Non-navigational GRIDDED BATHYMETRY DATA Washington - Oregon Coast : 1926-1998

Data release and description of methods

Version 1.0

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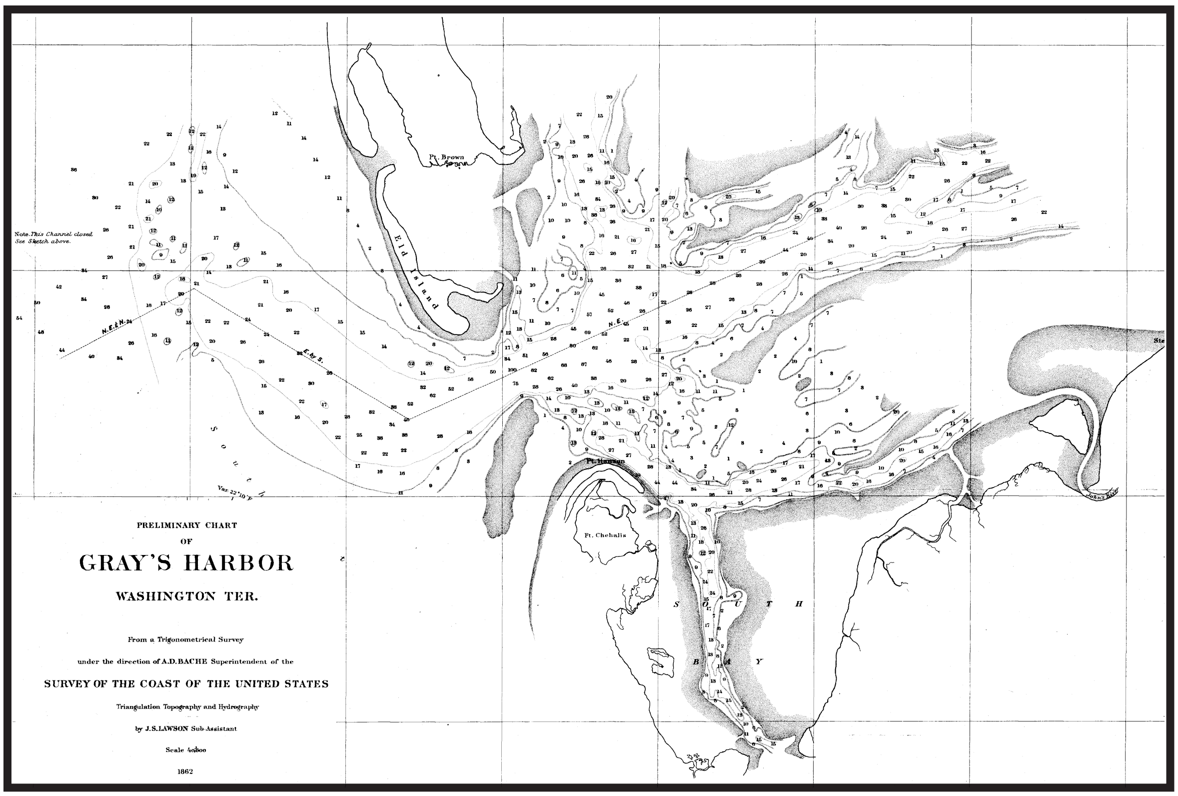

Open-File Report 00-448

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS USED IN THIS REPORT

ASCII	Standard text format
FAQ	Frequently Asked Question
FGDC	Federal Geographic Data Committee
HTML	Hypertext markup language
LIDAR	LIght Detection And Ranging
MAC	Apple Macintosh Computer/Operating System
MLLW	Mean Lower Low Water; vertical datum
NAD27	North American Datum of 1927; horizontal datum
NAD83	North American Datum of 1983; horizontal datum
NOAA	National Oceanic and Atmospheric Administration; U.S. Department of Commerce
NOS	National Ocean Service
ORWA	Oregon-Washington; boundary of large, regional data set
ORWA26	Large, regional surface grid data set including historical data circa 1926
ORWA98	Large, regional surface grid data set including modern data circa 1998
PC	Personal Computer (Microsoft Windows Operating System compatible)
SHOALS	Airborne LIDAR hydrographic data acquisition system
SWWA	Southwest Washington; boundary of study area data set
SWWA26	Study area surface grid data set including historical data circa 1926
SWWA98	Study area surface grid data set including modern data circa 1998
USACE	U.S. Army Corps of Engineers
USC&GS	U.S. Coast and Geodetic Survey
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WASP	Washington Stateplane South

INTRODUCTION

Sixteen digital bathymetric surface models (grids) of the seafloor off the coast of Washington and Oregon were created for wave modeling experiments along the coast of Washington. Surfaces were created for two areas over two time periods. The largest area (covering approximately 46 million km^2) extends along the coast of Oregon and Washington, between Heceta Head OR and Cape Johnson WA, from the shoreline to about 2000 -m water depth (hereafter referred to as the ORWA region; Fig. 1). The second area (covering approximately 7 million km^2) extends from Tillamook Head OR to Pt. Grenville WA, from the shore to approximately 700-m water depth. This area corresponds to the study area boundaries of the Southwest Washington Coastal Erosion Study (Kaminsky *et al.,* 1997, Gelfenbaum and Kaminsky, 1998; 1999) and is hereafter referred to as the SWWA region (Fig. 2). Surfaces defined by the ORWA and SWWA regions were created for two time periods; historical (circa 1926), and modern (a combination of c.1926 and 1998 as discussed below). Data are presented in both UTM and Washington State Plane South coordinate systems, at 500-m and 750-m grid cell spacing, in ARC/INFO 7.1 (ESRI), SURFER 6.0 (Golden Software), and ASCII formats. The vertical datum is mean lower low water (MLLW).

This report describes the data sets used and the methodology and techniques applied to create the historical and modern bathymetric surfaces. A companion CD-ROM including the bathymetric surface data, shorelines, and bathymetric contours accompanies this report. These data are intended for scientific research and should not be used for navigational purposes. The use of trade names or products does not imply endorsement by the U.S. Geological Survey.

This work was conducted in conjunction with the Southwest Washington Coastal Erosion Study (SWCES), a cooperative project directed by the U.S. Geological Survey, Coastal and Marine Geology Program and the Washington State Department of Ecology. A description of the study and initial results can be found in Kaminsky *et al.* (1997) and Gelfenbaum and Kaminsky (1998 and 1999), and online at: http://www.ecy.wa/programs/sea/swce.

DESCRIPTION OF DATA

Original hydrographic sounding data were acquired from two sources: NOAA-National Ocean Service (NOS; formerly U.S. Coast and Geodetic Survey; USC&GS; NGDC, 1998) and the U.S. Army Corps of Engineers (USACE, H. Rod Moritz and Eric Nelson, written comm.).

The historical sounding data (also referred to as the 1926 data) are originally from hydrographic surveys conducted between 1926 and 1974 by the NOS (Tables 1 and 2). The majority of historical data were collected between 1926 and 1930, however, where 1926-30 data did not exist, or were not available in digital format, data collected as recently as 1974 were used. These represent the most recent hydrographic surveys available on a region-wide scale off the coast of Oregon and Washington.

Modern sounding data (also referred to as the 1998 data) include data from hydrographic surveys collected around Grays Harbor, Willapa Bay, and Columbia River mouth by the USACE (Table 2, Fig. 3). Some data were also constructed by the authors to ensure the smooth transitions between the historical and modern bathymetry (refer to the section *Generating the Modern 1998 Hydrographic Data Set* for a more complete discussion).

Shoreline files are included in SURFER .bln and ARC/INFO arc coverage formats for reference. The coastline files (orwanoaacst and swwanoaacst) were derived from NOAA medium resolution, 1:70,000, vector shorelines (NOAA,1994). The data file ORWANOAACST includes data revised between July 1989 and September 1991; the data file SWWANOAACST includes data revised between March 1991 and September 1991.

DATA PROCESSING

Data were processed using both ARC/INFO (v. 7.1) and SURFER32 (v 6.0). Original NOS point data were projected from geographic units (latitude/longitude, datum NAD27) to the Washington State Plane South coordinate system (datum NAD83). Non-sounding data (cartographic code not equal to 711; rocks awash, pilings, etc.) and obviously erroneous or questionable data (based on contour *donuts*, trackline crossing inconsistencies, etc.) were edited out of the data set. USACE data for Grays Harbor and Willapa Bay were converted from Washington State Plane South (feet) and for the Columbia River from Oregon State Plane (feet). SURFER was used to generate preliminary grids of all the data. Data editing and final grid construction was completed using ARC/INFO.

Individual grids were processed using different data sets and gridding methodologies. Grid boundaries for the SWWA and ORWA grids are listed in Tables 3 and 4, respectively.

The SWWA26 grid was created by gridding three subsets of edited NOS point data (midshore; nearshore; shoreface; Fig. 2) using parameters that best fit the individual data set. Subset boundaries were determined based on differences in the original 1926 survey scale, sounding distribution, and data precision (see Gibbs and Gelfenbaum, 1999 for a more detailed description). Each subset was gridded separately in SURFER, using the processing steps outlined in Table 5, then imported into ARC/INFO, clipped to its specific boundary, and merged with the other sub-grids to create the final SWWA26 surface.

The SWWA98 grid is the SWWA26 grid with a subset of merged and gridded 1926/1998 point data nested within it. The merged 1926/1998 point data set includes both the 1998 USACE hydrographic data from the approaches to and ebb-tidal deltas of Grays Harbor, Willapa Bay, and the Columbia River, and portions of the 1926 NOS hydrographic data set. Because of large changes that have occurred in the location and morphology of these ebb-tidal deltas since 1926, the merged data have, in places, abrupt and irregular boundaries. In order to obtain a smooth transition across the survey boundaries, data was edited, modified, and, where necessary, point data added, based on inferred shoreface and ebb-tidal delta morphology. This modified and merged 1926/1998 data set was then gridded, clipped to the modified 1998 survey boundaries, and mosaicked with SWWA26 to produce the final SWWA98 surface. Specific techniques used to create the merged 1926/1998 point data set are discussed in the following section *Generating The Modern 1998 Hydrographic Data Set.* Specific grid processing parameters used to create SWWA98 are shown in Table 6.

The ORWA grids include gridded raw, unedited NOS hydrographic data with the more rigorously edited and processed SWWA grids nested within them. The NOS point data were gridded using a linear kriging algorithm, matrix smoothed, and mosaicked with either the SWWA26 or SWWA98 grid to create the final ORWA26 and ORWA98 surfaces, respectively. Specific processing parameters are shown in Table 7.

GENERATING THE MODERN 1998 HYDROGRAPHIC DATA SET

The discussion below describes the techniques employed to create the merged 1926/1998 hydrographic data set for the Columbia River, Willapa Bay, and Grays Harbor. The individual sections describe the data that were collected, any problems that were identified when combining the 1926 and 1998 data sets, and finally the specific modifications made to the original data to generate smooth transitions between the merged data sets. Although this work gives a reasonable estimate of the modern seafloor morphology, the user is cautioned to only use this data set with full knowledge of the original intent (wave modeling experiments), the limitations, and assumptions used to generate it. The data should not be used for navigational purposes.

COLUMBIA RIVER

Data collection and final results:

The Portland District USACE collected single channel echosounder surveys at the entrance and approaches to the Columbia River during the summer of 1998 (Fig. 4). Data from the two northernmost lines were not included because of anomalously deep (1 to 3-m deeper) values. Contours generated from the final merged and edited 1926/1998 data are shown in Figure 5.

Comparison between 1926 and 1998 data:

Contours generated from the merged but not edited 1926 and 1998 data set show a generally smooth transition between the two data sets across the northern boundary (Fig. 6). No additional data editing or processing was applied in this area. Across the southern boundary, however, the 1926 contours are dramatically skewed offshore relative to the 1998 contours (up to 350-m near 20-m water depth, with less offset in shallower and deeper water; Fig. 7a). The large offset in the contours across this boundary suggests dramatic steepening of the shoreface and nearshore between 1926 and 1998. This offset may also be enhanced as a result of registration and surveying errors within the 1926 survey set as discussed in Gibbs and Gelfenbaum (1999).

Data Modification:

To smooth the offset across the southern boundary of the 1926/1998 data set, an approximately 10-km x 5-km polygon of 1926 data was deleted and thirty-four linear contours between 11-m and 50-m water depth were added (Fig. 7b). The size of the polygon was selected to eliminate the sharp or angular transition between the two data sets (Fig. 7c). The 1926 contours portray the offshore morphology in this area as sinuous (Fig. 7a). In contrast, contours generated by the merged 1926/1998 data are more linear.

WILLAPA BAY

Data collection and results:

The Seattle District USACE, in conjunction with the USACE Waterways Experiment Station (Vicksburg Mississippi), collected single-channel echosounder surveys and high density SHOALS LIDAR surveys at the entrance to Willapa Bay during the summer of 1998 (Fig. 8). The original data set was clipped to include only data seaward of the inlet and any overlapping points were eliminated. Contours of merged and edited 1926/1998 data are shown in Figures 8 and 9c.

Comparison between 1926 and 1998 data:

The position of the Willapa Bay ebb-tidal delta migrated about 4.5-km northwestward between 1926 and 1998. Unfortunately, the 1998 USACE hydrographic survey did not cover the northern nor seaward extent of the entire ebb-tidal delta (Fig. 9a). In order to obtain a reasonable modern ebb-tidal delta surface, considerable data manipulation was required. The resulting data set should be considered an interim “best guess” and should not be used for any rigorous analysis.

Data Modification:

To generate a complete data set for the 1998 Willapa Bay ebb-tidal delta surface, data from the 1926 Willapa Bay ebb-tidal delta were shifted 4496-m northeast (from 221741.698 158005.741 to 222091.341 162488.038; a total of 4495.917-m) so that the -10m contour from both 1926 and 1998 ebb-tidal deltas coincided. These data were then rotated 4 degrees counter-clockwise around the center of the ebb-tidal shield (223394.744 157290.476) such that the rotated shoreface contours became coincident with the non-rotated 1926 contours north of the ebb-tidal delta. This “shifted” data set was added to the 1998 USACE data to create the northern boundary of the Willapa Bay ebb-tidal delta (Fig. 9b). Offshore and to the south of the 1998 ebb-tidal delta, six contours were added, at 5-m intervals, between 10-m and 40-m, in order to generate an outer edge of the delta, and a smooth transition with the 1926 contours to the south (Fig. 9b).

The results of the process described above are shown as contours in Figure 9c. The final results are poor. The seaward edge of the delta is likely too steep and the northern edge remains problematic. Multibeam surveys collected during the summer of 1999 by the Southwest Washington Coastal Erosion Study (Flood *et al*., 2000) cross the outer edges of the Willapa Bay ebb-tidal delta and will help constrain the morphology of this feature. Those data will be included in any future versions of this data release.

GRAYS HARBOR

Data collection and results:

The Seattle District USACE collected single-channel echosounder surveys at the entrance and approaches to Grays Harbor during the summer of 1998 (Fig. 10). Six overlapping survey tracklines were collected south of the inlet. Sounding data from lines collected from west to east are not included here, as they seem to impart some error to the results. Contours of merged and edited 1926/1998 data are presented in Figure 11.

Comparison between 1926 and 1998 data:

Contours generated from the merged 1926 and 1998 data set show a generally smooth transition between the two data sets across the southern boundary (Fig. 12). No additional data editing or processing was applied in this area. Across the northern boundary, the 1926 contours are offset shoreward relative to the 1998 contours between 0 and ~12-m water depth (Fig. 13a). The offset in contours across this boundary suggests shoaling and deposition of material on the shoreface between 1926 and 1998. The difference may also be enhanced as a result of registration and surveying errors within the 1926 survey set as discussed in Gibbs and Gelfenbaum, 1999.

Data Modification:

To smooth the offset across the northern boundary of the 1926/1998 data set, an approximately 3.5-km x 7-km polygon of 1926 data was deleted and four linear contours were added at 6-m, 8-m, 10-m, and 12-m water depth (Fig. 13b). The shape of the polygon and the length and orientation of the added contours were constrained by the requirement that the transition between the 1998 and 1926 contours were smooth and essentially linear (Fig. 13c).

DATA FORMAT

The following section describes the data directory file structure of the accompanying CD-ROM, the geographic format of the data, and the differences between SURFER and ARC/INFO grid formats.

DATA DIRECTORY FILE STRUCTURE

1_README.TXT	Simple overview of data structure
version_history.txt	OFR version history
OFR00-448.pdf	This document in Adobe Acrobat .pdf format
Acrobat	Adobe Acrobat Reader 4.0; tool for reading .pdf document (PC, MAC)
gzip:	Tools for unzipping data files (PC, UNIX, and MAC)
stateplane:	Data in Washington State Plane South (Zone 5626; NAD83) coordinates
utm:	Data in UTM Zone 10 (NAD83) coordinates

Subdirectories within both stateplane and utm directories include:

- grids: Bathymetric surface grids
  - *.e00 ARC/INFO export files
  - *.asc ARC/INFO ASCII grids
  - *.grd SURFER ASCII grids
  - *.dat ASCII XYZ coordinates
- contours: 1 meter bathymetry contours; ARC/INFO export files only
- shorelines: NOS composite shoreline for ORWA and SWWA areas
  - *.e00 ARC/INFO export files
  - *.bln SURFER blanking file
- pointdata: Hydrographic sounding data
  - .e00 ARC/INFO point coverages
  - .dat ASCII data
- conversions: Conversion programs and useful files
- metadata: FGDC formal metadata
  - *.txt ASCII text
  - *.faq html “frequently asked questions” format
  - *.html html format

GEOGRAPHIC FORMAT

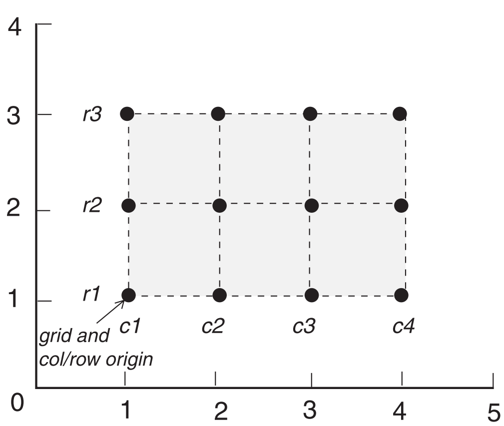
	UTM	WASP
Horizontal datum:	NAD83	NAD83
Vertical datum:	MLLW meters	MLLW meters
Projection:	UTM Zone 10	Washington State Plane South Zone 5626
Ellipsoid:	GRS 1980	GRS 1980

GRID FORMAT: SURFER vs. ARC/INFO

The SURFER and ARC/INFO programs read ASCII gridded data in slightly different formats. SURFER uses a node-based, mesh grid format with values at the nodes. ARC/INFO uses a cell-based raster grid format with values at the center of the grid cells. Both formats have the same total number of columns and rows, and the coordinates of the data values are coincident. However, the boundaries defined by gridded data in the two formats differ. Xmin and ymin values of ARC/INFO grids are offset -1/2 cell-size (dx,dy) relative to SURFER grids, while ARC/INFO xmax and ymax values are 1/2 dx, dy greater. The row-column origin also differs between the two formats. The row-column origin is the lower left corner in SURFER and the upper left corner in ARC/INFO.

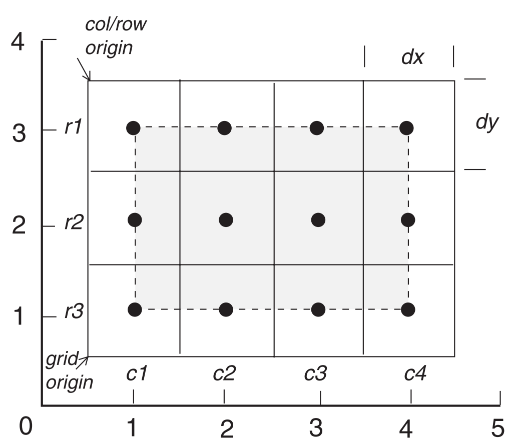
For example:
For the same size grid (4x3; same total number of data points), the ARC/INFO grid origin (xmin, ymin) is 1/2 dx,dy smaller than the same Surfer grid. The maximum extent (xmax, ymax) is 1/2 dx,dy greater.

4x3 Node based mesh grid
(Surfer)



xmin = 1 xmax = 4
ymin = 1 ymax = 3

4x3 Cell based raster grid
(ArcInfo)



xmin = .5 xmax = 4.5
ymin = .5 ymax = 3.5

These differences in data format require that the grids be flipped and headers modified when converting between the two formats. Two programs have been written to achieve this: The FORTRAN program *arc2grd* transposes ARC/INFO ASCII gridded data (*.asc files) into SURFER ASCII gridded data (*.grd files). The Arc Macro Language (AML) application *importsurfergrids.aml* imports SURFER *.grd files into ARC/INFO.

Header Formats

SURFER ASCII header format (.grd)*
DSAA
nrow ncol
xmin ymin
xmax ymax
zmin zmax
line format = 10 numbers per line
followed by a <CR>

ARC/INFO ASCII header format (.asc)*
ncols = xxx
nrows = xxx
xllcenter xxxxxx
yllcenter xxxxxxx
cellsize xxx
NODATA_VALUE -9999

Table 1. NOS hydrographic surveys included in the Oregon-Washington (ORWA) data sets

USC&GS Survey_Year	NGDC Number	LOCATION
H5069_1930	03001002	Northern Washington; shoreface
H5108_1930	03631003	Northern Washington; shoreface
H5107_1930	03631002	Northern Washington; shoreface
H4716_1927*	03NG1148	Central Washington; shoreface
H4715_1927*	03NG1147	Central Washington; shoreface
H4710_1927*	03NG1021	Central Washington; shoreface
H4621_1926*	03NG1015	Willapa Bay; shoreface
H4658_1928*	03NG1020	Willapa Bay; shoreface
H4620_1926*	03NG1142	Willapa Bay; shoreface
H4619_1926*	03NG1014	Washington; shoreface
H4618_1926*	03NG1296	Columbia River mouth; shoreface
H4611_1926*	03NG1342	Northern Oregon; shoreface
H4612_1926*	03NG1012	Northern Oregon; shoreface
H4613_1926	03NG1013	Southern Oregon; shoreface
H8346_1956	03F11531	Southern Oregon; shoreface; 1926 survey missing
H8370_1957	03F11534	Southern Oregon; shoreface; 1926 survey missing
H4745_1927	03NG1023	Southern Oregon; shoreface
H4746_1927	03NG1024	Southern Oregon; shoreface
H4747_1927	03NG1025	Southern Oregon; shoreface
H4748_1927	03NG1026	Southern Oregon; shoreface
H4878_1928	03NG1213	Southern Oregon
H4878a_1928	03NG1214	Southern Oregon; shoreface
H4749_1927	03NG1027	Southern Oregon; shoreface
H4879_1928	03NG1234	Southern Oregon; shoreface
H4880_1928	03NG1033	Southern Oregon; shoreface
H4881_1928	03NG1034	Southern Oregon; shoreface
H4884_1928	03NG1037	Southern Oregon; shoreface
H5110_1930	03631005	Washington; nearshore
H5068_1930	03631001	Washington; nearshore
H4729_1927*	03NG1149	Washington; nearshore
H4728_1927*	03NG1022	Washington; nearshore
H4634_1927*	03NG1016	Oregon/Washington; nearshore
H4635_1926*	03NG1017	Northern Oregon; nearshore
H4637_1926	03NG1145	Southern Oregon; nearshore
H4755_1927	03NG1028	Southern Oregon; nearshore
H4756_1927	03NG1029	Southern Oregon; nearshore
H4882_1928	03NG1035	Southern Oregon; nearshore
H4883_1928	03NG1036	Southern Oregon; nearshore
H4894_1928	03NG1044	Southern Oregon; nearshore
H9413_1974	03121083	Northern Washington; mid-offshore; overlaps with H5114
H9418_1974	03121084	Northern Washington; mid-offshore; overlaps with H5114
H5114_1930	03631073	Northern Washington; mid-offshore
H4735_1927*	03NG1226	Washington; mid-offshore
H4633a_1926*	03NG1143	Oregon/Washington; midshore
H4636_1926*	03NG1018	Northern Oregon; midshore
H4638_1926	03NG1146	Southern Oregon; midshore
H4754_1927	03NG1211	Southern Oregon; midshore
H4758_1927	03NG1151	Southern Oregon; midshore
H4895_1928	03NG1217	Southern Oregon; mid- shore
H4896a_1928	03NG1215	Southernmost Oregon; mid -shore
H4775_1927	03NG1031	Washington; offshore
H4633b_1926	03NG1144	Oregon/Washington; offshore
H4639_1926	03NG1019	Northern Oregon; offshore
H4753_1927	03NG1150	Southern Oregon; offshore
H4757_1927	03NG1030	Southern Oregon; offshore
H4888_1928	03NG1040	Southern Oregon; offshore

* Surveys also within the Southwest Washington (SWWA) area

Table 2. NOS and USACE surveys in the Southwest Washington (SWWA) data sets

USC&GS Survey_Year	NGDC Number	LOCATION
H4716_1927	03NG1148	Central Washington; shoreface
H4715_1927	03NG1147	Central Washington; shoreface
H4710_1927	03NG1021	Central Washington; shoreface
GH98ANP*	USACE	Grays Harbor mouth and approaches
H4621_1926	03NG1015	Willapa Bay; shoreface
H4658_1928	03NG1020	Willapa Bay; shoreface
WB98COE*	USACE	Willapa Bay and ebb tidal delta
H4620_1926	03NG1142	Willapa Bay; shoreface
H4619_1926	03NG1014	Washington; shoreface
PCOE98*	USACE	Columbia River mouth and approaches
H4618_1926	03NG1296	Columbia River mouth; shoreface
H4611_1926	03NG1342	Northern Oregon; shoreface
H4612_1926	03NG1012	Northern Oregon; shoreface
H4729_1927	03NG1149	Washington; nearshore
H4728_1927	03NG1022	Washington; nearshore
H4634_1927	03NG1016	Oregon/Washington; nearshore
H4635_1926	03NG1017	Northern Oregon; nearshore
H4735_1927	03NG1226	Washington; mid-offshore
H4633a_1926	03NG1143	Oregon/Washington; midshore
H4636_1926	03NG1018	Northern Oregon; midshore

* Surveys used in ORWA98 and SWWA98 grids

Table 3. Boundaries of SWWA grids

	UTM	WA State Plane South
FINAL GRIDS	swwa26_500utm swwa26_750utm	swwa26_500sp swwa26_750sp
500m grid	93 columns by 327 rows	117 columns by 324 rows
750m grid	62 columns by 218 rows	78 columns by 216 rows

SURFER grid boundaries

	UTM		WA State Plane South	
500 m grid	xmin: 382500	xmax: 428500	xmin: 190000	xmax: 248000
	ymin: 5081500	ymax: 5244500	ymin: 67000	ymax: 228500
750m grid	xmin: 382500	xmax: 428250	xmin: 190000	xmax: 247750
	ymin: 5081500	ymax: 5244250	ymin: 67000	ymax: 228250

ARC/INFO grid boundaries

	UTM		WA State Plane South	
500 m grid	xmin: 382250	xmax: 428750	xmin: 189750	xmax: 248250
	ymin: 5081250	ymax: 5244750	ymin: 66750	ymax: 228750
750m grid	xmin: 382125	xmax: 428625	xmin: 189625	xmax: 248125
	ymin: 5081125	ymax: 5244625	ymin: 66625	ymax: 228625

Table 4. Boundaries of ORWA grids

	UTM	WA State Plane South
FINAL GRIDS	orwa26_500utm orwa26_750utm orwa98_500utm orwa98_750utm	orwa26_500sp orwa26_750sp orwa98_500sp orwa98_750sp
500m grid	198 columns by 885 rows	243 columns by 891 rows
750m grid	132 columns by 590 rows	162 columns by 594 rows

SURFER grid boundaries

500m grid	xmin: 330000	xmax: 428500	xmin: 127000	xmax: 248000
	ymin: 4875000	ymax: 5317000	ymin: -135500	ymax: 309500
750m grid	xmin: 330000	xmax: 428250	xmin: 127000	xmax: 247750
	ymin: 4875000	ymax: 5316750	ymin: -135500	ymax: 309250

ARC/INFO grid boundaries

500m grid	xmin: 329750	xmax: 428750	xmin: 126750	xmax: 248250
	ymin: 4874750	ymax: 5317250	ymin: -135750	ymax: 309750
750m grid	xmin: 329625	xmax: 428625	xmin: 126625	xmax: 248125
	ymin: 4874625	ymax: 5316750	ymin: -135875	ymax: 309625

Table 5. Processing steps used to create the SWWA26 grid

Projection	**UTM**	**WA State Plane**
FINAL GRIDS	swwa26_500utm swwa26_750utm	swwa26_500sp swwa26_750sp
SUB-GRIDS **Data Source**	swwa26pts_utm	swwa26pts_sp
MIdshore **Processing techniques**	1. Clip points to midshore window 2. Gaussian krig data using: C = 1720; L=83400; nugget = 0.1; search radius = 25000	1. Clip points to midshore window 2. Gaussian krig data using: SURFER defaults (except nugget) C = 3560; L = 90100; nugget = 2
Nearshore **Processing techniques**	1. Clip points to nearshore window 2. Gaussian krig data using: C = 617; L=20000; nugget=2.1; search radius = 20000	1. Clip points to nearshore window 2. Gaussian krig data using: SURFER Defaults. C = 458; L=87300
Shoreface **Processing techniques**	1. Clip points to shoreface window 2. Gaussian krig data using: C = 110; L=83500; nugget=0.09; search radius = 20000	1. Clip points to shoreface window 2. Gaussian krig data using: C = 110; L=83500; nugget=0.09; search radius = 20000
All sub-grids	3. Import gridded data to ARC/INFO, clip to sub-grid boundary and mosaic.	3. Import gridded data to ARC/INFO, clip to sub-grid boundary and mosaic.

Table 6. Processing steps used to create the SWWA98 grid

Projection	UTM	WA State Plane
FINAL GRIDS	swwa98_500utm swwa98_750utm	swwa98_500sp swwa98_750sp
Data source	nest98pts_utm	nest98pts_sp
Processing techniques	1. Gaussian krig data using: C = 1020; L=93000; nugget=0.1; search radius = 30000	1. Gaussian krig data using: C = 197; L=67800; nugget=0.1; search radius = 30000
	2. Import gridded data to ARC	2. Import gridded data to ARC
	3. Erase areas of 1998 data	3. Erase areas of 1998 data
	4. Merge with swwa26_(cellsize)utm	4. Merge with swwa26_(cellsize)sp

Table 7. Processing steps used to create ORWA grids

Projection	UTM	WA State Plane
FINAL GRIDS:	orwa26_500utm orwa26_750utm orwa98_500utm orwa98_750utm	orwa26_500sp orwa26_750sp orwa98_500sp orwa98_750sp
Data source	orwa26pts_utm*	orwa26pts_sp*
Processing techniques	**1.** Linear kriging: Using SURFER defaults (except search radius) C = 27100; A = 227000; search radius = 25000**	**1.** Linear kriging: Using SURFER defaults (except search radius) C = 38200; A = 228000; search radius = 25000**
	2. Matrix smoothed: *500m grid:* weight of matrix center = 2 number of rows on either side =3 number of columns = 3 *750m grid:* weight of matrix center = 2 number of rows on either side =2 number of columns = 2	**2.** Matrix smoothed: *500m grid:* weight of matrix center = 2 number of rows on either side =3 number of columns = 3 *750m grid:* weight of matrix center = 2 number of rows on either side =2 number of columns = 2
	3. SWWA area erased from large ORWA grid and mosaicked with 26 or 98 SWWA grid	**3.** SWWA area erased from large ORWA grid and mosaicked with 26 or 98 SWWA grid

*all NOS points within ORWA area (+1500m to account for smoothing) with cartographic code greater than –9999 (i.e. Sounding values are good)

** Pre-smoothed gridded boundary is 1500m larger than final ORWA grid

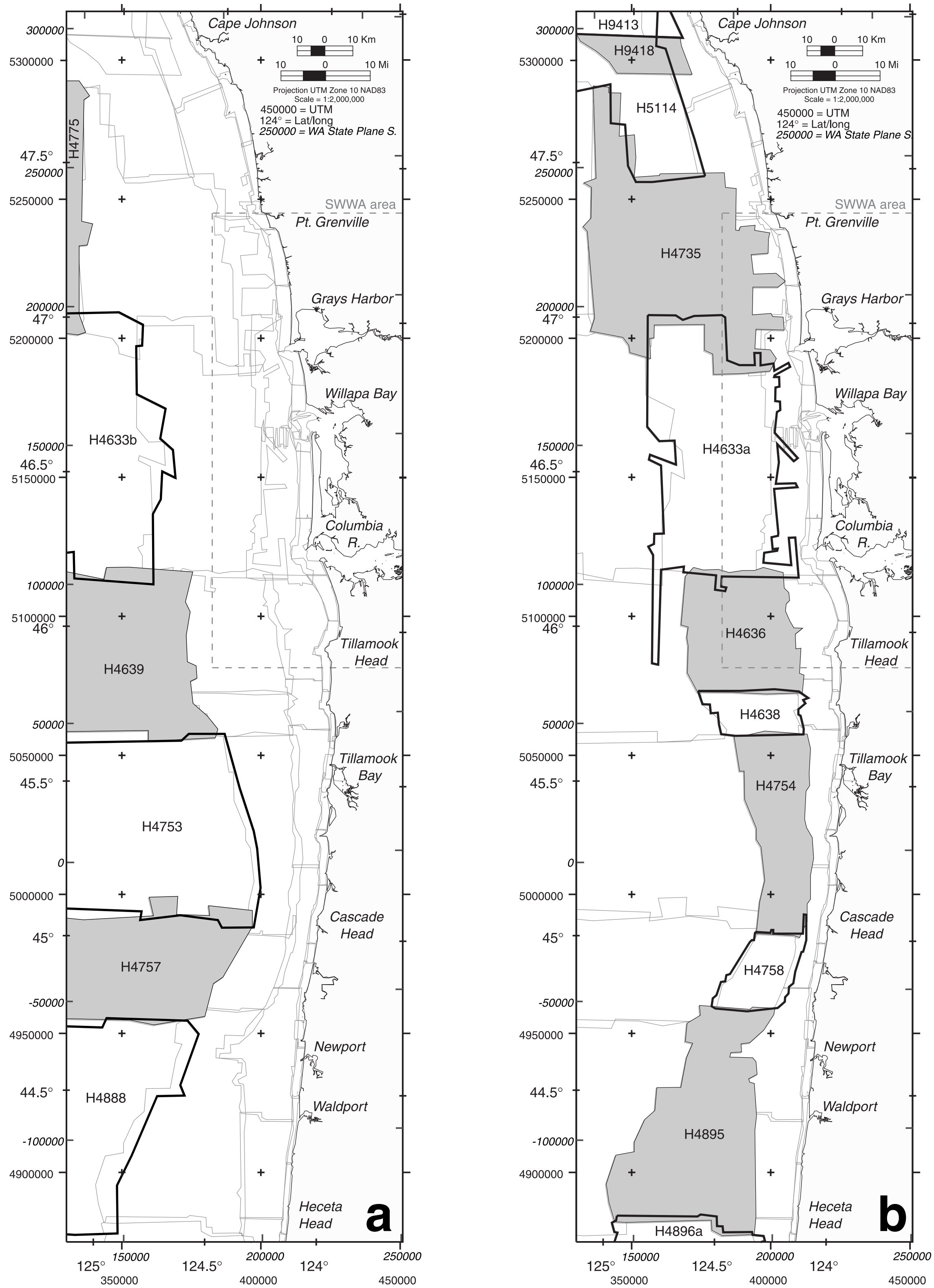


Figure 1a. NOS hydrographic surveys within the Oregon-Washington (ORWA) area. a) Off-shore surveys 1:120,000; b) Midshore surveys; 1:80,000

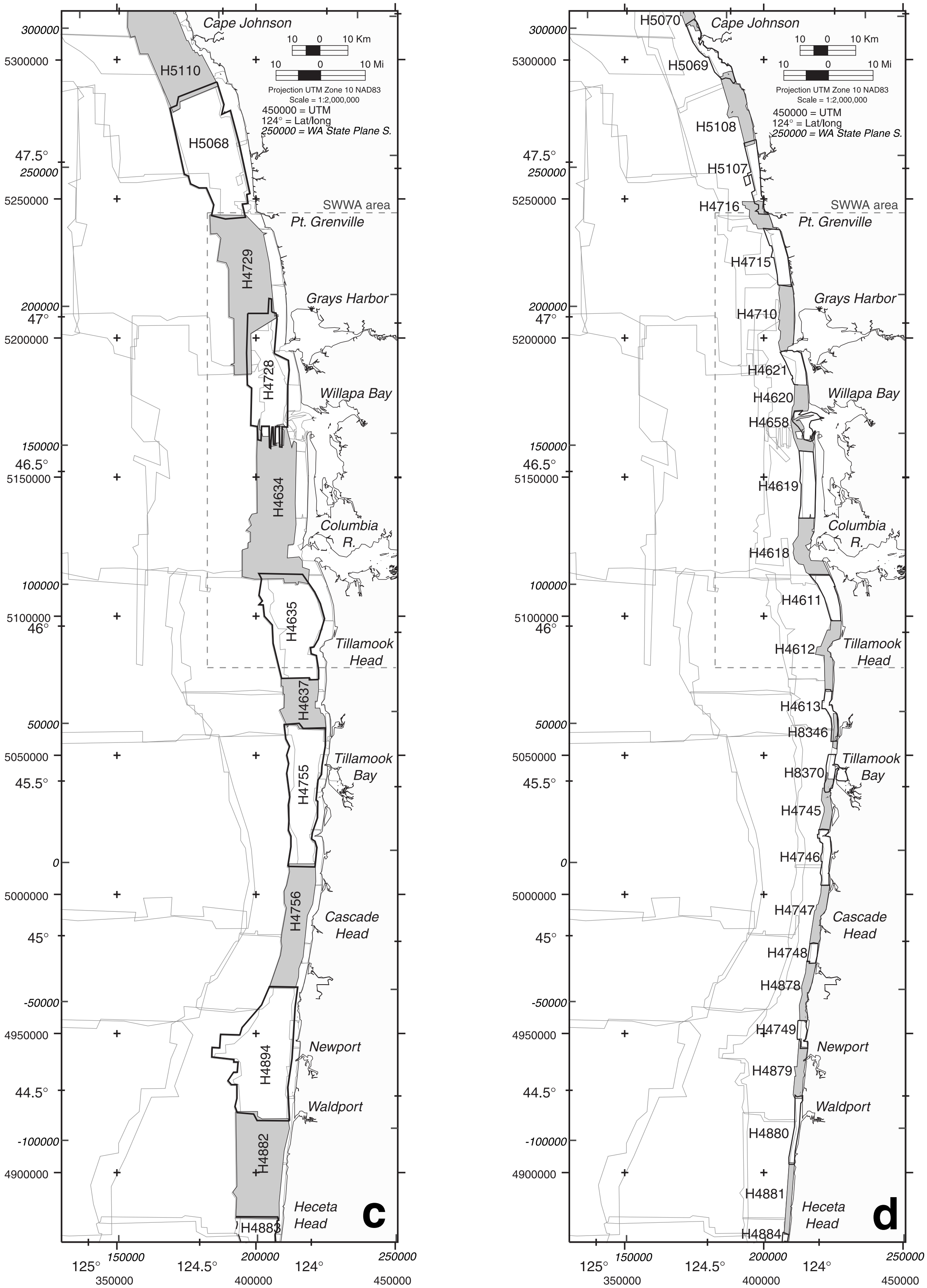


Figure 1b. NOS hydrographic surveys within the Oregon-Washington (ORWA) area. c) Nearshore surveys 1:40,000; d) Shoreface surveys; 1:20,000

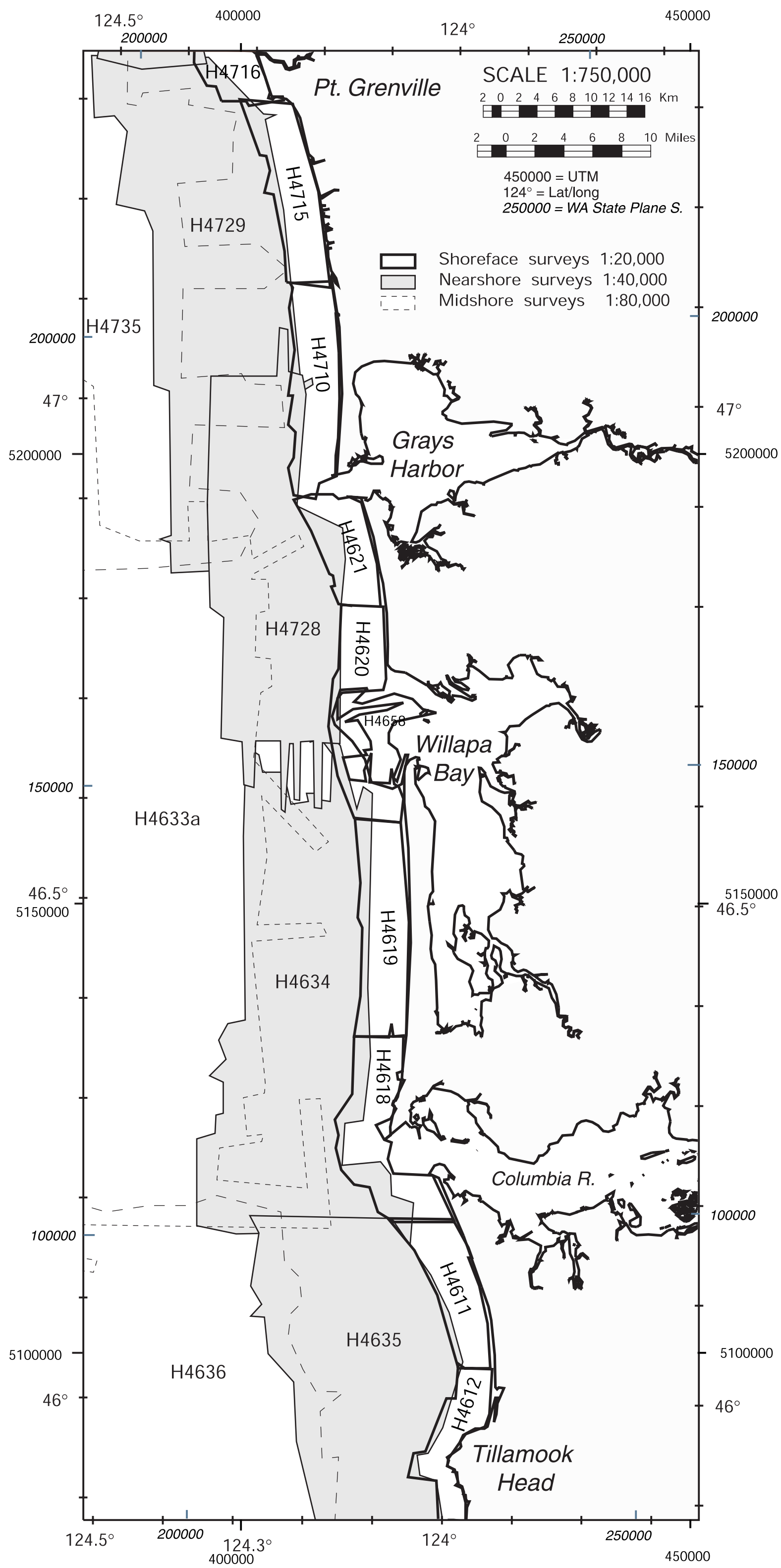


Figure 2. NOS hydrographic surveys within the Southwest Washington (SWWA) area.

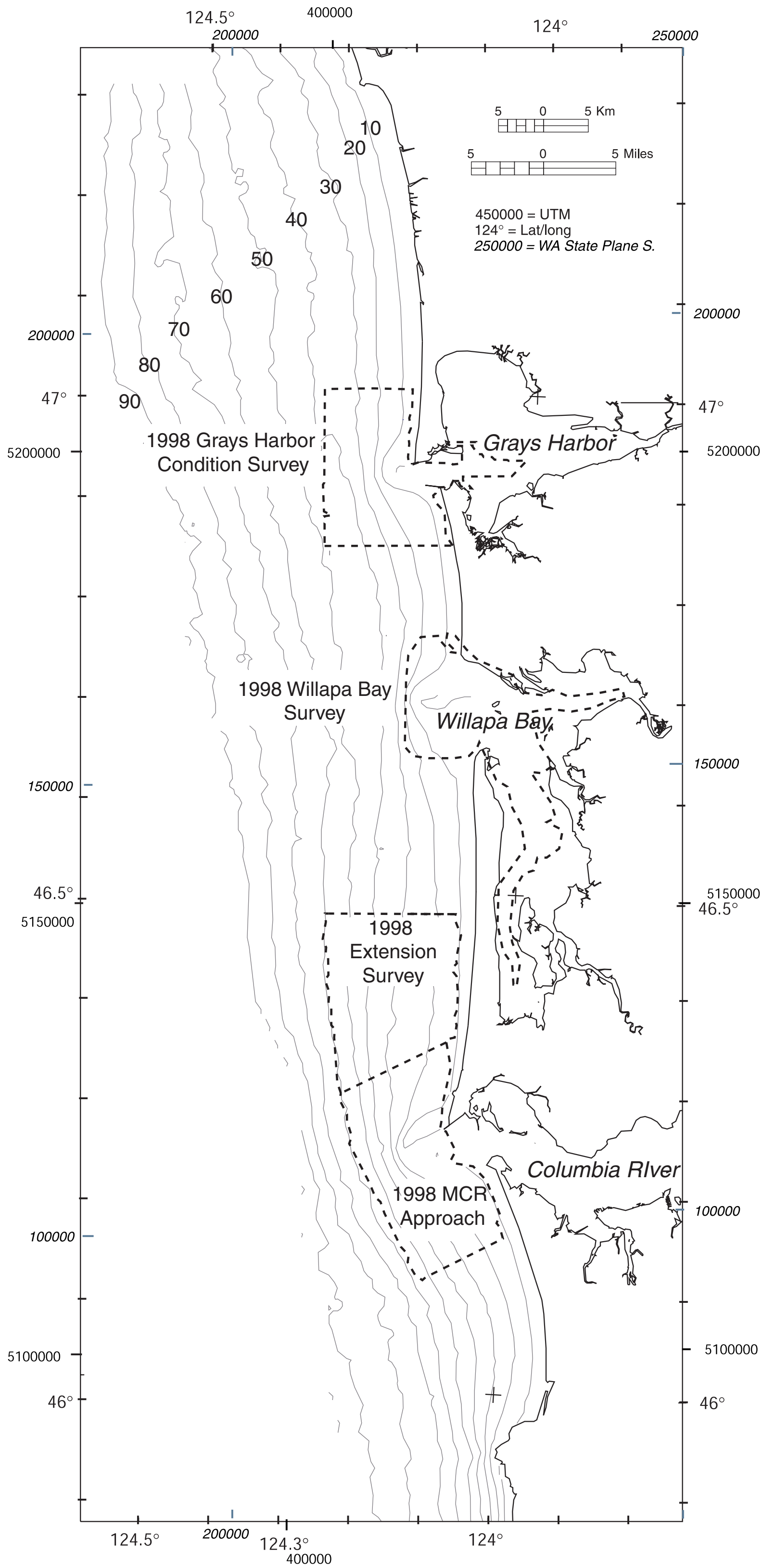


Figure 3. Boundaries of 1998 USACE hydrographic surveys.

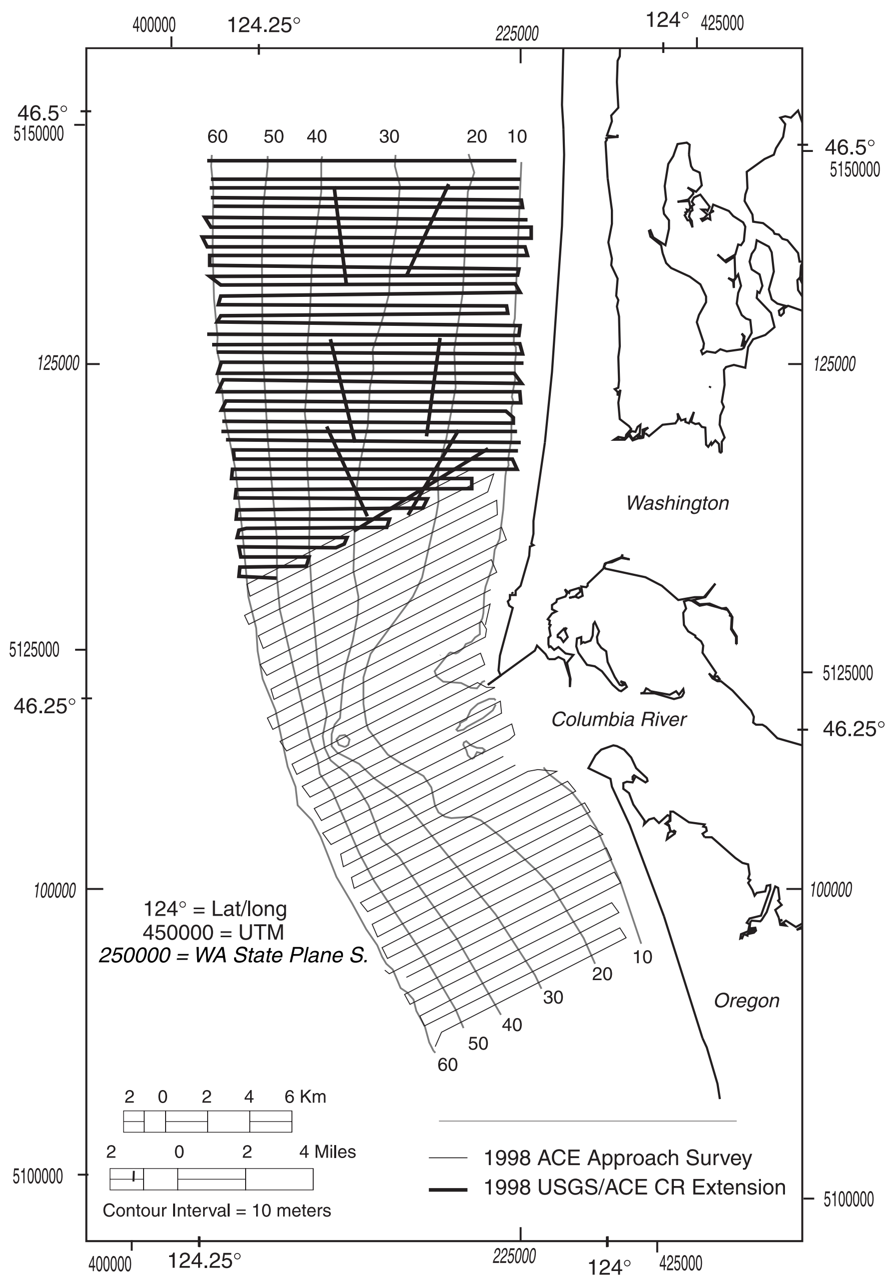


Figure 4. 1998 tracklines of Columbia River approach and extension surveys. Approach survey data courtesy of Portland District USACE.

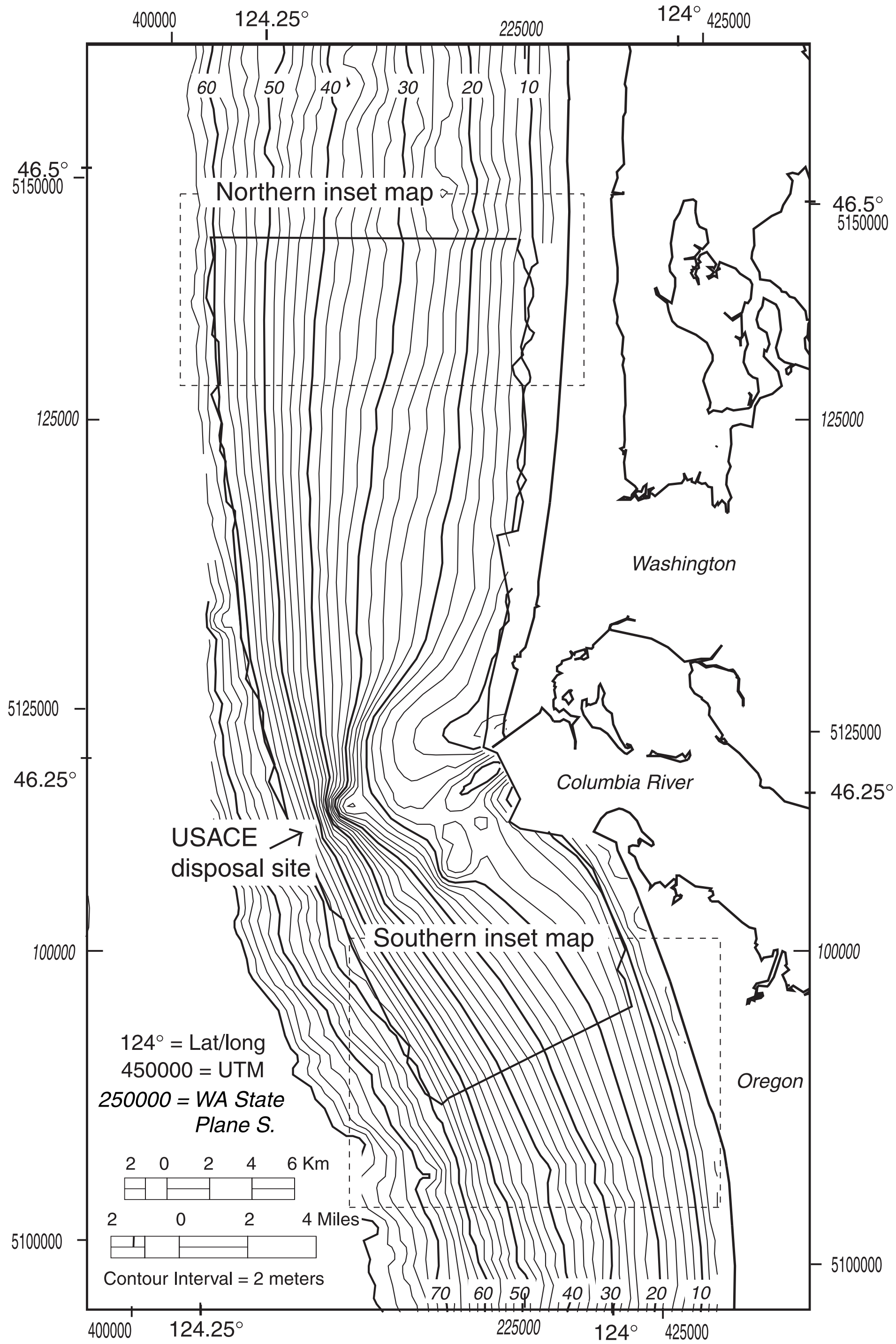
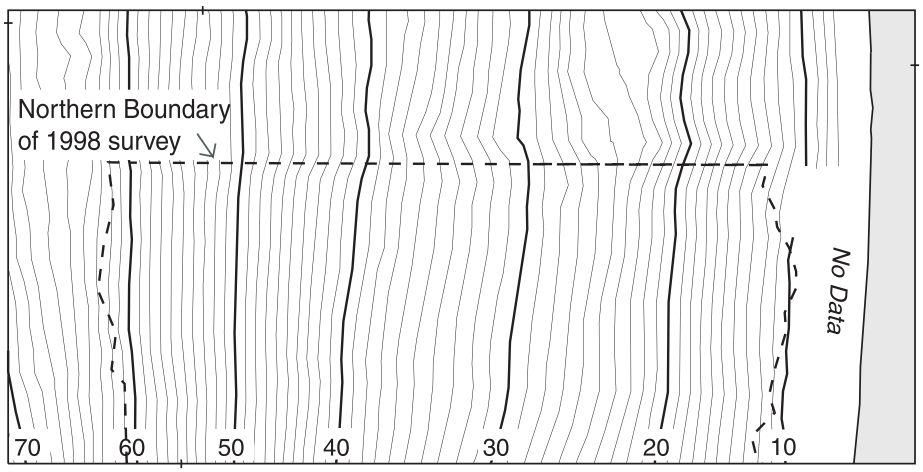
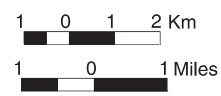
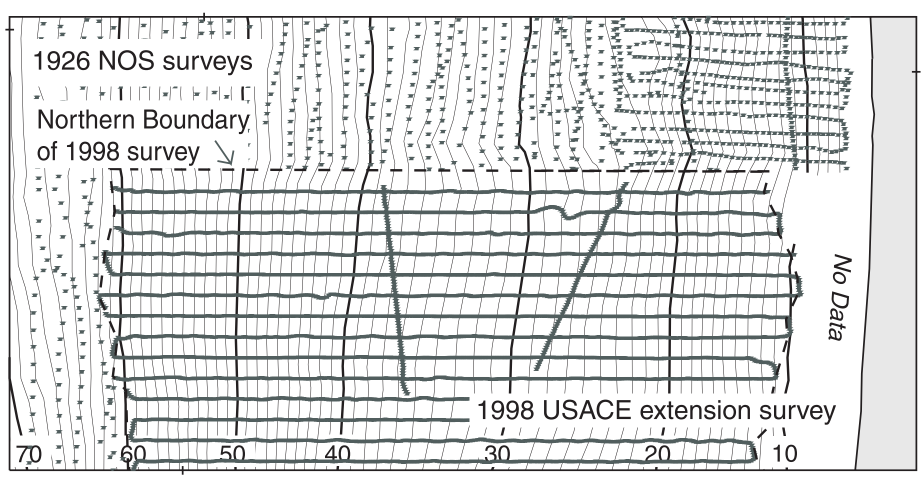


Figure 5. Bathymetric contours generated from edited and merged 1926/1998 data.



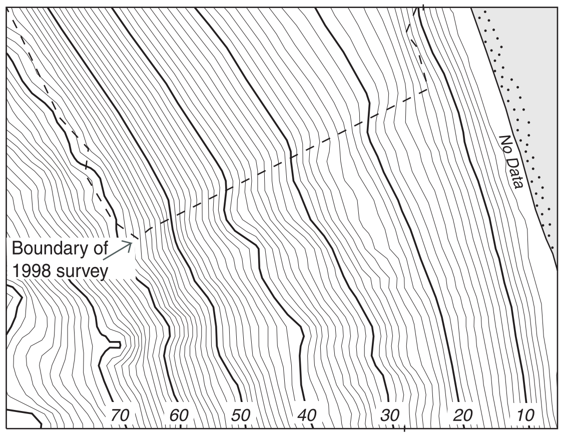
A. Merged, non-edited 1926 and 1998 hydrographic data.



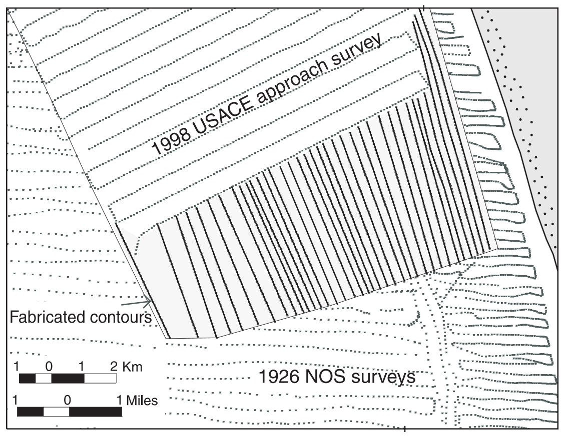


B. 1926 and 1998 hydrographic data and merged contours

Figure 6. Northern Columbia River inset maps. Note the minimal offset in the bathymetric contours across the 1926 and 1998 survey boundary.



A. Merged, non-edited 1926 and 1998 hydrographic data.



B. 1926, 1998, and fabricated hydrographic data. Shaded region is the area of deleted 1926 data.

C. Edited and merged 1926 and 1998 hydrographic data.

Figure 7. Southern Columbia River inset maps. A) Note the large seaward offset in the bathymetric contours across the boundary between the 1926 and 1998 data sets. B) 1926 data were replaced with thirty-four NW-SE trending contours to; C) produce a smooth transition between the two data sets.

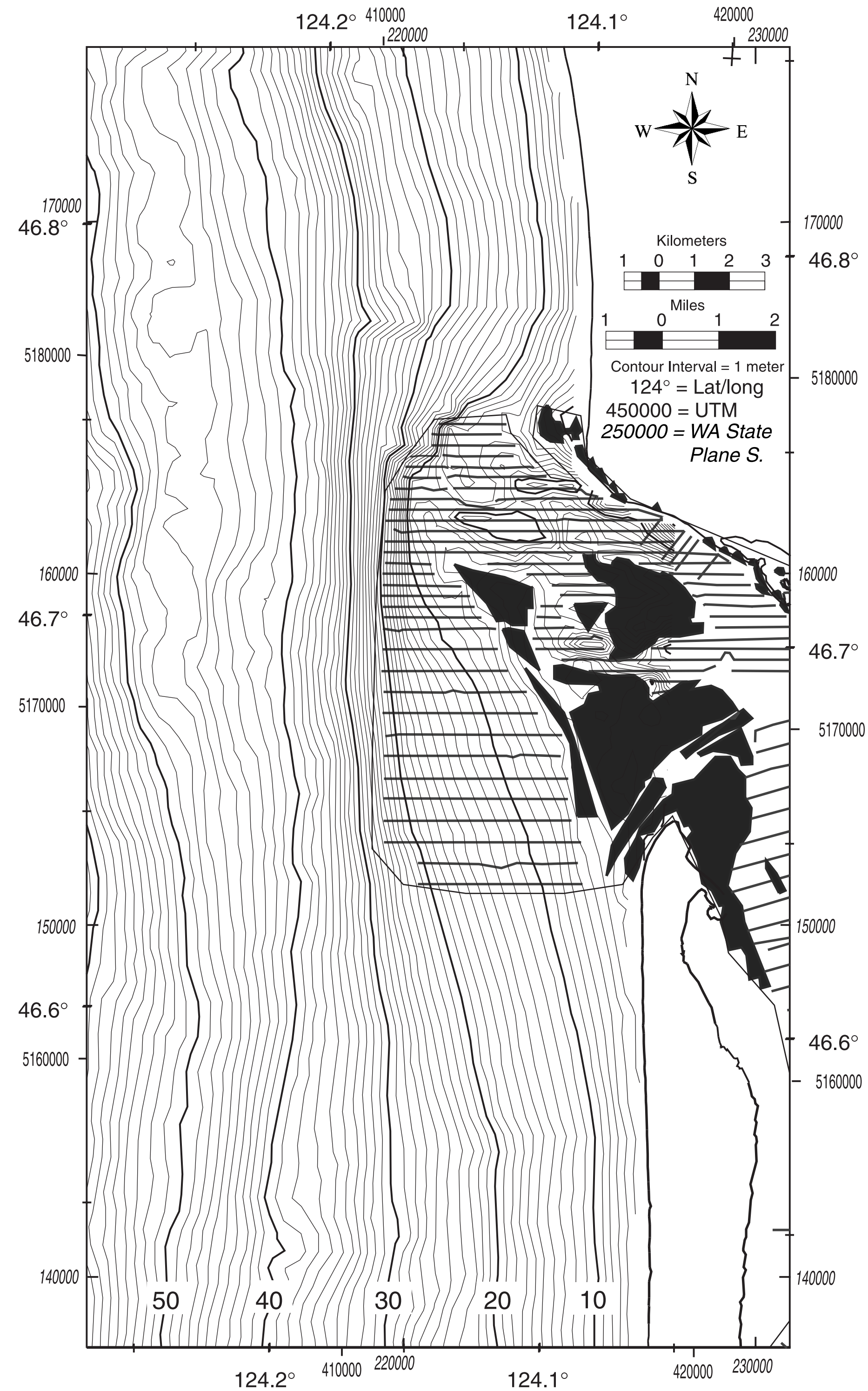
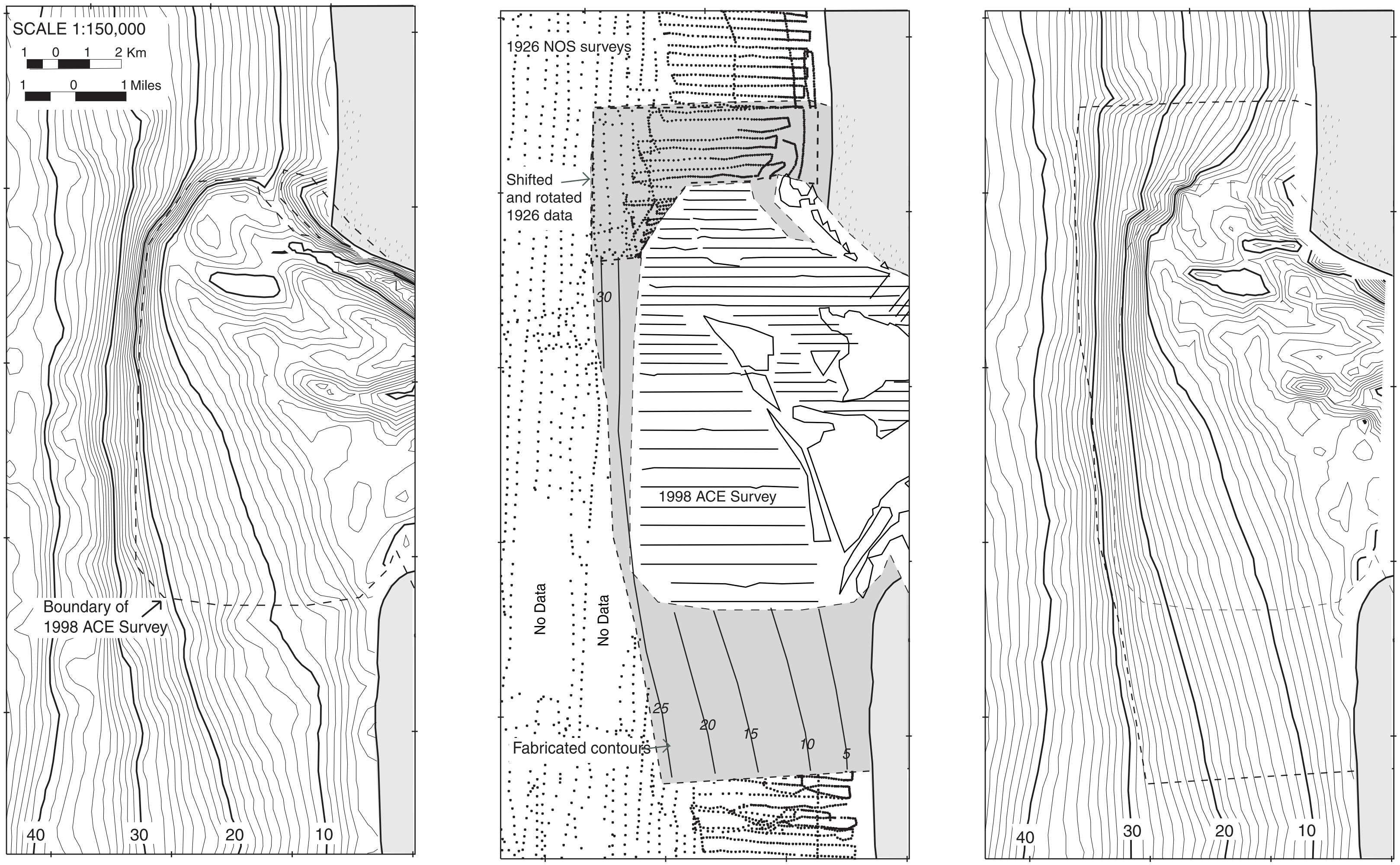


Figure 8. Bathymetric contours from merged and edited 1926/1998 data, and location of 1998 survey tracklines, Willapa Bay. The dark areas show regions of high-density SHOALS data coverage over tidal flats.



A. Merged, non-edited 1926 and 1998 hydrographic data.

B. 1926, 1998, and fabricated hydrographic data. Shaded region is the area of deleted 1926 data.

C. Edited and merged 1926 and 1998 hydrographic data.

Figure 9. Willapa Bay inset maps. A) Note the large offset in contours across the boundary between the 1926 and 1998 data sets. B). To obtain smooth contours across this boundary it was neccssary to delete, move, and rotate 1926 data and insert create six NW-SE trending data contours.

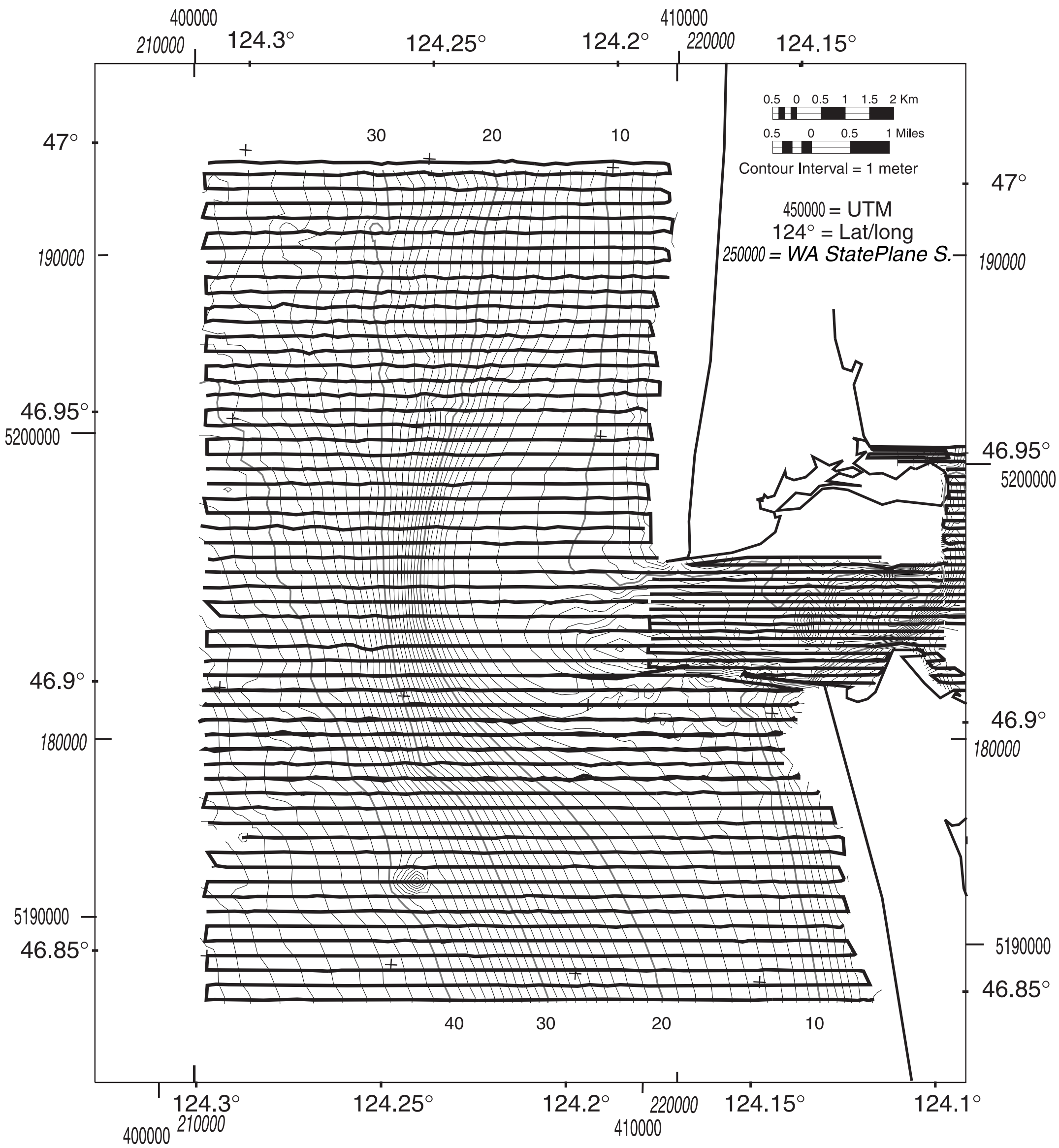


Figure 10. 1998 USACE annual survey tracklines for Grays Harbor. Data courtesy of the Seattle District Army Corps of Engineers.

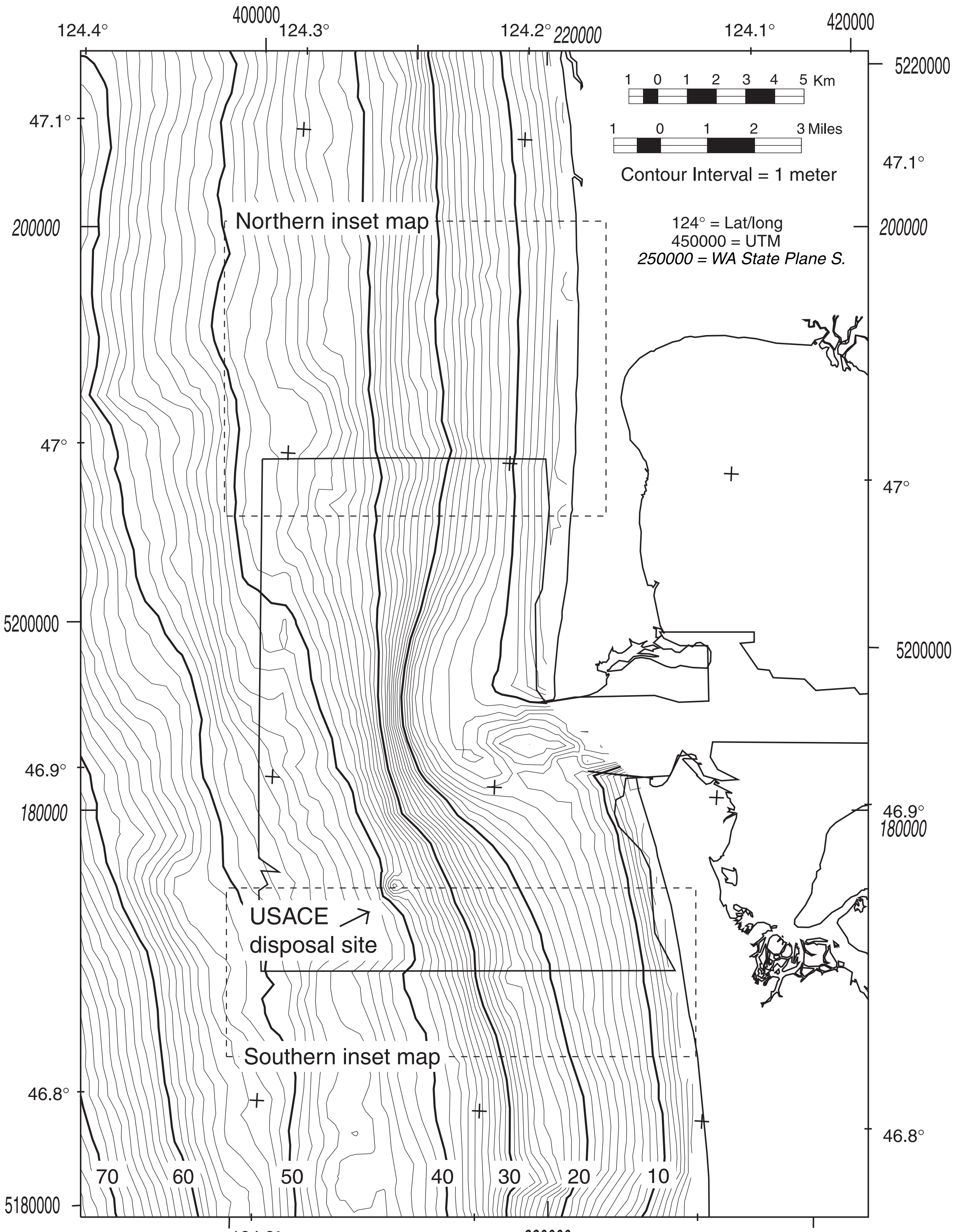
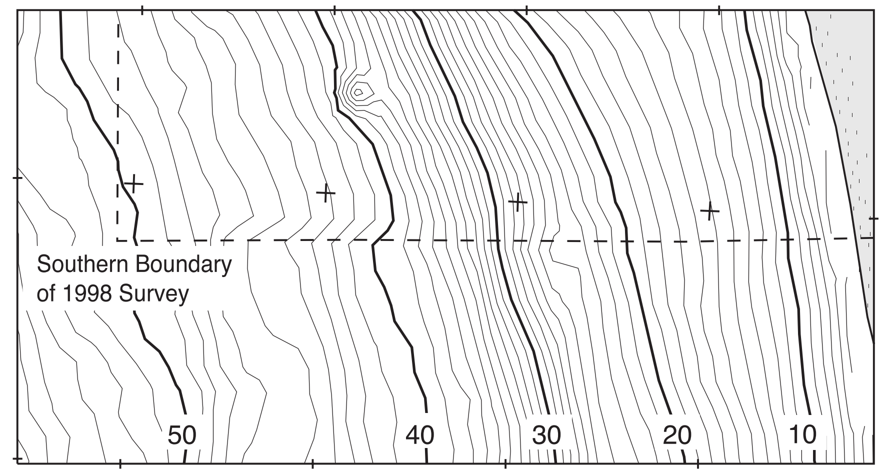
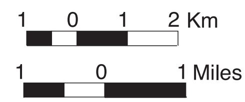
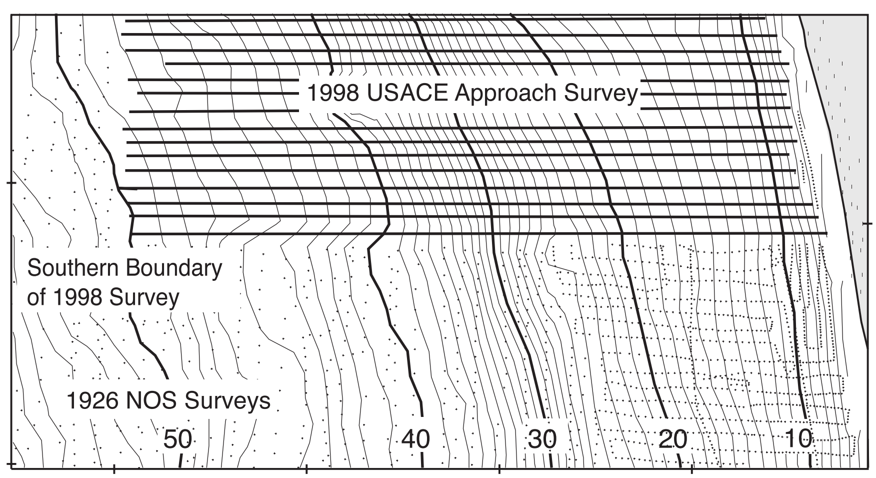


Figure 11. Bathymetric contours generated from merged and edited 1926/1998 data, Grays Harbor Washington.



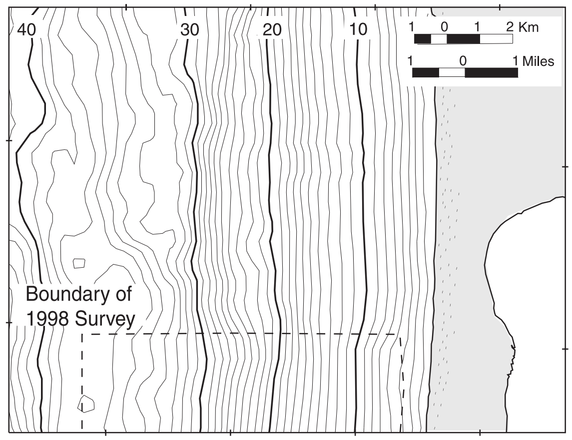
A. Merged, non-edited 1926 and 1998 hydrographic data.



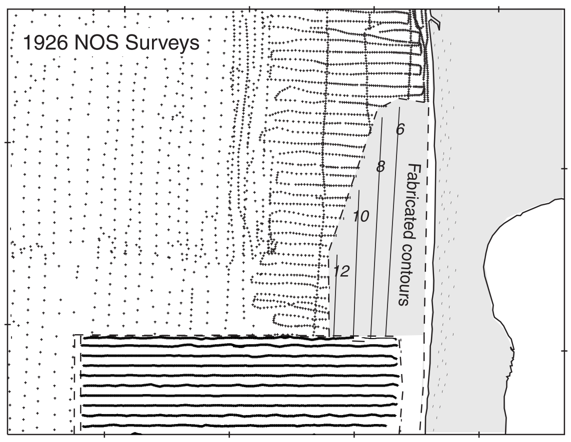


B. 1926 and1 998 hydrographic data and merged contours.

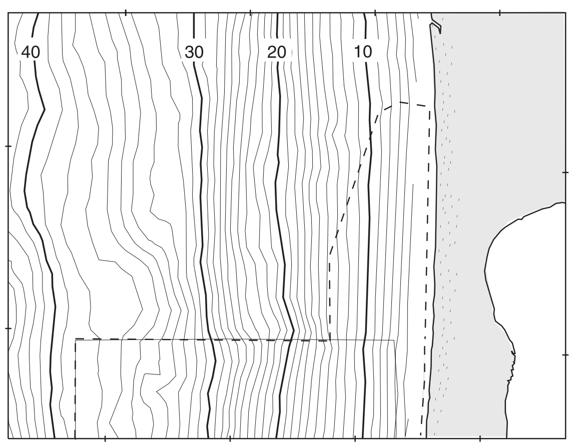
Figure 12. Southern Grays Harbor inset maps. Note the minimal offset in the bathymetric contours across the 1926/1998 survey boundary.



A. Merged, non-edited 1926 and 1998 hydrographic data.



B. 1926, 1998, and fabricated hydrographic data. Shaded region is the area of deleted 1926 data.



C. Edited and merged 1926 and 1998 hydrographic data.

Figure 13. Northern Grays Harbor inset maps. A) Note the large seaward offset of contours across the merged 1926/1998 data sets. B) To obtain smooth contours across this boundary, it was necessary to insert four NW-SE trending data contours.

ACKNOWLEDGEMENTS

The authors would like to thank Eric Nelson of the Seattle District USACE for the Grays Harbor and Willapa Bay survey data, and H. Rod Moritz of the Portland District USACE for the Columbia River entrance survey data. Critical reviews of this report by Florence Wong and Guy Gelfenbaum of the U.S. Geological Survey, and George Kaminsky of the WA State Dept. of Ecology were most helpful and greatly appreciated. This report was completed as part of the Southwest Washington Coastal Erosion Study. This study is jointly funded by the Washington State Department of Ecology and the US Geological Survey, Coastal and Marine Geology Program.

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APPENDIX – Programs used

Program: importsurfergrids.aml

```
/*******************************************************************
/* PROGRAM        importsurfergrids.aml
/* PURPOSE        Imports and projects SURFER format ascii files
                  into ARC/INFO grid format
/* AUTHOR         Ann Gibbs, USGS CMG
/* CREATED        10-12-00
/* MODIFIED       latest version
/*
/******************************************************************
/*
/*
&echo &brief
/* IF YOU WANT TO ENTER USER SPECIFIED FILES THEN
  &goto user
/* OTHERWISE SPECIFY FILE PARAMETERS BELOW:
  &s area /* swwa or orwa
  &s year /* 26 or 98
  &s cellsize /*500 or 750
  &goto aml

/* USER INTERACTIVE
  &label user

  &s area [response 'Select Area: orwa or swwa']
  &s year [response 'Select Year: 26 or 98']
  &s cellsize [response 'Select Cellsize: 500 or 750']

  &label aml

  &s infile %area%%year%_%cellsize%sp
  &s tmpfile tmpgrid

  &if [exists %tmpfile%.grd -file] &then
   &sys /bin/rm -r %tmpfile%.grd

  &system cat %area%_%cellsize%.hdr %infile%.grd | sed 7,12d > %tmpfile%.grd

/*  START GRID PROGRAM

  &if [locase [show program]] <> grid &then
   grid
  &if [extract 1 [show display]] <> 9999 &then
   display 9999 size 550 850


/* CREATE A TEMPORARY FILE USING THE ARCASCII COMMAND

  &IF [EXISTS tmp -GRID] &THEN
    kill tmp all

  tmp = asciigrid (%tmpfile%.grd, FLOAT)

  &IF [EXISTS tmp2 -GRID] &THEN
    kill tmp2 all
```

```
  &IF [EXISTS %infile% -GRID] &THEN
    kill %infile% all

/*PROJECT THE COVERAGE TO WASHINGTON STATEPLANE SOUTH PROJECTION

  &sys arc project grid tmp tmp2 wasp_wasp.prj

/* wasp_wasp.prj
 /*input
 /*projection stateplane
 /*units meters
 /*zone 5626
 /*datum nad83
 /*parameters
 /*output
 /*projection stateplane
 /*units meters
 /*zone 5626
 /*datum nad83
 /*parameters
 /*end

/* FLIP THE GRID AND CREATE FINAL GRID

  &sys arc gridflip tmp2 %infile%


/* PLOT THE GRID

  &IF [EXISTS %infile%.map -DIRECTORY] &THEN
    killmap %infile%.map

  map %infile%.map
  mape %infile%

  shadeset rainbow
  gridshades %infile% # linear

  map end

&echo &off
```

```
program arc2grd
c
c     Program to read ArcView ASCII files and write them as
c     ASCII .GRD file formats for Surfer
c
c     Variable names are mostly those used by Surfer.
c
c     Chris Sherwood, USGS
c     October 10, 2000
c
      implicit none
      integer MAXX, MAXY
      parameter(MAXX=2501, MAXY=2501)

      character*40 ver /'arc2grd, version of October 10,2000'/
      character*60 infn, outfn
      integer mx, ny, m, n
      double precision xlo, xhi, ylo, yhi, zlo, zhi
      real z(MAXX, MAXY)
      real conv /-1.0/
      double precision nodata /1.d35/
      double precision eps /0.1d0/
      real fac /1.0/
      integer nhedf /0/

      write(*,'(1x,a)') ver
      write(*,*) '   Note: corrects for ARC export by increasing'
      write(*,*) '   xll, yll by 1/2 dx, dy'
      write(*,*) 'Enter input filename (max. 60 char): '
      read(*,'(a60)') infn
      write(*,*) 'Enter output .grd filename (max. 60 char): '
      read(*,'(a60)') outfn
      write(*,*) 'Enter conversion factor: '
      read(*,*) conv

      call read_arc(50,infn,mx,ny,xlo,xhi,ylo,yhi,
     &     nodata,z,MAXX,MAXY)

c     ...convert and find limits of z
      zlo =  99999.99
      zhi = -99999.99
      do n=1,ny
         do m=1,mx
            if( dabs(z(m,n)-nodata) .gt. eps )then
               z(m,n)=z(m,n)*conv
               if(z(m,n) .lt. zlo ) zlo=z(m,n)
               if(z(m,n) .gt. zhi ) zhi=z(m,n)
            endif
         enddo
      enddo

      call write_grd( 60, outfn, mx, ny, xlo, xhi, ylo, yhi,
     &   zlo, zhi, z, nodata, MAXX, MAXY )

      end
```

```
c**********************************************************************
*
c
      subroutine read_arc(lfn,cfname,mx,ny,xlo,xhi,ylo,yhi,
     &     nodata,z,MAXX,MAXY)
c
c     Reads grid in ARC format
c
c*****************************************************************
      implicit none
      character*60 cfname
      character*12 junk
      integer lfn, mx, ny, m, n, MAXX, MAXY
      double precision xlo,ylo,xhi,yhi,zlo,zhi,dx,dy,nodata
      real z(MAXX, MAXY)

      open(lfn,file=cfname,status='old')
      call ireadfil3(lfn,'ncols',5,0,0,mx)
      call ireadfil3(lfn,'nrows',5,0,0,ny)
      write(*,*) 'mx: ',mx
      write(*,*) 'ny: ',ny
      call dreadfil3(lfn,'xllcorner',9,0.d0,0,xlo)
      call dreadfil3(lfn,'yllcorner',9,0.d0,0,ylo)
      call dreadfil3(lfn,'cellsize',8,0.d0,0,dx)
      call dreadfil3(lfn,'NODATA_value',12,0.d0,0,nodata)
      dy = dx
c     ...next operation is needed because ARC is cell-based and
c        exported xllcorner, yllcorner is at corner of cell
      xlo = xlo+0.5*dx
      ylo = ylo+0.5*dy
      xhi = xlo+dble(mx-1)*dx
      yhi = ylo+dble(ny-1)*dy

      rewind(lfn)
      call skip_rec(lfn,6)
      do n=ny,1,-1
         read(lfn,*) (z(m,n),m=1,mx)
      enddo
      close(lfn)
      end
c*****************************************************************
c
      subroutine write_grd( lfn, cfname, mx, ny, xlo, xhi, ylo, yhi,
     &   zlo, zhi, z, nodata, MAXX, MAXY )
c
c     Writes ASCII .grd file format for SURFER
c
c     Note that the magic blanking value must be written exactly as
c     shown...thus the character writes, instead of free-format writes.
c
c****************************************************************
      implicit none
      character*60 cfname
      integer lfn, mx, ny, m, n, MAXX, MAXY
      double precision  xlo, xhi, ylo, yhi, zlo, zhi, nodata
      double precision eps /0.1d0/
      real z(MAXX, MAXY)
```

```
      character*4 ctag /'DSAA'/
      character*14 blank /'  1.70141e+038'/, cout
      open(unit=lfn,file=cfname,status='unknown')
      write(lfn,'(a4)') ctag
      write(lfn,*) mx, ny
      write(lfn,*) xlo,xhi
      write(lfn,*) ylo,yhi
      write(lfn,*) zlo,zhi
      do n=1,ny
         do m=1,mx
            write(cout,'(a14)') blank
            if( dabs(z(m,n)-nodata) .gt. eps )then
               write(cout,'(g14.8)') z(m,n)
            endif
            write(lfn,'(a14)') cout
         enddo
      enddo
      close(lfn)
      end
c*****************************************************************
c
      subroutine skip_rec(lfn,nrec)
c
c     Reads a line of input from lfn and discards
c     Only works with ASCII files opened with formatting
c
      character*1 c
      do i=1,nrec
         read(lfn,'(a)') c
      enddo
      return
      end
c*****************************************************************
c
      subroutine ireadfil3(nin,anot,nchar,dvar,ifail,ivar)
c
c     Reads INTEGER variable from file based on keyword.
c     Adapted from John Hunter's ireadfil2.
c
c     Input:
c        nin ..... File input device
c        anot .... Keyword in file
c        nchar ... Number of characters in ANOT (max. 40)
c        dvar  ... Default value to use
c        ifail ... 0 = Stop if not found
c                  1 = Warn and use default if not found
c                  2 = Silent and use default if not found
c     Returns:
c        ivar .... Resultant INTEGER variable
c
c******************************************************************
      integer nin,nchar,ivar,ifail,dvar
      character*(*) anot
      integer ios
      logical found
      character*80 buff
      logical isbot
```

```
      rewind(nin)
      ios=0
      found=.false.
      do while(ios.eq.0.and..not.found)
        read(nin,1000,iostat=ios) buff
 1000   format(a80)
        if(buff(1:nchar).eq.anot.and.
     &    isbot( buff(nchar+1:nchar+1) )) then     ! Match has been
found
          read(buff(nchar+2:80),*,iostat=ios) ivar
          found=.true.
        endif
      end do
      if(ios.eq.0) then
         write(*,1400)anot,ivar
 1400    format(1x,a,4x,i7)
        return                  ! Match found and no error
      else
        if(ifail.eq.0)then
           write(*,1100) anot
 1100      format(1x,'Fatal error reading ',a)
           stop
        elseif(ifail.eq.1)then
           write(*,1200) anot
 1200      format(1x,'Warning: Could not read ',a)
           ivar = dvar
           write(*,1300) ivar
 1300      format(1x,'Using default value of: ',i8)
           return
        elseif(ifail.eq.2)then
           ivar = dvar
           return
        else
           stop 'Bad value of ifail passed to ireadfil3.'
        endif
      endif
      end
c*****************************************************************
c
      subroutine dreadfil3(nin,anot,nchar,dvar,ifail,var)
c
c     Reads double precision variable from file based on keyword.
c     Adapted from John Hunter's ireadfil2.
c
c     Input:
c        nin ..... File input device
c        anot .... Keyword in file
c        nchar ... Number of characters in ANOT (max. 40)
c        ifail ... 0 = Stop if not found
c                  1 = Warn and use default if not found
c                  2 = Silent and use default if not found
c     Returns:
c        var .... Resultant double precision variable
c
c******************************************************************
      integer nin,nchar,ifail
```

```
      double precision dvar,var
      character*(*) anot
      integer ios
      logical found
      character*80 buff
      logical isbot

      rewind(nin)
      ios=0
      found=.false.
      do while(ios.eq.0.and..not.found)
        read(nin,1000,iostat=ios) buff
 1000   format(a80)
        if(buff(1:nchar).eq.anot.and.
     &    isbot( buff(nchar+1:nchar+1) )) then     ! Match has been
found
          read(buff(nchar+2:80),*,iostat=ios) var
          found=.true.
        endif
      end do
      if(ios.eq.0) then
         write(*,1400)anot,var
 1400    format(1x,a,4x,g14.8)
         return                 ! Match found and no error
      else
         if(ifail.eq.0)then
            write(*,1100) anot
 1100       format(1x,'Fatal error reading ',a)
            stop
         elseif(ifail.eq.1)then
            write(*,1200) anot
 1200       format(1x,'Warning: Could not read ',a)
            var = dvar
            write(*,1300) var
 1300       format(1x,'Using default value of: ',g12.6)
            return
         elseif(ifail.eq.2)then
            var = dvar
            return
         else
            stop 'Bad value of ifail passed to dreadfil3.'
         endif
      endif
      end
c*****************************************************************
c
      logical function isbot( c )
c
c     Returns true if character is blank or tab
c
      character*1 c
      character*1 b,t
      b = char(32)
      t = char(9)
      isbot = ((c .eq. b) .or. (c .eq. t))
      return
      end
```