Final Report
(PostScript Version)

A GEOGRAPHIC INFORMATION SYSTEM FOR NEAR REAL-TIME USE OF REMOTE SENSING IN FISHERIES MANAGEMENT IN THE GULF OF MEXICO

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LIST OF DEFINITIONS, ABBREVIATIONS, AND ACRONYMS

The following terms, abbreviations, and acronyms are used throughout this report:

AM	Analysis Menu
ARCVCUT	Software utility for cutting and reformatting selected subareas of the global, self-consistent, hierarchical high resolution shoreline (GSHHS) file
ASCII	American Standard Code for Information Interchange
Avenue	ArcView object-oriented scripting language
AVHRR	Advanced Very High Resolution Radiometer
cron	A UNIX command which operates continuously to schedule programs to be executed in the future
CW	NOAA/NESDIS CoastWatch Program
DBDB5	U.S. Naval Oceanographic Office Digital Bathymetric Database - 5 Minute Resolution
DC	Data Catalog
DECCON	Decompression and Conversion of NESDIS CoastWatch Imagery
ESRI	Environmental Systems Research Institute, Inc., proprietor of ARC/INFO and ArcView GIS software
FM	File Menu
GIF	Graphics Interchange Format
GIS	Geographic Information System
GPMP	General Perspective Map Projection
GCP	Ground Control Point
GOMEX	Gulf of Mexico
GSHHS	Global, Self-consistent, Hierarchical High Resolution Shoreline File
GMMM	Gulf of Mexico Master Map
Geographic Transformer	Proprietary software for re-projecting raster images
GRID file	ARC/INFO and ArcView native raster file format
GRS-80	Geodetic Reference System of 1980 reference ellipsoid
GMRN	CoastWatch Gulf of Mexico Regional Node
GUI	Graphical User Interface
HDF	Hierarchical Data Format
IDL	Interactive Data Language software
IMS	Internet Map Server; proprietary ArcView extension for publishing maps on the WWW
IPS	Image Product System

LIST OF DEFINITIONS, ABBREVIATIONS, AND ACRONYMS (continued)

Java	A general purpose object oriented programming language developed by Sun Microsystems, Inc.
JNMC	NMFS Java Network Map Client
JNMS	NMFS Java Network Map Server
JPEG	Joint Photographic Expert Group Image File Format
MapCafé	A proprietary Java applet which accompanies the Internet Map Server for serving maps on the WWW
MHW	Mean High Water vertical datum
MMS	U.S. Dept. of the Interior, Minerals Management Service
NAD27	North American Datum of 1927
NAD83	North American Datum of 1983
NADCON	PC software for converting latitude and longitude coordinates referenced to NAD27 to NAD83
NASA	National Aeronautics and Space Administration
NESDIS	NOAA National Environmental Satellite, Data, and Information Service
NGDC	NOAA National Geophysical Data Center
NGS	NOAA National Geodetic Survey
NMFS	NOAA National Marine Fisheries Service
NODC	NOAA National Oceanographic Data Center
NOAA	National Oceanic and Atmospheric Administration
NOS	NOAA National Ocean Service
OIC	Orbital Imaging Corporation
OSDPD	NOAA/NESDIS Office of Satellite Data Processing and Distribution
Raster map	Spatial information presented using homogeneous cells or pixels in a square or rectangular matrix
RPC	Remote Procedure Call
RSF	Reference Settings File
SAS	The Statistical Analysis System
SAS/IML	The SAS Interactive Matrix Language
SeaDAS	SeaWiFS Data Analysis System
SEAMAP	Southeast Area Monitoring and Assessment Program
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SGI	Silicon Graphics, Inc.
Shape file	ArcView native vector file format
Spatial Analyst	Proprietary ArcView extension for analyzing raster maps
SSC	Stennis Space Center
SST	Sea Surface Temperature

LIST OF DEFINITIONS, ABBREVIATIONS, AND ACRONYMS (concluded)

TB	Toolbar
Theme table	A table of attributes associated with an ArcView map theme
TIFF	Tagged Image File Format
TRW	Table Reply Window
UNGENERATE	ASCII file format required by ARC/INFO and ArcView extensions to import point, line, and polygonal data from external files.
USEEZ	United States Exclusive Economic Zone
Vector map	Spatial information constructed with arcs and nodes and rendered as points, lines, and polygons.
WDB	World Data Bank II digital shoreline file
WGS-72	World Geodetic System of 1972 reference ellipsoid
World File	ASCII file containing earth location parameters required to navigate raster files imported into ArcView
WVS	World Vector Shoreline digital file
WWW	World Wide Web

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1.0 PROJECT OBJECTIVE AND OVERVIEW

The objective of the project was to develop a near-real time geographic information system (GIS) to support fishery management concerns in the Gulf of Mexico which can be accessed remotely through the Internet using a customized graphical user interface (GUI). The near-real time data consists of satellite-observed sea surface temperature (SST) images derived from the Advanced Very High Resolution Radiometer (AVHRR) carried aboard NOAA polar orbiting satellites and chlorophyll-a images from the SeaWiFS (Sea-viewing Wide Field-of-view Sensor) onboard the SEASTAR-2 satellite owned and operated by Orbital Imaging Corporation. Seastar-2 was launched in August, 1997, and data have been available regularly on a two-week delayed basis since April, 1998. AVHRR products are currently distributed in near-real-time through seven regional nodes that are part of the the NOAA CoastWatch (CW) Program (Scavia et al. 1995). The CW Regional Node located at Stennis Space Center (SSC), Mississippi distributes Gulf of Mexico data products. Although only a few sample chlorophyll-a SeaWiFS data products were available for the project, these data products are expected to be available operationally in the near future. Static data maps were developed for the project such as a coastline, bathymetry, NMFS shrimp statistical subareas, and jurisdictional boundaries between U.S. and state waters, and U.S. and international waters. The prototype uses a customized Java map client GUI for publishing maps on the World Wide Web (WWW) which mimics many of the functions and tools on the ArcView[1] GIS native GUI. The customized GUI also contains a data catalog to enable the user to select near real time SST images and static map layers and perform overlay operations, queries, and other analyses using GIS utilities.

2.0 ANALYTICAL TOOLBOX

The prototype was developed on Silicon Graphics (SGI) UNIX workstations and personal computers (PCs) utilizing the Windows NT (version 4.0) operating system. The GIS components of the toolbox utilized ArcView GIS software, version 3.1, and the ArcView extensions Spatial Analyst[1],

[1] Proprietary computer software developed, marketed, and maintained by the Environmental Systems Research Institute, Inc., 380 New York St., Redlands, California 92373-8100.

PowerTools[2], and TheEngine[3]. The ArcView extension, the Internet Map Server[1], the Borland Jbuilder 2[4] Java programming toolkit, and Microsoft C++[5] were used to develop utilities to provide access through a GUI over the Internet. The remaining support software included the Geographic Transformer[6], Data Automation Kit[1], NADCON datum conversion software[7], the Statistical Analysis System (SAS)[8], the SAS Interactive Matrix Language (IML)[8], the Decompression and Conversion of NESDIS CoastWatch Imagery (DECCON) software[9], the Interactive Data Language (IDL)[10], and the SeaWiFS Data Analysis System (SeaDAS)[11].

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[2] Proprietary computer software, developed, marketed, and maintained by the Geowarehouse, 150 Sunset Ridge, Dripping, Springs, Texas 78620.

[3] Proprietary computer software, developed, marketed, and maintained by Geokinetic Systems, Inc., 907 Friar Cres, North Vancouver, British Columbia, Canada V76 1MS.

[4] Proprietary computer software developed, marketed, and maintained by Inprise Corporation, P.O. Box 660001, Scotts Valley, California 95067-0001.

[5] Proprietary computer software developed, marketed, and maintained by Microsoft Corporation, One Microsoft Way, Redmond, Washington 98052.

[6] Proprietary computer software developed, marketed, and maintained by Blue Marble Geographics, Inc., 48 Water Street, Gardiner, Maine 04345.

[7] Public domain PC software available from the NOAA National Geodetic Survey: http://sinbad.ngs.noaa.gov/PC_PROD/pc_prod.html

[8] Proprietary computer software, developed, marketed, and maintained by the SAS Institute, SAS Campus Drive, Cary, North Carolina 27513.

[9] Public domain software available from the U.S. Geological Survey: ftp://boris.er.usgs.gov/pub/deccon

[10] IDL is proprietary software developed, maintained, and marketed by Research Systems, Inc., 4990 Pearl East Circle, Boulder, Colorado 80301.

[11] SeaDAS was developed by the National Aeronautics and Space Administration (NASA) and requires an IDL license. Additional information is available from the NASA Goddard Space Flight Center: http://seadas.gsfc.nasa.gov.

3.0 GENERATION OF STATIC DATA LAYERS

3.1 The Gulf of Mexico Master Map (GMMM)

The GMMM was developed as the base map for the project and was defined as the area from 18° to 31° north latitude and 80° to 98° west longitude and uses a geographic, i.e., linear latitude-longitude, coordinate system. A continental land mask was created from the global, self-consistent, hierarchical, high-resolution shoreline database (GSHHS) compiled by Wessel and Smith (1996). The GSHHS is public domain digital coastline file available from the School of Ocean and Earth Science Technology at the University of Hawaii[12] and the NOAA National Geophysical Data Center[13] (NGDC) and contains coastlines and closed waterbodies extracted from two widely used public domain databases, the World Data Bank II coastline (WDB) and the World Vector Shoreline (WVS). Lohrenz (1988) indicated that the working scale of the WVS data is about about 1:250,000 and is referenced to the World Geodetic System of 1972 (WGS-72) horizontal datum and the mean high water (MHW) vertical datum. A C utility, ARCVCUT, was adapted from software that accompanied the GSHHS and used to cut the Gulf of Mexico coastline from the global file and reformat the data into the ASCII file format required by ArcView extensions (i.e., the ARC/INFO UNGENERATE format). The intermediate (1 km) resolution version of the GSHHS was also developed into a similar shape file to reduce the display time when accessing the system via the Internet.

Raster and vector maps (Aronoff 1989) were required for the project and registered to the GMMM. Raster files were standardized to a pixel size of 0.01° x 0.01° in the x and y dimensions, respectively. Vector data were obtained for the project as ASCII files, ArcView Shape files, and ARC/INFO coverages. The vector data were assembled into shape files and edited with ArcView tools and extensions. Raster data were converted to GRID files using Spatial Analyst.

3.2 Longitude/Latitude Grid

Longitude and latitude lines were generated from ASCII coordinates on a 1° grid and converted to a shape file. The individual grid cells were defined as polygons and an ArcView theme table, i.e., attribute table, associated the minimum and maximum longitudes and latitudes with each grid

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[12] http://www.soest.hawaii.edu/wessel/gshhs/gshhs.html

[13] http://web.ngdc.noaa.gov/mgg/shorelines/gshhs.html

to later facilitate selection and querying aggregations of two or more cells.

3.3 Bathymetric Data

A Gulf of Mexico (GOMEX) bathymetric map generated by Herring (1993) for the Minerals Management Service (MMS) was imported into ArcView as a raster binary floating point file and later rounded into an integer GRID file. The data were gridded and contoured from hydrographic survey data acquired from the U.S. Naval Oceanographic Office's (DBDB5) database, the National Ocean Service (NOS), and Texas A&M University. Herring's original raster file provided full coverage of the GMMM, utilized a geographic coordinate system, and a 0.01° pixel size and thus required only a minimal effort to convert the file for use in the project. GOMEX bathymetric contours produced for another project (Davis et al. 1998) were generated by vectorizing the integer version of the bathymetry file into isobaths corresponding to National Oceanographic Data Center's (NODC) standard depths (Boyer and Levitus 1994), with the exception of the zero depth level. The bathymetric contours were converted into two shape (polyline) files to improve the display time over the WWW. The first file contained NODC bathymetric contours ranging from 10 m to the continental shelf break (200 m). The second file contained the other contours ranging from 250 to 3,500 m.

3.4 Federal/State and U.S. Exclusive Economic Zone Boundaries

The jurisdictional boundary between U.S. state and Federal waters was initially obtained from MMS as an ASCII line vector[14]. Since the eastern boundary of the MMS data ended northwest of the Florida Keys, additional data were obtained from the State of Florida as an ARC/INFO coverage. Both data are considered to be in draft form and are for display purposes only. The Florida data were originally in an Albers equal area map projection (Snyder 1987) and were converted to geographic coordinates and appended to the MMS data. A state waters polygon was constructed by appending the jurisdictional boundary to the GSHHS and a section of the U.S. Exclusive Economic Zone boundary (USEEZ) delineating U.S. and Mexican waters at 26° N latitude.

[14] http://www.gomr.mms.gov/homepg/pubinfo/repcat/arcinfo/index.html

The USEEZ was downloaded from a National Ocean Service (NOS) server[15] as an ARC/INFO coverage and converted to a shape file. A polygon shape file encompassing Federal jurisdictional waters was created by cutting the original file and appending the boundary to the Federal/State waters jurisdictional line described in the previous section.

3.5 National Marine Fisheries Service (NMFS) Shrimp Statistical Subareas

The coastal waters adjacent to the U.S. and Mexico have been partitioned by NMFS into 40 statistical subareas delineated by Kutkuhn (1962) and Patella (1975) and are used as a basis for tabulating Gulf shrimp catch statistics each month by species, depth, size class. The zones are numbered consecutively beginning in the Florida Keys and extend counterclockwise around the Gulf to the Yucutan Peninsula. A line vector file used to prepare annual environmental and biological atlases for the Southeast Area Monitoring and Assessment Program (SEAMAP) (e.g., Donaldson et al. 1996) was adapted using ArcView editing tools and converted to a polygon shape file.

4.0 INTEGRATION OF SATELLITE DATA

4.1 Conversion of the CoastWatch (CW) Sea Surface Temperature (SST) Images to an ArcView-Compatible Image Format

4.1.1 Modification of DECCON Software

CoastWatch (CW) image products derived from the Advanced Very High Resolution Radiometer (AVHRR) are produced by the Image Product System (IPS) operated by National Environmental Satellite, Data, and Information Service (NESDIS). The image data have 11-bit radiometric resolution and are navigated to a spherical Mercator projection. The images are registered to the GMMM and have a pixel resolution of 0.01 x 0.01 degrees. The compressed binary format consists of the raster map and two graphics files, i.e., a Gulf of Mexico coastline derived from the World Data Bank II coastline file and a latitude/longitude grid (Jarva 1992). Although ArcView will import several raster formats, the CW native format is not currently supported. The Decompression and Conversion of NESDIS CoastWatch Imagery Files (DECCON) software was designed to read and convert CW data to several 8-bit image formats including Graphics Interchange Format (GIF), tagged image

[15] ftp://seaserver.nos.noaa.gov/datasets/efh

file format (TIFF), SunRaster, and plain raster (Stumpf and Townsley 1993). DECCON was developed in the public domain to support the CW program and was designed to operate on a minimally equipped PC with MS-DOS. The DECCON source code is written in C and is available on a server maintained by the U.S. Geological Survey (USGS).

The objective of this task was to modify DECCON to include a fifth image conversion option to convert the CW SST files to an ArcView compatible format and capture the full 11-bit resolution SST data. The initial effort focused on modifying DECCON to write a GRID file, i.e., the proprietary raster file format used by ARC/INFO and ArcView software, using utility libraries furnished with the Spatial Analyst extension. This approach was abandoned, however, since the GRID utility libraries are proprietary and thus could not be freely distributed. A binary raster format appeared to be the best choice since the format is supported by the Spatial Analyst extension and not encumbered by distribution restrictions. Thus, a modified version of the software (version 1.4.1) was developed to convert the CW images to 11-bit binary raster files which can then be converted to GRID files with Spatial Analyst. A bug was also corrected in the TIFF reformatting option which corrupted images with dimensions larger than 512 x 512 elements and scan lines. A lookup table and equations to convert SST digital count values to degrees Celsius was available in one of the DECCON subroutines.

4.1.2 Rectification of CW Satellite Images

CW AVHRR products are navigated automatically with Image Product System (IPS) utilities, assuming a circular orbit geometry and spherical earth, at 51 equally-spaced points along each scan line. IPS mapping subroutines relate earth coordinates, (latitude and longitude) to image coordinates (column and row) in Mercator and polar stereographic map projections, and geographic (linear latitude/longitude) coordinates (Jarva 1992). More detailed information on the production of CW images is available through online documentation[16]. The standard AVHRR products available through the GMRN are based on a spherical Mercator projection (Snyder 1987) with the earth radius defined as the average radius at 60° north Latitude, i.e., 6,371.2 km (Pichel et al. 1994). ArcView will support a spherical Mercator projection, but it apparently does not accommodate the CW earth radius parameter since it is a departure from

[16] CW Image Production Software, System Description Document, http://psbsgi1.nesdis.noaa.gov:8080/PSB/EPS/CW/cwdocs.html#sd2

equatorial radiuses associated with standard reference ellipsoids, e.g., the Geodetic Reference System of 1980 (GRS-80). This precluded the use of the CW Mercator projection as a base map for the project.

4.1.2.1 Re-projection of the Mercator SST Images

The OSDPD is currently providing SST images in geographic coordinates to support the project. Prior to the availability of these products, however, and given the apparent difficulties of using the CW Mercator projection as a base map, this task focused on the development of a protocol to resample and rectify images to conform to the specifications of the GMMM.

One possible method was to select coastline features visible in the SST images and on a map, determine their image coordinates and corresponding earth coordinates on a reference map (referred to as ground control points, GCPs), and use image processing software to rectify the images. This method was not feasible because an analyst has to interact with each SST image and a hardcopy map to compile a list of GCPs which is a tedious and time consuming process. Another consideration is that cloud cover in the Gulf of Mexico region could obscure some or all of the coastline features and perhaps induce navigational errors in the output image.

A technique was developed to automatically generate a GCP file using geographic data extracted from the header of a high resolution GOMEX (synoptic coverage) SST image and a modified version of an IPS subroutine, MERCAT. The geographic data, i.e., minimum and maximum bounding longitudes and latitudes, pixel size (1.47 km), and x- and y-offsets, were extracted from the image file header using DECCON. MERCAT is used operationally to convert earth coordinates to Mercator image coordinates to produce mapped CW images. The MERCAT FORTRAN code was converted to SAS code and integrated into a program designed to generate a grid of geographic coordinates across the image, transform the longitude and latitude coordinates to Mercator image coordinates, and write an ASCII GCP file in the format required by the Geographic Transformer. A total of 48 GCPs were generated for the task.

The rectification process continued by using DECCON to convert the SST image into an 8-bit TIFF image, a file format supported by the Geographic Transformer. TIFF images and an associated file containing earth location coordinates, i.e., a world file, can be imported, displayed, navigated in ArcView and later converted to GRID files with the Spatial Analyst extension. The TIFF image and GCP file were imported into the Geographic Transformer. The GCP file was used to generate a polynomial least squares mapping equation to relate the Mercator Image coordinates to the geographic coordinates. Ultimately the test images were successfully registered to the GMMM but required a time-consuming iterative process which included multiple runs of the Geographic Transformer and a regression analysis with the SAS Interactive Matrix Language (IML). After the transformation settings were determined, the Blue Marble batch processor would enable the user to rectify one or more of the high resolution, synoptic GOMEX images and write the data as TIFF images and generate the world files required for navigation. A detailed description of the technique including the support programs and data are given in Appendix B. There were at least two disadvantages to the technique: (1) the SST values in the image were smoothed twice during the process; once when aggregating the data from the original 11-bit resolution to 8-bits with DECCON (this was prior to the availability of DECCON); and again by resampling and rectifying the image to fit the GMMM; and (2) the Geographic Transformer does not have a command line processing option or scripting language and therefore may have been difficult to integrate into an automated processing scheme required to provide real-time support for the project. This technique also provided a method to convert historical SST images stored in the GMRN archive to support other projects with ArcView.

4.1.2.2 Final Rectification

An x-y translation, frequently referred to as ‘nudging’, was required for each SST image to correct for slight registration errors related primarily to timing inaccuracies and other factors (Emery et al. 1989). This is an interactive operation which requires shifting the image (in whole pixel units, i.e., 0.01° increments) in the x- and/or y-direction until it fits a reference map, typically a vector coastline. This task required the development of an ArcView Avenue extension (corrections.avx) to allow the server administrator to overlay a graphic rendition of the high resolution GSHHS on the image, zoom in on selected areas of the coast, interactively shift the image until the fit is correct, and save the correctly navigated image.

4.2 Conversion of SeaWiFS Chlorophyll-a images to an ArcView-compatible Image Format

Near-real time ocean color images derived from SeaWiFS data are not yet available without purchase from Orbital Imaging Corporation (OIC). Therefore only a few sample retrospective images were available for the project to test the conversion and display procedures in ArcView. Chlorophyll-a images are rectified to fit a general perspective map projection (Snyder 1987) and processed into the hierarchical data format (HDF) by the NESDIS Ocean Color Processing Group. The images are transferred to the GMRN on an intermittent basis. Since the map projection and data format were not compatible with the GMMM and ArcView, respectively, the images were rectified to geographic coordinates and converted to binary raster floating point images using the SeaWiFS Data Analysis System (SeaDAS) software. SeaDAS was developed by the National Aeronautics and Space Administration (NASA) using the Interactive Data Language (IDL) software. The image and an ASCII navigation file were converted to a GRID file using Spatial Analyst and inserted into the data catalogue along with a specially constructed chlorophyll-a color legend file. A detailed description of the processing steps is given in Appendix A.

5.0 NEAR-REAL TIME PIPELINE PROCESSOR AND DATA CATALOG

A near-real time pipeline processor was assembled by integrating the UNIX utility cron, the modified DECCON software, and ArcView/Avenue scripts to periodically search for new acquisitions in the GMRN directory and reformat the SST images for serving on the WWW. Cron is a standard UNIX utility which operates continuously to schedule programs to be executed in the future. Cron was configured to initiate a remote procedure call (RPC) to start ArcView at 0501, 0801, and 1801 hrs each day to search for new SST images in the CW image directory. If new images are present, processing continues through DECCON to convert the CW native format to binary raster floating point images. The binary images are then processed into GRID files with Spatial Analyst. The images are moved to the unprocessed GRID directory in preparation for final rectification. At this point, the processing ceases to allow the administrator to complete the final rectification ("nudging") of the images with the ArcView extension, *corrections.avx*. After each image is rectified it is stored in a catalog directory. A catalog update script is also initiated by cron which performs two tasks: (1) checks for newly acquired images in the catalog directory and moves files more than 7 days old to an archive directory; and (2) creates a thumbnail image of the file in a Joint Photographic Expert Group (JPEG) format for display in the image catalog. The thumbnail images are presented in the image catalog in chronological order beginning with the most recent acquisition. The resolution is adequate to enable users to screen the images for cloud cover, data drop outs, and areas outside of the orbital path of the satellite where no data were acquired. A flow chart of the process is shown in Figure 5.1.

6.0 INTERNET SUPPORT AND ACCESS

6.1 ArcView on the World Wide Web

The Internet Map Server (IMS) extension was purchased to enable ArcView to function as a map server on the World Wide Web (WWW) and send and receive maps and data to client sites over the Internet. The IMS was shipped with a Java applet, called the *MapCafé*, which provides a user interface for serving maps on the WWW and simple tools for perusing and querying the data. The functions built into the *MapCafé* applet, however, did not meet the project requirements and therefore necessitated the development of a custom ArcView extension for serving geographic data and a Java-based client application to analyze maps provided by the map server. The ArcView extension (jnms.avx) was developed to serve geographic data over an Internet connection and provide more functionality than the IMS. The features include: (1) personal work spaces for each user; (2) uploading of custom theme files over the network; (3) converting map displays to Joint Photographic Expert Group (JPEG) files to local disks for printing; (4) commonly available interactive operations, e.g., panning/zooming, feature selection, feature identification tool, and hiding/showing themes; and (5) advanced analytical operations, e.g., theme queries, theme-on-theme selection, theme-on-theme cross-tabulation. The application features an accessible graphical user interface and works with any Internet browser connection. Since this is a Java-based application, it can run on any computer system that supports graphical user interfaces (GUIs) and Java version 1.1.x. The application was tested on Windows 95/98/NT and SGI Irix version 6.2 operating systems. A user’s guide was drafted for the Map Client application as well as an administrator guide for the Map Server.

6.2 The NMFS Java Network Map Client GUI

The NMFS Java Network Map Client GUI is similar in appearance to the standard ArcView "View" interface, with the exception of the data catalog added to the left side of the window (Figure 6.1).

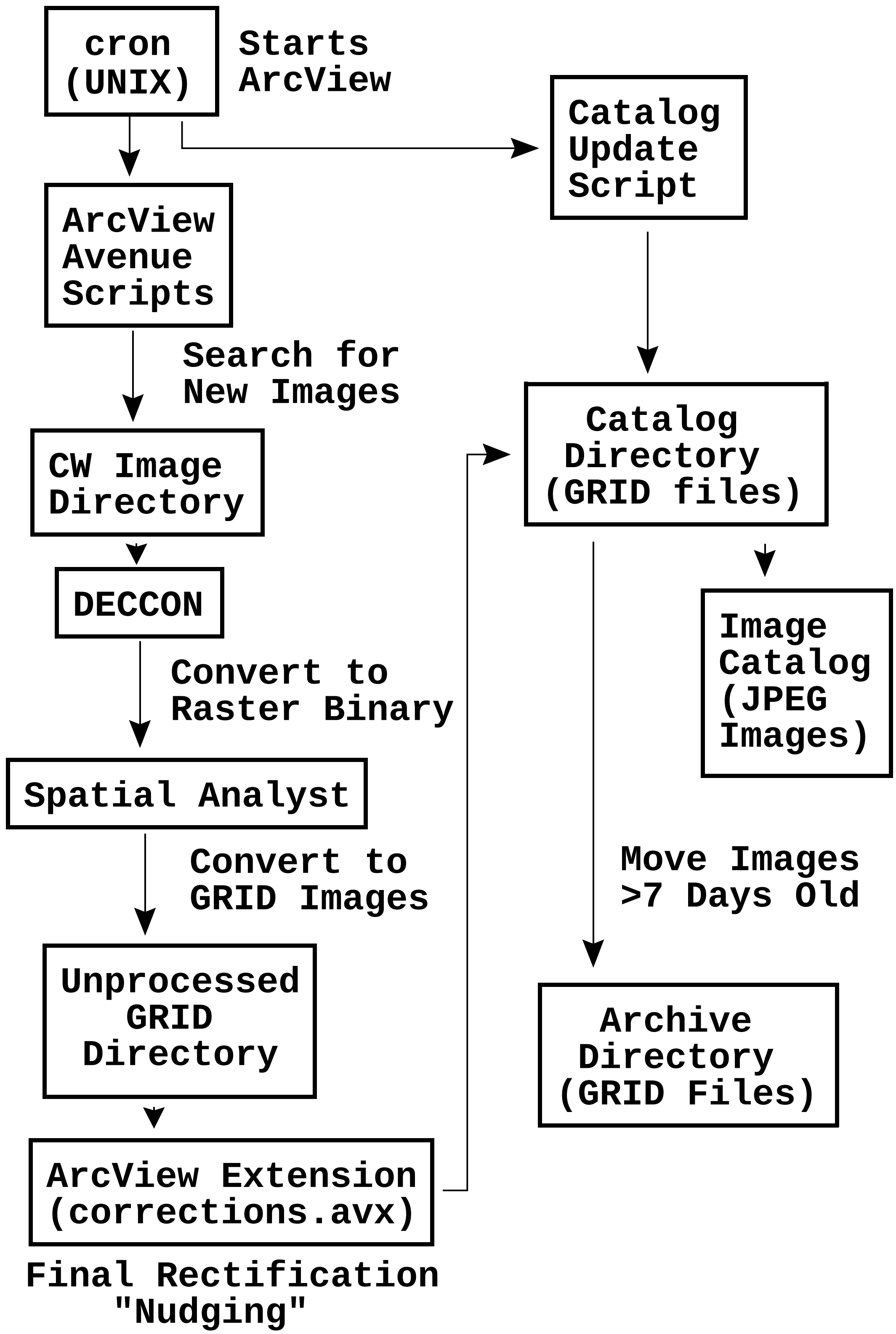


Figure 5.1. Processing sequence for CW SST images.

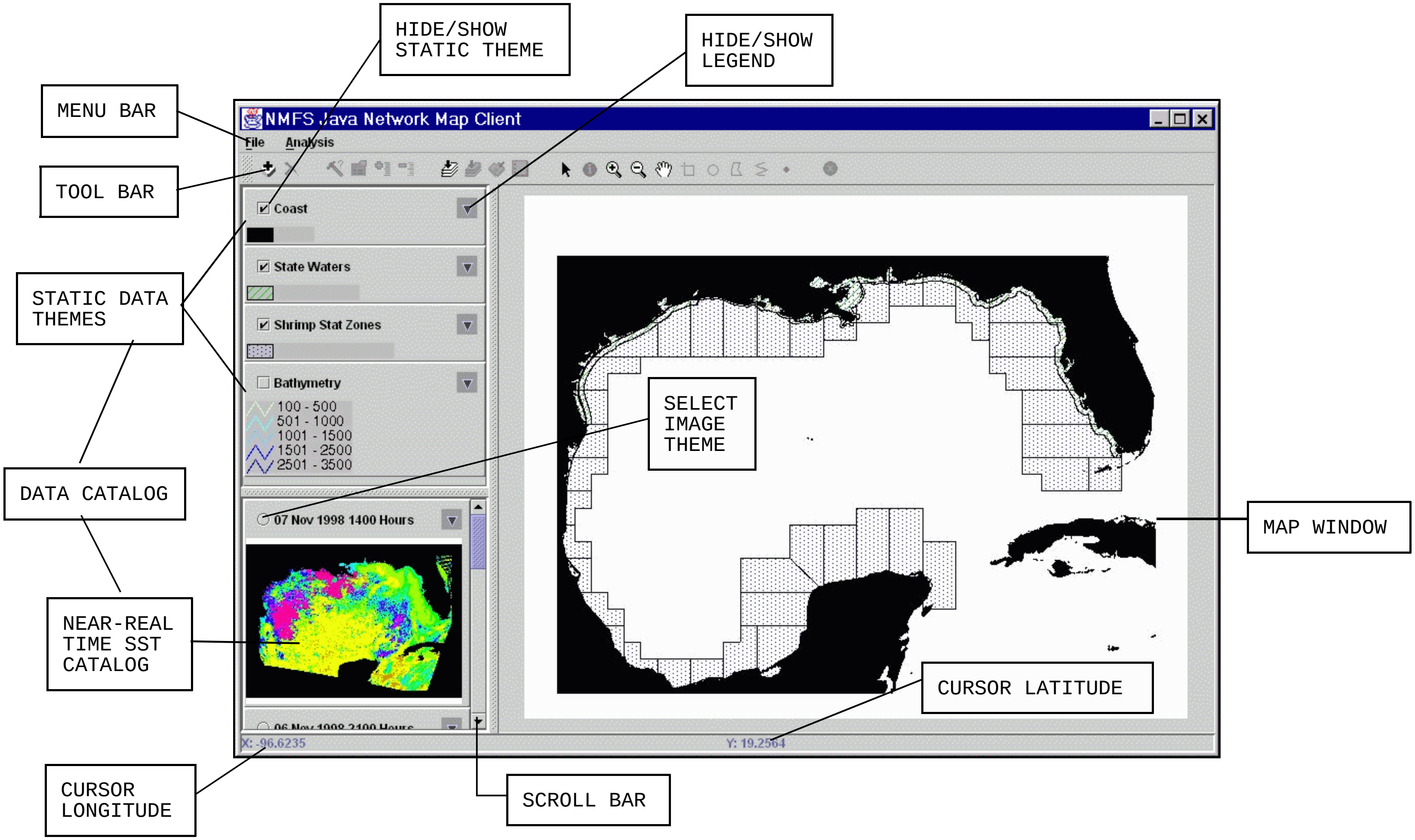


Figure 6.1. Basic components of the NMFS Java Network Map Client graphical user interface.

The major components and features of the GUI are as follows:

- *Menu and Tool Bars*: The utilities and tools in the pull-down menus and on the toolbar provide the primary means of user interaction with the map. The pull-down menus provide file management utilities and tools to query and summarize data (Figure 6.2). The toolbar offers a similar tool set to that available in the native ArcView interface, although some functionality differs (Figure 6.3).

- *Data Catalog*: This area of the GUI contains the list of static themes and the image catalog (Figure 6.1). The static themes list has a similar function as the Table of Contents in the standard ArcView GUI and users can toggle a specific map on or of by clicking a checkbox with the mouse. The image catalog displays thumbnail images in chronological order beginning with the most recent acquisition. A scroll bar is used to peruse the catalog and select images for display or analysis.

- *Map View Area*: This region displays the maps served by the GIS server (Figure 6.1). Users are able pan and zoom the map and move the cursor around the map to determine geographic coordinates of features.

6.3 Summary of Client Requests and Expected Return Values

Table 6.1 summarizes the capabilities of the NMFS Java Map Client software. The summary is presented in terms of the range of requests that the client is capable of submitting to the server, as well as the expected return values of each request. The requests are divided into groups of similar functionality:

- *System/File Management*: Requests to save map images, and to open locally-defined theme files.

- *Map Interaction*: Requests for zooming and panning the map

- *Theme Display*: Requests for toggling the visibility of themes and Image Catalog entries in the map.

- *Feature Selection*: Requests for selecting features based on spatial or tabular attributes

- *Tabular requests*: Requests for features attributes or summaries of feature selections in tabular form.

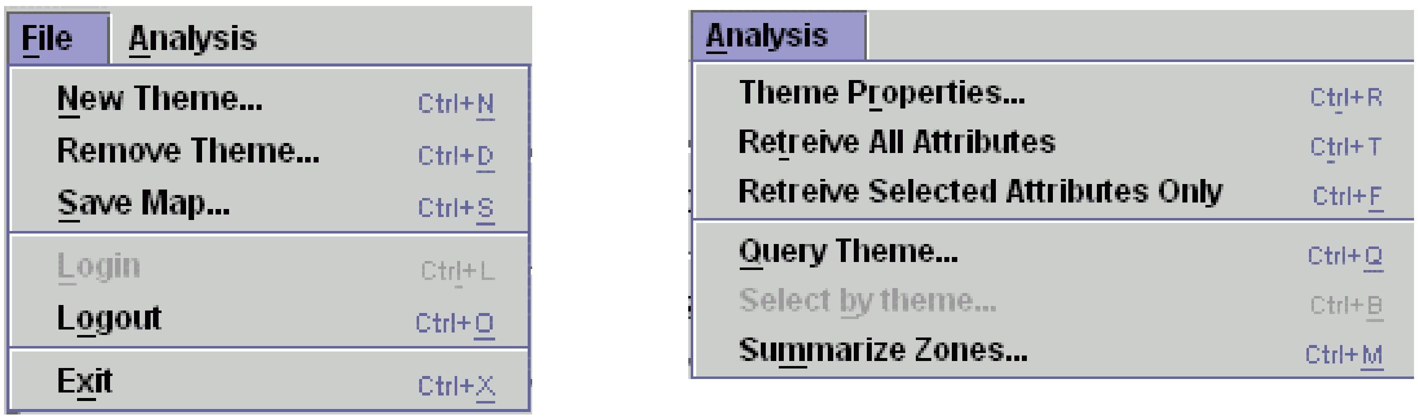


Figure 6.2. Contents of the file and analysis menus on the NMFS Java Network map client graphical user interface.

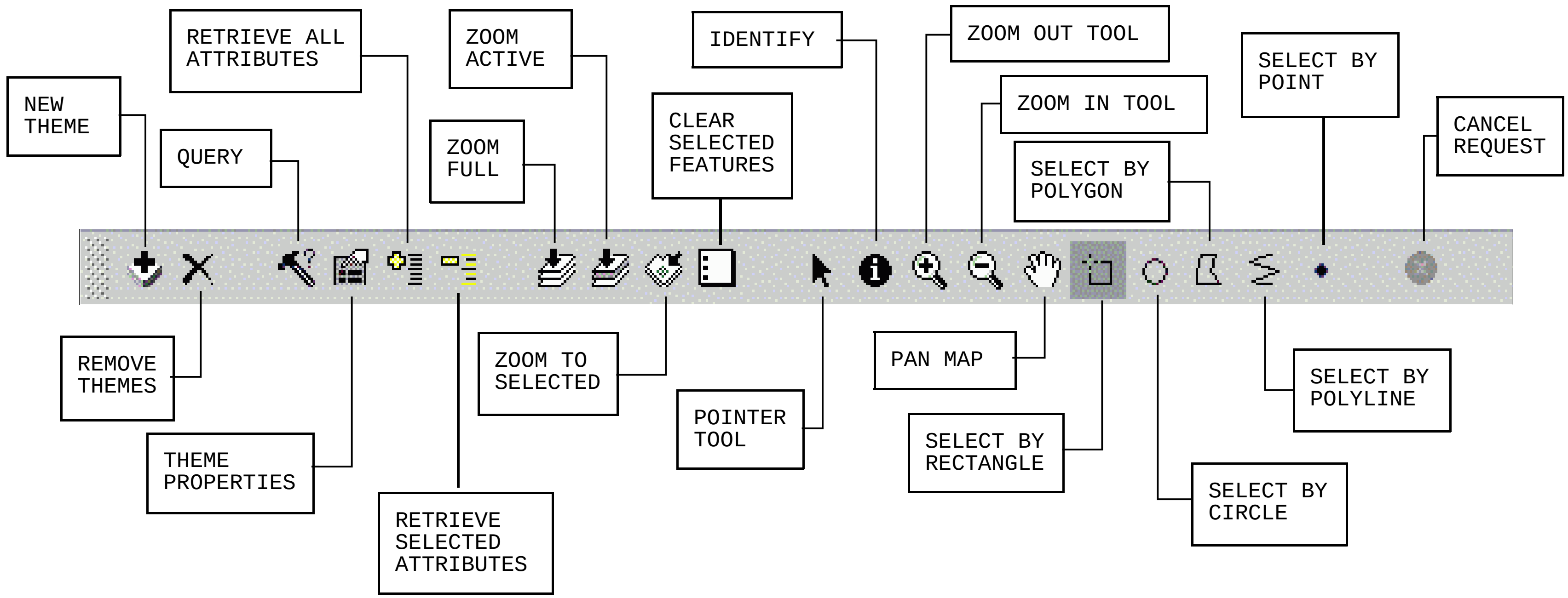


Figure 6.3. Components of the NMFS Java Map Client toolbar.

Table 6.1. Locations and functions of menu and tool selections on the NMFS Java Network Map Client GUI.

Category	Menu/tool selection	Location	Function
System/file management	New theme	FM[1]/TB[2]	Loads a user-defined point, line, or polygon file and associated attributes. The client supports a modified version of the ESRI UNGENERATE ASCII file
	Remove theme	FM/TB	Temporarily removes active static and/or SST themes from the data catalog; permanently deletes active custom themes
	Save map	FM	Saves current map image as a Joint Photographic Expert Group (JPEG) file and a corresponding ArcView navigation file, i.e., a world file
	Login	FM	Opens login dialog to connect to the map server
	Logout	FM	Initiates disconnect from server
	Exit	FM	Exits the program
	Cancel request	TB	Cancels a request sent to the server; identical in function to the STOP function on web browsers
	Save table	TRW[3]	Saves tabular data to an ASCII file that can be imported into other programs for further analysis

Table 6.1. Locations and functions of menu and tool selections on the NMFS Java Network Map Client GUI (continued).

Category	Menu/tool selection	Location	Function
Map Interaction	Zoom full	TB	Zooms map display to the full extent of all themes
	Zoom active	TB	Zooms the map to the extent of the active theme(s)
	Zoom to selected	TB	Zooms the map to the extent of the selected features in the active themes
	Pointer tool	TB	Resets mouse to operate in standard mode
	Zoom out	TB	Expands the view extent
	Zoom in	TB	Enlarges the area of the map display defined by a rectangle constructed by dragging and clicking the mouse
	Pan map	TB	Drags the map to a new location
	Cursor coordinates	GUI[4]	Displays longitude and latitude coordinates as the cursor is moved across the map display
Theme display	Hide/show static theme	DC[5]	Toggles static themes in the data catalog on or off in the map display
	Select image theme	DC	Toggles SST images in the image catalog on or off in the map display
Feature selection	Clear selected features	TB	Refreshes the map display with all features of the active theme unselected

Table 6.1. Locations and functions of menu and tool selections on the NMFS Java Network Map Client GUI (continued).

Category	Menu/tool selection	Location	Function
Feature selection	Select by rectangle	TB	Selects features in active themes that intersect a rectangle created by dragging and clicking the mouse
	Select by circle	TB	Selects features in active themes that intersect a circle created by dragging and clicking the mouse
	Select by polygon	TB	Selects features in active themes that intersect a polygon created from three or more polylines and closed by double-clicking the mouse
	Select by polyline	TB	Selects features in active themes that intersect a polyline created by dragging and clicking the mouse
	Select by point	TB	Selects features in active themes by clicking on a single point on the map
	Select by query	TB/AM[6]	Selection of features, e.g. by depth or SST range, based on a query of the theme table associated with the bathymetric file or an SST image
	Select by theme	AM	Selection based on the intersection or proximity of two themes (similar to ArcView's Select by Theme function)
	Clear selection	TB	Unselects any selected features in the active themes

Table 6.1. Locations and functions of menu and tool selections on the NMFS Java Network Map Client GUI (concluded).

Category	Menu/tool selection	Location	Function
Tabular Requests	Theme properties	AM/TB	Opens table of descriptive information, i.e., theme name, data type, and attributes, for each active theme
	Retrieve all attributes	AM/TB	Lists attributes of each feature in an active theme
	Retrieve selected attributes	AM/TB	Displays a table listing the attributes of selected features in an active theme
	Identify	TB	Lists attributes of features clicked on with the mouse (similar to ArcView's identify tool)
	Summarize zones	AM	Summarizes features in one theme based on groups defined in another theme

[1]FM - file menu
[2]TB - toolbar
[3]TRW - table reply window
[4]GUI - graphical user interface
[5]DC - data catalog
[6]AM - analysis menu

6.4 Examples of Selected Menu and Toolbar Functions

6.4.1 Prior to Starting

Make sure that the Java and the map client software have been properly installed on the system, and that a username and password have been assigned to the user by the server administrator.

6.4.2 Logging In

After the Java Network Map Client (JNMC) software is started, the first screen that will appear is the login screen to enter the username, password, and the server address (Figure 6.4). If the error message "Connection Refused" appears, then either the server is temporarily down or the server address was entered incorrectly. A "Timed Out" message indicates that the server is very busy.

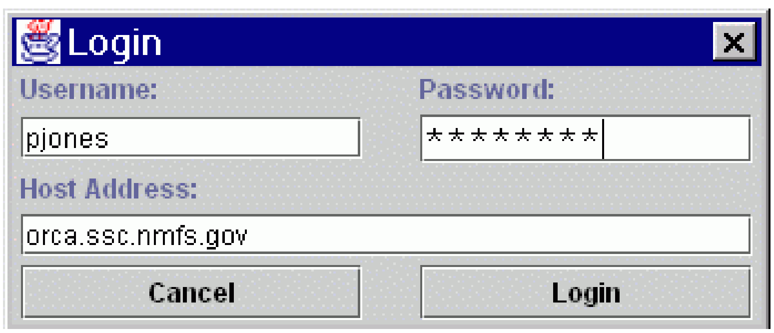


Figure 6.4. The login screen.

6.4.3 The Program Screen

After pressing the LOGIN button, an empty map VIEW FRAME will appear (Figure 6.5) while the server performs a number of operations to prepare the session and transfers the entire view definition over the network. During the setup, the CANCEL button is the only enabled button on the graphical user interface (GUI). This button is similar to the "Cancel" or "Stop" buttons found in web browsers and allows the user to cancel a pending request. Depending on network demands, the first map may require a minute or more to arrive. Subsequent requests generally require less time.

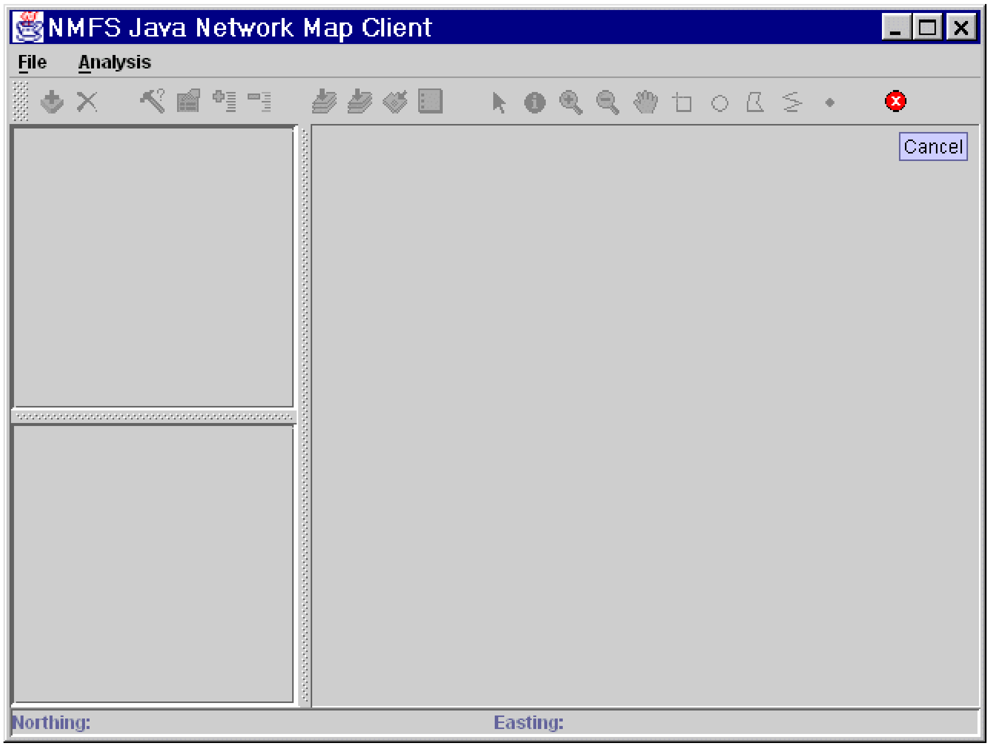


Figure 6.5. The initial view after logging on.

6.4.4 The Map View Interface

Figure 6.6 shows the screen after the first map arrives. The area on the right shows the map itself. The split pane on the left holds the static themes on the top, and preview images of the image catalog themes on the bottom. The divider between the static themes and the image catalog can be repositioned by clicking on the dividing bar and dragging the mouse. At the bottom is a coordinate panel; as the mouse pointer moves over the map image, the coordinate panel shows the geographic coordinates of the mouse (in decimal degrees). The buttons, tools, and menus line the top of the screen. All of the buttons have tool tips, so if you want to know what a button does, simply hold the mouse over it for a second.

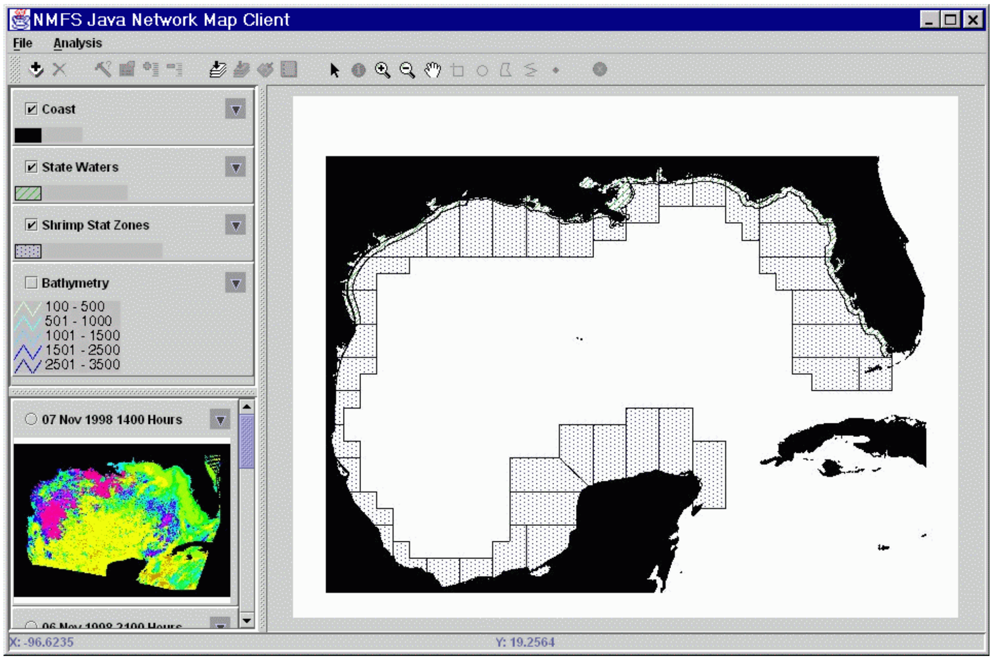


Figure 6.6. The view after the maps arrive.

6.4.5 Navigating the Map

Moving around within the map is accomplished using the ZOOM IN, ZOOM OUT, and PAN tools, shown in Figure 6.7. For example, clicking on the ZOOM IN button will make the tool active and enable the user to select the region of the map to zoom to by clicking and dragging the mouse. When the mouse button is released, the zoom request will be sent to the server. While the zoom request is being processed, the map and buttons will be grayed out. When the server finishes processing the request, the new map will be loaded into the view.

Figure 6.7. The ZOOM IN,ZOOM OUT, and PAN tools.

The ZOOM OUT tool zooms out the map in the ratio of the zoom box relative to the current map extent, i.e., if a small rectangle is drawn, the image zooms out a lot, and if a large rectangle is drawn, the image only zooms out a relatively small amount. In contrast, the ZOOM FULL button, depicted in Figure 6.8, zooms the view to the full extent of all themes.

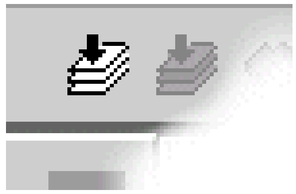


Figure 6.8. The ZOOM FULL button highlighted on the left.

6.4.6 Working with Static and SST Themes

The themes are the "layers" of the map, shown in the split panes at the left side of the view frame. In ArcView, a theme is made up of geographic features (e.g., the separate zones that make up the Shrimp Statistical Zones theme). Additional data may be associated with each of these features. For example, each statistical zone in the *Shrimp Stat Zones* theme is assigned an ID number. Similarly, each pixel in the sea surface temperature (SST) images in the Image Catalog is associated with a numerical value, i.e., temperature in degrees Celsius.

Three properties of themes can be adjusted: their visibility, the visibility of their legends (or thumbnail previews, for image catalog themes), and whether or not they are "active".

- *Legends Theme*: Legends can be hidden and shown by clicking the small triangular icon to the right of the theme’s name (Figure 6.9). When the legend is hidden, it is "rolled up" into the theme name (see the "State Waters" theme in the graphic). This is a quick process, because it does not require a call to the server.

- *Theme Visibility*: Theme visibility (in the map) can be changed by checking or un-checking the box by the theme’s name (clicking on the box’s label also toggles the check). This process takes more time, because it requires a request to the server to produce a new map image. In order to minimize needless extra calls to the server, there is a one and a half second delay from the last check box click before the request is actually fired. This allows you to turn several themes on or off, and have all of the requests handled at once. Or, if you accidentally click on a theme's check box, you can quickly click on it again to prevent the request from firing.

• *Active/Inactive*: For most analyses and operations, you are only interested in a few of the themes present in the view (or even just one). You specify which themes you want to be the target of your actions by making them **active.** A theme is made active by clicking anywhere on the theme's panel besides the check box, its label, or the legend visibility button. When a theme is active, its panel looks depressed (e.g., the "Shrimp Stat Zones" theme in the graphic). Toggling a theme's active status does not require a call to the server.

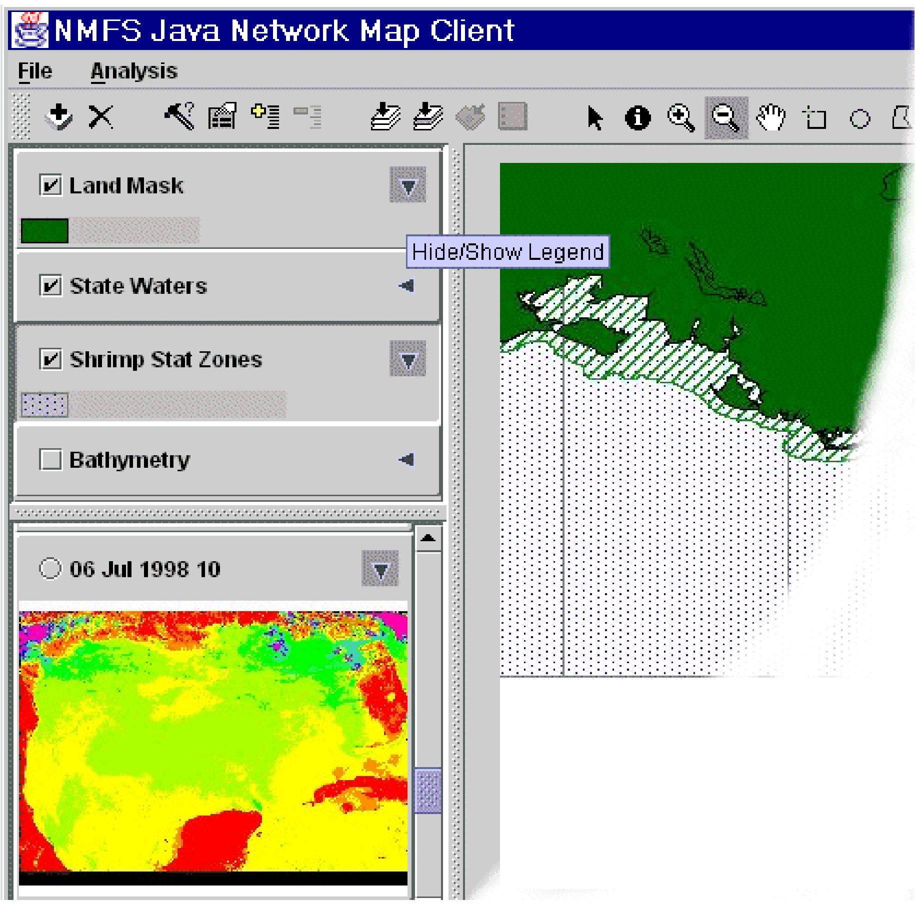


Figure 6.9. Clicking the triangular area to the right of the theme hides or shows the legend.

Data queries and summaries can be extracted and are presented in tabular form. For example, reading an SST value in an image begins by selecting an image from the image catalog and clicking on its check box to make the image visible. Once the new map returns (Figure 6.10), make the image theme active by clicking on it. Also make the theme *Shrimp Stat Zones* active, and select the IDENTIFY tool from the toolbar.

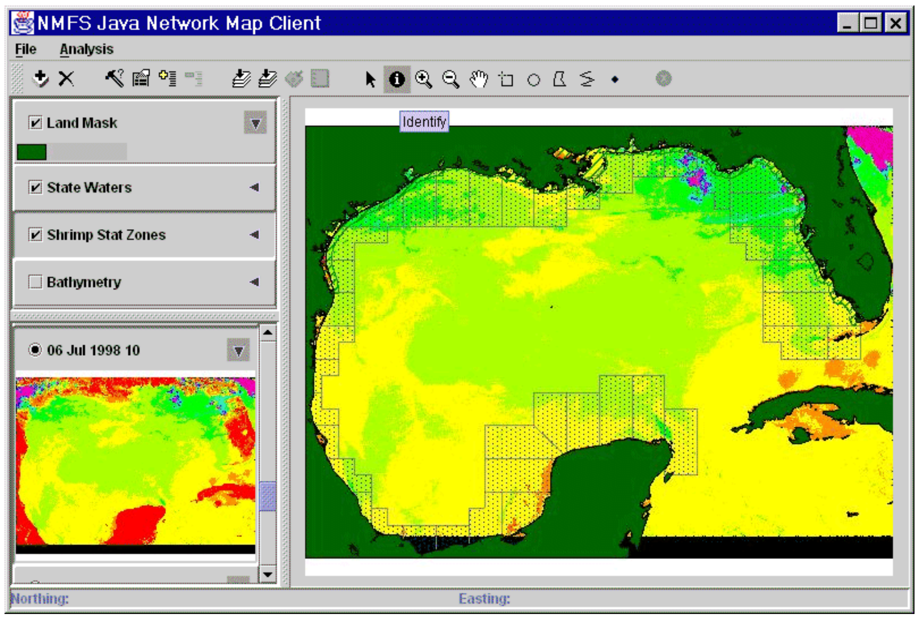


Figure 6.10. SST image and Shrimp Stat Zones themes selected from the data catalog.

By clicking on a point of interest, e.g., off of the Louisiana Coast, the server will return a tabular listing for each of the two active themes, one of which is shown in Figure 6.11. The table indicates that the SST measured at -88.9383° west longitude and 28.5157° north latitude was 21.95°C. There is one table for every active theme (unless there are no theme features present, e.g., there would be no table for the Shrimp Stat Zones after clicking a point in the middle of the Gulf of Mexico). The tabs at the bottom of the window enables the user to switch tables for viewing.

Figure 6.11. SST value measured off of the Louisiana Coast.

6.4.7 Selecting Features

6.4.7.1 Interactive Selection with the Mouse

In another example, assume that a user is interested in the four Shrimp Statistical Zones located off of the Florida Panhandle (zones 7-10). After confirming that the *Shrimp Stat Zones* theme is active and activating the SELECT BY RECTANGLE tool, the mouse is clicked and dragged into a rectangle to select the four zones (Figure 6.12).

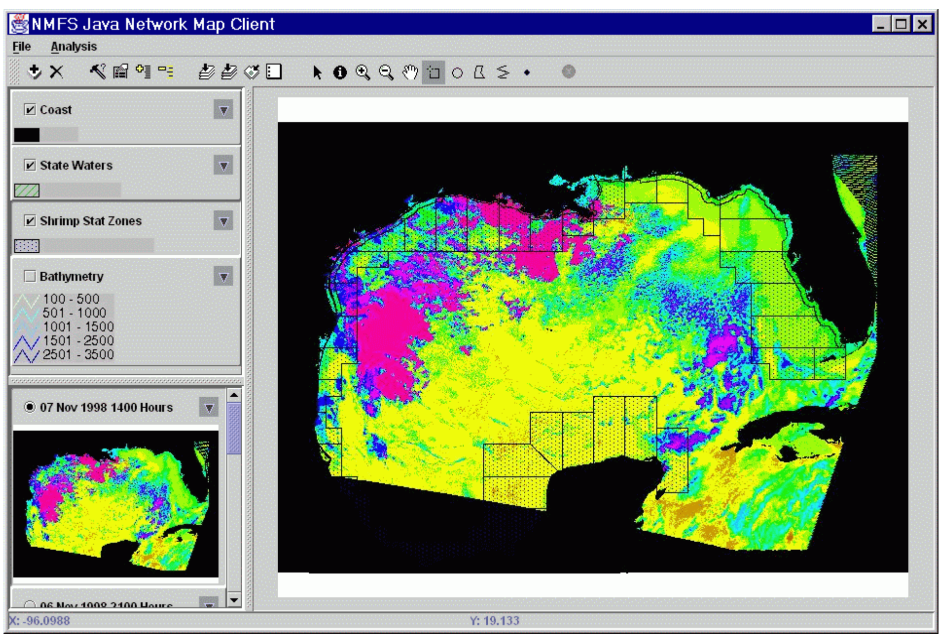


Figure 6.12. Shrimp Statistical Zones selected off of the Florida Panhandle.

Note that the selected shrimp zones are highlighted in yellow. However, to confirm that the correct zones were selected, click the RETRIEVE SELECTED ATTRIBUTES ONLY button which returns a tabular list of the attributes of the selected features. The result from this action is shown in the Figure 6.13.

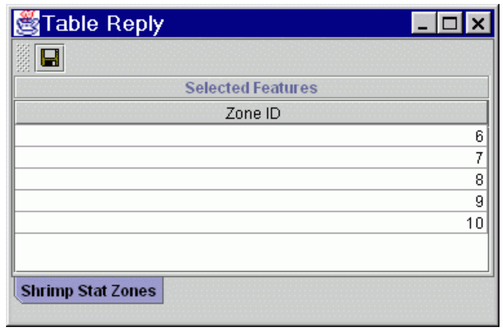


Figure 6.13. Tabular response from the RETRIEVE SELECTED ATTRIBUTES ONLY button.

According to this table, zone 6 was inadvertently selected in addition to the zones in our study area. Feature selections can be made more precisely by performing a database query on the "Shrimp Stat Zones" theme.

6.4.7.2 Selection by Query

Before performing a query on a theme, the analyst may want to peruse the types of data associated with the theme With the *Shrimp Stat Zones* theme active, clicking the THEME PROPERTIES button will display a tabular response depicted in Figure 6.14.

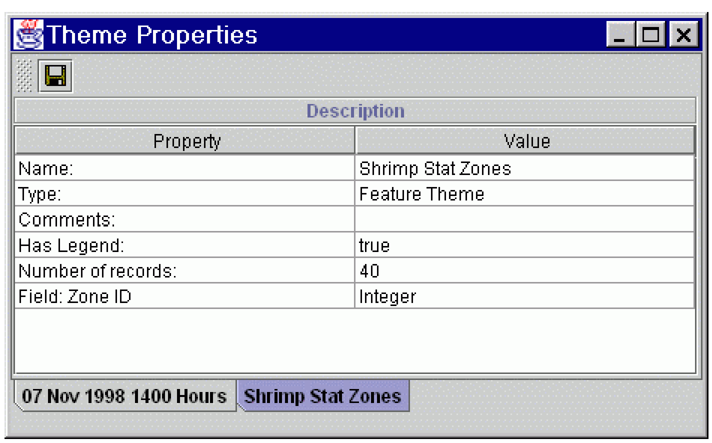


Figure 6.14. Tabular response showing the types of data associated with the *Shrimp Stat Zones* theme.

Figure 6.14 shows the basic characteristics of the *Shrimp Stat Zones* theme. Among other things, it shows that this theme has only one field associated with it: a field called "Id" which holds integer values. Closing the *Theme Properties* window and clicking the QUERY THEME button opens a dialog window which allows the user to build a query to select zones 7-10 from the *Shrimp Stat Zones* theme. The Query dialog has several features worth noting. First, a list of available fields is given in the left-hand list box (there is only one field for this theme). When the user clicks on a field name, the box on the right side lists the type of data in the field (integer in this example), and the minimum and maximum values. This allows the user to avoid wasting time looking for zones numbered 40 or more, since you know that 40 is out of range (note: this information will not be available for all themes).

To build the query, the user can type in the query manually or use the buttons in the query window to build the text. Double-clicking the field's name will insert the field name into the query. ArcView's query language requires rigid adherence to a standard format. Note that field names are surrounded by brackets ("[ ]") and parentheses are used to partition the different terms in the query. The query window set up to select zones 7 through 10 in the *Shrimp Stat Zones* theme is shown in Figure 6.15.

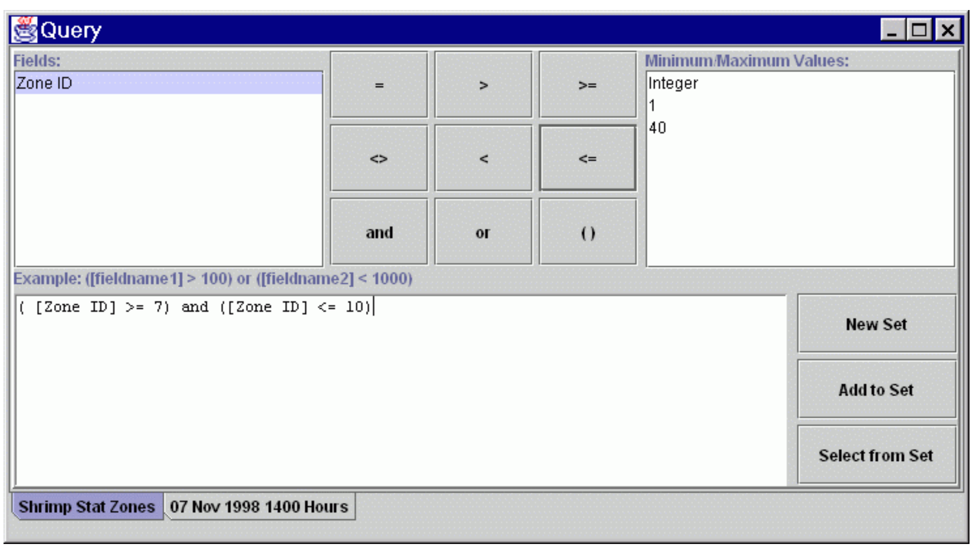


Figure 6.15. Query window set up to select Shrimp Statistical zone numbers 7 through 10.

When the query is ready, clicking on the NEW SET button in the query window will generate a map similar to Figure 6.16 with zones 7 through 10 selected, i.e., highlighted in yellow.

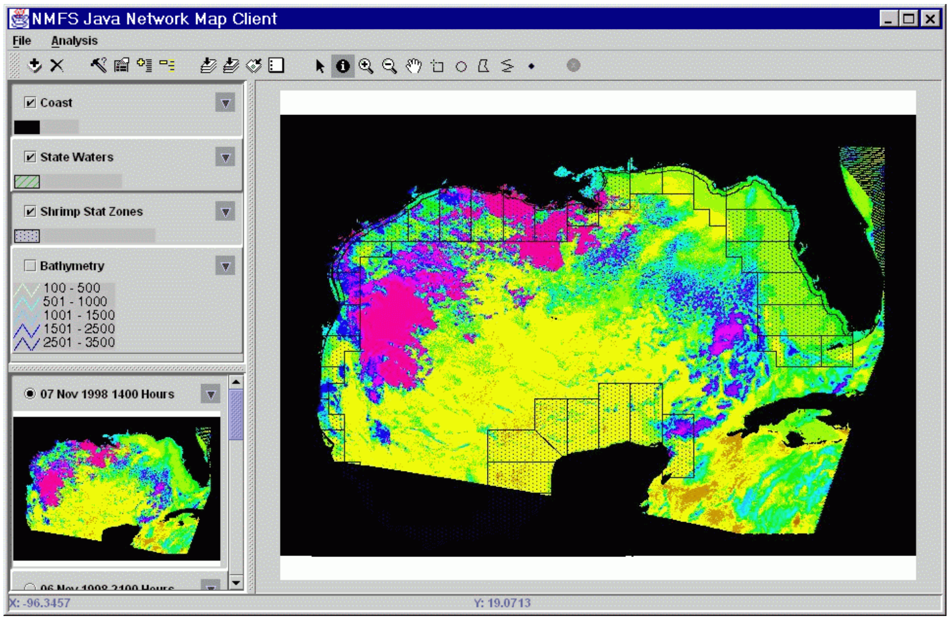


Figure 6.16. Results of using a query to select zone numbers 7 through 10 in the Shrimp Statistical Zones theme.

6.4.8 Summarizing Information

After the zones are selected, a tabular summary of SST in each zone may be generated by initiating the SUMMARIZE ZONES item in the *Analysis* menu which responds with the dialog box shown in Figure 6.17.

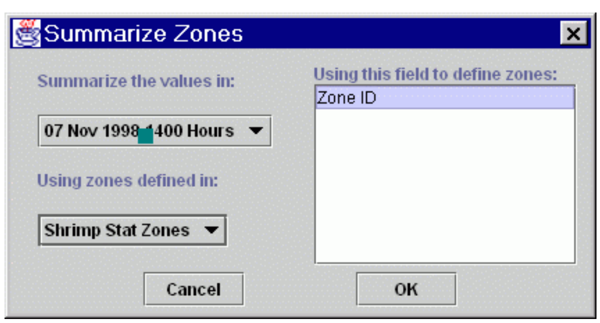


Figure 6.17. The SUMMARIZE ZONES dialog box from the *Analysis* menu.

The pull down list located at the top left of Figure 6.17 enables the user to define the SST theme to generate the tabular summary and in this example, an image acquired on November 7, 1998 at approximately 1400 hrs. The pull down list at the lower left of the dialog box presents a list of themes that can be used to summarize the SST data, i.e., the *Shrimp Stat Zones* theme. The data field, *Zone ID*, is selected in the window on the right. Continuing with the example, the user has set the SUMMARIZE ZONES dialog box to tabulate SST statistics from the image acquired on November 7th for each of the four selected zones in the *Shrimp Stat Zones* theme. By clicking the OK button, a tabular summary similar to Figure 6.18 will be displayed.

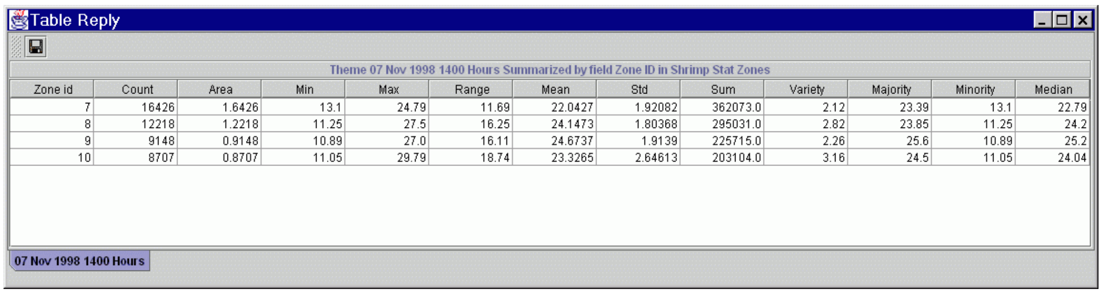


Table Reply

Theme 07 Nov 1998 1400 Hours Summarized by field Zone ID in Shrimp Stat Zones

Zone id	Count	Area	Min	Max	Range	Mean	Std	Sum	Variety	Majority	Minority	Median
7	16426	1.6426	13.1	24.79	11.69	22.0427	1.92082	362073.0	2.12	23.39	13.1	22.79
8	12218	1.2218	11.25	27.5	16.25	24.1473	1.80368	295031.0	2.82	23.85	11.25	24.2
9	9148	0.9148	10.89	27.0	16.11	24.6737	1.9139	225715.0	2.26	25.6	10.89	25.2
10	8707	0.8707	11.05	29.79	18.74	23.3265	2.64613	203104.0	3.16	24.5	11.05	24.04

07 Nov 1998 1400 Hours

Figure 6.18. Tabular summary of SST data for each of the four zones selected in the *Shrimp Stat Zone* theme.

Figure 6.18 presents a tabular summary statistics for the sea surface temperature image specified in the *Summarize Zones* dialog box in Figure 6.17. For example, the mean temperature in zone 11 was 24.6°C. The results of the analysis may be saved on the user’s machine by clicking the SAVE TABLE button on the toolbar window. The table will be saved as a ASCII text file with the data fields delimited by tabs and thus can be easily imported into almost any spreadsheet or database program.

6.4.9 Uploading Custom Point, Line, and Polygon Themes

The JNMC allows the user to upload custom point, e.g., the location of a harmful algal bloom; line, e.g., an aerial survey transect where a rare species of marine mammal was sighted; and polygon themes, e.g., a longline set; from a drive on the local computer to the server to use in analysis. The format required for uploading custom themes and associated attributes is described in Appendix C and in the online tutorial available through the NMFS Java Network Map Client Download Page (see section 7.0). A sample theme definition file, called *custom_theme.txt*, will be automatically installed with the JNMC software, located in the HELP directory, and is also listed in Appendix C, Section C.4. The sample theme is an example of how to perform other analyses using SST themes from the Image Catalog.

Clicking the NEW THEME button or selecting NEW THEME from the *File* menu opens a file dialog box used to locate the *custom_theme.txt* file. Clicking the OPEN button in the file dialog box will automatically upload the custom theme definition to the server and add it to the current view. Note that the custom theme, *Survey Points*, has been added to the data catalog and rendered in the current view (Figure 6.19).

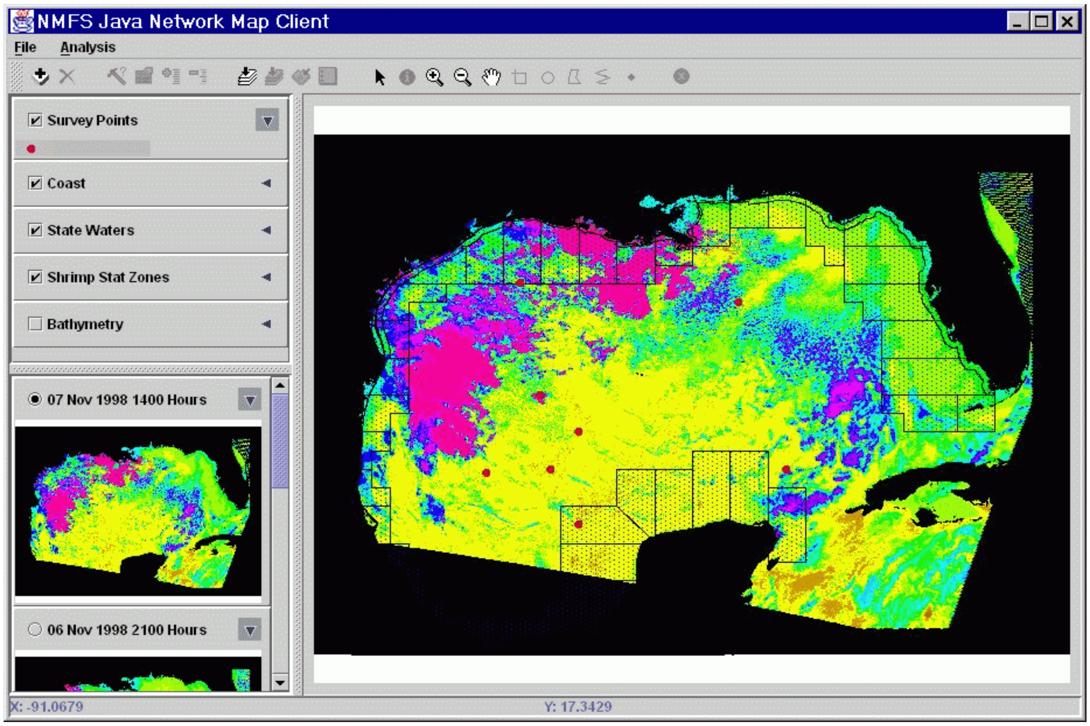
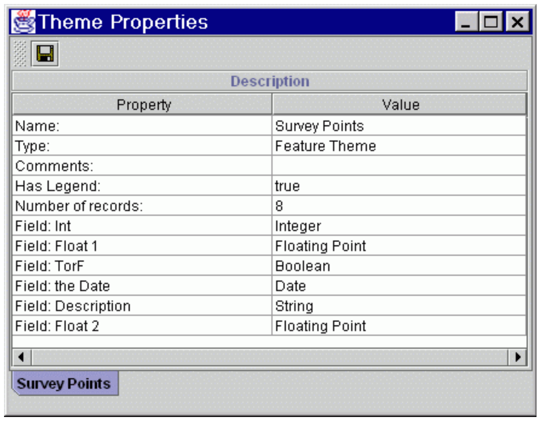


Figure 6.19. The custom theme, *Survey Points*, uploaded into the data catalog and rendered on the SST theme acquired on November 7th.

By making the *Survey Points* theme the only active theme (i.e., clicking on any currently active themes to deactivate them and clicking on the *Survey Points* theme to make it active) and clicking on the THEME PROPERTIES button, a dialog box will be displayed on the screen (Figure 6.20). The dialog box indicates that the *Survey Points* theme has several fields associated with each point such as an integer value, a boolean value, and data field. In actual data, these fields may represent sample numbers, the date the sample was taken, and the value of a measurement taken at a particular location.

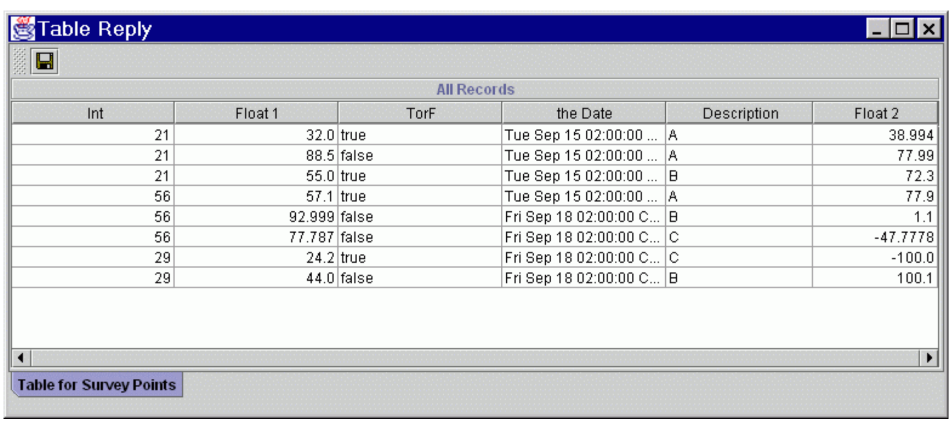


Property	Value
Name:	Survey Points
Type:	Feature Theme
Comments:	
Has Legend:	true
Number of records:	8
Field: Int	Integer
Field: Float 1	Floating Point
Field: TorF	Boolean
Field: the Date	Date
Field: Description	String
Field: Float 2	Floating Point

Figure 6.20. Properties of the *Survey Points* theme.

6.4.10 Summarizing Data Using the Custom Theme

Continuing the demonstration, summarize SST values at each point in the *Survey Points* theme. By clicking the RETRIEVE ALL ATTRIBUTES button, it is evident in the theme's table that several of the points have the same values in some fields. For example, in the "Description" column, three points have an "A", three have a "B", and two have a "C". Assuming that these are codes for different sample types, the user may want to compare the mean SSTs for each of the three sample types.



Int	Float 1	TorF	the Date	Description	Float 2
21	32.0	true	Tue Sep 15 02:00:00 ...	A	38.994
21	88.5	false	Tue Sep 15 02:00:00 ...	A	77.99
21	55.0	true	Tue Sep 15 02:00:00 ...	B	72.3
56	57.1	true	Tue Sep 15 02:00:00 ...	A	77.9
56	92.999	false	Fri Sep 18 02:00:00 C...	B	1.1
56	77.787	false	Fri Sep 18 02:00:00 C...	C	-47.7778
29	24.2	true	Fri Sep 18 02:00:00 C...	C	-100.0
29	44.0	false	Fri Sep 18 02:00:00 C...	B	100.1

Figure 6.21. Theme table listing attributes for the *Survey Points* theme.

The SUMMARIZE ZONES utility demonstrated Section 6.3.8 will be used with the *Survey Points* theme to tabulate data from an SST theme. In contrast to the previous exercise where each zone in the Shrimp Stat Zone theme had a unique identifier (i.e., zone number) this data will be summarized for each of the three levels, i.e., A, B, and C, in the DESCRIPTION field (Figure 6.21). The SUMMARIZE ZONES dialog box set up for the analysis using the SST theme acquired on November 7th is shown in Figure 6.22.

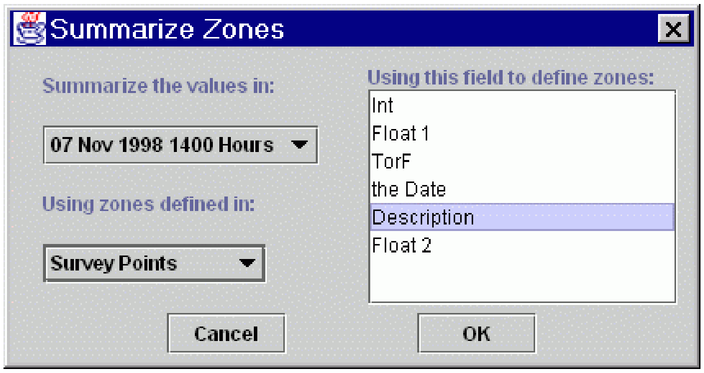


Figure 6.22. The SUMMARIZE ZONES dialog box set up to summarize SST data for each of the three levels in the DESCRIPTION field.

A tabular summary of the data is shown in Figure 6.23. Clicking the SAVE TABLE button will download the data to a local drive.

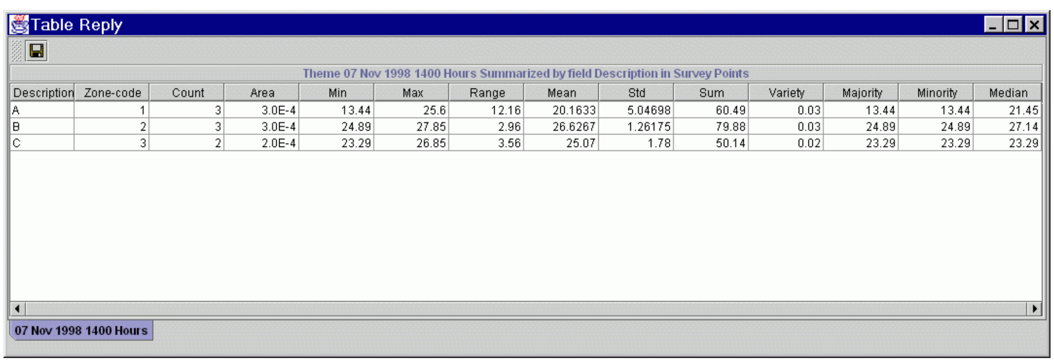


Table Reply

Theme 07 Nov 1998 1400 Hours Summarized by field Description in Survey Points

Description	Zone-code	Count	Area	Min	Max	Range	Mean	Std	Sum	Variety	Majority	Minority	Median
A	1	3	3.0E-4	13.44	25.6	12.16	20.1633	5.04698	60.49	0.03	13.44	13.44	21.45
B	2	3	3.0E-4	24.89	27.85	2.96	26.6267	1.26175	79.88	0.03	24.89	24.89	27.14
C	3	2	2.0E-4	23.29	26.85	3.56	25.07	1.78	50.14	0.02	23.29	23.29	23.29

07 Nov 1998 1400 Hours

Figure 6.23. SST data tabulated from the image acquired on November 7th for each of the three levels of the DESCRIPTION field associated with the *Survey Points* theme.

6.4.11 Deleting Themes

After the user uploads a custom theme to the view, it will remain there until it is explicitly deleted. The theme will even persist between sessions. To remove a theme that is no longer needed, the theme must be made active and then deleted by clicking the REMOVE THEME button. The REMOVE THEME button will delete all active themes so the user should carefully check all active themes before executing the command. Custom themes are permanently deleted from the server by this command to prevent the server from becoming cluttered with dated or obsolete files. The custom theme definition may be re-loaded, however, from the local computer if the theme is required again. If one of the themes supplied by the server (e.g., one of the static themes, or a theme from the Image Catalog) is deleted, the theme is not permanently removed; it will reappear the next time user logs in.

6.4.12 Logging Out

When the session is finished, the user can log out either by choosing LOGOUT from the file menu, or by simply exiting the program.

7.0 CONTACTS FOR ACCESSING THE SYSTEM

Instructions for downloading the Java software and the JNMC software are maintained at the NMFS Java Network Map Client download page located at SSC[17]. There is a user's guide and tutorial online at the same location. A modified version of the online tutorial was presented beginning in Section 6.0. The Java Network Map Server Administrator's Guide given in Appendix D provides more detailed information on how the server components function. A brief summary of the online version of the JNMC User's Guide is given in Appendix E. Dr. Thomas D. Leming[18], Research Oceanographer, is the server administrator and sets up user accounts and issues passwords.

8.0 RECOMMENDATIONS FOR IMPROVEMENTS

The current system is slow since it requires 30 or more seconds to respond to a request submitted by a remote user. The problem is the outmoded SGI UNIX workstation configured as the server. The workstation is about eight years old and will no longer be supported directly by SGI at the end of the year. Moving the system to a Windows NT operating environment may result in significant improvements in

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[17] http://marlin.ssc.nmfs.gov/gis

[18] E-mail address: tom@bluefin.ssc.nmfs.gov; Telephone: 228-688-1214.

response times but would require modification of the server software, a dedicated Windows NT Server, the purchase of an additional copy of ArcView and the Spatial Analyst extension, and possibly additional licensing fees to use ArcView to publish maps on the WWW. Comparing the relative costs of the two platforms, purchasing and configuring a Windows NT server may be a more cost effective solution than replacing the UNIX server.

- *Recommendation 1*: Modifying the server software and replacing the current UNIX server with a Windows NT server is estimated to increase the speed of processing client requests by a factor of four.

The pipeline processor currently used to update the catalog directory and image catalog is currently hard coded for CW SST images.

- *Recommendation 2*: Expand the capabilities of the pipeline processor by modifying the Avenue scripts to accommodate other CW AVHRR products distributed through the GMRN, e.g., the channel 1 through 4 images.

SST images are stored as GRID files in the archive directory, a cumbersome format that is difficult to distribute to other users.

- *Recommendation 3*: Modify the Avenue script that updates the archive directory to convert the SST GRID files to binary raster floating point files and corresponding ASCII navigation files.

SeaWiFS images are currently processed manually through SeaDAS software to re-project and reformat the data for use in ArcView.

- *Recommendation 4*: Integrate SeaDAS software into a pipeline processor to convert and re-project SeaWiFS chlorophyll-a images into GRID files for the catalog directory and image catalog.

There is no efficient way to search for historical data in the GMRN CW archive.

- *Recommendation 5*: Continue developing the image catalog prototype into an archive catalog by developing a generic cataloging engine to handle a wide range of ArcView-compatible vector and raster data that could support projects through the JNMC. Front end tools would enable the user to select near real time as well as historical imagery by product type, date and time of acquisition, and geographic coverage as well as peruse thumbnail images of each map file.

9.0 COLLABORATIVE ACTIVITIES OR FISCAL LEVERAGING

The U.S. Environmental Protection Agency’s (EPA) Gulf of Mexico Programs Office has agreed to continue funding contractual support to develop additional data layers for the GIS. Contoured environmental data collected as part of the SEAMAP program are of interest to the group, particularly hypoxia zones off of the Mississippi River inferred from bottom oxygen measurements.

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APPENDIX A: A PROCEDURE FOR GENERATING ARCVIEW-COMPATIBLE SEAWIFS IMAGES

A.1 Computer Hardware and Software Requirements

This procedure was developed with the Interactive Data Language (IDL), SeaDAS, ArcView version 3.0b, and the ArcView Spatial Analyst extension installed on SGI UNIX workstations.

A.2 Rectifying the Images

The SeaWiFS images are received at the GMRN in a general perspective map projection (GPMP) and must be rectified to fit the geographic coordinate system of the Gulf of Mexico Master Image (GMMM). The following processing steps were used to re-project the images with SeaDAS software:

(1) From the SeaDAS main menu, select 'Display/seadisp'.
(2) From the Seadisp main menu, select 'Load/SeaWiFS'.
(3) From the Product Selection menu, select 'file/OK'.
(4) Select the desired SeaWiFS product, e.g., 'chlorophyll-a', then 'Load'.
(5) From Seadisp main menu, select 'Projection'.
(6) From Seadisp Projection Function Menu:
   a. Select product for projection
   b. Use cylindrical map projection
   c. Set then minimum and maximum latitude and longitude coordinates of the output image, e.g., for the GMMM: 18° North Latitude, -80° West Longitude and 31° N Latitude, -98° W Longitude.
   d. Activate the 'isotropic' button
   e. Set number of columns and rows for output file, i.e., for the GMMM, 1801 columns by 1301 lines.
   f. Initiate the rectification procedure by selecting 'Go'

A.3 Conversion from HDF to Binary Raster Format

When the re-projection is completed, the new image will be added to the band selection list in active memory with the prefix 'mapped' added. Select this new file as the active file and continue processing in SeaDAS to convert the image to a binary floating point output image:

(1) Select 'Display', then 'Functions', then 'Output/Binary'.

(2) From the Output Setup Menu, set Type to ‘Image Data’, activate the ‘GeoPhys’ button (encodes the data with physical values, in this case, chlorophyll-a expressed in mg/l in floating point format), set File Type to ‘Flat File’, Window to ‘Entire’, then initiate the reformatting by typing ‘Go’.
(3) The binary output flat file will be created with the suffix ‘.flat’ with the label ‘mapped’ in the filename prefix.
(4) Before the flat binary file can be imported to ArcView with the Spatial Analyst extension, it must be renamed with the filename extension, ‘.flt’.

A.4 Creating the Navigation File

The Spatial Analyst extension also requires a corresponding navigation file which is created with an ordinary ASCII text editor. The navigation file must use a filename prefix identical to the binary raster file, end with a .hdr extension, and be stored in the same directory with the image. The contents of the .hdr file for the GMMM is as follows:

ncols 1801	(Total number of columns in image)
nrows 1301	(Total number of rows in image)
xllcorner -98.00	(W longitude of lower left corner of image)
yllcorner 18.00	(N latitude of lower left corner of image)
cellsize 0.01	(Pixel size in degrees)
nodata_value 0	(Optional keyword and value - defines data value that is missing or unknown; in this example, missing data are defined as zeros)
byteorder msbfirst	(Byte order for binary pixel values, i.e., most significant byte first (msbfirst) for SGI workstations; the other option is least significant byte first (lsbfirst) which is usually the case for a Windows-based PC).

.

A.5 Importing the Image with Spatial Analyst

The following steps were used to convert the binary raster file to a GRID file and add the image to a view:

(1) Open ArcView
(2) Under the ‘File/Extensions’ menu, activate the ‘Spatial Analyst’ extension

(3) Open a new view
(4) From the view menu, select ‘File/Import Grids’
(5) Select the ‘binary’ option in the ‘Import File Type’ menu.
(6) Select the ‘.flt’ file created previously and click ‘ok’.
(7) Define the path and name for the GRID output file and click ‘ok’.
(8) Add the new GRID theme to the view:
    a. Open the ‘View’ menu and select ‘Add Theme’
    b. In the ‘Add Theme’ menu under ‘Data Source Types’ select ‘Image Data Source’.
    c. Select the new GRID file and click ‘ok’.

APPENDIX B: A TECHNIQUE FOR RE-PROJECTING COASTWATCH SATELLITE IMAGE PRODUCTS FROM A MERCATOR MAP PROJECTION TO A GEOGRAPHIC (LINEAR LONGITUDE/LATITUDE) COORDINATE SYSTEM

B.1 Computer Hardware and Software Requirements

This technique was developed using a personal computer with a Windows NT version 4.0 operating system installed along with the following software: Decompression and Conversion of NESDIS CoastWatch Imagery (DECCON); the Blue Marble Geographic Transformer, v 3.07; The Statistical Analysis System (SAS), and the SAS Interactive Matrix Language (IML).

B.2 Automatic Generation of Ground Control Points (GCPs)

A technique was developed to automatically generate a GCP file using geographic data extracted from the header of a high resolution Gulf of Mexico (synoptic coverage) SST image and a modified version of an Image Product System subroutine, MERCAT . The geographic data, i.e., minimum and maximum bounding longitudes and latitudes, pixel size (1.47 km), and x- and y-offsets, were extracted from the image file header using DECCON software. The MERCAT FORTRAN code was converted to SAS code and integrated into a program (GCP_GEN.SAS) designed to generate a grid of geographic coordinates across the image, transform the longitude and latitude coordinates to Mercator image coordinates, and write an ASCII GCP file in the format required by the Geographic Transformer. The SAS program is listed in section B.6.2. The ASCII output file was formatted as a *Reference Settings File* (RSF) for the Geographic Transformer. The Mercator image coordinates in the RSF were originally rounded off to integer values and later computed as floating point values to provide a better "fit" with the map transformation equation. The contents of the RSF is shown in section B.6.3. A total of 48 GCPs were generated for the task and a modified version adapted from the RSF is shown in section B.6.4.

B.3 Initial Run with the Geographic Transformer

The rectification process continued by using DECCON to convert the SST image into an 8-bit TIFF image, a file format supported by the Geographic Transformer. The TIFF image and RSF file were imported into the Geographic Transformer. The RSF file was used to generate a polynomial least squares mapping equation to relate the Mercator Image coordinates to the geographic coordinates (Figure B.1). In the initial run with the Geographic Transformer the resolution specified in the output ("destination") image was 1,113.19490793273 m, the linear distance of 0.01° of longitude at the equator using WGS-84 equatorial radius. The dimensions (scan lines x elements) of the output image did not conform to the Gulf of Mexico master image dimensions since pixel sizes were slightly larger that the desired 0.01° pixel size as evidenced in the corresponding ESRI world file generated during the transformation.

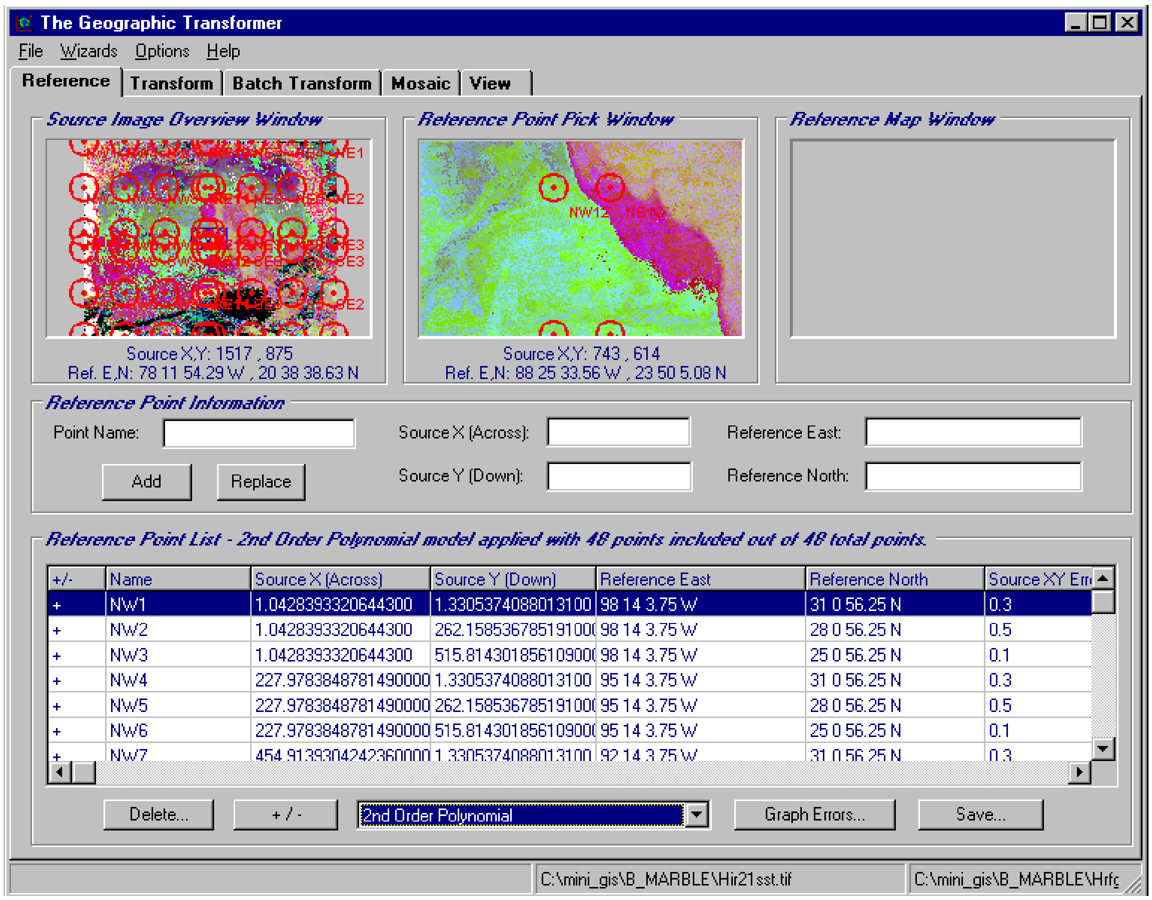

Figure B.1. The Geographic Transformer's reference map GUI set up with the test SST (source) file imported as a TIFF file, the reference settings file listed in section B.6.3, and the polynomial least-squares map transformation equation computed in preparation for the transformation step.

B.4 Computing the Correct Destination Resolution

Since the determination of the correct destination resolution by trial and error with repeated runs of the Geographic Transformer would have been a time-consuming process, a no-intercept regression model was developed (IML_REGR.SAS, section B.6.5) to predict the required value. The data for the computation were obtained from six runs of the Geographic Transformer using trial destination resolutions ranging from 1,105 - 1,120 m. The corresponding pixel sizes (in angular degrees) from the ESRI world files generated from the runs were used as the independent (x) variable and the destination resolutions as the dependent (y) variable in the equation. The equation predicted that a destination resolution of 1105.74275822796 m would result in the desired pixel size of 0.01° in the output image. The regression results are shown in section B.6.6.

B.5 Final Rectification

Using the destination resolution predicted by the regression equation, the image was successfully rectified to fit the Gulf of Mexico master map. The output file was written as a TIFF image, an image format supported by ArcView. The transform settings file for the operation is listed in section B.6.7. The software also generated a world file (section B.6.8) that is required by ArcView to correctly navigate the image. The transformation parameters are depicted in Figure B.2.

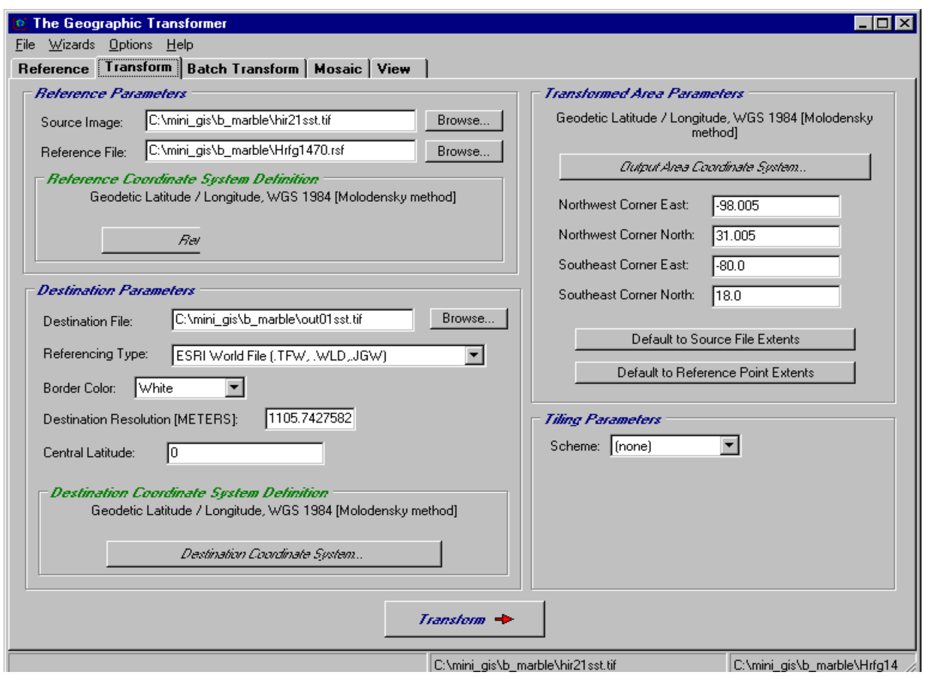

Figure B.2. The Geographic Transformer's map transformation GUI with parameters set to rectify the Mercator source image to a geographic coordinate system, write the data as a TIFF image, and generate a world file.

B.6 Programs and Data

B.6.1 The Image Product System MERCAT FORTRAN subroutine.

```
      SUBROUTINE MERCAT(XLAT,XLON,XI,XJ,ICONV)
C
C**********************************************************************
C
C   NAME- MERCAT                         EXPIRES- 12/31/99
C
C   LANGUAGE- FORTRAN     TYPE- SUBROUTINE
C
C   VERSION- 1.0    DATE- 11/11/84   PROGRAMMER- KRISHNA (SMSRC)
C   VERSION- 2.0    DATE- 04/11/89   PROGRAMMER- AGNI (SMSRC)
C
C   FUNCTION- TRANSFORMS LAT/LONGS TO I/JS AND VICE VERSA
C             USING MERCATOR PROJECTION.
C
C   FILES-NONE
C
C   CALLING SEQUENCE PARAMETERS-
C      VARIABLE                TYPE I/O FUNCTION
C      --------                ---- --- --------
C      XLAT                    R*4  I/O LATITUDE
C      XLON                    R*4  I/O LONGITUDE.
C      XI                      R*4  I/O PROJECTED I VALUE.
C      XJ                      R*4  I/O PROJECTED J VALUE.
C      ICONV                   I*4  I   ICONV = 1 : CONVERTS
C                                       LAT/LONGS TO I/JS
C                                       ICONV = 0 : CONVERTS
C                                       I/JS TO LAT/LONGS.
C
C   COMMON AREA PARAMETERS- NONE
C
C   LOCAL PARAMETERS-
C      VARIABLE                TYPE     FUNCTION
C      --------                ----     --------
C      ARG                     R*4     ARGUMENT USED TO CALCULATE
C                                      THE COORDINATES
C      COL                     R*4     THE CALCULATED COLUMN
C      EARTHR                  R*4     RADIUS OF THE EARTH
C      IHEMI                   I*4     DATA FLAG
C      OFFSET                  R*4     CONSTANT
C      PI4                     R*4     THE CONSTANT PI/4
C      RADPDG                  R*4     CONSTANT
C      ROW                     R*4     THE CALCULATED ROW
C      RPD2                    R*4     CONSTANT
C      SCALE                   R*4     USED TO CALCULATE PROJECTED X & Y
C      XCOR                    R*4     THE X COORDINATE
C      YCOR                    R*4     THE Y COORDINATE
C
C   BLOCK DATA- NONE
C
C   SUBPROGRAMS CALLED- NONE
C
C   EXIT STATES- NONE
C
C   RESTRICTIONS- NONE
C
C   ATTRIBUTES- NONE
C
C   COMMENTS- SEE FUNCTION
C
C**********************************************************************
C
```

B.6.1 MERCAT SUBROUTINE, CONCLUDED:

```
      DATA RADPDG/1.745329252E-2/
      DATA RPD2/8.7266462E-3/
      DATA PI4/0.785398163/
      DATA EARTHR/6371.2/
      DATA OFFSET/4.14159203/
      SCALE = EARTHR
      IF ( ICONV .EQ. 0 ) GO TO 10
C
C     CONVERT LAT/LONG TO I/JS
C
      XCOR = XLON*RADPDG
      IF ( XLAT .GT. 85.0 ) XLAT = 85.0
      IF ( XLAT .LT. -85.0 ) XLAT = - 85.0
      ARG = PI4 + ABS(XLAT)*RPD2
      YCOR = ALOG(TAN(ARG))
      IF ( XLAT .GT. 0.0 ) YCOR = - YCOR
      ROW = YCOR + OFFSET
      COL = XCOR
      XJ = ROW * SCALE
      XI = COL * SCALE
      GO TO 999
C
C     CONVERT I/JS TO LAT/LONGS
C
   10 CONTINUE
      IHEMI = -1
      COL = XI/SCALE
      ROW = XJ/SCALE
      XCOR = COL
      YCOR = ROW - OFFSET
      IF ( YCOR .LT. 0.0 ) IHEMI = 1
      IF ( YCOR .LT. 0.0 ) YCOR = - YCOR
      ARG = ATAN(EXP(YCOR))
      XLAT = ( ARG - PI4 )/RPD2
      IF ( IHEMI .EQ. - 1 ) XLAT = - XLAT
      XLON = XCOR/RADPDG
  999 CONTINUE
      RETURN
      END
```

B.6.2 The SAS program, GCP_GEN.SAS.

```
*****************************************************************************;
*               WINDOWS SAS (VERSION 6.10) PROGRAM: GCP_GEN.SAS             *;
*                                                                           *;
*       THIS PROGRAM READS THE GEOGRAPHIC COORDINATES OF A COASTWATCH (CW)   *;
*  GULF OF MEXICO IMAGE PRODUCT, GENERATES A LATITUDE AND LONGITUDE GRID, AND *;
*  PROCESSES THE DATA THROUGH THE CW SPHERICAL MERCATOR EQUATIONS TO GENERATE *;
*  CORRESPONDING SCAN LINE AND ELEMENT COORDINATES.  BOTH SETS OF COORDINATES *;
*  ARE REFORMATTED INTO A BLUE MARBLE REFERENCE SETTINGS (ASCII) FILE USED   *;
*  IN THE GEOGRAPHIC TRANSFORMER TO WARP THE MERCATOR PROJECTION TO A        *;
*  GEOGRAPHIC (LAT/LONG) COORDINATE SYSTEM.                                  *;
*                                                                           *;
*       THIS WAS WRITTEN TO SUPPORT THE NEAR REAL-TIME GIS DEVELOPMENT FUNDED *;
*  BY NOAA/NESDIS DURING 1996-98.                                            *;
*                                                                           *;
*       REFERENCE FOR THE SPHERICAL MERCATOR EQUATIONS:                      *;
*                                                                           *;
*  SNYDER, J.P. 1987. MAP PROJECTIONS - A WORKING MANUAL. U.S. GEOLOGICAL    *;
*       SURVEY PROFESSIONAL PAPER 1395, 383 PP.                             *;
*                                                                           *;
*                                                                           *;
*                                                                           *;
*                                                                           *;
* L.N. MAY, JR.                                                  28-AUG-96 *;
* DOC/NOAA/NMFS/SEFSC                               REVISION 1: 07-OCT-96 *;
* MISSISSIPPI LAB                                   REVISION 2: 05-NOV-96 *;
* BLDG 1103, RM 218                                 REVISION 3: 19-NOV-96 *;
* STENNIS SPACE CENTER, MS 39529-6000               REVISION 4: 20-NOV-96 *;
*                                                                           *;
*****************************************************************************;

*** READ THE MINIMUM AND MAXIMUM LATITUDES, MAXIMUM AND MINIMUM LONGITUDES, ***;
*** PIXEL RESOLUTION, AND HORIZONTAL AND VERTICAL OFFSET VALUES TAKEN FROM  ***;
*** A COASTWATCH IMAGE HEADER FILE GENERATED USING DECCON SOFTWARE          ***;

DATA A;
 INFILE CARDS;
  INPUT
   @1 MIN_LAT 9.
    @11 MAX_LAT 9.
     @21 MAX_LONG 10.
      @32 MIN_LONG 10.
       @43 RES 8.
        @52 H_OFFSET 5.
         @58 V_OFFSET 5.;

 INDEX = 1;

*** TABULATE THE LONG/LAT COORDINATES OF THE MIDDLE OF THE IMAGE ***;

  MID_LONG = (MAX_LONG + MIN_LONG)/2;
   MID_LAT = (MAX_LAT + MIN_LAT)/2;

  *MID_LONG = ROUND(((MAX_LONG + MIN_LONG)/2),0.1);
   *MID_LAT = ROUND(((MAX_LAT + MIN_LAT)/2),0.1);
```

B.6.2 The SAS program, GCP_GEN.SAS, continued:

```
*** GENERATE A LONG/LAT COORDINATE GRID FOR THE NW ***;
*** QUADRANT STARTING AT THE NW CORNER AND ENDING  ***;
*** AT ABOUT THE MIDDLE OF THE IMAGE. NOTE THAT THE***;
*** RESOLUTION OF THE GRID CAN BE ALTERED BY       ***;
*** CHANGING THE DEGREE INTERVALS AFTER THE 'BY'   ***;
*** IN EACH OF THE FOUR DO LOOP GROUPS, E.G., SET- ***;
*** TING THE RESOLUTION TO 3 DEGREES GENERATES A   ***;
*** TOTAL OF 48 COORDINATE PAIRS FOR THE FULL      ***;
*** (1.47 KM) RESOLUTION, GULF OF MEXICO SYNOPTIC  ***;
*** IMAGE PRODUCT (1101 SCAN LINES X 1401 ELEMENTS)***;

DO XLON = MAX_LONG TO MID_LONG BY 3 WHILE(XLON < MID_LONG);
 DO XLAT = MAX_LAT TO MID_LAT BY -3 WHILE(XLAT > MID_LAT);
  QUADRANT = 'NW';
   COUNT + 1;
    Q_COUNT + 1;
    OUTPUT;
    END;
   END;
  Q_COUNT = 0;

*** GENERATE A SIMILAR COORDINATE GRID FOR THE NE QUADRANT ***;

DO XLON = MIN_LONG TO MID_LONG BY -3;
 DO XLAT = MAX_LAT TO MID_LAT BY -3;
  QUADRANT = 'NE';
   COUNT + 1;
    Q_COUNT + 1;
    OUTPUT;
    END;
   END;
  Q_COUNT = 0;

*** GENERATE A SIMILAR COORDINATE GRID FOR THE SE QUADRANT ***;

DO XLON = MIN_LONG TO MID_LONG BY -3 WHILE(XLON > MID_LONG);
 DO XLAT = MIN_LAT TO MID_LAT BY 3 WHILE(XLAT < MID_LAT);
  QUADRANT = 'SE';
   COUNT + 1;
    Q_COUNT + 1;
    OUTPUT;
   END;
  END;
 Q_COUNT = 0;

*** GENERATE A SIMILAR COORDINATE GRID FOR THE SW QUADRANT ***;

DO XLON = MAX_LONG TO MID_LONG BY 3;
 DO XLAT = MIN_LAT TO MID_LAT BY 3;
  QUADRANT = 'SW';
   COUNT + 1;
    Q_COUNT + 1;
    OUTPUT;
   END;
  END;
```

B.6.2 The SAS program, GCP_GEN.SAS., continued:

```
*** COORDINATES OF THE GULF OF MEXICO SYNOPTIC 1.47 KM RESOLUTION PRODUCT PANEL
***;

CARDS;
17.820312 31.015625 -98.234375 -79.726562 1.470000 -7431 15480
;

/*
*** COORDINATES OF THE TEXAS 1.47 KM RESOLUTION PRODUCT PANEL ***;

CARDS;
24.289062 30.289062 -97.968750 -91.218750 1.470000 -7411 15544
;

*** COORDINATES OF THE GULF OF MEXICO SYNOPTIC 4.41 KM RESOLUTION PRODUCT PANEL
***;

CARDS;
12.296875 31.015625 -98.234375 -77.968750 4.410000 -2477 5160
;

*** COORDINATES OF THE LOUISIANA/MISSISSIPPI 1.47 KM RESOLUTION PRODUCT PANEL
***;

CARDS;
25.039062 31.000000 -94.007812 -87.250000 1.470000 -7111 15482
;

*** COORDINATES OF THE WESTERN FLORIDA 1.47 KM RESOLUTION PRODUCT PANEL ***;

CARDS;
25.039062 31.000000 -87.671875 -80.914062 1.470000 -6632 15482
;
*/;

*** PROCESS THE LATITUDE AND LONGITUDE COORDINATES THROUGH THE ***;
*** COASTWATCH SPHERICAL MERCATOR (MERCAT) ROUTINE TO GENERATE ***;
*** CORRESPONDING SCAN LINE AND ELEMENT COORDINATES            ***;

DATA B;
 SET A;

PI = 3.141592654;          *** CONSTANT ***;
 RADPDG = PI/180;          *** CONVERTS DEGREES INTO RADIANS ***;
  RPD2 = RADPDG/2;         *** TERM IN THE XJ COORDINATE CONVERSION EQUATION ***;
   PI4 = PI/4;             *** TERM IN THE XJ COORDINATE CONVERSION EQUATION ***;
    EARTHR = 6371.2;       *** AVERAGE RADIUS OF THE EARTH (KM) AT 60 DEGREES
LATITUDE ***;
     OFFSET = 4.14159203; *** VARIABLE OF UNKNOWN ORIGIN RETAINED FROM THE
ORIGINAL ALGORITHM ***;
      SCALE = EARTHR;

XCOR = XLON*RADPDG;
 IF (XLAT GT 85) THEN XLAT = 85;
  IF (XLAT LT -85) THEN XLAT = -85;
   ARG = PI4 + ABS(XLAT) * RPD2;
    YCOR = LOG(TAN(ARG));
     IF (XLAT GT 0) THEN YCOR = -YCOR;
      ROW = YCOR + OFFSET;
       COL = XCOR;
        XJ = ROW * SCALE;
         XI = COL * SCALE;
```

B.6.2 The SAS program, GCP_GEN.SAS, continued:

```
*** WRITING THE IMAGE COORDINATES AS FLOATING POINT NUMBERS     ***;
*** INSTEAD OF ROUNDING THEM OFF INTO INTEGERS GIVES A BETTER   ***;
*** FIT WITH THE POLYNOMIAL MAPPING EQUATIONS IN THE GEOGRAPHIC ***;
*** TRANSFORMER                                                 ***;

          *J_OFFSET = ROUND(XJ/RES,1);
           *I_OFFSET = ROUND(XI/RES,1);
            J_OFFSET = XJ/RES;
             I_OFFSET = XI/RES;
              IMAGE_X = (I_OFFSET - H_OFFSET) + 1;
               IMAGE_Y = (J_OFFSET - V_OFFSET) + 1;

*PROC PRINT;


/*
*** THE INVERSE FORM OF THE COASTWATCH SPHERICAL MERCATOR EQUATIONS ADAPTED FROM
***;
*** THE MERCAT ROUTINE.  TESTED BUT NOT USED, 28-AUG-97
***;

DATA C;
 SET B;
  IHEMI = -1;
   COL = XI/SCALE;
    ROW = XJ/SCALE;
     XCOR = COL;
      YCOR = ROW - OFFSET;
       IF (YCOR LT 0) THEN IHEMI = 1;
        IF (YCOR LT 0) THEN YCOR = -YCOR;
         ARG = ATAN(EXP(YCOR));
          XLAT = (ARG - PI4)/RPD2;
           IF (IHEMI EQ -1) THEN XLAT = -XLAT;
            XLON = XCOR/RADPDG;


PROC PRINT;
*/;


PROC SORT DATA = B;
 BY INDEX COUNT;

*** DETERMINE THE TOTAL COUNT OF GROUND CONTROL POINTS AND MERGE THE ***;
*** VARIABLE BACK INTO THE DATA SET. REQUIRED VARIABLE FOR THE BLUE  ***;
*** MARBLE REFERENCE SETTINGS FILE                                   ***;

PROC MEANS NOPRINT DATA = B;
 BY INDEX;
  VAR COUNT;
   OUTPUT OUT = C
    MAX = MAX_N;

DATA MERGE;
 MERGE C B;
  BY INDEX;

*** REFORMAT THE DATA INTO A BLUE MARBLE REFERENCE SETTINGS FILE (.RSF) FOR ***;
*** USE IN THE GEOGRAPHIC TRANSFORMER AND WRITE IT AS AN ASCII TEXT FILE    ***;

DATA DUMP;
 SET MERGE;
  BY INDEX COUNT;
   M = -1;
    *FILE PRINT;
    FILE 'C:\MINI_GIS\B_MARBLE\HRFG1470.RSF';
```

B.6.2 The SAS program, GCP_GEN.SAS, concluded:

```
   IF FIRST.INDEX THEN PUT
    @1 '3' @3 MAX_N
     #2 '"'
      QUADRANT +M
       Q_COUNT +M
        '"' +INDEX
         IMAGE_Y 21.16 +INDEX
          IMAGE_X 21.16 +INDEX
           '0.0' +INDEX
            XLAT 19.16 +INDEX
             XLON 20.16 +INDEX
              '0.00' +INDEX
                '1';

    ELSE PUT
     '"'
      QUADRANT +M
       Q_COUNT +M
        '"' +INDEX
         IMAGE_Y 21.16 +INDEX
          IMAGE_X 21.16 +INDEX
           '0.0' +INDEX
            XLAT 19.16 +INDEX
             XLON 20.16 +INDEX
              '0.00' +INDEX
               '1';

RUN;
```

B.6.3 Reference Settings File

The first field on line one is the version number of the Geographic Transformer and the second field is the total number of ground control points in the file. The remaining 48 records consist of the ground control point label field, e.g., "NW1", followed by coordinate fields (x,y, and a z field that is not currently used in version 3.07): scan line coordinate, element coordinate, first z-coordinate (not used and set to zero), latitude coordinate (decimal degrees), longitude coordinate (decimal degrees), second z-coordinate (not currently used and set to zero), and a binary switch to include (1) or exclude (0) a specific record in the computation of the mapping equations.

```
3 48
"NW1" 1.3305374088013100 1.0428393320644300 0.0 31.015625 -98.234375 0.00 1
"NW2" 262.1585367851910000 1.0428393320644300 0.0 28.015625 -98.234375 0.00 1
"NW3" 515.8143018561090000 1.0428393320644300 0.0 25.015625 -98.234375 0.00 1
"NW4" 1.3305374088013100 227.9783848781490000 0.0 31.015625 -95.234375 0.00 1
"NW5" 262.1585367851910000 227.9783848781490000 0.0 28.015625 -95.234375 0.00 1
"NW6" 515.8143018561090000 227.9783848781490000 0.0 25.015625 -95.234375 0.00 1
"NW7" 1.3305374088013100 454.9139304242360000 0.0 31.015625 -92.234375 0.00 1
"NW8" 262.1585367851910000 454.9139304242360000 0.0 28.015625 -92.234375 0.00 1
"NW9" 515.8143018561090000 454.9139304242360000 0.0 25.015625 -92.234375 0.00 1
"NW10" 1.3305374088013100 681.8494759703210000 0.0 31.015625 -89.234375 0.00 1
"NW11" 262.1585367851910000 681.8494759703210000 0.0 28.015625 -89.234375 0.00 1
"NW12" 515.8143018561090000 681.8494759703210000 0.0 25.015625 -89.234375 0.00 1
"NE1" 1.3305374088013100 1401.0697193387100000 0.0 31.015625 -79.726562 0.00 1
"NE2" 262.1585367851910000 1401.0697193387100000 0.0 28.015625 -79.726562 0.00 1
"NE3" 515.8143018561090000 1401.0697193387100000 0.0 25.015625 -79.726562 0.00 1
"NE4" 1.3305374088013100 1174.1341737926200000 0.0 31.015625 -82.726562 0.00 1
"NE5" 262.1585367851910000 1174.1341737926200000 0.0 28.015625 -82.726562 0.00 1
"NE6" 515.8143018561090000 1174.1341737926200000 0.0 25.015625 -82.726562 0.00 1
"NE7" 1.3305374088013100 947.1986282465400000 0.0 31.015625 -85.726562 0.00 1
"NE8" 262.1585367851910000 947.1986282465400000 0.0 28.015625 -85.726562 0.00 1
"NE9" 515.8143018561090000 947.1986282465400000 0.0 25.015625 -85.726562 0.00 1
"NE10" 1.3305374088013100 720.2630827004530000 0.0 31.015625 -88.726562 0.00 1
"NE11" 262.1585367851910000 720.2630827004530000 0.0 28.015625 -88.726562 0.00 1
"NE12" 515.8143018561090000 720.2630827004530000 0.0 25.015625 -88.726562 0.00 1
"SE1" 1100.9845602449800000 1401.0697193387100000 0.0 17.820312 -79.726562 0.00 1
"SE2" 860.4719348696470000 1401.0697193387100000 0.0 20.820312 -79.726562 0.00 1
"SE3" 615.1186581214880000 1401.0697193387100000 0.0 23.820312 -79.726562 0.00 1
"SE4" 1100.9845602449800000 1174.1341737926200000 0.0 17.820312 -82.726562 0.00 1
"SE5" 860.4719348696470000 1174.1341737926200000 0.0 20.820312 -82.726562 0.00 1
"SE6" 615.1186581214880000 1174.1341737926200000 0.0 23.820312 -82.726562 0.00 1
"SE7" 1100.9845602449800000 947.1986282465400000 0.0 17.820312 -85.726562 0.00 1
"SE8" 860.4719348696470000 947.1986282465400000 0.0 20.820312 -85.726562 0.00 1
"SE9" 615.1186581214880000 947.1986282465400000 0.0 23.820312 -85.726562 0.00 1
"SE10" 1100.9845602449800000 720.2630827004530000 0.0 17.820312 -88.726562 0.00 1
"SE11" 860.4719348696470000 720.2630827004530000 0.0 20.820312 -88.726562 0.00 1
"SE12" 615.1186581214880000 720.2630827004530000 0.0 23.820312 -88.726562 0.00 1
"SW1" 1100.9845602449800000 1.0428393320644300 0.0 17.820312 -98.234375 0.00 1
"SW2" 860.4719348696470000 1.0428393320644300 0.0 20.820312 -98.234375 0.00 1
"SW3" 615.1186581214880000 1.0428393320644300 0.0 23.820312 -98.234375 0.00 1
"SW4" 1100.9845602449800000 227.9783848781490000 0.0 17.820312 -95.234375 0.00 1
"SW5" 860.4719348696470000 227.9783848781490000 0.0 20.820312 -95.234375 0.00 1
"SW6" 615.1186581214880000 227.9783848781490000 0.0 23.820312 -95.234375 0.00 1
"SW7" 1100.9845602449800000 454.9139304242360000 0.0 17.820312 -92.234375 0.00 1
"SW8" 860.4719348696470000 454.9139304242360000 0.0 20.820312 -92.234375 0.00 1
"SW9" 615.1186581214880000 454.9139304242360000 0.0 23.820312 -92.234375 0.00 1
"SW10" 1100.9845602449800000 681.8494759703210000 0.0 17.820312 -89.234375 0.00 1
"SW11" 860.4719348696470000 681.8494759703210000 0.0 20.820312 -89.234375 0.00 1
"SW12" 615.1186581214880000 681.8494759703210000 0.0 23.820312 -89.234375 0.00 1
```

B.6.4 List of ground control points adapted from the Reference Settings File in the previous section.

	Mercator image coordinates		Geographic Coordinates (°)		
Quad	Column (x)	Row (y)	W longitude	N latitude	Image corner
NW1	1.042839	1.330537	-98.234375	31.015625	NW
NW2	1.042839	262.158537	-98.234375	28.015625	
NW3	1.042839	515.814302	-98.234375	25.015625	
NW4	227.978385	1.330537	-95.234375	31.015625	
NW5	227.978385	262.158537	-95.234375	28.015625	
NW6	227.978385	515.814302	-95.234375	25.015625	
NW7	454.913930	1.330537	-92.234375	31.015625	
NW8	454.913930	262.158537	-92.234375	28.015625	
NW9	454.913930	515.814302	-92.234375	25.015625	
NW10	681.849476	1.330537	-89.234375	31.015625	
NW11	681.849476	262.158537	-89.234375	28.015625	
NW12	681.849476	515.814302	-89.234375	25.015625	
NE1	1401.069719	1.330537	-79.726562	31.015625	NE
NE2	1401.069719	262.158537	-79.726562	28.015625	
NE3	1401.069719	515.814302	-79.726562	25.015625	
NE4	1174.134174	1.330537	-82.726562	31.015625	
NE5	1174.134174	262.158537	-82.726562	28.015625	
NE6	1174.134174	515.814302	-82.726562	25.015625	
NE7	947.198628	1.330537	-85.726562	31.015625	
NE8	947.198628	262.158537	-85.726562	28.015625	
NE9	947.198628	515.814302	-85.726562	25.015625	
NE10	720.263083	1.330537	-88.726562	31.015625	
NE11	720.263083	262.158537	-88.726562	28.015625	
NE12	720.263083	515.814302	-88.726562	25.015625	
SE1	1401.069719	1100.984560	-79.726562	17.820312	SE
SE2	1401.069719	860.471935	-79.726562	20.820312	
SE3	1401.069719	615.118658	-79.726562	23.820312	
SE4	1174.134174	1100.984560	-82.726562	17.820312	
SE5	1174.134174	860.471935	-82.726562	20.820312	
SE6	1174.134174	615.118658	-82.726562	23.820312	
SE7	947.198628	1100.984560	-85.726562	17.820312	
SE8	947.198628	860.471935	-85.726562	20.820312	
SE9	947.198628	615.118658	-85.726562	23.820312	
SE10	720.263083	1100.984560	-88.726562	17.820312	
SE11	720.263083	860.471935	-88.726562	20.820312	
SE12	720.263083	615.118658	-88.726562	23.820312	
SW1	1.042839	1100.984560	-98.234375	17.820312	SW
SW2	1.042839	860.471935	-98.234375	20.820312	
SW3	1.042839	615.118658	-98.234375	23.820312	
SW4	227.978385	1100.984560	-95.234375	17.820312	

B.6.4 List of ground control points, concluded:

SW5	227.978385	860.471935	-95.234375	20.820312
SW6	227.978385	615.118658	-95.234375	23.820312
SW7	454.913930	1100.984560	-92.234375	17.820312
SW8	454.913930	860.471935	-92.234375	20.820312
SW9	454.913930	615.118658	-92.234375	23.820312
SW10	681.849476	1100.984560	-89.234375	17.820312
SW11	681.849476	860.471935	-89.234375	20.820312
SW12	681.849476	615.118658	-89.234375	23.820312

B.6.5 SAS IML program, IML_REGR.SAS, used to compute the correct destination resolution of the output image. The x-values are output pixel sizes (in degrees) from ESRI world files generated from six runs of the Geographic Transformer using trial destination resolutions (y-values).

```
**********************************************************;
*    WINDOWS SAS (V 6.11) IML PROGRAM: IML_REGR.SAS       *;
*                                                         *;
*  SIMPLE LINEAR REGRESSION TO COMPUTE THE DESTINATION    *;
*  RESOLUTION VARIABLE REQUIRED BY THE BLUE MARBLE GEO-   *;
*  GRAPHIC TRANSFORMER TO TRANSFORM A HIGH RESOLUTION     *;
*  (1.47 KM) COASTWATCH GULF OF MEXICO SYNOPTIC IMAGE IN  *;
*  A MERCATOR PROJECTION TO A LINEAR LATITUDE/LONGITUDE   *;
*  FILE CONFORMING TO THE GULF MASTER IMAGE, I.E., 0.01   *;
*  DEGREE PIXEL RESOLUTION AND 1800 ELEMENTS BY 1300 SCAN *;
*  LINES.                                                 *;
*                                                         *;
*  THE X-VALUES WERE TRANSCRIBED FROM ESRI WORLD FILES    *;
*  GENERATED BY REPEATED RUNS OF THE GEO TRANSFORMER USING *;
*  THE CORRESPONDING Y-VALUES IN THE DESTINATION IMAGE    *;
*  PORTION OF THE TRANSFORM MENU.                         *;
*                                                         *;
*  THE REGRESSION IS A NO INTERCEPT MODEL, I.E., FORCED   *;
*  THROUGH THE ORIGIN.                                    *;
*                                                         *;
*                                                         *;
* L.N. MAY, JR                                 19-NOV-96 *;
* DOC/NOAA/NMFS/SEFC                  REVISION 1:         *;
* MISSISSIPPI LABORATORY              REVISION 2:         *;
* BLDG. 1103 ROOM 218                 REVISION 3:         *;
* STENNIS SPACE CENTER, MS 39529      REVISION 4:         *;
*                                                         *;
**********************************************************;

PROC IML;

 RESET NOPRINT FW = 16; /* SET THE NUMERIC FIELD WIDTH */

 X = {0.010067394967,
      0.010074675974,
      0.010128938143,
      0.010174156617,
      0.009948064248,
      0.009993282721,
      0.010038501195}; /* PIXEL RESOLUTIONS FROM ESRI WORLD FILES, ANGULAR
DEGREES */

 Y = {1113.19490793273,
      1114.00000000000,
      1120.00000000000,
      1125.00000000000,
      1100.00000000000,
      1105.00000000000,
      1110.00000000000};  /* CORRESPONDING LENGTH (M) OF THE PIXELS AT THE
EQUATOR */

 I = 0.010000000000;      /* DESIRED PIXEL SIZE OF OUTPUT IMAGE, ANGULAR DEGREES
*/

 XPXI = INV(X'*X);
 BETA = XPXI * (X'* Y);   /* ESTIMATE SLOPE */
 LENGTH = BETA * I;       /* COMPUTE THE LENGTH OF 0.01 DEGREE PIXEL */
 YHAT = X * BETA;         /* PREDICTED Y VALUES */
```

B.6.5 SAS IML program, IML_REGR.SAS, concluded:

```
 RESID = Y - YHAT;          /* RESIDUALS */
 SSE = SSQ(RESID);          /* SUM OF SQUARED ERRORS */
 N = NROW(X);               /* NUMBER OF OBSERVATIONS */



 DFE = N - NCOL(X);         /* DEGREES OF FREEDOM ERROR */
 MSE = SSE / DFE;           /* MEAN SQUARED ERROR */
 CSSY = SSQ(Y-Y[+]/N);      /* SS FOR Y CORRECTED FOR MEAN */
 RSQUARE = (CSSY - SSE)/CSSY;      /* COEFFICIENT OF SIMPLE DETERMINATION */
 STDB = SQRT(VECDIAG(XPXI) * MSE); /* STANDARD ERROR OF SLOPE ESTIMATE */

 PRINT,
 "DESTINATION RESOLUTION (M) VARIABLE REQUIRED",
 " FOR THE BLUE MARBLE GEOGRAPHIC TRANSFORMER",
 LENGTH;

 PRINT,
 "REGRESSION RESULTS - NO INTERCEPT MODEL",
 BETA STDB DFE MSE RSQUARE;

 PRINT,
 Y YHAT RESID;

QUIT;
```

B.6.6 Edited output from the SAS IML Program, IML_REGR.SAS. The variable LENGTH is the correct destination resolution (m) parameter predicted by the regression equation that is required to rectify the output image to fit the Gulf of Mexico master map. The regression output are estimates of the: slope (SLOPE), standard error of the slope (SDE_SLOPE), degrees of freedom for error (DFE), mean squared error (MSE), coefficient of simple determination (RSQUARE), dependent variable (Y - pixel lengths in m), predicted values of Y (YHAT), and the residuals (RESID).

```
LENGTH = 1105.74275822796

                    REGRESSION RESULTS - NO INTERCEPT MODEL

      SLOPE        SDE_SLOPE     DFE         MSE            RSQUARE
110574.275822796 1.39604174939E-6   6  1.380938731E-15            1


       Y                YHAT            RESID
1113.19490793273 1113.19490789809  3.46442448063E-8
1114.00000000000 1113.99999997437  2.56281964539E-8
1120.00000000000 1120.00000001612 -1.61207935890E-8
1125.00000000000 1125.00000003248 -3.24828306470E-8
1100.00000000000 1100.00000006125 -6.12474195800E-8
1105.00000000000 1104.99999996704  3.29648628394E-8
1110.00000000000 1109.99999998340  1.66030531545E-8
```

B.6.7 Transform settings file generated for the output image by the Geographic Transformer.

```
[Transform Settings]
SourceFile=C:\mini_gis\b_marble\hir21sst.tif
ReferenceFile=C:\mini_gis\b_marble\Hrfg1470.rsf
RefSysGroupKey=LAT-LONG
RefSysCoordSysKey=LAT-LONG
RefSysDatumKey=WGS84
RefSysUnitKey=METERS
DestSysGroupKey=LAT-LONG
DestSysCoordSysKey=LAT-LONG
DestSysDatumKey=WGS84
DestSysUnitKey=METERS
ReferenceModel=1
Resolution=1105.74275822796
CentralLatitude=0
OutputRefType=2
BorderValue=-2
OutputAreaSysGroupKey=LAT-LONG
OutputAreaSysCoordSysKey=LAT-LONG
OutputAreaSysDatumKey=WGS84
OutputAreaSysUnitKey=METERS
OutputAreaNWE=-98.005
OutputAreaNWN=31.005
OutputAreaSEE=-80.0
OutputAreaSEN=18.0
Output=C:\mini_gis\b_marble\out01sst.tif
Tile=NO
```

B.6.8 ESRI world file generated by the Geographic Transformer and required to navigate the output image in ArcView. The file consists of the following six parameters in order: (1) the pixel size (x-dimension) in angular degrees; (2) and (3) are rotation terms not currently supported in ArcView and thus are set to null values; (4) the pixel size (y-dimension) in angular degrees; (5) the x-coordinate, i.e., longitude in angular degrees, of the center of the upper left (northwest) pixel; and (6) the y-coordinate, i.e., latitude in angular degrees, of the center of the upper left (northwest) pixel;

```
  0.010000000000
  0.000000000000
  0.000000000000
 -0.010000000000
-98.000000000000
 31.000000000000
```

APPENDIX C: THE FILE FORMAT REQUIRED FOR UPLOADING CUSTOM POINT, LINE, AND POLYGON THEMES AND ATTRIBUTES

C.1 Structure of a Custom Theme Definition Consisting of Two Lines and Associated Attributes

```
#NAME Theme Name
#TYPE LINE
#ATTRIBUTE_TYPES INT FLOAT BOOL DATE STRING FLOAT
#ATTRIBUTE_NAMES Int Float 1 TorF the Date Description Float
3
1
-98 28
-98.5500 28.01
-98.4345 27.90
-98 27
END
2
-97.75 27.00
-97.75 27.50
-97.50 27.50
-97.50 27.00
END
END
1 27 32 true 1998:09:15 First Line 38.994
2 21 88.5 0 1998:09:16 Second line 77.99
```

C.2 Notes on the Example

This example shows a two record line file. Each line shape has six attributes. The components of the file consist of a header, coordinate file, and the attributes associated with each line.

C.2.1 The Header Structure

The header defines the name, type (point, line or polygon), and optionally, the field types and names of the attributes for the theme. A TAB delimiter is required between the header item name and its value, i.e.,:

```
#NAME[TAB]Theme Name
```

Blanks and other delimiters (with the exception of TABS) are permitted for use in the theme name.

The #NAME and #TYPE definitions are required; if attributes are being omitted then #ATTRIBUTE_TYPES and #ATTRIBUTE_NAMES definitions are not required. However, if you have either of the #ATTRIBUTE entries, you must have both, and you must have an equal number of attribute types and names. Also, #ATTRIBUTE_TYPES must be above #ATTRIBUTE_NAMES. The acceptable #TYPEs are LINE, POLY, and POINT. The acceptable #ATTRIBUTE_TYPES are: INT (integer), FLOAT (floating point numbers), BOOL (Boolean), DATE, and STRING. Integers can be up to 16 digits wide and floating point values can be 16 digits wide before the decimal point, and 6 digits wide after the decimal point. Dates must be in a YYYY:MM:DD format. The #ATTRIBUTE entries are also tab-delimited, e.g.:

```
#ATTRIBUTE_TYPES[TAB]FLOAT[TAB]INT and
#ATTRIBUTE_NAMES[TAB]A[space]Float[TAB]A[space]Int
```

Again, the #ATTRIBUTE_NAMES list is tab-separated and attribute names may be delimited by blanks and other delimiters, with the exception of TABS.

C.2.2 The Shape Definitions

C.2.2.1 Points

The shape definitions are identical to the standard ESRI UNGENERATE format for points, lines, and polygons. The point format requires a single record containing three data fields. The first field contains an integer value to uniquely identify each point, followed by the longitude and latitude coordinate fields. The three data fields may be delimited by blanks, commas, or TABS. Longitude and latitude coordinates are required to be in a decimal equivalent format. Longitudes must be negatively signed (e.g., -93.667°) and latitudes positively signed to denote the western and northern hemispheres, respectively, and thus are correctly navigated within the Gulf of Mexico Master Map (GMMM). The END statement defines the end of the file. Using the example from section C.1, modify the shape component of the file to define eight points:

```
#NAME Point file
#TYPE POINT
1 -98 28
2 -98.5500 28.01
3 -98.4345 27.90
4 -98 27
5 -97.75 27.00
6 -97.75 27.50
7 -97.50 27.50
8 -97.50 27.00
END
```

C.2.2.2 Polygons

The structure of the polygon file is similar to the line file except that the first coordinate pair defining a polygon must be identical to the last coordinate pair to "close" the polygon. Using the example in section C.1, modify the file to define two polygons:

```
#NAME Polygon file
#TYPE POLY
1
-98 28
-98.5500 28.01
-98.4345 27.90
-98 27
-98 28
END
2
-97.75 27.00
-97.75 27.50
-97.50 27.50
-97.50 27.00
-97.75 27.00
END
END
```

C.3 The Attribute Listings

These are the values for the attributes named in the header. If there are no attributes defined in the header, then this section of the file may be eliminated. Each line starts with the ID number of the shape that the attributes belong to, then lists the values for the attributes. Note that the attribute list must be TAB delimited. There must be the same number of attributes on each line as there are listed in the header and the attributes must be in the same order as the way they are listed in the header. For example, given the header:

```
#ATTRIBUTE_TYPES BOOL FLOAT INT
#ATTRIBUTE_NAMES Checked Pressure Diameter
```

The following attribute listing is acceptable:

```
33 true 99.8 24
34 0 44.9972 44
```

Note that floating point values can have variable numbers of digits after the decimal point. Boolean values can be represented as words ("true" or "false") or as numbers (0 = false, non-zero = true).

At this time, there can be no missing values in the attribute listings. Missing values will cause an error. A record entry is required for every shape. Record entries do not have to be in the same order as the shapes, but processing speed is enhanced if they are. Note that tab-delimited tables, suitable for use in the attribute listing section, can be exported from most standard spreadsheet applications. For Statistical Analysis System (SAS) users, the hexadecimal character ‘09'x is used to insert TAB delimiters between data fields when writing ASCII files to disk. For example:

```
/****************************************************/
/*    SAS PROGRAM:  TAB_DELIM_EXAMPLE.SAS           */
/*                                                  */
/* EXAMPLE PROGRAM USED TO WRITE AN ASCII FILE WITH */
/* DATA FIELDS DELIMITED BY TABS. FIELDS ARE THUS   */
/* DEFINED AS CELLS FOR INPUT INTO A WORDPERFECT    */
/* TABLE FORMAT OR SPREADSHEET APPLICATION SUCH AS  */
/* EXCEL.                                           */
/*                                                  */
/* SAS ENCODES THE HEXADECIMAL CHARACTER ’09’x AS A */
/* TAB IN THE SCREEN PRINTED VERSION OF THE FILE AND */
/* AND THE ASCII OUTPUT FILE                        */
/*                                                  */
/* L.N. MAY, JR.                        08-DEC-1998 */
/* DOC/NOAA/NMFS/SEFSC                              */
/* MISSISSIPPI LABORATORY                           */
/* BLDG 1103, RM 218                                */
/* STENNIS SPACE CENTER, MS 39529                   */
/****************************************************/

DATA READ_IT;
 INFILE CARDS;
  INPUT NAME $CHAR15. AGE SALARY;

  CARDS;
I.A. RANGE    28  38900
I.R.A. DUMMKOPF 37 143280
;

/* WRITE FILE TO THE C DRIVE */

DATA WRITE_IT;
 SET READ_IT;
  FILE ’C:\TABDELIM.TXT’;

 PUT
 @1 NAME $CHAR15.
  ’09’x
   @17 AGE 2.
   ’09’x
    @20 SALARY 6.;

 RUN;
```

C.4 The *Survey Points* custom theme definition (custom_theme.txt) used as an example in Section 6.3.9 of the Final Report and in the online tutorial available through the NMFS Java Network Map Client Download Page (http://marlin.ssc.nmfs.gov/gis).

```
#NAME Survey Points
#TYPE POINT
#ATTRIBUTE_TYPES  INT  FLOAT   BOOL DATE     STRING FLOAT
#ATTRIBUTE_NAMES  Int  Float 1 TorF the Date Description   Float 2

1 -93 25
2 -93.5500 28.01
3 -94.4345 22.90
4 -92 24
5 -92.75 23
6 -87.75 27.50
7 -92 21.50
8 -86.50 23.00
END

1     21 32    1 1998:09:15 A 38.994
2     21 88.5 0 1998:09:15 A 77.99
3     21 55    1 1998:09:15 B 72.3
4     56 57.1 1 1998:09:15 A 77.9
5     56 92.999 0  1998:09:18 B 1.1
6     56 77.787 0  1998:09:18 C -47.77777
7     29 24.2 1 1998:09:18 C -100
8     29 44    0 1998:09:18 B 100.1
```

APPENDIX D: THE NMFS JAVA NETWORK MAP SERVER (JNMS) ADMINISTRATOR'S GUIDE

D.1 Running the JNMS

The JNMS application server is composed of two main applications: (1) an ArcView GIS session, which processes user requests; and (2) a Java-based messaging system, which handles all network communications with the remote clients. Although each of these applications may be run separately from one another, both must be operating for the system to be available to client applications.

Each of these applications require some configuration before serving maps. ArcView requires the more extensive configuration; the procedures for configuring ArcView are discussed in section D.2. The Java messaging software requires very little configuration and procedures for running the utilities are given in Section D.3.

D.2 Configuring ArcView to be a Network Map Server

D.2.1 Basic Steps

Configuring ArcView as a network map server requires three steps:

- Creating a new project with a *VIEW* that contains all of the static themes (the themes that will be included in every user's basic view).

- Loading the ArcView JNMS extension into the project.

- Setting the preferences in the Server Configuration dialog box.

When the three steps have been properly completed, ArcView will be prepared to act as a map server. The following paragraphs describe these steps in more detail.

D.2.2 Creating the Project

The first step in setting up the server is to create a project that contains the information to be served. Although any project with a view can be served, it will generally be best to create a project specifically for the server to reduce clutter within the project.

Every served project must have at least one *VIEW* to serve as the Static View, i.e., contains the set of static themes that will be included in every view served to each user. Currently the static themes consist of the GMMM (coastline), longitude/latitude grid, NMFS shrimp statistical subareas, state and federal waters, and the two depth contours files. The Static View essentially serves as the template from which user views are generated.

Note that the Static View does *not* include the near-real time satellite grid themes that are presented in the *Image Catalog*. The *Image Catalog* is automatically generated by the server, and should not be added manually to the Static View.

The themes in the Static View may be arranged in any way that is appropriate; their order, and their legends and color schemes, may be configured in any way that effectively conveys the spatial data presented in the maps.

However, there are several points that the administrator should consider when configuring the themes:

- The ArcView menu commands View->*ADD THEME* and Edit->*DELETE THEME* are used to add or remove, respectively, themes from the Static View. Any grid themes present in the Static View should be placed *below* all vector themes (polygon, line, and point themes), for two reasons. First, grid themes generally obscure all themes placed below them when they are visible. Second, when the grid themes from the Image Catalog are merged with the Static View to form a user’s view, the Image Catalog themes will be added *above* the highest grid theme in the Static themes.

- The default names of the themes will probably **not** be appropriate for using with the server. First, the names generated by ArcView will probably not be informative to most users (e.g., "coast_1km.shp" is a less informative name than "Coastline"). Second, because the server relies on passing specially formatted text strings to communicate with outside applications, there are several characters which cannot be used in theme names. The following characters are **illegal** for usage in theme names:

~ # $. / \ + - = % &

The theme names may be changed with the menu command Theme->*PROPERTIES* and changing the name in the dialog box.

- The administrator can choose whether or not the theme's legend will be visible to the users, simply by setting the theme's visibility with the standard menu command Theme->*HIDE/SHOW LEGEND*. Legends that are visible in the Static View will be visible to users also. Legends hidden in the Static View will not be available to users.

- The administrator can also choose which fields in a theme's table will be visible to users in the same manner. Fields that are hidden in the theme's table will be hidden from the user also. Similarly, field names can be set to an alias that is more readable for the user (e.g., ZONE_NUM can be called "Shrimp Zone"). Field names should follow the same naming rules as themes as discussed in a previous section. The "Shape" field is never visible to users, since it does not contain any relevant information. (Note: these features in ArcView can be accessed by making the theme's table visible using the menu command Theme->*TABLE*, and then editing the table's properties using the menu command Table->*PROPERTIES*.

D.2.3 Loading the ArcView JNMS extension

The JNMS extension contains the scripts, dialogs, and resources required to configure ArcView to be a map server. The extension can be loaded by activating the *Project* window and selecting the File->*EXTENSIONS* menu command. Check the box next to the JNMS entry in the resulting dialog box, and ArcView will load the extension, as well as other extensions which JNMS depends upon to work correctly. These dependencies are:

- *avdlog.dll*: A shared library which allow the use of the custom dialogs in the projects

- *avimgexp.dll*: A shared library which allows ArcView to export images in the JPEG format

- *spatial.avx*: The ESRI Spatial Analyst extension, which is required to work with grid data.

- *dirchoose.avx*: A custom extension, developed for this project, which implements a standard file system dialog box within ArcView. This is needed because the standard ArcView file dialog does not allow the user to select directories, only files.

- *utility.avx*: A custom extension which contains a library of generally useful functions. These functions are used by JNMS, but are not unique to it.

These files should all be located in the ArcView installation's /ext directory. Once installed, the JNMS extension adds a dialog box for setting server preferences, editing user names and passwords, and starting the server.

D.2.4 Setting Server Preferences

A number of preferences must be set before the ArcView server can operate properly. These options can be accessed through the File->*MAP SERVER* menu command in the *VIEW* GUI. This will produce a dialog box listing the configuration options for the server (Figure D.1). Most of these options specify the location of disk directories to hold different files needed by the server. In addition, there are facilities for editing the list of authorized users and their passwords, and for configuring automatic updates to the image catalog. The various options are explained below.

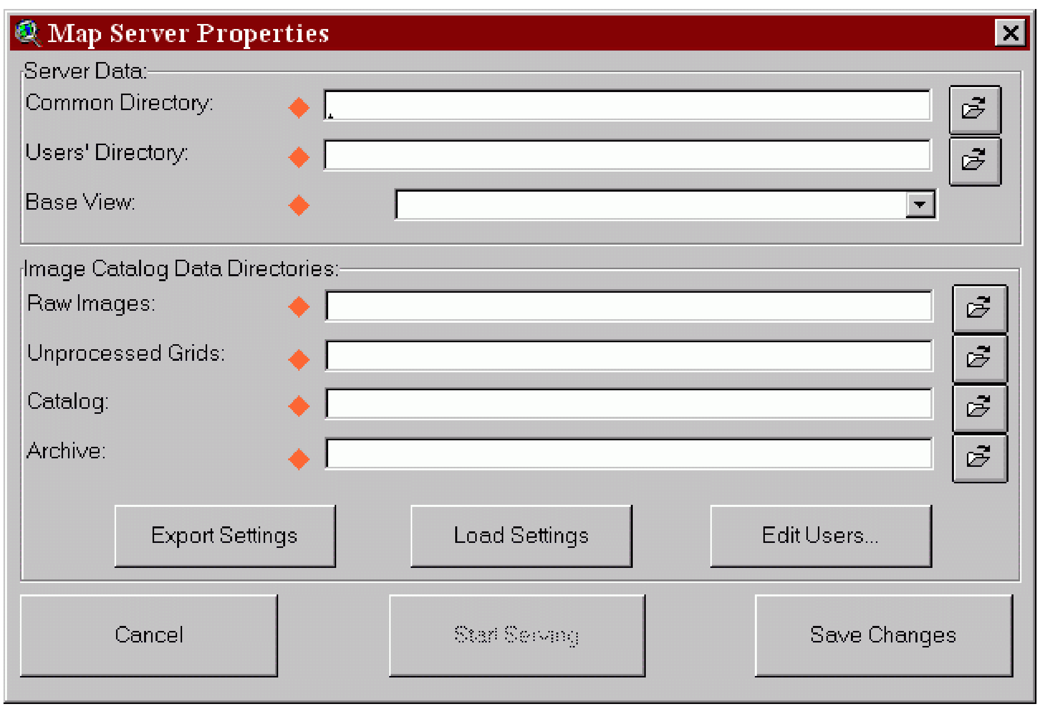

Figure D.1. The Map Server Properties Dialog Box.

- *Common Directory*: A directory where the server will write temporary files, i.e., the JPEG thumbnail images presented in the data catalog, to be served to all clients. Any directory on the local file system which allows read/write access is appropriate.

- *User's Directory*: A directory where files served to individual users will be created. In addition, user's personal files (such as custom themes uploaded to the server) will be placed here. When a user logs into the system, a subdirectory with the same name as the user is automatically created under the user's directory.

- *Base View*: All of the views in the project will be listed in this drop-down list. Choose the name of the view previously configured as the static view and discussed in section D.2.2.

- *Raw Images*: The name of the directory where raw, compressed CoastWatch images are located. Images that are added to this directory will be automatically converted to ArcView GRID files.

- *Unprocessed Grids*: This directory is used to hold GRID files that have been converted from the native CoastWatch format, but have not yet undergone final rectification ("nudging").

- *Catalog*: This directory holds GRIDs that are ready to serve as part of the image catalog. GRID files whose names conform to the CoastWatch naming convention (in which the date of image acquisition is encoded in the filename) will be automatically removed from the catalog after one week.

- *Archive*: A directory where outdated files from the image catalog are stored.

Note that *all* of these directories must be **readable and writeable**, except for the *Raw Images* directory, which must at least be **readable**.

Other features and components include:

- *EDIT USERS* Button: This button provides access to the list of user names and passwords for editing.

- *EXPORT SETTINGS* Button: This utility will save the currently specified settings (including existing usernames and passwords) to a text file with the same name as the current project, except with a "*.p" extension (e.g., properties exported from /gis/arcsvr/server.apr would be written to /gis/arcsvr/server.p).

- *IMPORT SETTINGS* Button: This allows the administrator to import settings previously exported from another project.

- The *Properties (*.p) File*: This file is in the ArcView Object Data Base (ODB) file format and is a simple, text-based serialization of Avenue objects. The *.p file contains two Dictionary objects: (1) a dictionary relating properties names to property values; and (2) a dictionary of usernames and passwords. For more information on dictionaries and ODB files, refer to the Avenue documentation.

D.2.5 Starting the ArcView Server

Once the server properties have been set, the server can be started by clicking the *START SERVING* button. It will take a few minutes before the server is actually ready to accept client since ArcView must first construct and export summaries of all Views and Themes to be served.

D.3 Running the Java-based Messaging Software

D.3.1 Overview

The Java messaging software acts as a communication layer between the ArcView session running on the server and the client programs running on remote computers. The messaging software fulfills the following functions:

- Listens on a port on the server machine (port 10208) for client requests to connect.

- Interprets client requests, as communicated through the network, into a form that the ArcView session can understand.

- Passes requests to ArcView through a Remote Procedure Call (RPC). Once ArcView processes the request, the results are returned in the same manner.

- Replies to client requests (including map images, tables of data, etc.) that are packaged for network transport, and returned to the client.

D.3.2 Running the Software

The Java messaging software does not require extensive configuration. Most server properties (such as the locations of the various directories) are retrieved in a query to ArcView.

Before running the Java software, the path where the Java software is installed must be added to the system *PATH* variable. This is because programs and shared libraries, which the system must be able to locate, are stored there (specifically, DECCON, a shell script called *run_deccon*, and a shared library called *libjnms_relay.so*). This directory can be added to *PATH* in the runtime command file for the shell (e.g., .cshrc, .bash_profile) so that these files are always available.

The administrator may run the server messaging software by executing the shell script called *jnms*, which is supplied in the **jars** directory. The shell scripts simply executes this line:

jre -cp ./:./swing.jar:./multi.jar:./jgl3.1.0.jar -Djnms.log=./jnms.log gov.nasa.ssc.lmso.jnms.server.JNMS

There are four parts to this command:

- *jre*: This invokes the Java interpreter (jre stands for "Java Runtime Environment").

- *-cp ./:./swing.jar:./multi.jar:./jgl3.1.0.jar*: This tells jre where to finds the class files (the Java program files) which make up the software (it is similar to the PATH variable found on UNIX or DOS).

- *-Djnms.log=./jnms.log*: This command-line option tells the server to save a log of transactions to a file named jnms.log.

- *gov.nasa.ssc.lmso.jnms.server.JNMS*: This tells jre which class file has the "main" function (the starting execution point for the program).

When jnms begins execution, it will print a status message to the screen, such as this:

```
orca: Program not registered
Fri Jan 01 17:30:23 CST 1999  ArcView does not appear to be running.
Fri Jan 01 17:30:24 CST 1999  ServerSocket created:
Fri Jan 01 17:30:24 CST 1999  10208
Fri Jan 01 17:30:25 CST 1999
ServerSocket[addr=0.0.0.0/0.0.0.0,port=0,localport=10208]
```

This *jnms* session was started before ArcView was running; the dire-sounding messages "program not registered" and "ArcView does not appear to be running" simply means that ArcView has not yet been placed into server mode. This is not a problem; *jnms* will establish the necessary connection after ArcView is in server mode. The other status lines indicate that *jnms* is now listening on port 10208 for client connections. Once *jnms* is running, and ArcView has been placed into server mode, the GIS application server will be fully functional and available to users of the system.

APPENDIX E: A BRIEF INTRODUCTION ON INSTALLING AND USING THE NMFS JAVA NETWORK MAP CLIENT VERSION 1.0

This section provides a brief summary of the steps required to install and use the NMFS Java Network Map Client (JNMC) software. The JNMS is a stand-alone Java-based application which connects to an ArcView map server over the Internet and allows the user to view, query, and perform analyses on geographic data stored on the server. A more detailed description of the installation process including hyperlinks to the required software is given in the NMFS Java Network Map Client download page[19]. Although the JNMC should run on most newer computers with a recent version of Java installed (v. 1.1.x) it has only been tested on Windows 95/NT and SGI Irix operating systems.

E.1 Installing Java

To determine if Java is installed on the local machine, type "java -version" or "jre" at the command line. If JVM is installed, the system should respond with a message indicating the version of Java installed on the system. If Java is not installed, then the following two steps are required:

- Download the specific installer for your system, e.g., Windows 95/98/NT , IRIX 5.3, IRIX 6.2 and above, Solaris 2.5.1 and 2.6, or MacOS 8.x.

- Install the Java software using the directions on the WWW site where the software was obtained.

E.2 Installing the JNMC

Installing the JNMC program is a simple two step process which varies slightly among platforms.

- Download the client installation program for your system, e.g. Windows 95/98/NT, IRIX, other UNIX systems, or MacOS.

- Run the installer

E.3 Running the JNMC

After completing the installation, the JNMC is started the same way as any other program on your platform:

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[19] http://marlin.ssc.nmfs.gov/gis

- On Windows, find "*Programs->NMFS Java Network Map Client*" in the Start menu and click on the shortcut to JNMC there.
- On UNIX, type "*sh jnmc*" in the directory where the JNMC was installed.
- On MacOS, double click the *jnme* program in the folder where the program was installed.