAP

ACTION CODES ARE: P - CHANGE POSITION, V - CHANGE VALUE, O - TOPMOD, X - EXIT
L - RIGHT, H - LEFT, K - UP, J - DOWN, W - REFRESH Q - QUIT
R - MOVE TO POINT NEAREST INPUT LAT,LONG D - DISPLAY BATHYMETRIC DEPTHS

104     4040.4  4405.6  4495.3  4472.7  4002.5  4398.0  4373.0  4827.9  4957.8
103     4046.3  4464.6  4570.2  4632.7  4222.9  4108.0  3948.6  4772.2  4947.1
102     4377.0  4448.5  4389.1  4555.1  4431.6  3370.1  2594.9  3480.8  3906.1
101     4067.9  3945.4  3094.2  3202.1  3722.2  2896.1  1644.3  1261.2  1842.2
100    >1542.8  1072.8  1000.0   473.0  1456.3  1877.8  1200.9   -10.0    -1.0
 99      -10.0   -10.0   -10.0   500.0  1041.7  1568.1  1249.8  1088.7  2326.5
 98      -10.0   -10.0   -10.0  1644.1  2408.8  2579.5  1994.5  2023.7  2167.2
 97     1243.7  1047.8  1286.4  2607.1  2767.9  2392.2  1338.0  2280.0  2404.7
 96     2683.8  2862.1  2817.8  2839.8  2665.8  2214.6  1328.7  2331.2  1489.0
                                          ^
                                         102

POINT (126.9010E, 7.6250S) HD(102,100) = 1.4562600E+03

ENTER ACTION CODE OR SUBSTITUTION CODE ==>
```

Option O allows the modification of bathymetry values over large areas to a single value using the topmod option. This option is especially well suited for modifying large areas of the bathymetry, especially when the changes are uniform over the entire area. When the topmod option is selected, the program first asks the user to define the region to be modified.

```
I,J INDICES FOR CORNERS OF AREA TO BE CHANGED:

ENTER LOWER LEFT INDICES (0,0 TO EXIT)                I,J ==> "1,1"

ENTER UPPER RIGHT INDICES                             I,J ==> "2,2"

YOU JUST ENTERED ( 1, 1) FOR THE LOWER LEFT
                AND ( 2, 2) FOR THE UPPER RIGHT CORNER

ARE THESE O.K.?                              (Y)ES OR (N)O ==>

ENTER MODIFICATION TYPE (0 FOR LIST OF TYPES) ==>
```

After the region has been selected, the program asks for modification type. The choices are:

```
VALID TYPES ARE 1, 2, 3, 4, AND 5.

1 ==> CHANGE ALL SEA POINT WITHIN THE REGION TO
      MODEL-LAND/PLOT-SEA POINTS WHILE LEAVING LAND POINTS UNCHANGED

2 ==> CHANGE ALL POINTS TO THE SAME VALUE

3 ==> CHANGE POINTS INDIVIDUALLY

4 ==> CHANGE ALL SEA POINTS THAT ARE SHALLOWER THAN
      A GIVEN VALUE TO SOME OTHER VALUE

5 ==> CHANGE ALL SEA POINTS THAT ARE DEEPER THAN
      A GIVEN VALUE TO SOME OTHER VALUE

ENTER MODIFICATION TYPE (0 FOR LIST OF TYPES) ==>
```

Typing option 3 allows the user to interactively change every point within the region selected, so care must be made in the selection of a suitably sized region. These choices allow the user maximum flexibility and convenience in modifying large regions depicted by the bathymetry file.

The W action code redraws the screen and the Q action code allows the user to exit the program without any modification of the current topography file. The X code allows the user to exit the program, saving any changes made to the file in a new file. When the X action code is selected, the program queries the user for any changes to the program name, the program label, and the HTOT parameter. HTOT is used in the Naval Layered Ocean Model as a scaling factor for the amplitude of the bathymetry and has to be larger than the deepest point in the bathymetry file. As mentioned, the changes are saved to a new file; if that file name already exists, the already existing file will be renamed by adding the suffix .bck1 to the root file name. If a file already has the .bck1 suffix, it will be renamed with a .bck2 suffix. There can be up to five backup copies with the same root name.

6.0 SMOOTHING A DATA SET

To reduce sharp depth gradients in the bathymetry, BATHYEXT allows the user to smooth the data sets. The smoothing can be done in two ways: using either a nine-point smoother or a nonlinear smoother. When option 4 is selected from the main menu, the data file can be smoothed using a nine-point smoother. The smoothed values are calculated by using a weighted average of nine data points with the point to be smoothed in the center. Shown below are the relative weights:

$$\begin{matrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{matrix}$$

Only sea points are included in the smoothing process and gridpoints cannot be changed from land to water or vice versa. Usually two passes of the nine-point smoother are sufficient to remove the sharp gradients from the bathymetry file.

Once the data set smoothing process begins the following messages appear:

```
DATA SET SMOOTHING PHASE
READING INPUT FROM FILE                    ==> "top133cj.d"
THIS PROGRAM IS USED TO APPLY A NINE-POINT REAL SMOOTHER A SPECIFIED
NUMBER OF TIMES.
THE MODEL LABEL FOR THIS DATA SET IS 133
ENTER THE NUMBER OF TIMES YOU WISH TO APPLY THE SMOOTHER: ISMTH == > "2"
```

In response to the prompt from the program, the user enters the number of times the data is to be smoothed. During each iteration of the data, the program indicates the number of times the data have been smoothed. When the program is finished, the new maximum depth of the data is written out, and the program allows the user to change the file name, the model label, and the HTOT of the smoothed data set; otherwise, they remain the same as the input file. The program then returns to the main menu.

```
APPLY NINE-POINT REAL SMOOTHER      2 TIMES
APPLYING SMOOTHER                   1 TIME
APPLYING SMOOTHER                   2 TIMES

THE NEW MAXIMUM DEPTH IS            6498.8M.

WRITING OUTPUT TO FILE                        ==> "top133cj.sm2.d"
```

If option 5 is selected from the main menu, the smoothing is done using a nonlinear smoother. A value greater than 1 and less than 3 is entered into the program as a multiplier. This scaling factor is used as a limit on the data set to make sure that the ratio of the depths of all adjoining data points is less than the multiplier.

```
THIS PROGRAM IS USED TO APPLY A NON-LINEAR SMOOTHER.
THE MODEL LABEL FOR THIS DATA SET IS 133
ENTER THE LARGEST MULTIPLIER BETWEEN ADJACENT GRID POINTS:    DMULT ==> "1.8"
```

After the smoothing is finished, a message will appear indicating the number of points which were smoothed.

```
NON-LINEAR SMOOTHER ALTERED 27780 ( 6.19%) OF THE NODES.
```

7.0 SUMMARY

This report details the suite of routines that comprise the BATHYEXT program. This robust set of user-friendly programs facilitates the management of bathymetric data sets. BATHYEXT was developed to support the oceanographic modeling efforts at NRL. This program allows the development of accurate bathymetric files that are needed to simulate the oceanic circulations over a wide range of spatial and temporal scales.

ACKNOWLEDGMENTS

This work was performed as part of the Naval Research Laboratory Global Ocean Prediction System projects. These components of the Navy Ocean Modeling Program were managed by Robert Peloquin under program elements 0602435N and 0603207N.

REFERENCES

Central Intelligence Agency, *WDBII General Users Guide*, (Washington, D.C., unpublished, 1977) p. 7.

Sloss, P. W., *Relief Surface of the Earth*, (Marine Geology and Geophysics Division, National Geophysical Data Center, Boulder, CO, unpublished, 1986) p. 3.

VanWykhouse, R.J., "Synthetic Bathymetric Profiling System (SYNBAPS)," Naval Oceanographic Office, Stennis Space Center, MS, NAVOCEANO Technical Note TR-233, 1973.